Contents

1.0 INTRODUCTION

This document describes the Distribution Planning Criteria and Strategy that will be used by the Liberty Utilities Engineering Department to review and evaluate the performance of its distribution system for each Planning Study Area ("PSA"). A PSA is a group of distribution facilities, including substations, feeders, transformers, and sub-transmission lines, within a specific geographic area that are interconnected and are studied as a group. There are four PSAs in Liberty's service territory: Salem, Lebanon, Bellows Falls and Monroe. See Attachment A for Liberty Utilities Planning Study Area Map. The review and evaluation of each PSA is to be documented in a report ("Distribution PSA Study") that describes the assumptions, procedures, economic comparison, conclusions, and recommendations for the PSA. Liberty will conduct a PSA Study periodically, or when conditions within the PSA change, such as: changes in overall PSA demand forecast; changes in how load is distributed within the PSA; significant load additions; and/or other changes in conditions that warrant a PSA Study.

When preparing a PSA Study, Liberty will consider wires and non-wires alternatives to address system needs, such as those listed in Table 1 below.

Table 1. Distribution System Planning Alternatives

Wires Alternatives	Non-Wires Alternatives
• Load Balancing • Power Factor Improvement • Reconductoring/Recabling • Circuit and Substation Equipment Upgrades • Voltage Conversions (e.g. 4kV to 13.2kV) • Feeder reconfigurations	• Distributed Generation • Controllable Load Curtailment • Energy Efficiency • Energy Storage Devices • Demand Side Management • Distribution Automation • Smart Grid Solutions (Ex: Dynamic Ratings, Real Time Load Transfers and Capacitor Activation, etc.)

1.1 Objective

The goal of these planning criteria is to provide adequate capacity for safe, reliable and economic service to customers with minimal impact on the environment. To achieve that goal, the distribution system is planned, measured, and operated with the objective of providing electric service to customers under system intact conditions (i.e., "normal") and first contingency conditions ("N-1").

1.2 New Planning Criteria

Since the purchase of the New Hampshire electric assets from National Grid in 2012, Liberty Utilities has refined the distribution planning criteria to better fit Liberty's strategy and scale of facilities.[1] These refinements, such as reducing the normal operating ratings limit from 100% to 75% on feeders and transformers and from 100% to 90% on supply lines, reflect Liberty's strategy of having sufficient capacity available to meet changes in demand, including new customer demand, to improve operations during emergency conditions, and to allow more time for the planning, analysis and construction, as needed, of new facilities. In addition the refinements reflect the operating parameters of Liberty's smaller distribution footprint and resource base.

Table 2 shows an estimate of additional facilities that may be required as a result of new planning criteria for the entire system over the next 15 years, based on the results of a sample of areas.

Table 2. Additional Facilities as a Result of New Criteria

Asset	Additional Quantity Required
Transformers (at existing or new substations)	0
Sub-Transmission Lines	0
Distribution Feeders	7

The new criteria will be scaled in over a 15-year period, and initially, will be applied to new installations and/or significant rebuilds initially. The criteria shall be reviewed and refined further, as needed, to reflect any major changes in standards or operating criteria.

2.0 PLANNING CRITERIA SUMMARY

The planning criteria are used to review and evaluate the performance of its distribution system for each Planning Study Area ("PSA"). The planning criteria are a critical input to identifying system deficiencies in Liberty's distribution planning process. See Figure 1 for the planning process. The planning criteria described

[1] Attachment B provides a summary of the changes to Liberty's new criteria from the previous criteria under National Grid.

in this document provides the framework to identify normal and emergency conditions, the acceptable equipment ratings under these conditions, and the corrective action required when the criteria is exceeded. For normal loading conditions, the planning criteria are based on feeders and transformers to remain within 75% of normal ratings at all times and supply lines to remain within 90% of normal ratings at all times.

For N-1 contingency situations, the planning criteria is based on interrupted load returning to service via system reconfiguration through switching, installation of temporary equipment, such as mobile transformers or generators, and/or by repair of a failed device. Where practical, at least three feeder ties are planned for each feeder for switching flexibility and are integrated into the system design to minimize the duration of customer outages to meet reliability objectives.

The following criteria summarized in Table 3 shall guide planning on the distribution system:

Table 3. Distribution System Design Criteria Summary

Condition	Sub-Transmission	Substation Transformer	Distribution Circuit
Normal	• Loading to remain within 90% of normal rating. • Voltage at customer meter to remain within acceptable range. • Circuit phasing is to remain balanced.	• Loading to remain within 75% of normal rating. • Voltage at customer meter to remain within acceptable range. • Circuit phasing is to remain balanced.	• Loading to remain within 75% of normal rating. • Voltage at customer meter to remain within acceptable range. • Circuit phasing is to remain balanced. • Each feeder should have at least three feeder ties to adjacent feeders.
N-1 Contingency, which results in facilities operating above their Long Term Emergency (LTE) rating but below their Short Term Emergency (STE) rating.	• Load must be transferred to other supply lines in the area to within their LTE rating. • Repairs expected to be made within 24hrs. • Evaluate alternatives if more than 36 MWhr of load at risk results following post-contingency switching.	• Load must be transferred to nearby transformers to within their LTE rating. • Repairs or installation of Mobile Transformer expected to take place within 24 hours. • Evaluate alternatives if more than 60 MWhr of load at risk results following post-contingency switching.	• Load must be transferred to nearby feeders to within their LTE rating. • Repairs expected to be made within 24hrs. • Evaluate alternatives if more than 16 MWhr of load at risk results following post-contingency switching.
N-1 Contingency, which results in facilities operating above their Short Term Emergency (STE) rating	• As Needed – Typically 15min for OH conductors and 1-24 hours for UG cables	• Loads must be reduced within 15 minutes to operate within their LTE rating	• As Needed – Typically 15min for OH conductors and 1-24 hours for UG cables

3.0 DESCRIPTION OF THE DISTRIBUTION SYSTEM

Liberty's distribution system consists of lines and equipment operated at a voltage at or below 23 kilovolts ("kV"). The components of the distribution system include: distribution substations, sub-transmission lines, and distribution circuits or feeders.

3.1 Distribution Substations

The distribution substations within Liberty Utilities are a mixture of stations with one, two or three or more transformers. A typical substation consists of 23/13 kV, 5-10 MVA rated transformers with individual voltage regulators applied to the feeders. Some distribution substations are supplied by the 115 kV circuits and are jointly owned by Liberty Utilities and National Grid. Liberty Utilities and National Grid maintain approximately 16 distribution substations containing approximately 26 power transformers in the Liberty

Utilities' service territory. Liberty Utilities anticipates that the distribution planning criteria will, in general, be applied to both Liberty and New England Power assets serving Liberty customers, however all 115kV transformers serving Liberty customers are owned and maintained by National Grid. System Non-Wires and Wires solution alternatives will be developed along the lines of these criteria recognizing, however, the unique nature of transmission supply contingencies on the distribution system.

3.2 Sub-Transmission System

The sub-transmission system provides supply to distribution substations as well as large three phase customers. It consists of those parts of the system that are considered neither bulk transmission nor distribution. The voltages for Liberty's sub transmission system include 23 and 13.8 kV. The voltages for National Grid sub transmission system include 46 kV. The sub-transmission system is designed in an open loop or "radial" system and generally provides a redundant supply for distribution substations. The sub-transmission system is presently designed with conductors ranging from 336.4 ACSR to 1113 thousand circular mils ("kcmil") overhead conductors and from 500 to parallel 1000 kcmil copper underground conductor. There are eight sub-transmission lines that are maintained by Liberty Utilities.

3.3 Distribution Feeders

The distribution feeders from each substation are in a "radial" configuration with provisions for manual or automatic transfer of load between feeders, including feeders from adjacent substations. Distribution feeders originate at circuit breakers connected within the distribution substations. Feeders are generally comprised of 477 or 336 kcmil aluminum mainline overhead conductors and 1/0 AWG aluminum branch line conductors. Some feeders have underground getaway cables exiting from the substation with 500 to 1000 kcmil aluminum or copper conductors. Protections for faults on the feeders consist of relays at the circuit breaker, automatic circuit reclosers at points on the mainline and fuses and trip savers on the branch circuits. The Liberty Utilities distribution system is comprised of approximately 41 feeders ranging from 2.4kV to 13.2kV.

4.0 EQUIPMENT RATINGS

Thermal limits are recognized for all system elements in conducting planning studies. Current in equipment and lines are limited so that voltage drops are held to reasonable values; so that conductors will not be severely annealed or damaged; so that switches, connectors, etc. will not be overloaded and that clearances are not exceeded. Several factors are taken into account, including: 1) ambient temperatures, 2) load cycles, 3) wind velocities, and 4) potential loss of life of equipment.

Liberty's Distribution Planning Department maintains equipment ratings for all major equipment, including transformers, overhead lines, and underground cables. Overcurrent protection system settings are also taken into account where applicable.

4.1 Overhead Conductors

The current carrying capacity (also known as, "ampacity") of an overhead conductor may be limited either by conductor clearances or maximum allowable operating temperature under a predefined set of reasonably severe summer or winter ambient conditions. The Company's Overhead Construction Standards book lists maximum ratings not to be exceeded for each conductor for normal and emergency operation.

As part of system operation, standard conductor sizes for overhead distribution construction of #2 AAAC, 1/0 AAAC and 477 AAAC or equivalent tree wire have been selected by Liberty Utilities.

The following general guidelines were developed for 13.2 kV overhead distribution lines:

- New single-phase overhead distribution lines should be constructed with #1/0 AAAC and new single-phase underground distribution lines should be constructed with #1/0 AL for loads less than 500kW.
- The single-phase lines should be reconductored to three-phase wherever needed based on operating conditions, phase imbalance and voltage drop.
- New three-phase overhead distribution lines and/or future distribution line upgrades should be constructed with the specified conductors at the initial load given as follows:
    - For loads less than 3,000 kW: 1/0 AAAC
    - For loads greater than 3,000 kW: 477 AAAC
- The single-phase and three phase lines should be reconductored with covered tree conductor or spacer cable wherever needed based on operating conditions in tree prone areas.

The maximum ampacity of an overhead conductor is estimated for Normal (continuous) and Long-Time Emergency (LTE) operations for summer and winter conditions.

4.1.1 Normal Capability

The Normal rating shall be interpreted as the maximum value for normal peak loads on all new and rebuilt feeders. This is done to accommodate emergency conditions where ampacity may be increased for a period of time no greater than 24 hours. The temperature limit for 100% ampacity for normal operating conductor is 176°F/80°C for bare conductors and 167°F/75°C for spacer cable, tree wire, and covered conductors.

4.1.2 **Long-Time Emergency Capabilities (24 hours)**

The LTE rating shall be interpreted as the absolute maximum ampacity allowed for a given conductor. This ampacity should not be exceeded at any time unless an appropriate engineering review has been conducted. The temperature limit for LTE for 100% ampacity for operating conductor at an elevated temperature during emergency conditions limited to a 24 hour period is 194°F/90°C for both bare and spacer cable, tree wire, and covered conductors.

4.1.3 Short-Time Emergency Capability (As needed)

Other short duration ratings, such as Short Time Emergency (STE) if required for maintenance or construction, are estimated conservatively using seasonal ambient data along with circuit specific information by the engineering department. These are typically less than 15 minutes in duration.

4.2 Underground Cables

Underground distribution line ratings were derived from the October 1957 AIEE paper entitled “The Calculation of the Temperature Rise and Load Capability of Cable System” by J.H. Neher and M.H. McGrath. These calculations integrate all aspects of the cable system design such as conductor material, conductor size, insulation, properties, insulation thickness, cable type, shield connections, load characteristics, installation conditions and environment. Cable ampacities are based on normal and emergency operating conditions. Normal cable ampacities are based on a 90° insulation operating temperature while emergency cable ampacities are based on 130° insulation operating temperature. The Company’s underground construction standards book provides estimates of cable ampacity for common sizes and configuration of main line cables. Given the many different aspects of a cable system, specific cable ratings are typically derived using computer software such as Synergee Electric or PC Amp.

New three-phase underground distribution lines or future three-phase underground distribution line upgrades should be constructed with the specified conductors at the initial load given as follows:

- For loads less than 1000 kW: #1/0 AL
- For loads greater than 1000 kW: 500 MCM CU
- For feeder cable getaways: 1000 MCM CU

Ampacities are defined for underground cables as follows:

4.2.1 Normal Ampacity (Continuous)

This is the maximum loading on the cable that does not cause the conductor temperature to exceed its design value at any time during a 24-hour load cycle.

4.2.2 100-300 Hour Ampacity (LTE)

This is the maximum emergency loading on the cable that does not cause the conductor temperature to exceed its applicable emergency value over a period of several consecutive 24-hour load cycles. At the end of the emergency time period, the load on the cable must be reduced to a value within its normal ampacity.

4.2.3 One-Hour to 24-Hour Emergency Ampacities (STE)

Other short duration ratings, such as Short Time Emergency (STE) if required for maintenance or construction, are estimated conservatively using seasonal ambient data along with circuit specific information by the engineering department. These are the maximum emergency loadings on the cable that do not cause the conductor temperature to exceed its allowable emergency value at any time during the period. At the end of the emergency time period, the load on the cable must be reduced so that the peak load in the next load cycle does not exceed the LTE ampacity (defined above).

4.3 Transformers

Distribution substation transformers are rated for loading according to the American National Standards Institute ("ANSI") standards for maximum internal hot spot and top oil temperatures. This is detailed in the Institute of Electrical and Electronics Engineers ("IEEE") Guide for Loading Mineral-Oil-Immersed Power Transformers up to and including 100 MVA with 55°C, or 65°C, winding temperature rise (ANSI/IEEE C57.91 latest version). The manufacturer's factory test data and the experienced 24-hour loading curve data are used in an iterative computer program that calculates allowable loading levels.

The transformer's "ratings" for the Normal ("N"), Long Term Emergency ("LTE"), and Short Term Emergency ("STE") load levels are identified based upon maximum internal temperatures and selected values for the loss of the transformer's life caused by its operation at the criteria temperatures for a specified duration, and on a defined load curve. Three categories of transformer capabilities are defined below:

4.3.1 Normal Capability

Winter normal and summer normal capabilities are based on a normal daily load cycle and on the maximum 24-hour average ambient temperature for the period involved. The maximum load for Normal operation of the transformer is determined and set when the operation of the transformer at that level for the peak hour in the 24-hour load cycle causes a cumulative (24 hour) 0.2% loss of Transformer life, or the Top Oil Temperature exceeds 110 °C, or the Hot Spot Copper temperature exceeds 180 °C. Conditions above any of these limitations will result in a shortening of the transformer service life beyond prescribed design levels and/or physical damage to the equipment.

4.3.2 Long-Time Emergency Capabilities (1 hour to 300 hours)

These capabilities are based on a normal daily load cycle, with the emergency load increment added. The maximum 24-hour average ambient temperature is used for the appropriate season. The LTE rating of a substation transformer is determined and set when the 24 hour operation of the transformer, with that additional load in each of the hours in the 24 hour load cycle curve, causes a cumulative (24 hour) 3.0% loss of transformer life or the Top Oil temperature to exceed 130 °C, or the hot spot copper temperature to exceed 180 °C.

4.3.3 Short-Time Emergency Capability (15 minutes or less)

The STE rating of a transformer is determined and set when the one hour operation of the transformer at that level for the peak hour in the 24 hour load cycle causes a cumulative (i.e., 24 hour) 3.0% Loss of

Transformer Life or a hot spot copper temperature exceeding 180°C. However, the maximum STE rating is limited to a value equal to twice the transformer's "nameplate" rating (i.e., 200%).

4.4 Other Equipment

In addition to the items above, normal and emergency capabilities are reviewed for switches, circuit breakers, voltage regulators, and instrument transformers. Emergency capabilities usually involve elevated temperatures with some potential loss of equipment life. However, any circuit rating may be limited by other circuit equipment such as circuit breakers, disconnects, regulators, et cetera. These ratings are generally based on the allowable maximum temperature of the equipment. The facility (feeder, sub transmission line, and/or transformer) rating is determined by identifying the "limiting device" and applying the rating criteria for that device or equipment.

4.4.1 Distribution Overhead Transformers

The following generic ratings in % of nameplate are used:

NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter
145%	180%	160%	200%

4.4.2 Distribution Single Phase Padmount Transformers

The following generic ratings in % of nameplate are used:

NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter
140%	160%	140%	160%

4.4.3 Distribution Three Phase Padmount

The following generic ratings in % of nameplate are used:

NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter
110%	110%	110%	110%

4.4.4 Distribution Step-Down Transformers

The following generic ratings in % of nameplate are used:

NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter
110%	110%	110%	110%

4.4.5 **Circuit Breakers**

The following generic ratings in % of nameplate are used: NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter
107%	123%	115%	130%

4.4.6 **Voltage Regulators**

The following generic regulator ratings in % of nameplate for 10% regulation are used:

55ºC INSULATION SYSTEM				**65ºC INSULATION SYSTEM**			
NORMAL		EMERGENCY		NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
125%	148%	125%	148%	141%	160%	141%	160%

4.4.7 **Disconnect Switches**

The following generic air switches ratings in % of nameplate:

NORMAL		EMERGENCY	
Summer	Winter	Summer	Winter
113%	134%	139%	147%

4.5 Equipment Rating Criteria Summary

The major equipment ratings to be used by planning engineers relate to transformers, overhead lines and underground cables. The normal and LTE rating limits for feeders, sub transmission lines and transformers may be applied for the time associated with each rating. Table 4 summarizes the durations for emergency loading that system operators must be aware of including the limiting factor involved in any contingency. There is also a short time emergency (STE) rating that is mainly used for transformers and must not exceed

200% of nameplate rating. Table 5 summarizes the Equipment Rating criteria, as described in more detail above.

Table 4. Facility Rating Durations

Equipment	Normal	LTE	STE
Feeders	Continuous	24 Hours	As Needed
Sub Transmission lines	Continuous	24 Hours	As Needed
Transformer	Continuous	1 - 300 Hours	15 Minutes

Table 5. Equipment Rating Criteria Summary

	Overhead Conductors		Underground Cables		Transformers	
Condition	**Duration**	**Design Criteria**	**Duration**	**Design Criteria**	**Duration**	**Design Criteria**
Normal	Continuous	• The maximum value for normal peak loads on all new and rebuilt feeders • Temperature limit for 100% ampacity for normal operating conductor is 176°F/80°C for bare conductors and 167°F/75°C for spacer cable, tree wire, & covered conductors	Continuous	• Maximum loading that does not cause the conductor temperature to exceed its design value at any time during a 24-hour load cycle • Normal cable ampacities are based on a 90° insulation operating temperature.	Continuous	• Level for the peak hour in the 24-hour load cycle causes a cumulative (24 hour) 0.2% loss of Transformer life, or • The Top Oil Temperature exceeds 110 °C, or • The Hot Spot Copper temperature exceeds 180 °C
LTE	24 Hours	• The absolute maximum ampacity allowed for a given conductor and should not be exceeded at any time. • Temperature limit for 100% ampacity for operating at an elevated temperature during emergency conditions limited to a 24 hour period is 194°F/90°C for both bare and spacer cable, tree wire, & covered conductors	100 - 300 Hours	• Maximum loading that does not cause the conductor temperature to exceed its design value over several consecutive 24-hour load cycles. • Emergency cable ampacities are based on 130° insulation operating temperature.	1 - 300 Hours	• Level for the peak hour with the emergency load added in the 24-hour load cycle causes a cumulative (24 hour) 3.0% loss of Transformer life, or • the Top Oil Temperature exceeds 130 °C, or • the Hot Spot Copper temperature exceeds 180 °C
STE	As Needed	• Estimated conservatively using seasonal ambient data along with circuit specific information by the Engineering Department	1 - 24 Hours	• Maximum loading that does not cause the conductor temperature to exceed its allowable emergency value at any time during a 24-hour load cycle. • Emergency cable ampacities are based on 130° insulation operating temperature.	15 minutes	• The one hour operation of the transformer at that level for the peak hour in the 24 hour load cycle causes a cumulative (24 hour) 3.0% loss of Transformer Life, or • a hot spot copper temperature exceeding 180°C. • Maximum STE rating is limited to twice the transformer's "nameplate" rating (200%).

5.0 DISTRIBUTION SUBSTATION TRANSFORMER LOADING CRITERIA

The ratings of transformers are calculated from their thermal heat transfer characteristics and the expected electric loading experience over a 24-hour cycle. All distribution substation transformer bank ratings are evaluated seasonally for their summer and winter values.

5.1 Normal Operation Design Criteria

Normal operation is the condition under which all-electric infrastructure equipment is fully functional. A substation transformer will not be loaded above 75% of its Normal rating during non-contingency operating periods.

5.2 First Contingency Emergency Design Criteria

First contingency operation is the condition under which a single element (feeder circuit or distribution substation transformer) is out of service. For first contingency emergency conditions involving the loss of one distribution substation transformer in an existing two-bank or more configuration, the following system design criteria applies:

- In cases where a first contingency situation causes the LTE rating of the remaining transformer to be exceeded, all load above the LTE rating of the remaining transformers must be transferred to neighboring facilities or shed 15 minutes without exceeding the LTE rating of the substation transformers or distribution circuits receiving the load.
- In cases where a first contingency situation will cause the STE rating of a remaining transformer to be exceeded, load must be immediately reduced (dropped/shed) to a level within the STE. All load between the LTE and STE ratings, and any load that was initially shed to get the remaining transformer below its STE rating, must be transferred to peripheral facilities without exceeding the LTE rating of the substation transformers or the distribution circuits receiving the load.
- Repairs or the installation of mobile equipment are expected to require at least a 24 hour implementation.
- For a typical Liberty owned substation consisting of 9.375 MVA transformers, the quantity of load at risk of being out of service following post contingency switching should be limited to 2.5 MW. If more than 60MWhrs of load is at risk at peak load periods for a transformer or substation bus fault, alternatives to eliminate or significantly reduce this risk shall be evaluated and prioritized considering the load at risk, reliability impacts and the cost to mitigate.

5.3 Automatic Transfer of Load

Locations with two or more transformers at a substation utilize automatic bus transfers. Based on the loading limitations on Section 5.2, it may be necessary to block the automatic transfer on either the main bus tie or one of the feeder bus tie breakers to avoid exceeding the STE limit during a first contingency. Cases where automatic restoration is disabled will be communicated with Electric Control as part of an annual summer preparedness review. Disabling of automatic bus transfer schemes will not be considered as a permanent solution to a criteria violation.

6.0 DISTRIBUTION CIRCUIT LOADING CRITERIA

6.1 Normal Operation Design Criteria

A feeder circuit should be loaded to no more than 75% of capacity during normal conditions. This loading level provides reserve capacity that can be used to carry the load of adjacent feeders during first contingency N-1 conditions and/or provides capacity to serve new business or commercial applications in a timely manner.

After 75% loading is reached, unacceptable voltage levels are often experienced on tap lines and at the end of the feeder.

6.2 First Contingency Emergency Design Criteria

For first contingency emergency conditions on a distribution circuit, the worst of which is the loss of the circuit's getaway cable or circuit breaker. For the loss of a distribution feeder, the following criterion applies:

- Feeders shall tie to neighboring feeders as much as practical as the flexibility to reconfigure feeders has a positive reliability impact for a wide range of possible contingencies. In general, and whenever practical, each feeder should have three feeder ties to neighboring feeders.
- Distribution feeders should be limited to 2,500 customers and sectionalized such that the number of customers does not exceed 500 or 2,000kVA of load between disconnecting devices.
- After transfers, all resultant components must be below the emergency ratings as defined by the appropriate loading guides. All adjoining tie feeders can be loaded to their maximum LTE rating.
- Feeder ties and cascading of load within the area can be utilized to the emergency limits of feeders to offload adjoining feeders.
- If more than 16 MWh of load is at risk at peak load periods for a single feeder fault, alternatives to eliminate or significantly reduce this risk shall be evaluated and prioritized considering the load at risk, reliability impacts, and the cost to mitigate.
- For a typical Liberty owned 10 MW feeder, approximately 8 MW would need to be restored via switching within one hour. The remaining 2 MW would be restored after

repairs within 4 hours. Where longer repair times are needed such as for a cable getaway fault, the load out of service should be reduced to 1 MW.

6.3 Automatic transfer on feeders

In some cases it will be necessary to adjust a feeder rating to below normal summer or winter thermal rating due to automatic backup or Second Feeder Service commitments to certain customers or due to automatic reclosing loop schemes in the distribution lines.

6.4 Primary Circuit Voltage Criteria

The normal and emergency voltage to all customers shall be in line with limits specified by the state of NH and within the limits of ANSI C84.1-2006.

These upper and lower voltage ANSI limits, as measured at the customer's meter, are listed below in Table 6:

Table 6. Voltage Requirements for LU

For 120 V – 600 V Systems				
Nominal Voltage (V)	**Service Voltage (V)**			
	Range A		**Range B**	
	Max	Min	Max	Min
120	126	114	127	110
240	252	228	254	220
480	504	456	508	440

Source: ANSI

Voltage at the customer meter will be maintained within 5% of nominal voltage (120V). Voltage on the feeders is controlled by the station load tap changer or station regulators on feeders, the application of distribution capacitor banks, and the application of pole or pad mounted line regulators.

Voltage regulation of the feeders and supply lines must be adequate to ensure the voltage requirements in Table 7 above are maintained. The ultimate goal is to keep all customers' service voltages within accepted limits. From a supply point of view, the acceptability of voltage regulation is determined at the distribution substation buses. At substations with feeder or bus regulating equipment, the regulation (the extreme range of voltages expressed as a percentage of normal peak load voltage) should be no greater than 10 percent for normal and 15 percent for emergency conditions on the source side of the regulating equipment. Most substation regulating equipment has a range of 20 percent. Under normal conditions, therefore, half the regulator range can compensate for variations in supply voltage, leaving the other half available for voltage drops on the distribution feeders. The substation transformer taps are chosen to allow this control.

6.5 Distribution Circuit Phase Imbalance Criteria

Adding new customer loads to the distribution circuit must be done in the manner to minimize phase imbalance on the distribution system. This criterion is established to limit the load imbalance among the three phases of a primary distribution circuit. Such an imbalance gives rise to return current through the neutral conductor which contributes towards additional losses and voltage drop. Heavily loaded phases overstress the conductors reducing their life and can also lead to their eventual burn down or connector overheating, even at low loadings of the circuit. A high imbalance could also lead to the ground relay operating on the feeder breaker. These criteria call for the correction of phase imbalances of existing and new distribution circuits. Phase imbalance is defined on the basis of connected KVA (CKVA) load for that circuit as:

$$\%imbalance = \frac{(phase\ load - average\ phase\ load)}{average\ phase\ load} X\ 100$$

Two criteria should be met for the circuit to be considered for corrective action:

1. The calculated neutral current should not exceed 30% of the feeder ground relay pickup setting.

2. The loading between the low and high phase should not exceed 100A

Any circuit violating these criteria will be monitored to get actual loading data, and will be corrected if the imbalance is verified. Any new load addition to a circuit should adhere to these criteria.

For all new single phase load additions, the new installation is connected to the phase with the least connected KVA, if it is available, to maintain a balanced circuit.

7.0 SUB-TRANSMISSION LINE LOADING CRITERIA

7.1 Normal Operation Design Criteria

A sub transmission line should be loaded to no more than 90% of capacity during normal conditions. This loading level provides reserve capacity that can be used to carry the load of adjacent supply lines during first contingency N-1 conditions.

7.2 First Contingency Emergency Design Criteria

For first contingency emergency conditions on a supply circuit, the worst of which is the loss of the circuit's getaway cable or circuit breaker. After transfers, all resultant components must be below the emergency ratings as defined by the appropriate loading guides. For the loss of a supply line, the following criterion applies:

- The initial load increase at the remaining sub-transmission supply lines within the area must not exceed the summer or winter LTE rating.
- Every effort must be made to return the failed sub-transmission line to service within 24 hours.
- Feeder ties and cascading of load within the area can be utilized to the emergency limits of feeders to offload a sub-transmission line.
- For a typical LU owned sub-transmission supply line consisting of either 13.8 kV or 23 kV, the quantity of load at risk of being out of service following post contingency switching should be limited to 1.5 MW. If more than 36MWh of load is at risk at peak load periods for a single fault, alternatives to eliminate or significantly reduce this risk shall be evaluated and prioritized considering the load at risk, reliability impacts and the cost to mitigate.

7.3 Automatic Transfer of Load

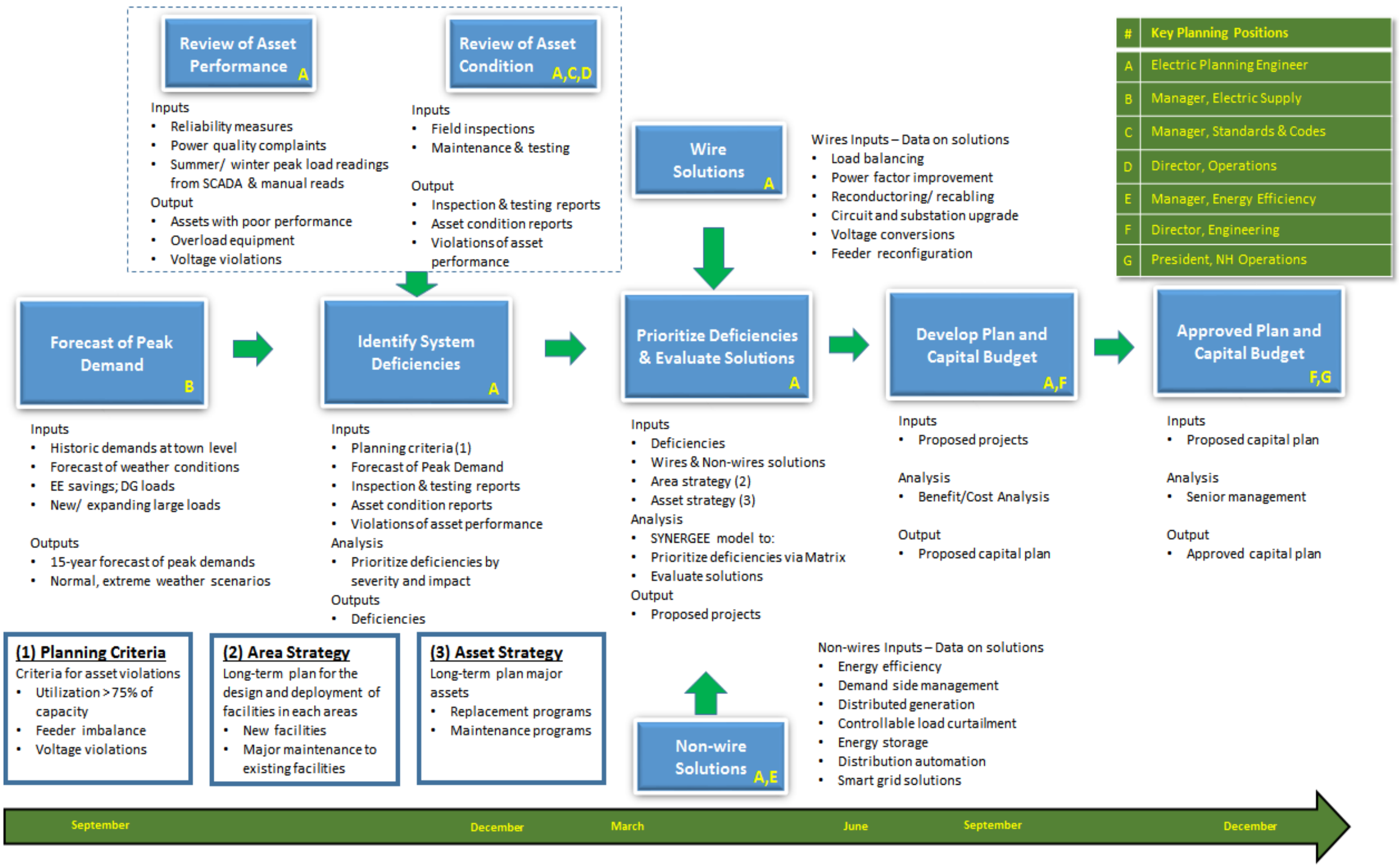
Auto transfer of load on the sub-transmission may be employed, but may not exceed the LTE ratings of the remaining supply lines. When available, EMS control of sub-transmission lines will be utilized to block auto transfers and avoid overloading of lines as needed.

8.0 PLANNING STUDIES

A planning study area ("PSA") within Liberty Utilities is a grouping of distribution substations, feeders, transformers, and sub-transmission lines within a specific geographic area that are interconnected and can be studied as a group. PSA's in Liberty's service territory are totally independent from each other. A listing of the planning study areas that exist in the LU service territory are presented in Attachment A.

Liberty conducts an annual capacity planning process covering a 5 year period with inputs from various stakeholders that is intended to meet future customer demands, identify thermal capacity constraints, ensure adequate delivery voltage, and assess the capability of the system to respond to contingencies that might occur. The distribution planning process is illustrated in Figure 1 below:

Figure 1. Distribution Planning Process Map and Timeline



8.1 Electric System Planning Criteria and Methodology

8.1.1 Modeling Guidelines

As shown in Figure 1 above, the planning process for designing the Distribution System begins with the load forecast. The PSA load forecast is updated annually. The load forecast at the system level is based on econometric models, and is developed on both a weather-normalized and weather-probabilistic basis. Currently, the Liberty distribution system is modeled for a "peak hour" load level that has a 5% probability of occurrence such that those weather conditions are expected to occur once in 20 years. Specific major known or planned load additions are factored into the load forecast. Historical DSM and DG along with specific DSM/DG installations are also factored into the forecast. The resultant load forecasts are utilized in two types of planning studies which assess the ability of the distribution system to meet future customer load requirements. These studies include (1) Area Studies, and (2) Interconnection Studies, and are described below.

Load flow analyses are used to determine expected circuit overloads and to evaluate alternatives for system reinforcements. Liberty Utilities utilizes the Synergee computer application to model load flows in the distribution system.

Substation circuit breakers are modeled using their rated interrupting capability in the ASPEN™ short circuit analysis computer program. Any breaker that meets or exceeds its rated interrupting capability is targeted for replacement.

Area studies

Are generally 15-year forecast time frames and address specific load areas, including the area supply system, substations, and distribution feeders.

Interconnection studies

System interconnection studies are designed to determine the interconnection facilities and system reinforcements required for specific generation and distribution growth projects to enable them to be effective over the life of the project.

9.0 SYSTEM RELIABILITY

The supply and distribution system in the Liberty Utilities system are designed to limit the interruption of energy delivery for a loss of any single element.

The indices of service reliability are the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI). The SAIDI measures the total duration of an interruption for the average customer during a given time period. The SAIFI measures the average number of times that a customer experiences an outage during a given time period.

The supply and distribution systems shall be designed so that the annual SAIDI and SAIFI do not exceed the five-year rolling averages, excluding severe weather related events and support a nominal improving five-year reliability trend. When an exceedance does occur, efforts shall be made in the subsequent year(s) to further improve reliability performance to an improving trend level.

10.0 OTHER CONSIDERATIONS

The planning engineer must consider the effect of each plan on all aspects of system design. These include:

- Protection: Protection or Coordination studies are performed when it is needed to adjust relay settings at substations to increase rating of the facility. Settings are carefully selected to avoid miss-coordination and trips due to load imbalance.
- Operation and Maintenance ("O&M"): O&M is taken into account when ranking different project alternatives.
- System Power Factor: Liberty will strive to maintain a 95% power factor at the substations to provide quality power to its customers and limit system losses via the addition of new capacitor banks. In addition, annual Surveys for system power factor will allow Liberty Utilities to properly manage reactive support by adjusting settings from capacitor bank controls.
- Short Circuit Duty: Substation circuit breakers are modeled using their rated interrupting capability in the ASPEN™ short circuit analysis computer program. Any breaker that meets or exceeds its rated interrupting capability is targeted for replacement.

11.0 BENEFITS OF PLANNING CRITERIA STRATEGY

The principal benefits to the planning criteria are improved reliability performance, customer service and efficiency.

11.1 Safety and Environmental

In the long term, the planning criteria will result in overall lower equipment loading. This will translate into improved safety and environmental performance for equipment overload related problems.

11.2 Reliability

The planning criteria will increase operating flexibility and reduce equipment loading. Both of these items support improved reliability performance due to smaller customer interruptions, faster service restoration times and fewer load related interruptions. Additionally, lower feeder loading will support future distribution automation to further improve reliability. The increased operating flexibility will allow for better response to weather related events and major storms.

11.3 Customer and Regulatory

The customer benefit associated with planning criteria is significant. Improved system reliability and lower equipment loading provide greater flexibility in serving both existing and new customers. This increased flexibility creates an opportunity to better meet our obligations to both customers and regulators. Additionally, this planning strategy provides a documented approach to managing our system. This will better support the investment plans needed to implement the loading guidelines outlined in the strategy.

11.4 Efficiency

The planning strategy provides a consistent approach for feeder/substation/supply line and PSA loading analysis across Liberty. All studies being conducted under one new criterion will make way for a consistent reference for ranking studies as part of the budgeting process. Both of these improvements will result in a more efficient organization and a streamlined flow of information from the planning study results into the budgeting process.

12.0 COST ESTIMATES

Application of these criteria will result in somewhat less load at risk than previous criteria which generally limited load at risk to between 4 and 20 MW pending the installation of a mobile device. Therefore it is expected that the Load Relief budgets will increase from historic levels for a given load growth rate. The capital cost associated with meeting the new criteria for both normal and N-1 contingency conditions are shown in Table 7:

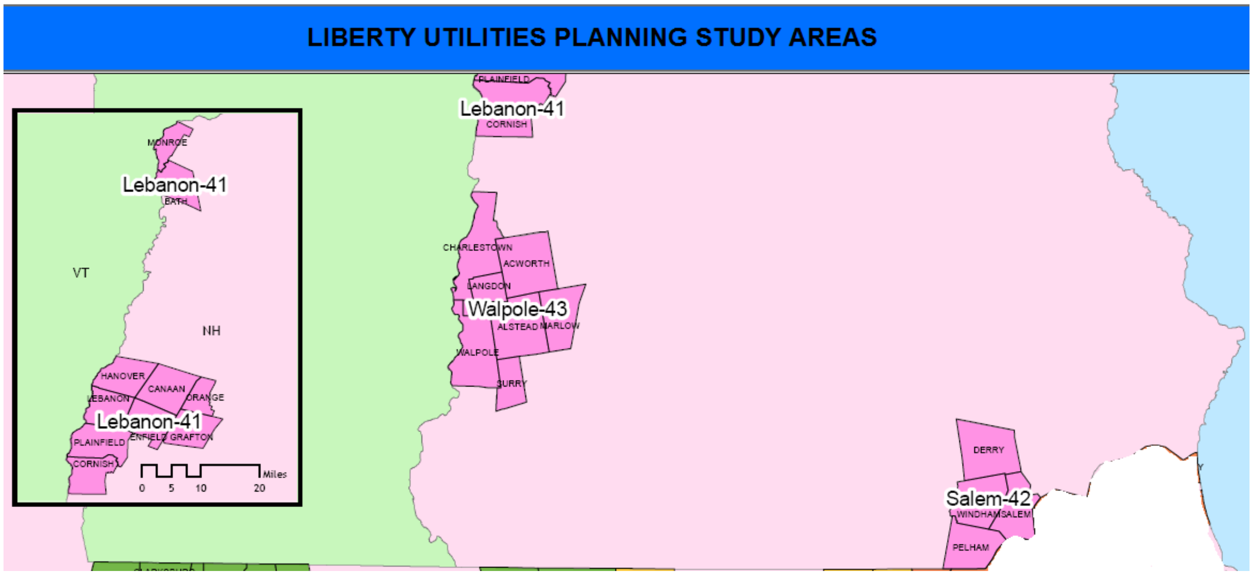
Table 7. Estimated Capital Costs of New Criteria

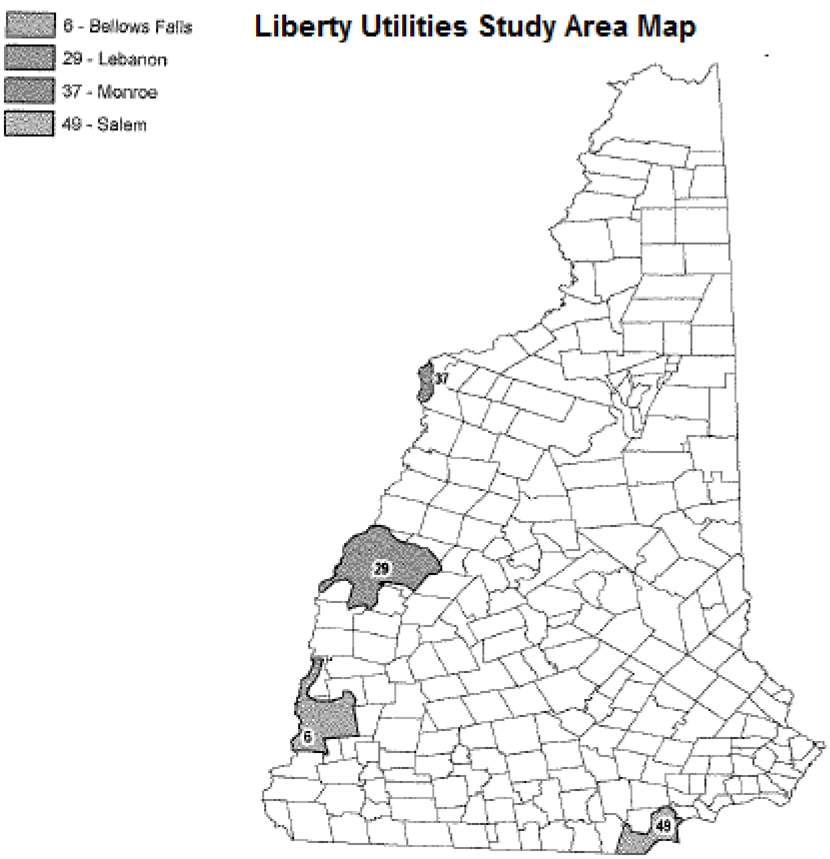
	($ Millions)	15 Year Annualized ($Millions)[1]
Total Substation Scope	$6.5	$0.98
Other Distribution Line Scope	$7.5	$1.13
Total Cost over 15 Years	$14.0	$2.10

[1.] Assumes 15% carrying cost

The new criteria may result in an increase in capital requirements up to $2.10 million per year over the existing criteria for the 15-year period studied.

Attachment A – Liberty Utilities Planning Study Area Map





Attachment B – Summary of Planning Criteria Changes

New Criteria	Previous Criteria	Reason for Change
During normal operation, all distribution feeders to remain within 75% of normal ratings.	During normal operation, all distribution feeders to remain within 100% of normal ratings.	Allows for adequate capacity on adjacent lines to restore load post-contingency and reflects Liberty's strategy to proactively plan for sufficient capacity to meet changes in demand.
During normal operation, all sub-transmission lines to remain within 90% of normal ratings.	During normal operation, all sub-transmission lines to remain within 100% of normal ratings.	Allows for adequate capacity on adjacent lines to restore load post-contingency and reflects Liberty's strategy to proactively plan for sufficient capacity to meet changes in demand.
During normal operation, all transformers to remain within 75% of normal ratings.	During normal operation, all transformers to remain within 100% of normal ratings.	Reflects Liberty's strategy to proactively plan for sufficient capacity to meet changes in demand.
For the loss of a distribution feeder, if more than 16MWhrs of load at risk results for a single feeder fault evaluate alternatives to mitigate.	No Change.	Existing targets are adequate given size of a typical Liberty distribution feeder.
For the loss of a sub-transmission supply line, the quantity of load at risk of being out of service following post contingency switching should be limited to 1.5MW combined. If more than 36MWhrs of load at risk results for a single line fault evaluate alternatives to mitigate.	For the loss of a sub-transmission supply line, the quantity of load at risk of being out of service following post contingency switching should be limited to 20MW combined. If more than 240MWhrs of load at risk results for a single line fault evaluate alternatives to mitigate.	Reflects Liberty's strategy and scale of facilities.
For the loss of a transformer, the quantity of load at risk of being out of service following post contingency switching should be limited to 2.5MW combined. If more than 60MWhrs of load at risk results for a single line fault evaluate alternatives to mitigate.	For the loss of a transformer, the quantity of load at risk of being out of service following post contingency switching should be limited to 10MW combined. If more than 240MWhrs of load at risk results for a single line fault evaluate alternatives to mitigate.	Reflects Liberty's strategy and scale of facilities.

Every effort must be made to return the failed sub-transmission line to service within 12 hours.	Every effort must be made to return the failed sub-transmission line to service within 24 hours.	Establishes a new limit for repairing feeder faults on Liberty's distribution feeders.
N/A	Every effort must be made to return the failed distribution feeder to service within 24 hours.	Establishes a new limit for repairing feeder faults on Liberty's distribution feeders.
In general, and whenever practical, each feeder should have three feeder ties to neighboring feeders.	N/A	Reflects Liberty's strategy to increase operating flexibility and support improved reliability performance due to faster service restoration times and future implementation of distribution automation.
Distribution feeders should be limited to 2,500 customers and sectionalized such that the number of customers does not exceed 500 or 2,000kVA of load between disconnecting devices.	N/A	Reflects Liberty's strategy to increase operating flexibility and support improved reliability performance due to faster service restoration times and future implementation of distribution automation.

Approved by: ______________________________________ Date: ____________________

Christian Brouillard
Director of Engineering
Liberty Utilities

Liberty Utilities New Hampshire

Final Seasonal Peak Forecasts
2018-2034

Prepared By

Business Economic Analysis and Research

January 2019

Summary of Results

The weather adjusted actual seasonal peaks appear in Table 1 below for Liberty Utilities New Hampshire (LUNH). Note that the peak load series reflects the historic impacts of both energy efficiency programs and distributed generation activities in the LUNH service territory. Since the forecast is based on normal weather conditions, weather adjusting actual peaks enhances comparisons between historic and forecasted peaks.

Table 1
Historic Weather Adjusted Peaks

year	Summer month	Wthr Adj Peak Mw	Growth	Winter month	Wthr Adj Peak Mw	Growth
2004	7	184.555		12	151.111	
2005	7	193.986	5.11%	12	162.349	7.44%
2006	7	186.673	-3.77%	1	152.805	-5.88%
2007	7	187.153	0.26%	12	152.433	-0.24%
2008	7	194.86	4.12%	12	146.156	-4.12%
2009	7	190.024	-2.48%	12	153.679	5.15%
2010	7	188.816	-0.64%	12	148.528	-3.35%
2011	8	200.696	6.29%	2	151.769	2.18%
2012	8	189.021	-5.82%	1	152.708	0.62%
2013	7	194.125	2.70%	12	155.566	1.87%
2014	7	200.63	3.35%	1	158.976	2.19%
2015	7	184.56	-8.01%	1	148.31	-6.71%
2016	7	187.134	1.39%	1	144.578	-2.52%
2017	8	185.065	-1.11%	12	144.559	-0.01%
2013-2017 Avg			-0.42%			-1.07%

The summer peak has dropped .42% per year over the past five years compared to the winter peak declining 1.07% annually over the same period.

Table 2 displays the LUNH 2018-2034 seasonal peak forecasts under normal peak day weather conditions. The forecasted peak values include the historic impacts from both energy efficiency programs and distributed generation activities in the LUNH service territory. The 2018 growth is based on the 2017 weather adjusted actual shown in Table 1.

Table 2
Forecasted Peaks Normal Weather

year	Summer month	Peak Mw	Growth	Winter month	Peak Mw	Growth
2018	7	193.324	4.46%	12	149.036	3.10%
2019	7	194.168	0.44%	12	149.322	0.19%
2020	7	194.898	0.38%	12	149.483	0.11%
2021	7	195.572	0.35%	12	149.636	0.10%
2022	7	196.27	0.36%	12	149.836	0.13%
2023	7	196.994	0.37%	12	150.047	0.14%
2024	7	197.702	0.36%	12	150.223	0.12%
2025	7	198.396	0.35%	12	150.4	0.12%
2026	7	199.093	0.35%	12	150.583	0.12%
2027	7	199.797	0.35%	12	150.771	0.12%
2028	7	200.508	0.36%	12	150.969	0.13%
2029	7	201.228	0.36%	12	151.175	0.14%
2030	7	201.957	0.36%	12	151.39	0.14%
2031	7	202.693	0.36%	12	151.61	0.15%
2032	7	203.433	0.37%	12	151.834	0.15%
2033	7	204.177	0.37%	12	152.063	0.15%
2034	7	204.927	0.37%	12	152.298	0.15%
2020-2024 Avg			0.36%			0.12%

The average annual summer growth rate in peak for 2020-2024 is .36% while the winter average annual growth rate is .12% over the same period.

Table 3 provides the LUNH 2018-2034 seasonal peak forecasts under extreme weather. Although the peaks are higher, the annual growth rates for 2020-2024 are just less than the growth rates using normal weather.

Table 3
Forecasted Peaks Extreme Weather

year	Summer month	Peak Mw	Growth	Winter month	Peak Mw	Growth
2018	7	212.317		12	155.069	
2019	7	213.19	0.41%	12	155.355	0.18%
2020	7	213.95	0.36%	12	155.516	0.10%
2021	7	214.653	0.33%	12	155.669	0.10%
2022	7	215.38	0.34%	12	155.87	0.13%
2023	7	216.133	0.35%	12	156.08	0.13%
2024	7	216.87	0.34%	12	156.256	0.11%
2025	7	217.593	0.33%	12	156.433	0.11%
2026	7	218.32	0.33%	12	156.616	0.12%
2027	7	219.052	0.34%	12	156.804	0.12%
2028	7	219.793	0.34%	12	157.002	0.13%
2029	7	220.542	0.34%	12	157.208	0.13%
2030	7	221.299	0.34%	12	157.423	0.14%
2031	7	222.064	0.35%	12	157.644	0.14%
2032	7	222.833	0.35%	12	157.867	0.14%
2033	7	223.607	0.35%	12	158.096	0.15%
2034	7	224.386	0.35%	12	158.331	0.15%
2020-2024 Avg			0.35%			0.12%

In previous peak day studies performed by National Grid, Eastern PSA and Western PSA hourly data was the source of historic peak day analysis and subsequent forecasts. In this study, LUNH system hourly data was the only source of historic peak day analysis. Once the LUNH system seasonal peak day forecasts were developed in this analysis, Eastern PSA and Western PSA forecasts were derived by using the average summer coincident peak Eastern and Western PSA percent contributions for 2014 through 2018 and the average winter coincident peak Eastern and Western PSA percent contributions for 2015 through 2018. Table 4 below reveals the Eastern PSA seasonal forecasts under normal weather conditions.

Table 4
Eastern PSA Peaks Normal Weather

year	Summer month	Peak Mw	Growth	Winter month	Peak Mw	Growth
2018	7	97.8993		12	71.0305	
2019	7	98.3267	0.44%	12	71.1669	0.19%
2020	7	98.6964	0.38%	12	71.2435	0.11%
2021	7	99.0377	0.35%	12	71.3165	0.10%
2022	7	99.391	0.36%	12	71.4118	0.13%
2023	7	99.7577	0.37%	12	71.5125	0.14%
2024	7	100.1162	0.36%	12	71.5963	0.12%
2025	7	100.4677	0.35%	12	71.6807	0.12%
2026	7	100.8208	0.35%	12	71.7679	0.12%
2027	7	101.1773	0.35%	12	71.8575	0.12%
2028	7	101.5373	0.36%	12	71.9518	0.13%
2029	7	101.9018	0.36%	12	72.05	0.14%
2030	7	102.271	0.36%	12	72.1524	0.14%
2031	7	102.6437	0.36%	12	72.2574	0.15%
2032	7	103.0185	0.37%	12	72.3641	0.15%
2033	7	103.3952	0.37%	12	72.4733	0.15%
2034	7	103.775	0.37%	12	72.5852	0.15%
2020-2024 Avg			0.36%			0.12%

Table 5 lists the Western PSA seasonal forecasts under normal weather conditions. The Eastern PSA numbers are slightly higher than the Western peak day values in the summer but somewhat lower in the winter months.

Table 5

Western PSA Peaks Normal Weather

year	Summer month	Peak Mw	Growth	Winter month	Peak Mw	Growth
2018	7	95.4248		12	78.0054	
2019	7	95.8414	0.44%	12	78.1554	0.19%
2020	7	96.2016	0.38%	12	78.2394	0.11%
2021	7	96.5343	0.35%	12	78.3194	0.10%
2022	7	96.8789	0.36%	12	78.4242	0.13%
2023	7	97.2362	0.37%	12	78.5347	0.14%
2024	7	97.5858	0.36%	12	78.6266	0.12%
2025	7	97.9284	0.35%	12	78.7195	0.12%
2026	7	98.2723	0.35%	12	78.8148	0.12%
2027	7	98.6199	0.35%	12	78.9135	0.13%
2028	7	98.9709	0.36%	12	79.0173	0.13%
2029	7	99.3262	0.36%	12	79.1251	0.14%
2030	7	99.6859	0.36%	12	79.2376	0.14%
2031	7	100.0491	0.36%	12	79.3526	0.15%
2032	7	100.4148	0.37%	12	79.4698	0.15%
2033	7	100.7816	0.37%	12	79.5897	0.15%
2034	7	101.1519	0.37%	12	79.7129	0.15%
2020-2024 Avg			0.36%			0.12%

Tables 6 and 7 provide the Eastern PSA and Western PSA seasonal forecasts under extreme weather conditions. As the case with the normal weather forecasts, The Eastern PSA values are higher than the Western PSA numbers in the summer but lower during the winter period.

Table 6
Eastern PSA Peaks Extreme Weather

year	Summer month	Peak Mw	Growth	Winter month	Peak Mw	Growth
2018	7	107.5173		12	73.9059	
2019	7	107.9595	0.41%	12	74.0422	0.18%
2020	7	108.3443	0.36%	12	74.119	0.10%
2021	7	108.7002	0.33%	12	74.1918	0.10%
2022	7	109.0684	0.34%	12	74.2877	0.13%
2023	7	109.4498	0.35%	12	74.3876	0.13%
2024	7	109.823	0.34%	12	74.4716	0.11%
2025	7	110.189	0.33%	12	74.556	0.11%
2026	7	110.5572	0.33%	12	74.6433	0.12%
2027	7	110.9279	0.34%	12	74.7328	0.12%
2028	7	111.3032	0.34%	12	74.8272	0.13%
2029	7	111.6825	0.34%	12	74.9254	0.13%
2030	7	112.0658	0.34%	12	75.0278	0.14%
2031	7	112.4532	0.35%	12	75.1331	0.14%
2032	7	112.8427	0.35%	12	75.2394	0.14%
2033	7	113.2346	0.35%	12	75.3486	0.15%
2034	7	113.629	0.35%	12	75.4606	0.15%
2020-2024 Avg			0.35%			0.12%

Table 7
Western PSA Peaks Extreme Weather

year	Summer month	Peak Mw	Growth	Winter month	Peak Mw	Growth
2018	7	104.7997		12	81.1631	
2019	7	105.2306	0.41%	12	81.3128	0.18%
2020	7	105.6058	0.36%	12	81.3971	0.10%
2021	7	105.9527	0.33%	12	81.4771	0.10%
2022	7	106.3115	0.34%	12	81.5821	0.13%
2023	7	106.6833	0.35%	12	81.6922	0.13%
2024	7	107.047	0.34%	12	81.7843	0.11%
2025	7	107.4041	0.33%	12	81.8771	0.11%
2026	7	107.7628	0.33%	12	81.9728	0.12%
2027	7	108.1243	0.34%	12	82.0713	0.12%
2028	7	108.4899	0.34%	12	82.175	0.13%
2029	7	108.8596	0.34%	12	82.2826	0.13%
2030	7	109.2332	0.34%	12	82.3951	0.14%
2031	7	109.6111	0.35%	12	82.5109	0.14%
2032	7	109.9904	0.35%	12	82.6275	0.14%
2033	7	110.3723	0.35%	12	82.7473	0.14%
2034	7	110.7569	0.35%	12	82.8704	0.15%
2020-2024 Avg			0.35%			0.12%

The report describes the analytical approach employed in developing the seasonal LUNH forecasts and details the data available for the analysis.

Introduction

This report presents the Liberty Utilities New Hampshire (LUNH) seasonal peak forecasts for 2018-2034 under both normal and extreme weather. Regression analysis was used to estimate the LUNH historic monthly peak day model. The historic monthly peaks were net of all energy efficiency and distributed generation load impacts. The monthly peak day model coefficients were then employed to develop seasonal peak forecasts at the LUNH system level. The LUNH system seasonal peak forecasts were then split into Eastern and Western jurisdictions using LUNH township sales information as well the average summer coincident peak Eastern and Western PSA percent contributions for 2014 through 2018 and the average winter coincident peak Eastern and Western PSA percent contributions for 2015 through 2018.

The remainder of this report is organized as follows. First, the data used in the analysis is described. Second, the regression model specifications are provided. Third, the results from the regression models are discussed. Finally, the 2018-2034 seasonal forecast process is detailed.

Data

There were three data sources employed to perform the historic peak day modeling. These sources include LUNH hourly load and annual township sales, economic drivers for the LUNH service area, and daily weather information.

Hourly system load for LUNH from October 2000 through April 2014 was supplied by National Grid while historic system loads from May 2014 through October 2018 was provided by LUNH staff. LUNH also supplied hourly Eastern and Western PSA loads for March 2014 through October 2018. The historic peak load data includes the impacts of energy efficiency programs as well as distributed generation activities. Also, National Grid supplied annual sales data for 21 townships from 1996 through 2013 and 2014-2017 township volumes came from LUNH. The 2014-2017 township volumes collapsed 2 small townships into larger ones so the 1996 through 2013 data was aggregated as well down to 19 townships.

The system load and annual township sales information was utilized to create the dependent variables for the various regression models estimated. For the monthly peak day analysis, the maximum hourly load for each month from October 2000 through October 2018 was identified as the dependent variable (LUNH staff requested not using 2002-2003 peak day values). A total of 193 months of peaks are used in the peak day analysis. Each of the 19 townships has 22 years of annual sales in the annual usage analysis. Appendix A contains the historic monthly peak values for LUNH.

Annual employment and number of households for Rockingham and Grafton counties from 1970 through 2043 was purchased from Moody's Economy.com to develop an economic variable for the monthly peak model. Employment and household values were summed across the two counties. Each series was then divided by the 2017 employment and household value to create annual ratios. The annual ratios were then combined using a 60% weight for employment and 40% weight for households based on previous work performed by National Grid. The annual ratios were converted to monthly numbers over the historic and forecast period by spreading the annual growth rate into 12 equal parts. Appendix B reveals the annual total employment and total households for Rockingham and Grafton counties from 2000 to 2034 along with the development of the annual employment/household ratio term.

Weather information came from NOAA. Daily high temperature, low temperature, and dew point temperature information from the Concord New Hampshire Airport (WBAN #14745) was obtained for March 1994 through October 2018. Using the above mentioned weather elements, the temperature humidity index (THI) and heating degree days (HDD) were used in the peak day modeling analysis while annual cooling degree days (CDD) was used when modeling annual township sales. The discussion of how each specific weather element is computed resides in the model specification section of this report.

Specification of Models

This section first provides the specification of the peak day model followed by a description of the annual township sales models.

Peak Day Model Specification

The monthly peak day usage was primarily driven by weather conditions. The most important weather term was the temperature humidity index (THI). The daily THI was defined as follows:

THI = .55 * maximum temperature + .2 * average dew point temperature + 17.5

A weighted THI variable (WTHI) was used in the model to account for the heat buildup impact on energy usage. The WTHI equaled:

WTHI = .7 * THI on the peak day + .2 * THI day before + .1 * THI two days before

In addition to the WTHI term, a summer period (June through September) indicator was interacted with the WTHI as follows:

WTHI_SUMMER = WTHI * summer period

To account for the increased saturation of air conditioning in the service territory, the WTHI_SUMMER term defined above was also interacted with a time trend term (the value of the trend started at 1 in year 2000 and increased to 19 in year 2018) as described below:

WTHI_SUMMER_T = WTHI_SUMMER * time trend

The coefficient values of three THI terms defined above are expected to be positive in the regression model based on the assumption that the higher the WTHI value, the higher the peak day value will be. To account for peaks during the winter period, a heating degree day (HDD) term was added based on the maximum daily temperature on the peak day, the day before the peak, and two days prior to the peak (WTMAX). WTMAX equaled:

WTMAX = .7*max temp on peak day + 2*max temp day before +.1*max temp 2 days before

The term HDD was defined as

HDD = (55 – WTMAX), or 0 if the value of WTMAX was greater than or equal to 55

The expected value of the HDD coefficient in the regression equation is greater than zero which suggests the peak day use rises as the temperature becomes colder. The economic variable included in the peak day model was the weighted employment and household (EMP_HH) index variable discussed in the previous section of this report. EMP_HH was defined as

EMP_HH = .6 * employment index + .4 * household index

The index portion of this variable was computed by dividing the actual employment and household count variables by the 2017 values. It is expected that a positive relationship exists between peak day use and the value of the index. The remaining variables included in the peak day model were monthly indicators. These indicators take the value of one for a particular month, zero otherwise. The monthly indicators included are as follows:

FEB = one if month is February, zero otherwise

MAR = one if month is March, zero otherwise

APR = one if month is April, zero otherwise

MAY = one if month is May, zero otherwise

JUN = one if month is June, zero otherwise

JUL = one if month is July, zero otherwise

AUG = one if month is August, zero otherwise

SEP = one if month is September, zero otherwise

OCT = one if month is October, zero otherwise

NOV = one if month is November, zero otherwise

DEC = one if month is December, zero otherwise

The final LUNH peak day model expressed in mathematical terms is as follows:

PeakDay Mw = a + b * WTHI + c * WTHI_SUMMER + d * WTHI_SUMMER_T
+ e * HDD + f * EMP_HH + g * FEB + h * MAR + i * APR + j * MAY
+ k * JUN + l * JUL + m * AUG + n * SEP + o * OCT + p * NOV
+ q * DEC

Values of the estimated coefficients (a, b …, q) will be presented and discussed in the next section of the report.

Annual Township Sales Model Specification

The principal factor that influences annual sales at the township level has been a time trend that takes the value of one in 1996 and increases to twenty two in 2017. In order to flatten the change in township usage over the historic period, the time trend variable was expressed as a log function. The trend term variable was expressed as follows:

TIME = log(time trend value + 1)

The value of TIME is expected to have a positive coefficient value if the township experienced sales growth from 1996 through 2017 and a negative value if township sales declined from 1996 through 2017. The other term included in the annual township sales models was annual cooling degree days (CDD). CDD was based on the average daily temperature (daily maximum temperature plus daily minimum temperature divided by two). Daily cooling degree days was defined as:

CDD = (average temp – 60), or 0 if the average temp was less than or equal to 60.

The daily CDD values were then summed for the entire calendar year for final inclusion into the township models. It was expected that a positive relationship existed between CDD and annual sales. Township regression models that generated a negative coefficient for CDD had that variable removed from the analysis. The final LUNH annual township models expressed in mathematical terms are as follows:

Annual kWh = a + b * TIME + c * CDD

Values of the estimated coefficients (a, b, and c) will be presented and discussed in the next section of the report.

Regression Results

This section provides the overall model statistics as well as estimated coefficient values for the peak day and annual township models. The peak day model adjusted R-Squared value was .8750 which means that almost 88% of the monthly historic peak day variation was explained by the model coefficients. The monthly peak day Mw model coefficients are as follows:

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
INTERCEPT	64.86846	23.20202	2.8	0.0058
WTHI	0.85693	0.20588	4.16	<.0001
WTHI_SUMMER	3.1535	0.46812	6.74	<.0001
WTHI_SUMMER_T	0.00632	0.00306	2.06	0.0406
HDD	0.96711	0.23931	4.04	<.0001
EMP_HH	24.462	21.59604	1.13	0.2589
FEB	-4.66736	2.84739	-1.64	0.103
MAR	-8.22188	3.20446	-2.57	0.0111
APR	-17.97462	4.53312	-3.97	0.0001
MAY	-2.41446	5.41104	-0.45	0.656
JUN	-239.189	36.00799	-6.64	<.0001
JUL	-234.42314	36.64564	-6.4	<.0001
AUG	-234.567	36.24369	-6.47	<.0001
SEP	-241.3816	35.23254	-6.85	<.0001
OCT	-13.51145	4.82839	-2.8	0.0057
NOV	-5.35602	4.05034	-1.32	0.1878
DEC	2.16819	2.96977	0.73	0.4663

The values of the WTHI terms have the expected positive coefficient signs and significant. The HDD term also has a significant expected positive coefficient sign. Likewise, the EMP_HH term has an insignificant expected positive coefficient sign and the coefficient value is smaller than in previous models. Only the MAY, NOV and DEC monthly terms are not significant at the 80% level. The JUN through SEP indicators have large negative values to offset the impact of the WTHI_SUMMER and WTHI_SUMMER_T terms.

The Eastern area annual kWh models by township appear as follows:

Eastern Township Regression Results

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|		
Town=Derry					R-Square	0.1887
INTERCEPT	-1835369	2055463	-0.89	0.3831		
TIME	693431	390994	1.77	0.0922		
CDD	2451.71302	2090.285	1.17	0.2553		
Town=Pelham					R-Square	0.843
INTERCEPT	23190627	7417272	3.13	0.0056		
TIME	12696638	1410926	9	<.0001		
CDD	16722	7542.929	2.22	0.039		
Town=Salem, NH					R-Square	0.3481
Intercept	260455731	18672477	13.95	<.0001		
TIME	4661243	3489929	1.34	0.1983		
CDD	23524	19167	1.23	0.2355		
YEAR 2005	27801238	10711572	2.6	0.0183		
Town=Windham					R-Square	0.7684
INTERCEPT	8359128	1308965	6.39	<.0001		
TIME	1749608	248994	7.03	<.0001		
CDD	2533.59809	1331.141	1.9	0.0723		

Note that the Salem Township had a year 2005 indicator variable added to capture a spike in annual usage for that year. All the CDD terms were significant at the 75% confidence level which is reasonable for a twenty two year historic series.

Western area annual kWh models by township are displayed below. The Grafton Township had a year 2002 indicator variable to capture a spike in usage for that year and Monroe Township had inserted a year 2015 indicator variable to capture a sharp decline in usage for that year.

Western Township Regression Results #1

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|		
Town=Acworth					R-Square	0.2872
INTERCEPT	1138893	40922	27.83	<.0001		
TIME	51619	16782	3.08	0.006		
Town=Alstead					R-Square	0.2703
INTERCEPT	9911652	279550	35.46	<.0001		
TIME	339631	114640	2.96	0.0077		
Town=Bath					R-Square	0.6263
INTERCEPT	-24230	18148	-1.34	0.1976		
TIME	16396	3452.176	4.75	0.0001		
CDD	34.64262	18.45562	1.88	0.0759		
Town=Canaan					R-Square	0.5829
INTERCEPT	10109160	992313	10.19	<.0001		
TIME	939189	188760	4.98	<.0001		
CDD	626.87929	1009.124	0.62	0.5418		
Town=Charlestown, NH					R-Square	0.662
INTERCEPT	1341700	7090630	0.19	0.8519		
TIME	7708582	1348792	5.72	<.0001		
CDD	7084.15717	7210.754	0.98	0.3382		
Town=Cornish					R-Square	0.2728
INTERCEPT	737101	125034	5.9	<.0001		
TIME	60214	23784	2.53	0.0203		
CDD	106.30368	127.1522	0.84	0.4135		

Western Township Regression Results #2

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|		
Town=Enfield					R-Square	0.696
INTERCEPT	14777186	1182050	12.5	<.0001		
TIME	1424926	224852	6.34	<.0001		
CDD	816.14872	1202.076	0.68	0.5054		
Town=Grafton, NH					R-Square	0.2885
INTERCEPT	58659	6089.404	9.63	<.0001		
TIME	1831.8423	2481.113	0.74	0.4693		
YEAR 2002	25472	7934.861	3.21	0.0046		
Town=Hanover, NH					R-Square	0.7912
INTERCEPT	71690818	10136017	7.07	<.0001		
TIME	15531554	1928091	8.06	<.0001		
CDD	9687.25295	10308	0.94	0.3591		
Town=Lebanon					R-Square	0.8205
INTERCEPT	75964275	26385845	2.88	0.0096		
TIME	41806548	5019161	8.33	<.0001		
CDD	54227	26833	2.02	0.0576		
Town=Marlow					R-Square	0.1333
INTERCEPT	27954	7196.082	3.88	0.001		
TIME	2734.8391	1368.851	2	0.0602		
CDD	2.38771	7.31799	0.33	0.7478		

Western Township Regression Results #3

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|		
Town=Monroe, NH					R-Square	0.0412
INTERCEPT	1749590	49783	35.14	<.0001		
TIME	10203	20693	0.49	0.6276		
YEAR 2015	-112537	66177	-1.7	0.1053		
Town=Plainfield					R-Square	0.4926
INTERCEPT	4730329	569497	8.31	<.0001		
TIME	417108	108331	3.85	0.0011		
CDD	691.89342	579.1449	1.19	0.2469		
Town=Surry					R-Square	0.5655
INTERCEPT	126126	47772	2.64	0.0161		
TIME	44633	9087.18	4.91	<.0001		
CDD	18.33472	48.58082	0.38	0.7101		
Town=Walpole					R-Square	0.4369
INTERCEPT	22018299	1526600	14.42	<.0001		
TIME	1065108	290392	3.67	0.0016		
CDD	1156.39317	1552.462	0.74	0.4655		

Except for Grafton, all the western area townships had significant time trend coefficients at the 90% confidence level. All of the larger usage Western Townships had CDD coefficients significant at the 70% confidence level.

An explanation of how the peak day and township model coefficients are employed to generate seasonal peak day forecasts appears in the next section.

Seasonal Forecast Development for 2018-2034

The peak day model coefficients detailed in the previous section of the report are used along with the economic driver forecast (shown in Appendix B) and normal/extreme weather to estimate seasonal peak forecasts for 2018 through 2034. The normal monthly WTHI and HDD values were computed by taking the average values for those terms during the October 2000 through September 2018 LUNH system monthly peak days. The extreme monthly WTHI and HDD values were extracted by taking the maximum values for those monthly terms during the October 2000 through September 2018 LUNH system monthly peak days. The normal and extreme monthly WTHI and HDD values appear below.

	Weather Values Used in Forecast			
Month	Normal WTHI	Extreme WTHI	Normal HDD	Extreme HDD
January	30.315	21.9	34.7444	45
February	34.0047	26.995	29.9167	38.1
March	39.7611	30.86	22.3111	32.6
April	62.9111	78.18	5.0389	25.1
May	75.9147	81.925	0	0
June	80.3658	84.525	0	0
July	81.8786	86.475	0	0
August	80.9872	84.61	0	0
September	78.1219	82.16	0	0
October	67.4789	75.035	1.3737	10.7
November	48.2356	37.26	12.0667	23.8
December	37.5533	21.37	25.8222	46.4

The normal and extreme LUNH system seasonal peak day forecasts appear in Tables 2 and 3 in the Summary of Results section of the report. The system peak day values were allocated to the Eastern and Western PSA regions by using the average summer coincident peak Eastern and Western PSA percent contributions for 2014 through 2018 and the average winter coincident peak Eastern and Western PSA percent contributions for 2015 through 2018. The summer Eastern coincident peak proportion was 50.64% while the Western proportion was 49.36%. The winter Eastern coincident peak contribution was 46.66% compared to the Western value of 53.34%. Appendix C lists the Eastern and Western coincident peak contributions for March 2014 through October 2018.

The individual township peaks were then calculated by utilizing the annual township sales regression models. For townships with CDD in the model, normal CDD value equaled 1057 and the extreme CDD took the value of 1265 which were computed based upon 1998 through 2017 Concord weather data. Once the annual township forecasts were completed, they were totaled so that individual township annual proportions under normal and extreme weather could be applied to the area peak values.

The Derry township results are shown below. The annual growth rates for 2020-2024 are much larger than the overall system average.

Derry Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.7228		0.5244		0.9092		0.625	
2019	0.7314	1.19%	0.5294	0.95%	0.9186	1.03%	0.63	0.80%
2020	0.7394	1.09%	0.5337	0.81%	0.9273	0.95%	0.6344	0.70%
2021	0.747	1.03%	0.5379	0.79%	0.9355	0.88%	0.6385	0.65%
2022	0.7545	1.00%	0.5421	0.78%	0.9437	0.88%	0.6428	0.67%
2023	0.762	0.99%	0.5463	0.77%	0.9519	0.87%	0.6469	0.64%
2024	0.7693	0.96%	0.5502	0.71%	0.9598	0.83%	0.6508	0.60%
2025	0.7764	0.92%	0.5539	0.67%	0.9675	0.80%	0.6546	0.58%
2026	0.7834	0.90%	0.5576	0.67%	0.9751	0.79%	0.6584	0.58%
2027	0.7903	0.88%	0.5613	0.66%	0.9827	0.78%	0.662	0.55%
2028	0.7971	0.86%	0.5648	0.62%	0.9901	0.75%	0.6656	0.54%
2029	0.8038	0.84%	0.5684	0.64%	0.9975	0.75%	0.6692	0.54%
2030	0.8105	0.83%	0.5718	0.60%	1.0048	0.73%	0.6727	0.52%
2031	0.8172	0.83%	0.5753	0.61%	1.0121	0.73%	0.6762	0.52%
2032	0.8238	0.81%	0.5786	0.57%	1.0193	0.71%	0.6796	0.50%
2033	0.8303	0.79%	0.582	0.59%	1.0264	0.70%	0.683	0.50%
2034	0.8367	0.77%	0.5853	0.57%	1.0335	0.69%	0.6864	0.50%
2020-2024 Avg		1.04%		0.79%		0.90%		0.66%

The Pelham township results are provided next. The 2020-2024 annual growth rates for Pelham are not as large as Derry but larger than the overall system.

Pelham Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	19.8326		14.3895		22.193		15.2552	
2019	20.006	0.87%	14.4799	0.63%	22.3766	0.83%	15.3466	0.60%
2020	20.1645	0.79%	14.5557	0.52%	22.545	0.75%	15.4232	0.50%
2021	20.3145	0.74%	14.6283	0.50%	22.7043	0.71%	15.4965	0.48%
2022	20.4642	0.74%	14.7034	0.51%	22.8634	0.70%	15.5725	0.49%
2023	20.6143	0.73%	14.7776	0.50%	23.0226	0.70%	15.6473	0.48%
2024	20.7604	0.71%	14.8464	0.47%	23.1777	0.67%	15.7169	0.44%
2025	20.903	0.69%	14.9137	0.45%	23.329	0.65%	15.7849	0.43%
2026	21.044	0.67%	14.9799	0.44%	23.4787	0.64%	15.8518	0.42%
2027	21.1839	0.66%	15.0451	0.44%	23.627	0.63%	15.9177	0.42%
2028	21.3228	0.66%	15.1099	0.43%	23.7745	0.62%	15.9832	0.41%
2029	21.4611	0.65%	15.1742	0.43%	23.9211	0.62%	16.0482	0.41%
2030	21.599	0.64%	15.2381	0.42%	24.067	0.61%	16.1128	0.40%
2031	21.7361	0.63%	15.3014	0.42%	24.2123	0.60%	16.1769	0.40%
2032	21.8725	0.63%	15.3641	0.41%	24.3567	0.60%	16.2402	0.39%
2033	22.008	0.62%	15.4262	0.40%	24.5003	0.59%	16.303	0.39%
2034	22.1431	0.61%	15.4879	0.40%	24.6432	0.58%	16.3654	0.38%
2020-2024 Avg		0.75%		0.51%		0.72%		0.48%

Salem forecasts are displayed next. The Salem annual growth rates are lower than the overall system rates and since Salem contributes the most to Eastern PSA total, Salem pushes down the Eastern PSA numbers that appear in Tables 4 through 7 in the Summary of Results section.

Salem Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	73.2909		53.176		79.9279		54.9413	
2019	73.5093	0.30%	53.2046	0.05%	80.1487	0.28%	54.9687	0.05%
2020	73.6882	0.24%	53.1915	-0.02%	80.3308	0.23%	54.9548	-0.03%
2021	73.8492	0.22%	53.1784	-0.02%	80.4952	0.20%	54.9409	-0.03%
2022	74.0223	0.23%	53.1845	0.01%	80.6718	0.22%	54.9464	0.01%
2023	74.2081	0.25%	53.1969	0.02%	80.8613	0.23%	54.9575	0.02%
2024	74.3905	0.25%	53.199	0.00%	81.0475	0.23%	54.9588	0.00%
2025	74.5701	0.24%	53.2035	0.01%	81.2311	0.23%	54.9625	0.01%
2026	74.7531	0.25%	53.212	0.02%	81.4187	0.23%	54.9702	0.01%
2027	74.9408	0.25%	53.224	0.02%	81.6104	0.24%	54.9814	0.02%
2028	75.1331	0.26%	53.2412	0.03%	81.8076	0.24%	54.9978	0.03%
2029	75.3306	0.26%	53.2627	0.04%	82.0097	0.25%	55.0185	0.04%
2030	75.5332	0.27%	53.2889	0.05%	82.2167	0.25%	55.0439	0.05%
2031	75.7401	0.27%	53.3182	0.05%	82.4283	0.26%	55.0727	0.05%
2032	75.9499	0.28%	53.3501	0.06%	82.6431	0.26%	55.1034	0.06%
2033	76.1627	0.28%	53.385	0.07%	82.8612	0.26%	55.1375	0.06%
2034	76.379	0.28%	53.4231	0.07%	83.0826	0.27%	55.1748	0.07%
2020-2024 Avg		0.24%		0.00%		0.22%		0.00%

The last Eastern PSA township, Windham, forecasts are displayed next. The annual growth rate in peaks for Windham from 2020-2024 are somewhat higher than the overall system average.

Windham Township Peaks								
	Summer		Winter		Summer		Winter	
	Normal		Normal		Extreme		Extreme	
year	Peak Mw	Growth	Peak Mw	Growth	Peak Mw	Growth	Peak Mw	Growth
2018	4.053		2.9406		4.4872		3.0844	
2019	4.08	0.67%	2.953	0.42%	4.5156	0.63%	3.0969	0.41%
2020	4.1043	0.60%	2.9626	0.33%	4.5412	0.57%	3.1066	0.31%
2021	4.127	0.55%	2.9719	0.31%	4.5652	0.53%	3.1159	0.30%
2022	4.15	0.56%	2.9818	0.33%	4.5895	0.53%	3.126	0.32%
2023	4.1733	0.56%	2.9917	0.33%	4.614	0.53%	3.1359	0.32%
2024	4.196	0.54%	3.0007	0.30%	4.638	0.52%	3.1451	0.29%
2025	4.2182	0.53%	3.0096	0.30%	4.6614	0.50%	3.154	0.28%
2026	4.2403	0.52%	3.0184	0.29%	4.6847	0.50%	3.1629	0.28%
2027	4.2623	0.52%	3.0271	0.29%	4.7078	0.49%	3.1717	0.28%
2028	4.2843	0.52%	3.0359	0.29%	4.731	0.49%	3.1806	0.28%
2029	4.3063	0.51%	3.0447	0.29%	4.7542	0.49%	3.1895	0.28%
2030	4.3283	0.51%	3.0536	0.29%	4.7773	0.49%	3.1984	0.28%
2031	4.3503	0.51%	3.0625	0.29%	4.8005	0.49%	3.2073	0.28%
2032	4.3723	0.51%	3.0713	0.29%	4.8236	0.48%	3.2162	0.28%
2033	4.3942	0.50%	3.0801	0.29%	4.8467	0.48%	3.2251	0.28%
2034	4.4162	0.50%	3.0889	0.29%	4.8697	0.47%	3.234	0.28%
2020-2024 Avg		0.57%		0.32%		0.54%		0.31%

The Western Township forecasts are shown next starting with Acworth. The Acworth annual growth rates are much lower than the overall system for 2020-2024.

Acworth Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.242		0.1979		0.258		0.1998	
2019	0.2422	0.08%	0.1975	-0.20%	0.2581	0.04%	0.1995	-0.15%
2020	0.2422	0.00%	0.197	-0.25%	0.2581	0.00%	0.199	-0.25%
2021	0.2421	-0.04%	0.1965	-0.25%	0.2581	0.00%	0.1985	-0.25%
2022	0.2422	0.04%	0.1961	-0.20%	0.2581	0.00%	0.1981	-0.20%
2023	0.2423	0.04%	0.1957	-0.20%	0.2582	0.04%	0.1977	-0.20%
2024	0.2424	0.04%	0.1953	-0.20%	0.2583	0.04%	0.1974	-0.15%
2025	0.2425	0.04%	0.195	-0.15%	0.2585	0.08%	0.197	-0.20%
2026	0.2427	0.08%	0.1946	-0.21%	0.2586	0.04%	0.1967	-0.15%
2027	0.2429	0.08%	0.1943	-0.15%	0.2588	0.08%	0.1964	-0.15%
2028	0.2431	0.08%	0.1941	-0.10%	0.259	0.08%	0.1962	-0.10%
2029	0.2433	0.08%	0.1938	-0.15%	0.2592	0.08%	0.1959	-0.15%
2030	0.2436	0.12%	0.1936	-0.10%	0.2595	0.12%	0.1957	-0.10%
2031	0.2439	0.12%	0.1934	-0.10%	0.2598	0.12%	0.1955	-0.10%
2032	0.2442	0.12%	0.1932	-0.10%	0.2601	0.12%	0.1954	-0.05%
2033	0.2445	0.12%	0.1931	-0.05%	0.2604	0.12%	0.1952	-0.10%
2034	0.2449	0.16%	0.193	-0.05%	0.2608	0.15%	0.1951	-0.05%
2020-2024 Avg		0.02%		-0.22%		0.02%		-0.21%

Alstead township forecast appears next. As the case with Acworth, Alstead annual growth in peak is much lower than the system average.

Alstead Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	2.0418		1.6691		2.1768		1.6858	
2019	2.042	0.01%	1.6652	-0.23%	2.1768	0.00%	1.682	-0.23%
2020	2.0414	-0.03%	1.6603	-0.29%	2.1761	-0.03%	1.6772	-0.29%
2021	2.0406	-0.04%	1.6555	-0.29%	2.1751	-0.05%	1.6726	-0.27%
2022	2.0403	-0.01%	1.6516	-0.24%	2.1747	-0.02%	1.6688	-0.23%
2023	2.0405	0.01%	1.6481	-0.21%	2.1748	0.00%	1.6654	-0.20%
2024	2.0409	0.02%	1.6444	-0.22%	2.1751	0.01%	1.6618	-0.22%
2025	2.0413	0.02%	1.6409	-0.21%	2.1755	0.02%	1.6584	-0.20%
2026	2.042	0.03%	1.6377	-0.20%	2.1761	0.03%	1.6553	-0.19%
2027	2.043	0.05%	1.6348	-0.18%	2.177	0.04%	1.6524	-0.18%
2028	2.0442	0.06%	1.6321	-0.17%	2.1781	0.05%	1.6498	-0.16%
2029	2.0457	0.07%	1.6297	-0.15%	2.1796	0.07%	1.6474	-0.15%
2030	2.0475	0.09%	1.6275	-0.13%	2.1812	0.07%	1.6453	-0.13%
2031	2.0495	0.10%	1.6255	-0.12%	2.1832	0.09%	1.6434	-0.12%
2032	2.0517	0.11%	1.6237	-0.11%	2.1853	0.10%	1.6416	-0.11%
2033	2.054	0.11%	1.6221	-0.10%	2.1876	0.11%	1.64	-0.10%
2034	2.0565	0.12%	1.6206	-0.09%	2.19	0.11%	1.6386	-0.09%
2020-2024 Avg		-0.01%		-0.25%		-0.02%		-0.24%

The Bath township forecasts are displayed below. The annual growth in the Bath peaks from 2020-2024 is higher than the system average although the peaks are very small.

Bath Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.012		0.0098		0.0142		0.011	
2019	0.0121	0.83%	0.0099	1.02%	0.0143	0.70%	0.0111	0.91%
2020	0.0122	0.83%	0.0099	0.00%	0.0144	0.70%	0.0111	0.00%
2021	0.0123	0.82%	0.01	1.01%	0.0145	0.69%	0.0112	0.90%
2022	0.0124	0.81%	0.01	0.00%	0.0146	0.69%	0.0112	0.00%
2023	0.0125	0.81%	0.0101	1.00%	0.0147	0.68%	0.0113	0.89%
2024	0.0126	0.80%	0.0101	0.00%	0.0148	0.68%	0.0113	0.00%
2025	0.0127	0.79%	0.0102	0.99%	0.0149	0.68%	0.0114	0.88%
2026	0.0127	0.00%	0.0102	0.00%	0.015	0.67%	0.0114	0.00%
2027	0.0128	0.79%	0.0103	0.98%	0.0151	0.67%	0.0115	0.88%
2028	0.0129	0.78%	0.0103	0.00%	0.0152	0.66%	0.0115	0.00%
2029	0.013	0.78%	0.0104	0.97%	0.0153	0.66%	0.0115	0.00%
2030	0.0131	0.77%	0.0104	0.00%	0.0154	0.65%	0.0116	0.87%
2031	0.0132	0.76%	0.0104	0.00%	0.0154	0.00%	0.0116	0.00%
2032	0.0133	0.76%	0.0105	0.96%	0.0155	0.65%	0.0117	0.86%
2033	0.0133	0.00%	0.0105	0.00%	0.0156	0.65%	0.0117	0.00%
2034	0.0134	0.75%	0.0106	0.95%	0.0157	0.64%	0.0118	0.85%
2020-2024 Avg		0.83%		0.40%		0.70%		0.36%

Forecasts for the Canaan Township appear below. The annual growth rate in Canaan is less than the system average during the 2020-2024 years.

Canaan Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	2.5555		2.089		2.7503		2.13	
2019	2.5597	0.16%	2.0874	-0.08%	2.7545	0.15%	2.1284	-0.08%
2020	2.5627	0.12%	2.0842	-0.15%	2.7575	0.11%	2.1254	-0.14%
2021	2.5652	0.10%	2.0812	-0.14%	2.7601	0.09%	2.1225	-0.14%
2022	2.5683	0.12%	2.079	-0.11%	2.7632	0.11%	2.1204	-0.10%
2023	2.5719	0.14%	2.0773	-0.08%	2.7669	0.13%	2.1187	-0.08%
2024	2.5756	0.14%	2.0752	-0.10%	2.7706	0.13%	2.1167	-0.09%
2025	2.5792	0.14%	2.0733	-0.09%	2.7743	0.13%	2.1149	-0.09%
2026	2.5831	0.15%	2.0716	-0.08%	2.7782	0.14%	2.1133	-0.08%
2027	2.5872	0.16%	2.0702	-0.07%	2.7824	0.15%	2.112	-0.06%
2028	2.5915	0.17%	2.0691	-0.05%	2.7869	0.16%	2.1109	-0.05%
2029	2.5962	0.18%	2.0682	-0.04%	2.7916	0.17%	2.11	-0.04%
2030	2.601	0.18%	2.0675	-0.03%	2.7965	0.18%	2.1094	-0.03%
2031	2.6061	0.20%	2.067	-0.02%	2.8017	0.19%	2.109	-0.02%
2032	2.6114	0.20%	2.0667	-0.01%	2.807	0.19%	2.1087	-0.01%
2033	2.6168	0.21%	2.0665	-0.01%	2.8125	0.20%	2.1086	0.00%
2034	2.6224	0.21%	2.0666	0.00%	2.8182	0.20%	2.1086	0.00%
2020-2024 Avg		0.12%		-0.12%		0.12%		-0.11%

The Charlestown township forecasts are shown next below. The annual growth rate in peak forecasts is higher than the system average during the 2020-2024 years.

Charlestown Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	6.1913		5.0611		6.8924		5.3379	
2019	6.2426	0.83%	5.0906	0.58%	6.9461	0.78%	5.3673	0.55%
2020	6.2892	0.75%	5.1149	0.48%	6.9951	0.71%	5.3916	0.45%
2021	6.3331	0.70%	5.1381	0.45%	7.0412	0.66%	5.4147	0.43%
2022	6.3769	0.69%	5.1622	0.47%	7.0872	0.65%	5.4387	0.44%
2023	6.4208	0.69%	5.1858	0.46%	7.1333	0.65%	5.4623	0.43%
2024	6.4634	0.66%	5.2077	0.42%	7.178	0.63%	5.4841	0.40%
2025	6.5049	0.64%	5.2289	0.41%	7.2216	0.61%	5.5053	0.39%
2026	6.5458	0.63%	5.2498	0.40%	7.2647	0.60%	5.5261	0.38%
2027	6.5864	0.62%	5.2703	0.39%	7.3073	0.59%	5.5466	0.37%
2028	6.6268	0.61%	5.2907	0.39%	7.3497	0.58%	5.567	0.37%
2029	6.6669	0.61%	5.3109	0.38%	7.3918	0.57%	5.5872	0.36%
2030	6.7068	0.60%	5.3311	0.38%	7.4338	0.57%	5.6073	0.36%
2031	6.7466	0.59%	5.351	0.37%	7.4755	0.56%	5.6273	0.36%
2032	6.7861	0.59%	5.3706	0.37%	7.5169	0.55%	5.6469	0.35%
2033	6.8253	0.58%	5.3901	0.36%	7.5581	0.55%	5.6664	0.35%
2034	6.8644	0.57%	5.4095	0.36%	7.5991	0.54%	5.6858	0.34%
2020-2024 Avg		0.71%		0.46%		0.67%		0.44%

The Cornish township forecast numbers are displayed next. The annual growth in Cornish peaks is less than the 2020-2024 system average growth.

Cornish Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.1934		0.1581		0.2105		0.163	
2019	0.1936	0.10%	0.1579	-0.13%	0.2107	0.10%	0.1628	-0.12%
2020	0.1937	0.05%	0.1576	-0.19%	0.2109	0.09%	0.1625	-0.18%
2021	0.1938	0.05%	0.1573	-0.19%	0.211	0.05%	0.1622	-0.18%
2022	0.194	0.10%	0.1571	-0.13%	0.2111	0.05%	0.162	-0.12%
2023	0.1942	0.10%	0.1569	-0.13%	0.2113	0.09%	0.1618	-0.12%
2024	0.1944	0.10%	0.1566	-0.19%	0.2116	0.14%	0.1616	-0.12%
2025	0.1946	0.10%	0.1565	-0.06%	0.2118	0.09%	0.1614	-0.12%
2026	0.1949	0.15%	0.1563	-0.13%	0.212	0.09%	0.1613	-0.06%
2027	0.1951	0.10%	0.1561	-0.13%	0.2122	0.09%	0.1611	-0.12%
2028	0.1954	0.15%	0.156	-0.06%	0.2125	0.14%	0.161	-0.06%
2029	0.1957	0.15%	0.1559	-0.06%	0.2128	0.14%	0.1609	-0.06%
2030	0.196	0.15%	0.1558	-0.06%	0.2131	0.14%	0.1608	-0.06%
2031	0.1963	0.15%	0.1557	-0.06%	0.2135	0.19%	0.1607	-0.06%
2032	0.1967	0.20%	0.1556	-0.06%	0.2138	0.14%	0.1606	-0.06%
2033	0.197	0.15%	0.1556	0.00%	0.2142	0.19%	0.1606	0.00%
2034	0.1974	0.20%	0.1556	0.00%	0.2145	0.14%	0.1605	-0.06%
2020-2024 Avg		0.08%		-0.16%		0.09%		-0.15%

Enfield Township seasonal peak forecasts are listed next. Much like Cornish, the annual 2020-2024 growth in Enfield peaks is lower than the system average numbers.

Enfield Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	3.7467		3.0627		4.0279		3.1195	
2019	3.7532	0.17%	3.0606	-0.07%	4.0345	0.16%	3.1175	-0.06%
2020	3.7579	0.13%	3.0562	-0.14%	4.0393	0.12%	3.1133	-0.13%
2021	3.7619	0.11%	3.0521	-0.13%	4.0434	0.10%	3.1093	-0.13%
2022	3.7667	0.13%	3.0492	-0.10%	4.0483	0.12%	3.1066	-0.09%
2023	3.7723	0.15%	3.0468	-0.08%	4.0541	0.14%	3.1044	-0.07%
2024	3.778	0.15%	3.044	-0.09%	4.0598	0.14%	3.1017	-0.09%
2025	3.7836	0.15%	3.0414	-0.09%	4.0656	0.14%	3.0993	-0.08%
2026	3.7895	0.16%	3.0392	-0.07%	4.0716	0.15%	3.0972	-0.07%
2027	3.7959	0.17%	3.0374	-0.06%	4.0781	0.16%	3.0954	-0.06%
2028	3.8025	0.17%	3.0359	-0.05%	4.0849	0.17%	3.0941	-0.04%
2029	3.8095	0.18%	3.0348	-0.04%	4.092	0.17%	3.093	-0.04%
2030	3.8169	0.19%	3.034	-0.03%	4.0995	0.18%	3.0923	-0.02%
2031	3.8246	0.20%	3.0334	-0.02%	4.1074	0.19%	3.0919	-0.01%
2032	3.8326	0.21%	3.0332	-0.01%	4.1154	0.19%	3.0916	-0.01%
2033	3.8407	0.21%	3.0331	0.00%	4.1238	0.20%	3.0916	0.00%
2034	3.8491	0.22%	3.0333	0.01%	4.1323	0.21%	3.0919	0.01%
2020-2024 Avg		0.13%		-0.11%		0.13%		-0.10%

Grafton Township forecast results are provided below. Annual growth in Grafton peaks is lower than the system average.

Grafton Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.012		0.0098		0.0128		0.0099	
2019	0.012	0.00%	0.0098	0.00%	0.0128	0.00%	0.0099	0.00%
2020	0.012	0.00%	0.0097	-1.02%	0.0128	0.00%	0.0098	-1.01%
2021	0.012	0.00%	0.0097	0.00%	0.0128	0.00%	0.0098	0.00%
2022	0.012	0.00%	0.0097	0.00%	0.0128	0.00%	0.0098	0.00%
2023	0.012	0.00%	0.0097	0.00%	0.0128	0.00%	0.0098	0.00%
2024	0.012	0.00%	0.0096	-1.03%	0.0128	0.00%	0.0097	-1.02%
2025	0.012	0.00%	0.0096	0.00%	0.0128	0.00%	0.0097	0.00%
2026	0.012	0.00%	0.0096	0.00%	0.0128	0.00%	0.0097	0.00%
2027	0.012	0.00%	0.0096	0.00%	0.0128	0.00%	0.0097	0.00%
2028	0.012	0.00%	0.0096	0.00%	0.0128	0.00%	0.0097	0.00%
2029	0.012	0.00%	0.0096	0.00%	0.0128	0.00%	0.0097	0.00%
2030	0.012	0.00%	0.0095	-1.04%	0.0128	0.00%	0.0096	-1.03%
2031	0.012	0.00%	0.0095	0.00%	0.0128	0.00%	0.0096	0.00%
2032	0.012	0.00%	0.0095	0.00%	0.0128	0.00%	0.0096	0.00%
2033	0.012	0.00%	0.0095	0.00%	0.0128	0.00%	0.0096	0.00%
2034	0.012	0.00%	0.0095	0.00%	0.0128	0.00%	0.0096	0.00%
2020-2024 Avg		0.00%		-0.41%		0.00%		-0.40%

The Hanover township forecasts appear next. As one of the larger Western PSA townships, the Hanover annual growth rate from 2020-2024 is slightly lower than the system average growth.

Hanover Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	24.3897		19.9375		26.401		20.4465	
2019	24.4794	0.37%	19.9621	0.12%	26.4937	0.35%	20.472	0.12%
2020	24.5554	0.31%	19.9706	0.04%	26.5731	0.30%	20.4816	0.05%
2021	24.6251	0.28%	19.9786	0.04%	26.646	0.27%	20.4907	0.04%
2022	24.6984	0.30%	19.9935	0.07%	26.7225	0.29%	20.5065	0.08%
2023	24.7754	0.31%	20.0103	0.08%	26.8027	0.30%	20.524	0.09%
2024	24.851	0.31%	20.0229	0.06%	26.8813	0.29%	20.5374	0.07%
2025	24.9253	0.30%	20.0361	0.07%	26.9587	0.29%	20.5514	0.07%
2026	25.0003	0.30%	20.0504	0.07%	27.037	0.29%	20.5665	0.07%
2027	25.0767	0.31%	20.0658	0.08%	27.1163	0.29%	20.5825	0.08%
2028	25.1543	0.31%	20.0829	0.09%	27.197	0.30%	20.6002	0.09%
2029	25.2333	0.31%	20.1013	0.09%	27.279	0.30%	20.6192	0.09%
2030	25.3138	0.32%	20.1212	0.10%	27.3624	0.31%	20.6396	0.10%
2031	25.3955	0.32%	20.1421	0.10%	27.447	0.31%	20.6611	0.10%
2032	25.478	0.32%	20.1637	0.11%	27.5324	0.31%	20.683	0.11%
2033	25.5612	0.33%	20.1863	0.11%	27.6186	0.31%	20.706	0.11%
2034	25.6454	0.33%	20.2098	0.12%	27.7057	0.32%	20.7299	0.12%
2020-2024 Avg		0.30%		0.06%		0.29%		0.06%

Lebanon township seasonal peak forecasts are listed next. As the largest Western PSA township, Lebanon peak growth from 2020-2024 is somewhat higher than the overall system growth.

Lebanon Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	49.4416		40.4163		54.9438		42.5517	
2019	49.7017	0.53%	40.53	0.28%	55.2134	0.49%	42.664	0.26%
2020	49.9308	0.46%	40.608	0.19%	55.4519	0.43%	42.7403	0.18%
2021	50.1438	0.43%	40.6822	0.18%	55.674	0.40%	42.813	0.17%
2022	50.3613	0.43%	40.7679	0.21%	55.9007	0.41%	42.8976	0.20%
2023	50.5842	0.44%	40.8552	0.21%	56.1328	0.42%	42.9834	0.20%
2024	50.8016	0.43%	40.9318	0.19%	56.3593	0.40%	43.0588	0.18%
2025	51.0141	0.42%	41.0076	0.19%	56.5811	0.39%	43.1334	0.17%
2026	51.2263	0.42%	41.0839	0.19%	56.8028	0.39%	43.2086	0.17%
2027	51.4393	0.42%	41.1607	0.19%	57.0247	0.39%	43.2844	0.18%
2028	51.6531	0.42%	41.2393	0.19%	57.248	0.39%	43.3621	0.18%
2029	51.8683	0.42%	41.3192	0.19%	57.4725	0.39%	43.4412	0.18%
2030	52.085	0.42%	41.4009	0.20%	57.6982	0.39%	43.5221	0.19%
2031	52.3027	0.42%	41.4832	0.20%	57.9253	0.39%	43.604	0.19%
2032	52.5208	0.42%	41.5659	0.20%	58.1526	0.39%	43.6857	0.19%
2033	52.7391	0.42%	41.6494	0.20%	58.3806	0.39%	43.7686	0.19%
2034	52.9584	0.42%	41.7339	0.20%	58.6093	0.39%	43.8526	0.19%
2020-2024 Avg		0.44%		0.20%		0.42%		0.19%

Marlow township forecast values are shown next. The Marlow growth is much lower than the system average during the 2020-2024 years.

Marlow Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.0073		0.0059		0.0079		0.0061	
2019	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.0061	0.00%
2020	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.0061	0.00%
2021	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.0061	0.00%
2022	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.0061	0.00%
2023	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.0061	0.00%
2024	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.006	-1.64%
2025	0.0073	0.00%	0.0059	0.00%	0.0079	0.00%	0.006	0.00%
2026	0.0074	1.37%	0.0059	0.00%	0.0079	0.00%	0.006	0.00%
2027	0.0074	0.00%	0.0059	0.00%	0.008	1.27%	0.006	0.00%
2028	0.0074	0.00%	0.0059	0.00%	0.008	0.00%	0.006	0.00%
2029	0.0074	0.00%	0.0059	0.00%	0.008	0.00%	0.006	0.00%
2030	0.0074	0.00%	0.0059	0.00%	0.008	0.00%	0.006	0.00%
2031	0.0074	0.00%	0.0059	0.00%	0.008	0.00%	0.006	0.00%
2032	0.0074	0.00%	0.0059	0.00%	0.008	0.00%	0.006	0.00%
2033	0.0075	1.35%	0.0059	0.00%	0.008	0.00%	0.006	0.00%
2034	0.0075	0.00%	0.0059	0.00%	0.0081	1.25%	0.006	0.00%
2020-2024 Avg		0.00%		0.00%		0.00%		-0.33%

Monroe township peak forecasts are shown below. The annual growth in Monroe Township is smaller than the system average during the 2020-2024 years.

Monroe Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.331		0.2706		0.3529		0.2733	
2019	0.3307	-0.09%	0.2697	-0.33%	0.3526	-0.09%	0.2724	-0.33%
2020	0.3303	-0.12%	0.2686	-0.41%	0.3521	-0.14%	0.2714	-0.37%
2021	0.3299	-0.12%	0.2676	-0.37%	0.3516	-0.14%	0.2704	-0.37%
2022	0.3295	-0.12%	0.2667	-0.34%	0.3512	-0.11%	0.2695	-0.33%
2023	0.3293	-0.06%	0.2659	-0.30%	0.3509	-0.09%	0.2687	-0.30%
2024	0.329	-0.09%	0.2651	-0.30%	0.3507	-0.06%	0.2679	-0.30%
2025	0.3289	-0.03%	0.2643	-0.30%	0.3505	-0.06%	0.2672	-0.26%
2026	0.3287	-0.06%	0.2636	-0.26%	0.3503	-0.06%	0.2665	-0.26%
2027	0.3286	-0.03%	0.2629	-0.27%	0.3502	-0.03%	0.2658	-0.26%
2028	0.3286	0.00%	0.2623	-0.23%	0.3501	-0.03%	0.2652	-0.23%
2029	0.3286	0.00%	0.2617	-0.23%	0.3501	0.00%	0.2646	-0.23%
2030	0.3286	0.00%	0.2612	-0.19%	0.3501	0.00%	0.2641	-0.19%
2031	0.3287	0.03%	0.2607	-0.19%	0.3502	0.03%	0.2636	-0.19%
2032	0.3288	0.03%	0.2603	-0.15%	0.3503	0.03%	0.2631	-0.19%
2033	0.329	0.06%	0.2598	-0.19%	0.3504	0.03%	0.2627	-0.15%
2034	0.3292	0.06%	0.2594	-0.15%	0.3506	0.06%	0.2623	-0.15%
2020-2024 Avg		-0.10%		-0.34%		-0.11%		-0.33%

Plainfield township forecasts appear next. The Plainfield growth rate is peak from 2020-2024 is much lower than the system average over this time frame.

Plainfield Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	1.2609		1.0307		1.3727		1.0631	
2019	1.2626	0.13%	1.0296	-0.11%	1.3744	0.12%	1.062	-0.10%
2020	1.2637	0.09%	1.0278	-0.17%	1.3755	0.08%	1.0602	-0.17%
2021	1.2646	0.07%	1.026	-0.18%	1.3764	0.07%	1.0584	-0.17%
2022	1.2658	0.09%	1.0247	-0.13%	1.3776	0.09%	1.0571	-0.12%
2023	1.2673	0.12%	1.0236	-0.11%	1.3791	0.11%	1.056	-0.10%
2024	1.2688	0.12%	1.0223	-0.13%	1.3806	0.11%	1.0548	-0.11%
2025	1.2704	0.13%	1.0212	-0.11%	1.3821	0.11%	1.0536	-0.11%
2026	1.272	0.13%	1.0201	-0.11%	1.3837	0.12%	1.0526	-0.09%
2027	1.2738	0.14%	1.0192	-0.09%	1.3855	0.13%	1.0517	-0.09%
2028	1.2757	0.15%	1.0185	-0.07%	1.3874	0.14%	1.0509	-0.08%
2029	1.2777	0.16%	1.0178	-0.07%	1.3895	0.15%	1.0503	-0.06%
2030	1.2799	0.17%	1.0173	-0.05%	1.3917	0.16%	1.0497	-0.06%
2031	1.2821	0.17%	1.0169	-0.04%	1.394	0.17%	1.0493	-0.04%
2032	1.2845	0.19%	1.0166	-0.03%	1.3964	0.17%	1.049	-0.03%
2033	1.2869	0.19%	1.0163	-0.03%	1.3988	0.17%	1.0487	-0.03%
2034	1.2895	0.20%	1.0162	-0.01%	1.4014	0.19%	1.0486	-0.01%
2020-2024 Avg		0.10%		-0.14%		0.09%		-0.14%

Surry Township forecast values are listed next. The annual growth in the Surry peak from 2020-2024 is higher than the system average.

Surry Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	0.0534		0.0436		0.0577		0.0447	
2019	0.0537	0.56%	0.0438	0.46%	0.058	0.52%	0.0448	0.22%
2020	0.0539	0.37%	0.0438	0.00%	0.0582	0.34%	0.0449	0.22%
2021	0.0541	0.37%	0.0439	0.23%	0.0584	0.34%	0.0449	0.00%
2022	0.0544	0.55%	0.044	0.23%	0.0587	0.51%	0.045	0.22%
2023	0.0546	0.37%	0.0441	0.23%	0.0589	0.34%	0.0451	0.22%
2024	0.0548	0.37%	0.0442	0.23%	0.0592	0.51%	0.0452	0.22%
2025	0.0551	0.55%	0.0443	0.23%	0.0594	0.34%	0.0453	0.22%
2026	0.0553	0.36%	0.0443	0.00%	0.0597	0.51%	0.0454	0.22%
2027	0.0555	0.36%	0.0444	0.23%	0.0599	0.34%	0.0455	0.22%
2028	0.0557	0.36%	0.0445	0.23%	0.0601	0.33%	0.0455	0.00%
2029	0.056	0.54%	0.0446	0.22%	0.0604	0.50%	0.0456	0.22%
2030	0.0562	0.36%	0.0447	0.22%	0.0606	0.33%	0.0457	0.22%
2031	0.0564	0.36%	0.0448	0.22%	0.0609	0.50%	0.0458	0.22%
2032	0.0567	0.53%	0.0448	0.00%	0.0611	0.33%	0.0459	0.22%
2033	0.0569	0.35%	0.0449	0.22%	0.0613	0.33%	0.046	0.22%
2034	0.0571	0.35%	0.045	0.22%	0.0616	0.49%	0.0461	0.22%
2020-2024 Avg		0.41%		0.18%		0.41%		0.18%

The final township, Walpole forecasts of peak appear below. The Walpole average annual growth is less than the system average for the 2020-2024 years.

Walpole Township Peaks

year	Summer Normal Peak Mw	Growth	Winter Normal Peak Mw	Growth	Summer Extreme Peak Mw	Growth	Winter Extreme Peak Mw	Growth
2018	4.9462		4.0433		5.3208		4.1208	
2019	4.9486	0.05%	4.0354	-0.20%	5.3228	0.04%	4.113	-0.19%
2020	4.9489	0.01%	4.0249	-0.26%	5.3229	0.00%	4.1027	-0.25%
2021	4.9485	-0.01%	4.0148	-0.25%	5.3222	-0.01%	4.0928	-0.24%
2022	4.9494	0.02%	4.0066	-0.20%	5.3229	0.01%	4.0847	-0.20%
2023	4.9516	0.04%	3.9993	-0.18%	5.3249	0.04%	4.0775	-0.18%
2024	4.954	0.05%	3.9915	-0.20%	5.327	0.04%	4.0699	-0.19%
2025	4.9565	0.05%	3.9843	-0.18%	5.3294	0.05%	4.0628	-0.17%
2026	4.9596	0.06%	3.9776	-0.17%	5.3324	0.06%	4.0562	-0.16%
2027	4.9633	0.07%	3.9716	-0.15%	5.336	0.07%	4.0503	-0.15%
2028	4.9677	0.09%	3.9661	-0.14%	5.3402	0.08%	4.0449	-0.13%
2029	4.9726	0.10%	3.9613	-0.12%	5.345	0.09%	4.0401	-0.12%
2030	4.9781	0.11%	3.957	-0.11%	5.3504	0.10%	4.0359	-0.10%
2031	4.9841	0.12%	3.9531	-0.10%	5.3564	0.11%	4.0321	-0.09%
2032	4.9906	0.13%	3.9496	-0.09%	5.3628	0.12%	4.0287	-0.08%
2033	4.9974	0.14%	3.9466	-0.08%	5.3696	0.13%	4.0256	-0.08%
2034	5.0047	0.15%	3.944	-0.07%	5.3768	0.13%	4.023	-0.06%
2020-2024 Avg		0.02%		-0.22%		0.02%		-0.21%

APPENDIX A

	LUNH Historic Peak Day Values			
year	month	day	hour	Mw
2000	10	30	18	120.587
2000	11	21	18	132.537
2000	12	14	18	133.21
2001	1	10	18	130.276
2001	2	22	19	131.967
2001	3	1	19	117.486
2001	4	24	14	125.857
2001	5	11	16	134.29
2001	6	27	16	159.728
2001	7	24	15	168.319
2001	8	6	14	173.866
2001	9	10	15	142.882
2001	10	4	14	121.58
2001	11	29	18	126.458
2001	12	17	18	137.219
2004	1	14	19	150.948
2004	2	17	19	138.039
2004	3	16	19	135.111
2004	4	30	15	126.933
2004	5	12	16	137.766
2004	6	9	15	166.476
2004	7	22	14	172.492
2004	8	3	15	169.516
2004	9	17	14	141.094
2004	10	8	15	124.583
2004	11	17	18	140.077
2004	12	21	19	151.159
2005	1	18	19	148.961
2005	2	21	19	137.439
2005	3	9	19	141.04
2005	4	20	13	125.3
2005	5	11	15	127.421
2005	6	27	15	184.603
2005	7	19	14	191.871
2005	8	10	16	179.92
2005	9	14	16	158.878
2005	10	25	19	145.312

2005	11	23	18	135.463
2005	12	13	18	161.546
2006	1	23	19	149.003
2006	2	8	19	139.41
2006	3	1	19	134.011
2006	4	4	20	123.651
2006	5	31	17	147.724
2006	6	19	13	181.58
2006	7	18	16	191.959
2006	8	2	15	195.419
2006	9	18	16	138.005
2006	10	4	20	126.699
2006	11	30	18	132.703
2006	12	4	18	146.719
2007	1	26	18	141.539
2007	2	5	19	146.216
2007	3	6	19	144.084
2007	4	4	19	130.327
2007	5	25	16	148.856
2007	6	27	14	187.416
2007	7	27	14	178.707
2007	8	3	15	187.522
2007	9	7	16	165.591
2007	10	22	19	150.267
2007	11	26	18	139.867
2007	12	5	18	152.389
2008	1	3	18	144.175
2008	2	1	18	139.664
2008	3	5	19	132.501
2008	4	23	16	127.896
2008	5	27	14	135.302
2008	6	10	15	195.262
2008	7	8	15	186.04
2008	8	18	16	159.613
2008	9	5	15	163.176
2008	10	9	20	127.515
2008	11	5	18	133.241
2008	12	8	18	146.578
2009	1	14	18	147.427
2009	2	5	19	142.883
2009	3	2	19	138.703
2009	4	28	15	140.767
2009	5	21	16	145.009

2009	6	26	13	145.615
2009	7	29	15	176.68
2009	8	18	14	190.698
2009	9	3	16	139.939
2009	10	28	19	131.489
2009	11	30	18	136.288
2009	12	17	18	154.02
2010	1	12	18	143.943
2010	2	4	19	140.447
2010	3	3	19	131.958
2010	4	7	20	124.039
2010	5	26	16	174.742
2010	6	28	14	171.967
2010	7	7	16	196.543
2010	8	31	17	187.363
2010	9	1	16	186.389
2010	10	1	10	139.359
2010	11	29	18	138.456
2010	12	15	18	149.16
2011	1	24	19	150.041
2011	2	2	18	155.316
2011	3	21	20	144.149
2011	4	28	12	140.458
2011	5	31	16	162.456
2011	6	9	15	183.139
2011	7	22	15	205.939
2011	8	1	15	186.77
2011	9	14	14	157.534
2011	10	10	16	139.923
2011	11	28	18	138.63
2011	12	19	18	146.848
2012	1	16	18	150.194
2012	2	29	19	139.924
2012	3	1	19	140.808
2012	4	16	18	142.882
2012	5	31	14	149.487
2012	6	21	16	192.762
2012	7	17	17	191.846
2012	8	3	16	188.008
2012	9	7	16	165.842
2012	10	15	19	137.546
2012	11	7	18	141.017
2012	12	16	18	149.861

2013	1	24	18	154.659
2013	2	5	19	146.904
2013	3	7	19	139.796
2013	4	12	14	130.322
2013	5	31	16	182.108
2013	6	24	12	191.469
2013	7	19	13	203.761
2013	8	21	17	181.325
2013	9	11	16	191.313
2013	10	2	15	140.756
2013	11	25	18	145.9
2013	12	17	19	159.28
2014	1	2	18	161.33
2014	2	11	19	145.35
2014	3	3	19	144.09
2014	4	15	14	122.63
2014	5	12	16	133.566
2014	6	30	17	172.905
2014	7	23	16	193.21
2014	8	27	16	175.731
2014	9	2	15	177.966
2014	10	16	12	134.995
2014	11	18	18	135.778
2014	12	8	18	143.234
2015	1	8	18	148.541
2015	2	16	19	144.885
2015	3	5	19	137.502
2015	4	2	11	123.717
2015	5	27	16	159.605
2015	6	23	17	149.229
2015	7	30	14	184.893
2015	8	18	14	186.141
2015	9	9	16	187.326
2015	10	13	19	153.086
2015	11	30	18	131.008
2015	12	29	18	133.603
2016	1	9	18	142.592
2016	2	15	18	142.576
2016	3	3	19	129.165
2016	4	4	12	125.539
2016	5	31	16	152.579
2016	6	20	16	167.76
2016	7	28	15	185.985

2016	8	12	16	193.151
2016	9	9	16	176.143
2016	10	17	19	125.149
2016	11	21	18	128.994
2016	12	19	18	143.2
2017	1	9	18	143.485
2017	2	7	19	134.572
2017	3	4	19	127.668
2017	4	11	16	124.478
2017	5	18	16	162.931
2017	6	12	17	181.34
2017	7	20	15	179.727
2017	8	22	17	179.089
2017	9	25	16	172.378
2017	10	9	19	136
2017	11	28	18	129.146
2017	12	28	18	150.426
2018	1	2	18	154.265
2018	2	7	18	135.615
2018	3	7	18	127.866
2018	4	16	12	121.766
2018	5	31	18	145.275
2018	6	18	16	170.718
2018	7	3	14	194.416
2018	8	29	15	197.82
2018	9	5	16	185.689
2018	10	10	16	141.038

Appendix B

Rockingham and Grafton Economic Variabls

Year	Employment	Households	Ratio Employment	Ratio Households	EMP_HH
2000	187.909556	136.67992	0.883437547	0.868487589	0.878499
2001	190.210754	138.994921	0.894256394	0.883197501	0.890603
2002	188.792392	141.139531	0.88758811	0.89682472	0.890639
2003	188.11389	142.7048	0.884398203	0.906770707	0.891788
2004	192.798123	144.091146	0.906420645	0.915579786	0.909446
2005	195.972244	145.783314	0.92134345	0.926332111	0.922991
2006	198.973063	147.631915	0.935451493	0.938078438	0.936319
2007	200.824353	148.693788	0.944155144	0.944825761	0.944377
2008	200.732851	150.063565	0.943724956	0.953529558	0.946964
2009	194.529293	150.820776	0.914559563	0.958341006	0.929022
2010	195.290864	151.627674	0.918140011	0.963468174	0.933113
2011	196.932633	151.990988	0.92585862	0.965776733	0.939045
2012	199.207744	153.358134	0.936554822	0.974463813	0.949077
2013	201.188058	154.136489	0.945865066	0.979409614	0.956946
2014	203.497594	153.967144	0.956723113	0.978333567	0.963862
2015	206.784935	154.604545	0.97217821	0.982383722	0.975549
2016	209.789856	155.970247	0.986305539	0.991061626	0.987877
2017	212.702705	157.376941	1	1	1
2018	216.594529	159.020301	1.018297012	1.010442191	1.015702
2019	219.530696	160.178698	1.032101101	1.017802843	1.027378
2020	220.939724	161.212455	1.038725502	1.024371512	1.033984
2021	222.306633	162.130018	1.045151885	1.030201864	1.040214
2022	224.20116	163.196886	1.054058809	1.036980926	1.048418
2023	226.155081	164.359214	1.063244969	1.044366557	1.057009
2024	227.736127	165.42675	1.070678095	1.051149863	1.064227
2025	229.310686	166.501942	1.078080723	1.057981817	1.071442
2026	230.937906	167.622535	1.085730931	1.065102257	1.078917
2027	232.615046	168.783076	1.093615833	1.072476533	1.086633
2028	234.367337	169.997032	1.10185405	1.080190217	1.094698
2029	236.235999	171.209275	1.110639373	1.087893016	1.103126
2030	238.188653	172.464594	1.119819576	1.095869528	1.111908
2031	240.21632	173.724622	1.129352445	1.103875961	1.120937
2032	242.281408	174.98734	1.139061245	1.111899487	1.130089
2033	244.416009	176.245366	1.149096853	1.1198932	1.13945
2034	246.633113	177.497101	1.159520341	1.127846938	1.149058

Appendix C

year	month	day	hour	system mw	psa total	mw_e	mw_w	Eastern %	Western %
2014	3	3	19	144.09	144.0875	66.7299	77.3576	46.31%	53.69%
2014	4	15	14	122.63	122.6254	50.2352	72.3902	40.96%	59.04%
2014	5	12	16	133.566	133.5654	57.9524	75.613	43.39%	56.61%
2014	6	30	17	172.905	156.8357	69.5198	87.3159	40.21%	59.79%
2014	7	23	16	193.213	193.2128	96.326	96.8868	49.85%	50.15%
2014	8	27	16	175.731	175.7307	87.134	88.5967	49.58%	50.42%
2014	9	2	15	177.966	177.966	87.896	90.07	49.39%	50.61%
2014	10	16	12	134.995	134.9956	54.57	80.4256	40.42%	59.58%
2014	11	18	18	135.892	135.8918	62.217	73.6748	45.78%	54.22%
2014	12	8	18	143.321	143.3214	68.071	75.2504	47.50%	52.50%
2015	1	8	18	148.451	148.4504	69.655	78.7954	46.92%	53.08%
2015	2	16	19	144.833	144.8328	68.698	76.1348	47.43%	52.57%
2015	3	5	19	137.502	137.5021	63.046	74.4561	45.85%	54.15%
2015	4	2	11	123.717	123.7167	53.196	70.5207	43.00%	57.00%
2015	5	27	16	173.241	173.2414	80.931	92.3104	46.72%	53.28%
2015	6	23	17	163.897	163.8974	76.974	86.9234	46.96%	53.04%
2015	7	30	14	185.508	185.5081	88.65	96.8581	47.79%	52.21%
2015	8	18	14	186.141	186.141	90.612	95.529	48.68%	51.32%
2015	9	9	16	187.326	187.3256	90.746	96.5796	48.44%	51.56%
2015	10	13	19	126.066	126.0657	54.757	71.3087	43.44%	56.56%
2015	11	30	18	131.179	131.1792	61.125	70.0542	46.60%	53.40%
2015	12	29	18	135.02	135.0195	64.717	70.3025	47.93%	52.07%
2016	1	19	18	142.656	142.6563	66.52	76.1363	46.63%	53.37%
2016	2	15	18	142.576	142.576	66.849	75.727	46.89%	53.11%
2016	3	3	19	129.165	129.1652	58.534	70.6312	45.32%	54.68%
2016	4	4	12	125.627	125.6264	55.789	69.8374	44.41%	55.59%
2016	5	31	16	152.932	152.9326	72.016	80.9166	47.09%	52.91%
2016	6	20	16	168.23	168.2302	80.188	88.0422	47.67%	52.33%

2016	7	28	15	187.268	187.268	92.677	94.591	49.49%	50.51%
2016	8	12	16	193.773	193.7728	101.455	92.3178	52.36%	47.64%
2016	9	9	16	176.143	176.1425	88.094	88.0485	50.01%	49.99%
2016	10	17	19	125.149	125.1491	54.943	70.2061	43.90%	56.10%
2016	11	21	18	128.994	128.9941	59.783	69.2111	46.35%	53.65%
2016	12	19	18	143.2	143.2006	68.277	74.9236	47.68%	52.32%
2017	1	9	18	143.485	143.4859	67	76.4859	46.69%	53.31%
2017	2	7	19	134.572	134.5725	62.075	72.4975	46.13%	53.87%
2017	3	4	19	127.668	127.6675	59.331	68.3365	46.47%	53.53%
2017	4	11	16	124.478	124.4777	53.157	71.3207	42.70%	57.30%
2017	5	18	16	162.931	162.9316	80.043	82.8886	49.13%	50.87%
2017	6	12	17	181.34	181.3401	93.591	87.7491	51.61%	48.39%
2017	7	20	15	179.727	179.7268	89.606	90.1208	49.86%	50.14%
2017	8	22	17	179.089	179.0891	88.946	90.1431	49.67%	50.33%
2017	9	25	16	172.378	172.378	80.833	91.545	46.89%	53.11%
2017	10	9	19	136	136.0002	59.58	76.4202	43.81%	56.19%
2017	11	28	18	129.146	129.1464	60.506	68.6404	46.85%	53.15%
2017	12	28	18	150.426	150.4257	73.259	77.1667	48.70%	51.30%
2018	1	2	18	154.265	154.265	73.013	81.252	47.33%	52.67%
2018	2	7	18	135.615	135.6153	62.193	73.4223	45.86%	54.14%
2018	3	7	18	127.866	127.8662	58.701	69.1652	45.91%	54.09%
2018	4	16	12	121.766	121.7653	54.945	66.8203	45.12%	54.88%
2018	5	31	18	145.275	145.2743	67.507	77.7673	46.47%	53.53%
2018	6	18	16	170.718	170.718	83.684	87.034	49.02%	50.98%
2018	7	3	14	194.416	194.4155	95.599	98.8165	49.17%	50.83%
2018	8	29	15	197.82	197.8195	100.733	97.0865	50.92%	49.08%
2018	9	5	16	185.689	185.6899	90.481	95.2089	48.73%	51.27%
2018	10	10	16	141.038	141.0376	62.74	78.2976	44.48%	55.52%

2018 Annual Plan Feeder Problem Identification Spreadsheet

Bellows Falls Study Area

Conditional Formatting			
(pink)		0.74500000	>75%
(yellow)	0.60000000	0.74500000	60%-75%
(green)		0.60000000	<60%

Bellows Falls Feeder Analysis

Projected Load

Study Area	Substation	Voltage (kV)	Feeder	SN Rating (Amps)	SE Rating (Amps)	2018 Amps	2018 N-1	2018 %SN	2019 Growth Rate	2019 Spot Loads	2019 Amps	2019 N-1	2019 %SN	2020 Growth Rate	2020 Spot Loads	2020 Amps	2020 N-1	2020 %SN	2021 Growth Rate	2021 Spot Loads	2021 Amps	2021 N-1	2021 %SN	2022 Growth Rate	2022 Spot Loads	2022 Amps	2022 N-1	2022 %SN	2023 Growth Rate	2023 Spot Loads	2023 Amps	2023 N-1	2023 %SN
Bellows Falls	CHARLESTOWN 32	13.2	8L1C	320	355	243	112	76%	14.7%	-278	0	0	0%	0.4%		0	355	0%	0.3%		0	355	0%	0.3%		0	355	0%	0.4%		0	355	0%
Bellows Falls	CHARLESTOWN 32	13.2	8L2C	170	170	72	98	43%	14.7%	-83	0	0	0%	0.4%		0	170	0%	0.3%		0	170	0%	0.3%		0	170	0%	0.4%		0	170	0%
Bellows Falls	MICHAEL AVE	13.2	40L1	530	612	264	348	50%	14.7%		303	309	57%	0.4%		304	308	57%	0.3%		305	307	58%	0.3%		306	306	58%	0.4%		307	305	58%
Bellows Falls	MICHAEL AVE	13.2	40L3	530	612	50	562	9%	14.7%	278	278	334	52%	0.4%		279	333	53%	0.3%		280	332	53%	0.3%		281	331	53%	0.4%		282	330	53%
Bellows Falls	VILAS BRIDGE 34	13.2	12L1	336	421	227	194	68%	14.7%		261	160	78%	0.4%		262	159	78%	0.3%		263	158	78%	0.3%		264	157	78%	0.4%		264	157	79%
Bellows Falls	VILAS BRIDGE 34	13.2	12L2	425	476	201	275	47%	14.7%		231	245	54%	0.4%		231	245	54%	0.3%		232	244	55%	0.3%		233	243	55%	0.4%		234	242	55%

2018 Annual Plan Transformer Problem Identification Spreadsheet

Bellows Falls Study Area

Conditional Formatting			
		0.74500000	>75%
	0.60000000	0.74500000	60%-75%
		0.60000000	<60%

Bellows Falls Transformer Analysis

Projected Load

Study Area	Substation	Tranf. ID.	System Voltage (kV) From	System Voltage (kV) To	Maximum Nameplate Rating	Rating (MVA) SN	Rating (MVA) SE	2018 MVA	2018 N-1	2018 % SN	2019 Growth	2019 Spot	2019 MVA	2019 N-1	2019 % SN	2020 Growth	2020 Spot	2020 MVA	2020 N-1	2020 % SN	2021 Growth	2021 Spot	2021 MVA	2021 N-1	2021 % SN	2022 Growth	2022 Spot	2022 MVA	2022 N-1	2022 % SN	2023 Growth	2023 Spot	2023 MVA	2023 N-1	2023 % SN
Bellows Falls	CHARLESTOWN 32	T1	46	13.2	5	7.33	8.1	5.5	2.6	76%	14.7%		0.0	8.1	0%	0.4%		0.0	8.1	0%	0.3%		0.0	8.1	0%	0.3%		0.0	8.1	0%	0.4%		0.0	8.1	0%
Bellows Falls	CHARLESTOWN 32	T2	46	13.2	2.5	3.9	3.9	1.7	2.2	42%	14.7%		0.0	3.9	0%	0.4%		0.0	3.9	0%	0.3%		0.0	3.9	0%	0.3%		0.0	3.9	0%	0.4%		0.0	3.9	0%
Bellows Falls	MICHAEL AVE	T1	115	13.2	9.375	12.4	13	7.2	5.8	58%	14.7%		8.2	4.8	66%	0.4%		8.3	4.7	67%	0.3%		8.3	4.7	67%	0.3%		8.3	4.7	67%	0.4%		8.4	4.6	67%
Bellows Falls	VILAS BRIDGE 34	T1	46	13.2	5.7	7.7	9.6	5.2	4.4	67%	14.7%		6.0	3.6	77%	0.4%		6.0	3.6	78%	0.3%		6.0	3.6	78%	0.3%		6.0	3.6	78%	0.4%		6.0	3.6	79%
Bellows Falls	VILAS BRIDGE 34	T2	46	13.2	8.4	10.05	12.84	4.6	8.2	46%	14.7%		5.3	7.6	52%	0.4%		5.3	7.5	53%	0.3%		5.3	7.5	53%	0.3%		5.3	7.5	53%	0.4%		5.3	7.5	53%

2023 Annual Plan Feeder Contingency Problem Identification Spreadsheet

2023

Feeder	Amps	MVA	N-1 Avail	All Feeder Ties Available	Sum of Available Ties	Available ties MVA (calc.)	Is Avail capacity > Fdr load?	*MWHR Outage from switching*	Load at Risk (Amps) = Fdr Peak minus % Avail Ties	Feeder Load at Risk in MVA	*MWHR Outage with 4 Hour Repair*	*Total MWHR Outage for 1hr switch and 4hr repair*	Does this violate a 16 MWHR Criteria?
8L1C	0	0.0	355		0	0.0	No	*0.0*	0	0.0	*0.0*	*0.0*	No
8L2C	0	(0.0)	170		266	6.1	Yes	*0.0*	Ties>feeder load	None	*0.0*	*0.0*	No
40L1	307	7.0	305	40L3	248	5.7	No	*4.2*	59	1.4	*5.4*	*9.7*	No
40L3	282	6.4	330	40L1, 12L1	346	7.9	Yes	*4.8*	Ties>feeder load	None	*0.0*	*4.8*	No
12L1	264	6.0	157	12L2	121	2.8	No	*2.1*	143	3.3	*13.1*	*15.2*	No
12L2	234	5.3	242	12L1	78	1.8	No	*1.3*	156	3.6	*14.2*	*15.6*	No

2018 Annual Plan Transformer Contingency Problem Identification Spreadsheet

Bellows Falls Study Area

Conditional Formatting			
		0.99500000	>100%
	0.89500000	0.99400000	90%-100%
		0.89400000	<90%

Bellows Falls Transformer Contingency Analysis

Study Area	Substation	Tranf. ID.	System Voltage (kV) From	System Voltage (kV) To	Maximum Nameplate Rating	Rating (MVA) SN	Rating (MVA) SE	2018 MVA	2018 % SE	2019 Growth	2019 Spot	2019 MVA	2019 % SE	2020 Growth	2020 Spot	2020 MVA	2020 % SE	2021 Growth	2021 Spot	2021 MVA	2021 % SE	2022 Growth	2022 Spot	2022 MVA	2022 % SE	2023 Growth	2023 Spot	2023 MVA	2023 % SE
Bellows Falls	CHARLESTOWN 32	T1	46	13.2	5	7.33	8.10	0.0	0%	14.7%	0.0	0.0	0%	0.4%	0.0	0.0	0%	0.3%	0.0	0.0	0%	0.3%	0.0	0.0	0%	0.4%	0.0	0.0	0%
Bellows Falls	CHARLESTOWN 32	T2	46	13.2	2.5	3.90	3.90	0.0	0%	14.7%	0.0	0.0	0%	0.4%	0.0	0.0	0%	0.3%	0.0	0.0	0%	0.3%	0.0	0.0	0%	0.4%	0.0	0.0	0%
Bellows Falls	MICHAEL AVE	T1	115	13.2	9.375	12.40	13.00	7.2	55%	14.7%	0.0	8.2	63%	0.4%	0.0	8.3	64%	0.3%	0.0	8.3	64%	0.3%	0.0	8.3	64%	0.4%	0.0	8.4	64%
Bellows Falls	VILAS BRIDGE 34	T1	46	13.2	5.7	7.70	9.60	9.8	102%	14.7%	0.0	11.2	117%	0.4%	0.0	11.3	117%	0.3%	0.0	11.3	118%	0.3%	0.0	11.4	118%	0.4%	0.0	11.4	119%
Bellows Falls	VILAS BRIDGE 34	T2	46	13.2	8.4	10.05	12.84	9.8	76%	14.7%	0.0	11.2	88%	0.4%	0.0	11.3	88%	0.3%	0.0	11.3	88%	0.3%	0.0	11.4	88%	0.4%	0.0	11.4	89%

Liberty Utilities

Calendar Year 2016

Granite State Electric (GSE) Distribution Capital Work Plan

The following pages list the capital projects and programs that will make up the CY16 Distribution Capital Work Plan. The vegetation management maintenance initiatives are also included in the plan. It is the expectation of this work plan that 80% or more of the target points in the plan will be met.

Prepared by: Anthony Strabone — Date: 12/07/2015

Approved By: Chris Brouillard, Director of Engineering LU East — Date: 12/7/15

Accepted By: Kurt Demmer, Director of Electric Operations LU East — Date: 12/7/15

<u>Executive Summary</u>

This Work Plan identifies both Capital and Vegetation Management projects and programs for Calendar Year 2016. The purpose of the Work Plan is to:

- prioritize work requirements;
- roll into the Resource Plan to establish the "road map" for Operations to successfully guide the workforce toward completion of prioritized projects within specified budget requirements;
- aid in the establishment of a multi-year strategy to allow completion of required work within the specified budget;
- generate "buy-in" to the Work Plan at all levels of the Organization;

There are three main categories to the projects/programs identified in this Work Plan. These are:

- **Targeted Capital Projects**
- **Priority Programs**
- **Vegetation Management**

The 2016 GSE Capital Investment Plan in included at the end of this Work Plan in order to provide for completeness and visibility of the entire scope of capital work planned for 2016.

<u>Targeted Capital Projects</u>

Specific projects that were included in the CY 2016 Capital Investment Plan (Budget) in the high level categories of Growth, Improvement, and Replenishment are targeted for tracking. For each listed capital project, a target (milestone description) has been identified. The target details the CY 2016 completion expectation for the project, which may be engineering, design, materials procurement, or construction related.

In addition, each targeted capital project has been assigned a Target Point value that will be awarded for successfully achieving the defined milestone. The methodology used in assigning Target Points to projects was as follows:

- Total Target Points assigned to each project are a whole number that ranges from 1 to 5
- In determining total Target Points:
    - The points are assigned to the project based on the project's CY 2016 budget as follows:
        - <$25k = 1 point
        - $25k to $100k = 2 points
        - >$100k to $500k = 3 points
        - >$500k to $1M = 4 points
        - >$1M = 5 points
    - Example:
        - A capital project with a CY 2016 budget of $400k
            - Target Points = 3

- For projects that, at the time of work plan issue, it is determined that the project will not likely mature enough to spend the CY 2016 budget amount, then a more appropriate target and associated target points will be established.

Target Points assigned to projects are summed to determine available Target Point Total for Granite State. It is the expectation of this Work Plan that 80% or more of these Target Point Totals be achieved by the end of CY 2016. The status of work on Target Projects will be a specific topic of discussion at the monthly construction meetings.

Projects that are dependent on customer or governmental timelines will be designated as "Cust Compl", which means that if project is delayed beyond the end of the calendar year by the customer or governmental authority, the project will be re-assigned 0 points.

Certain Blanket projects are listed to provide budgeting and resource visibility, but are assigned 0 points in the plan.

As can be determined from the below tables, the CY 2016 Target Point Totals for distribution line Targeted Capital Projects are as follows:

Type	Target Point Total	Revised Target Pts	Achieved Pts
Line	24	39	32
Substation	12	12	12
Facilities	2	2	2
Priority Program	35	32	31
Total Capital	**73**	**85**	**77**

Also, the CY 2016 Target Point Totals for Vegetation Management is as follows:

Area	Target Point Total	Revised Target Pts	Achieved Pts
Vegetation Mgmt	24	21	21

Distribution Line Projects

Please note the following:

1. The 2016 Scope for the 16L5 Feeder Addition Project (8830-C36425) at Mount Support Substation was revised from Engineering Only to Construction Complete. An additional 2 points were added to the targeted points for this project; increasing the target to 5 points
2. 2016 allocated funding for URD Cable Replacement (8830-C31402) was re-allocated to the 16L5 Feeder Addition Project at Mount Support Substation. Target Points were reduced to zero.
3. Fairmont Rd, Salem was added to the 2016 Capital Plan. This project was added in support to provide more capital work for the Salem Area Operations folks.
4. Slayton Hill Rd, Lebanon was also added to the 2016 Capital Work Plan. This project consisted of pole relocations and re-conductor of bare wire with covered wire. This project was needed due to the City of Lebanon reconstructing Slayton Hill Rd due to flooding in past years.
5. School Street, Lebanon was added to the 2016 capital Work Plan. This project consisted of pole relocations and re-conductor of bare wire with covered wire. This project was needed due to the City of Lebanon adding a bike lane and sidewalks to School Street and the surrounding area.
6. Replacement of H-body Splices was added to the 2016 Capital Work Plan. This project was added due to a failure of H-body splice. Failure of the splice was determined to be a workmanship issue and a subsequent project was initiated to replace all suspect splices.
7. **The following table details the 2016 Distribution Line Targeted Capital Projects:**

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C18620	Charlestown 32 Dline	Distribution Line	Charlestown	Area Study Complete	100% Complete	12/31/2016	$5,000	1	1
8830-C36424	Mt Support-New 16L3 Feeder	Distribution Line	Lebanon	100% Construction Complete	100% Complete	12/31/2016	$1,550,000	5	5
8830-C36425	Mt Support-New 16L5 Feeder	Distribution Line	Lebanon	UG- 100% Construction Complete OH- 100% Design Complete	100% Complete	12/31/2016	$100,000	5	5
8830-C36463	Mt. Support - Relocate 1363 Line	Distribution Line	Lebanon	100% Complete Construction	100% Complete	12/31/2016	#N/A	3	3
8830-C36463	Mt. Support - Remove 1303 Line	Distribution Line	Lebanon	100% Design Complete	100% Complete	12/31/2017	#N/A	3	0
8830-C36431	04377 Pelham-New 14L4 Fdr	Distribution Line	Pelham	UG duct bank- 100% Construction Complete 100% Complete - OH Design Only	100% Complete	12/31/2017	$350,000	4	4
8830-C42852	04377 Pelham-New 14L5 Fdr	Distribution Line	Pelham	UG duct bank- 100% Construction Complete 100% Complete - OH Design Only	100% Complete	12/31/2017	$150,000	4	4
8830-C36427	Feeder Getaway Cable Replacement Program	Distribution Line	Salem	100% Inspection Complete	100% Complete	6/1/2015	$100,000	3	3
8830-C31402	IE-NN URD Cable Replacement	Distribution Line	Salem	100% Construction Complete	100% Complete	11/1/2016	$100,000	0	0
8830-C26263	NN D-Line Work Found by Insp.	Distribution Line	Various				$50,000	0	0
8830-CNN014 - Dist-Damage&Failure Blanket	Damage Failure Blanket	Distribution Line	Various				$800,000	0	0
8830-CNN016 - GSE-Dist-Load Relief Blanket	Load Relief Blanket	Distribution Line	Various				$75,000	0	0
8830-CNN015 - GSE-Dist-Reliability Blanket	Reliability Blanket	Distribution Line	Various				$400,000	0	0
8830-CNN017 - GSE-Dist-Asset Repl Blanket	Asset Replacement Blanket	Distribution Line	Various				$400,000	0	0
8830-C42926	Fairmont Rd- Salem- 18L3	Distribution Line	Salem	100% Construction Complete	100% Complete		$105,000	3	1
8830-CNN013	School Street, Lebanon	Distribution Line	Lebanon	100% Construction Complete	100% Complete		$400,000	3	3
8830-CNN015	Slayton Hill, Lebanon	Distribution Line	Lebanon	100% Construction Complete	100% Complete		$400,000	3	1
8830-C42921	6L4- Splice Replacement	Distribution Line	Hanover	100% Construction Complete	100% Complete		$80,000	2	2

Distribution Substation Projects

The following table details the 2016 Distribution Substation Targeted Capital Projects:

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C18630	Charlestown DSub	Distribution Sub	Charlestown	Area Study Complete	100% Complete	12/31/2016	$15,000	1	1
8830-C36423	Mt Support Sub- New LP Fdr Pos	Distribution Sub	Lebanon	100% Construction Complete	100% Complete	12/31/2016	$3,700,000	5	5
8830-C36430	Pelham Sub-Add 2nd Xfmr and Fdr Pos	Distribution Sub	Pelham	Final Engineering 100% Complete	100% Complete- Engineering Only	12/31/2017	$600,000	4	4
8830-C33766	NEN-NH Electric Fence	Distribution Sub	Hanover	100% Construction Complete	100% Complete	11/1/2016	$25,000	2	2
8830-CNN002 - 01737 GSE-Dist-Subs Blanket	Substation Blanket	Distribution Sub	Various				$50,000	0	0

Facilities Projects

The following table details the 2016 Facilities Targeted Capital Projects:

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-CNN026	Misc Capital Improvements GSE Facilities	Facilities	Various	100% Complete	100% Complete	12/31/2016	$100,000	2	2

Priority Programs

These are the capital and combined capital and expense efforts that have been defined and determined to be priority work. For these programs, specific CY 2016 completion targets have been set. It should be noted that work activity associated with these programs at times overlaps with the work activities defined in the Targeted Capital Projects.

For each Priority Program, a unique scoring methodology was developed. It is the expectation of this Work Plan that 100% of the Total Priority Program Points assigned to all programs combined be achieved at the Area level by the end of CY 2016. A target of 100% was assigned to Priority Programs as the majority of these initiatives are tied to regulatory programs and commitments, some of which have a special rate recovery mechanism. The status of work on Priority Programs will be a specific topic of discussion at the monthly construction meetings. The Priority Programs determined for CY 2016 are as follows:

Bare Conductor Replacement Program

This program is targeted towards the re-conductoring of bare mainline primary conductor with spacer cable in tree outage prone areas that are too costly to rely on vegetation management practices alone to mitigate feeder lockouts. Seven points are awarded upon completion of this program.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C18603 - Bare Conductor Replacement Program	REP - Bare Conductor Replacement Project - Bridge St Pelham	Bare Conductor Replacement	Pelham	100% Construction Complete	100% Complete	6/1/2016	$1,200,000	7	7

Enhanced Bare Conductor Replacement Program

This program is targeted towards additional re-conductoring of bare mainline primary conductor with spacer cable in tree outage prone areas. Four points are awarded upon completion of this program.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C42851 - Enhanced Bare Conductor Replacement	Enhanced Bare Conductor Replacement Project - 14L1 Main St.	Enhanced Bare Conductor Replacement	Pelham	100% Construction Complete	100% Complete	6/1/2016	$500,000	4	4

Single Phase Recloser and and Trip Saver Programs

This program is targeted towards the application of single phase reclosers and "Trip Saver" electronic cutouts to target rural and suburban circuit segments that would realize reliability benefits from single phase tripping and reclosing and to isolate faults down to the smallest segment possible. Two points are awarded for each single phase recloser application and one point for each trip saver application.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C20473 - IE - NN Recloser Installations	REP Recloser Installation - 6L3 East Wheelock St	Single PH Recl /Trip Savers	Hanover	100% Construction Complete	100% Complete	8/1/2016	$250,000	2	2
8830-C20473 - IE - NN Recloser Installations	REP Recloser Installation - 16L1 Etna Rd	Single PH Recl /Trip Savers	Hanover	100% Construction Complete	100% Complete	8/1/2016	$250,000	2	2
8830-C20473 - IE - NN Recloser Installations	REP Recloser Installation - 8L1 Sullivan St	Single PH Recl /Trip Savers	Charlestown	100% Construction Complete	100% Complete	8/1/2016	$250,000	2	2
8830-C20473 - IE - NN Recloser Installations	REP Recloser Installation - Trip Saver II	Single PH Recl /Trip Savers	Various	100% Construction Complete	100% Complete	8/1/2016	$250,000	8	8

Pocket of Poor Performance Program
This program will resolve reliability concerns in underperforming areas of distribution feeders. Four points are awarded upon completion of this program

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C22214 Pockets of Poor Perf	13L3 Main St Recloser	Cap/Perf Program	Salem	100% Construction Complete	100% Complete	8/1/2016	$50,000	2	2

Overloaded Transformer Replacement Program
This program is designed to replace overloaded transformers. Two target points will be achieved when the Area has replaced the number of transformers targeted in the table below. Therefore, a total of 2 points is available for the New Hampshire Area.

- 2016 allocated funding was re-allocated to 16L5 Feeder Addition Project at Mount Support Substation

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C21093	Overloaded Transformer Replacement.	Overloaded trfrm	Various	100% Complete	100% Complete	6/1/2016	$25,000	0	0

Under Performing Feeder Program
This program will resolve reliability concerns on distribution feeders listed in a report which details the three most under-performing feeders in New Hampshire, based upon the SAIDI performance for the preceding 3 years. The action items are expected to be a combination of capital and expense initiatives. Two Target Points will be achieved for each under-performing feeder completed; therefore a total of 2 points is available.

- Engineering was completed for this project, however, due to customer commitments, Switching support for Mount Support Substation and other area work, construction was not completed for Etna Rd in 2016.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. Pts	Achieved Pts
8830-C42901- Under Performing Feeder	16L1 Etna Rd Reconductoring	Cap/Perf Program	Hanover	100% Construction Complete	100% Complete	8/1/2016	$50,000	2	1

Capacity and Performance Programs

These programs will resolve reliability concerns on distribution feeders in key areas listed below. They address an array of areas which in the past may have not have received an adequate level of attention and funding.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2016 Budgeted Capital	Target. P	Achieved Pts
8830-C36433	Distribution Feeder Power Factor Correction 9L3	Cap/Perf Program	Salem	100% Construction Complete	100% Complete	6/1/2016	$25,000	1	1
8830-C36435-Lebanon Area Low Voltage Mitigation	Shaker Blvd	Cap/Perf Program	Enfield	100% Construction Complete	100% Complete	8/1/2016	$50,000	2	2

Priority Program Total Points

The Total Priority Program Points for each New Hampshire Area is summarized in the table below.

Program	Priority Program Points	Revised Program Points	Achieved Points
Bare Conductor Replacement	7	7	7
Enhanced Bare Conductor Replacement	4	4	4
Single Phase Reclosers & Trip Savers	14	14	14
Pocket of Poor Performance	2	2	2
Overloaded Transformers Replacement	2	0	0
Underperforming Feeders	2	2	1
Capacity and Performance	4	3	3
Total	**35**	**32**	**31**

Vegetation Management Program

This program defines the tree trimming goals/objectives for CY 2016. The table below summarizes this program. A more detailed description of the program including the specific feeders to be trimmed is available from the arborist that manages forestry issues for the Area.

Line		CY 2016 Budgeted Expenses
1	**VMP O&M**	
2	Work Planners for Veg Plan	$135,000
3	Spot Tree Trimming	$12,500
4	Trouble & Restoration Maint	$12,500
5	Planned Cycle Trimming	$1,120,000
6	Cycle Trimming Traffic Control/Police Details	$198,000
7	Hazard Tree Removal	$350,000
8	Interim Trimming	$12,500
9	Tree Planting	$5,000
10	Other Police Detail Expenses	$12,500
11	Sub-transmission Right of Way Clearing-Floor	$90,000
12	Fairpoint Credits	$350,000
13	Total: VMP O&M Expenses	$1,948,000
14	Less: Reimbursements from Fairpoint	($350,000)
15	VMP O&M Expenses Net of Fairpoint Credits	$1,598,000
16	Total REP and VMP O&M Expenses	$1,598,000

Area	Substation	Feeder	OH_Miles	Target PTS	Achieved PTS
Lebanon	Craft Hill	11L1	13.64	2	2
Lebanon	Enfield	7L1	66.9	3	3
Lebanon	Enfield	7L2	43.2	0	0
Lebanon	Hanover	6L2	4.2	1	1
Salem	Spicket River	13L3	24.12	3	3
Salem	Pelham	14L2	35.17	3	3
Salem	Salem Depot	9L1	9.77	3	3
Salem	Salem Depot	9L2	1.37	1	1
Salem	Salem Depot	9L3	18.04	3	3
		Total OH_Miles	**216.41**	**19**	19

Area	Subtransmission		Miles	Target PTS	Achieved PTS
Lebanon	1303/1304 Line Hanover #6 to Lebanon #1	ROW Clearing-Floor	6.60	2	2

- Jeff Carney confirmed the 7L2 circuit was removed from the Capital Work Plan in July/August of 2016

A target of 100% was assigned to the Vegetation Management Program as this initiative is tied to the Vegetation Management regulatory program and has a special rate recovery mechanism.

Summary

As detailed previously in this document, it is the expectation of this Work Plan that 80% or more of the Total Priority Project and Program Points assigned to all capital projects and programs combined be achieved at the company level by the end of CY 2016.

Finally, the overall Capital Work Plan completion goal will be measured as follows:

(0.5) x (% of Target Capital Project Points Achieved)
+
(0.5) x (% of Target Priority Program Points Achieved)
=
% of Capital Work Plan Achieved

0.5 x (46/53) + 0.5 x (31/32) = 0.434 +0.484 = 0.918 or 91.8 %

2016 GSE Capital Investment Plan

Priority	Project #	Project_Description	Sum of LU FY2016 Capital Budget
3. Growth	8830-CD0291	Sky View URD - Salem, NH	10,000
	8830-CNN010	GSE-Dist-New Bus-Resid Blanket	1,050,000
	8830-CNN011	GSE-Dist-New Bus-Comm Blanket	1,200,000
	8830-CRSRVNBC_01	Reserve for New Business Residential	50,000
	8830-CRSRVNBC_01	Reserve for New Business Commercial Unident spec	100,000
3. Growth Total			**2,410,000**
2. Mandated	8830-C14646	IE-NN UG Structures and Equipment	5,000
	8830-C18750	Security Conversion GSE	25,000
	8830-C21595	01663 GS Storm Program Proj	50,000
	8830-C26263	NN D-Line Work Found by Insp.	50,000
	8830-C36433	Distribution Feeder Power Factor Correction	25,000
	8830-C36435	Lebanon Area Low Voltage Mitigation	50,000
	8830-CN4104	01659 Granite St Meter Purchases	250,000
	8830-CN4120	01660 Granite St Transformer Purchases	350,000
	8830-CNN002	01737 GSE-Dist-Subs Blanket	50,000
	8830-CNN004	GSE-Dist-Meter Blanket	20,000
	8830-CNN007	GSE-Dist-Water Heater Blanket	121,000
	8830-CNN009	GSE-Dist-Land/Land Rights Blanket	10,000
	8830-CNN012	GSE-Dist-St Light Blanket	225,000
	8830-CNN013	GSE-Dist-Public Require Blanket	400,000
	8830-CNN014	Dist-Damage&Failure Blanket	800,000
	8830-CNN015	GSE-Dist-Reliability Blanket	400,000
	8830-CNN016	GSE-Dist-Load Relief Blanket	75,000
	8830-CNN017	GSE-Dist-Asset Replace Blanket	400,000
	8830-CNN020	Dist-Transf/Capac Install Blanket	10,000
	8830-CNN021	GSE-Dist-Telecomm Blanket	10,000
	8830-CNN022	GSE-Dist-3rd Party Attach Blanket	110,000
	8830-CNN023	GSE Distributed Generation Blanket	75,000
2. Mandated Total			**3,511,000**
4. Regulatory Progra	8830-C18603	Bare Conductor Replacement Program	1,200,000
	8830-C20473	IE - NN Recloser Installations	250,000
	8830-C36423	Mt Support Sub- New LP Fdr Pos	3,700,000
	8830-C36424	Mt Support-New 16L3 Feeder	1,550,000
	8830-C36425	Mt Support-New 16L5 Feeder	100,000
4. Regulatory Programs Total			**6,800,000**
5. Discretionary	8830-C13968	PS&I Activity - New Hampshire	10,000
	8830-C18620	Charlestown 32 Dline	5,000
	8830-C18630	Charlestown DSub	15,000
	8830-C18650	Salem area Study	0
	8830-C18819	Balancing Placeholder	0
	8830-C21093	IE-NN Dist Transformer upgrades	25,000
	8830-C22214	NN ERR/Pockets of Poor Perf	50,000
	8830-C26047	NH ARP Batts/Chargers Repl Prog	0
	8830-C26061	NH ARP Relay & related	5,000
	8830-C31402	IE-NN URD Cable Replacement	100,000
	8830-C32279	01757 NN ARP Breakers & Reclosers	0
	8830-C33766	NEN-NH Electric Fence FY10	25,000
	8830-C36092	Salem Depot#9 Repl 23/13kV Trans	0
	8830-C36426	SCADA and Distribution Automation	0
	8830-C36427	Feeder Getaway Cable Replacement	100,000
	8830-C36428	Amerductor replacement program	0
	8830-C36430	Pelham Sub-Add 2nd Xfmr and Fdr Pos	600,000
	8830-C36431	Pelham-New 14L4 Fdr	350,000
	8830-C42901	Underperforming Feeder Program	50,000
	8830-C36437	Old Bridge North St Pelham - Reliability Improvemer	0
	8830-C42851	Enhanced Bare Conductor Replacement	500,000
	8830-C42852	Pelham-New 14L5 Fdr	150,000
	8830-C42854	Repave Parking Lot - 9 Lowell Rd Salem	0
	8830-CNN006	GSE-Dist-Genl Equip Blanket	50,000
	8830-CNN025	IT Systems & Equipment Blanket	25,000
	8830-CNN026	Misc Capital Imprvmnts GSE Facilities Blanket	100,000
	8830-CNN027	Transportation Fleet & Equip. Blanket	250,000
	8830-CRSRVARS_01	Reserve for Sub Asset Repl Specifics	25,000
	8830-CRSRVDF_014	Reserve for Damage/Failure Unidentified Specifics &	75,000
	8830-CRSRVLRL_01€	Reserve for Load Relief Unidentified Specifics	25,000
	8830-CRSRVLRS_01€	Reserve for Substation Load Relief Specifics	0
	8830-CRSRVPR_013	Reserve for Public Requirements Unidentified Specif	50,000
	8830-CRSRVRL_015	Reserve for Reliability Unidentified Specifics	100,000
5. Discretionary Total			**2,685,000**
Grand Total			**15,406,000**

Liberty Utilities

Calendar Year 2017

Granite State Electric (GSE) Distribution Capital Work Plan

The following pages list the capital projects and programs that will make up the CY17 Distribution Capital Work Plan. The vegetation management maintenance initiatives are also included in the plan. It is the expectation of this work plan that 80% or more of the target points in the plan will be met.

Prepared by: Anthony Strabone — Date: 4/06/2017

Approved By: CPBrouillard
Digitally signed by CPBrouillard
DN: cn=CPBrouillard, o=Liberty Utilities, ou=Engineering, email=chris.brouillard@libertyutilities.com, c=US
Date: 2017.04.12 05:33:51 -04'00'
Chris Brouillard
Director of Engineering LU East — Date: 4/12/17

Accepted By: ______________
Patrick O'Neill

Area Manager- Electric Operations LU East — Date: ___________

Executive Summary

This Work Plan identifies both Capital and Vegetation Management projects and programs for Calendar Year 2017. The purpose of the Work Plan is to:

- prioritize work requirements;
- roll into the Resource Plan to establish the "road map" for Operations to successfully guide the workforce toward completion of prioritized projects within specified budget requirements;
- aid in the establishment of a multi-year strategy to allow completion of required work within the specified budget;
- generate "buy-in" to the Work Plan at all levels of the Organization;

There are three main categories to the projects/programs identified in this Work Plan. These are:

- **Targeted Capital Projects**
- **Priority Programs**
- **Vegetation Management**

The 2017 GSE Capital Investment Plan in included at the end of this Work Plan in order to provide for completeness and visibility of the entire scope of capital work planned for 2017.

Targeted Capital Projects

Specific projects that were included in the CY 2017 Capital Investment Plan (Budget) in the high level categories of Growth, Improvement, and Replenishment are targeted for tracking. For each listed capital project, a target (milestone description) has been identified. The target details the CY 2017 completion expectation for the project, which may be engineering, design, materials procurement, or construction related.

In addition, each targeted capital project has been assigned a Target Point value that will be awarded for successfully achieving the defined milestone. The methodology used in assigning Target Points to projects was as follows:

- Total Target Points assigned to each project are a whole number that ranges from 1 to 5
- In determining total Target Points:
  - The points are assigned to the project based on the project's CY 2017 budget as follows:
    - <$25k = 1 point
    - $25k to $100k = 2 points
    - >$100k to $500k = 3 points
    - >$500k to $1M = 4 points
    - >$1M = 5 points
  - Example:
    - A capital project with a CY 2017 budget of $400k
      - Target Points = 3

- For projects that, at the time of work plan issue, it is determined that the project will not likely mature enough to spend the CY 2017 budget amount, then a more appropriate target and associated target points will be established.

Target Points assigned to projects are summed to determine available Target Point Total for Granite State. It is the expectation of this Work Plan that 80% or more of these Target Point Totals be achieved by the end of CY 2017. The status of work on Target Projects will be a specific topic of discussion at the monthly construction meetings.

Projects that are dependent on customer or governmental timelines will be designated as "Cust Compl", which means that if project is delayed beyond the end of the calendar year by the customer or governmental authority, the project will be re-assigned 0 points.

Certain Blanket projects are listed to provide budgeting and resource visibility, but are assigned 0 points in the plan.

As can be determined from the below tables, the CY 2017 Target Point Totals for distribution line Targeted Capital Projects are as follows:

Type	Target Point Total
Line	23
Substation	14
Facilities	2
Priority Program	20
Total Capital	**59**

Also, the CY 2017 Target Point Totals for Vegetation Management is as follows:

Area	Target Point Total
Vegetation Mgmt	17

Distribution Line Projects

The following table details the 2017 Distribution Line Targeted Capital Projects:

Project No	Project Name	Distribution Capital Work Plan Categor	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C18620	Charlestown 32 Dline	Distribution Line	Charlestown	100% Construction Complete	100% Complete	12/31/2017	$316,992	3
8830-C36424	Mt Support-New 16L3 Feeder	Distribution Line	Lebanon	100% Construction Complete	100% Complete	12/31/2016	$50,000	2
8830-C36425	Mt Support-New 16L5 Feeder	Distribution Line	Lebanon	100% Construction Complete	100% Complete	12/31/2016	$50,000	2
8830-C36436	Mt. Support - Remove 1303 Line	Distribution Line	Lebanon	100% Design Complete	100% Complete	12/31/2017	#N/A	1
8830-C36431	04377 Pelham-New 14L4 Fdr	Distribution Line	Pelham	100% Construction Complete	100% Complete	12/31/2017	$1,000,000	4
8830-1702	NN D-Line Work Found by Insp.	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$25,000	0
8830-1712	Damage Failure Blanket	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$800,000	0
8830-1722	Load Relief Blanket	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$25,000	0
8830-1721	Reliability Blanket	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$500,000	0
8830-1713	Asset Replacement Blanket	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$400,000	0
8830-1723	Distributed Generation Blanket	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$75,000	0
8830-C42912	Install 9L2-9L3 Feeder Tie	Distribution Line	Salem / Windham	100% Design Complete	100% Complete	12/31/2018	$25,000	1
8830-C42934	Air-break Switch Upgrade	Distribution Line	Various	100% Construction Complete	100% Complete	12/31/2017	$112,000	3
8830-C42930	Install Service to Tuscan Village Salem	Distribution Line	Salem	100% Construction Complete	100% Complete	12/31/2017	$200,000	3
8830-C36428	Amerductor Replacement Program	Distribution Line		100% Design Complete	100% Complete	12/31/2017	#N/A	1
8830-C36427	Feeder Getaway Cable Replacement	Distribution Line	Salem	100% Construction Complete	100% Complete	12/31/2017	$0	3

Distribution Substation Projects

The following table details the 2017 Distribution Substation Targeted Capital Projects:

Project No	Project Name	Distribution Capital Work Plan Categor	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C18630	Charlestown DSub	Distribution Sub	Charlestown	100% Construction Complete	100% Complete	12/31/2017	$650,000	2
8830-C36423	Mt Support Sub- New LP Fdr Pos	Distribution Sub	Lebanon	100% Construction Complete	100% Complete	6/1/2017	$300,000	3
8830-C36430	Pelham Sub-Add 2nd Xfmr and Fdr Pos	Distribution Sub	Pelham	100% Construction Complete	100% Complete	12/31/2017	$3,600,000	5
8830-1705	Substation Blanket	Distribution Sub	Various	100% Construction Complete	100% Complete	12/31/2017	$10,000	2
8830-C18710	RTU Installations	Distribution Sub	Various	100% Construction Complete	100% Complete	12/31/2017	#N/A	0
8830-1717	NH ARP Relay & Related	Distribution Sub	Salem	100% Construction Complete	100% Complete	12/31/2017	$10,000	1
8830-C18650	Salem area Study Dist Sub	Distribution Sub	Salem	100% Design Complete	100% Complete	12/31/2017	#N/A	1

Facilities Projects

The following table details the 2017 Facilities Targeted Capital Projects:

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-CNN026	Misc Capital Imprvmnts GSE Facilities Blanket	Facilities	Various	100% Construction Complete	100% Complete	12/31/2017	$50,000	2

Priority Programs

These are the capital and combined capital and expense efforts that have been defined and determined to be priority work. For these programs, specific CY 2017 completion targets have been set. It should be noted that work activity associated with these programs at times overlaps with the work activities defined in the Targeted Capital Projects.

For each Priority Program, a unique scoring methodology was developed. It is the expectation of this Work Plan that 100% of the Total Priority Program Points assigned to all programs combined be achieved at the Area level by the end of CY 2017. A target of 100% was assigned to Priority Programs as the majority of these initiatives are tied to regulatory programs and commitments, some of which have a special rate recovery mechanism. The status of work on Priority Programs will be a specific topic of discussion at the monthly construction meetings. The Priority Programs determined for CY 2017 are as follows:

Bare Conductor Replacement Program

This program is targeted towards the re-conductoring of bare mainline primary conductor with spacer cable in tree outage prone areas that are too costly to rely on vegetation management practices alone to mitigate feeder lockouts. Eight points are awarded upon completion of this program.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C18603	REP - Bare Conductor Replacement Project - Lowell Rd	Bare Conductor Replacement	Salem	100% Construction Complete	100% Complete	12/31/2017	$1,300,000	1
8830-C18603	REP - Bare Conductor Replacement Project - Mammoth Rd	Bare Conductor Replacement	Pelham	100% Construction Complete	100% Complete	12/31/2017	$1,300,000	2
8830-C18603	REP - Bare Conductor Replacement Project - 12L1 Rt. 123	Bare Conductor Replacement	Walpole	100% Construction Complete	100% Complete	12/31/2017	$1,300,000	5

Enhanced Bare Conductor Replacement Program

This program is targeted towards additional re-conductoring of bare mainline primary conductor with spacer cable in tree outage prone areas. Four points are awarded upon completion of this program.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C42851	Enhanced Bare Conductor Replacement Project - 14L1 Dutton Rd	Enhanced Bare Conductor Replacement	Pelham	100% Construction Complete	100% Complete	12/31/2017	$500,000	3

Single Phase Recloser and and Trip Saver Programs

This program is targeted towards the application of single phase reclosers and "Trip Saver" electronic cutouts to target rural and suburban circuit segments that would realize reliability benefits from single phase tripping and reclosing and to isolate faults down to the smallest segment possible. The scope of this program has been reduced in order to utilize a portion of the 2017 Capital funding for this program for Bare Conductor Replacement. A total of 2 points is awarded to this program.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	% Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C20473	REP Recloser Installation -	Single PH Recl /Trip Savers	Various	100% Construction Complete	100% Complete	12/31/2017	$200,000	2

Pocket of Poor Performance Program
This program will resolve reliability concerns in underperforming areas of distribution feeders. Two points are awarded upon completion of this program

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	%Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C22214	Pocket of Poor Performance- Shore Dr - 13L1	Pocket of Poor Performance	Salem	100% Construction Complete	100% Complete	12/31/2017	$75,000	2

Overloaded Transformer Replacement Program
This program is designed to replace overloaded transformers. One target point will be achieved when the number of transformers targeted in the table below has been replaced.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	%Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C21093	Overloaded Transformer Replacement	Overloaded trfrm	Various	100% Construction Complete	100% Complete	6/1/2017	$10,000	1

Under Performing Feeder Program
This program will resolve reliability concerns on distribution feeders listed in a report which details the three most under-performing feeders in New Hampshire, based upon the SAIDI performance for the preceding 3 years. The action items are expected to be a combination of capital and expense initiatives. Funding for this Program has been reduced and therefore no project had been identified for construction and/or engineering for 2017.

Capacity and Performance Programs
These programs will resolve reliability concerns on distribution feeders in key areas listed below. They address an array of areas which in the past may have not have received an adequate level of attention and funding.

Project No	Project Name	Distribution Capital Work Plan Category	Town	Target	Study/Design/NTP Date	%Construction/ Completion Date	CY2017 Budgeted Capital	Target. P
8830-C31402	IE-NN URD Cable Replacement	Cap/Perf Program	Lebanon	100% Construction Complete	100% Complete	12/31/2017	$100,000	2
8830-C36433	Distribution Feeder Power Factor Correction - 23kV Cap Bank Transformers	Cap/Perf Program	Salem	100% Construction Complete	100% Complete	6/1/2017	$25,000	2

Priority Program Total Points

The Total Priority Program Points for each New Hampshire Area is summarized in the table below.

Program	Priority Program Points
Bare Conductor Replacement	8
Enhanced Bare Conductor Replacement	3
Single Phase Reclosers & Trip Savers	2
Pocket of Poor Performance	2
Overloaded Transformers Replacement	1
Underperforming Feeders	0
Capacity and Performance	4
Total	**20**

Vegetation Management Program

This program defines the tree trimming goals/objectives for CY 2017. The table below summarizes this program. A more detailed description of the program including the specific feeders to be trimmed is available from Program Manager, Vegetation and Inspections.

Line		CY 2017 Budgeted Expenses
1	**VMP O&M**	
2	Work Planners for Veg Plan	$224,000
3	Spot Tree Trimming (Unplanned)	$30,000
4	Trouble & Restoration Maint (Unplanned)	$30,000
5	Planned Cycle Trimming	$1,147,803
6	Traffic Control (All)	$325,000
7	Hazard Tree Removal	$350,000
8	Interim Trimming (Unplanned)	$30,000
9	Tree Planting	$5,000
10	Sub-transmission Right of Way Clearing-Floor	$140,000
11	Fairpoint Credits	$420,000
12	Total: VMP O&M Expenses	$2,281,803
13	Less: Reimbursements from Fairpoint	($420,000)
14	VMP O&M Expenses Net of Fairpoint Credits	$1,861,803
15	Total REP and VMP O&M Expenses	$1,861,803

Area	**Substation**	**Feeder**	**OH_Miles**	**PTS**
Lebanon	Lebanon #1	1L2	87.64	3
Lebanon	Lebanon #1	1L4	2.08	1
Lebanon	Enfield #7	7L2	33.12	3
Lebanon	Vilas Bridge #12	12L2	55.38	3
Salem	Barron Ave. #10	10L4	9.4	2
Salem	Pelham #14	14L1	37.21	3
		Total OH_Miles	**224.83**	**15**

Area	**Subtransmission**		**Miles**	**PTS**
Lebanon	Lebanon 1L1/1L4	ROW Clearing-Floor	7.40	2

A target of 100% was assigned to the Vegetation Management Program as this initiative is tied to the Vegetation Management regulatory program and has a special rate recovery mechanism.

<u>Summary</u>

As detailed previously in this document, it is the expectation of this Work Plan that 80% or more of the Total Priority Project and Program Points assigned to all capital projects and programs combined be achieved at the company level by the end of CY 2017.

Finally, the overall Capital Work Plan completion goal will be measured as follows:

(0.5) x (% of Target Capital Project Points Achieved)
+
(0.5) x (% of Target Priority Program Points Achieved)
=
% of Capital Work Plan Achieved

2017 GSE Capital Investment Plan

Budget Class	Project Description	2017 Revised Budget
LU CapEx - Growth	8830-C42912 Install 9L2-9L3 Feeder Tie	$ 25,000
	8830-C42930 Install Service to Tuscan Village Salem	$ 200,000
	8830-CNN010 GSE-Dist-New Bus-Resid Blanket	$ 1,000,000
	8830-CNN011 GSE-Dist-New Bus-Comm Blanket	$ 1,200,000
LU CapEx - Improvement	8830-C18603 Bare Conductor Replacement Program	$ 1,300,000
	8830-C18750 Security Conversion GSE	$ 25,000
	8830-C20473 IE - NN Recloser Installations	$ 200,000
	8830-C22214 NN ERR/Pockets of Poor Perf	$ 75,000
	8830-C36423 Mt Support Sub- New LP Fdr Pos	$ 300,000
	8830-C36424 Mt Support-New 16L3 Feeder	$ 50,000
	8830-C36425 Mt Support-New 16L5 Feeder	$ 50,000
	8830-C36430 Pelham Sub-Add 2nd Xfmr and Fdr Pos	$ 3,600,000
	8830-C36431 Pelham-New 14L4 Fdr	$ 1,000,000
	8830-C36433 Distribution Feeder Power Factor Correction	$ 25,000
	8830-C42851 Enhanced Bare Conductor Replacement	$ 500,000
	8830-C42901 Underperforming Feeder Program	$ 150,000
	8830-CNN015 GSE-Dist-Reliability Blanket	$ 500,000
	8830-CNN016 GSE-Dist-Load Relief Blanket	$ 25,000
	8830-CNN023 GSE Distributed Generation Blanket	$ 75,000
	8830-CNN025 IT Systems & Equipment Blanket	$ 50,000
	8830-CNN026 Misc Capital Imprvmnts GSE Facilities Blanket	$ 50,000
	8830-CNN027 Transportation Fleet & Equip. Blanket	$ 250,000
	8830-FACCHA Misc Capital Imprvmnts GSE Facilities Charlestown	$ 15,000
	8830-FACLEB Misc Capital Imprvmnts GSE Facilities Lebanon	$ 84,996
	8830-FACLON Misc Capital Imprvmnts GSE Facilities Londonderry	$ 25,000
	8830-FACSAL Misc Capital Imprvmnts GSE Facilities Salem	$ 39,996
	8830-IT IT Systems Allocations - Corporate	$ 250,000
	EAM Foundation Year	$ 291,361
	ERP Foundation Year	$ 291,361
	GIS - One Graphic Card	$ 8,992
	GIS & OMS Electric Upgrade	$ 322,928
	Londonderry Snow Canopy	$ 17,631
	NHE Mobiletech Roll Out (Lineworks)	$ 50,000
LU CapEx - Replenishment	8830-C13968 PS&I Activity - New Hampshire	$ 5,000
	8830-C21093 IE-NN Dist Transformer upgrades	$ 9,996
	8830-C21595 01663 GS Storm Program Proj	$ 50,000
	8830-C26047 NH ARP Batts/Chargers Repl Prog	$ 25,000
	8830-C26061 NH ARP Relay & related	$ 10,000
	8830-C26263 NN D-Line Work Found by Insp.	$ 25,000
	8830-C31402 IE-NN URD Cable Replacement	$ 100,000
	8830-CN4104 01659 Granite St Meter Purchases	$ 195,000
	8830-CN4120 01660 Granite St Transformer Purchases	$ 390,000
	8830-CNN002 01737 GSE-Dist-Subs Blanket	$ 10,000
	8830-CNN004 GSE-Dist-Meter Blanket	$ 15,000
	8830-CNN006 GSE-Dist-Genl Equip Blanket	$ 40,000
	8830-CNN007 GSE-Dist-Water Heater Blanket	$ 75,000
	8830-CNN009 GSE-Dist-Land/Land Rights Blanket	$ 2,575
	8830-CNN012 GSE-Dist-St Light Blanket	$ 250,000
	8830-CNN013 GSE-Dist-Public Require Blanket	$ 387,000
	8830-CNN014 Dist-Damage&Failure Blanket	$ 800,000
	8830-CNN017 GSE-Dist-Asset Replace Blanket	$ 400,000
	8830-CNN022 GSE-Dist-3rd Party Attach Blanket	$ 125,000
	8830-CRSRVARS_017 Reserve for Sub Asset Repl Specifics	$ 24,996
	Air Break Switch Upgrade	$ 112,000
	Charlestown 32 Dline	$ 316,992
	Charlestown Dsub	$ 525,000
Grand Total		$ 15,940,824

GREY COLOR – Indicates for Reference Only and Not Applicable to Liberty Utilities

1.0 REVISION HISTORY

Version	Date	Description of Revision
1.0	05/01/13	Converted from National Grid document version 24.0
2.0	07/01/14	Updated NG-EOPs to LU-EOPs
2.1	04/01/15	Updated NG-EOPs to LU-EOPs
2.2	07/01/15	Updated NG-EOPs to LU-EOPs
2.3	11/01/15	Converted the following NG-EOPs to LU-EOPs EOP-G030. EOP-G032, EOP-D002, EOP-UG016, EOP-UG017, EOP-UG018
2.4	12/01/15	Converted the following NG-EOPs to LU-EOPs EOP-G030
2.5	12/01/17	Updated documents for System Use

INTRODUCTION

Liberty Utilities vision is to be a world-class safety organization, with zero injuries every day. This EOP will provide direction on installation, replacement and removal of solid core type current transformers and the work procedures that shall be utilized when performing work on the energized secondary (metering/relaying) side of these devices.

A Current Transformer (CT) is an isolation transformer with a primary winding, a magnetic core and a secondary winding. Current transformers (CT's) are utilized when the current in an electrical circuit is too high to directly apply that current to metering or relay equipment. Current transformers produce a reduced current on the secondary side of the current transformer that is directly proportional to the current that is flowing in the circuit on the high side of the current transformer; this secondary current can be conveniently connected to measuring, relaying and recording instruments.

Liberty Utilities uses a variety of styles of current transformers. Current transformers that are used on secondary voltage installations for metering of single and three-phase installations of 400 amperes and larger are usually single ratio solid core ring (donut) and bar (blade or lug) style. Current transformers that are utilized on higher voltage Substation and Transmission circuits may be single or multi ratio, split or solid core, ring, bar or bushing style. These CT's may be used for customer primary metering installations or substation relay and protection schemes. Current transformers that are used in substations on high voltage circuits are frequently mounted on porcelain or polymer insulators to insulate them from ground.

Ring (donut) style current transformers that are generally used in substation work are built in two different varieties, split core and solid core. The solid/split core defines how the current transformer is designed, and how it can be installed on a circuit. Closed core CT's are designed to be installed on de-energized circuit conductors. Split core CT's are designed so that they may be installed on an energized conductor that is carrying load current as long as the secondary terminals of the split core CT are properly connected to a metering/relaying circuit or they are bridged/shorted until the metering/relay circuit is installed.

The secondary side metering/relaying terminals of a CT shall not be opened or disconnected from its load (metering or relaying while the high side of the current transformer is energized. If the secondary is opened/disconnected while current is flowing in the high side circuit, the current transformer secondary will attempt to drive current across the open/disconnected secondary terminals which now have infinite impedance. This will produce a high voltage across the open secondary (several thousand volts), which may cause arcing or possible severe failure of the CT.

1. The rated current on the secondary side of a current transformer is normally standardized at 1 to 5 amperes. For example a 2000:5 CT would produce a 5 ampere current on the secondary side of the CT when 2000 amperes of current is flowing on the primary side of the CT.

PURPOSE

The purpose of this document is to provide workers with an understanding of the different types of current transformers, their propose, how they operate, hazards that they present and the required safety precautions that must be utilized when performing work either on the current transformer, or on the secondary metering/relaying circuit that is connected to the current transformer.

ACCOUNTABILITY

1. Standards, Codes, and Policies
   A. Update procedure as required.
   B. Provide appropriate guidance to field personnel when requested for specific work related tasks.
2. Electric Distribution Operations
   A. Ensure this procedure is implemented in the field.
   B. Ensure that workers are trained on procedure.
   C. Provide input as to any required revisions.
3. Liberty Utilities Employees and Contractors
   A. Demonstrate an understanding of the procedure.
   B. Comply with the requirements of the procedure.
   C. Provide feedback regarding effectiveness of the procedure.

REFERENCES

LU-EOP G014 – Clearance and Control

Liberty Utilities Employee Safety Handbook and Safety Rules

OSHA 1910.269

DEFINITIONS

CT: Current transformer is an isolation transformer with a primary winding, a magnetic core and a secondary winding. Current transformers are used on an electrical system when the currents in the circuit conductors are too high to directly apply the currents to metering, relaying or recording equipment. Current transformers produce a reduced current on the secondary side of the current transformer that is directly proportional to the current flowing in the conductor on the high side of the current transformer.

Circuit: A conductor or system of conductors through which an electric current is intended to flow.

De-energized: Free from any electrical connection to a source of potential difference and from electrical charges. Not having a potential difference from that of earth.

Note: The term is used only with reference to current-carrying parts which are sometimes alive (energized).

Electrically Isolated: All switches, jumpers, taps or other means through which known sources of electrical energy may be supplied to the particular lines and equipment have been opened.

TRAINING

A written request should be submitted to Liberty Utilities Learning and Development by user group.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

All Work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook, Safety Rules and all appropriate Liberty Utilities Electric Operating Procedures.

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook, Safety Rules, and applicable work procedures.

If there is more that one worker assigned to the task, the employee in charge of the work shall conduct a written job brief with the employees involved prior to the start of each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

Rubber gloves of the appropriate class shall be worn while performing work on either the primary or secondary (metering) side of an energized current transformer. Liberty Utilities Employee Safety Handbook section 2.11.20 (d) allows an exception to use of rubber gloves when performing work on transformer-rated metering circuits, relay circuits or control circuits energized at 300 volts or less, if you:

1.1 Have covered up energized, exposed equipment, and are insulated from the ground, or

1.2 Use insulated tools

The circuit on the secondary side of a current transformer **SHALL** never be opened while the current transformer is energized. If work is performed on the secondary (metering) side of a CT while the primary circuit of the current transformer is energized, the secondary side of the CT shall be bridged/shorted so that the current transformer secondary will not be electrically opened. Electrical measurements shall be taken to ensure the secondary (metering or relaying) circuit to be worked is shorted/bridged.

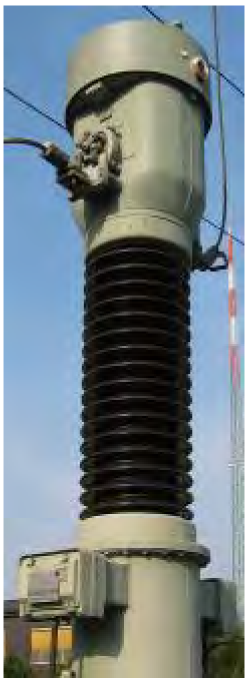
Only approved test instruments as specified in the Liberty Utilities shall be used to determine if the current transformer is de-energized or the secondary of the current transformer is effectively bridged/shorted.

2.0 STYLES OF CURRENT TRANSFORMERS

Current Transformers are produced in various styles and designs, but generally they can be separated into three basic designs, ring, bar (spade and lug) and bushing.

The following pictures will show an example of current transformers of various styles; there are variations in design within each style, therefore, the pictures shown may not exactly resemble the current transformer you are working with. Employees in Electric Operations may encounter installations of the different style current transformers on Transmission or Substation facilities, but the standard CT's that are utilized by workers in the Electric Operations group on primary and secondary distribution circuits are solid core ring and bar (blade or lug) style current transformers.

TRANSMISSION & SUBSTATION



BUSHING STYLE CURRENT TRANSFORMER

Bushing style CT's are normally utilized on higher voltage distribution, sub-transmission and transmission systems. The most common will have a NEMA two or four bolt pad for connections to the primary tap of the CT.

The CT's pictured here are being used on a 115 kV substation.

DISTRIBUTION – PRIMARY VOLTAGE

15 kV Primary Metering Installation Lug Style CT'S

Current Transformer

Potential Transformer

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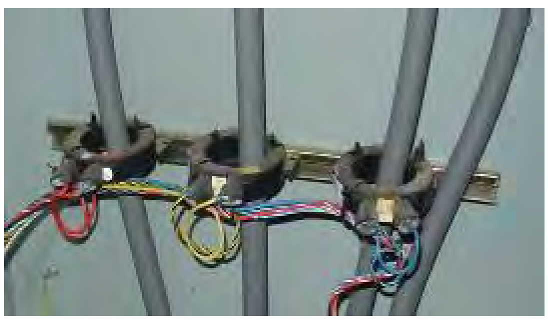
DISTRIBUTION – SECONDARY VOLTAGE

RING (DONUT) STYLE

Ring (donut) style current transformers are used in many different applications. The current carrying conductor or bushing is placed in the center opening of the donut CT so that all current passes through the opening.



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DISTRIBUTION – SECONDARY VOLTAGE BAR (Blade) Style

3.0 INSTALLATION, REPLACEMENT or REMOVAL OF SOLID CORE CURRENT TRANSFORMERS

The installation, replacement or removal of ring, bar or lug style solid core CT's shall only be performed on de-energized electrical circuits that comply with circuit criteria and work methods as listed below:

3.1 New Circuit

A new electrical circuit is a circuit on which the electrical conductors have never been attached to a known source of electrical potential. The new conductors may be physically attached at an existing location enclosure or structure that has existing energized electrical conductors as long as there is a complete physical isolation of the existing and new conductors. As soon as the new conductors are connected to any device (switch, disconnect, terminal board or loop of wire) that could be operated to bridge the connection between the new and existing circuit conductors, those new circuit conductors shall be treated as existing conductors.

3.1.1 The conductors of a new circuit shall be visually inspected to determine that there is no physical connection to a potential source of electrical potential and electrically tested with an approved tester to verify the absence of electrical potential. After the appropriate inspection and testing has been performed to verify the circuit conductors as de-energized the circuit conductors may be worked on utilizing approved work gloves and all other required PPE.

3.2 Existing Circuit

An existing electrical circuit is an electrical circuit on which the conductors are physically connected to a known source of electrical potential or an electrical circuit with conductors that at some previous time were connected to an electrical potential, but are now isolated from all known sources by use of a mechanical device, fuse, switch or disconnect. The circuit or conductors may still have connections to potential sources of electrical potential such as transformers, metering or customer generation. All work to install, replace or remove solid core current transformers on these circuits/conductors shall be performed in accordance with one of the following approved methods:

3.2.1 Work may be performed on conductors of an existing circuit to install, replace or remove solid core current transformers utilizing "live" work methods. The circuit shall be isolated and tagged to remove all known sources of electrical potential and then all work that will be performed on the circuit/conductors will be accomplished utilizing accepted safe work practices, appropriate PPE, Insulate and Isolate practices and rubber sleeves and/or rubber gloves appropriate for the voltage of the isolated circuit. Contact Distribution Engineering for proper "live" work methods before by-passing primary metering replacement.

3.2.2 Work may be performed on conductors of an existing circuit to install, replace or remove solid core current transformers utilizing "de-energized" work methods. The circuit/conductors shall be isolated, tagged, tested and grounded in accordance with all appropriate Liberty Utilities EOP's and the Liberty Utilities Employee Safety Handbook and Safety Rules.

3.3 Verification

Prior to installation or replacement of a solid core current transformer a check shall be made to verify the following information:

3.3.1 The circuit operating Map/Print for correct circuit voltage

3.3.2 The work order for correct voltage and current ratings of the installation

3.3.3 The nameplate of the current transformer for correct operating voltage and current ratio

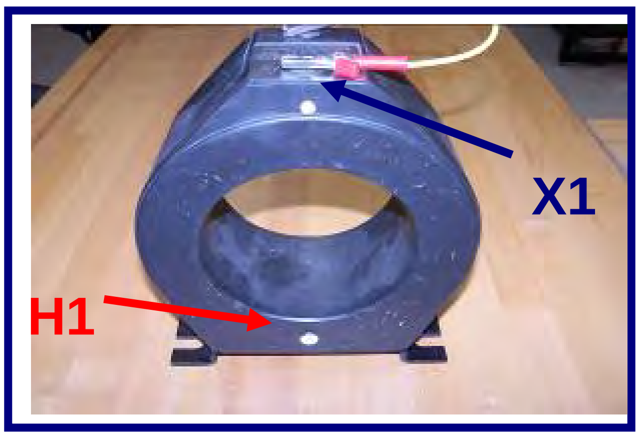
3.3.4 Markings for direction of current flow or polarity for the primary coil

3.3.5 Markings for the polarity on the secondary side of the current transformer

EXAMPLES OF POLARITY MARKINGS

H1 = Primary

X1 = Secondary



3.4 Installation or Replacement of Solid Core Current Transformer

Prior to the start of any work to install or replace a solid core current transformer the primary side circuit/conductors shall be isolated, de-energized and worked shall be performed in accordance with the procedures discussed above for either a new circuit or an existing circuit.

3.4.1 Install CT into correct mounting position, verifying that the primary side polarity marking or direction arrow is facing in the correct position.

3.4.2 Install the high side conductors to the current transformer primary connection points on bar or lug style CT's. Install the primary conductors or transformer bushing through the center opening for ring style current transformers.

3.4.3 Install the secondary metering/relaying side wiring. Applications for measurement of three phase power must have the polarity of the secondary terminals wired properly to avoid phase reversal situations. The voltage and current measurements must have the same polarity to keep power factor and direction of power flow consistent.

a. If the secondary metering/relaying circuit is not completed and it is necessary to energize the primary side of the CT, the secondary terminals of the CT must be shorted with an appropriate shorting bar or a piece of # 12 AWG or larger 600 volt rated conductor.

NOTE: The primary side of the CT shall never be energized unless the secondary side metering/relay circuit is a complete circuit or the secondary terminals of the CT are properly bridged/shorted.

3.4.4 Energize the conductor for the high side of the CT and verify the secondary metering/relay operation.

3.5 Removal of Solid Core Current Transformers

Prior to the start of any work to remove a solid core current transformer the primary side circuit/conductors shall be isolated, de-energized and work shall be performed in accordance with the procedures discussed above for either a new circuit or an existing circuit.

3.5.1 Disconnect/remove primary side conductors form the current transformer.

3.5.2 Disconnect/remove the secondary metering/relaying conductors for the secondary terminals of the current transformer.

3.5.3 Remove current transformer from the mounting attachment point.

4.0 WORKING ON ENERGIZED SOLID OR SPLIT CORE CURRENT TRANSFORMER SECONDARIES

Work on energized secondary circuits of solid or split core current transformers can be performed safely by short circuiting or bridging of the secondary terminals or the secondary metering/relaying circuit of the current transformer. The method that is chosen to safely perform this work is dependent on the circuit configuration and specific conditions that exist at each job location and, thus, will be determined on a case by case analysis.

Any of the following methods are acceptable for shorting/bridging the secondary of a current transformer:

4.1 Short circuiting of the current transformer secondary metering/relaying circuit utilizing an approved test device.

4.2 Short circuiting the current transformer secondary terminals utilizing shorting type terminal blocks or manufacturer's shorting straps at the CT location.

4.3 Short circuiting and grounding the current transformer secondary metering/relaying circuit utilizing temporary jumpers placed upstream, between the work location and the current transformer. If placement of these temporary jumpers is in close proximity to the work location and a possibility exists as to them becoming loosened or dislodged during performance of work, a more permanent jumper should be placed downstream of the temporary jumper, between the temporary jumper and the work location to short circuit and ground the current transformer secondary circuit.

4.3.1 The following requirements shall be utilized for jumpers:

a. Temporary jumpers shall have alligator clips and 600 volt wiring which have a minimum current rating of 10 amps.

b. Permanent jumpers shall be made of at least #12AWG wire with 600 volt rated insulation. The terminations on the jumpers will be appropriate for the type of connections required at the specific location.

NOTE: Extreme caution must be utilized when working on energized current transformer metering/relaying circuits with temporary jumpers to ensure the alligator clips do not loosen or become dislodged.

4.4 When current transformer energized secondary metering/relaying circuits are short circuited to perform work the following procedure shall be used:

4.4.1 Identify the appropriate circuit and attached devices.

4.4.2 Using an approved ammeter measure the current in the section of the CT secondary metering/relaying circuit where the work will be performed.

4.4.3 Apply one of the above listed approved methods for shorting/bridging the secondary circuit of the current transformer.

a. If a temporary jumper is utilized, it shall be installed up stream of the work location. If placement of these temporary jumpers is in close proximity to the work location and a possibility exists as to them becoming loosened or dislodged during performance of work, a more permanent jumper shall be placed downstream of the temporary jumper, between the temporary jumper and the work location to short circuit and ground the current transformer secondary circuit. The temporary jumper shall be left in place until a permanent jumper has been installed on the down stream side of this temporary jumper.

4.4.4 Measure the current in the CT secondary meter/relay circuit at points both before and after the point of attach of the shorting/bridging device. The current observed on the CT secondary meter/relay circuit at the point below the shorting/bridging devices shall be less than the current observed at the point above the shorting/bridging device.

a. If a temporary jumper is being used as a shorting/bridging device, verify using an approved ammeter that there is current flow in the jumper.

1. Verify that the temporary jumper is carrying a portion of the current that was identified on the metering/relaying circuit.
2. Verify that there is reduced current flow in the metering/relaying circuit down stream of the temporary jumper.
3. Install a permanent jumper downstream of the temporary jumper towards the work location to short circuit and ground the current transformer secondary metering/relaying circuit. This permanent jumper shall be no smaller than #12AWG, 600 volt insulated wire.

NOTE: When the secondary metering/relaying circuit of an energized CT is shorted/bridged and grounded the ground point shall only be installed at that one point on the circuit.

4.4.5 Perform the desired work on the current transformer secondary metering/relaying circuit.

4.4.6 Verify the integrity of the metering/relaying circuit after work has been completed and prior to the removal of any shorting/bridging devices on the current transformer secondary metering/relaying circuit.

4.4.7 Remove all permanent shorting/bridging and grounding devices and then remove any temporary jumpers that may have been applied to the current transformer secondary metering/relaying circuit.

4.4.8 Verify with and approved ammeter that there is a current flow in the current transformer secondary metering/relaying circuit that was worked on.

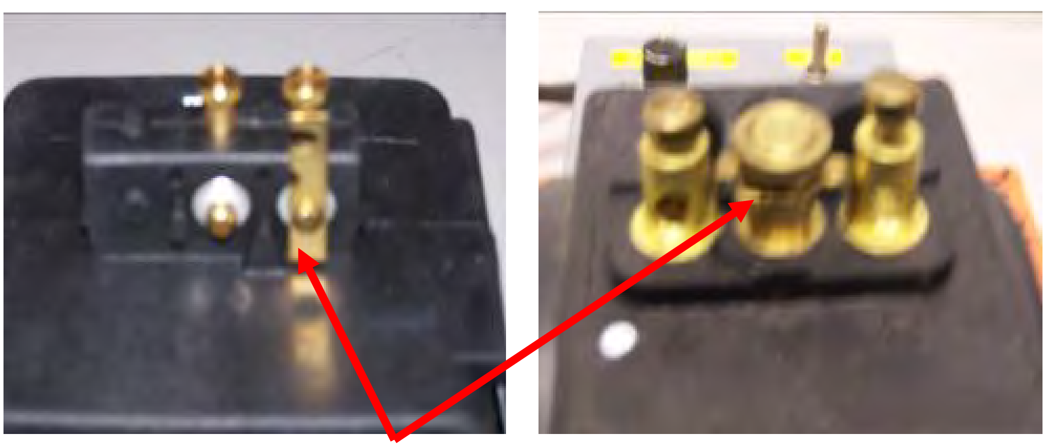
5.0 CURRENT TRANSFORMER RELATED EQUIPMENT

The following pictures will show some common equipment that is utilized on current transformers and CT rated metering installations. This is not intended to show every item that will ever be encountered with CT rated metering installations, but it will provide a basic overview of the most common.

The most important thing for employees that work on or around CT rated metering installations to understand is it is not safe to create an open circuit on the secondary metering/relaying side on any current transformer that is still connected to energized conductors on the primary side of the CT. Any work that is done on the energized conductors of the secondary metering/relaying system must be done with the circuit properly shorted/bridged and any work to install remove or replace the meter on a CT installation must be done with the CT secondary circuit properly shorted/bridged.

5.1 Test Device: This device may be mounted inside the CT cabinet on some older style installations. It may have a plastic, metal or bake light cover over the exposed blades. This device provides an approved method of shorting/bridging the secondary metering/relaying side of the CT’s for work downstream of this device.

5.2 Shorting/bridging Bars: Many manufacturers have designed CT's with an attached assembly that is capable of properly shorting/bridging the secondary metering/relaying terminals of the current transformer without disturbing the permanent circuit wiring.



SHORTING/BRIDGING BARS

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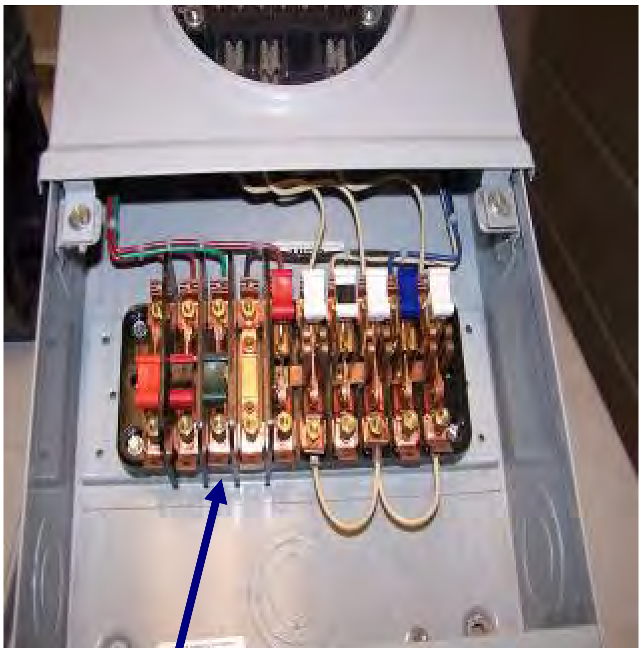
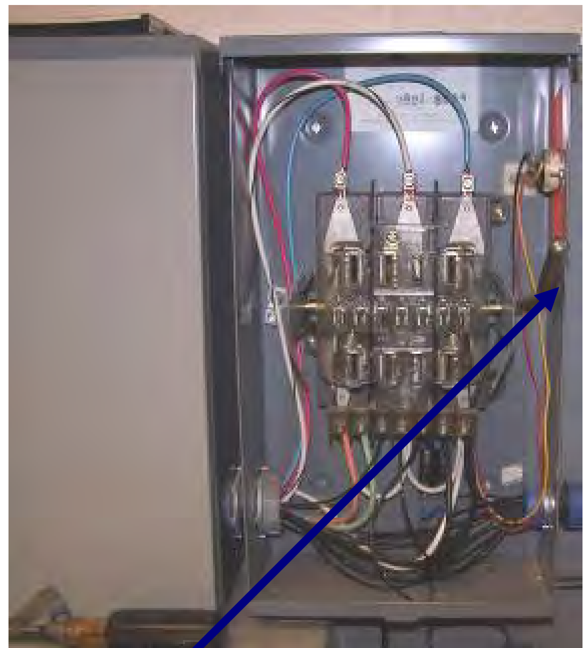
5.3 Meter Sockets: There are several styles of meter sockets that are utilized for CT metered services; the following pictures will depict the two most common styles. Both of these meter sockets have shorting/bridging assemblies incorporated into the meter socket to allow for installation, replacement and removal of the meter while the customer service is energized and carrying load current.





Knife blade switches can be operated to provide a shorting/bridging connection of the CT secondary metering circuit to allow for installation, replacement or removal of the meter on and energized service installation.

Meter by-pass handle can be operated to provide a shorting/bridging connection of the CT secondary metering circuit to allow for installation, replacement or removal of the meter on and energized service installation.

6.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
04/01/2015	1.1	Updated Format	Robert J Johnson
01/01/2017	1.2	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G002		
Electric Operating Procedure	**01-01-2017**	**General**	
Chain Saw Operation and Safety	**Revision #**	**1.1**	**Page: 1 of 11**

INTRODUCTION

This procedure outlines the care, maintenance, and operating requirements of gasoline powered chainsaws. The guidelines in this procedure comply with OSHA regulations and Liberty Utilities Employee Safety Handbook, Safety Rules, and work procedures.

PURPOSE

This procedure will apply whenever a chain saw is used.

ACCOUNTABILITY

1. Standards, Codes, and Policies
   - A. Update procedure as required.
   - B. Provide appropriate guidance to field personnel when requested for specific work related tasks.
2. Electric Distribution Operations
   - A. Ensure this procedure is implemented in the field.
   - B. Ensure that workers are trained on procedure.
   - C. Provide input as to any required revisions.
3. Liberty Utilities Employees and Contractors
   - A. Demonstrate an understanding of the procedure.
   - B. Comply with the requirements of the procedure.
   - C. Provide feedback regarding effectiveness of the procedure.
   - D. It is the workers responsibility to read and fully understand and follow the manufacturer's instruction manual and specifications before operating any equipment.

COORDINATION

Not Applicable

REFERENCES

Manufacturer's Operating Instructions.

OSHA 1910.269 (r) (5) Standards in Line Clearance Tree Trimming Operations

OSHA 1910.266 (e) Standards in Logging Operations

Liberty Utilities Employee Safety Handbook and Safety Rules

DEFINITIONS

Backcut (felling cut): The final cut in a felling operation after the tree has been notch cut

Chain Brake: A device that stops the rotation of the chain if activated in a kickback situation by the operator's hand or by inertia

Chaps: leg protection constructed with cut-resistant material, such as ballistic nylon

Clutch: Couples engine to chain sprocket when engine is accelerated beyond idle speed

Fell (fall): To cut down trees using a notch and backcut to guide tree during fall

Feller: The person that performs the backcut to cut down the tree

Guide Bar: Supports and guides the saw chain

Kevlar Gloves: Cut resistant gloves that protect workers hands from sharp objects.

Scabbard: A protective sheath or guard that covers the chainsaw bar and chain

TRAINING

A written request should be submitted to Liberty Utilities Learning and Development by user group.

DOCUMENT CONTENTS

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1.0 SAFETY

Only employees with proper training authorized by their supervisor may operate chain saws.

All work shall be performed in accordance with Liberty Utilities Employee Safety Handbook and Safety Rules.

All appropriate personal protective equipment, which includes, but is not limited to safety boots, hard hat, safety glasses/eye protection, hearing protection, gloves, and chaps shall be worn by all employees when performing work as required by the Liberty Utilities Employee Safety Handbook, Safety Rules, and applicable work procedures.

Before work begins a Job Brief shall be conducted during which the boundaries of the work areas and the associated hazards will be reviewed and understood.

2.0 CHAIN SAW CHECKLIST

Read and follow all manufacturers' guidelines.

2.1 Inspection of Saw:

2.1.1 Guards and handles shall be sound, tight, in place and free from splinters and sharp edges.

2.1.2 Chain saw controls shall be adjusted in accordance with manufacturer's instructions and clutch shall be adjusted as to not engage chain at idle.

2.1.3 Chain shall be properly adjusted and sharpened.

2.1.4 Mufflers/spark arresters shall be in place and operational.

2.1.5 Chain brake shall be in place and functioning properly. (All chain saws placed into initial service after February 9, 1995 shall be equipped with a chain brake. Saws placed in service before that date must be equipped with a protective device that minimizes kickback. No chain saw kickback device shall be removed or disabled.

2.1.6 Always use a scabbard when storing the chain saw.

2.2 Saw Operation:

2.2.1 Fuel or refill saw at least 10 feet from any open flame or other ignition source (i.e., truck, vehicle).

2.2.2 Start saw at least 10 feet from refueling site.

2.2.3 Avoid using chainsaw above shoulder level

2.2.4 The chainsaw shall not be used to cut directly overhead.

2.2.5 Prior to starting the saw, the employee and chain saw shall be in a secure working position. Place it on level ground, get good footing, hold firmly with one hand (and a foot if model permits), pull starter cord slowly to engage cogs and then rapidly in a short motion to start saw, with other hand. Drop starting the saw is prohibited, except when working from an aerial lift or when climbing

2.2.6 Chain saw shall be started with chain brake engaged.

2.2.7 The Chain saw shall be held with the thumbs and fingers of both hands encircling the handles during operation.

2.2.8 Chain must stop rotating when throttle is released.

2.2.9 Operator shall be certain of footing.

2.3 Felling Trees

2.3.1 Prior to felling, clear all saplings, trees, bushes and vines that could interfere with operation.

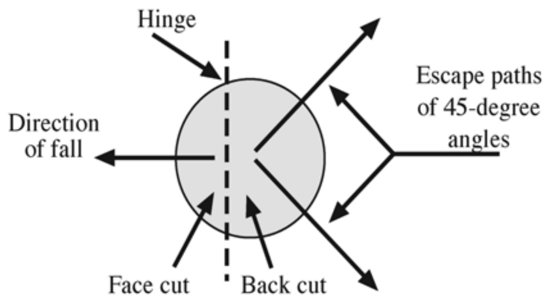
2.3.2 A backcut shall be made in each tree being felled. The backcut shall leave sufficient hinge wood to hold the tree to the stump during most of its fall so that the hinge is able to guide the tree's fall in the intended direction.

a. While back cutting, OSHA regulations requires the back cut to be above the level of the horizontal face cut, and recommends that it be placed at least one inch above horizontal face cut when using a Conventional or Humboldt notch The Company recommends the back cut be placed two inches above the horizontal face cut of the notch. This is required in order to provide an adequate platform to prevent trees from kicking back and hitting feller. (Back cut on Open-Faced notch is placed at the level where the face cuts of the notch meet).

Tree Notching Methods

			
	Open-faced Notch	**Conventional Notch**	**Humbolt Notch**
Total Angle	ideally 90 degrees; at least 70 degrees	45 degrees	45 degrees
Top Cut	angled downward 70 degrees	angled downward 45degrees	flat horizontal
Bottom Cut	angled upward 20 degrees	flat horizontal	angled upward 45 degrees
Back Cut	horizontal; at the same height as the corner of the notch	horizontal; at least 1 inch above the bottom cut	horizontal; at least 1 inch above the top cut
Depth	1/4 - 1/3 of tree diameter	1/4 - 1/3 of tree diameter	1/4 - 1/3 of tree diameter
Point of Notch Closure	just before tree hits ground	middle of fall	middle of fall
Degree of Safety	high	medium	medium
Advantages	1. greater accuracy of felling into target area 2. hinge stays intact until tree hits ground 3. less danger of kickback and other out-of-control movement	1. familiar to many loggers	1. saves slightly more wood 2. familiar to many loggers
Disadvantages	hinge may have to be cut off	hinge breaks early	hinge breaks early
While all three of these notches are acceptable, the Open-faced Notch is clearly the safest and most accurate.			

2.3.3 Prepare an escape route 45 degrees opposite the direction of felling. See diagram below for illustration of escape route relative to direction of felling.



2.3.4 The chainsaw shall be shut down or the chain brake shall be engaged whenever a saw is carried further than 50 feet. The chainsaw shall be carried in a manner as to keep guide bar pointed to the rear and muffler away from operator.

2.3.5 The chainsaw shall be shut off or at idle before tree feller begins retreat.

3.0 GENERAL USE

3.1 Know your saw. Keep it in good condition - thus easy to start. If saw does not start after three or four pulls, do not continue to crank it. Shut off the ignition switch and "trouble shoot."

3.2 Keep saw clean, free of oil, gasoline and sawdust.

3.3 Always keep the chain sharp and properly tensioned. A chain that is too loose will tend to derail and whip about dangerously. On the other hand, a chain which is too tight will bind and wear prematurely. All chains stretch with use and frequently need checking and readjusting. Good lubrication helps to prolong chain life and maintain tension adjustment. Check the oil often and refill according to manufacturer instructions. Be sure to use the correct bar oil.

3.4 One-man saw should be carried with blade to rear, especially when not covered by chain guard. Guard should be used to cover the chain at all times except when in continuous use.

3.5 The use of a gas chain saw from an aerial insulated bucket is allowed to be used in the vicinity of energized lines by a qualified lineman wearing all required PPE and following rules for work in primary zone.

3.6 When used "off the ground" saw must be secured either by hand line or lanyard.

3.7 When used "off the ground" saw should be started, warmed up and test run on the ground to check proper operation (with special emphasis on centrifugal clutch behavior) prior to being sent aloft. When aloft, engine must be stopped except when in actual use. A power saw shall not be running when ascending or descending a tree.

3.8 Dangerous cuts should not be attempted. Wait until safe working position can be attained.

3.9 Maintain clearances from energized lines.

3.10 Protective Footwear shall be worn when operating a chain saw and shall comply with ANSI Z41 part 91 I/75 C/75 EH as per the Employee Safety Handbook and Safety Rules.

3.11 Safety glasses with side shields or equivalent shall be worn while saw is in actual operation.

3.12 Hard hats shall be worn on the job site.

3.13 Hearing protection shall be worn when employees are using a chain saw.

3.14 Chaps SHALL be worn by all employees when operating a chain saw. The leg protection shall cover the full length of each leg, to protect against contact with a moving chain saw chain. Exceptions to this chaps requirement are allowed:

3.14.1 When working from within a bucket of an aerial lift.

4.0 HAZARDS

4.1 Most accidents involving chain saws arise from one or more of the following categories. All chain saw operators should recognize these areas of potential hazards and plan their work accordingly.

4.1.1 Cuts from chain.

4.1.2 Falling trees or limbs, rolling logs.

4.1.3 Falls while carrying saw.

4.1.4 Falls while on an "escape route;" that is, while moving to a safe location after completing the felling cut.

4.1.5 Strains or sprains.

4.1.6 Saw Kick Back.

4.1.7 Burns from exhaust.

4.1.8 Eye injuries.

4.1.9 Cuts while filing.

4.1.10 Poor footing - side slopes, sandy areas, woodchuck holes, loose ground, etc.

5.0 JOB SITE PREPARATION

5.1 Clear work area of brush, vines and debris (be on lookout for barbed wire and nails in and near butt of tree). Also be aware that small brush and vines may “whip” when cut with a chain saw.

5.2 Make certain of good footing before starting operation of saw.

5.3 Choose and prepare an escape route. This is a clear path which operator will take to reach safe position when tree begins to fall. Generally at a 45 degree angle opposite the direction of felling.

5.4 Chain saws are equipped with a centrifugal clutch which actuates the chain when the engine speeds up. As it is necessary to open the throttle to start the engine, the chain will turn upon starting when the chain brake is released. For this reason, all personnel should stand clear while the chainsaw is started.

5.5 The distance between adjacent occupied work areas shall be at least two tree lengths of the trees being felled

6.0 USE OF CHAIN SAW

6.1 Set the face plate firmly against the log or limb being cut so that the saw will not slip.

6.2 When sawing, attain a well balanced body position. This will help reduce saw kicking. On small cuts, stand with your legs wide behind the saw so that it will not strike your legs in the event of kicking. If the character of the work allows, stand to one side of the cut.

6.3 When using a saw in the bucket, staying above the cut will give better control over the swing of the saw once the cut is completed.

6.4 During the felling operations, a second worker may push against the tree using a push pole or similar tool. When pushing the tree over by hand always turn off saw and be sure of the direction of fall (using a rope to pull the tree from a safe distance and direction is safer and is the preferred method). Stay at least six feet away from the operator when the saw is being operated.

6.5 Always turn the saw off between cuts, except when engaged in a continuous operation such as felling, bucking or ground cutting.

6.6 Do not needlessly run the chain or idle the engine.

7.0 GENERAL MAINTENANCE GUIDELINES

7.1 Preventative: Avoid letting the saw chain contact the ground, cut muddy logs or cut metal such as wire or nails in stumps.

7.2 File or check the chain only when the saw is stopped and the ignition switch is turned “off”.

7.3 When filing chain, wear gloves and hold your arms and hands high to prevent accidental raking over the teeth. Cut resistant Kevlar gloves should be worn whenever sharpening or adjusting chainsaw chain to prevent cuts from sharp edges of chain.

7.4 Touch up the chain frequently during a day's operation.

7.5 When filing chain on saw, hold saw securely. Place in vise if possible.

7.6 Pull chain around bar with stick, or other object that won't dull chain or gloved hand -never with bare hand.

7.7 Clean and regularly change air filter and spark plugs. Occasionally check fuel filter.

7.8 Never operate saw without muffler. This will increase noise level of the saw and can ignite a fire in dry litter.

8.0 FUELING AND REFUELING

8.1 Carry fuel only in approved cans.

8.2 Do not smoke while refueling.

8.3 Stop saw and allow to cool before refueling.

8.4 Saws shall be fueled on the ground away from streams, lakes, ponds, wetlands, etc.

8.5 Use proper gas and oil mix as recommended by manufacturer.

8.6 Avoid spilling fuel. Wipe off any spilled fuel. Move saw at least ten feet from refueling spot before restarting.

9.0 STORAGE

9.1 Do not store saw with ropes.

9.2 Store saw so it will not move in transit.

9.3 Keep chain covered with approved guard while stored.

10.0 THE MECHANICS OF CHAIN SAW MAINTENANCE

10.1 A working knowledge of the following procedures is essential and is described in the Operator's Manual for your chainsaw.

10.1.1 Start and Stopping - Covered in text under Job Site Preparation.

10.1.2 Fuel requirements – 2 cycle oil type and grade and gasoline octane requirement, recommended mix ratio

10.1.3 Bar oil requirements – viscosity recommendations for summer and winter useage

10.1.4 Installing and tensioning the chain – proper adjustment for chain

10.1.5 Filing chain cutters and rakers – proper angle and depth for filing chain

10.1.6 Sprocket and guide bar maintenance – proper inspection of alignment and wear

10.1.7 Air filter maintenance – frequency of cleaning and replacement

10.1.8 Fuel tank maintenance – proper fuel cap and tank integrity, no cracks or leaks, when to replace the fuel filter

10.1.9 Muffler and cylinder maintenance – inspect muffler for condition and proper function (spark arrest and noise reduction). Check compression relief valve on cylinder

10.1.10 Carburetor adjustments – Correct idle and Hi/Lo jet settings

10.1.11 Operation of chain brake – Proper function and adjustment of brake

11.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

INTRODUCTION

Neutral-to-earth voltages have been referred to by a number of names including stray, transient, or tingle voltages. Liberty Utilities has committed to resolving stray voltage complaints where investigation reveals utility contribution to neutral-to-earth voltage of 0.5 VAC RMS steady state or greater (as measured at the contact point with a digital voltmeter & 500 ohm shunt resistor). A steady state voltage has time duration of at least one (1) second.

Every effort should be made to identify and attempt to resolve stray voltage complaints within 15 business days.

PURPOSE

This procedure shall apply whenever the Company receives a call from a customer stating that they have a neutral-to-earth voltage (stray voltage) complaint. This typically occurs in livestock facilities. If a neutral-to-earth voltage is found for which Liberty Utilities is determined to be responsible, every effort shall be made to eliminate the voltage.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate guidance to field personnel when requested for a specific work related tasks.

2. Electric Distribution Operations
   - A. Ensure this procedure is implemented in the field.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   - A. Demonstrate an understanding of the procedure.
   - B. Comply with the requirements of the procedure.
   - C. It is the workers responsibility to read and fully understand and follow the manufacturer's instruction manual and specifications before operating any equipment.

COORDINATION

Electric Planning Engineering

REFERENCES

Liberty Utilities Employee Safety Handbook, Safety Rules, and Work Procedures

LU-EOP G004 Shock Complaints

National Electrical Safety Code

National Electrical Code

Liberty Utilities Overhead Distribution Construction Standards

DEFINITIONS

Neutral-to-Earth (or Stray Voltage): is a voltage measured between two contact points that is greater than 0.5 V rms. This is below the perception level for people.

TRAINING

A written request should be submitted to Liberty Utilities Learning and Development by user group whenever training is required.

DOCUMENT CONTENTS

Table of Contents

1.0 GENERAL

1.1 As the electric utility, Liberty Utilities takes the lead responsibility in all Stray Voltage investigations providing notification and assistance for the CATV and telephone companies in joint investigations.

1.2 Electric Planning Engineering or Electric Operations is responsible for investigating, analyzing, and resolving all "stray voltage" complaints **that are not classified as Privileged & Confidential**.

1.3 Electric Planning Engineering or Electric Operations will work in conjunction with the Safety Department and personnel from other designated departments. For Privileged & Confidential incidents, all involved Departments will work under the direction of the Legal Department. Additionally, the Electric Planning Engineering or the Electric Operations Metering is responsible for retaining complete records of all Stray Voltage Reports and locations if isolation devices are installed. Electric Planning Engineering or Electric Operations is also responsible for keeping a completed copy of a stray voltage investigation on file.

1.4 Electric Planning Engineering or Electric Operations is responsible for overall documentation, direction and guidance, and is available for assistance in analysis and corrective action.

2.0 PROCEDURE

2.1 **Collect information on suspected farm**

2.1.1 Record customer information in the table below.

CUSTOMER INFORMATION TABLE	
NAME	
STREET	
CITY/TOWN	
DISTRICT	
TELEPHONE NO.	
TELEPHONE CO.	
CATV COMPANY	
FEEDER NO.	
ELECTRICIAN	
ELECTRICIAN CONTACT NO.	

2.2 **Check the reason for investigation.**

____ Initial Response to:

____ Customer's request for measurements to determine what level of animal contact voltages exist on farm.

____ Customer's believes that contact voltage is affecting livestock.

____ Retest of customer site:

____ At customer request.

____ At utility request.

____ To repeat measurements of primary/secondary distribution system.

____ To check isolation and isolation device.

2.3 **Record the history of investigation in the table below.**

DATE OF REQUEST		RECEIVED BY	
DATE OF INVESTIG.		INVESTIGATED BY	

2.4 **Record customer observations in the tables below.**

ANIMAL RESPONSES			
<u>NONE</u>		DECREASED PRODUCTION	
ANIMALS NERVOUS		INCOMPLETE/UNEVEN MILK OUT	
REDUCED FEED INTAKE		INCREASED MILKING TIME	
REDUCED WATER INTAKE		MILKING MACHINES KICKED OFF	
INCREASED MANURE PRODUCTION		<u>INCREASED SOMATIC CELL COUNT</u>	
WEIGHT LOSSES		INCREASED MASTITIS	
REFUSE TO ENTER AREAS		PERSONAL SHOCKS	
OTHERS (specify):			
DETAILS: Approximately where and when are conditions observed?			

2.5 **Follow-up questions:**

Do all cows/livestock respond similarly? Yes ___ No___

Do cows/livestock avoid specific areas? Yes ___ No ___

Does weather have an effect?

Cold (Y or N) ___ Wet(Y or N) ___ Hot (Y or N) ___ Dry(Y or N) ___

What is the change in milk production? _____lbs _____%

How many animals are milked or animals raised? _____milked _____

What is the somatic cell count? SCC: ___________________________

Have any changes been made in herd makeup? ______________________

Have any changes been made in feeding? __________________________

Have any personnel changes occurred? ____________________________

Other changes? ____

2.6 **On-Farm Changes**

Have any of the following on-farm changes been made recently?

CHANGE	YES	NO	CHANGE	YES	NO
ELECTRICAL			EQUIPMENT CHANGES		
CONSTRUCTION			OTHERS?		
Describe all changes made					

Have electrical problems been experienced? Yes ___ No ___

Any recent lightning damage? Yes ___ No ___

Do the barn/milking parlor have an equipment potential plane? Yes ___ No ___

Is there a common well for the house and barn? Yes ___ No ___

Well casing depth (if known? __________ Ft.)

Type of water connections?

Well to Tank: Plastic ______ Metal ______

Tank to House: Plastic ______ Metal ______

Tank to Barn: Plastic ______ Metal ______

Barn to Other Buildings: Plastic ______ Metal ______

Did farmer, electrician or other person make any electrical measurements?

Yes ___No ___

(If yes, attach copy if available).

Additional Comments:

____

____

____

2.7 **Collect the information on the electrical service**

SERVICE INFORMATION						
POLE NUMBER						
STREET/ROAD						
DISTRIBUTION TYPE	DELTA		WYE			
ISOLATOR INSTALLED	Y OR N		YES:TYPE			
ON-FARM ACTIVE SUPPRESSION DEVICE	2.7.1 Y OR N		YES:TYPE			
PRIMARY VOLTAGE		SECONDARY VOLTAGE		TYPE SERVICE		TRANSFORMER SIZE
2400		1 PH - 120/240		OH TRI		
4160		3 PH - 120/240		OH OW		
4800		3 PH - 120/208		OH & UG		
7200		3 PH - 120/208/240				
7620						
12470						
13200						
19900						
34500						
Other Voltage						

2.8 **Electrical Configuration**

Primary configuration- single phase or three phase ________________

Wye-delta ratio bank near customer- yes/no _______________________

Number of services fed from transformer - ________________________

pri/sec svc connections pressed or mechanical_______________

Customers sec svc drop connections pressed or mechanical___________

Customers approximate distance (in miles) from the source distribution facility? _______

Customers approximate distance (in miles) from the end of the distribution circuit or tap? __________

2.9 **Isolation Devices**

Is there an isolation device installed on the service? Y or N ____

If yes:

What type of isolation device is used? ______________________

Is the device labeled properly (See Exhibit 2) Y or N ____

Is the pole labeled at eye-level (See Exhibit 1) Y or N____

Is an additional ground rod installed at the transformer pole for the isolated secondary and is the distance between primary and secondary ground rods greater than 6 feet?

Y or N _________; _____ft

Is there a cable television connection and is isolated? Y or N _____

Is there a telephone connection and is it isolated? Y or N _____

2.10 **Make a drawing of the farm**

2.10.1 Show farm buildings and their function, location of transformer and primary wires, wire locations with gauge and lengths indicated, and other relevant information.

3.0 PRELIMINARY MEASUREMENTS

3.1 Measure voltage and current at the customer's meter channel or main switch; record readings in Table 1.

3.2 Measure ground resistance, ground current and voltage from ground rods to isolated reference ground rod. Record as found readings in Table 2a

3.3 Measure ground resistance, ground current and voltage from ground rods to isolated reference ground rod. Record as left readings in the Table 2b

3.4 Determine quality of bonding; record reading in Table 3

3.5 Animal contact measurements; record readings in Table 4 If readings are less than 0.5 VAC, go to step 4.0 (Set Monitoring Equipment).

3.6 If any readings are ≥ 0.5 VAC RMS; investigate the source by disconnecting all loads from the customer's transformer. This may include other customers served from the same transformer.

3.7 If instantaneous readings in Table 4 remain at ≥ 0.5 VAC when all loads are removed the source is off farm; go to step 5.0 (Determine off Farm Causes of Stray Voltage).

3.8 If instantaneous readings in Table 4 reduce to less than 0.5 VAC RMS when the customers load is removed the source is on farm; go to step 9.0 (Determine On Farm Causes of Stray Voltage).

4.0 SET MONITORING EQUIPMENT IF ALL READINGS IN TABLE 4 ARE < 0.5 VAC RMS

4.1 Check locations in the barn to determine the highest animal contact voltage. Compare these readings with and without the salt water solution on paper towel method. The paper towel should be soaked with the salt water solution, new plate placed on top of it with some weight applied. (1 cup NaC1 to 1 gal. water) Record the readings using the method that indicates the highest reading.

4.2 Set monitoring equipment from one to seven days.

4.3 Motors may be started to provide a signature on the recording equipment.

4.4 Monitoring points should include one animal contact point, barn sub panel ground to isolated reference ground rod and one other animal contact point.

4.5 Set recording equipment without shunt resistors to determine if there is a source of high impedance and/or stray voltage. If this voltage is < 0.5 VAC RMS stray or high impedance voltage is not present, the investigation is complete. If RMS voltage is 0.5 VAC, add shunt resistors to the recording equipment to determine if stray voltage or a high impedance source voltage is present. High impedance voltage is not stray voltage but may be an indication of deteriorated wiring on the farm.

4.6 If the monitored voltage with a 500 ohm shunt resistor is 0.5 VAC RMS or greater; identify the source and mitigate. If the monitored voltage is less than 0.5 VAC RMS, stray voltage is not present and the investigation is complete.

5.0 DETERMINE OFF FARM CAUSES OF STRAY VOLTAGE

5.1 Apply customer 240v (≥20amps) loads or artificial loads to check for primary neutral connection problems; an increase in secondary neutral voltage or animal contact voltage may be an indication of a poor primary neutral connection. **Record readings in Table 5**

5.2 Apply 120v (≥10amps) loads at the customer's service causing the stray voltage. The 120 volt loads should be applied from each leg to neutral of the service. **Record readings in Table 5**

Note 1: All readings in Table 5 may not be needed to mitigate the problem.

Note 2: If the source of off farm stray voltage is the primary neutral it may be corrected by reducing primary neutral current below 10 amps, improving neutral connections and moving a ratio bank if in close proximity to the customer.

Note 3: Set recorder 1-7 days, when changes are made to correct off farm causes of stray voltage.

6.0 CHECK PRIMARY GROUNDING

6.1 The National Electrical Safety Code requires a minimum of four primary down grounds per mile on wye system. Check compliance one mile in each direction from the customer.

6.2 Record the readings in Table 6 only if the primary neutral is the source of the stray voltage.

7.0 ISOLATE THE CUSTOMER'S NEUTRAL

7.1 When the utility contribution to animal contact voltage is ≥0.5 VAC RMS and the source is determined to be the primary neutral and corrective action cannot be taken immediately; the primary and secondary neutrals shall be separated with an isolation device. (See Exhibit #1)

7.2 Set monitoring equipment for several days to determine if the stray voltage has been eliminated.

8.0 IF REQUIRED, NOTIFY TELEPHONE AND CABLE COMPANIES PROVIDING SERVICE TO THE CUSTOMER WITH THE ISOLATED NEUTRAL. (Note in Table 7)

9.0 DETERMINE ON FARM CAUSES OF STRAY VOLTAGE

9.1 Apply customer 240v (20amps) and 120v (10amps) loads or artificial loads at different locations on the farm's service. The 120 volt loads should be applied from each leg to neutral of the service. Record readings in Table 8 If improvements are made to correct on farm causes of stray voltage; set monitoring equipment from one to seven days to see if the problem has been corrected.

Note: All readings in Table 8 may not be needed to mitigate the problem.

10.0 REPORTS

10.1 A copy of a report including a summary of test results, corrective actions, recommendations and suggestions given to the customer shall be maintained by the Director of Electric Operations.

10.2 **For Privileged & Confidential incidents, all documents and/or information must be labeled and handled according to the requirements set by the Legal Department.**

11.0 Tables

11.1 **Table 1 – Customer's Meter Channel or Main Switch Measurements**

METER CHANNEL OR MAIN SWITCH MEASUREMENTS			
VOLTAGE		CURRENT	
L1-N		L1	
L2-N		L2	
L1-L2		NEUTRAL	

11.2 **Table 2a – "As Found" Readings**

GROUND RESISTANCE, GROUND CURRENT & VOLTAGE TO ISOLATED GROUND ROD MEASUREMENTS											
			"AS FOUND" READINGS				"AS FOUND" READINGS				"AS FOUND" READINGS
			NORMAL FARM LOAD VOLTAGE TO REF GRD				NO LOAD VOLTAGE TO REF GRD				>10 AMPS NEUTRAL CURRENT See Note 5
LOCATION	RESISTANCE (OHMS)	CURRENT (AMPS)	5K SH. RES		NO RES.		5K SH. RES.		NO RES.		5K SHUNT RES.
			AC	DC	AC	DC	AC	DC	AC	DC	
PRI GRD ROD											N/A
ISOL GRD ROD-1			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A
METER											N/A
SER ENTR. BARN											
SER. ENTR. HOUSE											

NOTE 1: INSTALL THE ISOLATED GROUND ROD AT AN APPROXIMATE DEPTH OF 4 FT, 25FT OR MORE FROM THE BARN, SERVICE POLE AND ANY UNDERGROUND STRUCTURES.

NOTE 2 REMOVING ALL LOAD FROM THE CUSTOMER'S TRANSFORMER MAY INCLUDE OTHER CUSTOMERS.

NOTE 3 GROUND ROD RESISTANCE MEASUREMENTS ARE NOT REQUIRED ON DELTA PRIMARY SYSTEMS.

NOTE 4 IF THE READINGS ARE D.C., THE PROBLEM IS LIKELY CAUSED BY ELECTROLYSIS OR IS RELATED TO TELEPHONE CIRCUITS. ADVISE CUSTOMER THAT WE ARE NOT THE SOURCE OF THE PROBLEM AND SUGGEST POSSIBLE SOURCES.

NOTE 5 APPLY $\geq$ 10 AMPS ON EACH 120V LEG AT THE BARN AND HOUSE SERVICE ENTRANCE; RECORD HIGHEST READING.

Table 2b – "As Left" Readings

GROUND RESISTANCE, GROUND CURRENT & VOLTAGE TO ISOLATED GROUND ROD MEASUREMENTS											
			"AS LEFT" READINGS				"AS LEFT" READINGS				"AS LEFT" READINGS
			NORMAL FARM LOAD VOLTAGE TO REF GRD				NO LOAD VOLTAGE TO REF GRD				$\geq$ 10 AMP NEUTRAL CURRENT
LOCATION	RESISTANCE (OHMS)	CURRENT (AMPS)	5K SH. RES		NO RES.		5K SH. RES.		NO RES.		SHUNT 5K RES.
			AC	DC	AC	DC	AC	DC	AC	DC	
PRI GRD ROD											N/A
ISOL GRD ROD-1			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A
METER											N/A
SER ENTR. BARN											
SER. ENTR. HOUSE											

NOTE 1: AS LEFT VOLTAGE READINGS ARE ONLY REQUIRED IF AS FOUND READINGS WERE >= 0.5 VAC RMS.

11.3 Table 3 – Bonding To Sub Panel Ground Measurements

RESISTANCE IN OHMS - "FROM" BARN SUB PANEL GROUND "TO"								
WATERLINE			BULK TANK					
STANCHION			H2O BOWL					

NOTE 1: SUGGEST CUSTOMER IMPROVE BONDING IF ANY READINGS ARE GREATER THAN 4 OHMS.

NOTE 2: CHECK AND RECORD ANY BONDING READINGS THE FARMER THINKS MAY BE CAUSING A STRAY VOLTAGE PROBLEM.

11.4 Table 4 - Animal Contact Measurements

	AS FOUND	AS FOUND	AS FOUND		AS LEFT	AS LEFT	AS LEFT
VOLTAGE FROM	TO FLOOR: OPEN CKT	TO FLOOR: SHUNTED	TO FLOOR: SHUNTED	SHUNT RES. (+-2%)	TO FLOOR: OPEN CKT	TO FLOOR: SHUNTED	TO FLOOR: SHUNTED
	(RMS VAC)	(RMS VAC)	(VDC)	OHMS	(RMS VAC)	(RMS VAC)	(VDC)
METAL STANCHION				500			
MILK LINE				500			
MILK MACH. CLAW				500			
WATERING CUP				500			
METAL FEEDER				500			
BULK TANK				500			
ELECTRIC CONDUIT				500			
STEP POTENTIAL FROM- T0-				500			

NOTE 1: A 4" x 4" COPPER PLATE ON THE BARN FLOOR WITH SOME WEIGHT APPLIED WILL BE USED FOR ANIMAL CONTACT MEASUREMENTS. A SALT WATER SOLUTION MAY BE APPLIED TO THE FLOOR TO MAKE BETTER CONTACT WITH THE 4 "x 4" COPPER PLATE.

NOTE 2: SALT WATER SOLUTION - 1 CUP NaC1 TO 1 GAL. OF WATER

NOTE 3: AS LEFT READINGS ARE ONLY REQUIRED WHERE THE AS FOUND READINGS ARE 0.5 VAC RMS or 0.5 VDC.

11.5 **Table 5 - Off Farm Cause of Stray Voltage Measurements**

OFF FARM CAUSE OF STRAY VOLTAGE MEASUREMENTS							
		240 VOLT LOAD		120 VOLT LOAD			
		LOCATION-		LOCATION-			
		AMPS-		AMPS-			
LOCATION	TIME	NO LOAD	LOAD	NO LOAD	LOAD L1-N	LOAD L2-N	LOAD L3-N
VOLTAGE							

11.6 **Table 6 – Primary Grounding Check**

PRIMARY GROUNDING CHECK					
DIRECTION	POLE NO.	DIST (MILES)	RES. (OHMS)	CURR. (AMPS)	VOLTAGE TO RR
A					
B					

PRIMARY GROUNDED PER NATIONAL ELECTRICAL SAFETY CODE
YES OR DATE CORRECTED ____________________________________

TRANSFORMER AND ARRESTORS ARE WIRED PER ELECTRIC DISTRIBUTION STANDARDS
YES OR DATE CORRECTED ____________________________________

11.7 Table 7 - Inter-Utility Protocol/Notification

INTER-UTILITY PROTOCOL/NOTIFICATION			
TELE/CATV COMPANY	DATE NOTIFIED	HOW NOTIFIED	CONTACT PERSON

11.8 Table 8 - Farm Causes of Stray Voltage Measurements

FARM CAUSES OF STRAY VOLTAGE MEASUREMENTS							
		240 VOLT LOAD		120 VOLT LOAD			
		LOCATION-		LOCATION-			
		AMPS-		AMPS-			
LOCATION	TIME	NO LOAD	LOAD	NO LOAD	LOAD L1-N	LOAD L2-N	LOAD L3-N
VOLTAGE							
PRI NEUT. TO RR		1		2			
SEC NEUT		3		4			
CONTACT VOLTAGE		5		6			
L1-2 @ MTR		7					
L1-2 @ SVC PNL		8					
L1-N @ MTR				9			
L2-N @ MTR				10			
L1-N @ SVC PNL				11			
L2-N @ SVC PNL				12			
CURRENT							
L1 @ MTR		13		14			
L2 @ MTR		15		16			
NEUT @ MTR		17		18			
L1 @ SVC PNL		19		20			
L2 @ SVC PNL		21		22			
NEUT @ SVC PNL		23		24			

VOLTAGE DROP							
PRI GRD TO MTR GRD				25			
MTR GRD TO SVC PNL GRD				26			

NOTE 1: BALANCING LOAD, REDUCING SECONDARY NEUTRAL RESISTANCE & IMPROVING GROUNDS MAY BE WAYS TO REDUCE ON FARM CAUSES OF STRAY VOLTAGE.

11.9 **Table 8 - Farm Causes of Stray Voltage Measurements Continued: Farm Source**

11.9.1 Using the information gathered in the chart, Table 8, review the following partial listing for potential problems.

11.9.2 An increase in primary NEV with the application of only 240 volt loads (measurement 1) may be an indicator of neutral or grounding problems at the transformer or primary neutral. If no problems can be found, isolation may be the only way of mitigating these voltages for the customer.

11.9.3 An increase in contact voltage with the application of 240 volt loads (measurement 5), without a corresponding increase in the primary neutral to a RR voltage (measurement 1), may be an indication of equipment or wiring problems. If it can be isolated to a specific circuit, notify the customer.

11.9.4 A large increase in contact voltage with the application of a 120 volt load (measurement 6), may be an indication of equipment or wiring problems. If it can be isolated to a specific circuit, notify customer.

11.9.5 A voltage differential between the phase voltages measured at the meter (measurement 7) and the service panel (measurement 8) can indicate an undersized service.

11.9.6 A differential in phase currents (measurements 14, 16, 20 and 22) and neutral currents (measurements 18 and 24) when applying 120 volt loads can be an indication of equipment failure, high resistance connections, or improper wiring.

11.9.7 An increase in neutral currents (measurements 17 and 23) when applying 240 volt loads can be an indication of improper wiring or, if using on farms loads, equipment failure.

11.9.8 If any secondary neutral voltage drops (measurements 25 and 26) exceed 1 volt, then calculate the resistance of the neutral and its connections to determine if action should be taken. Using the voltage drops (measurements 25 and 26) and the neutral currents (measurements 18 and 24) entered on the chart (Table 8), calculate the resistance of the service neutral wire and connections and compares it to the values listed on the resistance chart (Table 8a).

Length of Neutral _______________ V drop________________ Current__________________

Measured Resistance_________________ **Resistance from Chart**____________________

Table 8a – Wire Resistance:

WIRE RESISTANCE AT 20C (68F) (CHANGES AT CA. +0.35%/C FOR COPPER)

SIZE	AL	CU	SIZE	AL	CU
AWG	OHMS/100FT	OHMS/100FT	AWG	OHMS/100FT	OHMS/100FT
18	1.050	0.63850	3	0.0323	0.01970
16	0.659	0.40160	2	0.0256	0.01563
14	0.414	0.25250	1	0.0203	0.01239
12	0.261	0.15880	1/0	0.0161	0.00982
10	0.164	0.09989	2/0	0.0128	0.00779
8	0.103	0.06282	3/0	0.0101	0.00618
6	0.0648	0.03951	4/0	0.00804	0.00490
4	0.0408	0.02485			

11.10 **SUMMARY OF TEST RESULTS**

Corrective Action, Recommendations and Suggestions Given to the Customer

CUSTOMER'S NAME ____________________________ **DATE** _____________________

ADDRESS ____________________________________ **TESTED BY** _______________

PHONE # _____________________________________

PREMISE # ___________________________________

POLE # ____

Stray Voltage at animal contact greater than 0.5 VAC RMS YES OR NO

i. CAUSE:

A) Off farm YES OR NO

B) On farm YES OR NO

Neutral isolation device installed ________________________

Primary and Secondary isolated YES OR NO

Bonding

Water line _______ ohms OK or IMPROVE ___________

Stanchion _______ ohms OK or IMPROVE ___________

Bulk Tank _______ ohms OK or IMPROVE ___________

H2O bowl _______ ohms OK or IMPROVE ___________

Describe any other corrective action taken, suggestions/recommendations given to the customer.

____

____

____

____

____

____

____

____

____

2. Customer satisfied or unsatisfied with investigation results. YES OR NO
   The Electric Meter Services Supervisor or Electric Planning Engineer will mail a copy of this page to the customer.
   Date ___________________

3. The Electric Meter Services Supervisor or Electric Planning Engineer will mail a form letter with results of the stray voltage investigation and any recommendations to the farmer.
   Mailing Date: ________________

12.0 EQUIPMENT:

The following tools are recommended to perform a stray voltage investigation:

12.1 Digital Multimeter (such as the Fluke Model87)
AEMC Instruments L205 Stray Voltage Logger or Equivalent.

12.2 Stray Voltage Complaint Equipment Verification Procedure

12.2.1 Secure a calibrated Digital Multimeter with the following capabilities: (i.e. Fluke Model 87)

12.2.2 Function: DC Volts (.5 VDC to 5 VDC sensitivity range)

12.2.3 Required Accuracy: ±0.5%

12.2.4 Function: AC Volts (0.5 VAC to 5 VAC sensitivity range)

12.2.5 Required Accuracy: ±1.0%

12.2.6 Voltage Resolution: 0.1 Volt level

12.2.7 Function: Resistance 0 to 10000 ohms

12.2.8 Required Accuracy: ±0.5%

12.2.9 Capacity of Not Reading D.C. on the A.C. Scale

12.2.10 A high input impedance (>5000 ohms) and be battery operated.

12.2.11 Record Digital Multimeter Model, ID# and Calibration Due Date in Accuracy Verification Date column in Equipment Verification Table

12.2.12 Recorder Verification:

a. Record Recorder Model and ID # on Equipment Verification Table

b. Verify the Stray Voltage Recorder operates and reads properly at 0.5 VAC, 1.0 VAC, 2.5 VAC and 5.0 VAC using a voltage source and the calibrated Digital Multimeter for comparison. Record date in Equipment Verification Table

12.2.13 500 ohm and 5000 ohm Shunt Resistor Verification:

a. A 5000 ohm shunt resistor will be used when taking voltage readings from a secondary neutral to auxiliary ground. A 500 ohm shunt resistor shall be used for animal contact measurements.

b. Verify the Shunt Resistors are within ±2% using the calibrated Digital Multimeter. Record in the Equipment Verification Table

12.2.14 Ground Resistance Meter Verification:

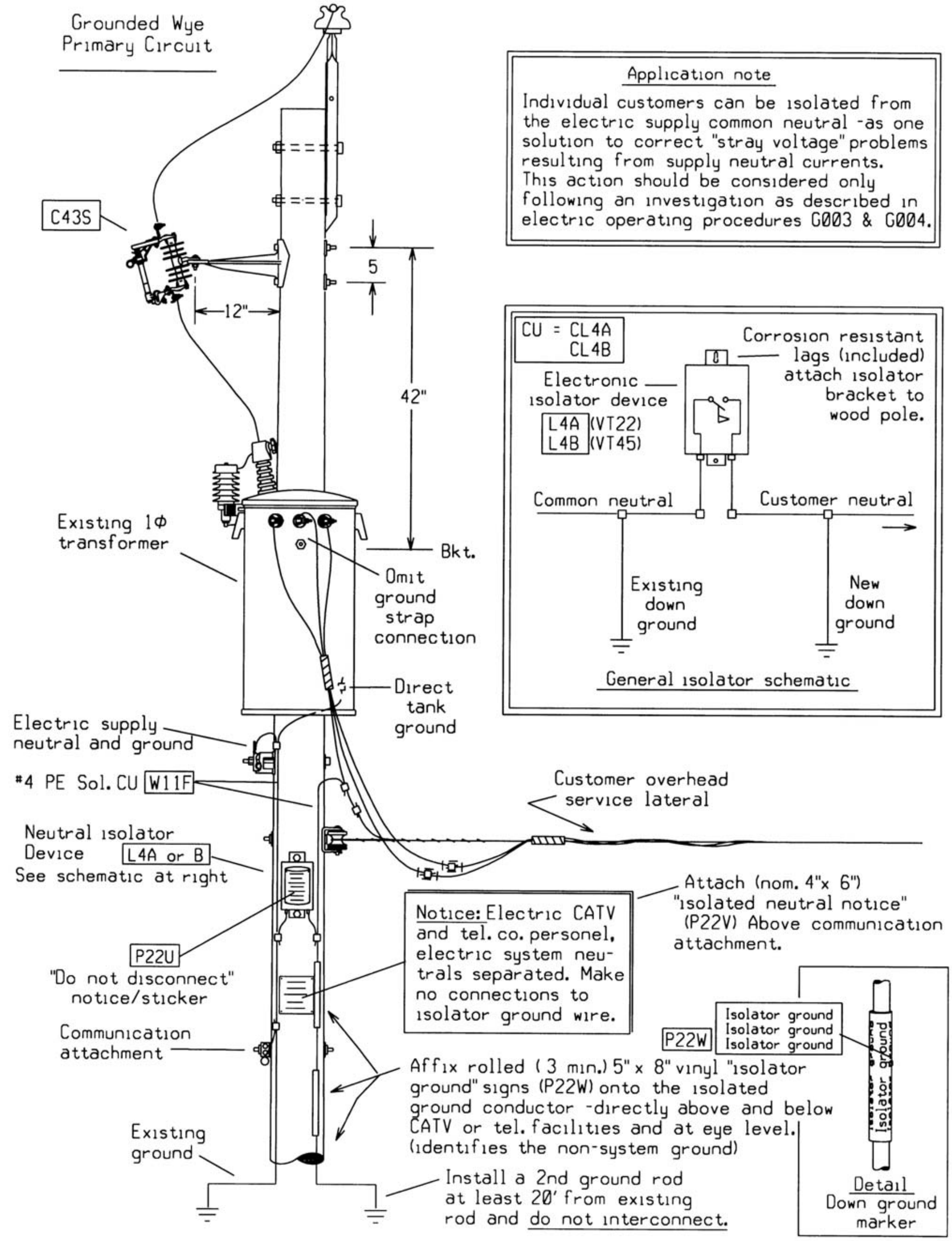
a. Record Ground Resistance Meter Model and ID # on Test Card.
b. Verify the Ground Resistance Meter operates and reads properly per manufacturer's operation check procedure. Record date on Equipment Verification Table.

12.2.15 Equipment Verification Table

EQUIPMENT VERIFICATION TABLE				
Device	**Manufacturer**	**Model #**	12.2	**Accuracy Verification. Date**

Liberty Utilities	Doc. # LU-EOP G003		
Electric Operating Procedure	**01-01-2017**	**General**	
Shock and/or Neutral-to-Earth Voltage Complaint	**Revision #**	**1.1**	**Page: 23 of 25**

13.0 EXHIBITS: Exhibit 1 – "Isolated Neutral Transformer Connection for Customers Affected by Neutral-to-Earth Potential – WYE Circuits"



13.1 **Exhibit 2 – "Isolator Labels" P-22U, P-22V, P22-W Symbol #'s 0810204, 0810205, 0810206**

MARKER, NOTICE – DO NOT DISCONNECT OR BYPASS

Label, pressure sensitive vinyl decal, NOTICE – white letters on blue background, all other letters – black on white background.

STD ITEM	CU	ITEM ID
P22U	CP22U[1] CL4A[1,2] CL4B[1,2]	8830-0810204

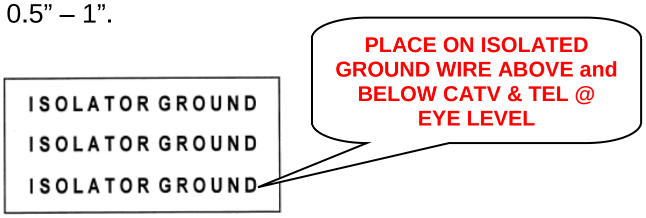
SIGN, NOTICE – ELECTRIC SYSTEM NEUTRALS SEPARATED

Label, NOTICE – 3.75" X 5.75", aluminum baked enamel with urethane, NOTICE – white letters on blue, all other letters black on white.

STD ITEM	CU	ITEM ID
P22V	CP22V[1] CL4A[1,2] CL4B[1,2]	8830-0810206

MARKER, CABLE – ISOLATOR GROUND

4 ¾" X 8" X 0.010" vinyl. Black letters on yellow for use on special isolated neutral poles.
0.5" – 1".



STD ITEM	CU	ITEM ID
P22W	CP22W[1] CL4A[1,2] CL4B[1,2]	8830-0810205

14.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
4/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

INTRODUCTION

This procedure describes the requirements for investigating and reporting on a customer's shock complaint. A shock complaint is a customer call that states a person has received a shock. When investigating of a shock complaint, the Company field personnel must determine if the shock was caused by faulty customer equipment, a neutral-to-earth voltage associated with the Company's distribution system, or an external DC voltage source. Regardless of the cause, a shock complaint is considered a high priority and shall be dispatched as soon as possible. The appropriate Dispatch & Control Center shall be notified of all shock incidents by the field, and all communications shall be completed as required by Liberty Utilities Electric Operating Procedure LU-EOP G009.

PURPOSE

This document details specific steps that should be followed when Liberty Utilities receives a shock complaint call.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide appropriate guidance to field personnel when requested for a specific work related tasks.

2. Electric Distribution Operations
   A. Ensure this procedure is implemented in the field.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   A. Demonstrate an understanding of the procedure.
   B. Comply with the requirements of the procedure.
   C. It is the workers responsibility to read and fully understand and follow the manufacturer's Instruction manual and specifications before operating any equipment.

COORDINATION

N/A

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

LU-EOP G003 Shock and/or Neutral-to-Earth Voltage Complaint

LU-EOP G009 Personal Injury Accidents/Newsworthy Event Reports

Liberty Utilities Distribution Construction Standards

DEFINITIONS

Shock Voltage: Voltage between two points that is high enough to be perceptible to people.

Primary Voltage: All distribution circuit cables or conductors energized at 4, 15, 23, or 34.5 kV.

Shall: The word shall is to be understood as mandatory.

Should: The word should is understood as recommended.

TRAINING

A written request should be submitted to Learning and Development by user group whenever training is required.

DOCUMENT CONTENTS

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1.0 SAFETY

1.1 All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook, Safety Rules, and all appropriate Liberty Utilities Electric Operating Procedures.

1.2 All appropriate Personal Protective Equipment including, but not limited to, hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook, Safety Rules, and applicable work procedures.

2.0 ORDER PROCESSING

2.1 Regardless of the cause, all shock complaints are considered an emergency order type that requires immediate dispatch. When the Customer Call Center (CCC) receives a call from a customer stating that a person has received a shock, the CCC:

2.1.1 Immediately transfers to Dispatch any calls from 911 officials with an associated emergency or life threatening situation.

2.1.2 Retrieve the customer's account information and verify the customer's account information on the Account window.

2.1.3 Inform the customer that someone needs to be present at the premise in order for the shock complaint to be investigated. Inform the customer that their service may be disconnected if no one is present at the premise and a problem is detected.

2.1.4 Complete the Issue Investigation Order for Account or a Service Order Form (paper copy) in its entirety and fax the completed form to the appropriate dispatch office when the Customer Service System is down.

2.1.5 Call Dispatch office to verify receipt the Investigation Order or the Faxed Service Order.

3.0 INVESTIGATION

3.1 The individual investigating (generally a field service representative) a shock complaint shall:

3.1.1 Initiate Shock and/or Neutral to Earth Voltage Complaint Investigation Form (Exhibit 1)

Use this form on **every** shock complaint order, even when the individual conducting the investigation resolves the problem him/herself without involving outside departments.

3.1.2 Make the first check with a Liberty Utilities approved testing device between a known ground source and the origin of the shock.

3.1.3 If the test between the ground and the shock source indicates higher than secondary voltages:

a. Safely evacuate customer(s) from the premise.

b. Contact Electric Operations Supervisor and System Operations Dispatch & Control from a remote location and request Electric Operations assistance.

c. Safeguard and keep the hazardous area clear until Electric Operations provides relief.

3.1.4 If the test between ground and the source of the shock indicates secondary or lower voltages:

a. Connect an AC multi-range voltmeter (such as Fluke 87) that provides true RMS at the same location and observe the readings. Leave the voltmeter connected at this location.

b. Check for proper bonding. If additional bonding is required, assist or advise the customer accordingly.

c. Open the customer's main breaker(s)/fuse(s), remove the meter and observe the voltmeter.

1. If voltage drops to zero, the problem is within the customer's equipment.
   i. Reinstall meter and close main breaker(s)/fuse(s).
   ii. Isolate the trouble circuit by opening each breaker/fuse one at a time until the voltage reading on the voltmeter drops to zero.
   iii. Identify equipment and wiring on troubled circuit.
   iv. Isolate and disconnect troubled equipment.
   v. The individual conducting the investigation shall inform the customer to contact a licensed electrician or appliance repair person to check out internal wiring or appliances.
   vi. Record this information on the Shock and/or Neutral to Earth Voltage Complaint Investigation Form (Exhibit 1).
2. If the voltage does not drop to zero, each customer on the same secondary shall be disconnected in the same manner as above. Any other customers in close proximity and with a common water supply may also have to be checked. In each case, the voltmeter should remain connected at the original complaint's premise.
3. If voltage is still present after steps 1 & 2 have been completed, it will be necessary to determine if the condition is the result of a neutral-to-earth AC source or a DC voltage. Connect the AC-DC multi-range voltmeter that provides true RMS and use the DC scale to observe readings:
   i. If DC voltage is measured, the problem is with a DC source (i.e., cable TV, telephone). Inform the customer that the problem is with a source that Liberty Utilities cannot correct or check.
   ii. Record this information on the Shock and/or Neutral to Earth Voltage Complaint Investigation Form (Exhibit 1).
   iii. Notify Communications Companies.
4. If voltage is still present after steps 1 & 2 have been completed and the voltage is AC:
   i. Further investigation is required by the Electric Planning Engineering or the Electric Operations Department as per Electric Operating Procedure G003 – Shock and/or Neutral-to-Earth Voltage Complaint.
   ii. Record this information on the Shock and/or Neutral to Earth Voltage Complaint Investigation (Exhibit 1) and forward to the Electric Planning Engineering.

Liberty Utilities	Doc. # LU-EOP G004		
Electric Operating Procedure	**01-01-2017**	**General**	
Shock Complaints	**Revision #**	**1.1**	**Page: 5 of 6**

EXHIBIT 1
"Shock and/or Neutral-to-Earth Voltage Complaint Investigation Report"

SHOCK AND /OR NEUTRAL TO EARTH
VOLTAGE COMPLAINT INVESTIGATION REPORT

Liberty Utilities

Customers's Name			Phone
Street, Road, Etc.	Circuit	Pole or Enclosure	
City, Town Village			

TEST LOCATION SKETCH

VOLTAGE READINGS

CIRCUIT CONFIGURATION	A.C. Volts As Found	A.C. Volts As Left	D.C. Volts As Found	D.C. Volts As Left	CORRECTIVE ACTION
Normal					
Meter Removed					

REMARKS

DATE:	BY:

RS0024 (11/06)

4.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
4/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

INTRODUCTION

This procedure details the information required to determine adequacy of insulation of tools and insulated equipment which are subjected to high voltage dielectric testing. High voltage dielectric shall be performed on the following tools and insulated equipment as required:

1. Mobile insulated equipment.
2. Platform (bucket) liner.
3. Hydraulic fluid.
4. Hydraulic hoses.
5. Live Line Tool (Hot Sticks).
6. Switch sticks, tel-o-scopic switch sticks and cable spears.
7. Test sticks and phasing sticks.
8. Ground sticks.
9. Tree trimming tools including, but not limited to, hydraulic limb loppers, chain saws, and insulated hand trimming pruners and pole saws.
10. Line hoses and insulated covers.
11. Rubber gloves and sleeves.
12. Insulated blankets.
13. Visual inspection of personal grounds.

PURPOSE

Not Applicable

ACCOUNTABILITY

Lab & Testing Service Approved Vendor

COORDINATION

Not applicable

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

Code of Federal Regulations 29CFR1910.269 (l) Live Line Tools

Code of Federal Regulations 29CFR1910.137 Electrical protective equipment

ASTM Procedures

ANSI Standards

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon written request.

DOCUMENT CONTENTS

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1.0 TESTING OF INSULATED MOBILE EQUIPMENT

1.1 Responsibility

1.1.1 Liberty Utilities Fleet Management shall be responsible for scheduling, with Electric Operations Department, all tests to be performed on mobile insulated equipment. These tests shall be scheduled according to the "Schedule for Testing Tools and Insulated Equipment Chart." It shall be the responsibility of Fleet Management or contracted vendor to correct the conditions which caused the failure and to retest. The User Department shall be responsible for scheduling tools and equipment per appropriate Liberty Utilities EOP.

1.2 Type and Frequency

ANY TIME ANY WORK IS PERFORMED ON THE EQUIPMENT THAT MIGHT AFFECT THE DIELECTRIC PERFORMANCE; A PERIODIC DIELECTRIC TEST SHALL BE MADE.

1.2.1 Acceptance testing shall be performed on the following:

a. all newly purchased equipment

b. newly rented equipment, and

c. all rebuilt equipment

The acceptance testing will subject the equipment to the following:

d. Bucket trucks will be subjected to an AC proof test per LU-EOPG5.01.

e. Digger Derricks will be subjected to either an AC or DC proof test per LU-EOPG5.02.

An acceptance test is <u>not required</u> to be completed internally if proof of a successful acceptance test is provided by the vendor. In this case, a periodic dielectric test shall be completed.

1.2.2 A four (4) month test is not performed. The periodic test is scheduled and performed on a yearly basis or under special conditions by the Testing Contract Vendor.

1.2.3 Failure of any one of these tests shall dictate that the aerial equipment be tagged, and shall not be used in an energized area until the condition is corrected.

1.3 Special Tests

1.3.1 In addition to the above test schedule, any chief of a crew using insulated mobile equipment may request supplemental dielectric tests when, in his/her judgment, the equipment has been subjected to abnormal conditions.

1.4 Tagging

1.4.1 When equipment has failed a dielectric test, or when any work has been performed on insulated aerial mobile equipment that might affect its dielectric performance, a tag shall be placed on all bucket controls and in a prominent position on the driver's side of the cab. When equipment is so tagged, it shall not be used in energized areas until the condition is corrected.

1.5 Test Review and Records

1.5.1 These tags shall be removed only by the responsible testing department following a successful dielectric test.

1.5.2 Test data on insulated mobile equipment is recorded and maintained by the Testing Contract Vendor and Liberty Utilities Fleet Management. The data is available on request.

1.5.3 Certification of dielectric testing on the equipment shall also be shown by listing the test date, month and year, and the tester's name on the label located behind the driver on the cab roof.

2.0 TESTING OF PLATFORM (BUCKET) LINERS

2.1 Responsibility

2.1.1 Liberty Utilities Fleet Management/Electric Operations shall be responsible for scheduling all tests on new platform (bucket) liners and conducting the associated test on field used platform (bucket) liners as directed by the "Schedule for Testing Tools and Insulated Equipment Chart" on page 11.

2.2 Type and Frequency

2.2.1 When received from the supplier and at twelve (12) month intervals thereafter, all platform (bucket) liners shall be subjected to a dielectric test of either 35 kV AC or 100 kV DC as directed by LU-EOPG5.03.

2.2.2 The liner shall be considered dielectrically adequate if it withstands a minimum of 35kV AC for one (1) minute or 100kV DC for three (3) minutes.

2.2.3 On failure of the above test, repairs shall be made according to the procedure stated in LU-EOPG5.03.

2.2.4 Any liner may be rejected for further use if it exhibits signs of severe wear, physical or dielectric deterioration.

2.3 Special Tests

2.3.1 In addition to the above test schedule, any crew chief using platform (bucket) liners, may request supplemental dielectric tests when, in his/her judgment, the equipment has been subjected to abnormal conditions.

2.4 Test Review and Records

2.4.1 Certification of successful dielectric testing shall be shown on all platform (bucket) liners by writing the test voltage, liner size, truck number and due date on the outside of the liner. Test data shall be maintained for all bucket liners tested.

3.0 TESTING OF HYDRAULIC FLUID

3.1 Responsibility

3.1.1 Fleet Management shall be responsible for Acceptance Testing of Hydraulic Fluid per Fleet Management Procedures.

4.0 TESTING OF HYDRAULIC HOSES

4.1 Responsibility

4.1.1 The User Department /Fleet Management shall be responsible for scheduling and conducting the testing of hydraulic hose in accordance with the "Schedule for Testing Tools and Insulated Equipment Chart" on page 11.

All hydraulic hose shall be subjected to a visual inspection by the user prior to use. If, in the judgment of the Crew Leader, the visual inspection reveals defects that could obviously affect the dielectric or mechanical integrity of the hose, he/she shall be responsible to remove the hose from service

4.2 Type and Frequency

4.2.1 When received from the supplier and at 24-month intervals thereafter, all non-conductive hydraulic hose shall be subjected to a dielectric test in accordance with OSHA Standard 29 CFR Part 1910.269(j) Live Line Tool Testing.

4.2.2 Each hydraulic hose shall be wiped clean and visually inspected for defects before use each day by the user department.

4.2.3 Each hose will be considered dielectrically adequate if it passes one of the two tests below:

a. Each hydraulic hose must withstand a minimum of 100kV DC for one (1) minute or 75kV AC for three (3) minutes. For DC testing the maximum leakage current shall not exceed 10 micro-amps end to end and 125 micro-amps per foot of insulated section. For AC testing the maximum leakage current shall not exceed 100 micro-amps per foot or applicable manufacturer's specifications.

b. Alternately, hydraulic hose can be tested by the user department using an approved tester. (Hipotronics DC Hose Tester, Model BH50/A375). Note: Calibration of the Hipotronics DC Hose Tester shall be performed by an approved testing service.

4.2.4 When a hydraulic hose fails any one of the above tests, it shall be tagged "Defective," removed from service and notification of the failure be given to the Supervisor.

4.3 Test Review and Records

4.3.1 The Liberty Utilities Fleet Management/Testing Contract Vendor will maintain records for each hydraulic hose tested and provide copies to Electric Operations Department.

4.3.2 All field locations using the Hipotronics DC Hose Tester, Model BH50/A375 shall maintain records for each hydraulic hose tested.

4.4 Label

4.4.1 All non-conductive hose shall be identified with a red or orange cover. Certification of successful dielectric testing shall be shown on all hydraulic hose by the use of a label showing the test date. The label must be applied to the insulated portion of the hydraulic hose following successful completion of the dielectric test.

<u>5.0 TESTING OF LIVE LINE TOOLS</u>

THIS INCLUDES THE TESTING OF TOOLS REFERRED TO AS:

1. SWITCH STICKS
2. HOT STICKS
3. CABLE SPEARS
4. TEL-O-POLES
5. TEST STICKS
6. PHASER POLES
7. GROUND STICKS
8. SHOTGUN STICKS

5.1 Responsibility

5.1.1 The User Department shall be responsible for scheduling and conducting the testing of the equipment in accordance with the "Schedule for Testing Tools and Insulated Equipment Chart" on page 11.

5.2 Live Line Tools

5.2.1 Each live line tool shall be wiped clean and visually inspected for defects before use each day. If the crew leader determines that any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the live line tool is present after wiping, the tool shall be removed from service and examined and tested before being returned to service.

5.3 Type and Frequency

5.3.1 Live line tools shall be tested for surface leakage in accordance with OSHA standard 29 CFR Part 1910, which requires the above listed sticks to pass a wet test.

5.3.2 The wet test shall be performed as follows:

a. Wipe clean.

b. Using laundry type spray bottle - apply a light mist of demineralized water until beading occurs.

c. Avoid over wetting - excessive water on tool can cause a false reading.

d. Use the A.B. Chance L.S. 80 or Hastings wet/dry tester model 6799 to perform test.

5.3.3 When equipment has failed an above test, it shall be tagged "Defective," removed from service, and notification of the failure shall be given to the Supervisor.

5.4 Test Review and Records

5.4.1 The Manager of Electric Operations shall maintain all records for the testing of live line tools.

5.5 Label

5.5.1 A test label showing the test date is applied to the tool following successful completion of the dielectric test.

6.0 TESTING OF TREE TRIMMING TOOLS

6.1 Responsibility

6.1.1 It shall be the responsibility of the Tree Trimming Contractor, to schedule all tree trimming tools for testing according to the "Schedule for Testing Tools and Insulated Equipment Chart" on page 11.

6.2 Type and Frequency

6.2.1 The Tree Trimming Contractor shall perform the following on all tree trimming tools that have been sent to outside vendors for repair:

a. disassemble the tool

b. visually inspect to ensure that the internal insulating portions of the stick on hydraulic tools have not been repaired or replaced with metal "orchard" tools parts.

c. surface test the internal and external insulating sections using an approved tester, (i.e., Chance "Hot Stick Tester" Model LS-80). See instruction sheets accompanying the test equipment for specific test voltages to be applied to various insulation ratings.

6.2.2 All tree trimming tools shall be tested every twelve (12) months by the User Department, using an approved tester, (i.e., Chance "Hot Stick Tester" Model LS-80 or Hastings Wet/Dry Tester Model 6799). See instruction sheets accompanying the test equipment for specific instructions.

6.2.3 When equipment has failed an above test, it shall be tagged "Defective," removed from service, and notification of the failure shall be given to the Supervisor.

6.3 Test Review and Records

6.3.1 The Tree Trimming Contractor tool tests shall be recorded and kept on file and shall be provided to Liberty Utilities upon request.

6.4 Label

6.4.1 A test label showing the test date, must be applied to each tree trimming tool following successful completion of dielectric test.

7.0 INSPECTION OF INSULATED COVERS, LINE HOSES AND BARRIERS

7.1 Responsibility

7.1.1 The User Department shall be responsible for conducting the visual test on insulated covers, line hoses and barriers in accordance with the "Schedule for Testing Tools and Insulated Equipment Chart" on page 11.

7.2 Type and Frequency

7.2.1 Prior to using an insulated cover, line hose or barrier a detailed visual inspection shall take place over the entire inner and outer surfaces for evidence of punctures, cuts, severe ozone cuttings, contaminants, or any other physical conditions that could adversely affect the insulating quality of the material. The User Department is responsible for training personnel in proper visual inspection techniques. Contaminants can be removed by washing and drying the equipment as recommended by the equipment manufacturer.

7.2.2 If a line hose fails the visual inspection, the item shall be discarded. If an insulated cover fails the visual inspection the item shall be cleaned or discarded as appropriate.

8.0 TESTING OF RUBBER GLOVES AND SLEEVES

8.1 Responsibility

8.1.1 A Liberty Utilities Approved and Certified Vendor shall schedule and perform the testing on rubber gloves and sleeves as required by the "Schedule for Testing Tools and Insulated Equipment Chart on Page 11.

8.2 Type and Frequency

8.2.1 Gloves and sleeves shall be tested in accordance with OSHA standard 29CFR Part 1910.137.

8.2.2 Gloves Class 0/II - When received from the supplier and at three (3) month intervals, all rubber gloves shall receive a voltage-proof-test conducted at their appropriate class rating test voltage. Reference "Test Procedure for Electrical Testing of Rubber Gloves" (LU-EOPG5.04).

8.2.3 leeves Class II - When received from the supplier and at six (6) month intervals, all rubber sleeves shall receive a voltage-proof-test conducted at their appropriate class rating test voltage. Reference "Test Procedure for Electrical Testing of Rubber Sleeves" (LU-EOPG5.05).

8.2.4 Rubber gloves and sleeves shall be considered dielectrically adequate if they sustain the applied voltage for one (1) to three (3) minutes and exhibit, when visually inspected, no punctures, tears, cuts, bruises, ozone cutting or cracking, or any other conditions that would adversely affect performance.

8.3 Test Review and Records

8.3.1 Certification of dielectric testing shall be shown on all rubber gloves and sleeves by labeling the equipment with the next test due date.

8.3.2 All testing records are recorded in the database by serial number.

9.0 TESTING ON INSULATED BLANKETS:

9.1 Responsibility

9.1.1 A Liberty Utilities Approved and Certified Vendor shall schedule and perform testing on insulated blankets according to the “Schedule for Testing Tools and Insulated Equipment Chart” on page 11.

9.2 Type and Frequency

9.2.1 Blankets shall be tested in accordance with OSHA standard 29CFR Part 1910.137.

9.2.2 When received from the supplier and at yearly intervals thereafter, all insulated blankets shall be voltage-proof-tested. Refer to the "Test procedure for Electrical Testing of Insulated Blankets" (LU-EOPG5.06).

9.2.3 An insulated blanket shall be considered dielectrically adequate if it sustains the applied voltage for one (1) to three (3) minutes.

9.2.4 On failure of dielectric testing, an insulated blanket may be repaired with permanently applied rubber patches, using an approved method and then retested before returning to the field.

9.3 Test Review and Records

9.3.1 Certification of dielectric testing shall be shown on all insulated blankets by labeling the equipment with next test due date.

9.3.2 All testing records are recorded in the database by serial number.

10.0 VISUAL INSPECTION OF PERSONAL PROTECTIVE GROUNDS

10.1 Responsibility:

10.1.1 The user department is responsible to inspect their personal protective grounds.

10.2 Type and Frequency

10.2.1 All personal protective grounds must be inspected before and after each use for broken or loose fittings including ferrule attachment points, and wire inspection for chafed or cut insulation. All duckbill and flat faced clamps shall be inspected at their attachment point and maintained on a regular basis to insure easy open/close operation.

10.2.2 Refer to LU-EOP T011, D009, and Substation Maintenance Procedure (SMP) SMP499.01.2 for more information.

11.0 EQUIPMENT

11.1 See each technical section for test equipment.

12.0 SCHEDULE FOR TESTING TOOLS AND INSULATING EQUIPMENT

Item	Type of Test	Frequency of Test	Scheduled By	Tested By	Remarks
Insulated Mobile Equipment	Acceptance Periodic	New/Newly Rented/Rebuilt 12 Mos.	Fleet Management	Approved Test Vendor	An Acceptance test is to be completed upon arrival unless presented the results of a previous successful acceptance test from the vendor. If this occurs then a periodic dielectric test may be completed instead. Date marked on cab roof behind driver
Platform Liners	Acceptance Periodic	New 12 Mos.	Fleet Management	Approved Test Vendor	Next Test Due Date marked on equipment
Hydraulic Fluid	Acceptance	New	Fleet Management	Fleet Management	Per Fleet Management Procedures
Hydraulic Hose	Type Acceptance Visual Periodic	New Prior to use 24 Months	User Dept. User Dept. User Department	Approved Test Vendor User Dept. User Department	Periodic testing is to be performed on all non-conductive hydraulic hoses being used to make direct contact with energized equipment/ conductor. This hose will be red or orange in color and will be identified and tested as a live line tool.
Live Line Tools	Periodic	24 Months	User Department	User Department	Test date marked on label and results documented
Tree Trimming Tools (see Note [A])	Acceptance Acceptance Periodic	New Rebuilt 12 mos.		Tree Trimming Contractor	Provided as requested by Liberty Utilities
Insulated Covers (See Note [B])	Visual Inspection	Prior to use	User Department	User Department	
Class 0/II - Rubber Gloves	Acceptance/Periodic	New / 3 Mos.	Approved Test Vendor	Approved Test Vendor	Next Test Due Date marked on equipment.
Class II – Rubber Sleeves	Acceptance/Periodic	New / 6 Mos.	Approved Test Vendor	Approved Test Vendor	Next Test Due Date marked on equipment
Insulated Blankets	Acceptance/Periodic	New / 12 Mos.	Approved Test Vendor	Approved Test Vendor	Next Test Due Date marked on equipment
Personal Protective Grounds	Visual Inspection	Prior to use	User Department	User Department	

<u>NOTES:</u>
[A] Hydraulic and Pneumatic Limb Loppers, Chain Saws, and Insulated Hand Trimming Pruners and Pole Saws
[B] Conductor Covers, Pole Guards, Barriers, Insulator Covers, etc.

13.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
7/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities
WATER | GAS | ELECTRIC

AC/DC ELECTRICAL TESTS
ON INSULATED MOBILE EQUIPMENT

Unit Number	Make/Model	Location

DIGGER DERRICK BOOM					AERIAL LIFT (UPPER BOOM)				AERIAL LIFT (LOWER BOOM)				Ambient Temp. (°F)	% Relative Humidity	BOOM TIP OR PEDESTAL HEIGHT	CONDITION OF BOOM OR PEDESTAL			TEST BY
		MICROAMPS				MICROAMPS				MICROAMPS									
DATE	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.				DRY	DAMP	WET	

Liberty Utilities	Doc. # LU-EOP G005		
Electric Operating Procedure	**01-01-2017**	**General**	
Testing Tools and Insulated Equipment	**Revision #**	**1.1**	**Page: 14 of 14**

Liberty Utilities
WATER · GAS · ELECTRIC

PERIODIC TOOL AND EQUIPMENT

DISTRICT	DIVISION	AREA/STATION
FREQUENCY OF TEST	MONTH	TYPE OF TEST

SERIAL NUMBER	LOCATION OR TRUCK	6 MONTH TEST DATE	BY	TEST RESULT	A	6 MONTH TEST DATE	BY	TEST RESULT	A	6 MONTH TEST DATE	BY	TEST RESULT	A	6 MONTH TEST DATE	BY	TEST RESULT	A

NOTES: A - DATE OF ANNUAL HYDRAULIC FLUID CHANGE.
IF HOSE TESTS BAD, REMOVE FROM SERVICE, TAG " DEFECTIVE" AND NOTIFY SUPERVISOR.

SERIAL NUMBER CODE: 1ST LETTER - AREA (EACH DIVISION TO ASSIGN)
2ND LETTER - DISTRICT OR SUB GROUP (EACH DIVISION TO ASSIGN)
NUMBER - (TO BE ASSIGNED BY DISTRICT OR SUBGROUP)
LAST LETTER - HY - HYDRAULIC P - PNEUMATIC

*TEST RESULT - INDICATE "OK" OR "NG"

Liberty Utilities	Doc. # LU-EOP G005.01		
Electric Operating Procedure	01-01-2017	General	
Dielectric Acceptance Testing of Insulated Mobile Equipment	Revision #	1.1	Page: 1 of 11

INTRODUCTION

The following procedure lists the steps needed when performing an A.C. dielectric acceptance test of the boom and controls of a Category C insulating aerial device.

PURPOSE

All dielectric testing to be performed shall be done without intentional pre-wetting of the equipment. At the end of a successful test, tester must initial and date the Electrical Insulation Test Sticker in the truck cab Form LU0335 shown at the end of this procedure.

ACCOUNTABILITY

Lab & Testing Services Approved Vendor

COORDINATION

Not applicable

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/SIA A92.2-2001 - Vehicle-Mounted Elevating and Rotating Aerial Devices

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

Table of Contents

1.0 ACCEPTANCE TEST REQUIREMENTS

1.1 Perform all A.C. tests with the power takeoff disengaged and the truck engine off.

1.2 Remove any plastic covers from the bucket liners since they may catch fire if subjected to high voltage.

1.3 Position the platform at least 8 feet above the normal nested position. The preferable position of the upper boom is parallel to the ground.

1.4 Position the elbow at least 3 feet above the nested position. The preferable position of the lower boom is perpendicular to the ground.

1.5 Do not ground truck body for this A.C. test.

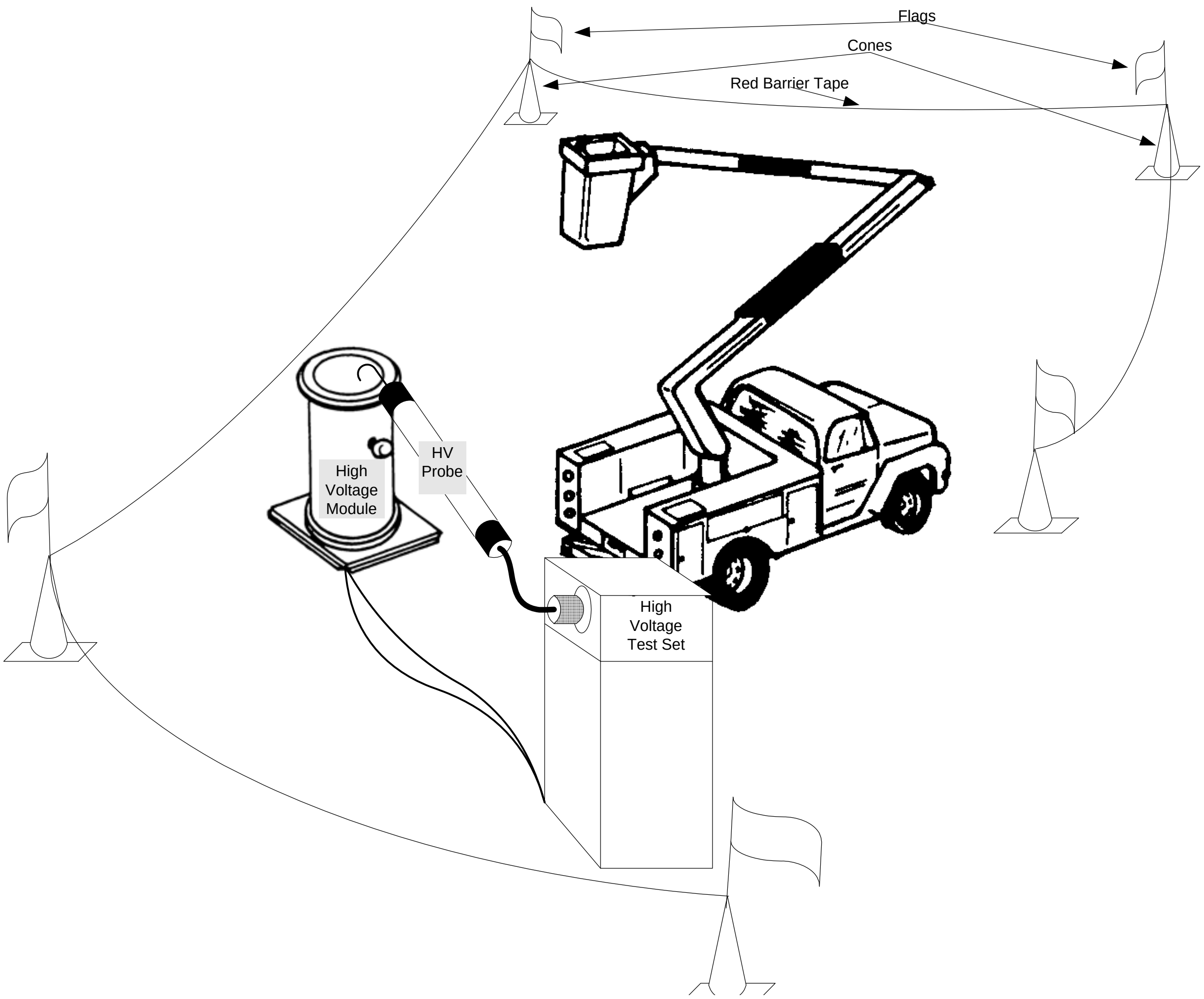
CAUTION: During the testing phase, the truck is to be considered ENERGIZED.

1.6 If outriggers are extended, they must be insulated from ground by extending onto insulated blankets.

1.7 Vehicle's steel belted tires must be further insulated from ground by driving the vehicle's tires onto insulated blankets.

1.8 Measure distance from bottom of platform to ground. If the vehicle has no prior testing history, record this measurement on data sheet; it will be used as a reference for all future testing. If the vehicle has prior testing history, duplicate the platform-to-ground distance from previous tests to ensure consistency in measurement process.

1.9 Protect work area with flags, cones and red barrier tape around the truck BEFORE applying the voltage for the test, and check to see that all personnel are in the clear. Red barrier tape must be approximately at waist height. Test set and vehicle must be within protected area, as depicted in the following diagram:



1.10 Appropriate Personal Protective Equipment (PPE) must be worn per applicable National Grid Safety Rules & Procedures.

1.11 Bonding jumpers must be #2 copper (or larger), and *only* long enough to jumper around intended point. Longer jumpers will contribute to erroneous readings during the A.C. testing.

1.12 The High Voltage lead from the A.C. test set must be run and tied in such a way as to not hang closer than one foot to the truck body or to the ground.

1.13 A.C. Test Set must display a valid calibration sticker, and be within calibration period specified on sticker.

1.14 Raise the test voltage gradually from zero (0) volts, watching the ammeter for signs of excess current.

1.15 If no abnormal current is noticed, continue to the specified voltage and energize the tested part for the prescribed time.

1.16 At the prescribed time, read and record the voltage and the leakage current on Form NG0336 shown at the end of this procedure.

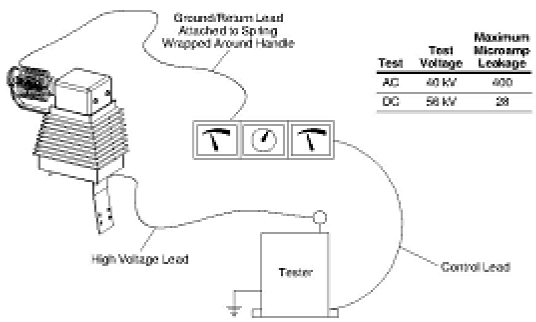
1.17 Gradually lower the test voltage to zero (0).

1.18 Short the high voltage lead and return lead to ground for **at least 1 minute** before attempting to remove any connections.

1.19 Upon completion of successful Acceptance Test, remove platform (bucket) liner and replace with a Company tested liner. Ensure that removed liner is forwarded to the appropriate Company department for dielectric testing.

<u>2.0 A.C. DIELECTRIC TEST OF INSULATED HANDLE CONTROL</u>

Dielectric Test Form for Insulated Single Handle Control



Test	Test Voltage	Maximum Microamp Leakage
AC	40 kV	400
DC	56 kV	28

CAUTION: The insulated single handle controller is identified as GREEN in color. The unit is to be operated from the **lower control station only** during this test. Before starting this test the emergency hydraulic dump lever located at the upper controls platform is to be **placed in the dump position before attempting to perform this test to prevent inadvertent boom movement** when installing or removing the Spring (for the Ground Lead to connect to) around the upper control interlock trigger. Failure to maintain the unit in the lower control position during the testing or failure to activate the emergency hydraulic dump at the platform may result in serious injuries/damage.

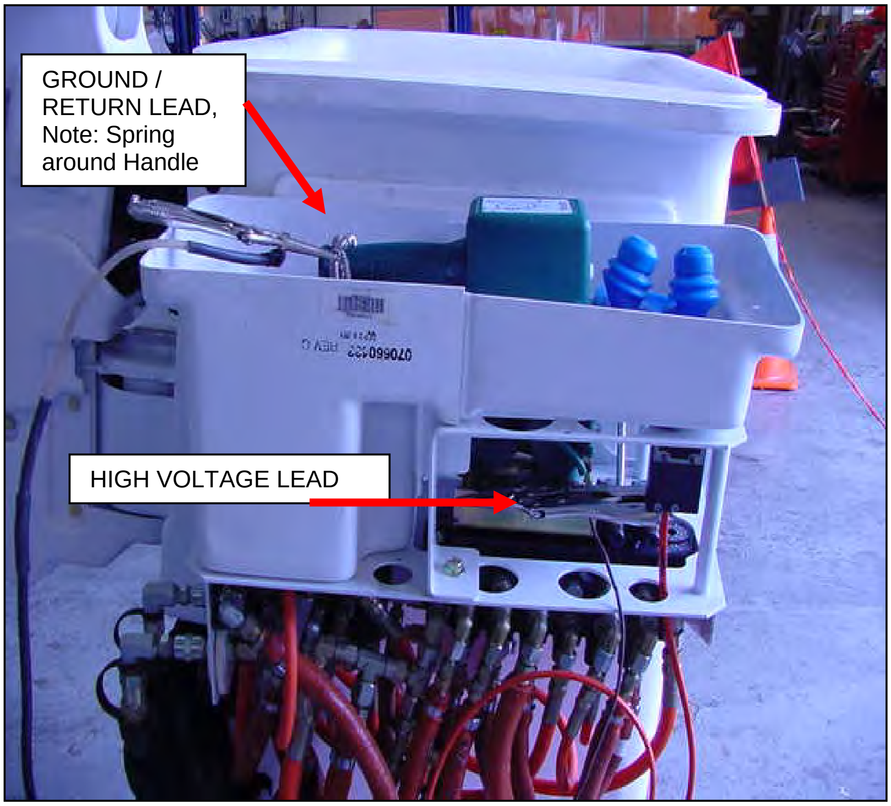
2.1 For this test, the test must be insulated from ground by placing polyethylene pads beneath each tire and outrigger leg.

2.1.1 Wrap a 0.375 to 1.0 inch diameter spring around the control handle.

2.1.2 Attach the ground / return leads to the spring on the control handle as shown below.

2.1.3 Attach the high voltage test lead (insulated from ground) to the control base. (The bellows must be in place for this test.)

Note: Do not use cancel (null) circuit if the tester is so equipped.



2.1.4 Gradually increase the voltage up to 40 kV. Maintain that voltage level for three (3) minutes. If flashover occurs or the leakage current exceeds the maximum 400 microamps, the control has failed the test. Follow the procedure for the failure of insulated mobile equipment. Record the leakage current readings.

<u>3.0 A.C. TEST OF UPPER INSULATED BOOM</u>

Note: If upper boom has a telescopic boom extension, test must be performed with insulated section extended to the *minimum* extension required by the manufacturer. Ordinarily, this would mean that the boom should be fully retracted. Check the manufacturer's manual to verify recommended extension.

3.1 Connect electrically the High Voltage lead from the test set to the steel insert located at the upper boom tip. If the truck is equipped with any hydraulic valves at the platform (bucket), it will be necessary to also jumper from the steel insert to those valve spool bodies (boom functions valve spool body or winch/jib/platform-rotate valve spool body) in order to involve those metal components in the test. DO NOT ENERGIZE ANY FIBER OPTIC CONTROLS OR CONTROL PANEL.

3.2 Install bonding jumper around boom knuckle using #2 copper (or larger). Jumper shall only be of sufficient length to bypass boom knuckle.

3.3 Using #2 copper (or larger), install bonding jumper around chassis insulating system on lower boom. Jumper shall only be of sufficient length to bypass insulator.

3.4 Connect the Return (RTN) to truck body through a shielded lead, the shield of which is connected to the Ground terminal of the test set. Jumper Guard to Ground on the test set.

3.5 Connect the Ground terminal of the test set to a suitable ground.

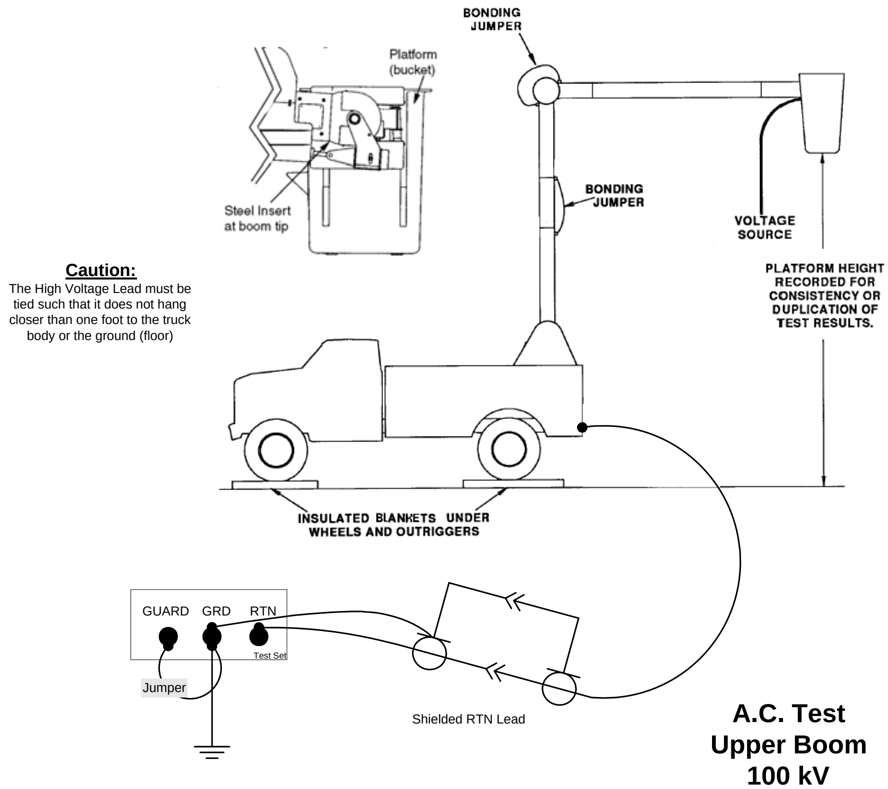
3.6 Test set and truck shall be within protected area as depicted in Acceptance Test Requirements.

3.7 Apply test voltage, which should be 100 kV rms 60 Hz, for 3 minutes. The leakage current should not exceed 1,000 microamperes.

3.8 Lower test voltage to zero (0). Short the high voltage lead and return lead to ground for **at least 1 minute** before attempting to remove any connections.

3.9 Remove bonding jumper around boom knuckle.

3.10 Remove bonding jumper around chassis insulating system on lower boom.



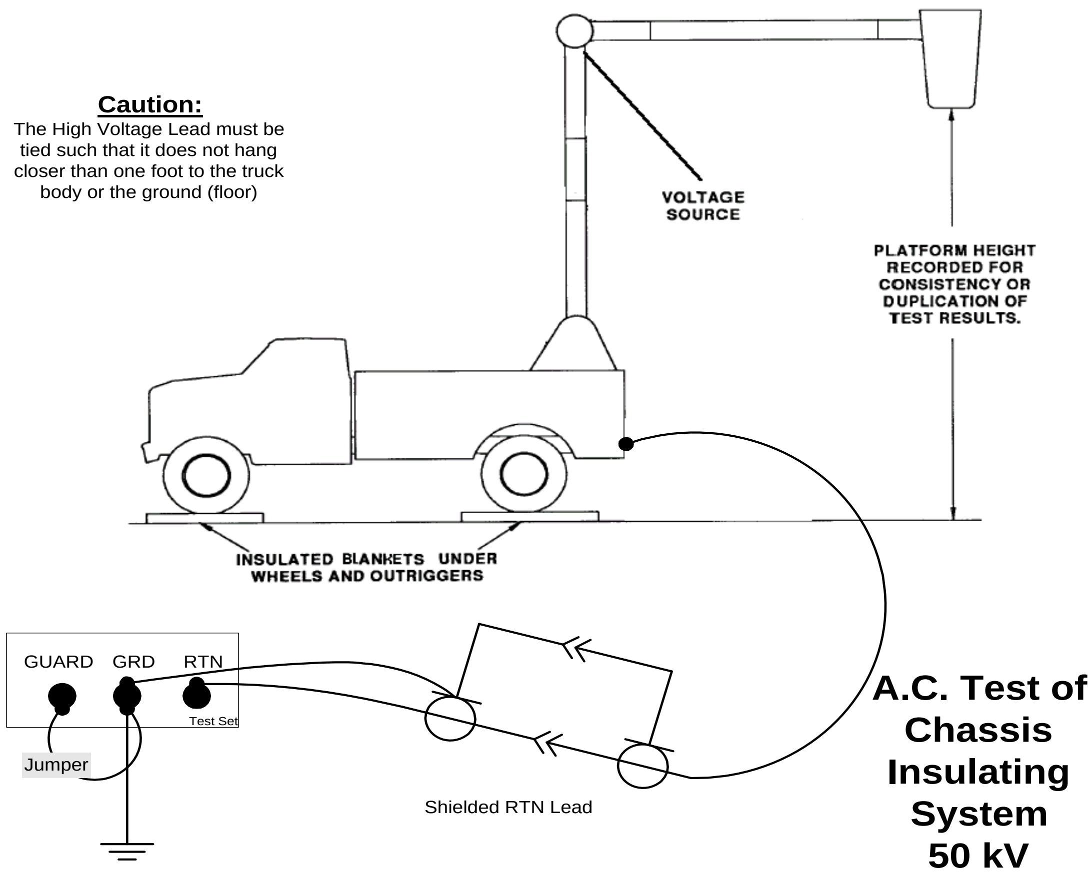
**A.C. Test
Upper Boom
100 kV**

NOTE: If this test is performed indoors, care should be taken to assure a minimum of 5 feet clearance from any wall or ceiling structure.

4.0 A.C. TEST OF CHASSIS INSULATING SYSTEM

4.1 Connect electrically the High Voltage lead to the elbow. Connect the Return (RTN) lead to the truck body through a shielded cable, the shield of which is connected to the Ground terminal of the test set. See figure below.

4.2 Jumper Guard to Ground. Connect the test set Ground terminal to a suitable ground. Test set and truck should be within protected area as depicted in A.C. Test Requirements.



4.3 Apply test voltage, which should be 50 kV and 60 Hz, for 3 minutes. The leakage current should not exceed 3,000 microamperes.

4.4 Lower test voltage to zero (0). Short the high voltage lead and return lead to ground for **at least 1 minute** before attempting to remove any connections.

NOTE: If this test is performed indoors, care should be taken to assure a minimum of 5 feet clearance from any wall or ceiling structure.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
7/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

3.5 x 4

Liberty Utilities

AC/DC ELECTRICAL TESTS ON INSULATED MOBILE EQUIPMENT

Form # NG0336(04/10)

Unit Number	Make/Model	Location

DIGGER DERRICK BOOM					AERIAL LIFT (UPPER BOOM)				AERIAL LIFT (LOWER BOOM)				Ambient Temp. (°F)	% Relative Humidity	BOOM TIP OR PEDESTAL HEIGHT	CONDITION OF BOOM OR PEDESTAL			TEST BY
		MICROAMPS				MICROAMPS				MICROAMPS									
DATE	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.				DRY	DAMP	WET	

INTRODUCTION

All dielectric testing to be performed shall be done without intentional pre-wetting of the equipment. At the end of a successful test, tester must initial and date the Electrical Insulation Test Sticker in the truck cab shown at the end of this procedure.

PURPOSE

Not Applicable

ACCOUNTABILITY

Lab & Testing Services or Approved Vendor

COORDINATION

Not applicable

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/SIA A92.2-2001 - Vehicle-Mounted Elevating and Rotating Aerial Devices

ANSI/ASSE A10.31-2006 - Safety Requirements, Definitions, and Specifications for Digger Derricks.

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

The following procedure lists the details associated with the periodic dielectric testing of insulated mobile equipment:

There are two methods of dielectric testing insulated mobile equipment approved by Liberty Utility, either of which can be used to test the dielectric quality of the equipment.

1. The first method utilizes an AC voltage source, and is available as LU-EOPG005.02a for Bucket Trucks or as LU-EOPG005.02c for Digger Derricks.
2. The second method utilizes a DC voltage source, and is available as LU-EOPG005.02b for Bucket Trucks or as LU-EOPG005.02d for Digger Derricks.

Each method is valid and choice should be based upon the availability of test equipment and materials.

1.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
7/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G005.02		
Electric Operating Procedure	01-01-2017	General	
Periodic Dielectric Testing of Insulated Mobile Equipment	Revision #	1.1	Page: 4 of 4

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

3.5 x 4

Liberty Utilities	Doc. # LU-EOP G005.02a		
Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 1 (AC Source)	**Revision #**	**1.1**	**Page: 1 of 11**

INTRODUCTION

The following procedure lists the steps and requirements for performing the periodic A.C. dielectric test of the boom and controls of an insulated elevating and rotating aerial device.

PURPOSE

All dielectric testing to be performed shall be done without intentional pre-wetting of the equipment. At the end of a successful test, tester must initial and date the Electrical Insulation Test Sticker in the truck cab using the form shown at the end of this procedure.

ACCOUNTABILITY

Lab & Testing Services or Approved Vendor

COORDINATION

Not applicable

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/SIA A92.2 2001- Vehicle-Mounted Elevating and Rotating Aerial Devices

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

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DOCUMENT CONTENTS

Table of Contents

1.0 PERIODIC TEST REQUIREMENTS

1.1 Perform all A.C. tests with the power takeoff disengaged and the truck engine off.

1.2 Remove any plastic covers from the bucket liners since they may catch fire if subjected to high voltage.

1.3 Position the platform *at least* 8 feet above the normal nested position. The *preferable* position of the upper boom is parallel to the ground.

1.4 Position the elbow *at least* 3 feet above the nested position. The *preferable* position of the lower boom is perpendicular to the ground.

1.5 Do not ground truck body for this A.C. test. CAUTION: During the testing phase, the truck is to be considered ENERGIZED.

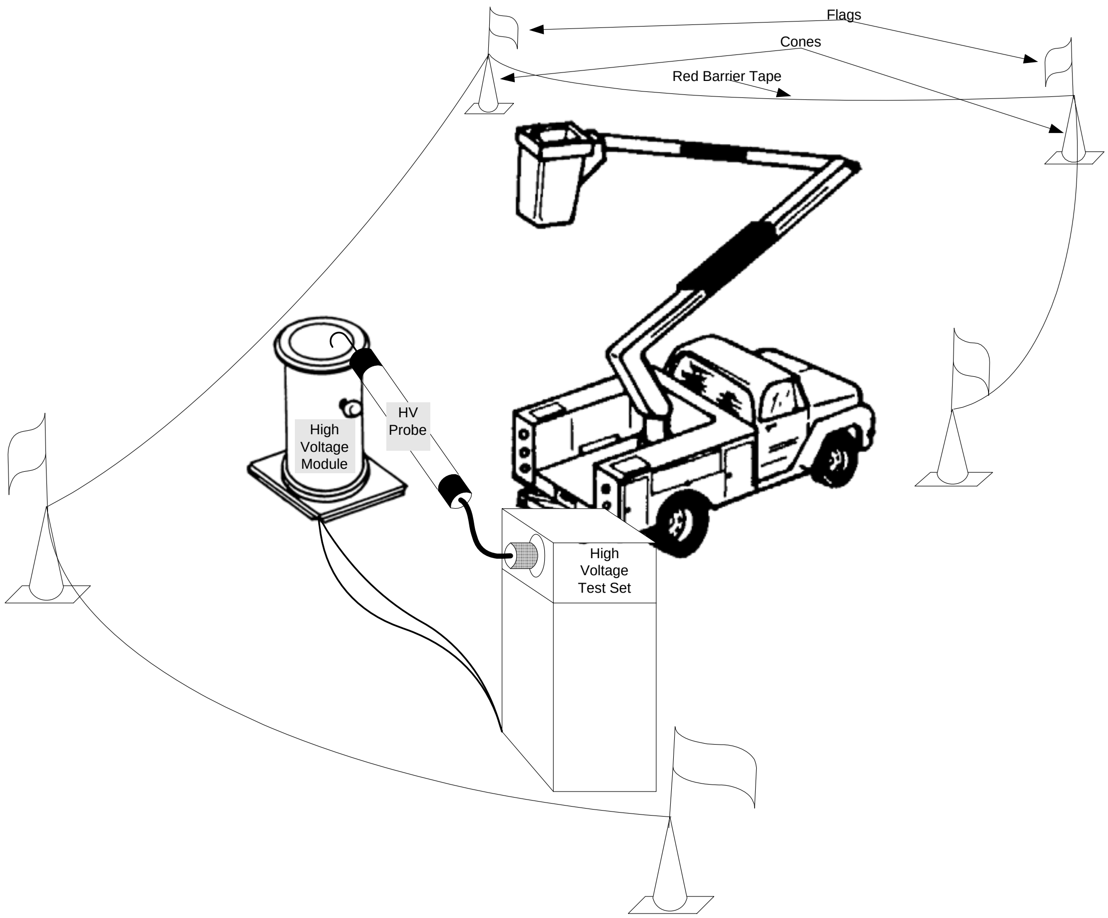
1.6 If outriggers are extended, they must be insulated from ground by extending onto insulated blankets.

1.7 Vehicle's steel belted tires must be further insulated from ground by driving the vehicle's tires onto insulated blankets.

1.8 Measure distance from bottom of platform to ground. Duplicate the platform-to-ground distance from previous tests to ensure consistency in test results. Record distance on test sheet.

1.9 Protect work area with flags, cones and red barrier tape around the truck BEFORE applying the voltage for the test, and check to see that all personnel are in the clear. Red barrier tape must be approximately at waist height. Test set and vehicle must be within protected area, as depicted in the following diagram:

Liberty Utilities	Doc. # LU-EOP G005.02a		
Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 1 (AC Source)	**Revision #**	**1.1**	**Page: 4 of 11**



1.10 Appropriate Personal Protective Equipment (PPE) must be worn per applicable National Grid Safety Rules & Procedures.

1.11 Bonding jumpers must be #2 copper (or larger), and *only* long enough to jumper around intended point. Longer jumpers will contribute to erroneous readings during the A.C. testing.

1.12 The High Voltage lead from the A.C. test set must be run and tied in such a way as to not hang closer than one foot to the truck body or to the ground.

1.13 A.C. Test Set must display a valid calibration sticker, and be within calibration period specified on sticker. Test set must be plugged into a grounded receptacle.

1.14 Raise the test voltage gradually from zero (0) volts, watching the ammeter for sign of excess current.

Liberty Utilities	Doc. # LU-EOP G005.02a		
Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 1 (AC Source)	**Revision #**	**1.1**	**Page: 5 of 11**

1.15 If no abnormal current is noticed, continue to the specified voltage and energize the tested part for the prescribed time.

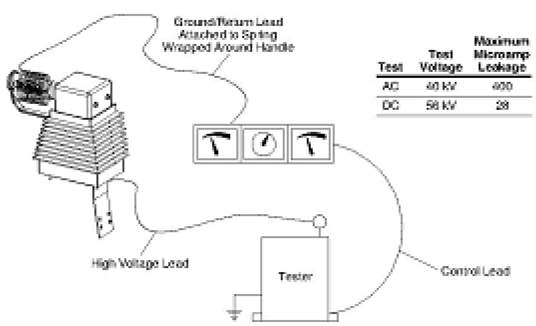
1.16 At the prescribed time, read and record the voltage and the leakage current on Liberty Utility form shown at the end of this procedure on Page 12.

1.17 Gradually lower the test voltage to zero (0).

1.18 Short the high voltage lead and return lead to ground for **at least 1 minute** before attempting to remove any connections.

<u>2.0</u> <u>A.C. DIELECTRIC TEST OF INSULATED HANDLE CONTROL</u>

Dielectric Test Form for Insulated Single Handle Control



CAUTION: The insulated single handle controller is identified as GREEN in color. The unit is to be operated from the lower control station only during this test. Before starting this test the emergency hydraulic dump lever located at the upper controls platform is to be placed in the dump position before attempting to perform this test to prevent inadvertent boom movement when installing or removing the Spring (for the Ground Lead to connect to) around the upper control interlock trigger. Failure to maintain the unit in the lower control position during the testing or failure to activate the emergency hydraulic dump at the platform may result in serious injuries/damage.

2.1 For this test, the test must be insulated from ground by placing polyethylene pads beneath each tire and outrigger leg.

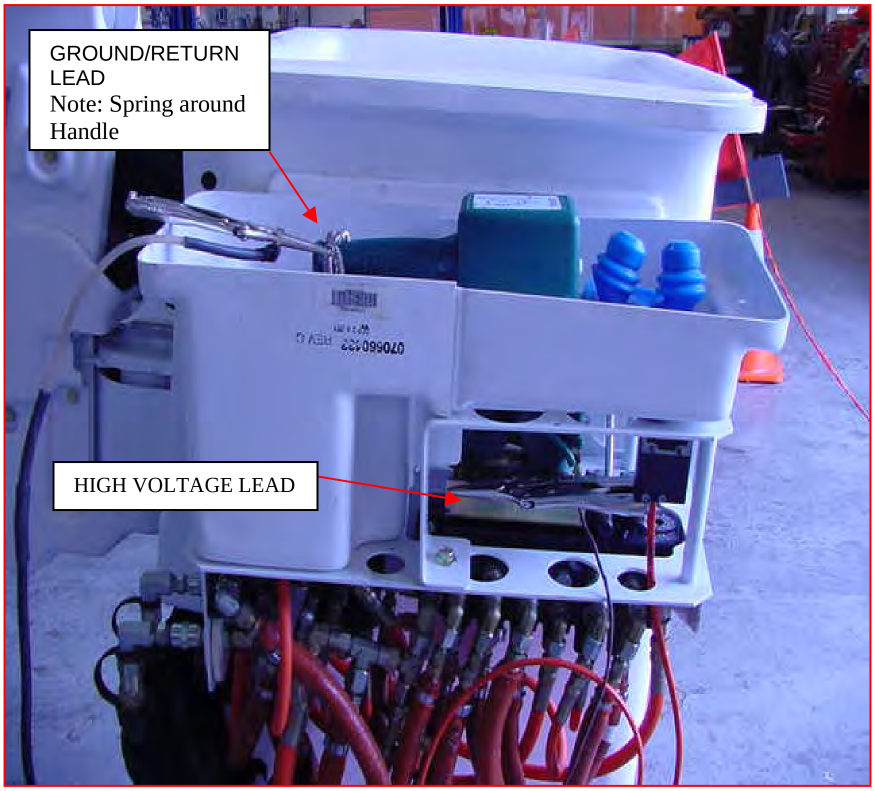
2.1.1 Wrap a 0.375 to 1.0 inch diameter spring around the control handle.

2.1.2 Attach the ground / return leads to the spring on the control handle as shown below.

2.1.3 Attach the high voltage test lead (insulated from ground) to the control base. (The bellows must be in place for this test.)

<u>NOTE</u>: Do not use cancel (null) circuit if the tester is so equipped.

Liberty Utilities	Doc. # LU-EOP G005.02a		
Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 1 (AC Source)	**Revision #**	**1.1**	**Page: 6 of 11**



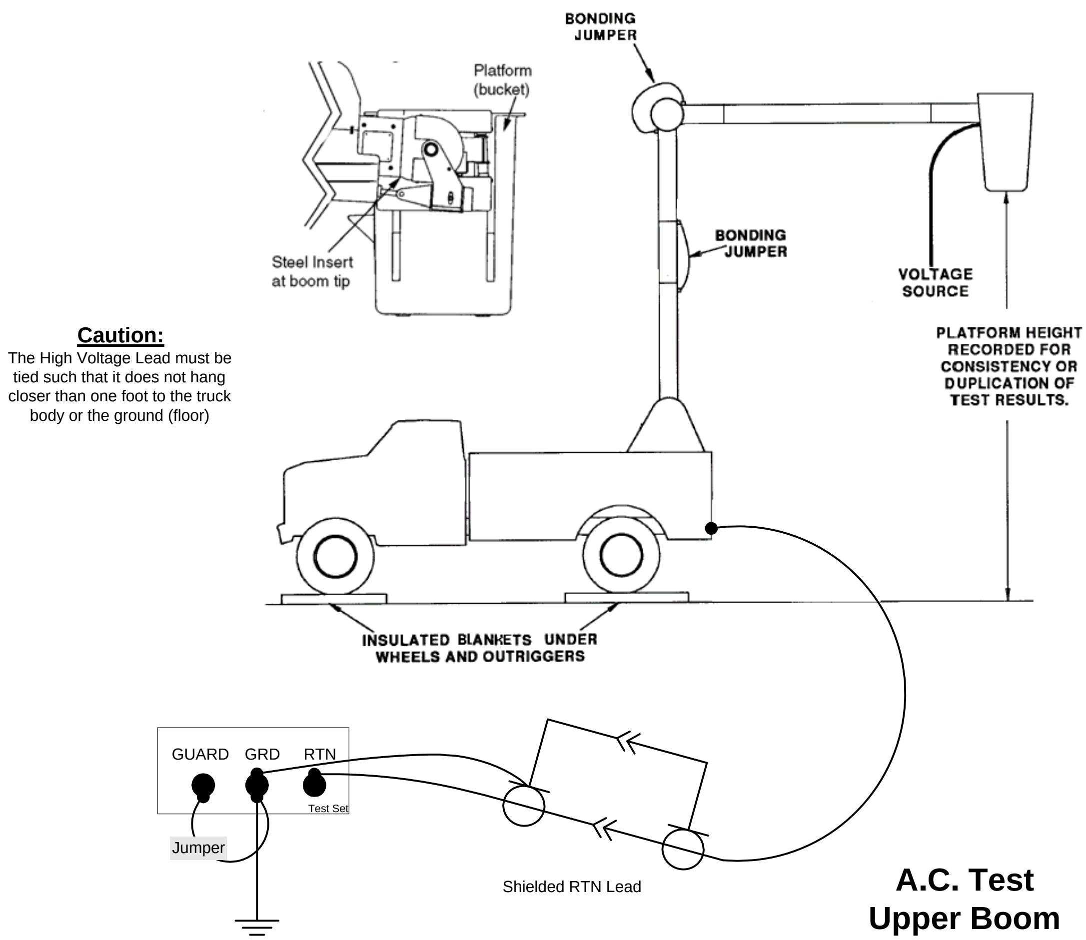
2.1.4 Gradually increase the voltage up to 40 kV. Maintain that voltage level for one (1) minute. If flashover occurs or the leakage current exceeds the maximum 400 microamps, the control has failed the test. Follow the procedure for the failure of insulated mobile equipment. Record the leakage current reading.

<u>3.0 A.C. TEST OF UPPER INSULATED BOOM</u>

Note: If upper boom has a telescopic boom extension, test must be performed with insulated section extended to the *minimum* extension required by the manufacturer. Ordinarily, this would mean that the boom should be fully retracted. Check the manufacturer's manual to verify recommended extension.

Liberty Utilities	Doc. # LU-EOP G005.02a		
Electric Operating Procedure	01-01-2017	General	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 1 (AC Source)	Revision #	1.1	Page: 7 of 11

3.1 Connect electrically the High Voltage lead from the test set to the steel insert located at the upper boom tip. If the truck is equipped with any hydraulic valves at the platform (bucket), it will be necessary to also jumper from the steel insert to those valve spool bodies (boom functions valve spool body or winch/jib/platform-rotate valve spool body) in order to involve those metal components in the test. DO NOT ENERGIZE ANY FIBER OPTIC CONTROLS OR CONTROL PANEL.



A.C. Test
Upper Boom
40 kV

3.2 Install bonding jumper around boom knuckle using #2 copper (or larger). Jumper shall only be of sufficient length to bypass boom knuckle.

3.3 Using #2 copper (or larger), install bonding jumper around chassis insulating system on lower boom. Jumper shall only be of sufficient length to bypass insulator.

3.4 Connect the Return (RTN) to truck body through a shielded lead, the shield of which is connected to the Ground terminal of the test set. Jumper Guard to Ground on the test set.

3.5 Connect the Ground terminal of the test set to a suitable ground.

3.6 Test set and truck shall be within protected area as depicted in A.C. Test Requirements.

NOTE: If this test is performed indoors, care should be taken to assure a minimum of 5 feet clearance from any wall or ceiling structure.

3.7 Apply test voltage, which should be 40 kV rms 60 Hz, for 1 minute. The leakage current should not exceed 400 microamperes.

3.8 Lower test voltage to zero (0). Short the high voltage lead and return lead to ground for **at least 1 minute** before attempting to remove any connections.

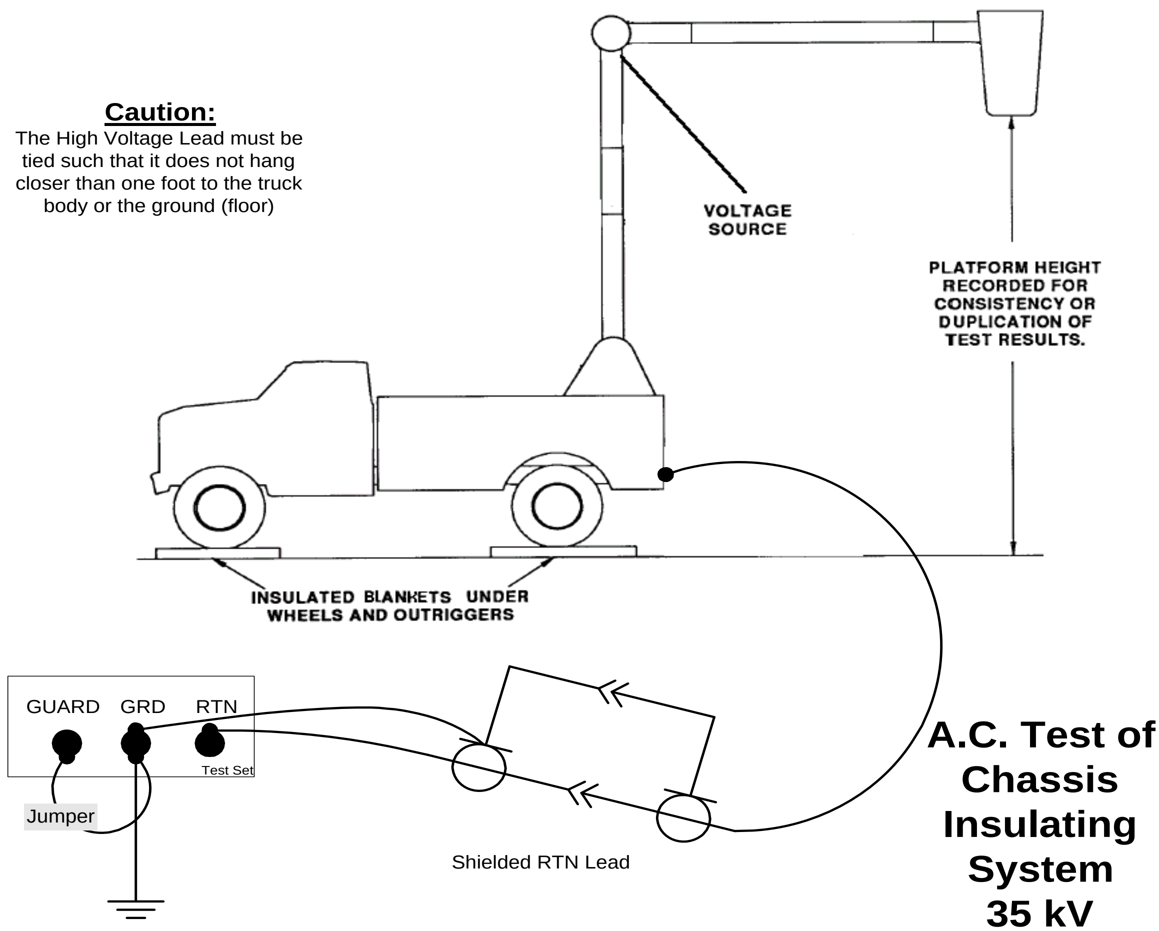
3.9 Remove bonding jumper around boom knuckle.

3.10 Remove bonding jumper around chassis insulating system on lower boom.

4.0 A.C. TEST OF CHASSIS INSULATING SYSTEM

4.1 Connect electrically the High Voltage lead to the elbow Connect the Return (RTN) lead to the truck body through a shielded cable, the shield of which is connected to the Ground terminal of the test set. See figure below.

4.2 Jumper Guard to Ground. Connect the test set Ground terminal to a suitable ground. Test set and truck shall be within protected area as depicted in A.C. Test Requirements.



NOTE: If this test is performed indoors, care should be taken to assure a minimum of 5 feet clearance from any wall or ceiling structure.

4.3 Apply test voltage, which should be 35 kV and 60 Hz, for 3 minutes. The leakage current should not exceed 3,000 microamperes.

4.4 Lower test voltage to zero (0). Short the high voltage lead and return lead to ground for **at least 1 minute** before attempting to remove any connections.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
7/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

NG0335(04.10)

3.5 x 4

Liberty Utilities
WATER | GAS | ELECTRIC

AC/DC ELECTRICAL TESTS ON INSULATED MOBILE EQUIPMENT

Unit Number	Make/Model	Location

DIGGER DERRICK BOOM					AERIAL LIFT (UPPER BOOM)				AERIAL LIFT (LOWER BOOM)				Ambient Temp. (°F)	% Relative Humidity	BOOM TIP OR PEDESTAL HEIGHT	CONDITION OF BOOM OR PEDESTAL			TEST BY
		MICROAMPS				MICROAMPS				MICROAMPS									
DATE	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.				DRY	DAMP	WET	

Liberty Utilities	Doc. # LU-EOP G005.02b		
Electric Operating Procedure	01-01-2017	General	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 2 (DC Voltage Source)	Revision #	1.1	Page: 1 of 10

INTRODUCTION

The following procedure lists the steps and requirements for performing the periodic D.C. dielectric test of the boom and controls of an insulated elevating and rotating aerial device.

PURPOSE

All dielectric testing to be performed shall be done without intentional pre-wetting of the equipment. At the end of a successful test, tester must initial and date the Electrical Insulation Test Sticker in the truck cab using the form shown at the end of this procedure.

ACCOUNTABILITY

Lab & Testing Services Approved Vendor

COORDINATION

Not applicable

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/SIA A92.2 2001- Vehicle-Mounted Elevating and Rotating Aerial Devices

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

Table of Contents

1.0 PERIODIC TEST REQUIREMENTS

1.1 Perform all D.C. tests with the power takeoff disengaged and the truck engine off.

1.2 Remove any plastic covers from the bucket liners since they may catch fire if subjected to high voltage

1.3 Position the platform *at least* 8 feet above the normal nested position. The *preferable* position of the upper boom is parallel to the ground.

1.4 Position the elbow *at least* 3 feet above the nested position. The *preferable* position of the lower boom is perpendicular to the ground.

1.5 Ground truck body for this D.C. test. Ground must be a known building ground.

1.6 If outriggers are extended, they need not be insulated from ground.

1.7 Measure distance from bottom of platform to ground. Duplicate the platform-to-ground distance from previous tests to ensure consistency in test results. Record distance on test sheet.

1.8 Protect work area with flags, cones and red barrier tape around the truck BEFORE applying the voltage for the test, and check to see that all personnel are in the clear. Red barrier tape must be approximately at waist height. Test set and vehicle must be within protected area, as depicted in the following diagram on page 4.

1.9 Appropriate Personal Protective Equipment (PPE) must be worn per applicable National Grid Safety Rules & Procedures.

1.10 Bonding jumpers must be #2 copper (or larger), and *only* long enough to jumper around intended point.

1.11 D.C. Test Set must display a valid calibration sticker, and be within calibration period specified on sticker. Test set must be plugged into an grounded receptacle.

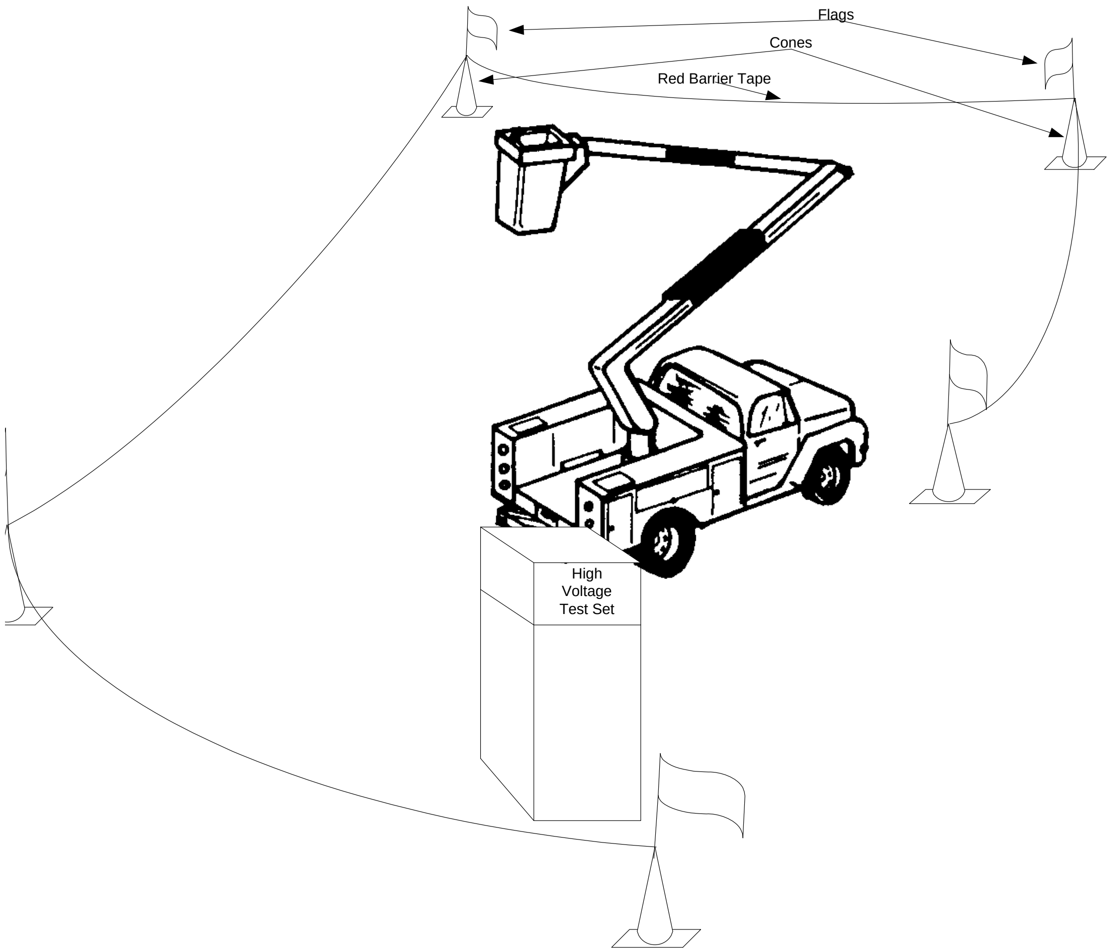
1.12 Raise the test voltage gradually from zero (0) volts, watching the ammeter for signs of excess current.

1.13 If no abnormal current is noticed, continue to the specified voltage and energize the tested part for the prescribed time.

1.14 At the prescribed time, read and record the voltage and the leakage current on the form shown at the end of this procedure, Page 10 of 10.

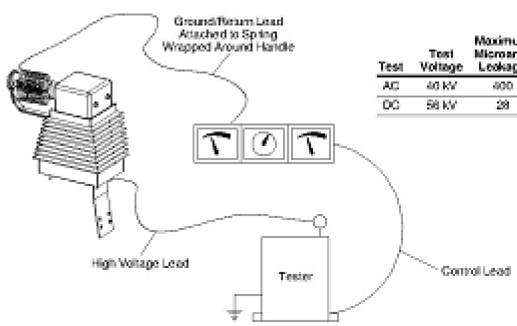
1.15 Gradually lower the test voltage to zero (0).

1.16 Short the high voltage lead to ground for **at least 1 minute** before attempting to remove any connections.



2.0 D.C. DIELECTRIC TEST OF INSULATED HANDLE CONTROL

Dielectric Test Form for Insulated Single Handle Control



Test	Test Voltage	Maximum Microamp Leakage
AC	40 kV	400
DC	56 kV	28

CAUTION: The insulated single handle controller is identified as GREEN in color. The unit is to be operated from the lower control station only during this test. Before starting this test the emergency hydraulic dump lever located at the upper controls platform is to be placed in the dump position before attempting to perform this test to prevent inadvertent boom movement when installing or removing the Spring (for the Ground Lead to connect to) around the upper control interlock trigger. Failure to maintain the unit in the lower control position during the testing or failure to activate the emergency hydraulic dump at the platform may result in serious injuries/damage.

2.1 Wrap a 0.375 to 1.0 inch diameter spring around the control handle.

2.2 Attach the ground / return leads to the spring on the control handle as shown below.

2.3 Attach the high voltage test lead (insulated from ground) to the control base. (The bellows must be in place for this test.)

2.4 Gradually increase the voltage up to 56 kV. Maintain that voltage level for three (3) minutes. If flashover occurs or the leakage current exceeds the maximum 28 microamps, the control has failed the test. Follow the procedure for the failure of insulated mobile equipment. Record the leakage current reading.

Note: Do not use cancel (null) circuit if the tester is so equipped.

3.0 D.C. TEST OF UPPER INSULATED BOOM

Note: If upper boom has a telescopic boom extension, test must be performed with insulated section extended to the *minimum* extension required by the manufacturer. Ordinarily, this would mean that the boom should be fully retracted. Check the manufacturer's manual to verify recommended extension.

3.1 Connect electrically the High Voltage lead from the test set to the steel insert located at the upper boom tip. If the truck is equipped with any hydraulic valves at the platform (bucket), it will be necessary to also jumper from the steel insert to those valve spool bodies (boom functions valve spool body or winch/jib/platform-rotate valve spool body) in order to involve those metal components in the test. DO NOT ENERGIZE ANY FIBER OPTIC CONTROLS OR CONTROL PANEL.

3.2 Install bonding jumper around boom knuckle using #2 copper (or larger). Jumper shall only be of sufficient length to bypass boom knuckle.

3.3 Using #2 copper (or larger), install bonding jumper around chassis insulating system on lower boom. Jumper shall only be of sufficient length to bypass insulator.

3.4 Connect the vehicle body to a known building ground.

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Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 2 (DC Voltage Source)	**Revision #**	**1.1**	**Page: 6 of 10**

3.5 Connect the Return terminal of the test set to the *same* point on the vehicle from step Test set and truck shall be within protected area as depicted in Periodic DC Test Requirements.

3.6 Jumper Ground to Return on the test set. This will allow both Ground currents and Return currents to pass through the ammeter.

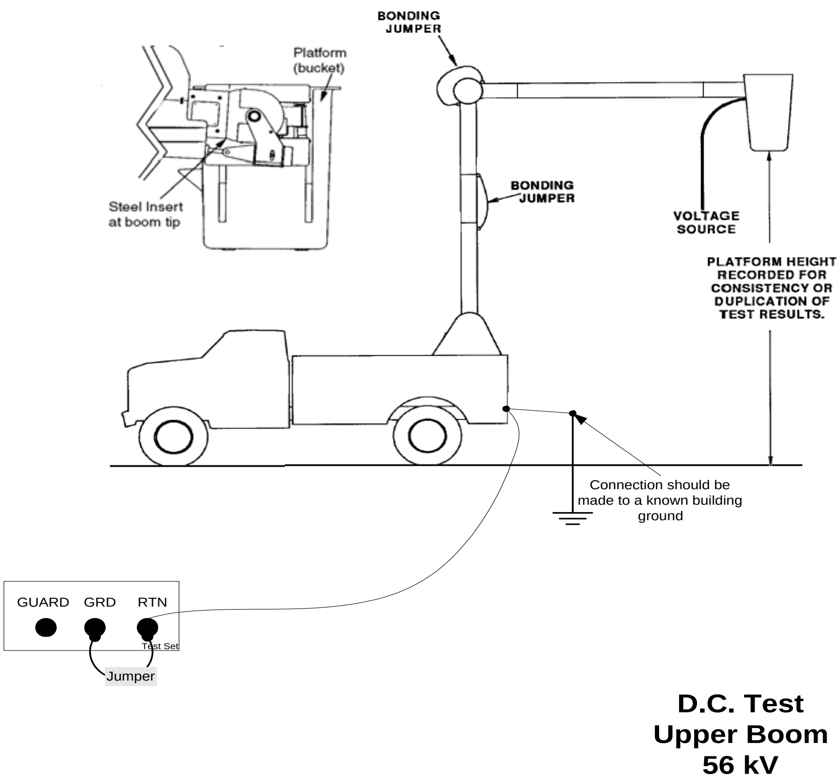
3.7 Apply test voltage, which should be 56 kVDC, for 3 minutes. The leakage current should not exceed 56 microamperes.

3.8 Lower test voltage to zero (0). Short the High Voltage lead and Return lead to ground for **at least 1 minute** beforeattempting to remove any connections.

3.9 Remove bonding jumper around boom knuckle.

3.10 Remove bonding jumper around chassis insulating system on lower boom.

Note: If this test is performed indoors, care should be taken to assure a minimum of 5 feet



clearance from any wall or ceiling structure.

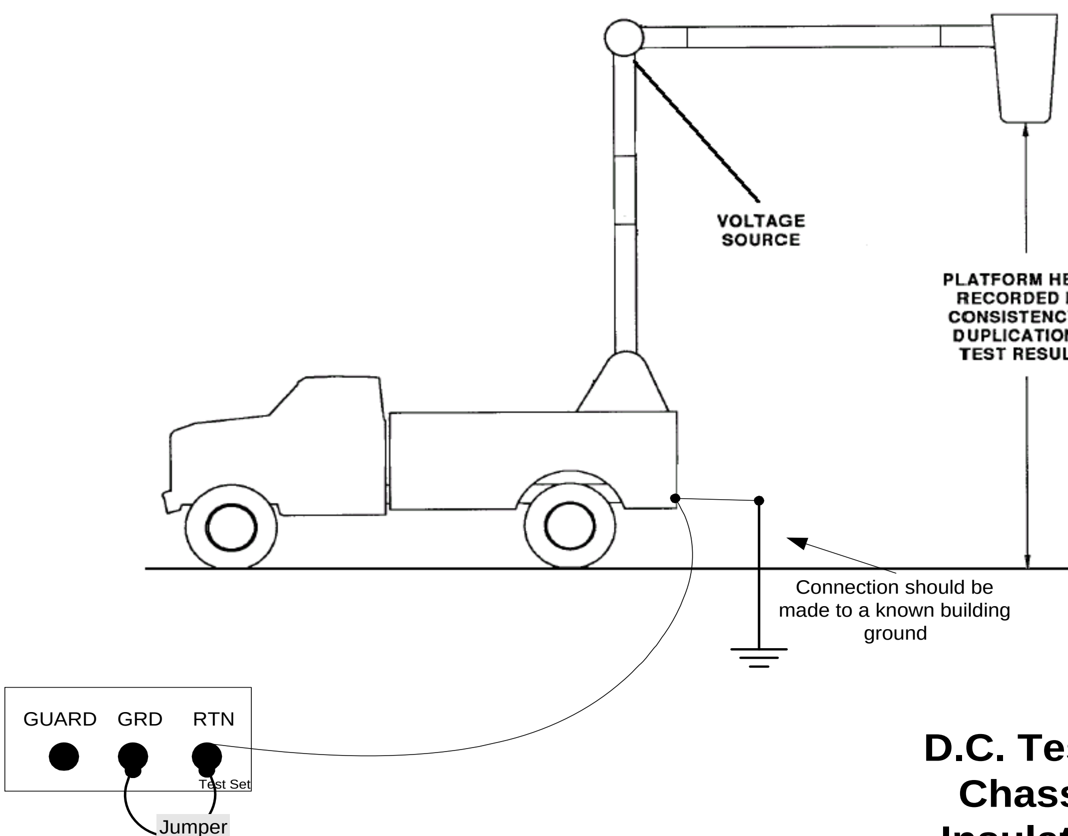
4.0 D.C. TEST OF CHASSIS INSULATING SYSTEM

4.1 Connect electrically the High Voltage lead to the elbow. See figure below.

4.2 Connect the vehicle body to a known building ground.

4.3 Connect the Return terminal of the test set to the *same* point on vehicle body from step 2. Test set and truck shall be within protected area as depicted in Periodic DC Test Requirements.

4.4 Jumper Ground to Return on the test set. This will allow both Ground currents and Return currents to pass through the ammeter.



D.C. Test of Chassis Insulating System 50 kV

4.5 Apply test voltage, which should be 50 kV DC for 3 minutes.

4.6 The leakage current should not exceed 50 microamperes.

4.7 Lower test voltage to zero (0). Short the High Voltage lead and Return lead to ground for **at least 1 minute** before attempting to remove any connections.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
7/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G005.02b		
Electric Operating Procedure	01-01-2017	General	
Periodic Dielectric Testing of Vehicle Mounted Elevating & Rotating Devices - Method 2 (DC Voltage Source)	Revision #	1.1	Page: 9 of 10

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TRUCK#	
TESTER	TEST DATE

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3.5 x 4

Liberty Utilities
WATER | GAS | ELECTRIC

AC/DC ELECTRICAL TESTS ON INSULATED MOBILE EQUIPMENT

Unit Number	Make/Model	Location

DIGGER DERRICK BOOM					AERIAL LIFT (UPPER BOOM)				AERIAL LIFT (LOWER BOOM)				Ambient Temp. (°F)	% Relative Humidity	BOOM TIP OR PEDESTAL HEIGHT	CONDITION OF BOOM OR PEDESTAL			TEST BY
		MICROAMPS				MICROAMPS				MICROAMPS									
DATE	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.				DRY	DAMP	WET	

Liberty Utilities	Doc. # LU-EOP G005.02c		
Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Digger Derricks - Method 1 (AC Voltage Source)	**Revision #**	**1.1**	**Page: 1 of 8**

INTRODUCTION

The following procedure lists the steps and requirements for performing the periodic A.C. dielectric test of the boom on an insulated digger derrick.

PURPOSE

All dielectric testing to be performed shall be done without intentional pre-wetting of the equipment. At the end of a successful test, tester must initial and date the Electrical Insulation Test Sticker in the truck cab on Form shown at the end of this procedure.

ACCOUNTABILITY

Lab & Testing Services Approved Vendor

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/ASSE A10.31-2006 - Safety Requirements, Definitions, and Specifications for Digger Derricks.

DEFINITIONS

Not Applicable.

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

Table of Contents

1.0 PERIODIC TEST REQUIREMENTS

1.1 Perform all A.C. tests with the power takeoff disengaged and the truck engine off.

1.2 Fully retract the intermediate boom. Disconnect the winch line from the third stage by removing clevis pin from rope at third stage. The winch line must not bridge upper boom when extended during testing.

1.3 Extend upper boom to provide at least 40 inches of clear fiberglass span between farthest projection of any metal component behind boom tip and farthest projection of any metal component forward from intermediate boom.

1.4 Do not ground truck body for this A.C. test. CAUTION: During the testing phase, the truck is to be considered ENERGIZED.

1.5 If outriggers are extended, they must be insulated from ground by extending onto insulated blankets.

1.6 Vehicle's steel belted tires must be further insulated from ground by driving the vehicle's tires onto insulated blankets.

1.7 Duplicate the boom angle position from previous tests on the vehicle to ensure consistency in test results. Record boom angle on test sheet.

1.8 Protect work area with flags, cones and red barrier tape around the truck <u>BEFORE</u> applying the voltage for the test, and check to see that all personnel are in the clear. Red barrier tape must be approximately at waist height Test set and vehicle must be within protected area, as depicted in the diagram on page 4.

1.9 Appropriate Personal Protective Equipment (PPE) must be worn per applicable National Grid Safety Rules & Procedures.

1.10 Bond all metal at boom tip using jumpers made from #2 copper (or larger), and *only* long enough to jumper metal together. Longer 5 jumpers will contribute to erroneous readings during the A.C. testing.

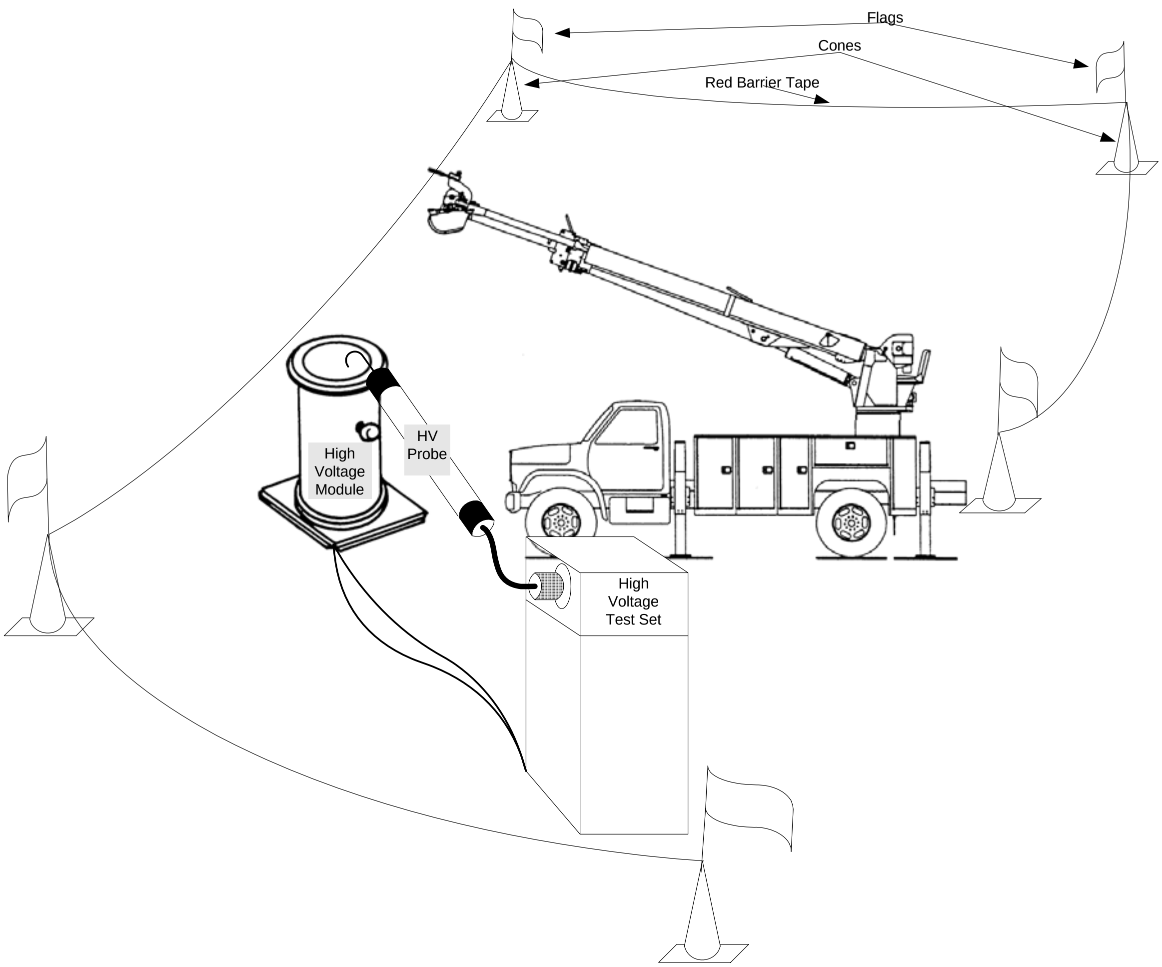
1.11 The High Voltage lead from the A.C. test set must be run and tied in such a way as to not hang closer than one foot to the truck body or to the ground.

1.12 A.C. Test Set must display a valid calibration sticker, and be within calibration period specified on sticker. Test set must be plugged into a grounded receptacle.

1.13 Raise the test voltage gradually from zero (0) volts, watching the ammeter for signs of excess current.

1.14 If no abnormal current is noticed, continue to the specified voltage and energize the tested part for the prescribed time.

1.15 At the prescribed time, read and record the voltage and the leakage current on the Form shown at the end of this procedure, Page 8 of 8.



1.16 Gradually lower the test voltage to zero (0).

1.17 Short the High Voltage lead and Return lead to ground for **at least 1 minute** before attempting to remove any connections.

<u>2.0 A.C. TEST OF INSULATED BOOM</u>

2.1 Connect electrically the High Voltage lead from the test set to the metal at the upper boom tip. All metal at boom tip shall be bonded using short jumpers of #2 copper (or larger).

2.2 Connect the Return (RTN) to truck body through a shielded lead, the shield of which is connected to the Ground terminal of the test set. Jumper Guard to Ground on the test set.

2.3 Connect the Ground terminal of the test set to a suitable ground.

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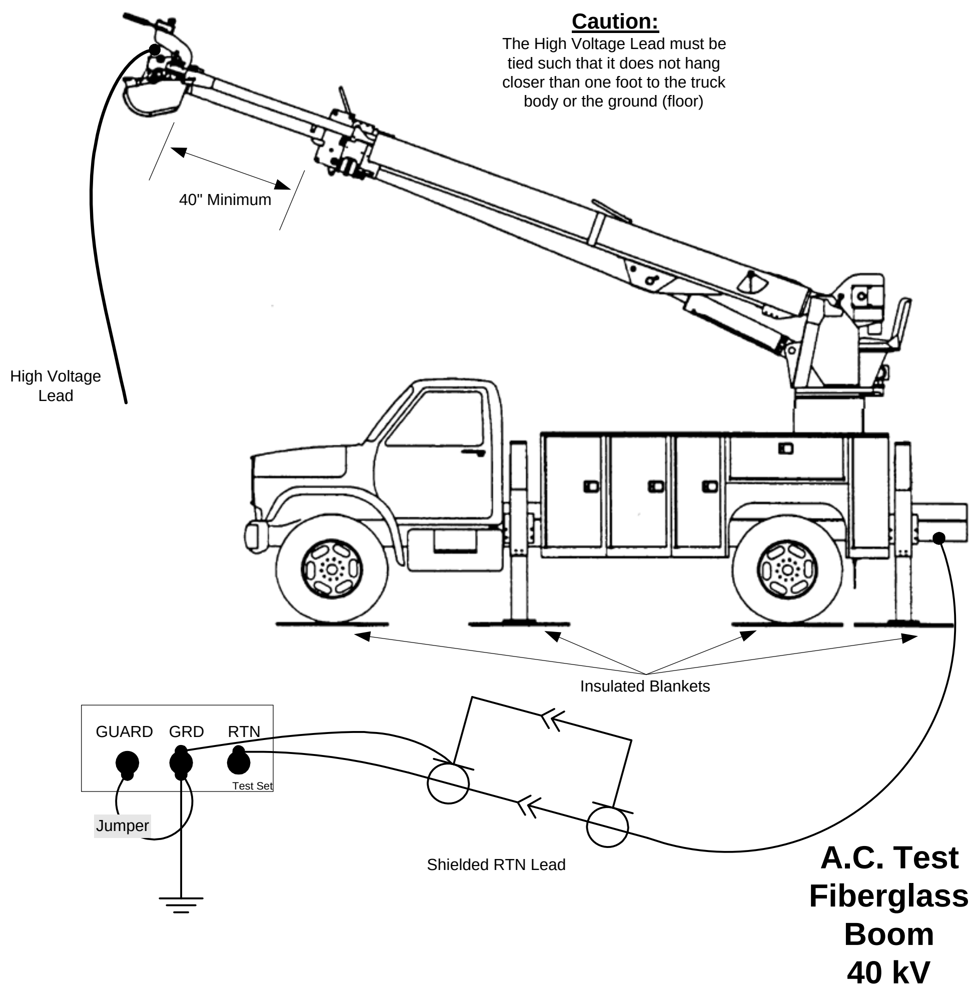
Periodic Dielectric Testing of Digger Derricks - Method 1 (AC Voltage Source)	**Revision #**	**1.1**	**Page: 5 of 8**

2.4 Test set and truck shall be within protected area as depicted in Periodic Test Requirements.



NOTE: **If this test is performed indoors, care should be taken to assure a minimum of 5 feet clearance from any wall or ceiling structure.**

2.5 Apply test voltage, which should be 40 kV rms 60 Hz, for 1 minute. The leakage current should not exceed 400 microamperes.

2.6 Lower test voltage to zero (0). Short the High Voltage lead and Return lead to

2.7 ground for **at least 1 minute** before attempting to remove any connections.

3.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

ELECTRIC INSULATION TEST	
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ELECTRIC INSULATION TEST	
TRUCK#	
TESTER	TEST DATE

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3.5 x 4

Liberty Utilities	Doc. # LU-EOP G005.02c		
Electric Operating Procedure	01-01-2017	General	
Periodic Dielectric Testing of Digger Derricks - Method 1 (AC Voltage Source)	Revision #	1.1	Page: 8 of 8

Liberty Utilities

AC/DC ELECTRICAL TESTS ON INSULATED MOBILE EQUIPMENT

Unit Number	Make/Model	Location

DIGGER DERRICK BOOM					AERIAL LIFT (UPPER BOOM)				AERIAL LIFT (LOWER BOOM)				Ambient Temp. (°F)	% Relative Humidity	BOOM TIP OR PEDESTAL HEIGHT	CONDITION OF BOOM OR PEDESTAL			TEST BY
		MICROAMPS				MICROAMPS				MICROAMPS									
DATE	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.				DRY	DAMP	WET	

Liberty Utilities	Doc. # LU-EOP G005.02d		
Electric Operating Procedure	01-01-2017	General	
Periodic Dielectric Testing of Digger Derricks - Method 2 (DC Voltage Source)	Revision #	1.1	Page: 1 of 8

INTRODUCTION

The following procedure lists the steps and requirements for performing the periodic D.C. dielectric test of the boom on an insulated digger derrick.

PURPOSE

All dielectric testing to be performed shall be done without intentional pre-wetting of the equipment. At the end of a successful test, tester must initial and date the Electrical Insulation Test Sticker in the truck cab using Form shown at the end of this procedure.

ACCOUNTABILITY

Lab & Testing Services Approved Vendor

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/ASSE A10.31-2006 - Safety Requirements, Definitions, and Specifications for Digger Derricks.

DEFINITIONS

Not Applicable.

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

Table of Contents

1.0 PERIODIC TEST REQUIREMENTS

1.1 Perform all D.C. tests with the power takeoff disengaged and the truck engine off.

1.2 Fully retract the intermediate boom. Disconnect the winch line from the third stage by removing clevis pin from rope at third stage. The winch line must not bridge upper boom when extended during testing.

1.3 Extend upper boom to provide at least 40 inches of clear fiberglass span between farthest projection of any metal component behind boom tip and farthest projection of any metal component forward from intermediate boom.

1.4 Ground truck body for this D.C. test. Ground must be a known building ground.

1.5 If outriggers are extended, they need not be insulated from ground.

1.6 Duplicate the boom angle position from previous tests on the vehicle to ensure consistency in test results. Record boom angle on test sheet.

1.7 Protect work area with flags, cones and red barrier tape around the truck BEFORE applying the voltage for the test, and check to see that all personnel are in the clear. Red barrier tape must be approximately at waist height. Test set and vehicle must be within protected area, as depicted in the diagram on page 4.

1.8 Appropriate Personal Protective Equipment (PPE) must be worn per applicable National Grid Safety Rules & Procedures.

1.9 Bond all metal at boom tip using jumpers made from #2 copper (or larger), and only long enough to jumper metal together.

1.10 D.C. Test Set must display a valid calibration sticker, and be within calibration period specified on sticker. Test set must be plugged into a grounded receptacle.

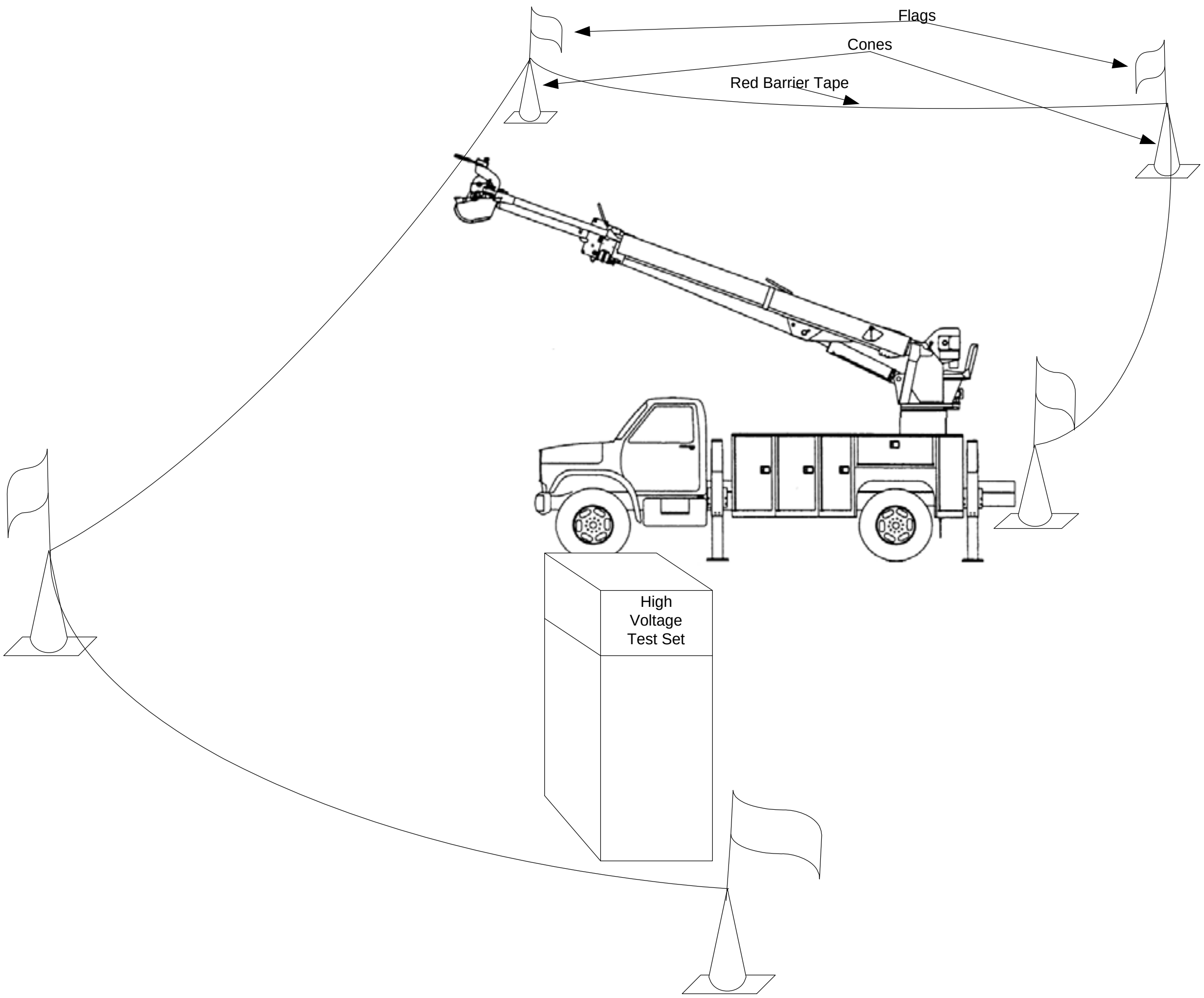
1.11 Raise the test voltage gradually from zero (0) volts, watching the ammeter for signs of excess current.

1.12 If no abnormal current is noticed, continue to the specified voltage and energize the tested part for the prescribed time.

1.13 At the prescribed time, read and record the voltage and the leakage current on Form shown at the end of this procedure, Page 8 of 8.

1.14 Gradually lower the test voltage to zero (0).

1.15 Short the High Voltage lead and Return lead to ground for at least 1 minute before attempting to remove any connections.


Flags
Cones
Red Barrier Tape
High Voltage Test Set

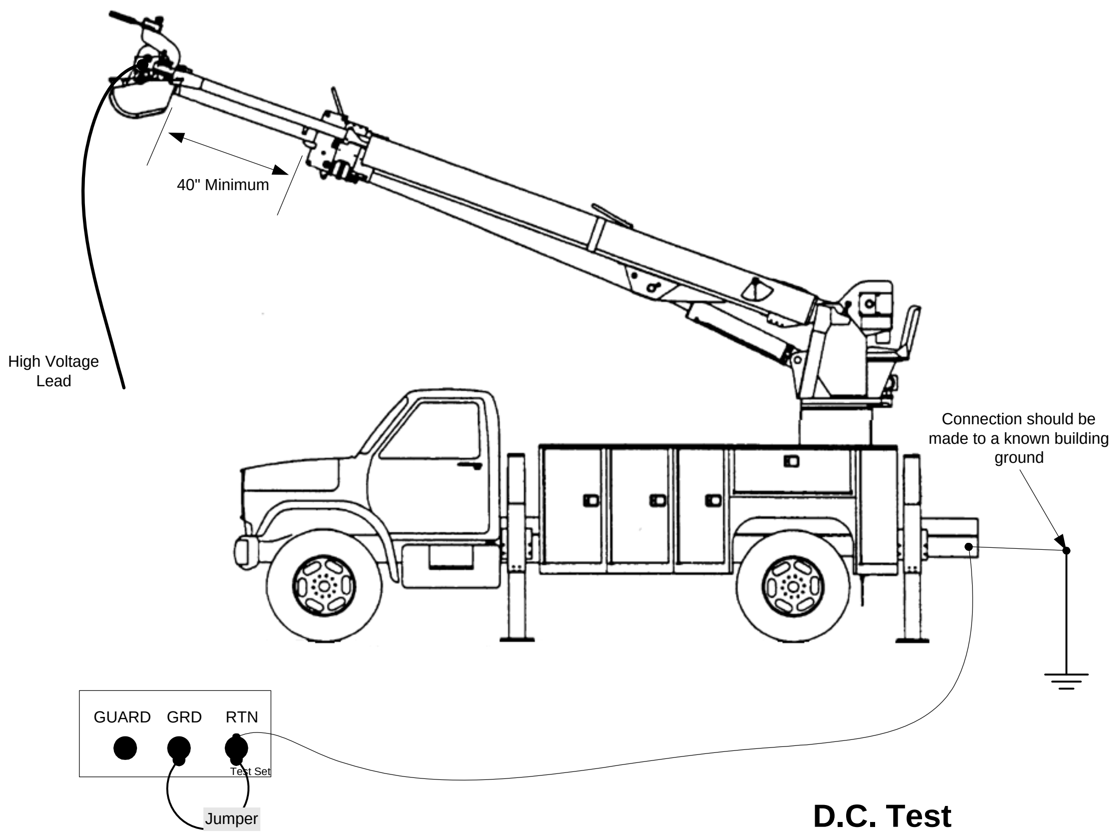
2.0 D.C. TEST OF INSULATED BOOM

2.1 Connect electrically the High Voltage lead from the test set to the metal at the upper boom tip. All metal at boom tip shall be bonded using short jumpers of #2 copper (or larger).

2.2 Connect the vehicle body to a known building ground.

2.3 Connect the Return terminal of the test set to the *same* point on vehicle body from step 2. Test set and truck shall be within protected area as depicted in Periodic DC Test Requirements.

2.4 Jumper Ground to Return on the test set. This will allow both Ground currents and Return currents to pass through the ammeter.



D.C. Test Fiberglass Boom 56 kV

NOTE: If this test is performed indoors, care should be taken to assure a minimum of 5 feet clearance from any wall or ceiling structure.

2.5 Apply test voltage, which should be 56 kVDC for 3 minutes.
The leakage current should not exceed 56 microamperes.

2.6 Lower test voltage to zero (0). Short the High Voltage lead and Return lead to ground for **at least 1 minute** before attempting to remove any connections.

3.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

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TESTER	TEST DATE

NG0335(04.10)

3.5 x 4

Liberty Utilities	Doc. # LU-EOP G005.02d		
Electric Operating Procedure	**01-01-2017**	**General**	
Periodic Dielectric Testing of Digger Derricks - Method 2 (DC Voltage Source)	**Revision #**	**1.1**	**Page: 8 of 8**

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AC/DC ELECTRICAL TESTS ON INSULATED MOBILE EQUIPMENT

Unit Number	Make/Model	Location

DIGGER DERRICK BOOM					AERIAL LIFT (UPPER BOOM)				AERIAL LIFT (LOWER BOOM)				Ambient Temp. (°F)	% Relative Humidity	BOOM TIP OR PEDESTAL HEIGHT	CONDITION OF BOOM OR PEDESTAL			TEST BY
		MICROAMPS				MICROAMPS				MICROAMPS									
DATE	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.	KV	AC or DC?	1 Min.	3 Min.				DRY	DAMP	WET	

Liberty Utilities	Doc. # LU-EOP G005.03		
Electric Operating Procedure	**01-01-2017**	**General**	
Dielectric Testing of Bucket Liners	**Revision #**	**1.1**	**Page: 1 of 3**

INTRODUCTION

This procedure lists the steps needed when performing both an AC and DC test of bucket liners.

PURPOSE

This procedure is intended to guide Lab & Testing Services personnel in performing acceptance (new) and periodic proof testing of insulated aerial bucket (platform) liners. All liners will be tested according to the established ANSI standard. The manufacturer performs initial testing of the bucket liner at 50/70 KVAC rms.

ACCOUNTABILITY

Lab & Testing Services or Approved Vendor

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

ANSI/SIA A92.2-2001 - Vehicle-Mounted Elevating and Rotating Aerial Devices

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

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Liberty Utilities	Doc. # LU-EOP G005.03		
Electric Operating Procedure	**01-01-2017**	**General**	
Dielectric Testing of Bucket Liners	**Revision #**	**1.1**	**Page: 3 of 3**

1.0 AC AND DC TEST OF BUCKET LINERS

1.1 Immerse the bucket liner in a tank of tap water to within six (6) inches of the liner top.

1.2 Apply the AC (35kV rms 60Hz) or DC (100kV) voltage at a rate sufficient to reach full voltage in approximately fifteen (15) seconds.

1.3 Apply full AC (35kV rms 60Hz) voltage for one (1) minute or DC (100kV) voltage for three (3) minutes, at which time the test shall be discontinued by gradually lowering the voltage to zero.

> **Note: I*t is important that the bucket liner be removed from the test tank ONLY while the high voltage connection from the test set is fully and continuously grounded.***

1.3.1 Test Failure: Locate and repair the puncture point if the bucket liner fails to withstand the test voltage.

1.4 Records all testing information into the database by serial number, as applicable.

1.5 Marking Certification of electrical testing shall be shown on all bucket liners passing the electrical test by writing the voltage tested, liner size, truck assigned to and due date on the outside surface of the bucket liner. Previous dates and voltage will be removed.

2.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G005.04		
Electric Operating Procedure	**01-01-2017**	**General**	
Dielectric Testing of Rubber Gloves	**Revision #**	**1.1**	**Page: 1 of 4**

INTRODUCTION

This procedure lists the typical steps used when performing electrical testing of rubber gloves.

PURPOSE

This procedure is intended to guide Lab & Testing Services personnel or Liberty Utility approved vendor in the proper handling and testing of rubber protective gloves. It is also intended to comply with ASTM Standard Specifications for Electrical Protective Equipment for Workers.

Each employee designated to wear rubber gloves is assigned a tested pair from Lab & Testing Services or Liberty Utility approved Vendor inventory. Each glove is marked with the assigned employee ID number, name and next test date and then placed in a plastic bag.

ACCOUNTABILITY

Lab & Testing Services or Approved Vendor

COORDINATION

Not applicable.

REFERENCES

Code of Federal Regulations 29CFR1910.137 Electrical protective equipment

Liberty Utilities Employee Safety Handbook and Safety Rules

ASTM Procedures

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

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1.0 LAB & TESTING SERVICES PERSONNEL

1.1 Checks in gloves received (by serial number) at the electrical test facility as soon as it is practical to eliminate any folds, creases or improper storage due to shipping.

1.2 Visually checks gloves prior to washing, for any obvious conditions that would adversely affect performance.

1.3 Lab personnel will notify their Superior of any missing or uncompleted glove changes. The Laboratory database contains all names, I.D. numbers, locations, sizes and other remarks for each user in the tracking of all rubber gloves.

1.4 Wash gloves with a suitable detergent and water that will not harm the gloves.

1.5 Rinse gloves thoroughly with water after washing to remove all detergent. Note: Gloves need to be dried prior to loading into test equipment when performing DC testing.

1.6 Load gloves into electrical test equipment, activates the test console which fills gloves, right side out, with clean tap water then immerses gloves to proper depth in water.

1.7 Gloves are then subject to test voltage for one to three minutes for the following classes:

Class of Glove	Test Voltage	Test Voltage
4	40kV AC	70kV DC
3	30kV AC	60kV DC
2	20kV AC	50kV DC
1	10kV AC	40kV DC
0	5kV AC	20kV DC

1.8 Places gloves in an automatic tumble dryer or glove dryer for drying.

1.9 Inspects gloves after drying for punctures, tears, cuts, bruises, ozone cutting or cracking, or any other condition that would adversely affect performance.

1.10 Records all testing information into the database by serial number stamped on the glove as applicable and places gloves in inventory for assignment.

1.11 Each pair of gloves is labeled with assigned employee name, ID number and next test date and placed in plastic bag prior to shipment to the user.

1.12 Segregates and identifies all defective (failed) gloves for shipment to Investment Recovery and/or disposal.

2.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G005.05		
Electric Operating Procedure	01-01-2017	General	
Dielectric Testing of Rubber Sleeves	Revision #	1.1	Page: 1 of 3

INTRODUCTION

This procedure lists the typical steps used when performing electrical testing of rubber sleeves.

PURPOSE

This procedure is intended to guide Lab & Testing Services personnel or Liberty Utilities approved vendor in the proper handling and testing of rubber protective sleeves. It is also intended to comply with ASTM Standard Specifications for Electrical Protective Equipment for Workers.

Each employee designated to wear rubber sleeves is assigned a tested pair from Lab & Testing Services or Liberty Utilities approved Vendor inventory. Each glove is marked with the assigned employee ID number, name and next test date and then placed in a plastic bag.

ACCOUNTABILITY

Lab & Testing Services or Approved Vendor

COORDINATION

Not applicable.

REFERENCES

Code of Federal Regulations 29CFR1910.137 Electrical protective equipment

Liberty Utilities Employee Safety Handbook and Safety Rules

ASTM Procedures

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

Table of Contents

1.0 LAB & TESTING SERVICES PERSONNEL

1.1 Checks in sleeves received (by serial number) at the electrical test facility as soon as it is practical to eliminate any folds, creases or improper storage due to shipping.

1.2 Visually checks sleeves prior to the electrical test, for any obvious conditions that would adversely affect performance

1.3 Lab personnel will notify their Superior of any missing or uncompleted sleeve changes. The Laboratory database contains all names, I.D. numbers, locations, sizes and other remarks for each user in the tracking of all rubber sleeves.

1.4 Wash sleeves with a suitable detergent and water that will not harm the sleeves.

1.5 Rinse sleeves thoroughly with water after washing to remove all detergent. Note: Sleeves need to be dried prior to loading into test equipment when performing DC testing.

1.6 Load sleeves into test equipment which immerse sleeves in water as described in the applicable ASTM procedure utilizing electrodes and a mounting hammock.

1.7 Class 2 sleeves are subjected to 50kV DC or 20 kV AC test voltage for one to three minutes when test console is activated.

1.8 Places sleeves in an automatic tumble dryer or glove dryer for drying after successful completion of the test.

1.9 Inspects sleeves after drying for punctures, tears, cuts, bruises, ozone cutting or cracking, or any other condition that would adversely affect performance.

1.10 Records all testing information into the database by serial number, as applicable and places the sleeves in inventory for assignment.

1.11 Each pair of sleeves is labeled with assigned employee name, ID number and next test date prior to shipment to the user.

1.12 Segregates and identifies as such all defective (failed) sleeves for shipment to Investment Recovery and/or disposal.

2.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G005.06		
Electric Operating Procedure	**01-01-2017**	**General**	
Dielectric Testing of Insulated Blankets	**Revision #**	**1.1**	**Page: 1 of 3**

INTRODUCTION

This procedure lists the typical steps needed when performing electrical testing on insulated blankets.

PURPOSE

This procedure is intended to guide Lab & Testing Services personnel or Approved Vendor in the proper handling and testing of blankets. It is also intended to comply with ASTM Standard Specifications for Electrical Protective Equipment for Workers.

Blankets are electrically tested once a year, and assigned to a work location by use of a label and serial number. The database for the system identifies work locations along with the size and quantity of blankets ordered for each work location. Each blanket received will be labeled with a serial number and the next test date. The database also tracks the shipping schedule.

Approximately six (6) 36" x 36" and eight (8) 22" x 22" blankets can be rolled in a blanket roll-up or in cardboard-type paper, taped and shipped to the work location. Blankets may also be placed laying flat in a large protective container for shipment.

ACCOUNTABILITY

Lab & Testing Services of Approved Vendor.

COORDINATION

Not applicable.

REFERENCES

Code of Federal Regulations 29CFR1910.137 Electrical protective equipment

Liberty Utilities Employee Safety Handbook and Safety Rules

ASTM Procedures

DEFINITIONS

Not Applicable

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

Liberty Utilities	Doc. # LU-EOP G005.06		
Electric Operating Procedure	01-01-2017	General	
Dielectric Testing of Insulated Blankets	Revision #	1.1	Page: 2 of 3

DOCUMENT CONTENTS

Table of Contents

1.0 LAB & TESTING SERVICES PERSONNEL

1.1 Tests solid/split blankets in the blanket tester.

1.1.1 Makes sure blankets to be tested are clean and visually inspected for damage.

1.1.2 Inserts blanket in applicable section of the blanket tester.

1.1.3 Starts the blanket tester, verifying that the test voltage and test times are appropriate for the blanket. Note: Blankets are tested at a 50kV DC or 20kV AC Class 2 level. If blankets are tested at a voltage level lower than the manufacturer specified level, they will be labeled as such.

1.1.4 Segregates passed blankets from defective/failed blankets.

1.1.5 Uses an approved method for repair of failed blankets. Note: cannot patch over a previously patched area.

1.1.6 Enters all applicable information into the database by serial number then places the blanket in inventory for future assignment.

1.2 Segregates and identifies as such all defective (failed) blankets for disposal and report such blankets to Liberty Utility.

1.3 Each blanket is labeled with location, serial number, the next test date and stamped with de-rating, if applicable, as referenced in step 1.1.3 above prior to shipment to the user.

1.4 Prepares blankets for shipping.

2.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

INTRODUCTION

The procedure applies to all employees working for Liberty Utilities electric operations or maybe assigned to assist in electric operations in an emergency situation that are required to wear Rubber PPE.

PURPOSE

To ensure compliance with Liberty Utilities safety and health rules, policies, and procedures as well as compliance with regulatory, safety and health requirements. And to establish guidelines for the exchange of Rubber PPE and to reduce unsafe employee actions.

ACCOUNTABILITY

Lab & Testing Services or Approved Vendor.

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

OSHA

DEFINITIONS

Exchange: the act of accepting tested Rubber Personal Protective Equipment from the Lab or Approved Vendor and returning same to the Lab or Approved Vendor when due for testing and re-distribution.

Rubber Personal Protective Equipment (PPE): specific equipment provided to employees as required to work on or around electrical circuits. Below are the Rubber PPE items provided to employees:

Rubber Gloves (Class “0” and Class “2”)
Rubber Sleeves
Rubber Blankets

Lab: Rubber Goods/Dielectric Test Laboratory Approved Vendor.

Exception Reports (Overdue for Test): are produced by the Lab. They are a compilation of a Department’s Rubber PPE that is overdue for test. It primarily lists the location, Rubber PPE identification number, employee name and date overdue. It is to be used to determine the disposition of the Rubber PPE listed in the Report. More information is provided in this procedure.

Assignment Sheets: the packing lists included with each shipment of Rubber PPE. They list the employee name and the Rubber PPE identification number assigned to them for that cycle. It should be used to ensure that employees sign-off when they have exchanged their Rubber PPE or to note reasons why they have not exchanged the Rubber PPE. More information is provided in this procedure.

Rubber Goods Memorandum: shall be used to identify new PPE issues or identify an employees’ change in location, glove size, sleeve size or special requests. This form must be signed by the department Supervisor and returned to the Lab.

TRAINING

Training is provided by in-house user department personnel as needed or upon request.

DOCUMENT CONTENTS

Table of Contents

1.0 RESPONSIBILITIES

1.1 The employees, supervisors and managers participating in the Rubber PPE exchange program shall be responsible for, but not limited to the following:

1.1.1 Wearing the appropriate personal protective equipment and apparel.

1.1.2 Exchanging Rubber PPE at the specified intervals for their department.

1.1.3 Facilitating the exchange of Rubber PPE.

1.1.4 Communicating to the Lab through the use of the following: Assignment Sheets shall be used to document any failure to exchange and reasons why not exchanged; the Rubber Goods Memorandum Form, shown at the end of this procedure. Shall be used to document new PPE issues or identify an employees' change in location, glove size, sleeve size or special requests. Reviewing Exception reports provided, locating overdue Rubber Goods PPE and returning to such item to the Testing Vendor. If item is not found, the Testing Vendor should be notified of the disposition of such item (i.e. lost or destroyed, etc.).

2.0 EMPLOYEE RESPONSIBILITIES

2.1 Employee(s) required to wear Rubber PPE under the Safety Manual are required to exchange Rubber PPE in prescribed intervals as outlined in this procedure.

2.2 After exchanging the Rubber PPE, employees are required to sign off on the Assignment Sheet provided by the test Lab in the shipping container.

2.3 If unable to exchange Rubber PPE, employees are required to notify their Supervisor of the reason why so it is documented and then reported to the Lab.

3.0 SUPERVISOR/MANAGER/DEPARTMENT HEAD RESPONSIBILITIES

3.1 Manager/Department Heads will be expected to facilitate and enforce the exchange of Rubber PPE in accordance with this procedure.

3.2 Supervisors or designee will be expected to:

3.2.1 Execute the exchange of Rubber PPE.

3.2.2 Ensure employees sign off on Assignment Sheets.

3.2.3 Record on Assignment Sheet reason why employee did not exchange Rubber PPE.

3.2.4 Forward copy of Assignment Sheet to Manager of Electric Operations for sign-off.

3.2.5 Keep original Assignment Sheet in Department Record.

3.2.6 Record on the Rubber Goods Memorandum new PPE issues or identify an employees' change in location, glove size, sleeve size or special requests.

3.2.7 Sign the Rubber Goods Memorandum and forward it to the Lab.

3.2.8 Review Exception Reports and take appropriate action to ensure this procedure is adhered to.

3.2.9 Maintain assignment listing and notify Testing Vendor of any employee changes.

4.0 RUBBER GOODS TESTING VENDOR RESPONSIBILITIES

4.1 The Testing Vendor will maintain historical testing data containing all names, I.D. numbers, locations, sizes and other remarks for each glove or sleeve processed by vendor. This data shall be retained for a period of five (5) years and shall be made available to Liberty Utilities upon request.

5.0 RUBBER PPE EXCHANGE COMMITTEE RESPONSIBILITIES

5.1 The Rubber Goods Exchange Committee or designees shall be responsible for, and not limited to the following:

5.1.1 Provide contact names for people responsible for exchange of Rubber PPE.

5.1.2 Ensure that this procedure is communicated to each of their respective contact persons responsible for the exchange of Rubber PPE.

5.1.3 Reviewing Exception reports provided, locating overdue Rubber PPE and ensure the item is returned to the Lab. If item is not found, Lab should be notified of the disposition of such item (i.e. lost or destroyed, etc.).

5.1.4 Monitor the effectiveness of the procedure by reviewing Exception Reports and taking appropriate action.

5.2 Review/Revisions

5.2.1 This procedure shall be reviewed periodically and revised as required. Revisions of this procedure may be made as a result of a management review, a change in safety management guidance, or company policies. The dates of reviews and revisions will appear on the front page of the procedure in the section titled “Record of Change”.

5.3 Documentation

5.3.1 Documentation related to this procedure and subsequent reviews and revisions will be maintained by Rubber Goods Testing Vendor. This procedure will be accessible to field operations both in paper and electronic format. The paper versions of the procedure will not be document controlled. The official, current version of this procedure and all procedures prepared under this guidance will be on the Liberty Utilities internal SharePoint site(s).

5.4 Assignment Sheet Procedure

5.4.1 Employees assigned Rubber PPE shall be responsible for signing off on Assignment Sheet at time of exchange.

5.4.2 Supervisors or Designee responsible for the distribution and exchange of Rubber PPE will ensure employees have exchanged and signed off on Assignment Sheet.

5.4.3 Manager Electric Operations shall review the Assignment Sheet and note reasons why Rubber PPE was not exchanged.

5.4.4 Original Assignment sheet shall be kept with the department records and a copy returned to the Lab for processing.

5.4.5 Rubber Goods Testing Vendor personnel will update the Rubber Goods PPE database with information provided and prepare Exception Reports for distribution.

5.5 Performance Metrics

5.5.1 The metric for Performance of this Procedure is the number of outstanding Rubber PPE. The procedure is established to reduce the number of outstanding PPE to as close to zero as practicable.

Liberty Utility Rubber PPE Exchange Cycles

Class 2 Rubber Gloves	3 months
Class 0 Rubber Gloves	3 months
Class 2 Rubber Sleeves	6 months
Rubber Blankets	12 months

Liberty Utilities

Overdue: Return to Test Lab

Date: 03/01/2010

Name	ID	Serial No	Overdue
ANYONE, MIKE S	100019999	22279	06/01/2008
	100216BKN	S10, C2, L16, BLK, SALISBURY	
	AWOHL	ANYWHERE O.H.L.	
ANYONE, MIKE S	100019999	22278	03/01/2006
	100011RDN	S10, C0, L11, NORTH	
	AWOHL	ANYWHERE O.H.L.	
ANYONE, MIKE S	100019999	22277	07/26/2007
	22LRGSALS	LARGE SLEEVE SALISBURY	
	AWOHL	ANYWHERE O.H.L.	
ANYONE, MIKE S	100019999	22276	07/26/2006
	36SPLIT	36"X36" CLASS 2 RUBBER BLANKET - SPLIT	
	AWOHL	ANYWHERE O.H.L.	

Liberty Utilities Assignment Sheet

Liberty Utilities

Packing Slip Detail 03/01/2010

Name	ID	Serial No	Due By
Anyone, Mike S	100004444 110216SBC AWOHL	35881 S 11.0, C2, L16, BELL CUFF (SALISBURY) ANYWHERE OHL	06/01/2010
Anyone, Mike S	100004444 26RGSSAL AWOHL	35882 REGULAR SLEEVE STRAIGHT SALISBURY 26 INCH ANYWHERE OHL	09/01/2010
Parking, John P	100005555 100011RDN AWOHL	26998 S 10.0, C0, L11, GLOVE (NORTH) ANYWHERE OHL	06/01/2010
Shmoe, Joseph R	100001111 100011RDN AWOHL	18556 S 10.0, C0, L11, GLOVE (NORTH) ANYWHERE OHL	06/01/2010
Shmoe, Joseph R	100001111 100216BKN AWOHL	35882 S10.0, C2, L16, BLK GLOVE (NORTH) ANYWHERE OHL	06/01/2010

Rubber Goods Memorandum

		Date:
To: Rubber Goods/Dielectric Test Laboratory	Phone/Extension/Fax: Fax :	Location:
Employee Name or Vehicle #:	Employee Number:	
Present Department:	Present Location:	

LOCATION CHANGE (*Please take your PPE with you to your new location*)

Previous Department:	Previous Location:

NEW ISSUE ☐ **REPLACEMENT** ☐ (*Check One*)

CLASS 0	CLASS 2	SLEEVE SIZE
☐ Size 8	☐ Size 8	
☐ Size 8.5	☐ Size 8.5	☐ Curved Arm ☐ Straight Arm
☐ Size 9	☐ Size 9	☐ Regular 26 in.
☐ Size 9.5	☐ Size 9.5	☐ Large 28 in.
☐ Size 10	☐ Size 10	☐ Extra Large 30 in.
☐ Size 10.5	☐ Size 10.5	☐ Other ____
☐ Size 11	☐ Size 11	
☐ Size 11.5	☐ Size 11.5	
☐ Size 12	☐ Size 12	
☐ Other ____	☐ Other ____	

CANCELLATION

GLOVES	SLEEVES
Reason:	Reason:

BLANKETS		SPECIAL REQUEST
Blankets	Qty	Other: (Shorter sleeves are available for special cases by using the SAFER process and contacting your Supervisor)
36" solid	____	
36" split	____	
22" solid	____	
22" split	____	

Supervisor: X	Phone/Extension:

6.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
08/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson
11/01/2018	1.2	Updated Section 4.0 Vendor Responsibilities	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G006		
Electric Operating Procedure	01/31/2013	GENERAL	
Requirements for Loading and Hauling Poles	Revision #	1.0	Page: 1 of 11

1.0 PURPOSE

The purpose of this Electric Operating Procedure is to define the requirements for a Liberty Utilities crew or Liberty Utilities contractor when they are required to load, secure, and transport utility poles. This procedure addresses Federal and State Departments of Transportation requirements for tow bars, flags, lights, load binders, overall length, permits and escort vehicles. All requirements are valid as of the issue date of this procedure and are subject to periodic revisions by the Federal and State Departments of Transportation.

2.0 SCOPE

This document establishes a standard policy for Liberty Utilities outlining the requirements for loading, securing and transporting of utility poles.

3.0 DEFINITIONS

FMCSR – Federal Motor Carrier Safety Regulations
NHDOT – New Hampshire Department of Transportation

4.0 REFERENCES

Liberty Utilities Employee Safety Handbook
Liberty Utilities Distribution Material Specification 2005
Federal Motor Carrier Safety Regulations dated Jan. 2003
New Hampshire DOT Regulations
Work Methods Bulletin #12-16

5.0 RESPONSIBILITY

Standards, Policies, and Codes

A. Administer and update procedure as necessary.
B. Provide appropriate personnel guidance when requested.

Electric Operations

A. Ensure the components of the procedure are implemented.
B. Ensure workers are trained in this procedure.
C. Provide revision input as necessary.

Workers

A. Demonstrate the understanding of the procedure.
B. Comply with the requirements of the procedure.

Training

A. Provided by appropriate Liberty Utilities training program. All personnel that load, secure, and transport poles or other similar material will be required to be trained in the Federal and State DOT statutes and the Liberty Utilities Company’s load securement requirements.

6.0 PROCEDURE

6.1 General Operational Information

It is the responsibility of the driver to ensure that any load is properly secured to the vehicle and that any trailer that is attached to the vehicle is in proper working order. Additionally, all flags, load securement devices, required permits and escorts are in place, when required by federal, state or local regulations.

All work must be done in accordance with the Liberty Utilities Employee Safety Handbook, utilizing all appropriate safe work methods.

All appropriate Personal Protective Equipment, which includes, but is not limited to hardhat, eye protection, footwear and work gloves shall be worn when performing work.

Before work begins a “Job Briefing” shall be conducted to identify the scope of the job, the work methods to be utilized and all hazards associated with the job.

6.2 Determining the Weight of the Poles

The operator should determine the weight of the pole (Load). Average pole weights in pounds are listed in the table below:

POLE LENGTH (Feet)	CENTER OF GRAVITY (Measured in feet from butt)	AVERAGE WEIGHT IN POUNDS					
	FULL LENGTH TREATED SOUTHERN YELLOW PINE POLES						
		CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6
20		-----	-----	-----	-----	330	284
25		-----	-----	674	573	490	422
30		-----	-----	921	784	660	550
35	16	1567	1343	1155	1004	862	742
40	18.5	1884	1622	1403	1219	1059	921
45	20.5	2222	1911	1664	1444	1274	1114
50	22	2585	2214	1925	1687	1494	-----
55	23	2990	2590	2245	1945	-----	-----
60	14 & 45	3755	3260	2820	2450	-----	-----
65	14 & 47.5	4265	3695	3205	-----	-----	-----
70	15 & 50	4805	4170	3610	-----	-----	-----
	FULL LENGTH TREATED WESTERN RED CEDAR POLES						
30		-----	-----	645	540	440	370
35	16	1055	880	750	660	570	495
40	17.5	1320	1145	970	790	705	615
45	19.5	1585	1365	1145	1010	880	-----
50	21.5	1760	1585	1365	1230	1145	-----
55	23	2025	1760	1540	1410	-----	-----

6.3 Weight Capacities of Pole Dinkeys and Pole Trailers

The weight capacity of a pole dinkey or pole trailer must be known. This information can be found on the manufacturer’s tag attached to the trailer and the information is kept on file at the local Fleet office. For trailers without a manufacturer’s tag, the information is kept on file by trailer number. All pole trailers and pole dinkeys are assigned an identification number or a trailer number that is located somewhere on the trailer. **Some types of pole**

dinkeys are not registered with the state Dept. of Motor Vehicles, but are permitted for use on the road when hauling a pole.

***Note:* An empty pole dinkey that does not have a DMV registration must be carried on the deck of the truck when not being utilized to haul a pole.**

6.4 Requirements for Tow Bars

Tow bars that attach to the pole and are used to couple the pole to the truck must comply with Federal Motor Carrier Safety Regulation 393.71 (h) (l). This regulation requires that all tow bars are structurally adequate and rated for the gross weight of the trailer. Tow bars are to be stamped or engraved with weight ratings. **Fleet requires that all tow bars will be purchased from the pole trailer manufacturer to ensure that the tow bar meets DOT standards**. Homemade tow bars or tow bars of an unknown capacity **are not** permitted for use and should be removed from service. Examples of properly rated tow bars are shown in Fig. 1 and Fig. 2. The tow bar in Fig. 1 can be purchased from the Bates Equipment Corp. It has a capacity rating of approximately 10,000 lbs. and weighs approximately 70 lbs. The tow bar in Fig. 2 can be purchased from the Sauber Trailer Co. and has a capacity rating of 12,500 lbs. Refer to the Approved Tool Catalog for the ordering information.

The tow bar must be equipped with two safety chains and hooks (with latches) that are attached to the bar rated for the tow bar capacity. **The chains are not permitted to be welded to the tow bar.** Federal Motor Carrier Reg. 393.71(h) (10) (ii), requires that if safety chains are used as the safety device, they shall be crossed and attached to the vehicle near the points of the bumper attachments to the chassis of the vehicle. The safety chains shown in the figure below are 3/8 inch diameter steel alloy.

Note: When trailer is equipped with electric brakes, the safety chains must not interfere with the operation of the break away switch.

Figure 1

Figure 2

6.5 Requirements for Load Securement

Federal Motor Carrier Safety Regulation (FMCSR) §393.100 requires that each commercial vehicle must, when transporting cargo on public roads, be loaded and equipped, and the cargo secured to prevent the cargo from leaking, spilling, blowing or falling from the vehicle. Cargo must be contained, immobilized or secured to prevent shifting upon or within the vehicle to such an extent that the vehicle's stability or maneuverability is adversely affected.

All devices and systems used to secure cargo to or within a vehicle must be capable of meeting the requirements of FMCSR §393.102.

All tiedowns, cargo securement systems, parts and components used to secure cargo must be in proper working order. Tiedowns and securing devices must not contain knots. If a tiedown is repaired, it must be repaired in accordance with the applicable manufacturing standards contained in 393.104 (e).

FMCSR §393.106 (b) requires that cargo must be firmly secured on or within a vehicle by tie downs of adequate strength and in good working order.

The aggregate working load limit for tiedowns used to secure an article (pole) or group of articles (poles) against movement must be at least one-half times the weight of the article (pole) or group of articles (poles). The aggregate working load limit is the sum of:

1. One-half the working load limit of each tiedown that goes from an anchor point on the vehicle to an anchor point on an article of cargo.
2. One-half the working load limit of each tiedown that is attached to an anchor point on the vehicle, passes through, over, or around the article of cargo, and then is attached to an anchor point on the same side of the vehicle.
3. The working load limit for each tiedown that goes from an anchor point on the vehicle, though, over, or around the article of cargo, and then attaches to an anchor point on the other side of the vehicle.

FMCSR §392.9 (b) requires that the driver inspect the cargo and devices used to secure the cargo within the first 50 miles after beginning the trip and make adjustments to the securement devices as necessary, including adding more devices to ensure that cargo cannot shift on or within, or fall from the vehicle. Reexamination of any adjustments must be made when the driver changes his/her driving status; or when the vehicle has been driven for 3 hours or for 150 miles, whichever comes first.

IT IS IMPLIED THAT THE DRIVER WILL HAVE ADDITIONAL TIE DOWN DEVICES, IN GOOD WORKING ORDER, STORED ON THE VEHICLE TO BE USED AS NEEDED TO FURTHER SECURE THE LOAD AFTER THE FIRST INSPECTION.

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Requirements for Loading and Hauling Poles	Revision #	1.0	Page: 5 of 11

6.6 General Requirements for Hauling Poles

Utility poles are defined by the Federal Motor Carrier Safety Regulations (§ 393.5) as longwood. Longwood must be cradled in two or more bunks and must either:

(i) Be secured to the vehicle by at least two tiedowns at locations that provide effective securement, or

(ii) Be bound by at least two tiedown-type devices, such as wire rope, used as wrappers that encircle the entire load at locations along the load that provide effective securement. If wrapper(s) is being used to bundle the logs together; the wrapper is not required to be attached to the vehicle.

6.7 Hauling Poles on Digger Derricks

Liberty Utilities newer style digger derricks are equipped with two bunks that have the appropriate tiedowns to comply with the tiedown requirements outlined in FMCSR §393.106 (d). To alleviate any over axle weight issues, it is recommended that the pole be loaded into the pole storage bunk on the digger derrick with the pole butt to the rear of the digger derrick. Placing the pole butt to the rear will remove some of the weight off the front axles and may avoid an overweight axle. Drivers of digger derricks must understand the limitations for the front axle weight rating and the gross vehicle weight limits of the equipment and how the placement of the material on the digger affects the axle weight ratings.

General Requirements:

- Pole is secured at each bunk with the tiedowns (2 total).
- During daylight hours the end of the pole must be marked with a red flag (Item ID 8830-0808933). During times of darkness or poor visibility the end of the pole should have a steady burn battery operated red light
- Poles extending greater than 6 ft. from the rear bumper should have a red flag (Item ID 8830-0808933) placed in the middle of the portion of pole extending beyond the bumper.
- Poles should be loaded so that the tip of the pole on the front of the truck is less than 13 ft. 6 in. which is the maximum allowable height without a permit.

Specific Requirements:

New Hampshire

40 ft. and 45 ft. poles can be transported on a digger derrick equipped with pole racks and tiedowns without a special permit. Poles greater than 45 ft. cannot be transported in the pole rack on the digger derrick.

6.8 Hauling Poles on Pole Trailers

A pole trailer is defined in Federal Motor Carrier Safety Regulation §390.5 as a motor vehicle which is designed to be drawn by another motor vehicle and attached to the towing motor vehicle by means of a "reach" or "pole", or by being "boomed" or otherwise secured to the towing motor vehicle, for transporting long or irregularly shaped loads such as poles, pipes, or structural members, which generally are capable of sustaining themselves as beams between the supporting connections. This definition of a pole trailer would include National Grid's pole trailers which are registered with the state registries that have the required lamps, reflective devices and electrical equipment in effect at the time of manufacture along with pole dinkeys which are not registered and do not have the required lamps, reflective devices and electrical equipment. ***(Note: Pole dinkeys must be transported in the bed of the truck when empty).***

During hours of darkness or poor visibility poles shall be marked near the middle with an amber rotating light visible from 360 degrees. Additionally, pole trailers without integrated rear lighting shall be marked with a light bar during hours of darkness or poor visibility.

Amber rotating light

Light bar

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Below are the requirements for each trailer type used by the field (does not include tractor trailer used by Stores):

1. Extendable pole trailer

GVWR 14,300 lbs, Capacity 9200 lbs.

General Requirements:

- Pole is secured at each bunk with the tiedowns (3 total). Safety chains from the trailer are secured to tow vehicle.
- The end of the pole will be marked with the integrated aluminum light bar with two red flags (Item ID 8830-0808933) attached to identify the outmost part.
- Poles extending greater than 6 ft. from the rear bumper should have a red flag (Item ID 8830-0808933) placed in the middle of the portion of pole extending beyond the bumper.

2. Pole trailer

Liberty Utilities	Doc. # LU-EOP G006		
Electric Operating Procedure	01/31/2013	GENERAL	
Requirements for Loading and Hauling Poles	Revision #	1.0	Page: 8 of 11

General Requirements:

- Pole is secured to the tow vehicle with a tow bar that is bolted to the tip of the pole.
- Pole is secured at each bunk with the tiedowns. National Grid requires that one additional tiedown be placed around the pole and the steel tongue of the trailer (3 total). Safety chains from the trailer should be wrapped around the pole and secure to avoid dragging the chains.
- The end of the pole will be marked with the integrated aluminum light bar with two red flags (Item ID 8830-0808933) attached to identify the outmost part.
- Poles extending greater than 6 ft. from the rear bumper should have a red flag (Item ID 8830-0808933) placed in the middle of the portion of pole extending beyond the bumper.
- Poles greater than 30 ft. should have the middle portion of the pole marked with a red flag (Item ID 8830-0808933) during daylight hours and shall be marked with an amber rotating light visible from 360 degrees during times of darkness or poor visibility.

Specific Requirements:

- When using this pole trailer, the pole which has the tow bar attached becomes part of the trailer when properly secured with the two tiedowns at each bunk. Additional poles loaded onto this pole trailer will require additional tiedowns. One tiedown for every ten feet of length should be added (i.e. 4 additional tiedowns for 40 ft. pole).

<u>Option:</u> Since the configuration of this trailer allows the tiedowns that are located at each bunk to encircle the entire load, they can be counted towards the additional tiedowns.

Liberty Utilities	Doc. # LU-EOP G006		
Electric Operating Procedure	01/31/2013	GENERAL	
Requirements for Loading and Hauling Poles	Revision #	1.0	Page: 9 of 11

Example: Hauling two (2) 40 ft. poles on this trailer

An additional 40 ft. pole would require an additional tiedown for every 10 ft. This would be 4 tiedowns. Since configuration of the two tiedowns at each bunk allow them to encircle the entire load, then only two additional tiedowns are required. These tiedowns should be placed greater than 10 ft. apart. See photo below:

1. Pole Dinkeys

Capacity 3 350 lbs

Capacity 5000 lbs

Capacity 6000 lbs

General Requirements:

- Pole is secured to the tow vehicle with a tow bar that is bolted to the tip of the pole.
- Pole is secured at each bunk with the tiedowns (2 total).
- Poles extending greater than 6 ft. from the rear bumper should have a red flag (Item ID 8830-0808933) placed in the middle of the portion of pole extending beyond the bumper.
- Poles greater than 30 ft. should have the middle portion of the pole marked with a red flag (Item ID 8830-0808933) during daylight hours and shall be marked with an amber rotating light visible from 360 degrees during times of darkness or poor visibility.

Specific Requirements:

- When using this pole trailer, the pole which has the tow bar attached becomes part of the trailer when properly secured with the two tiedowns at each bunk. Additional poles loaded onto this pole trailer will require additional tiedowns. One tiedown for every ten feet of length should be added (i.e. 4 additional tiedowns for 40 ft. pole).

6.9 Permit Requirements for Overall Length of Vehicle and Load to be Hauled

The overall length measurement includes the length of the towing vehicle and the length of the load being towed.

In New Hampshire (refer to NHDOT Regulations Chapter 266 sect. 266:11-a) No restriction on over length combination vehicles when hauling poles on a pole trailer. No special permits required. For single vehicle overall length a permit is required for an overall length over 45 feet. Maximum height from ground without a permit is 13 ft. 6 in.

6.10 Requirements for Escort Vehicles

New Hampshire State requirements for escort vehicles:

Escort personnel must be certified in the state they are performing this duty and the escort vehicle must be equipped with all the required equipment.

NHDOT Regulations for Oversize and Overweight Vehicle pg. 29: when the overall length of the vehicle is over 100 feet an escort shall be required 1 escort vehicle in the rear and a NH State police escort.

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
01/31/2013	0	Initial version of Document	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G007		
Electric Operating Procedure	01-01-2017	General	
Maintenance Outdoor Lighting Installations	Revision #	1.1	Page: 1 of 6

INTRODUCTION
This procedure describes the required maintenance practices to be performed any time a Liberty Utilities crew or Liberty Utilities Contractor has a need to perform any repairs on a company owned outdoor street lighting installations.

PURPOSE
This document covers the maintenance procedures required for company owned outdoor street lighting equipment. This covers both overhead and underground supplied installations.

ACCOUNTABILTY
1. Standards, Policies, and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate guidance to field personnel when requested for a specific work related tasks.

2. Electric Distribution Operations
   - A. Ensure this procedure is implemented in the field.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   - A. Demonstrate an understanding of the procedure.
   - B. Comply with the requirements of the procedure.
   - C. It is the workers responsibility to read and fully understand and follow the manufacturer's Instruction manual and specifications before operating any equipment.

COORDINATION

Not Applicable

REFERENCES
Liberty Utilities Employee Safety Handbook and Safety Rules

Liberty Utilities Construction Standards

Applicable OSHA Standards

National Electric Safety Code

DEFINITIONS
Luminaire – A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply. (IEEE-100)

Touch Potential - The voltage difference between an object which the worker may touch and the earth upon which the worker is standing. This voltage difference could be hazardous and could result from energization, induction, or faults

TRAINING

A written request should be submitted to Learning and Development by user group whenever training is required.

DOCUMENTS CONTENTS

Table of Contents

1.0 PROCEDURE

1.1 Required Maintenance – All Installations

1.1.1 Replace lamp as necessary.
a. Clean the reflector and refractor with a soft, dry, cloth.
b. Replace any cracked, broken, or badly discolored refractors.

1.1.2 Check photoelectric control for proper “turn on”/“turn off” operation.
a. Replace photoelectric control only if the existing unit is damaged or fails to operate.

1.1.3 Replace the starter in high pressure sodium vapor luminaires only if the unit has failed.

1.1.4 For luminaires with coastal exposure, check connections to the secondary supply conductors and replace if corrosion is evident.

1.1.5 For horizontal roadway luminaires check that the black plastic bird guard is in place between the bracket and the luminaire.
a. Replace if missing or damaged.

1.1.6 Replace the NEMA, color-coded, luminaire wattage label if existing one is missing or faded.

1.1.7 Check luminaire attachment bolts to insure that luminaire is securely attached to the arm/bracket.

1.2 Additional Maintenance – Overhead Supplied Installations

1.2.1 Check that bracket is properly grounded.
a. Replace the copper grounding conductor if damaged or missing.

1.2.1 Repair or replace the mechanical protection on the luminaire supply conductors between bracket and secondary supply conductors as necessary.

1.2.3 Check that all required lag screws are in place. Replace any that are missing.

1.3 Additional Maintenance – Underground Supplied Installations

1.3.1 Company owned metallic street lighting standards are required to be tested during each outage investigation notification and the data will be recorded for each instance. Perform “touch potential test” refer to LU-EOP G004 for testing procedure.

1.3.2 Check pole handhole access cover and replace if damaged or missing.

1.3.3 If the pole handhole access cover must be opened for any reason:
a. Check the pole grounding conductor and repair as needed.
b. Check luminaire wiring for any frayed insulation or bare spots. Re-insulate with PVC tape as needed.

1.3.4 Perform “touch potential test” on Liberty Utilities owned equipment within a 10’ radius of the pole. Do not inspect equipment in the traveled portion of a public roadway.

1.3.5 Replace pole numbers if missing or damaged.

1.3.6 When required, replace pole reflector if missing or damaged.

1.3.7 Clear disposable cover-up should be installed in streetlight handholes between the streetlight cables and any metal portion of the handhole.

1.4 Failed Luminaires

A Luminaire which has failed in service shall be replaced only with a luminaire of the same wattage size and lamp type. The only exceptions to this are as follows:

1.4.1 Mercury Vapor Luminaires: A mercury vapor (MV) luminaire shall be replaced with a high pressure sodium vapor (HPS) cutoff roadway luminaire. The replacement HPS cutoff roadway luminaire shall be sized to match as close as possible the lumen output (not the luminaire wattage). Table 1 lists recommended replacement luminaires:

Table 1

Existing		Replacement
100w MV	-	50w HPS
175w MV	-	100w HPS
250w MV	-	150w HPS
400w MV	-	250w HPS
1000w MV	-	400w HPS

1.4.2 Notify your supervisor any time an existing MV installation is converted to HPS so required billing changes to the customer can be made.

Note: The appropriate Monthly Confirming Light Order needs to be charged and documentation (field trouble report) see example sketch 1 below, submit to supervisor to account for the asset addition/retirement and inventory records in GIS and CSS-OL are to be corrected. This is required whenever a failed luminaire fixture is replaced in the field (whether HPS or MV) and using a Confirming Monthly Light Order.

1.4.3 Metal Halide Luminaires: A failed Probe Start Metal Halide (MH) luminaire shall be replaced with a Pulse Start Metal Halide (PSMH) luminaire if a replacement probe start unit is not available. Table 2 list recommended PSMH replacement luminaires. No customer billing changes are required.

Table 2

Existing		Replacement
175w MH	-	175w PSMH
250w MH	-	250w PSMH
400w MH	-	400w PSMH

SKETCH 1

Field Trouble Report

Liberty Utilities

Complaint: Light Out					
Date: 3/4/2016	Customer Name:				
Street: Chatham Circle				Town: Salem	
Electric Pole #: P4	Telephone Pole #:	Arrival Time:		Volt. @ Fault:	
Time Off:	Time On:	Construction Type:			
Conductor Size:	AL.	CU.	Bare	Covered	Other
Weather Conditions:					
Cause: Defective					
Protective Device:		Component Failed:			
Remarks/Replacement Equipment Data: WR # 18002142 replace 100W HPS St. Light Head					
Time Checked:	Work Remaining:				
Repaired By: M Parker		Truck Number:			

NG0105 (07.06)

2.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

1.0 PURPOSE

Liberty Utilities is required by the New Hampshire PUC to report employee personal injury accidents (refer to 6.1.2) and deaths (refer to 6.1.1), as well as all public injuries associated with the Company's electric facilities. Additionally, New Hampshire PUC requires notification on unusual events that receive media attention, loss of a substation due to damage or loss of supply, or storm/weather related preparation.

2.0 SCOPE

This procedure shall apply whenever the following occur - employee personal injury accidents and deaths, public incidents (injuries) with company facilities, and unusual or major events.

3.0 DEFINITIONS

NHPUC – New Hampshire Public Utilities Commission

4.0 REFERENCES

Liberty Utilities Employee Safety handbook
New Hampshire PUC Administration Rules 306.06

5.0 RESPONSIBILITY

Roles and Responsibilities are outlined in the "Procedure" section of this document

6.0 NEW HAMPSHIRE PUC NOTIFICATION REQUIREMENT GUIDELINES

6.1 In Compliance with requirements of New Hampshire Administration Rules PUC 306.06, Liberty Utilities, shall notify the commission immediately (direct contact) by telephone when it becomes aware that an accident or event has occurred in connection with its property, facilities or service in which:

6.1.1 A human fatality has occurred (Fatalities involving a motor vehicle striking a Company asset shall be reported).

6.1.2 An electrical contact that has occurred in which a human has received a shock, flash injury or other injury resulting from that contact.

6.1.3 Damage to Liberty Utilities' facilities that has occurred which interrupts service of an electrical substation resulting in a customer outage longer than 5 minutes.

6.1.4 A significant breach of security, or threat against, any of Liberty Utilities' facilities that has occurred.

6.1.5 Newsworthy/Major Event/Media Attention – Any accident or event listed below will require immediate NHPUC contact

- Involves power line contacts other than in 6.1.2
- Involves aircraft, trains or boats
- Results in closure of a state highway
- Is likely to be, or has been, reported on network television

Immediate notice is to be made by telephone utilizing the NHPUC Accident Notification Protocol Roster (Attachment A). Accidents or events should be reported per the contact order as specified on the NHPUC Protocol Roster. Once person-to-person contact has

been made with the NHPUC contact and required information is conveyed, or the procedure has been exhausted, notification is deemed complete.
The initial telephonic notification shall be completed by the appropriate Distribution System Operation Control Center upon receiving the appropriate information from company personnel. Additional notifications should be made to Liberty Utilities Director Electric Operations and Manager of Safety and Health. If accident occurred after hours telephonic notification should be made to Liberty Utilities area on call supervisor.

When the utility is first able to speak to a commission representative listed on the NHPUC Protocol Roster, the following information is required to be provided:

6.1.6 Name of Utility

6.1.7 Name of individual making report and telephone number

6.1.8 Brief description of accident and location

6.1.9 A description of any know fatalities, personal injuries and damages

6.1.10 Any other known information relevant to the cause of the accident and the extent of damages.

6.1.11 The time at which the accident occurred and the time the utility was first notified.

If unable to reach any of the Commission contacts from the NHPUC Protocol Roster or in the event of an Emergency or Electrical Contact if direct contact with one of the individuals listed on the Protocol Roster cannot be made during normal business hours, call Safety Division phone number (603)271-6022. Identify that you are required to make direct contact with a person in order to get the message to the proper person as soon as possible.
If unable to reach any of the Commission contacts from the NHPUC Protocol Roster outside of normal Commission hours, call the Commission’s general phone listed below and leave a voice mail message with required information.

- Commission normal working hours are Monday through Friday, 8:00 AM to 4:30 PM (EST)
- Commission General Phone number is (603)271-2431

6.1.12 A written report is required to be submitted to the NHPUC within 10 days of the accident utilizing Form E-5 Accident Report (Attachment B). Electric Operations shall complete and send report. Additionally, a detailed written report referencing the original E-5 report number is required within 60 days of notification. The report shall include any supportive documentation not provided in its original E-5 report. Electric Operations shall complete and send report. Refer to NHPUC Administrative Rule 308.06 E-5 Accident Reports for report information.

6.2 **Additional Reporting Requirements**

6.2.1 Liberty Utilities is required to inform NHPUC on storm or any weather related event preparation in regards to additional staffing levels (line worker contractors on standby in any electric operations areas). Electric Operations or designee shall make this notification. In the case of a Major Event, all NHPUC notifications will follow the procedures set forth in the Liberty Utilities Electric Emergency Response Plan.

7.0 TRAINING

There are no training requirements associated with this procedure.

8.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

None

Liberty Utilities	Doc. # LU-EOP G009.1		
Electric Operating Procedure	**12/01/2017**	**General**	
NHPUC Notification for Personal Injury Accidents/Newsworthy Events	**Revision #**	**1.1**	**Page: 4 of 6**

9.0 APPENDICES

9.1 Attachment A

CHAIRMAN
Amy L. Ignatius

COMMISSIONERS
Michael D. Harrington
Robert R. Scott

EXECUTIVE DIRECTOR
Debra A. Howland

STATE OF NEW HAMPSHIRE

PUBLIC UTILITIES COMMISSION
21 S. Fruit Street, Suite 10
Concord, N.H. 03301-2429

TDD Access: Relay NH
1-800-735-2964

Tel. (603) 271-2431

FAX (603) 271-3878

Website:
www.puc.nh.gov

<u>Accident Notification Protocol Roster</u>

Pursuant to PUC 306.06 (electric), 411.08 (telephone), 508.03 (gas), 608.03 (water), 707.03 (sewer), or 1105.05 (steam); the following is a list of commission staff contacts to be used for accident notification. Accidents should be reported per the contact order below for your specific industry. Once person-to-person contact has been made with one of the below listed individuals and required information is conveyed, or the procedure has been exhausted, notification is deemed complete.

<u>Primary – Monday through Sunday (24 hours):</u>

Contact Name	For Calls Related to	Work Phone	Home Phone**	Cell Phone
David Burnell	Gas, Water, Sewer, Steam, Telephone, Electric	(603) 271-6040	(603) 524-2597	(603) 419-0169

<u>Secondary – Monday through Sunday (24 hours):</u>

Randy Knepper	Gas, Water, Sewer, Steam, Telephone, Electric	(603) 271-6026	(603) 219-0331	(603) 419-0548

<u>Tertiary – Monday through Sunday (24 hours):</u>

William (Bill) Ruoff	Gas, Water, Sewer, Steam, Telephone, Electric	(603) 271-6532	(603) 588-2233	(603) 419-0701

If unable to reach any of the above, or in the event of an Emergency or Electrical Contact if direct contact with one of the individuals listed above cannot be made during normal business hours please press 0 (zero) to be transferred to the Safety Division or call 271-6022. Identify that you are required to make direct contact with a person in order to get the message to the proper person as soon as possible.

If unable to reach any of the above outside of normal Commission hours, call the Commission's general phone number listed below and leave a voice mail message with required information.

- Commission normal working hours are Monday through Friday, 8:00 AM to 4:30 PM (EST).
- Commission General Phone number is (603) 271-2431.
- This roster is for external use only within your utility and none of these numbers are to be given to anyone except the appropriate utility contact(s) who will be responsible for making the notification calls.

**Home phone numbers are to be utilized for accidents requiring immediate notification only.

NHPUC Revised – May 1, 2012.

<table>
<tr><td colspan="1">Liberty Utilities</td><td colspan="3">Doc. # LU-EOP G009.1</td></tr>
<tr><td>Electric Operating Procedure</td><td>12/01/2017</td><td colspan="2">General</td></tr>
<tr><td>NHPUC Notification for Personal Injury Accidents/Newsworthy Events</td><td>Revision #</td><td>1.1</td><td>Page: 5 of 6</td></tr>
</table>

9.2 Attachment B

NHPUC Electric and Telephone Accident Reporting Form (E-5)
The State of New Hampshire
Public Utilities Commission
Concord, NH 03301

☐ Ten Day Report (1) ☐ Quarterly Report (2)

General Information

Report No: ____________ Current Date: ____________

Utility Name: ______________________________

Date of Accident: ____________

Location of Accident: ______________________________

Did an Entire Substation lose service for more than 5 minutes? ☐ Yes ☐ No

Did an entire Telephone Exchange lose service for more than 15 minutes? ☐ Yes ☐ No

State Cause of Accident and Extent of Damage (3). ______________________________

____

____

____

Fatality/Injury Information

Name of Injured Person: ______________________

Injured Person's Relationship with Utility: ______________________

Nature and Extent of Injury (4): ______________________________

Did Accident Involve Electric Contact? ☐ Yes ☐ No Was Injury Fatal? ☐ Yes ☐ No

Date of Death: ____________ Previous Report No. (if applicable): ____________

Pole/Anchor Information

Was Pole Licensed? ☐ Yes ☐ No

Was PoleProperly Located (5) ☐ Yes ☐ No ☐ Undetermined

Was Anchor Licensed? ☐ Yes ☐ No

Was PoleProperly Located (5)? ☐ Yes ☐ No ☐ Undetermined

Signature: ______________________ Title: ______________________

(1) If "Ten Day Report" is checked, immediately or next day notification as defined by PUC 306.08 or PUC 405.06 is required, followed by this form being filed within 10 (ten) working days of the accident. A detailed report must then follow within 60 (sixty) calendar days of the accident.

(2) If "Quarterly Report" is checked, this form must be submitted at the end of the present quarter.

(3) Attach Diagram if necessary and also attach a police report if available.

(4) Attach Doctor's report if available. If death occures after this report is filed, that fact must be stated in a subsequent report.

(5) If "No", attach license and a diagram of the actual location versus the licensed location.

Revision - September 9, 1

10.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
07/03/2012	1.0	Initial Version of document	Robert J Johnson
12/01/2017	1.1	Updated document to be NH specific	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G012		
Electric Operating Procedure	**09-01-2013**	**General**	
Capacitors	**Revision #**	**0**	**Page: 1 of 18**

PURPOSE

The purpose of this Electric Operating Procedure is to provide employees with the information to be able to safely install, remove, inspect, operate and handle distribution and subtransmssion line capacitor units up through 34.5kV.

SCOPE

This procedure will provide guidelines for all Liberty Utilities employees who are required to work on or handle distribution line capacitor units.

ACCOUNTABILITY

1. CQ&EM, Standards, Codes, and Policies
   - A. Update procedure as necessary.
   - B. Provide Electric Operations personnel guidance when requested.
2. Electric Distribution Operations
   - A. Ensure the components of the procedure are implemented.
   - B. Ensure Electric Operations personnel are trained in this procedure.
   - C. Provide revision input as necessary.
3. Liberty Utilities Employees and Contractors
   - A. Demonstrate the understanding of the procedure.
   - B. Comply with the requirements of the procedure.
4. Learning and Development
   - A. Provide appropriate training on procedure when requested.

REFERENCES

Liberty Utilities Employee Safety Handbook

Liberty Utilities Overhead Construction Standards

Manufacturer's Operating Instructions: GEH-2710F

NEC 460.28

O.S.H.A. Reg. 1910.269 par. (w) (1)

S&C Loadbuster Specification Bulletin 811-31

Electric Planning Asset Management Distribution Line Capacitor Strategy

DEFINITIONS

Capacitor: A capacitor is a passive electrical component that can store energy in the electric field between a pair of conductors (called "plates").

Fixed: Capacitors that are always on

Switched: Capacitors that are programmed to be periodically switched on and off

Capacitance Test Meter: Electrical test equipment used to measure capacitance.

Halo Meter/SensorLink Ampstik: A high voltage digital ammeter for measuring current (Optional Section)

DOCUMENT CONTENTS

Table of Contents

1.0 SAFETY REQUIREMENTS

1.1 All appropriate PPE, which includes but is not limited to, hard hat, safety glass/eye protection, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Safety Manuals. All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.2 Before work begins a "Job Brief" shall be conducted to identify the boundaries of the work area, the work methods to be used and all hazards associated with the job.

1.3 Capacitors shall be considered as energized at full voltage unless a minimum #6 cu short circuiting wire is installed between the terminals. When working on installed capacitors, all cutouts shall be opened and capacitors discharged and short circuited.

1.4 Before attempting any capacitance measurements make sure the capacitor fuses are open. Wait 5 minutes for the capacitors to completely discharge. Test each phase de-energized with an approved high voltage tester.

2.0 GENERAL OPERATING INFORMATION

Whether the job is routine line work or necessitated by an emergency situation, a **thorough pole top inspection must be conducted** to evaluate such things as:

2.1 The condition of all equipment on the pole, especially porcelain cutouts or switches, the condition of the cross arms and pole top with particular attention to any signs of burning and any non-standard construction hazards.

2.2 Capacitors have the ability of retaining an electrical charge when removed from an energized source. An internal resistor is built into each capacitor unit to provide a path to discharge the voltage stored in the capacitor after it is removed from an energized source.

2.3 If the internal resistor is defective, a high voltage charge could remain in the unit. A defective capacitor may result in the capacitor tank and supporting metal structure on a delta, ungrounded wye or ungrounded system to be energized.

2.4 Tests show that on installations with ungrounded capacitor tanks, when one primary fuse fails, approximately half of the phase to ground voltage exists between the tank and ground.

2.5 All new capacitor installations are required to be grounded. Always check the capacitor rack ground connection before working on an existing capacitor installation. If there is no capacitor rack ground connection then the rack must be bonded to ground before work can be done on the capacitors.

2.6 Capacitor units are completely sealed. When an internal failure occurs, a gas pressure develops inside the tank that can bulge or rupture the tank.

2.7 When a capacitor with a bulged tank is found, it shall be removed from service and replaced.

Liberty Utilities	Doc. # LU-EOP G012		
Electric Operating Procedure	09-01-2013	General	
Capacitors	Revision #	0	Page: 4 of 18

Capacitors shall be tested before they are returned to service using an approved capacitance test meter, such as the Wave Tech CR50, B&K precision Capacitance Meter, model 830A or the Fluke 175 or equivalent.

Wave Tech CR50

B&K Precision Capacitance Meter
Model 830A

Fluke 175

Continuity testers and Quick check testers will not provide accurate information on the condition of the capacitor.

<u>Always open the fused cutouts utilizing an approved loadbreak tool</u>.
(See Table III – S&C Loadbuster Capacitor-Bank Switching) for proper Loadbuster Tool application 5300R3 & 5400R3 pictured below.

Catalog Number 5300R3
Rated: 14.4/25 kV Nominal
27 kV Maximum

Catalog Number 5400R3
Rated: 25/34.5 kV Nominal
38 kV Maximum

Any in service capacitor installation that is observed with a cutout door open or a fuse (s) blown shall be tested accordance with the procedures outlined in sections III an IV of this EOP. All remaining in service cutouts shall be opened to de-energize the capacitor installation.

2.8 Before working on capacitors, the capacitor shall be disconnected from energized sources and, after waiting at least 5 minutes for the capacitor to discharge, the terminals shall be short circuited with a #6 copper wire or equivalent using proper work procedures. See Figure 1 & 3 for short circuiting two bushing and single bushing capacitors.

2.9 The preferred method for discharging the capacitor is to use a short length of wire held by a Grip-all Clamp stick (shot-gun stick) when shorting out the terminals. If the internal discharge resistor is defective, line voltage could be present across the terminals and present a hazard to the worker. See Fig. 1.

2.10 Before capacitor units are handled, each unit in a series/parallel capacitor banks shall be short circuited between all terminals and the capacitor case or its rack. If the capacitors are on an ungrounded rack, the rack shall be bonded to ground first.

2.11 Capacitors shall be considered as energized at full voltage unless a short circuiting wire is installed between the terminals or between terminal and capacitor tank for single bushing capacitors. When working on installed capacitors, all cutouts shall be opened, capacitors discharged (wait 5 minutes), short circuited and grounded.

2.12 Capacitors that are stored **shall** have the terminals short circuited with a minimum size of #6 copper wire (Fig. 2,3,4). Capacitors not in service without the shorting wire **shall** be considered energized.

SHORTING CAPACITOR UNITS

Fig. 1

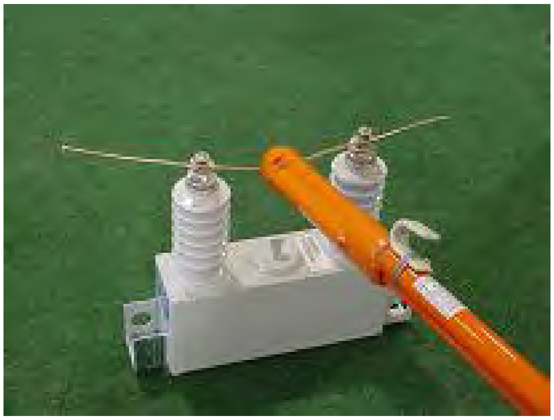
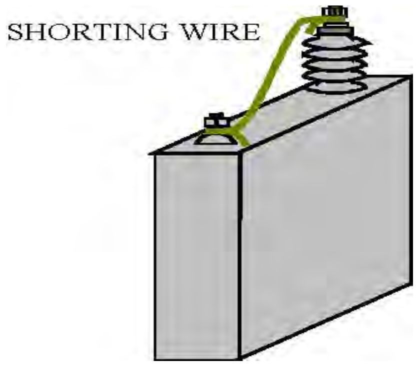


Fig. 2



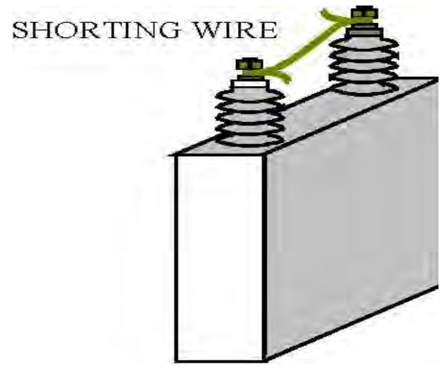


Fig. 4.

3.0 PROCEDURE FOR REMOVING CAPACITORS FROM SERVICE

3.1 If the capacitor bank is equipped with Loadbreak vacuum or oil switches, these shall be opened first before opening the cutouts and closed only after the cutouts have been closed.

3.2 Switched (time clock control operated) capacitor banks should be switched by setting the capacitor control to **MANUAL** and using the **TRIP-CLOSE** toggle switch in the capacitor control cabinet.

3.3 Loadbreak vacuum or oil switches cannot be considered as a visible open.

3.4 **All fused cutouts must be opened on the installation before work is performed on any of the units.**

3.5 Always open the fused cutouts utilizing an approved Loadbreak tool.

3.6 Wait at least 5 minutes fro the capacitor to discharge.

3.7 Short circuit and ground the capacitor terminals using a minimum size #6 copper wire or equivalent.

3.8 When a capacitor bank is found with one or more fuses blown, all remaining intact fuses must be opened and steps 3.6 and 3.7 performed before testing the capacitor.

3.9 Anytime a capacitor is switched off line, wait at least five minutes before putting it back on line. If a capacitor is restored to service in less than 5 minutes, an excessive voltage may result across the terminals and cause damage to the capacitor and pose a hazard to the worker.

3.10 When a capacitor is removed from service and brought in for disposal or storage, make sure the terminals are short circuited with a piece of #6 copper or equivalent, as shown in Figure 2, 3, & 4 for the protection of others who may handle the unit.

4.0 PROCEDURE FOR PLACING CAPACITORS IN SERVICE

4.1 Visually inspect the capacitor unit.

4.2 Remove the shorting leads from the terminals.

4.3 Test the capacitors as follows using the appropriate approved tester for capacitors:

NOTE: The capacitor must be discharged, short circuited and grounded before testing and connections must be clean for accurate readings. Scrape or wire brush as necessary.

4.4 Micro Farad readings are to be taken by placing the clips across the bushings of the capacitor unit or parallel units for two bushing units or between the bushing and the tank for single bushing capacitors. If testing results fall outside the minimum or maximum range for parallel or single units indicated on Table 1 then all units must be tested individually to identify the faulted unit.

4.5 Testing Capacitance Values

4.5.1 Measuring Phase Capacitance in Y Connected Capacitor Banks

READING CAPACITANCE - Y BANKS

Figure 4 below shows connections for measuring phase capacitance in a Y connected bank.

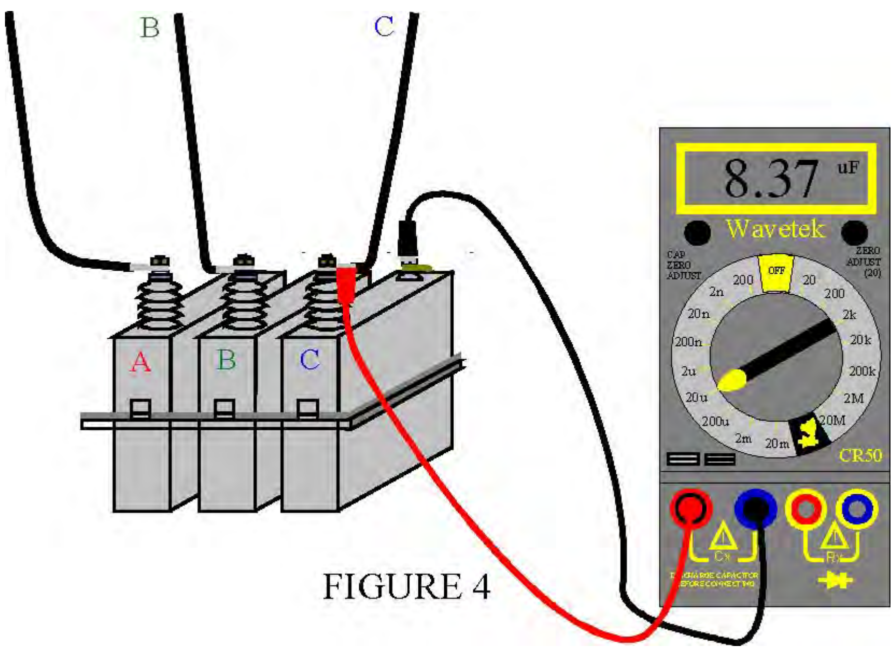


FIGURE 4

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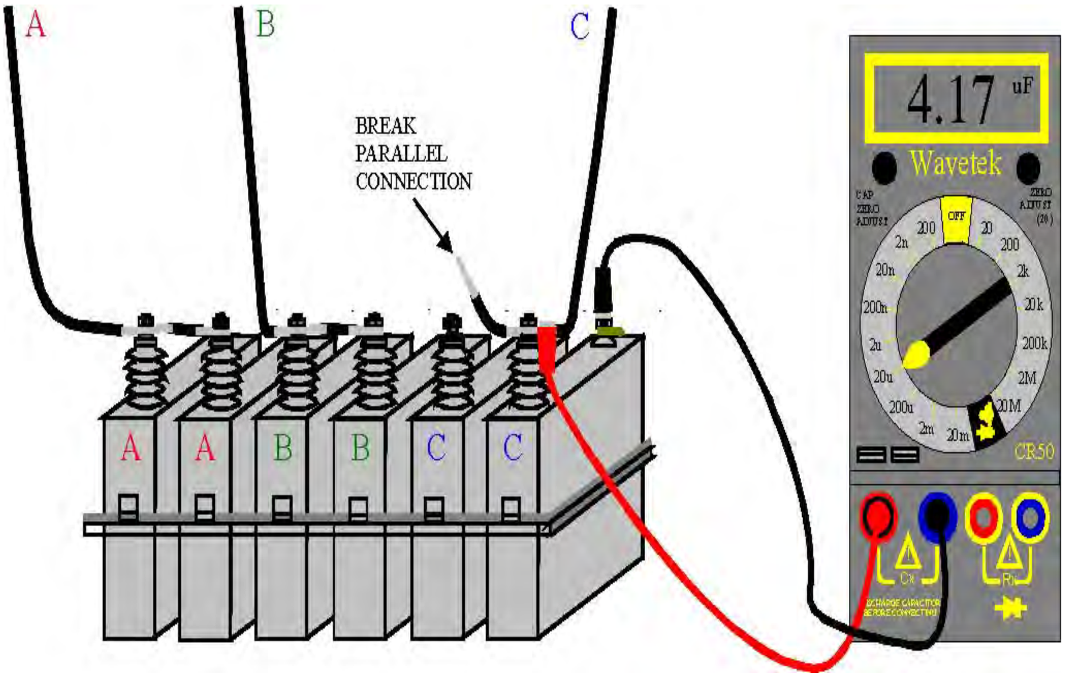


4.6 If there is more than one capacitor per phase, and the phase capacitance test fails, the capacitors in the phase should be disconnected and measured individually. See figure below.

4.6.1 Measuring Phase Capacitance in Delta Connected Capacitor Banks

READING CAPACITANCE – DELTA BANKS

4.7 The figure below shows the connections for measuring phase capacitance in a delta-connected bank. To correctly measure capacitors in a delta bank, one lead must be disconnected to break the delta.

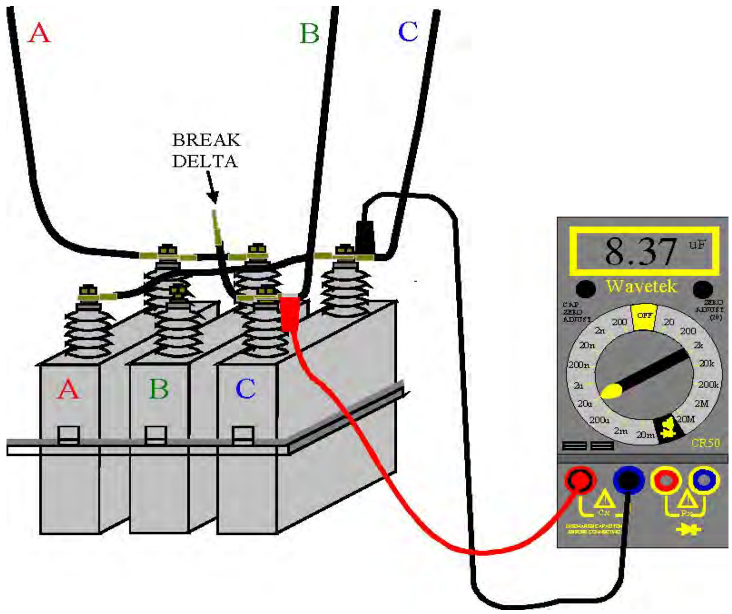
4.7.1 Only one lead needs to be lifted to measure all of the capacitors in the bank.

4.7.2 If the delta is not broken, the capacitors will read **1. 5** times the correct value.

4.7.3 A 12uf capacitor will read 18 uf (micro farads)

4.7.4 If there is more than one capacitor per phase and the phase capacitance test fails, the capacitors in that phase should be disconnected and measured individually.

4.7.5 Capacitor Measurements for 3 phase self contained capacitor units are taken from each bushing to the ground terminal one phase at a time.



From Table 1, this is a Good Capacitor – 4160 Volt 50 Kvar–micro farad range is min 7.7 max 8.8 actual 8.37.

4.8 Check that the unit is properly installed and wired correctly per Section 15 of the Distribution Construction Standards.

4.9 Close the fused cut-outs.

4.10 Close the vacuum/oil switches if so equipped.

4.11 A capacitor **shall not** be restored to service until it has been allowed to discharge for at least 5 minutes. If a capacitor is restored to service in less than 5 minutes, an excessive voltage my result across the terminals and cause damage to the capacitor and pose hazard to the worker.

5.0 INSPECTION SCHEDULE

Field inspection and testing of distribution line capacitors will be conducted annually in the Fall, beginning October 1st per the Distribution Line Capacitor Asset Management Strategy.

Three phase Switched distribution line capacitors will be inspected by Electric Operations Construction as designated by the Director of Electric Operations.

Single phase fixed distribution line capacitors will be inspected on a five year cycle and shall be performed by the Inspections Department.

Electric O&M Services will provide inspection data from the Cascade Data Base and inspection forms to the designated overhead supervisors for the individual platforms and departments. All inspection sheets shall be completed and returned to the local supervisors and inputted into data base.

6.0 FIELD INSPECTION AND TESTING OF CAPACITORS

6.1 Fixed Capacitor Bank Inspection

6.1.1 Check and update if required the following items on the Field Capacitor Inspection Sheet:

a. Location, feeder and pole number

b. Total Capacitor units in bank

c. Total KVAR of bank

d. Type (function) of bank

6.1.2 Visually inspect Bank for:

a. Potted Porcelain Cutouts and Blown Fuses

b. Leaking, bulging or split open capacitor unites.

c. Capacitor rack properly grounded

d. Signs of overheating primary connections and melted squirrel guards

e. Cracked, broken or flashed bushings.

6.1.3 Complete the Field Capacitor Inspection Sheet:

a. Fill out the As Found and Repair Codes on the Field Capacitor Inspection Sheet (See Attachment A)

6.2 Switched Capacitor Bank Inspection

6.2.1 Check and update if required the following items on the Field Capacitor Inspection Sheet:

a. Location, feeder and pole number

b. Total Capacitor units in bank

c. Total KVAR of bank

d. Type (function) of Bank

6.2.2 Visually Inspect Bank for:

a. Potted Porcelain Cutouts and Blown Fuses.

b. Leaking, bulging or split open capacitor units.

c. Capacitor rack properly grounded.

d. Signs of overheating primary connections or melted squirrel guards.

e. Cracked, broken, or flashed bushings.

f. Position of all capacitor switches (open or closed)

g. Condition of secondary control cables

h. Condition and mounting of capacitor control box.

6.2.3 Operate the Capacitor Switches:

a. Put the capacitor control on manual and trip the capacitor switches open with the Trip-Close toggle switch.

b. Visually check the mechanical indicators to verify the switches have operated.

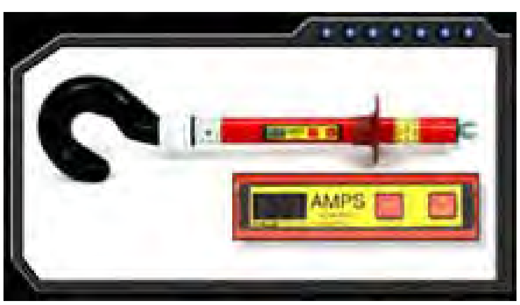
c. Wait five minutes and close the switches with the Trip-Close toggle switch.

d. Leave the capacitor control on manual until the clock has been checked and reset, if necessary.

6.2.4 Measure Phase Currents:

a. Measure the current on each phase and record the readings on the Field Capacitor Inspection Sheet. Use only approved high voltage current meters like the HD Electric Halo 1 or 2, high voltage digital ammeter and the high voltage SensorLink, Ampstik ammeter or equivalent.

Halo 1



Halo 2

SensorLink Ampstik

6.2.5 Check the Clock and Control for:

a. Correct Day of the Week

b. Correct Time of Day

c. Correct On Time

d. Correct Off Time

e. Correct Omit Days

f. Correct settings for Temp Close, Temp Open

g. Correct settings for Volts Close, Volts Open

h. Record Voltage with Cap Open and Closed

Put the capacitor control Auto-Manual switch on Auto.

6.2.6 Make Necessary Repairs:

a. Whenever possible, repairs should be made during the inspection.

6.2.7 Complete the Field Capacitor Inspection Sheet:

a. Fill out the remaining items on the Field Capacitor Inspection Sheet. (See Attachment A)

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ATTACHEMENT A
FIELD CAPACITOR INSPECTION SHEET

FIELD CAPACITOR INSPECTION SHEET

Liberty Utilities

Pole # ____________________

Date Inspected [ ]

Feeder # ____________________ Street ____________________ Town ____________________

Total # Units [ ]

Total KVAR [ ] (KVAR size of single cell) X (number of cells)

Counter [ ] (Displayed when HD control is in Auto)

Phase Amps*

Road = [ ]

Middle = [ ]

Field = [ ]

*Bank must be closed when measuring amp readings

Type of Control (Check One) ☐ HD ☐ Fisher Price ☐ Sagamo ☐ Radio ☐ None

Type of Switch (Check One) ☐ Oil ☐ Vacuum ☐ None (fixed bank w/fuses only)

Meter Socket (Check One) ☐ Yes ☐ No

As Found Code = [ ]

Repair Code = [ ]

For switched banks, the bank must be opened and closed at least once to verify control and all switches are operating correctly.

See cap inspection manual for "as found" and "repair" codes

Settings

CLOSE TEMP [ ]

OPEN TEMP [ ]

CLOSE VOLTS [ ]

OPEN VOLTS [ ]

VOLTS MONITOR

With Cap Open [ ]

With Cap Closed [ ]

CONTROL MODE ☐ TIME ☐ TMP/TIME ☐ TEMP ☐ VOLT/TMP ☐ VOLT ☐ VOLT/TIME ☐ V/TMP/TI

MON - FRI ☐ Active ☐ Off

SAT ☐ Active ☐ Off

SUN ☐ Active ☐ Off

HOLIDAYS ☐ Active ☐ Off

TIME ON [ ] ☐ AM ☐ PM

TIME OFF [ ] ☐ AM ☐ PM

START DATE [ ]

STOP DATE [ ]

Note: Time on = Time off means control is active 24 hrs a day

Note: HD control setting typically only use schedule 1, Start Date = 01/01 and Stop Date = 12/31. All other schedules are disabled when start date = stop date (typically both = 01/01)

TEMP MONITOR [ ]

As found SET TIME [ ] ☐ AM ☐ PM

Correct SET TIME [ ] ☐ AM ☐ PM

As found SET DATE [ ]

Correct SET DATE [ ]

DAYLIGHT SAVINGS ☐ Active ☐ Off

Control Serial Number [ ]

***** Don't forget to make control Auto when inspection is complete!!! *****

Remarks: ____________________

As Found Codes for Field Capacitor Inspection Sheet

- 001 Found and Left OK
- 002 One Primary Fuse Blown
- 003 Two Primary Fuses Blown
- 004 Three Primary Fuses Blown
- 005 Secondary Fuse Blown
- 006 Capacitor Failure Case Intact
- 007 Capacitor Failure Case Ruptured
- 008 Capacitor Control Defective
- 009 Clock Slow
- 010 Clock Fast
- 011 Clock Stopped
- 012 Cutout Failure
- 013 One Capacitor Oil Switch Failed

014 Two Capacitor Oil Switches Failed
015 Three Capacitor Oil Switches Failed
016 Three Capacitor Switches Failed
017 On and Off Levers Loose
018 Defective Micro Switch
023 Defective Wiring
024 L.A. Failure
025 Defective Time Clock
026 Defective Counter
027 Cutouts Open Fuses OK
029 Vacuum Switch Defective
099 Other

Repair Codes for Field Capacitor Inspection Sheet

Repair — Enter a repair code from the following list:

01 Found and Left OK
02 Repaired During Inspection
03 Left Off Line – Needs Repair
04 Left Off Line – Needs Engineering Review
05 Left On Line - Needs Repair
06 Left On Line – Needs Engineering Review

7.0 LINE CAPACITOR DATABASE

7.1 The Line Capacitor Database “Cascade” was created to replace the out going main frame database. The “Cascade” Line Capacitor Database is accessible from the Infonet by authorized users. The database can be edited and reports can be generated. Field Capacitor Inspection Sheets will be forwarded to O&M Services, Waltham and will enter the inspection data into the Cascade. Once the transition is complete a new data base system will be identified for use at Liberty utilities.

8.0 TABLE I

TEST VALUES IN MICRO FARADS FOR SHUNT POWER CAPACITORS							
VOLTAGE	KVAR	MICRO FARAD MIN	MAX	VOLTAGE	KVAR	MIN	MICRO FARAD MAX
2400	15	6.9	8.0	7620	50	2.3	2.6
	25	11.5	13.2		100	4.6	5.3
	50	23.0	26.5		150	6.9	7.9
	100	46.1	53.0		200	9.1	10.5
	150	69.1	79.4		300	13.7	15.8
4160	25	3.8	4.4	7960	50	2.1	2.4
	50	7.7	8.8		100	4.2	4.8
	100	15.3	17.6		150	6.3	7.2
	150	23.0	26.4		200	8.4	9.6
	200	30.7	35.3		300	12.6	14.4
4800	15	1.7	2.0	13200	100	1.5	1.7
	25	2.9	3.3		150	2.3	2.6
	50	5.8	6.6		200	3.0	3.5
	100	11.5	13.2		300	4.5	5.2
	200	23.0	26.5				
				13800	100	1.4	1.6
6640	50	3.0	3.5		150	2.1	2.4
	100	6.0	6.9		200	2.8	3.2
	150	9.0	10.4		300	4.2	4.8
	200	12.0	13.8				
	300	18.1	20.8	14400	100	1.3	1.5
					150	1.9	2.2
7200	50	2.6	2.9		200	2.6	2.9
	100	5.1	5.9		300	3.8	4.4
	150	7.7	8.8				
	200	10.2	11.8	19920	100	0.67	0.77
	300	15.4	17.7		150	1.00	1.15
					200	1.34	1.54
					300	2.01	2.31

9.0 TABLE II

FUSE SIZES FOR CAPACITORS

		SYSTEM VOLTAGE (kV)									
		2.4 3 Delta	2.4 1 or 2.4/4.16 Grd Wye 3	4.16 Delta 3	4.8 Delta 3	4.8 1 or 4.8/8.32 Grd Wye 3	7.2/12.47 Grd Wye 3	7.6/13.2 7.9/13.8 Grd Wye 3	13.2/23 13.8/23.9 14.4/24.9 Grd Wye 3		19.9/34.5 Grd Wye 3
kVAR		CAPACITOR VOLTAGE (kV)									
3	1	2.4	2.4	4.16	4.8	4.8	7.2	7.6,7.9	13.2 13.8	14.4	19.9
45	15	10K	10K	10K	10K	10K	-	-	-	-	-
75	25	20K	10K	15K	10K	10K	10K	10K	-	-	-
90	30	25K	15K	15K	10K	10K	-	-	-	-	-
120	40	30K	15K	15K	15K	10K	-	-	-	-	-
150	50	40K	20K	20K	20K	10K	10K	10K	-	-	-
180	60	50K	25K	25K	25K	15K	-	-	-	-	-
225	75	50K	40K	30K	25K	15K	10K	10K	-	-	-
300	100	80K	40K	40K	40K	25K	15K	15K	-	-	-
375	125	-	-	-	40K	25K	20K	20K	-	-	-
450	150	-	65K	65K	50K	40K	20K	20K	-	-	-
525	175	-	-	-	-	40K	25K	25K	-	-	-
600	200	-	-	-	65K	40K	30K	30K	15K	15K	-
900	300	-	-	-	-	65K	40K	40K	25K	20K	15K
1200	400	-	-	-	-	-	65K	50K	40K	30K	25K
1800	600	-	-	-	-	-	-	-	50K	40K	40K
2700	900	-	-	-	-	-	-	-	65K	65K	50K

10.0 TABLE III

Approved portable Loadbreak tools shall be used according to the instructions and limitation s as spelled out in each manufacturer's operating manual. It is the responsibility of any employee utilizing this tool to be familiar with the proper operation and application of the tool.

S&C Loadbuster Capacitor-Bank Switching Table

Loadbuster Catalog Number	Nominal System Voltage KV Three- Phase	Maximum Capacitor Bank Rating KVAC, Three Phase		
		Solidly or Effectively Grounded System		Ungrounded System
		Single* Banks, Grounded-Wye Connected	Single * Banks, Ungrounded-Wye Connected	Single* Banks, Grounded- or Ungrounded-Wye Connected
5300R3	12 thru 14.4 16 20.8 thru 23.9 24.9 and 26	1800 2400 3000 3600	1800 2400 @ @	1800 2400 @ @
5400R	20.8 thru 23.9 24.9 and 26 27.6 34.5	3000 3600 3600 4800	3000 3600 3600 @	3000 3600 3600 @

* Loadbuster must not be used for switching parallel ("back to back") capacitor banks.

@ Loadbusters must not be used for switching ungrounded-wye connected banks – or grounded-wye connected banks on ungrounded systems where maximum system operating voltage exceeds 18kV for Loadbuster, Catalog Number 5300R3; or 29 kV for Loadbuster, Catalog Number 5400R3.

Reference: S&C Electric Company – Specification Bulletin 811-31

11.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G013		
Electric Operating Procedure	**02-01-2015**	**General**	
Excavation Notification Requirements	**Revision #**	**0**	**Page: 1 of 9**

INTRODUCTION

This operating procedure provides the rules to follow when Liberty Utilities personnel moves or removes earth, rock or other materials in or on the ground by hand, by use of mechanized equipment or by blasting, including, but not limited to, digging, auguring, backfilling, drilling, grading, plowing in, pulling in, trenching and tunneling. This EOP establishes procedures for the protection of underground facilities in order to assure public safety, prevent damage to public and private property and comply with the applicable laws and regulations of New Hampshire.

PURPOSE

This procedure applies to all Liberty Utilities personnel who move or remove earth, rock or other materials in or on the ground by use of mechanized equipment or by blasting, including, but not limited to, digging, auguring, backfilling, drilling, grading, plowing in, pulling in, trenching and tunneling.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support and training upon request.
2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.
3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

REFERENCES

Federal:
OSHA No. 1926.651(b)(1-4) Specific Excavation Requirements
OSHA No. 1926.21(b)(2) Safety Training & Education
New Hampshire:
RSA 374:48 - 56
N.H. Admin. Rules, PUC 801.01 - 807.07

DEFINITIONS

Damage:

New Hampshire - "Damage" means any impact or exposure that results in the need to repair an underground facility due to the weakening or the partial or complete destruction of the underground facility, including, but not limited to, the protective coating, lateral support, corrosion control, or the housing for the line, device, or underground facility.

Emergency Situation:

New Hampshire – A sudden or unexpected occurrence involving a clear and imminent danger demanding immediate action to prevent or mitigate loss of, or damage to, life, health, property, or essential public services.

Excavation:

New Hampshire – Any operation conducted on private property or in a public way, right-of-way, easement, public street, or other public place, in which earth, rock, or other material in the ground is moved, removed, or otherwise displaced by means of any tools, equipment, or explosive, and includes but is not limited to drilling, grading, boring, milling, trenching, tunneling, scraping, tree and root removal, cable or pipe plowing, fence or sign post installation, pile driving, wrecking, razing, rending, or moving any structure or mass material, but does not include the tilling of soil for agricultural purposes, landscaping and maintenance of residential property performed with non-mechanized equipment, landscaping activities performed with mechanized equipment that are intended to cut vegetation, including lawn edging, aeration, and de-thatching, excavations permitted or grandfathered under RSA 155-E, or replacement of department-of-transportation-installed delineator posts in the same location.

Excavator:

New Hampshire – Any person performing an excavation.

One-call notification system or Notification Center:

New Hampshire - The entity that performs the primary function of the system, is open to all operators within the state of New Hampshire, maintains a data base of its members and operators and the specific geographic areas in which each of its members and operators desires to receive notice of proposed excavation, and which has the capability to transmit notices of proposed excavation to its members and operators by teletype, telecopy, personal computer, telephone, or other comparable means.

The one-call notification or notification center serving Massachusetts, New Hampshire and Rhode Island is Dig Safe System, Inc., which can be contacted at 888-DIG-SAFE (888-344-7233) or www.digsafe.com.

811 can also be called from anywhere within the United States and your call will be routed to the correct one-call notification center.

Operator:

New Hampshire - Any public utility and any cable television system and any liquefied petroleum gas company operating any jurisdictional facility or facilities as defined by the Natural Gas Pipeline Safety Act that owns or operates underground facilities.

Tolerance Zone:

New Hampshire - An area surrounding an underground facility which is 36 inches wide, measured horizontally and equidistant from the centerline of the underground facility, plus the width of the underground facility itself.

Underground Facility:

New Hampshire – Any private property or property which is buried, placed below ground, or submerged on a public way, right-of-way, easement, public street, or other public place and is being used or will be used for the conveyance of cable television, electricity, gas, sewerage, steam, telecommunications or water.

TRAINING

Provided by Liberty Utilities Learning & Development Training Program.

DOCUMENT CONTENTS

Table of Contents

1.0 RESPONSIBILITIES OF EXCAVATORS

1.1 General.

1.1.1 Compliance with Applicable Laws and Regulations. When excavating, Liberty Utilities personnel shall comply with all applicable laws and regulations of the state in which they are working.

1.1.2 Compliance with this EOP. When excavating, Liberty Utilities personnel shall comply with all applicable provisions of this EOP.

1.1.3 Based upon all of the relevant statutes, Liberty Utilities is required to comply with all excavation rules when removing poles in all of our jurisdictions.

1.2 Excavating on Land Owned or Formerly Owned by Liberty Utilities.

1.2.1 When excavating on land that is now or was formerly owned by Liberty Utilities, Liberty Utilities personnel shall verify that Liberty Utilities has not previously identified an environmental hazard or concern on the property. This verification may be done using a list of Liberty Utilities sites with known environmental hazards or concerns or by contacting Liberty Utilities's Environmental Department.

1.3 Excavating near Substations.

1.3.1 When excavating on the land occupied by substations, Liberty Utilities Operations personnel shall notify the local damage prevention coordinator or substation supervisor for underground locating requests. SMP 499.06.2 and LU-EOP UG019 shall be followed if Liberty Utilities personnel and/or Liberty Utilities contracted personnel are required to evaluate, locate, and mark substation underground power circuits, control circuits, telephone circuits, or gas lines.

1.4 New Hampshire Specific Requirements.

1.4.1 Timing of Notice and Excavation.

a. Before beginning any non-emergency excavation, Liberty Utilities shall notify the operator of any underground facilities in the municipality where the excavation will occur of the location and date of the proposed excavation. Distribution Design will fill out the Dig Safe form and attach with the job packet folder. Form is available on the Engineering folder on

T:Drive. Operations supervisor should call in to the one-call notification center or by calling 811 and shall be made at least five days prior to the start of excavation.

b. Before beginning any non-emergency excavation, Liberty Utilities shall notify Dig Safe System, Inc. at 888-DIG-SAFE (888-344-7233), 811 or www.digsafe.com, the one-call notification system serving New Hampshire, of the location and date of the proposed excavation. This notification shall be made at least 72 hours (3 days) prior to the start of excavation, excluding weekends and holidays, but not more than 30 days prior to the start of excavation.

c. Excavation required as a result of an emergency or to correct an immediate hazard may proceed immediately without prior notification to Dig Safe System, Inc., if the situation is so serious that the excavation cannot reasonably be delayed. However, excavators shall notify Dig Safe System, Inc. as soon as possible of such excavation. Extreme caution shall be employed by the excavator to prevent damage to existing underground facilities and to avoid endangering persons and property.

d. The notification to Dig Safe System, Inc. expires after 30 days, if excavation has not started. In New Hampshire, if an excavation will continue longer than 30 days, a new ticket should be obtained every 30 days.

e. When Liberty Utilities cancels the proposed excavation, Dig Safe System, Inc. should be promptly notified. A postponement past the expiration date of the Dig Safe System, Inc. “ticket” shall be considered a cancellation.

1.4.2 Detailed Notice Requirements.

Every notification Liberty Utilities provides to Dig Safe System, Inc. for proposed excavation shall contain at least the following information:

a. Name of the person making such notification;

b. Company name, address and telephone number;

c. Field telephone number, if any;

d. Name of the field contact person, if any;

e. Location and approximate extent and dimensions of the proposed work area;

f. Means of excavation;

g. Whether or not explosives are to be used;

h. Brief description of the proposed excavation;

i. Start date and time for the proposed excavation.

1.4.3 Pre-marking.

a. Liberty Utilities shall pre-mark with white paint, white flags or wooden stakes to delineate a work area prior to notifying Dig Safe System, Inc. of the proposed excavation. Such pre-marking is required by law in New Hampshire. The use of pre-marking at the job site helps locators avoid marking more area than necessary and helps locators know they are marking all of the areas of the proposed excavation. Pre-marking is required except for excavations over 100' in length and pole replacements within 5' of an existing location. In addition to the notification to Dig Safe System, Inc., the excavator and the facility operator should make direct contact to coordinate schedules and to review the extent and location of the proposed excavation for excavations exceeding 100' in length.

b. The following practices represent good practices when pre-marking:

1. These pre-markings shall be white to avoid confusion with colors used to mark locations of underground facilities.
2. Care should be taken to avoid confusion between white pre-marks and traffic or pedestrian control marks in the roadway.
3. A chalk based paint that will dissipate quickly with rain and wear is recommended where conditions permit.
4. Alerting property owners to the reason the paint was applied will save calls to utilities and the one-call notification system asking why the paint was applied.
5. Delineate individual excavations of known dimensions with white paint using dashes or a continuous line.
6. Trenches and larger excavations should be marked using intervals that allow the mark to be seen from adjacent marks.

1.4.4 Start of Excavation: Excavation may proceed 72 hours, excluding weekends and holidays after the notification to the one-call notification system.

1.5 Staking, Marking or Other Designation.

1.5.1 All Liberty Utilities employees shall be familiar with the provisions, especially those relating to size and depth indications, color coding, center line or offset staking, marking or otherwise designating the location of underground facilities.

1.5.2 Whenever Liberty Utilities determines that a review of the staking, marking or other designation is necessary or that additional information is required, Liberty Utilities shall contact the operator of the underground facility to obtain such a review or additional information.

1.5.3 As the excavator, Liberty Utilities is responsible for protecting and preserving the staking, marking or other designations of underground facility locations until Liberty Utilities' excavation or demolition work at or near the underground facility is complete. If the staking, marking or other designations are not maintained, Liberty Utilities shall call the appropriate one-call notification system to request that underground facility operators re-mark their facilities and shall halt its excavation at the site until the facilities have been re-marked.

1.6 Prior to Excavation.

The following steps shall be followed before excavating:

1.6.1 Verify that the appropriate one-call notification system has been notified and that the notification is still valid. The one-call notification system will assign a unique number or “ticket” to verify and identify each notification it receives and this number must be available at the job site. Verify that the notification is within the time frames appropriate for the state in which the excavation is occurring.

1.6.2 Review the work area to determine that:

a. The expected staking, marking or other designations of underground facilities have been made, are still visible and no re-mark of the facilities is necessary.

b. Look for visible signs of underground facilities that may not have been marked. Such signs may include pedestals, risers, meters, or trench lines in pavement.

c. Determine if hand digging is necessary to protect underground facilities while verifying their location.

d. Identify appropriate Personal Protective Equipment (PPE) to be worn during excavation.

1.7 During Excavation

1.7.1 Interpretation of Marks.

a. Where center line stakes or marks indicate the size of the underground facility, such facility shall be assumed to lie within a strip of land equal to the width of the facility plus four feet with the center line of such strip of land at the stakes or marks.

b. Where center line stakes or marks do not indicate the size of the underground facility, such facility shall be assumed to lie within a strip of land four feet in width with the center line of such strip of land at the stakes or marks.

c. Where offset stakes or remote tie-in markings indicate the size of the facility, the underground facility shall be assumed to lie in a strip of land equal to the width of the facility plus four feet with the center line of such strip of land at the center line of the facility as indicated by the stakes or markings.

d. Where offset stakes or remote tie-in markings do not indicate the size of the underground facility, the facility shall be assumed to lie in a strip of land four feet in width with the center line of such strip of land at the center line of the underground facility as indicated by the stakes or marking.

1.7.2 Verification of the location of Underground Facilities.

a. Where an underground facility has been staked, marked or otherwise designated by the operator within a proposed work area and the tolerance zone of an underground facility overlaps any part of the work area, or the projected line of a bore/directional drill intersects the path of an underground facility, the excavator shall verify the precise location, type, size, direction of run and depth of such underground facility or its encasement. Verification may be completed before the excavation or demolition is commenced or may be performed as the work progresses. Powered equipment may not be used in a tolerance zone prior to the verification of the location of the facilities within the tolerance zone.

b. The verification of the location of underground facilities shall be accomplished by the excavator by exposing the underground facility or its encasement to view by means of hand dug test holes at one or more points where the work area and tolerance zone overlap, or more points as designated by the operator of such facilities. Powered or mechanized equipment may be used for removal of pavement or masonry but only to the depth of such pavement or masonry.

c. Unverifiable Underground Facilities, if the precise location of an underground facility cannot be verified by the excavator after reasonable attempts by hand excavation to a reasonable depth within the strip of land as staked, marked or otherwise designated by the operator, the excavator shall notify the operator of such facilities. The operator shall verify the location of the underground facility or shall provide the excavator with prompt field assistance, or use other means mutually agreed to by the excavator and operator. Such agreement shall be provided in writing to the excavator upon his or her request.

1.7.3 Excavation in the Area of Power Lines.

a. When underground electric lines have been identified in the excavation area, appropriate precautions should be taken. These include grounding mechanized excavating equipment and wearing appropriate PPE.

1.7.4 Discovery of Unknown Underground Facilities.

Where an unmarked or otherwise unknown underground facility is discovered within a work area, the excavator shall report such discovery as follows:

a. If the operator of the discovered underground facility is known or can be readily identified, the excavator shall report the discovery to such operator and work with the operator to determine whether it is safe to work in the area.

b. If the operator of the discovered underground facility is not known and cannot be readily identified, the excavator shall report the discovery to the one-call notification system.

1.7.5 Discovery of Potentially Hazardous Materials.

Where an excavator encounters potentially hazardous materials or oily debris, the excavation should be stopped and the local environmental engineer shall be notified to make an initial assessment of the potential hazard.

1.7.6 Contact or Damage to Underground Facilities.

a. Excavators shall take reasonable precautions to prevent contact or damage to underground facilities and their protective coatings, including but not limited to, compliance with any reasonable directions or accepted engineering practices given by the affected underground facility operators.

b. The excavator shall immediately notify the operator of any underground facility that the excavator contacts or damages.

c. All excavation or demolition in the immediate vicinity of the contacted or damaged portion of the underground facility shall be suspended until such portion is repaired and the operator advises the excavator that excavation or demolition may proceed.

d. The excavator may not backfill in the vicinity of the contact or damage until the operator conducts an inspection and makes any necessary repairs, and the excavator may not make any repairs to the contacted or damaged facility without authorization from the operator.

e. If the excavator contacts or damages an underground facility containing gas or liquid petroleum products or an electrical short or escape of gas or hazardous fluids, creates a danger to life, health or property, the excavator shall immediately:

1. Notify the local police and fire departments and the operator of the affected facility of the exact location and nature of the emergency,

2. Evacuate all endangered persons, including Liberty Utilities employees, from the immediate vicinity.

1.7.7 Underground Facilities that have Failed or are in Danger of Failing.

a. An excavator that exposes an underground facility, that appears to have failed or be in danger of failing from corrosion or other causes, shall immediately report such condition to the operator of such underground facility.

b. The excavator shall delay any further work in the immediate vicinity of such underground facility which could jeopardize it, until the operator responds, makes any necessary repairs and advises the excavator that he or she may proceed.

c. The excavator may continue to work in areas not affecting the questionable facility.

1.7.8 Support and Protection of Underground Facilities.

a. When excavating near or crossing under existing underground facilities, the operator of such underground facilities should be contacted. In general, the operator should provide any necessary support and protection for its underground facilities.

b. If the operator is unwilling or unable to provide such support and protection, the excavator shall provide support and protection in accordance with generally accepted engineering practice, including but not limited to shoring and bracing. Such support shall be at least equivalent to the previously existing support and shall protect the underground facility against freezing and against traffic and other loads and shall be maintained during excavation, during backfilling and, if necessary, after backfilling is completed.

1.7.9 Backfilling.

a. When excavating around underground facilities, the excavator shall backfill using materials and methods reasonably specified by the operator or, in the absence of such specifications, with materials and methods appropriate to avoid damage to, and provide proper support for, the underground facility and its protective coating both during and after backfilling operations.

b. The excavator shall not place large rock, frozen earth, rubble, debris or other heavy or sharp materials or objects which could cause damage to or scraping against any underground facility.

c. The backfill beneath and around any underground facility shall be properly compacted in accordance with generally accepted engineering practice.

d. Heavy loads and excessive forces shall not be imposed on any exposed underground facility at any time during backfilling operations.

2.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
02/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

INTRODUCTION

The purpose of this document is to provide personnel safety, maintain integrity of service, and protect apparatus used in the transformation, transmission, and distribution of electrical energy. The Clearance and Control procedure shall be followed when isolating overhead and underground transmission circuits, overhead and underground distribution circuits, and substation apparatus.

The System Operator will direct this process through the use of disconnecting devices, tagging, and documentation. Authorized Persons shall be thoroughly familiar with this procedure and shall have a copy readily available for reference.

COORDINATION

This procedure applies only to the performing or directing of work on electrical circuits or apparatus used in the transformation, transmission, and distribution of electrical energy. All individuals involved in such work shall be designated as an Authorized Person.

This procedure applies to all new work or installations as soon as any connection is made which would permit any part of the new work to be energized by the operation of a switch, open loop, or other device. From that time until the new work is placed in service or reported available for normal operation the connecting switch(es), open loops, or device(s) shall be kept tagged at all times. If work is in progress a Red Tag shall be used (Clearance or PRT). If the work will be suspended for an extended period of time, a Hold Tag may be used in lieu of the Red Tag.

REFERENCES

Code of Federal Regulations 29 CFR 1910.269 (d), (m), (n), and (o) de-energizing lines and equipment, grounding, and testing. National Electrical Safety Code NESC ANSI C-2.

DEFINITIONS

Authorized Person: A person designated by a Departmental Manager, or their designee, who has successfully been tested and has demonstrated proficiency and understanding of EOP G014.

Exception: A person who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of an Authorized Person is considered to be an authorized person in the performance of those duties. Note: Only Authorized Persons shall issue or be issued Clearances, PRT's, etc.

Authorized Person List: A formal document developed and maintained semiannually by Liberty Utilities Control Center management listing all individuals designated as an Authorized Person.

Clearance (for work): Permission to an Authorized Person to perform specified work within a zone of protection.

Clearance Person: The person holding the Clearance.

Controllership: Permission given and documented by the System Operator to only an Authorized Person or to the De-centralized Location(s) to assume all the duties and responsibilities of the System Operator.

Dead: Isolated, tagged, tested de-energized and grounded.

De-energized: The absence of normal operating voltages associated with the operation of the system or control circuits.

Field Construction Coordinator (FCC): An Authorized Person assigned to coordinate the job with the Contractor and be a liaison with the System Operator.

Grounded: Intentionally connected to earth through a ground connection.

Grounds:

- Mechanical – Switching devices permanently installed in substations that are not to be used for personal protection except in Gas Insulated Substations (GIS), HVDC terminals, or network applications.
- Personal / Bracket / Equipotential Grounds – Portable conductors whose installation is directed by the Clearance Person and applied for the protection of workers.

Guarantee: A Guarantee is a formal statement given to an inter-connected utility that specified apparatus has been de-energized and that certain device(s) are tagged in the Protective Position and will remain so until the Guarantee is released by the recipient.

Higher Authority: An Authorized Person at the same or higher level of Management above the Clearance Person who is holding the Clearance and is knowledgeable in the work to be performed.

Isolated: Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means and absent from nominal voltages.

Limits: Open devices that define a zone of protection, also known as protective points.

Non-Authorized Contractor: Electrical Contractors who are not trained on the Clearance and Control procedure and are not listed as Authorized Persons that perform work under the authorization of an FCC and the "Contractor Permission to Work" process.

Non-Reclose Assurance: A formal statement from the System Operator to an Authorized Person to perform work on, or near, designated energized lines or apparatus after all its reclosing devices, including SCADA/EMS, are disabled and tagged.

Person in Charge of the Work: A qualified person responsible for the work to be performed.

Personal Red Tagging (PRT): Permission given by the System Operator to an Authorized Person to assume the duties and responsibilities with respect to the switching, tagging, testing, grounding, and restoring specific sections of the electrical system as defined by the System Operator.

Protective Position: The tagged position of a mechanical or electrical device with a visible air gap that prohibits the energizing or the re-energization of a specific work area.

Exceptions to a visible air gap: Oil Fused Cutout, Vacuum switches, network protectors, network Transformer Oil Disconnects (TOD), and other devices approved for this application.

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Re-Issue: The issuance of a surrendered Clearance from the System Operator to a Clearance Person.

Release of Clearance: The act in which a Clearance Person(s) reports to the System Operator that their grounds have been removed (if applicable), all workers and equipment are in the clear, and the status or condition of the line or apparatus they were working on.

Sign-On: Method permitting an Authorized Person to work independently on an existing Clearance with the same zone of protection.

Surrender: Permission from the System Operator to the Clearance Person to be relieved of further work and responsibility in connection with the Clearance. It differs from Release of Clearance in that it definitely implies that the work is unfinished, that tags cannot be removed, that the circuit may still be grounded, and the circuit or apparatus may not be restored to service.

Switch Person: A qualified Authorized Person that is knowledgeable in the operation of electrical apparatus for the purpose of isolation of electrical circuits or apparatus. A Non-Authorized qualified person may switch under the direct supervision of a qualified Authorized Person at the switching location. Direct supervision requires the Authorized Person being at the switching location, directing, and observing the Switch Person performing the work.

System Operator: An Authorized Person, who directs, controls, monitors, and operates the electric system and its associated apparatus.

TOA: An acronym used in the formal application for requesting outages or for other work on lines or apparatus through the System Operator. (Transmission Outage Application).

Transfer: A process to re-assign a Clearance or NRA from one Authorized Person to another through the System Operator.

Voltage Testing: Testing when applied voltages result in voltages greater than 50 volts. This includes but not limited to Fault Finder, Power Factor, Insulation Resistance measurements, TTR, Hi-Pot, or System Voltages, etc. Appropriate minimum approach distances shall be maintained within the area under test.

Zone of Protection: An area defined by opened protective points which isolate all known energy sources. This area is created by isolating, de-energizing and tagging every protective point of isolation from all forms of external sources of energy that could create a hazard for workers.

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1.0 GENERAL INFORMATION

1.1 Responsibilities of Individuals

1.1.1 Only an Authorized Person shall implement any section of this procedure.

1.2 Enforcement of Procedure

1.2.1 It is the duty of every Authorized Person to rigidly enforce this procedure and to assist workers and others to understand and comply with it.

1.2.2 If at any time this procedure has not been strictly complied with, the System Operator shall be notified as soon as possible.

1.2.3 System Control Management, Electric Distribution Operations Management, or their designee shall remove from the Authorized Person List any person who is not familiar with or fails to comply with this procedure and shall notify the department head on whose list the person's name appears.

1.2.4 Any person so removed from the Authorized Person List shall not be reinstated except on orders from the appropriate Operations Management head of the group involved.

1.3 Working on Red Tagged Device

1.3.1 No work may be performed on a Red Tagged device.

1.3.2 Exception: Work on a device that serves as a “tagged point” may be permitted on the de-energized side of a visible air gap provided all of the following are met:

1.3.3 The device is not to be operated.

1.3.4 The apparatus is physically protected against closing.

1.3.5 Working clearances are maintained.

1.4 Control of the Electrical System

1.4.1 Control is under the System Operator until such time that Controllership and responsibilities are delegated to others.

1.4.2 The System Operator is the controller of **all** disconnecting devices associated with the **distribution and substation systems** used to energize or de-energize circuits or apparatus. System Operators or those given Controllership cannot issue themselves a Clearance, an NRA, or grant permission to themselves to use Personal Red Tagging Procedures.

1.4.3 Non System Operator Based Operations.

Permission is not required from the System Operator for:

The operation of disconnecting devices used to energize or de-energize an individual distribution transformer (single or three phase overhead or underground transformer), distribution capacitor banks, series street lighting circuits, fused radial distribution side taps, or cutout mounted dropout reclosers (i.e. S&C Electric Trip Saver) on radial distribution side taps and the application of PRT on the associated disconnecting devices.

1.5 Duties and Responsibilities of the System Operator

1.5.1 The duties and responsibilities of a System Operator include but are not limited to the following:

1.5.2 Gives permission to work after necessary precautions are taken.

1.5.3 Authorizes qualified field personnel to operate switches or devices and maintains all necessary documentation.

1.5.4 Verifies the limits of a TOA Application and has the circuit/apparatus involved isolated from all known sources of energy.

1.5.5 Verify that The Clearance Person is on the Authorized Person List.

1.5.6 Issues, accepts the releases of, or re-assigns all Clearances on circuits or apparatus using appropriate formal language.

1.5.7 Completes appropriate documentation.

1.5.8 If any doubts arise regarding the qualifications or knowledge of an Authorized Person, the System Operator shall communicate the facts to the individual's supervisor.

1.5.9 Gives permission to use Personal Red Tags and maintains documentation of that information.

1.5.10 Issues and Releases HOLD tags.

1.5.11 Issues, accepts the release of, and re-assigns Non-Reclose Assurance and documents that information.

1.5.12 Issues and accepts release of Customer Tags.

1.5.13 Issues and accepts release of guarantees with foreign utilities or generators.

1.5.14 Accepts guarantees from foreign utilities or generators.

1.6 Demarcation Line of Authority

1.6.1 At all System device locations where switching and tagging may be done under the authority of System Operators of multiple Control Centers, Customers, or Generating Plants, there shall be one set of disconnecting switches common to both groups. This is the Demarcation Line of Authority.

1.6.2 At the Demarcation Line of Authority, either System Operator may issue orders, depending upon who is responsible for the work. Advance notice of the operation of such disconnecting switches shall be exchanged between System Operators.

1.6.3 The Demarcation Line of Authority for foreign utilities, generators, or customers shall be identified on System one-line diagrams.

1.7 Documentation and Records Retention

1.7.1 The Person in Charge of the Work shall document all pertinent information associated with a Clearance, PRT, or NRA on the Field Clearance and Control Form (6.5.2). All field documentation forms, switching orders, and tags shall be maintained by local supervision for a minimum of three (3) years. All System Operator forms shall be maintained for the life of the asset.

1.8 Inability to Release, Transfer, or Surrender

1.8.1 If a Clearance Person is unable to Release, Transfer, or Surrender a Clearance, a Higher Authority, through the System Operator, shall assume full responsibility and be issued the Clearance and then may Release, Transfer, or Surrender the Clearance. The Higher Authority shall also notify the original Clearance Person of the status of the Clearance at the earliest possible convenience.

1.8.2 This process shall also be used under Personal Red Tagging when it is necessary to Release the PRT; and for Non-Reclose Assurance to Release, Transfer, or Surrender and Re-Issue the NRA.

1.9 Public Safety and Protection of the Public

1.9.1 When general clearances can not be maintained on circuits energized at primary voltage, a Liberty Utilities Authorized Person shall hold a Clearance or PRT for the line(s) or apparatus and the lines(s) or apparatus shall be grounded. It is the Clearance Holder's responsibility to establish and maintain contact with the contractor to ensure the equipment is returned to service when the public/contractor is complete and all personnel and equipment are in the clear. The Clearance Person shall be responsible for and maintain all documentation regarding meeting, discussions, job briefs, etc. This process shall be documented using the Customer Work Notification Form. A duplicate form or copy shall be prepared and provided to the Customer.

1.9.2 For work in proximity of Liberty Utilities circuits or lines, Customer Tags are not to be used when OSHA general clearances to apparatus owned and operated by Liberty Utilities cannot be maintained.

1.10 Removal of Circuit or Apparatus for Working Clearances

1.10.1 No circuits are to be removed from service for physical clearances, where minimum working clearances are to be compromised, without being isolated, tagged, tested de-energized, and grounded.

1.11 Non-Authorized Contractors Working on Liberty Utilities Apparatus

1.11.1 Contractors (not authorized) shall work under a coordinated effort of an Authorized Person (i.e. FCC).

1.11.2 When utilizing the Clearance and Control procedure, the "Contractor Permission to Work" process shall be followed. See section 2.7.

1.12 Mutual Assistance in Storm Emergencies by Foreign Utility Crews

1.12.1 Liberty Utilities Employees who have been given controllership of distribution feeders or permission to use PRT's, may direct foreign crews to utilize their own protective procedures (i.e. tagging) to protect themselves during storm restoration efforts.

1.13 Overlapping Zones of Protection

1.13.1 Overlapping zones of protection are not allowed when either a Red Tag Clearance is issued or when Personal Red Tags are used at URD/UCD locations. Overlapping zones of protection are allowed for all other PRT applications.

2.0 PROCEDURE:

2.1 Qualification of Individuals

Individuals shall be an Authorized Person and have all of the following qualifications:

2.1.1 Clearance Person

a. Shall be an employee or contractor working for Liberty Utilities.

b. Shall be trained in and knowledgeable of the Clearance and Control Procedure.

c. Shall have appropriate knowledge of the type of apparatus included within the Clearance.

d. Shall have the ability to direct the performance of the work to be done.

2.1.2 System Operator

a. Shall be employed by Liberty Utilities.

b. Shall be trained in and knowledgeable of the Clearance and Control Procedures.

c. Shall have operational knowledge of the electrical system to be controlled.

2.1.3 Higher Authority

a. Shall be a management employee of Liberty Utilities at the same or higher level of management.

b. Shall be trained in and knowledgeable of the Clearance and Control Procedure.

c. Shall have appropriate knowledge of the type of apparatus included within the Clearance.

d. Shall have the ability to direct the performance of the work to be done.

2.1.4 Switch Person

a. Shall be an employee or contractor working for Liberty Utilities.

b. Shall be trained in and knowledgeable of the Clearance and Control Procedure.

c. Shall have appropriate knowledge of the type of apparatus that is to be operated.

d. A Non-Authorized qualified person may switch under the direct supervision of a qualified Authorized Person at the switching location.

2.2 Company Approved Tags

No device shall be operated if it bears a Red Tag, Personal Red Tag, Hold Tag, Customer Tag, Non-Reclose Assurance Tag, or Station Control Tag.

Exception: Approved gang operated three-position disconnecting devices, (CLOSED, OPEN, GROUNDED) may be operated (switched) from the “open” position to the “ground” position without removal of the Red Tag provided a mechanical device is incorporated to prevent inadvertent closing.

All tags used under this procedure shall be completely filled in with all the information called for on the tags.

Disconnecting devices, placed in the open position shall be tagged to provide a visual indication that the operation of the device while tagged is prohibited. The approved Liberty Utilities tags shall be securely attached to the energy isolating device so that they cannot be inadvertently or accidentally detached. The tag shall be placed on the lock, or in appropriate tag holders, or other provisions as close as possible to the isolation device. A protective point when so tagged may or may not be energized.

2.2.1 Red Tag:

a. Shall be placed on protective devices in the open position.

b. Shall be used for the protection of workers.

c. Shall be used to establish a zone of protection when used for a Clearance.

d. When used for Personal Red Tagging, may or may not establish a zone of protection, but prevents closing of the device.

e. **Does not** imply that grounds are installed. Grounds may or may not be applied as determined by the Clearance Person.

f. Shall be used for Guarantees between interconnected utilities.

g. Shall have a Number when a Clearance is issued by the System Operator.

h. Shall bear the name of an individual when used for Personal Red Tagging.

i. Can be used for adjacent or same zone of protection with a Customer Tag.

j. Only one Red Tag shall be applied on a protective point unless it is for a separate and adjacent Clearance.

k. A Red Tag and a HOLD tag may be applied on the same protective point.

l. Will provide assurance that a tagged device will not be operated during the switching sequence.

Exception: Approved gang operated three-position disconnecting devices, (CLOSED, OPEN, GROUNDED) may be operated (switched) from the "open" position to the "ground" position without removal of the Red Tag provided a mechanical device is incorporated to prevent inadvertent closing.

2.2.2 Non-Reclose Assurance (NRA) Tag:

a. Issued by the System Operator to indicate a Non-Reclose Assurance.

Exception: A Non Reclose Assurance on radial distribution side taps protected by cutout mounted dropout reclosers (i.e. S&C Electric Trip Saver) may be issued by the Person in Charge of the Work. The Person in Charge of the Work shall disable reclosing and place an NRA tag. The name of the Person in Charge of the Work shall be placed in the location of the NRA number on the tag. When the work is complete the Person in Charge of the Work shall remove the NRA tag and restore reclosing. These actions can be performed without direction or permission from the System operator. The switching and tagging to accomplish these actions shall be documented on the Field Clearance and Control Form (6.5.2).

b. Placed on device(s) and associated supervisory controls to prevent inadvertent line re-energization.

c. Shall have a Number when issued by the System Operator and if applied by someone given Controllership, the name of the person requesting the NRA shall be placed in the location of the NRA number.

2.2.3 Hold Tag:

The HOLD tag shall be administered by the System Operator and can be applied and released for an Authorized Person or the System Operator.

Hold tags:

a. Shall identify apparatus that is not to be operated due to system or their condition and/or is unsuitable for service.

b. May be placed on a device in the open or closed position.

c. Shall not to be used to provide safety clearance for the protection of employees working on electrical apparatus.

d. Shall have a Number when issued by the System Operator. If applied by someone given Controllership or Person in Charge of the Work, the name of the person requesting the Hold Tag shall be placed in the On For position of the Hold Tag.

The Clearance Person may use a HOLD tag to maintain ground continuity through a closed disconnecting device.

2.2.4 Station Control (SCT) Tag:

a. Non System Operator based.

b. Used for substation related low voltage or control work 600V or less.

c. May be applied on devices that do not provide a visible open.

d. Administered by the Authorized Person.

e. No device tagged with SCT shall be operated.

2.2.5 Customer Tag:

a. A two part pre-numbered tag used for work to be performed by a Customer or their agent on their apparatus.

b. The tag bears the Name of a Customer Representative or their agent.

c. Administered by the System Operator.

2.2.6 Ground Device Identification Ticket (GDIT)

a. Required for all grounds applied for personal protection.

b. Used as identification to track/control all ground locations.

c. The Person in Charge of the Work shall record the location of the grounds by the use of the GDIT.

d. The System Operator shall direct and document the application of station mechanical grounds with GDIT.

e. The System Operator shall direct and document the application of customer requested grounds with GDIT.

2.2.7 Worker Placard

a. Not System Operator based.

b. May be placed on an apparatus control (handle, button, switch, etc.) by the person in charge of the work.

c. Used to identify the apparatus being worked on.

d. The placard device can only be operated on orders from the person in charge of the work.

e. Only one Worker Placard shall be placed on a piece of apparatus at a time.

f. No other tag will be allowed on the control that has a Worker Placard on it.

2.3 <u>Red Tagging</u>

2.3.1 Applying for the Clearance

The person applying for the Clearance shall obtain the Clearance from the System Operator for all isolating devices necessary to isolate the circuit or apparatus being worked on from all known sources of energy. The limits of the Clearance shall be adequate for the work to be performed. Red Tags shall be used to establish the zone of protection. The Clearance can only be obtained by an Authorized Person.

2.3.2 Application Contents

An application for a Clearance shall be submitted to the System Operator or other Authorized Person in advance of the time when the Clearance will be needed. The lead time for submission is defined by the System Operator.

When applying for a Clearance, the application shall indicate the following:

a. The name of the Clearance Person, if available.

b. A precise identification of the circuit or apparatus upon which work is to be performed.

c. The time and date the Clearance is required and its approximate duration.

d. All devices that shall be tagged, as named and numbered on the operating diagram.

e. The nature of the work to be done.

f. A sketch or print shall be furnished at the time of the request to the Outage Coordinator when any system modifications are planned.

2.3.3 Preparation of the Clearance by the System Operator

a. The System Operator shall check carefully to make sure that no condition exists which will prevent the switching operations for the proposed Clearance.

b. The System Operator shall have the section of the circuit or apparatus involved isolated from all known sources of energy by directing that the appropriate devices be placed in the *protective position* and Red Tagged.

2.3.4 Requesting a Clearance

The Clearance Person shall communicate the following information at the time of the request:

a. Name

b. Transmission or Distribution or Substation apparatus to be worked on

c. All limits by number and location requested to be tagged for the Clearance

2.3.5 Issuance of the Clearance

A Clearance shall be issued by the System Operator and acknowledged by the Clearance Person utilizing the proper formal language and communication techniques to ensure all information is provided and repeated back by the Clearance Person. After receiving the Clearance from the System Operator, the Clearance Person shall visibly check all devices that are tagged where practicable.

If the Clearance Person finds it is not possible to finish in the allotted time, the Clearance Person, as soon as possible, shall notify the System Operator.

2.3.6 Release of a Clearance

Prior to the Release of a Clearance to the System Operator, the Clearance Person(s) shall:

a. Determine if lines or apparatus are ready for service.

b. Determine that all members in the crew are clear of the lines and/or apparatus.

c. Determine that all protective grounds (if applicable) installed by or for the crew have been removed.

d. Inform the System Operator of any change from the original operating position of any device operated within the zone of protection.

e. Report such to the System Operator that all workers are in the clear, grounds have been removed, and the status or condition of the line or apparatus they were working on

f. After the Release of Clearance, if additional work is required after the apparatus or circuit has or has not been energized, the System Operator may:

1. Issue orders to operate the necessary device(s) that will re-establish the original zone of protection for that apparatus or circuit.

2. Issue orders to tag the necessary device(s) using the original Clearance number assigned to that apparatus or circuit.

3. Issue Clearance(s) on the re-established zone of protection.

Note: The Release of Clearance is normally conducted for the Restoration of the circuit or apparatus to normal service. If testing with system voltage is required, the Clearance Person shall inform the System Operator of this requirement and the “Release of a Clearance for Testing with System Voltage” process will be followed.

2.3.7 Release of Clearance for Testing with System Voltages

Testing of apparatus or circuits using Primary System Voltages shall be performed **only** under the direction of the System Operator.

a. No testing shall be done on apparatus or circuits, until the System Operator has received a “Release of Clearance” from all persons holding the Clearance in that zone of protection.

b. The Clearance Person in charge of the test and the System Operator shall agree on which tagged device(s) will be operated in order to facilitate the test.

c. Prior to ordering any device closed, the System Operator will order the tag(s) removed from that device.

d. Once the apparatus or circuit has been energized, in-service checks may be performed as needed (i.e. phase checks, 3 phase voltage checks, soaking transformers/circuits, etc).

e. After the Clearance Person in charge of the testing has been satisfied of the test procedure, they shall inform the System Operator that all testing has been completed and the line or apparatus is ready for service.

f. The System Operator may return that apparatus or circuit to service, provided that no additional work is required.

g. If additional work is required after the apparatus or circuit has been energized for testing, the System Operator will:

   1. Issue orders to operate the necessary device(s) that will re-establish the original zone of protection for that apparatus or circuit.

   2. Issue orders to tag the necessary device(s) using the original Clearance number assigned to that apparatus or circuit.

   3. Issue Clearance(s) on the re-established zone of protection.

Note: When testing with system voltages and no Red Tag Clearance or PRT is issued, the System Operator and the person performing the testing (i.e. phasing) will discuss and incorporate the testing into the switching sequence.

2.3.8 Preparation for Work

a. Testing

After receiving the Clearance, an approved test device shall be used to test de-energized before grounding at the point of test. The testing and grounding process shall be continuous. Grounds shall be installed immediately after testing the circuit or apparatus. A re-test shall be conducted if the grounding process is interrupted. Reference the test device EOP for approved test equipment.

b. Working with Grounds Applied

When working with grounds applied, reference appropriate grounding procedures for the application of grounds.

c. Working without Grounds

When working on isolated and tagged substation apparatus and minimum approached distances will be maintained, grounds will not be required to perform work such as mechanism inspections or topping with SF6 gas.

Added safeguards are to be included where possible.

d. Ticketing of Grounds

   1. Clearance Person(s) shall ensure that a GDIT is applied on all Personal Grounds and maintain the documentation for the locations and GDIT number(s).

2. When mechanical grounding switches in substations are required, the System Operator will issue orders and apply GDIT and maintain the documentation for the locations and the GDIT number(s).

Note: The discharge grounding switch for distribution capacitor banks in substations are excluded, in this scenario work shall be directed by the Clearance Person and reported on the Field Clearance and Control form.

2.3.9 Routine Job Related Testing

Voltage testing of the apparatus or circuit utilizing a test set can only be directed by the Clearance Person. (Tags remain in place during the voltage test). Notification to the System Operator is not required.

When other person(s) are working under the Clearance Person, the Clearance Person shall conduct testing with the consent of all persons working under the Clearance Person and shall be responsible for the safe conduct of the test.

When multiple persons are signed on to the same zone of protection,

a. Prior to testing, the Clearance Person performing testing shall notify any other person(s) signed on to the same zone of protection and then request permission to perform testing from the System Operator.

b. Prior to the System Operator granting permission for testing, **the other person(s) signed on shall notify the System Operator** that all associated grounds have been removed, members of the crew are clear and will remain clear until notified by the System Operator. This shall be documented by the System Operator for each Clearance Person.

c. The System Operator will then grant permission to the Clearance Person to perform the test.

Note: Under no circumstances shall a Clearance Person apply a test potential in excess of normal system voltage when a Clearance has been issued on adjoining apparatus for the following tests:

1. Hi-pot testing of GIS Substations

2. Hi-pot testing of vacuum breakers

2.3.10 Multiple Persons Working within the same Zone of Protection

When multiple Clearance Persons must work within the same zone of protection, there are two options available. Only ONE set of tags will be used on the same zone of protection. These methods do not apply to the use of Personal Red Tags.

a. <u>Option One: Working Under someone else's Clearance</u>:

1. Separate crews can work under one Clearance issued to a single Clearance Person if the crews comprise a group of people working in a coordinated manner to accomplish a task on the same lines or apparatus under the direction of a single Clearance Person.

2. The System Operator is not notified of this arrangement.
3. The Clearance Person is responsible for the safety, testing and grounding and the work performed by all people working under their Clearance

b. Option Two: Sign-On Process through the System Operator:

The Sign-On option is not intended to be used to perform a Transfer of work.

This option shall be followed when multiple crews work independently or jointly under the same zone of protection (one set of Red Tags with multiple Clearances issued) provided the following requirements are met:

1. The existing zone of protection is adequate for the additional work at all times.
2. Issuance of another Clearance under the Sign-On process shall be permitted only with the knowledge and consent of the System Operator and all Clearance Person(s) working on the same zone of protection.
3. The System Operator shall ensure that the name of the Clearance Person signing on has been entered on the existing Clearance sheet for that zone of protection and then the Clearance is issued by the System Operator.
4. See section 2.3.9 for routine job related testing.
5. Each Clearance Person shall Release their Clearance with the System Operator when their work is completed and report to the System Operator that all their grounds have been removed, and that personnel and equipment are in the clear.
6. Each Clearance Person shall explain clearly to the System Operator all changes and/or repairs made by them.
7. While personal safety is the responsibility of each individual worker, the Clearance Person signed on is responsible for the safety, testing and grounding and the work performed by the people under their immediate direction.

2.3.11 Modifying the Zone of Protection

The Clearance Person shall determine if the zone of protection is adequate for the work to be performed and may request that the limits of the zone of protection be modified (expanded or collapsed) only with approval of the System Operator. The System Operator and the Clearance Person shall document all modifications on their appropriate forms when expanding or collapsing a zone of protection including a full Job Briefing for the change of work zone protection.

a. Expanding the Zone of Protection

During the expansion of the zone of protection, work may continue in the original zone of protection.

1. The System Operator shall notify all Clearance Person(s) issued the Clearance that the zone of protection is being expanded.
2. The System Operator shall order the new tag(s) placed to expand the zone of protection. These tag(s) shall have the same Clearance number as the original Clearance.
3. After the zone of protection has been expanded, the System Operator shall notify all Clearance Person(s) issued the Clearance that the zone of protection has been expanded and communicate to all Clearance Person(s) the new limits of the Clearance.
4. Once the expanded Clearance has been issued to all Clearance Person(s), the Clearance Person(s) shall Release the original tag(s) that are no longer needed for their zone of protection. Clearance Person(s) may then test de-energized and ground the newly expanded zone.
5. The System Operator shall direct the released tag(s) removed and The Clearance Person may close or request the System Operator close the device(s) only after notifying all Clearance Person(s), and confirming that the newly expanded zone has been grounded.
6. If grounding is not required by the work that is being done in the expanded zone, the System Operator shall direct the released tag(s) removed and the Clearance Person may close or request the System Operator close the device(s) only after notifying all Clearance Person(s) and confirming that the newly expanded zone has been tested de-energized.
7. The Clearance Person shall communicate with the System Operator the configuration of the circuit when the work has been completed and the Clearance is being released.

b. Collapsing the Zone-of-Protection

While establishing the new zone of protection within the existing zone of protection, work may continue in any part of the original zone of protection. Prior to releasing any tags associated with the original zone of protection, grounds shall be applied or relocated in the new zone of protection (if necessary) and all workers, equipment, and grounds shall be in the clear of the section to be re-energized.

1. The System Operator shall notify all Clearance Person(s) issued the Clearance that the zone of protection is being collapsed.

2. The System Operator shall order the new tag(s) placed to collapse the zone of protection. These tag(s) shall have the same Clearance number as the original Clearance.
3. After the zone of protection has been collapsed, the System Operator shall notify all Clearance Person(s) issued the Clearance that the zone of protection has been collapsed and communicate to all Clearance Person(s) the new limits of the Clearance.
4. Once the collapsed Clearance has been issued to all Clearance Person(s), the Clearance Person(s) shall Release the original tag(s) that no longer were needed for the original zone of protection.
5. The System Operator shall then direct the released tag(s) removed.

2.3.12 Re-Assignment of a Clearance

A Clearance may be re-assigned by the Transfer or Surrender and Re-issue processes from a Clearance Person to a new Clearance Person only through the System Operator. The Tags remain in place and the same Clearance number is used.

2.3.13 Transfer Process

Under this process the work can continue.

a. Prior to contacting the System Operator, both the existing and the new Clearance Person shall conduct a comprehensive job transfer brief covering the Job status, the isolated zone of protection and tag locations, worker status, Ground locations, and GDIT numbers.

b. The Clearance Person contacts the System Operator and informs them that he has conducted the briefing with the new Clearance Person and request the Transfer of Clearance.

c. The new Clearance Person contacts the System Operator and requests the Clearance limits by device and location and then is issued the Clearance by the System Operator.

d. The System Operator shall then inform the original Clearance Person that the Transfer has been completed.

2.3.14 Surrender and Re-Issue Process

Under this process the work under the surrendered Clearance stops.

a. Grounds may be left in place, work may not be complete, and the Clearance is administratively Surrendered to the System Operator and not Released. During the transition, it must be considered that there is no protection in place until the surrendered Clearance is re-issued. Minimum approach distances shall be maintained for the surrendered Clearance as if the line or apparatus was energized.

b. The Clearance Person shall contact the System Operator and inform them they are Surrendering their Clearance.

c. The Clearance Person shall contact the System Operator and fully describe all condition of the circuit or apparatus and the locations of all grounds and GDIT number(s), if still in place.

d. The new Clearance Person contacts the System Operator and requests that the Surrendered Clearance be Re-Issued. In certain cases, the Surrendered Clearance may be Re-Issued to the original Clearance Person.

e. The System Operator Re-Issues the Clearance and shall fully describe to the new Clearance Person all conditions and the locations of all grounds and GDIT number(s), if still in place, as reported in the surrender statement.

Note: If the apparatus or circuit are ready for service, all workers are in the clear, and all personal grounds installed by or for the crew have been removed, the Clearance shall be Released.

2.4 Personal Red Tagging (PRT)

2.4.1 General

a. The System Operator shall define the scope, limits, reporting requirements, and shall approve when *Personal Red Tagging* is utilized. No part of an area protected by Personal Red Tagging shall cover an area protected by an outstanding Red Tag Clearance issued by the System Operator.

Exception:

Personal Red Tagging may cover an area protected by an outstanding Red Tag Clearance issued by the System Operator and the application of the PRT on the associated disconnecting devices between the limits of a Clearance for the operation of disconnecting devices used:

1. To energize or de-energize an individual transformer (single or three phase overhead or underground transformer)
2. On distribution capacitor banks
3. On series street lighting circuits
4. On fused radial side taps
5. On radial distribution side taps protected by cutout mounted dropout reclosers (i.e. S&C Electric Trip Saver).

System Operator permission is required before placing a Personal Red Tag on a device on which there is a Red Tag (Clearance) or HOLD Tag.

b. Permission is given by the System Operator to the “Person in Charge of the Work,” who must be a qualified Authorized Person, to assume the duties and responsibilities with respect to the switching, tagging, testing, grounding, and restoring specific sections of the electrical system as defined by the System Operator. The Person in Charge of the Work shall follow all appropriate steps associated with Appendix A of this procedure.

c. The use of Personal Red Tags may or may not establish a zone of protection.

In the case where Personal Red Tagging is used to establish a zone of protection, testing and grounding are required before the equipment or circuit can be accepted as dead. Work may be done only after these steps have been completed either personally by the worker, or, at his/her request, by another.

Exceptions: Permission is not required from the System Operator for the operation of disconnecting devices used to energize or de-energize an individual distribution transformer (single or three phase overhead or underground transformer), distribution capacitor banks, series street lighting circuits, fused radial distribution side taps, or cutout mounted dropout reclosers (i.e. S&C Electric Trip Saver) on radial distribution side taps *and the application of PRT on the associated disconnecting devices.*

d. When a secondary switch (customer's or company) is used for isolation, a PRT shall be used. A Liberty Utilities lock (where possible) and a PRT tag shall be applied at the disconnecting device.

Note: When an employee has not been trained and authorized through this EOP, the employee will continue to utilize the lock out / tag out procedure to control the hazardous energy associated with the task(s) at hand. Lock out / tag out shall not be used for primary voltage isolation such as a riser pole or switchgear.

e. No feeder tie switch shall be operated without a switching order from the System Operator.

f. Personal Red Tags are not transferable. For work under Personal Red Tagging that has not been completed, the System Operator shall determine what appropriate action(s) shall be taken.

g. If a person is unable to continue their work, a Higher Authority shall assume full responsibility of any Personal Red Tags placed and inform the System Operator. The Higher Authority shall also notify the original Person In Charge of the Work of the status of the Personal Red Tags as soon as practicable.

2.4.2 Documentation - Refer to Section 1.7.1

2.4.3 Multiple Crews Working in the same Zone of Protection

a. Option One: Working under someone else's Tags

When multiple crews are working in the same zone of protection, and **one Person in Charge of the Work** assumes responsibility for the protection of all the crews working, only that individual's Personal Red Tag(s) is required for the work to be performed. The Person in Charge of the Work shall ensure that all crews working under the protection of their Personal Red Tag(s) are listed under their Field Clearance and Control Form.

b. Option Two: Working with individual Tags

Each Person in Charge of the Work, working independent of each other, shall have their Personal Red Tags placed on all devices necessary to establish the zone of protection for their crew(s). Each Person in Charge of the Work shall maintain their own Field Clearance and Control Form.

Note: Overlapping zones of protection are allowed under the PRT process. Disconnecting devices that have been tagged with a Hold Tag for continuity of grounds shall not be operated.

2.4.4 Removal of Personal Red Tags

Before removing any of their Personal Red Tags or operating any devices, the Person in Charge of the Work shall ensure that all of their workers, tools, equipment are in the clear and grounds have been removed. If no other tags are placed on the same device, the Person in Charge of the Personal Red Tagging shall remove their red tagging and the apparatus may be restored to service.

2.4.5 URD / UCD Locations

At no time shall multiple Personal Red Tags be placed on the same device unless the sections are separate and adjacent in Underground Residential Developments or Underground Commercial Developments.

2.4.6 Personal Red Tags ordered on by the System Operator

Personal Red Tagging is also used when a System Operator, upon the request of the local field forces, arranges for the switching and tagging of a specific protective point(s) which will not establish a zone of protection but is required to prevent the operation of a device(s).

In such cases the System Operator issues a Personal Red Tag covering the specific point(s) to the Person in Charge of the Work who is then responsible for providing protection from any other source by switching and applying additional Personal Red Tags as required. Personal Red Tags ordered on by the System Operator shall not be removed except under a switch order from the System Operator or by prior permission by the System Operator.

When such a Personal Red Tag is issued by the System Operator to the Person in Charge of the Work, the System Operator Personal Red Tagging Sheet must be filled out in the same manner as for a Clearance. The protective point(s) so covered must be tagged to the Person in Charge of the Work.

2.4.7 Routine Job Related Testing

Voltage testing of the apparatus or circuit utilizing a test set can only be directed by the Person in Charge of the Work. Tags remain in place during the voltage test. Notification to the System Operator is not required.

2.5 Non-Reclose Assurance (NRA)

2.5.1 A Non-Reclose Assurance is not a Clearance and no circuit or apparatus should be considered de-energized.

2.5.2 The System Operator shall tag all devices and all associated supervisory controls (i.e. SCADA/EMS) necessary to secure the Non-Reclose Assurance.

EXCEPTION: If the automatic reclosing feature of a reclosing device is disabled by a Supervisory Control and Data Acquisition System (SCADA), the system shall provide for the following:

a. At the SCADA Operating Point (System Control)

1. A signal is received by the System Operator confirming that the disabling operation has occurred at the reclosing device location, and

2. A readily visible tag or electronic display is used to inform the System Operator that a disabling operation has been initiated, and

3. The tag or electronic display (screen tag) is removed before action is taken to re-enable the automatic reclosing feature.

b. At the Reclosing Device Location (field or substation)

1. The reclosing feature is disabled in such a manner as to prevent manual override of the normal control by any potential on-site operator, or

2. A signal, flag, or other display is used in such a manner as to alert any potential on-site operator that the reclosing feature has been disabled.

2.5.3 A Non-Reclose Assurance can be issued after the reclosing control(s) for a specific circuit have been placed in the non-reclose position and the necessary NRA tags placed.

2.5.4 The Authorized Person(s) to whom the Non-Reclose Assurance has been issued has the responsibility to inform the System Operator or the person who has assumed Controllership of any conditions that may have caused the device to operate.

2.5.5 Manual reclosing shall not be performed until there is concurrence by the Authorized Person(s) holding the NRA and the appropriate System Operator.

2.5.6 The breaker(s) or device shall not be restored to the automatic reclose position until the Non Reclose Assurance has been released.

2.5.7 A Non-Reclose Assurance issued by the System Operator may be transferred using the Transfer or Surrender and Re-Issue Process.

2.5.8 Recloser Controls that are equipped with HOT LINE TAG feature shall be placed in the "**ON**" position and NRA tagged. (With the HOT LINE TAG "**ON**", the device will not automatically reclose and cannot be manually closed).

2.5.9 Only an NRA issued by the System Operator can have others signed on to the NRA.

2.5.10 After the Release of a Non-Reclose Assurance, if additional work is required, the System Operator may reissue the Non-Reclose Assurance to the same or another Authorized Person.

2.5.11 The Authorized Person in Charge of the Work may disable reclosing and install an NRA Tag in their name for work on radial distribution side taps protected by cutout mounted dropout reclosers (i.e. S&C Electric Trip Saver). When the work is complete the Person in Charge of the Work shall remove the NRA tag and restore reclosing.

Note: When an NRA is required for a prearranged job, the TOA process may be utilized by the System Operator and issued to the Person in Charge of the Work in lieu off completing a Field Clearance and Control Form. The time and date of issuance and release of the NRA as well as those working under the NRA shall be documented. In this case, document retention shall be as designated in section 1.7 of this Electric Operating Procedure.

2.6 HOLD Tags

HOLD tags are not to be used to provide safety clearance for the protection of employees or the public working on or near electrical apparatus. The HOLD tag is System Operator based unless used for ground continuity. The HOLD tag means that a device shall not be operated until the reason for the HOLD tag is determined and the tag is removed.

2.6.1 A HOLD tag prevents the operation of apparatus that is not ready for service or is desired to remain open or closed due to other circumstances.

2.6.2 A HOLD tag prevents apparatus that is damaged from being operated.

2.6.3 A HOLD tag may be used to identify devices that are not in their normal configuration or condition and/or are unsuitable for normal operation.

2.6.4 The HOLD tag may be placed on electrical apparatus in the open or closed position.

2.6.5 A Red Tag may be applied on an open device without clearing the HOLD tag.

Note: The device must be in the open position and safe for use as an isolation point.

2.6.6 HOLD tags may be used on various relay applications as determined by the System Operator where worker protection is not required.

2.6.7 The System Operator shall maintain a listing of HOLD tags within their area of responsibility.

2.6.8 The Authorized Person may order on and order off a HOLD Tag in their name to maintain ground continuity.

2.6.9 Can be applied for an Authorized Person or System Operator.

2.7 Non-Authorized Contractor Permission to Work Process

The FCC shall conduct a job brief with the Non-Authorized Contractor and:

2.7.1 Apply and obtain, a Clearance, permission to use PRT, or an NRA from the System Operator.

2.7.2 Upon receipt of Clearance, permission to use PRT, or an NRA, the FCC informs the Non-Authorized Contractor of the Clearance, PRT, or NRA and allows them to begin work utilizing the “Contractor Permission to Work” form.

2.7.3 Upon completion of the work, the Contractor shall inform the FCC of the completion of the work utilizing the “Contractor Completion of Work” section of the “Contractor Permission to Work” form.

2.7.4 The FCC Releases the Clearance, PRT, or NRA to the System Operator.

2.7.5 Under this process, the Contractor is solely responsible for the testing and application of required personal grounds and the work practices necessary to protect their employees and ensure safety at the job site.

2.7.6 Clearances and NRA’s which are held by an FCC can be transferred. All Transfer Process requirements found in Section 2.3.13 shall be followed; additionally, the contractor must be involved in the comprehensive job transfer brief. The transfer shall be noted by the FCC on the Job Brief and by the Contractor in the remarks box of the “Contractor Permission to Work Form”.

2.8 Customer / Customer’s Agent Requirements

The following are Rules applicable to Customers working on their apparatus which is connected to apparatus owned and operated by Liberty Utilities.

2.8.1 Customer Tag Person

The customer (or their agent) shall furnish the System Operator with the name of the person, and their affiliation, for whom the apparatus will be tagged.

2.8.2 Switching and Tagging for the Customer

a. Before the System Operator may utilize the Customer Tag to have a line or apparatus removed from service and tagged, a request shall have been received from the customer (or their agent) stating specifically the apparatus involved, the work to be performed, and if grounds are needed. For customers supplied from a primary network feeder, grounds shall be applied. See paragraph 6.2.11.

Note: If the following conditions exist:

1. A Customer plans to perform voltage testing in the zone of protection by applying a test set voltage (e.g. Megger a switch)

AND

2. Other Customer Tag(s) and/or a Clearance is requested by Liberty Utilities Personnel on the same zone of protection

THEN

A visible air gap shall be established and tagged to establish a zone of protection for that customer's work separate from the other Customer Tag(s) and/or Clearance.

b. The System Operator shall order the Switch Person to operate the controls and/or switches, and to fill out Customer Tag(s) and attach the "*Work in Progress*" section of the tag(s) in the manner provided (tag holders) to all Liberty Utilities sources of electrical energy.

2.8.3 Grounding for the Customer (if requested)

a. Grounds may be installed and removed at the request of the customer (or their agent), as directed by the System Operator after all required protective devices are in the open position and tagged.

b. Grounding performed by Liberty Utilities employees shall be done in accordance with Company testing and grounding EOP's. The Switch Person shall notify the System Operator that grounds have been installed, and identified by the Ground Device Identification Ticket number(s).

c. The customer (or their agent) will be advised by a Liberty Utilities representative that the grounds installed are only a visible indication that the line/apparatus has been de-energized at the point of grounding, and should not be considered protection for their workers.

d. The customer (or their agent) is responsible for grounding for the protection of their workers.

2.8.4 Notification to Customer that apparatus is tagged and Clearance to work

a. Upon completion of all necessary switching and tagging, and with the "*Work In Progress*" portion of the tag(s) in place, the System Operator will give direction to the Switch Person to give the customer (or their agent) Clearance to work. At that time, the "*Release of Clearance*" portion of the tag will be given to the customer (or their agent).

b. When multiple Customer Tags are used, only <u>one</u> "*Release of Clearance*" portion is required to be provided to the customer (or their agent).

2.8.5 Customer Release of Clearance

a. Prior to authorizing the removal of a Customer Tag and restoring service, the System Operator shall be satisfied that the "*Release of Clearance*" section of the Customer Tag has been received, signed by the customer (or their agent). The "*Release of Clearance*" indicates that work has been completed and all workers are clear of the line or apparatus, and that it is safe to restore service.

b. If the customer (or their agent) loses the "*Release of Clearance*" section of the Customer Tag, the Switch Person shall request the customer or their agent to complete and sign a new "Release of Clearance" section of a new Customer Tag. The original person (or an agent from the same affiliation) receiving the Customer Tag shall complete and sign the new Customer Tag. The Switch Person shall then notify the System Operator who shall document the new Customer Tag Number.

2.8.6 Removal of Grounds Before Restoring Apparatus to Service

The System Operator will order the removal of Liberty Utilities installed grounds if applied, identified by the Ground Device Identification Ticket number(s) after being informed by the Switch Person that the completed "Release of Clearance" section of the Customer Tag has been received.

2.8.7 Restoring Apparatus to Service, "OK to go normal"

The System Operator will give direction to the Switch Person to give the customer (or their agent) an "*OK to go normal*" after required switching has been completed. The Switch Person shall report back to the System Operator after such notification has been given.

2.8.8 Large Industrial Customers

Large industrial customers, as defined by the System Operator, may apply directly to the System Operator for requesting a Customer Tag Clearance. The System Operator may order such installed Customer Tags removed without the "Release of Clearance" section of the Customer Tag.

The "Release of Clearance" shall be obtained from the original person issued the Customer Tag unless an alternate has been designated by the original person at the time the Customer Tag was issued.

2.8.9 Liberty Utilities Authorized Person(s) and Customer(s) Working Jointly in the same Zone of Protection

a. For planned work all isolation points shall be tagged with Red Tags and Customer Tags.

b. For situations where a zone of protection has been established (or is in the process of being established) with Red Tagging and a Customer problem or request is received to work on that same zone of protection, only the source device(s) where the apparatus is normally energized from shall be tagged with the Customer Tag(s). The Red Tag Clearance number shall be cross referenced and documented with the System Operator.

2.8.10 Alternate Tagging Process for Multiple Customer Requests on the Same Zone of Protection

For situations where a zone of protection has been established (or is in the process of being established) using customer tagging and additional customer(s) with problem(s) or request(s) are received to work on that same zone of protection, the source device(s) where the apparatus is normally energized from, shall be tagged with customer tags representing each customer request for that zone of protection. Remaining device(s) shall be tagged with only the initial customer tag and shall remain tagged until all customers receiving the zone of protection have released the Clearance(s) or customer tag(s). The use of the initial customer tag on the remaining devices shall be cross referenced and documented by the System Operator.

2.9 Work on Customer-Owned Primary Voltage Electrical Facilities

This procedure is for Liberty Utilities workers that are to perform work on customer-owned electrical facilities circuits or apparatus greater than 600 Volts. Work preparation shall include verification and securing of circuit and facility diagrams, including the existence and implications of on-site generation, UPS systems, transformer back-feed, or induced voltages.

2.9.1 There shall be agreement between the Liberty Utilities management and agreed to by the customer on how the work is to proceed. There shall be concurrence between the System Operator and Liberty Utilities management as to which of the following two procedures shall be used:

a. If electrical prints are available or if the circuits involved are known to the System Operator, the Red Tag Clearance or Personal Red Tag procedures shall apply. If a device is accessible to non-Liberty Utilities personnel, a Liberty Utilities lock must be utilized if possible, OR,

b. If electrical prints or circuits are not known by the System Operator, Liberty Utilities personnel shall utilize Personal Red Tagging for the control of Hazardous Energy Sources.

2.9.2 Devices for establishing the zone of protection shall remain under control of the Person in Charge of the Work.

2.9.3 Workers must follow all applicable Liberty Utilities EOP's and Safety Rules when working on customer facilities.

2.9.4 Any unusual or unsafe conditions of customer apparatus must be reported immediately to your local supervision.

2.10 Interconnections with other Utilities and Generators

2.10.1 When foreign utilities or generators require a Guarantee

a. A designee of the foreign utility or generator, acting as their System Operator shall be issued a Guarantee by the Liberty Utilities System Operator.

b. A Red Tag shall be used to tag all protective devices listed on the Guarantee.

c. The Guarantee shall have a number issued by the Liberty Utilities System Operator.

d. The Liberty Utilities System Operator issuing the Guarantee shall record the name and contact number of the System Operator of the foreign utility or generator.

e. Grounds may be applied at the request of the foreign System Operator. The foreign utility or generator system operator will be advised by the Liberty Utilities System Operator that the grounds installed are only a visible indication that the line/apparatus has been de-energized at the point of grounding, and should not be considered protection for their workers.

2.10.2 When Liberty Utilities requires isolation from a foreign utility or generators

a. A Liberty Utilities System Operator will accept the foreign utility's or generator's isolation practices as defined by their rules or will direct a Liberty Utilities switch person to red tag the required limits for the Clearance. These limits shall be tagged only after a visual open has been created by the foreign utility or generator.

b. The Liberty Utilities System Operator shall document the limit(s) as part of the zone of protection in the Clearance to be issued to the Liberty Utilities Clearance Person(s).

c. The Liberty Utilities System Operator may request the foreign utility or generator to close mechanical grounds as part of the Clearance.

d. The Clearance shall not be released to the foreign utility or generator System Operator until after the Liberty Utilities System Operator receives the Release of Clearance from the Liberty Utilities Clearance.

2.10.3 When a foreign utility Control Center requires an NRA Guarantee

a. A designee of the foreign utility, acting as their System Operator shall be issued a NRA Guarantee by the Liberty Utilities System Operator.

b. The NRA Guarantee can be issued after the reclosing control(s) and supervisory controls for a specific circuit have been placed in the non-reclose position and the necessary NRA tags placed.

c. The NRA Guarantee shall have a number issued by the Liberty Utilities System Operator.

d. The Liberty Utilities System Operator issuing the NRA Guarantee shall record the name and contact number of the System Operator of the foreign utility.

e. The designee of the foreign utility, acting as their System Operator to whom the Non-Reclose Assurance has been issued has the responsibility to inform the Liberty Utilities System Operator of any conditions that may have caused the device to operate.

f. Manual reclosing shall not be performed until there is concurrence by the designee of the foreign utility, acting as their System Operator to whom the NRA Guarantee was issued and the Liberty Utilities System Operator.

g. The breaker(s) or device shall not be restored to the automatic reclose position until the NRA has been released by the designee of the foreign utility, acting as their System Operator.

2.10.4 When Liberty Utilities requires a NRA Guarantee from a foreign utility Control Center.

a. A Liberty Utilities System Operator will accept the foreign utility's Non Reclosing practices as defined by their rules.

b. The Liberty Utilities System Operator shall document the foreign utility's device(s) placed in the necessary position to secure the NRA Guarantee.

c. Manual reclosing shall not be performed until there is concurrence by the Liberty Utilities Authorized Person and the Liberty Utilities System Operator.

d. The NRA Guarantee shall not be released to the foreign utility System Operator until after the Liberty Utilities System Operator receives a Release of the NRA from the Liberty Utilities Authorized Person.

2.11 <u>Station Control Tag (Non-System Operator Based)</u>

The Station Control Tag is Non System Operator based and shall be utilized exclusively for substation related low voltage or control work at 600V or less. The Station Control Tag shall only be utilized by Authorized Person(s) trained and knowledgeable in the Clearance and Control procedures. Station Control Tag(s) shall be placed at all necessary locations to protect against inadvertent application of energy used for the **control and/or operation** of electrical apparatus such as circuit breakers, pumps, fans, motors, and compressors.

2.11.1 Application of SCT

a. The Station Control Tag shall **not** be used in lieu of a Clearance for the protection from system voltage above 600 volts.

b. Station Control Tag(s) shall be placed on protective point(s) and shall be installed with lock(s) if provisions are available.

c. Separate Station Control Tags shall be utilized by **each crew** working on the same electrical apparatus control circuit(s).

d. All Station Control Tags applied by field crews shall be documented. The documentation shall include the location, name of the individual installing the Station Control Tag, the date and time of the installation and the removal of the Station Control Tag. This will be accomplished by the use of the Station Control Tagging Sheet.

2.11.2 Previously Tagged Device

Permission is required before placing a Station Control Tag on a device previously tagged by the System Operator.

2.11.3 Applying SCT on secondary fuses

For secondary fuses, the tags are placed on the latch, lock or handle that holds the fuse cabinet or compartment door closed. When fuses are located behind a control panel in a control house, or other similar location, it is appropriate to place the tag on the de-energized side of the fuse block.

2.12 Delegation of Controllership

When Controllership is to be delegated from the System Operator to an Authorized entity (an Authorized Person or De-centralized location), the System Operator shall document the Authorized entity accepting controllership along with the specific lines and/or apparatus.

The System Operator shall inform the Authorized entity of any known abnormal conditions that exist on the line or apparatus under Controllership.

The Authorized entity shall assume all duties and responsibilities of the System Operator. TOA shall be utilized to establish the numbering system to be used during Controllership.

When the Controllership needs to be delegated further, the notification requirements for individuals or location shall be established with the System Operator at the time of the original delegation.

When blocking reclosing of devices the Authorized Person who has been delegated Controllership shall order the System Operator to have the EMS supervisory control(s) NRA tagged.

When Controllership is released, any known abnormal conditions that exist on the line or apparatus shall be communicated to the System Operator.

3.0 EXCEPTION APPROVALS:

It is expected that additional special cases (i.e., storm emergencies/field conditions) will be identified that may require clarification, exception or a revision to this procedure. Agreement and approval will be required by concurrence of the Manager of the Operating Department involved, the appropriate Director of Dispatch and Control or designee, and the Manager EHSS or their designees. If concurrence cannot be achieved among these parties, they will seek concurrence of the next higher level of management for the appropriate departments involved.

4.0 PROGRAM ADMINISTRATOR:

Questions and/or clarification regarding this document and proposed changes under the Exception Approval section of this document shall be forwarded to the Program Manager Standards, Policies, and Codes.

5.0 RESPONSIBILITIES:

5.1 Standards, Policies and Codes

5.1.1 Update this procedure as necessary.

5.1.2 Provide appropriate guidance to field personnel when requested for a specific work related task.

5.2 <u>Electric Distributions Operations Management and Supervision</u>

5.2.1 Ensure the components of this procedure are implemented.

5.2.2 Ensure personnel are trained in this procedure.

5.2.3 Provide revision input as necessary.

5.2.4 Ensure that individuals changing jobs are qualified to perform the function requested and must notify the System Operator of the employees status.

5.3 <u>Liberty Utilities Employees and Contractors</u>

5.3.1 Demonstrate the understanding and proficiency of this procedure and successfully pass testing requirements annually.

5.3.2 Shall comply with the requirements of this procedure.

5.3.3 Shall only perform work and switching within their capabilities.

5.4 <u>Liberty Utilities Learning & Development</u>

5.4.1 Develop training lesson plans and training aids.

5.4.2 Provide initial training.

5.4.3 Provide annual training.

6.0 APPENDICES:

These appendices are supplemental to the Clearance and Control procedure and shall be followed as described in each appendix:

6.1 - Appendix A - Switching

6.2 - Appendix B - Network Switching

6.3 - Appendix C - Grounding for the Protection of the Worker

6.4 - Appendix D - Formal Statements

6.5 - Appendix E - Sample Documents / Forms / Tags

6.1 Appendix A - Switching

6.1.1 Switching

a. Authority to Operate

No device whether on a line or in a station will be operated without permission from the System Operator.

Exception:

1. In an emergency.
2. Within a Clearance.
3. Disconnecting devices used to energize or de-energize an individual distribution transformer (single or three phase overhead or underground transformer), series street lighting circuits, distribution capacitor banks, radially fused distribution side taps, or cutout mounted dropout reclosers (i.e. S&C Electric Trip Saver) on radial distribution side taps and the application of PRT on the associated disconnecting devices.

b. Emergency Switching

Under emergency conditions that endanger life or property a qualified person working for Liberty Utilities can perform switching by opening apparatus without first contacting the System Operator to relieve the condition. This person performing the emergency switching assumes full responsibility for the switching and must relate all details to the System Operator as soon as possible. However, if a device is opened for any reason, it shall not be closed without receiving permission to do so from the System Operator to an Authorized Person.

c. Within a Clearance

When operating devices within a zone of protection the Clearance Person shall:

1. Notify others that are signed on or requesting to sign on.
2. Direct all switching within the zone of protection.
3. Track the status of the device(s) by documenting the operation of device(s) on the Field Clearance and Control Form. (6.5.2)
4. Inform the System Operator of any change from the original position of any device operated within the zone of protection when the Clearance is released.

d. Safety Stop

In the event that either the System Operator or the Switch Person determines that there is a safety or operational concern they should safely stop all switching, communicate these concerns to each other and, if necessary obtain direction from their supervisor before proceeding.

e. Phasing Responsibilities

Phasing is normally the responsibility of the crew performing the work. If phase integrity may have been compromised after work or repairs, the System Operator shall be notified and an order will be issued to perform phase check(s).

6.1.2 Switching Orders

The System Operator and the Switch Person are both accountable for the proper performance of the switching. Good communication during switching is paramount. To provide the best check and balance possible a pre-switching brief will be initiated by the System Operator before every switching order.

6.1.3 Pre-Switch Brief

The items below will be included in every pre-switching brief between the System Operator and the Switch person.

- Determine whether communications will be done using radios or phones.
- Confirm Switching Order Number and Revision Number

Who

- Exchange full names and truck or phone numbers.

What and Why

- Identify what equipment is being switched.
- Explain why the switching is being performed.
- Provide an overview of the switching procedure.
- Identify any unusual switching schemes or relays.

Where

- Confirm the proper location of the switching.

Understanding and Questions

- Ask the Switch Person if they have any questions.
- Verify that the Switch person understands the procedure.

6.1.4 Switching Review

A switching review is required by the switch person prior to any switching step.

The Switch Person shall review the switching instructions, and determine if the steps are listed in a safe order.

All switching orders received from the System Operator shall be repeated verbatim. In all cases of unplanned switching, the switching step(s) shall be written down before they are performed.

A review shall consist of the following:

a. Review the associated Station One Line Diagram and other circuit maps where possible.

b. Identify and become familiar with the devices to be operated at that location.

c. Determine or check the proper sequence for performing the required switching.

d. Check for defective or abnormal apparatus that could prevent the switching from being performed safely or properly.

e. Check for abnormalities in circuit or station loads/voltages, if applicable.

f. If any issues are discovered, contact the System Operator to discuss concerns.

The Switch Person shall carry the switching order with them while executing the order.

The Switch Person shall verify the device identification number to be operated prior to switching the device.

The Switch Person will denote the completion of each step as it is performed on the switching orders.

The Switch Person will report to the System Operator the completed switching steps and times as required.

6.1.5 Notification Before Switching in a Substation

The Switch Person is responsible for notifying all affected personnel in the station before any switching is performed in that station.

6.1.6 Responsibilities

a. Communications for Switching

1. The System Operator shall read the details of each switching step to the Switch Person.
2. The Switch Person shall write down, if not previously provided in writing, and repeat back the details of each switching order to the System Operator.
3. After the System Operator agrees the switching order read-back is correct, the System Operator authorizes the Switch Person to begin switching in exactly the order as directed, and requests to report back when complete.
4. After the completion of the specified switching, the Switch Person contacts the System Operator and reads back the switching order stating each switching step completed.
5. The System Operator then fully reads back each switching step completed by the Switch Person.
6. The Switch person verifies the System Operator has correctly read back the completed switching.

b. Responsibilities During Switching

When directed to conduct any switching, the Switch Person shall be responsible to perform the following:

1. Check all switches to be in the fully open or fully closed position on all phases.
2. Check any switch attachment/component to be in the proper position before and after switch operation.
3. Check all circuit breakers that are operated to be open or closed utilizing its position indicator, control lights, indicating meters, and potential lights as applicable.
4. Place locks and tags on apparatus at the proper location as applicable and as directed.
5. Anticipate the effects when performing a particular switching operation.
6. Properly record/report alarms, targets and operations.
7. Check circuit breaker and circuit switcher pressures/contact indicators normal before and after their operation.

6.1.7 Correct Terminology

When switching, both the Switch Person and the System Operator shall use proper terminology. Slang expressions and verbal short cuts shall not be used.

6.1.8 Unclear Switching Order

If any switching order is not clear due to terminology or communications systems interference, neither the System Operator nor the Switch Person shall assume what the other party said. The message shall be repeated until it is understood.

6.1.9 Locking/Unlocking and Tagging Devices

Each manually operated primary voltage switch with an operating rod shall normally be locked when in the open or closed position. The switch shall be unlocked only during the time it is being operated. If a switch cannot be securely locked, the System Operator shall be notified immediately. Tag shall be placed on the lock, or in appropriate tag holders, or other provisions as close as possible to the isolation device. A protective point when so tagged may or may not be energized.

6.1.10 When Accessible to the Public

When a switching device is accessible to the general public the tags shall be placed at the locking provision or shall be located at a sufficient height from the ground to discourage unauthorized removal.

6.1.11 Motor Operated Switches

Motor operated switches that are opened as an isolation point shall have the motor operator rendered inoperable, unless its design does not so permit, by disengaging the operating rod from the motor mechanism.

After disengaging the operating rod from the motor mechanism, it is to be locked open and properly tagged.

If there is a problem disengaging and/or securely locking the operating rod, the System Operator shall be consulted so that other arrangements can be made.

6.1.12 Tagging of Non-Gang Operated Devices

A single tag is required to be applied to stick-operated switches, open loops/jumpers, fuses or fused cutouts used to isolate apparatus. When tagging a structure the tag should be made obvious for easy identification. If the fuses or fused cutouts are removed (lifted out), the Red Tag must still be placed at the isolation point (in the holders). Oil Fused Cutouts (OFC's) and separable elbows shall have tags placed on each individual phase for added identification.

6.1.13 Tagging of Elbows

The air gap created is the limit for the isolation established and the elbow shall be tagged.

6.1.14 Truck Type Circuit Breakers (Metal-Clad Switchgear)

The air gap created is the protective point for the isolation established and the truck position shall be tagged.

6.1.15 Testing & Grounding – Gang Operated Ground Switches

For locations that have Gang Operated Grounding Switches the line shall be tested deenergized with an approved testing device before closing the Ground Switch.

Exception: For locations that have Gang Operated Grounding Switches where testing with a high voltage tester cannot be performed or is not practicable, the following procedure shall be used as applicable:

a. Before a line/apparatus is deenergized and isolated, voltage indication shall be checked at all ends of the line by live line indication and/or voltage readings from the Station control panel and by the EMS, if available.

b. The line/apparatus shall then be deenergized and the disconnecting means opened, locked opened, and tagged.

c. Check the line/apparatus deenergized at all ends of the line with live line indication, voltage readings, or open indication (GIS) from the Station control panel and by the EMS, if available.

d. Only after the line/apparatus has been verified deenergized, or open (GIS), and has been tagged and the Clearance issued, can the Gang Operated Grounding Switch(s) be closed. The System Operator will issue switching orders to close and ticket all gang operated grounding switches as required with GDIT's. The Switch Person shall note the GDIT number(s) and report them back to the System Operator when the switching order has been completed.

6.2 Appendix B – Network Switching *(For Reference no Network Systems Liberty Utilities-NH)*

This procedure covers the various procedures and requirements applicable to all A.C. Networks; and outlines the proper steps to provide protection for work on network components. All work on network systems shall be in accordance with these procedures.

6.2.1 General Information

a. Refer to NG-EOP UG022 for the methods used to perform visual and operational, diagnostic, acceptance and installation inspections and phasing on network transformers and protectors.

b. For all work assignments that require a 480Y/277 volt network protector enclosure to be opened, the 480Y/277 volt network protector shall first be de-energized from both its network transformer and the secondary network system.

c. Permission of the System Operator shall be obtained before any primary network feeders, network transformers or associated equipment is operated, removed from service, or returned to service.

EXCEPTION: Routine testing and maintenance of general network protectors only require notification to the System Operator.

d. Requests for prearranged work on network equipment shall be made on the TOA Application. The application shall be submitted to the System Operator in advance of the time when the work will be performed. For emergency work, such requests shall be referred immediately to the System Operator. The Person in Charge of the Work shall determine the zone of protection and protective points (limits) required; and these shall be checked by the System Operator.

e. Except in an emergency, no more than one primary feeder supplying network transformer units shall be taken out of service for an extended period of time. (Some networks are designed to sustain the loss of two primary feeders in an emergency. However, some voltage deterioration may result in this situation. If unsure of local configuration, check with engineering prior to switching additional network feeders out of service if possible.)

f. The normal operating status of a network transformer unit is that the Transformer Oil Disconnect (TOD) is locked in the CLOSED (TRANSFORMER on some units) position and the network protector is locked in the AUTOMATIC position.

g. Local operating personnel shall keep the System Operator informed of any condition which may affect the operation of the overall network system. This includes abnormal conditions such as (but not limited to): protector "pumping", protector fuses blown, possible feeder or transformer overloads, high transformer temperatures, etc.

h. The TOD of a network transformer shall not be operated unless both sides of the switch are de-energized. If in the course of executing a switch order to operate a TOD the switch person has reason to believe the transformer may be energized, the switch order shall be stopped and the System Operator notified.

i. Network TODs typically have three positions (OPEN, CLOSED & GROUND). When placed in the OPEN position, the cable is disconnected from the transformer. When placed in the CLOSED (or TRANSFORMER) position, the cable is connected to the transformer. When the TOD is placed in the GROUND position, it places a ground on the primary cable but does not ground the transformer. Some TOD switches have Sequential Grounding Positions, which allow a ground to be placed on the primary cable in a specific sequence of phase combinations.

NOTE: Network transformer interlock(s) where they exist prevent the TOD from being operated with the transformer energized and/or a closed network protector.

j. Switch orders may contain multiple locations (network vaults) in one switching order. The order of the vaults/pads to be switched may normally be done at the discretion of the switch person unless otherwise specified by the System Operator, but the sequence of switching steps at each vault shall be executed in the sequence given by the System Operator.

k. Primary network feeders may also supply non-network load. Examples of non-network load are, but are not limited to, feeder ties, substations (company or customer), switchgears, radial vaults etc. Non-network load shall be considered when switching and tagging primary network feeders.

6.2.2 Spot Networks

Spot networks are network transformers and protectors dedicated solely to serve one customer through their collector bus or switchgear and are not connected to the secondary general network grid. When removing a network transformer or protector from service in a two-transformer spot network, the spot network protector which is to remain in service shall be closed and/or checked closed and left in the AUTOMATIC position. In spot networks of three or more transformers where known cases of light load exist, at least one unit to remain in service shall be checked closed, and left in the AUTOMATIC position prior to taking a unit out of service. The spot network protector on the feeder to be removed from service shall then be placed in the OPEN position and locked open.

NOTE: When the protector to remain in service will not remain closed, corrective measures shall be determined by Operations and Engineering.

6.2.3 Work on the Network Primary Cable and/or Network Molded Vacuum Interrupter (NMVI)

NOTE: Steps a.1., a.2., and a.3 may be performed in any order and shall be completed prior to step b. Steps b. through f. shall be performed exactly in the order as written.

a. Take the following preliminary steps:

1. Open any feeder ties and Red Tag, if applicable.

2. Remove non-network load from the primary feeder and isolate from the feeder and Red Tag, if applicable.

3. Remove spot network loads from the feeder to be removed from service. Refer to section 6.2.2.

b. Open the primary circuit breaker at the source station (this de-energizes the feeder, and all associated network protectors should open automatically).

c. Test the feeder de-energized. Refer to section 6.2.12 if the feeder does not test de-energized.

d. If the feeder tests de-energized, open switches at the source station for isolation and Red Tag or disconnect the truck assembly from the bus and line, and Red Tag if a metal clad switchgear.

e. In all transformer vaults served by the de-energized feeder:

1. Open (and/or check open) and lock open the protector and Red Tag.

2. Open and lock open the TOD.

f. The System Operator shall issue the requested Clearance.

6.2.4 Restoration of the Network Primary Cable and/or NMVI

a. Release the Clearance when work is complete and grounds have been removed. If a Release for Test (see section 2.3.7) has been performed, de-energize the feeder and open the disconnects or disconnect the truck assembly from the bus and line prior to switching vaults.

b. Perform the following in each transformer vault served by the de-energized feeder:

1. Close and lock closed the TOD.

2. Remove the Red Tag from the protector (or secondary fuse openings or links where applicable). Replace the secondary fuses or links, if applicable. Place and lock the protector in the AUTOMATIC position.

c. Remove tags from the primary feeder disconnects (or truck position or air gap) at the station, if not previously removed.

d. Check open the associated circuit breaker and close the feeder disconnects or connect truck assembly to bus and line.

e. Close the feeder circuit breaker energizing the feeder. The protectors should close automatically.

f. Check feeder loading and operation.

g. Restore non-network load.

6.2.5 Work on the TOD of a Network Transformer

a. For network transformers which have a NMVI:

1. Open and lock open the NMVI and Red Tag.

2. Open (and/or check open) and lock open the network protector. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.

b. Otherwise:

NOTE: The air gap in the vault where the TOD is being worked on may be established and Red Tagged (step b.2.) prior to the other switching (step b.1.).

1. Use the same switching and tagging sequence as outlined in 6.2.3, except at the TOD to be worked on.

2. Open (and/or check open) and lock open the protector at the TOD to be worked on. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.

6.2.6 Work on the Network Transformer

a. For network transformers which have a NMVI:

1. Open and lock open the transformer NMVI and Red Tag.
2. Open (and/or check open) and lock open the network protector. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.

b. Otherwise:

NOTE: The air gap in the vault where the Network Transformer is being worked on may be established and Red Tagged (step b.2.) prior to the other switching below.

1. Use the same switching and tagging sequence as outlined in 6.2.3a. through 6.2.3d., except at the Network Transformer to be worked on. Red Tags on the feeder and feeder ties are not required. A visual open is required but is not required to be tagged. A Personal Red Tag Ordered On by the System Operator is required on a primary customer disconnect not controlled by the system operator.
2. Open (and/or check open) and lock open the protector at the Network Transformer to be worked on. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.
3. Open, lock open and Red Tag the TOD.

NOTE: When performing work on a network transformer such as adding oil and minimum approach distances will be maintained, the work can be performed under a Clearance between the TOD and the secondary air gap (fuses, links, or open conductors). Grounding is optional for this work. Added safeguards are to be included where possible.

6.2.7 Replacement of a Network Transformer

a. For network transformers which have a NMVI:

1. Open and lock open the transformer NMVI and Red Tag.
2. Open (and/or check open) and lock open the network protector. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.

b. Otherwise:

NOTE: The air gap in the vault where the Network Transformer is being replaced may be established and Red Tagged (step b.2.) prior to the other switching (step b.1.).

1. Use the same switching and tagging sequence as outlined in 6.2.3, except at the Network Transformer to be replaced.
2. Open (and/or check open) and lock open the protector. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.

6.2.8 Work on Network Protectors

a. Notify the System Operator.

Note: If the protector to be worked on is part of a customer spot network, the Person in Charge of the Work shall obtain permission from the System Operator and switch the protector out under System Operator switch orders.

b. If the network protector to be worked on is operated at 216Y/125 volts:

1. Open (and/or check open) and lock open the network protector.
2. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network

c. If the network protector to be worked on is operated at greater than 216Y/125 volts:

1. For network transformers which have a NMVI:
   i. Open and lock open the transformer NMVI and Red Tag.
   ii. Open (and/or check open) and lock open the network protector. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.
2. Otherwise:

   NOTE: The air gap in the vault where the Network Protector is being worked on may be established and Red Tagged (step 2.ii.) prior to the other switching below.

   i. Use the same switching and tagging sequence as outlined in 6.2.3a. through 6.2.3d., except at the protector being worked on. Red Tags on the feeder and feeder ties are not required. A visual open is required but is not required to be tagged. A Personal Red Tag Ordered On by the System Operator is required on a primary customer disconnect not controlled by the system operator.
   ii. Open (and/or check open) and lock open the protector being worked on. Then establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Red Tag.
   iii. Open, lock open and Red Tag the TOD.

NOTE: If restoration of the primary feeder is required to restore other transformers supplied by it, the primary feeder may be switched back.

6.2.9 Replacement of a Network Protector Enclosure

a. Refer to Section 6.2.8c. for all voltages.

6.2.10 Customer Work on a Spot Network Collector Bus

If a spot network customer requires a Clearance (using Customer Tags) for de-energizing the secondary collector bus for work on the customer equipment, establish a secondary air gap (fuses, links, or open conductors) between the protector and secondary network and Customer Tag.

a. For a spot network in which all network transformers have a NMVI:

1. Remove load from the collector bus.

2. Open and lock open all the transformer NMVIs.

3. Open and lock open all the protectors. Then establish a secondary air gap (fuses, links, or open conductors) between the protectors and collector bus and Customer Tag.

b. Otherwise:

1. Remove load from the collector bus (see section 6.2.1b.).

2. Open and lock open the protectors. Then establish a secondary air gap (fuses, links, or open conductors) between the protectors and collector bus and Customer Tag.

c. Restore the collector bus by reversing the sequence of the procedure above.

NOTE: A protector closed into an isolated collector bus may not remain closed. Load may be required to be connected to the bus before attempting energization. Some spot network installations are equipped with a load resistor for this purpose.

6.2.11 Customer Work on Customer Equipment Fed from Primary Network Feeders

If a customer is fed from a primary cable which is also a network feeder, and requires a Clearance (using Customer Tags) for de-energizing the primary feeder cable for the customer's work, the primary cable shall be grounded. Proceed as follows.

NOTE: Steps a.1., a.2., and a.3. may be performed in any order and shall be completed prior to step b. Step b. through step g. shall be performed exactly in the order as written.

a. Take the following preliminary steps:

1. Open any feeder ties and Customer Tag, if applicable.

2. Remove non-network load from the primary feeder and isolate from the feeder and Customer Tag, if applicable.

3. Remove spot network loads from the feeder to be removed from service. Refer to section 6.2.2.

b. Open the primary circuit breaker at the source station (this de-energizes the feeder, and all associated network protectors should open automatically).

c. Test the feeder de-energized. Refer to section 6.2.12 if the feeder does not test de-energized.

d. If the feeder tests de-energized, open switches at the source station for isolation and Customer Tag or disconnect the truck assembly from the bus and line, and Customer Tag if a metal-clad switchgear.

e. In all transformer vaults served by the de-energized feeder:

1. Open, lock open and Customer Tag the protector.

2. Open and lock open the TOD.

f. One set of grounds shall be applied to the primary cable per section 2.8.3.

g. The System Operator shall issue the requested Customer Tags.

6.2.12 Network Protector Stuck Closed

a. After opening the primary network feeder breaker to de-energize a primary network cable, if it does not check de-energized, a protector(s) has failed to open automatically.

b. Check each vault on the primary network feeder to locate which protector did not open. Identify and notify the System Operator and the local Operating Supervision of which protector(s) failed to open.

c. Once located, open and lock open the stuck protector. A diagnostic overhaul shall be performed on the protector, and the protector repaired and returned to service.

d. If the stuck protector cannot be opened to de-energize the primary cable, create a secondary air gap to de-energize the primary cable. The protector shall not be returned to service until repairs are made or the protector replaced.

e. If repairs cannot be performed immediately, the protector shall be locked open or a secondary air gap created and a HOLD Tag placed.

6.3 Appendix C – Grounding for the Protection of the Worker

6.3.1 General

No Personal grounds shall be applied until the zone of protection has been established and the Clearance has been issued by the System Operator or by those having permission to utilize Personal Red Tagging.

Testing and grounding are required before considering the lines or apparatus dead. Work may be done only after these steps have been completed either by the Clearance Person personally or at their request by another.

When necessary to ground apparatus at points other than where the work is to be done, the request for such grounds shall be made by the Clearance Person. The System Operator can be utilized to transmit the request for remote grounding.

a. All lines and apparatus, greater than 50 Volts, under the control of the System Operator are not to be considered dead until all of the following have been performed. Line or apparatus is isolated and tagged, tested de-energized, and grounded.

b. For an employee to work lines or apparatus as dead, the lines or apparatus shall be:

   1. Red Tagged under the provisions of EOP G014, and

   2. Tested and grounded as specified in appropriate Grounding Documents and EOP's.

c. Lines and apparatus may be worked ungrounded and treated as dead, only if LIBERTY UTILITIES Management can demonstrate that the installation of a ground is impracticable, or conditions resulting from the installation of a ground would present greater hazards than working without grounds, provided the following conditions are met:

   1. The apparatus or lines have been isolated and tested de-energized under the provisions of this documents and other associated referenced EOP's.

   2. There is no possibility of contact with any other energized source.

   3. The hazard of induced voltage is not present.

When working on isolated and tagged substation apparatus and minimum approached distances will be maintained, grounds will not be required. (i.e. ground level mechanism inspections and maintenance). Appropriate added safeguards are included where possible.

6.3.2 Placement of Grounding Device Identification Tickets (GDIT)

After the zone of protection has been established, the Clearance Person shall determine the number and location(s) of personal grounds needed to ground the apparatus properly. All grounds shall have GDIT applied on each ground clamp connection to ground.

a. Clearance Person - The Clearance Person shall record on the appropriate document the location and ticket number(s) of the GDIT for each ground connection for the Red Tag or PRT zone of protection. Additional Point of work grounds (A set(s) of grounding jumpers and a cluster bar applied at the pole or structure where the work is to be done) is the responsibility of the person applying the grounds and shall follow the GDIT requirements within this procedure.

b. GDIT Application – The GDIT shall be attached to the ground clamp connection of the personal ground(s) when applied to a phase conductor in such a manner that does not effect the electrical connection. No personal grounding device(s) shall be used without this ticket.

c. When using GIS or mechanical grounding switches in a substation, the System Operator will issue orders and apply GDIT and maintain the documentation for the locations and the GDIT number(s).

d. For network applications of personal grounds, the GDIT shall be attached to the operating handle under the direction of the Clearance Person.

6.3.3 Joint Use of Grounds

Joint use of grounds shall be permitted only with the knowledge and consent of each Clearance Person for whom the apparatus is tagged.

a. When personal grounds are to be used jointly, the additional Clearance Person(s) shall apply Grounding Device Identification Tickets in the same manner as the previous Clearance Person(s).

   1. If conditions exist which may be deemed more hazardous to the employee to place an additional GDIT, a conversation shall occur between the Clearance Persons to document in the Field Clearance and Control form the number of the GDIT and the name or the persons sharing the personal grounds.

b. The additional Clearance Person(s) shall ensure that the installation or removal of each additional GDIT shall not interfere with the grounds that are attached.

c. Personal Grounds shall not be removed until all the GDIT have been ordered removed by each Clearance Person.

d. When any Clearance Person who is not the last Clearance Person utilizing joint use of grounds, calls the System Operator to Release their Clearance, it is understood that the formal language used for their “Release of Clearance” does not infer that they have physically removed their jointly used personal grounds, only their GDIT’s.

e. The last Clearance Person to complete their work using the joint grounds in a zone of protection shall be responsible for the removal of their GDIT’s and their personal grounds.

6.3.4 Removal of Personal Grounds

a. When the apparatus is tagged for more than one Clearance Person, and there is a joint use of personal grounds, the Clearance Person desiring to report clear shall inform all other Clearance Person(s).

b. Upon completion of work, the Clearance Person, or another at the direction of the Clearance Person, shall verify that their appropriate GDIT(s) are removed. If there are no other GDIT(s) placed for others, the personal grounds shall be removed. If the personal grounds are removed by someone other than the Clearance Person, the person removing the personal grounds shall notify the Clearance Person that the grounds identified by ticket number(s) have been removed.

6.4 Appendix D – Formal Statements

6.4.1 Purpose

The intent of formal statements is to have the proper information relayed between individuals that are applying the Clearance and Control procedure.

The uniform wording shall be used in the issuance of Clearances and other control communications as required in the Clearance and Control procedure G014.

It is important that all System Operators and Authorized Persons follow the same procedures and use the same wording. Such uniform application is required to promote proper communications and to prevent misunderstanding or errors.

Since our entire Clearance and Control procedure depends on checks and balances, one cannot over-emphasize the importance of issuing formal statements and reporting them back to verify the correctness. The formal statements below depict typical examples and shall be followed.

This information shall include:

a. The Clearance Person shall state their name.

b. State your purpose or the work to be performed.

c. State the line or apparatus to be worked on.

d. State the limits as required.

6.4.2 Requesting a Clearance

The Clearance Person shall request the CLEARANCE.

NOTE: If any station mechanical grounds are required, ground device number and locations will be requested after the Clearance is issued and will be directed closed and ticketed by the System Operator.

Clearance Person:

"I, (state your name), REQUEST A CLEARANCE ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location)."

6.4.3 Issuing a Clearance

System Operator:

"YOU, (repeat name given), HAVE CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR YOU. TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

Clearance Person:

"I, (state your name), HAVE CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR ME. I WILL TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

System Operator:

"THAT IS CORRECT. DO YOU UNDERSTAND AND ACCEPT THIS CLEARANCE?"

Clearance Person:

"YES, I UNDERSTAND AND ACCEPT THIS CLEARANCE."

6.4.4 Releasing a Clearance

NOTE: Prior to the release of the Clearance, the Clearance Person shall request any station mechanical grounds that were requested closed to have the tickets removed and ordered opened by the System Operator.

Clearance Person:

"I, (state your name), RELEASE CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF MY WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT ENERGIZED. ALL GROUNDS APPLIED BY ME OR FOR ME HAVE BEEN REMOVED. ALL MY WORK UNDER CLERANCE NUMBER_____ IS COMPLETE AND IS READY FOR SERVICE. THE WORK PERFORMED OR CHANGES MADE BY ME ARE AS FOLLOWS: (Give exact details)."

System Operator:

"I RELEASE YOU, (state name given), OF CLEARANCE NUMBER ______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF YOUR WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT (equipment) ENERGIZED. ALL GROUNDS APPLIED BY YOU OR FOR YOU HAVE BEEN REMOVED. ALL YOUR WORK UNDER CLERANCE NUMBER_____ HAS BEEN COMPLETED AND IS AND READY FOR SERVICE. (Then restate the work done)."

Clearance Person:

"THAT IS CORRECT."

6.4.5 Surrendering and Re-issuing a Clearance

Surrendering a Clearance:

Clearance Person:

"I, (state your name), SURRENDER CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF MY WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT ENERGIZED. THE STATUS IS AS FOLLOWS; (Give exact details as to location of any grounds being left in place, GDIT #'s, and the condition of the circuit or apparatus)."

System Operator:

"YOU, (state name given), SURRENDER CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF YOUR WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT ENERGIZED. THE STATUS IS AS FOLLOWS; (Repeat exact details as to location of any grounds being left in place, GDIT #'s, and the condition of the circuit or apparatus)."

Clearance Person:

"THAT IS CORRECT."

Re-issuing a Surrendered Clearance after Receiving a Formal Request for Clearance:

System Operator:

"YOU, (repeat name given), ARE RE-ISSUED CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR YOU. THE STATUS IS AS FOLLOWS; (Give exact details as to location of any grounds left in place, GDIT #'s, & the condition of the circuit or apparatus). TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

Clearance Person:

"I, (state your name), AM RE-ISSUED CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR ME. (Repeat exact details as to location of any grounds left in place, GDIT #'s, & the condition of the circuit or apparatus). I WILL TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

System Operator:

"THAT IS CORRECT. DO YOU UNDERSTAND AND ACCEPT THIS CLEARANCE?"

Clearance Person:

"YES, I UNDERSTAND AND ACCEPT THIS CLEARANCE."

6.4.6 Transfer of Clearance

Existing Clearance Person:

"I, (state your name), REQUEST TRANSFER OF MY CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location) FROM ME TO (name of new Clearance Person)."

System Operator (to existing Clearance Person):

"YOU, (repeat name given), REQUEST TO TRANSFER YOUR CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location) TO (name of new Clearance Person)."

Existing Clearance Person:

"THAT IS CORRECT."

New Clearance Person:

"I, (state your name), REQUEST TRANSFER OF (name of existing Clearance Person's) CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location)."

System Operator (to new Clearance Person):

"YOU, (state name given), ARE ISSUED (name of existing Clearance Person's) TRANSFER OF CLEARANCE NUMBER _____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). DO YOU UNDERSTAND AND ACCEPT THIS CLEARANCE?"

New Clearance Person:

"YES, I UNDERSTAND AND ACCEPT THIS CLEARANCE."

System Operator (to original Clearance Person):

"(Original Clearance Person's name), YOUR CLEARANCE NUMBER _____ HAS BEEN TRANSFERRED TO (name of new Clearance Person)."

6.4.7 Personal Red Tagging

The procedure for requesting, issuing and releasing Personal Red Tags is the same as covered under Clearances, however, since such issuance by the System Operator may not necessarily cover all points of required protection, the wording of the formal statement by the System Operator shall be adjusted as follows:

6.4.8 Issuing Personal Red Tags – Ordered On by the System Operator

System Operator:

"(State name given), THE (list of devices by number and location) ARE IN THE OPEN POSITION AND HAVE BEEN PERSONAL RED TAGGED FOR YOU. PROVIDE YOUR OWN PROTECTION FROM ALL OTHER SOURCES OF ENERGY."

Person In Charge Of the Work:

"I, (state your name), UNDERSTAND AND ACCEPT PERSONAL RED TAGS ON (give devices) AT (give locations) AND WILL PROVIDE MY OWN PROTECTION FROM ALL OTHER SOURCES OF ENERGY."

System Operator:

"THAT IS CORRECT."

6.4.8a Releasing Personal Red Tags – Ordered on by the System Operator

Person in Charge of the Work:

"I, (state your name), RELEASE MY PERSONAL RED TAGS ON (give devices) AT (give locations). (Then state the work done)."

System Operator

"YOU, (state name given), RELEASE YOUR PERSONAL RED TAGS ON (give devices) AT (give locations). (Restate the work done)."

Person in Charge of Work:

"THAT IS CORRECT"

6.4.9 Issuing Personal Red Tags – Permission Granted by System Operator to use Personal Red Tagging

Person in Charge of the Work:

"I, (state name given), REQUEST PERMISSION TO UTILIZE PERSONAL RED TAGGING ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location)."

System Operator:

"YOU, (state name given), HAVE PERMISSION TO UTILIZE PERSONAL RED TAGGING ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location. CALL ME (Give switching and reporting requirements) PROVIDE YOUR OWN PROTECTION FROM ALL OTHER SOURCES OF ENERGY."

Person in Charge of the Work:

"I, (state name given), HAVE PERMISSION TO UTILIZE PERSONAL RED TAGGING ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). I WILL CALL YOU (Give switching and reporting requirements). I WILL PROVIDE MY OWN PROTECTION FROM ALL OTHER SOURCES OF ENERGY."

System Operator:

"THAT IS CORRECT."

6.4.10 Releasing Personal Red Tags – Permission Granted by System Operator to use Personal Red Tagging

Person In Charge of the Work:

"I, (state your name), RELEASE MY PERMISSION TO UTILIZE PERSONAL RED TAGGING ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). (Then state the work done)."

System Operator:

"YOU, (state name given), RELEASE YOUR PERMISSION TO UTILIZE PERSONAL TAGGING ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). (Restate the work done)."

Person In Charge of the Work:

"THAT IS CORRECT."

6.4.11 Issuance of a Tagging Guarantee

System Operator:

"YOU, (foreign utility, generator), HAVE TAGGING GUARANTEE NUMBER_____ ON (line/apparatus). ALL SOURCES OF POWER SUPPLY, THAT ARE NORMALLY OPERATED BY OR UNDER THE CONTROL OF THIS OFFICE, ARE GUARANTEED TO BE IN THE OPEN POSITION AND TAGGED AT THE FOLLOWING LOCATIONS: (list of all limits by number, location). THE GUARANTEE WILL REMAIN IN EFFECT UNTIL RELEASED BY YOU/YOUR OFFICE. PROVIDE YOUR OWN PROTECTION FROM ALL OTHER SOURCES OF ENERGY."

6.4.12 Release of Tagging Guarantee

System Operator:

"I RELEASE YOU, (utility, generator), OF TAGGING GUARANTEE NUMBER__ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location).

ALL OF YOUR WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT (equipment) ENERGIZED. ALL GROUNDS APPLIED BY YOU HAVE BEEN REMOVED. AS FAR AS YOU ARE CONCERNED, IT IS READY FOR SERVICE."

6.4.13 Issuance of Tagging Guarantee with Grounds

System Operator:

"YOU, (foreign utility, generator), HAVE TAGGING GUARANTEE NUMBER____, WITH GROUNDS ON (line/apparatus), ALL SOURCES OF POWER SUPPLY, THAT ARE NORMALLY OPERATED BY OR UNDER THE CONTROL OF THIS OFFICE, ARE GUARANTEED TO BE IN THE OPEN POSITION AND TAGGED AT THE FOLLOWING LOCATIONS: (list of all limits by number, location). GROUNDS HAVE BEEN APPLIED AT THE FOLLOWING LOCATIONS: (list of ground locations). YOU ARE ADVISED THAT THE GROUNDS INSTALLED ARE ONLY A VISIBLE INDICATION THAT THE

APPARATUS HAS BEEN DEENERGIZED AT THE POINT OF GROUNDING, AND SHOULD NOT BE CONSIDERED PROTECTION FOR YOUR WORKERS."

6.4.14 Release of Tagging Guarantee with Grounds

System Operator:

"I RELEASE YOU, (foreign utility, generator), OF TAGGING GUARANTEE NUMBER_____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF YOUR WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT (equipment) ENERGIZED. ALL GROUNDS APPLIED BY YOU HAVE BEEN REMOVED. AS FAR AS YOU ARE CONCERNED, IT IS READY FOR SERVICE."

6.4.15 Requesting Non-Reclose Assurance (NRA)

Authorized Person:

"I, (state your name), REQUEST AN NRA ON THE (line/apparatus) AND THE CONTROLS OF (list of all device(s) by number, location) FOR MY WORK AT (list the location of your work)."

6.4.16 Issuance of a Non-Reclose Assurance

System Operator:

"You, (state name given) HAVE NRA NUMBER ____ ON THE (line/ apparatus) AND THE CONTROLS OF (list all device(s) by number, location) FOR YOUR WORK AT (List location of work) DO YOU ACCEPT AND UNDERSTAND THIS NRA?"

Authorized Person:

"YES, I UNDERSTAND AND ACCEPT THIS NRA."

6.4.17 Issuance of a NRA Guarantee with a foreign utility Control Center

System Operator:

"YOU, (foreign utility), HAVE NRA GUARANTEE NUMBER_____, ON (line/apparatus) AND THE CONTROLS OF (list all device(s) by number, location) FOR YOUR WORK AT (List location of work). YOU ARE RESPONSIBLE TO INFORM THE LIBERTY UTILITIES SYSTEM OPERATOR OF ANY OF ANY CONDITIONS THAT MAY HAVE CAUSED THESE DEVICES(S) TO OPERATE."

6.4.18 Release of a NRA

Authorized Person:

"I, (state your name), RELEASE NRA NUMBER ______ ON THE (line/apparatus). THE CONTROLS OF (list of all device(s) by number, location) MAY BE RESTORED TO THE AUTOMATIC RECLOSE POSITION. (States details of work completed)."

System Operator:

"YOU, (state name given), RELEASE NRA NUMBER __________ ON THE (line/apparatus). THE CONTROLS OF (list of all device(s) by number, location) MAY BE RESTORED TO THE AUTOMATIC RECLOSE POSITION. (Restates details of work completed)."

Authorized Person:

"THAT IS CORRECT."

6.4.19 Release of a NRA Guarantee with a foreign utility Control Center

System Operator:

"I RELEASE YOU, (utility), OF NRA GUARANTEE NUMBER_______ ON THE (line/apparatus). THE CONTROLS OF (list of all device(s) by number, location) MAY BE RESTORED TO THEIR NORMAL POSITION."

6.4.20 Surrendering an NRA when work is not completed

System Operator:

"OK, (state name given), GO AHEAD AND SURRENDER YOUR NRA."

Authorized Person:

"I, (state your name), SURRENDER NRA NUMBER______ ON THE (line/apparatus) ON THE CONTROLS OF (list of all device(s) by number, location) AND THEY MAY BE RECLOSED IF THEY TRIP WHILE THE NRA IS SURRENDERED."

System Operator:

"YOU, (state name given), SURRENDER NRA NUMBER _ ON THE (line/apparatus) ON THE CONTROLS OF (list of all device(s) by number, location). THESE DEVICES MAY BE RECLOSED IF THEY TRIP WHILE THE NRA IS SURRENDERED."

Authorized Person:

"THAT IS CORRECT."

6.4.21 Transfer of Non Reclose Assurance

Existing Authorized Person:

"I, (state your name), REQUEST TRANSFER OF MY NRA NUMBER _____ ON THE (line/apparatus) ON THE CONTROLS OF; (list of all device(s) by number, location) FROM ME TO (name of new Authorized Person)."

System Operator (to existing Authorized Person):

"YOU, (repeat name given), REQUEST TO TRANSFER YOUR NRA NUMBER _____ ON THE (line/apparatus) ON THE CONTROLS OF; (list of all device(s) by number, location) TO (name of new Authorized Person)."

Existing Authorized Person:

"THAT IS CORRECT."

New Authorized Person:

"I, (state your name), REQUEST TRANSFER OF (name of existing Authorized Person's) NRA NUMBER _____ ON THE; (line/apparatus) ON THE CONTROLS OF; (list of all device(s) by number, location)."

System Operator (to new Authorized Person):

"YOU, (state name given), ARE ISSUED (name of existing Authorized Person's) TRANSFER OF NRA NUMBER _____ ON THE (line/apparatus) ON THE CONTROLS OF; (list of all device(s) by number, location). DO YOU UNDERSTAND AND ACCEPT THIS NON RECLOSE ASSURANCE?"

New Authorized Person:

"YES, I UNDERSTAND AND ACCEPT THIS NON RECLOSE ASSURANCE."

System Operator (to original Authorized Person):

"(Original Authorized Person's name), YOUR NRA NUMBER _____ HAS BEEN TRANSFERRED TO (name of new Authorized Person)."

6.4.22 Issuance of Customer Tags Directly to Large Industrial Customers

System Operator:

"YOU, (customer) , HAVE CUSTOMER TAG(s) ON (line/apparatus), ALL SOURCES OF POWER SUPPLY, THAT ARE NORMALLY OPERATED BY OR UNDER THE CONTROL OF THIS OFFICE, ARE IN THE OPEN POSITION AND CUSTOMER TAGGED AT THE FOLLOWING LOCATIONS:(list of all limits by number and location).

Note: If grounds were requested add the following statement:

GROUNDS HAVE BEEN APPLIED AT THE FOLLOWING LOCATIONS: (list of ground locations). YOU ARE ADVISED THAT THE GROUNDS INSTALLED ARE ONLY A VISIBLE INDICATION THAT THE APPARATUS HAS BEEN DEENERGIZED AT THE POINT OF GROUNDING, AND SHOULD NOT BE CONSIDERED PROTECTION FOR YOUR WORKERS."

6.4.23 Release of Customer Tags Directly to Large Industrial Customers

System Operator:

"I RELEASE YOU, (customer), OF CUSTOMER TAG(s) ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number and location). ALL OF YOUR WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE CIRCUIT (equipment) ENERGIZED. ALL GROUNDS APPLIED BY YOU HAVE BEEN REMOVED. AS FAR AS YOU ARE CONCERNED, THE CUSTOMER TAG(S) MAY BE REMOVED AND THE SOURCES OF POWER SUPPLY, THAT ARE NORMALLY OPERATED BY OR UNDER THE CONTROL OF THIS OFFICE MAYBE RETURNED TO SERVICE."

6.4.24 Requesting to Expand or Collapse an Existing Zone of Protection

Requesting a New Clearance

Clearance Person:

"I, (state your name), REQUEST THAT MY CLEARANCE NUMBER_____ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location), BE EXPANDED/COLLAPSED. THE NEW LIMIT(S) THAT I AM REQUESTING ARE AS FOLLOWS; (list of all limits by number, location)."

System Operator:

"I UNDERSTAND (repeat name given) YOU HAVE CLEARANCE NUMBER ______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). YOU ARE REQUESTING THAT YOUR ZONE OF PROTECTION BE EXPANDED/COLLAPSED AND THE NEW LIMIT(S) YOU ARE REQUESTING ARE AS FOLLOWS;(list of all limits by number, location)."

Clearance Person:

"THAT IS CORRECT."

System Operator:

"I WILL CALL YOU BACK WHEN THE RED TAGS ARE IN PLACE."

Issuing a New Clearance

System Operator:

"(Clearance Person), I HAVE ALL RED TAGS IN PLACE THAT YOU HAVE REQUESTED FOR YOUR EXPANDED/COLLAPSED ZONE OF PROTECTION. ARE YOU READY TO RECEIVE YOUR NEW CLEARANCE."

Clearance Person:

"YES I AM."

System Operator:

"YOU, (repeat name given), HAVE CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING NEW LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR YOU. TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

Clearance Person:

"I, (state your name), HAVE CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING NEW LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR ME. I WILL TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

System Operator:

"THAT IS CORRECT. DO YOU UNDERSTAND AND ACCEPT THIS CLEARANCE?"

Clearance Person:

"YES, I UNDERSTAND AND ACCEPT THIS CLEARANCE."

6.4.25 Releasing of Tags for Expanding or Collapsing a Zone of Protection

System Operator:

"AT THIS TIME (Clearance Person) WOULD YOU RELEASE YOUR RED TAGS ON THE LIMIT(S) THAT WERE PART OF YOUR ORIGINAL CLEARANCE AND ARE NO LONGER NEEDED."

Clearance Person:

Note: for expanding:

"I, (state your name), RELEASE MY RED TAGS ON THE FOLLOWING LIMITS; (list of all limits by number, location)."

Clearance Person:

Note: for collapsing:

"I, (state your name), RELEASE MY RED TAGS ON THE FOLLOWING LIMITS; (list of all limits by number, location). FOR THE SECTION OF THE CLEARANCE I AM RELEASING, ALL OF MY WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE RELEASED SECTION TO BE ENERGIZED, AND ALL GROUNDS APPLIED BY ME OR FOR ME HAVE BEEN REMOVED."

System Operator:

Note: for expanding:

"I UNDERSTAND (Clearance Person) YOU RELEASE YOUR RED TAGS ON THE FOLLOWING LIMIT(S); (list of all limits by number, location)."

System Operator:

Note: for collapsing:

"YOU, (state name), RELEASE YOUR RED TAGS ON THE FOLLOWING LIMITS; (list of all limits by number, location). FOR THE SECTION OF THE CLEARANCE YOU ARE RELEASING, ALL OF YOUR WORKERS ARE CLEAR AND HAVE BEEN TOLD TO CONSIDER THE RELEASED SECTION TO BE ENERGIZED, AND ALL GROUNDS APPLIED BY YOU OR FOR YOU HAVE BEEN REMOVED."

Clearance Person:

"THAT IS CORRECT."

6.4.26 Higher Authority

Clearance Person:

"I, (state your name), AS A HIGHER AUTHORITY ASSUME REPONSIBILITY AND REQUEST THE CLEARANCE CURRENTLY ISSUED TO (state Clearance person's name that you are assuming Clearance for) ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location), BE ISSUED TO ME (state your name)."

System Operator:

"YOU, (repeat name given), AS A HIGHER AUTHORITY ASSUME REPONSIBILITY FOR (state Clearance person's name that you are assuming Clearance for) CLEARANCE AND HAVE CLEARANCE NUMBER______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR YOU. TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

Clearance Person:

"I, (state your name), AS A HIGHER AUTHORITY ASSUME REPONSIBILITY FOR (state Clearance person's name that you are assuming Clearance for) CLEARANCE AND HAVE CLEARANCE NUMBER _______ ON THE (line/apparatus) BETWEEN THE FOLLOWING LIMITS; (list of all limits by number, location). ALL OF THESE DEVICES ARE IN THE OPEN POSITION AND RED TAGGED FOR ME. I WILL TEST AND THEN GROUND BEFORE CONSIDERING THE CIRCUIT (apparatus) DEAD."

System Operator:

"THAT IS CORRECT. DO YOU UNDERSTAND AND ACCEPT THIS CLEARANCE?"

Clearance Person:

"YES, I UNDERSTAND AND ACCEPT THIS CLEARANCE."

6.5 Appendix E - Sample Documents / Forms/Tags

6.5.1 Field Switching Order - Sample

6.5.2 Field Clearance and Control Form - Sample

6.5.3 Station Control Tag Form - Sample

6.5.4 Contractor Permission to Work Form - Sample

6.5.5 Customer Work Notification Form - Sample

To order forms request through Liberty Utilities Purchasing Dept. - Londonderry

6.5.6 Red Tag Sample

6.5.7 Non-Reclose Assurance Tag Sample

6.5.8 HOLD Tag Sample

6.5.9 Station Control Tag Sample

6.5.10 Customer Tag Sample

6.5.11 Ground Device Identification Ticket Sample

6.5.12 Worker Placard Sample

6.5.1 Field Switching Order

FIELD SWITCHING ORDER

Liberty Utilities

Page ________ of ________

DATE ______________________________ SWITCHING LOCATION(S) ______________________________

SYSTEM OPERATOR ____________________ ORDER NUMBER ____________________ SWITCH PERSON ____________________

REASON FOR SWITCHING ____

Remember the Six Basic Steps of Switching

1. Carry the Field Switching Order with you.
2. Verify the switching order for correct location and correct sequence.
3. Identify and ensure yourself of the device you are about to operate.
4. Verify the device position and anticipated status. (i.e. the closed switch is about to open).
5. Operate the device.
6. Verify that the device has operated properly as anticipated.

When in doubt of any switching step, STOP, and notify the System Operator.

FIELD SWITCHING ORDER		
TIME		LOCATION / SWITCHING DESCRIPTION
ISSUED	EXECUTED	

RETURN FIELD SWITCHING ORDER SHEET WITH TAGS TO LOCAL SUPERVISION FOR REVIEW
RETAIN LOCALLY FOR THREE (3) YEARS

FIELD SWITCHING ORDER

Liberty Utilities

Page ________ of ________

FIELD SWITCHING ORDER - Continued		
TIME		LOCATION / SWITCHING DESCRIPTION
ISSUED	EXECUTED	

RETURN FIELD SWITCHING ORDER SHEET WITH TAGS TO LOCAL SUPERVISION FOR REVIEW
RETAIN LOCALLY FOR THREE (3) YEARS

6.5.2 Field Clearance and Control Form

FIELD CLEARANCE and CONTROL FORM

PURPOSE				
☐ CLEARANCE	STATION / LINE	CLEARANCE / PRT / NRA No.	DATE ISSUED	TIME
☐ PERSONAL TAGGING	SYSTEM OPERATOR	CLEARANCE PERSON	DATE RELEASED	TIME
☐ NON-RECLOSE ASSURANCE	VOLTAGE kV	SCOPE OF WORK		

SWITCHING LOCATION and TAG POINTS		TAGS INSTALLED				TAGS REMOVED			GROUNDING INFORMATION	
Location	Device	Description of Switching	Date Time	Switch Person	Tagged Y / N	Description of Switching	Date / Time	Switch Person	GDIT # or HOLD TAG	REMOVED Date / Time

RETURN FIELD CLEARANCE and CONTROL FORM WITH TAGS TO LOCAL SUPERVISION
RETAIN LOCALLY FOR THREE (3) YEARS

FIELD CLEARANCE and CONTROL FORM — nationalgrid

SWITCHING LOCATION and TAG POINTS		TAGS INSTALLED				TAGS REMOVED			GROUNDING INFORMATION	
Location	Device	Description of Switching	Date Time	Switch Person	Tagged Y / N	Description of Switching	Date / Time	Switch Person	GDIT # or HOLD TAG	REMOVED Date / Time

CREW MEMBERS and/or OTHER CREW LEADS	DATE / TIME NOTIFIED		CREW MEMBERS and/or OTHER CREW LEADS	DATE / TIME NOTIFIED	
NAME & TRUCK #	To Start Work	Released	NAME & TRUCK #	To Start Work	Released
	/	/		/	/
	/	/		/	/
	/	/		/	/

TRANSFER / SURRENDER / Re-ISSUE	Date / Time ..../..........	To:	TRANSFER / SURRENDER / Re-ISSUE	Date / Time ..../..........	To:
TRANSFER / SURRENDER / Re-ISSUE	Date / Time ..../..........	To:	TRANSFER / SURRENDER / Re-ISSUE	Date / Time ..../..........	To:

Comments:

Continued on additional Field Clearance and Control Form(s) YES ______ NO ____

NG0062 (07.06)

6.5.3 Station Control Tag Form

STATION CONTROL TAG FORM nationalgrid

Station Control Tag is Non System Operator based for work in Substations. The Station Control Tag shall not be used on system voltages above 600 volts. Conduct a Job Brief and notify all affected workers on the crew of tag location, locks applied (if applicable), and equipment position before beginning work. Separate Station Control Tags shall be applied by each crew working on the same equipment or circuit. Prior to removal of any tags to operate any device, the lead individual shall ensure all personnel, tools, grounds, and equipment are in the clear.

AUTHORIZED PERSON UTILIZING STATION CONTROL TAGS
DESCRIPTION OF WORK SCOPE:

TAGGING POINTS							
STATION:		INSTALLED			REMOVED		
CABINET, PANEL, CIRCUIT NO., LOCATION	PROTECTIVE POSITION	TIME	DATE	BY	TIME	DATE	BY
1							
2							
3							
4							
5							
6							
7							
8							

STATION CONTROL TAG FIELD SWITCHING ORDER			
TIME		SWITCH PERSON	OPERATION
ISSUED	EXECUTED		

RETURN STATION CONTROL TAG SHEET WITH TAGS TO LOCAL SUPERVISION
RETAIN LOCALLY FOR THREE (3) YEARS

NG0063 (01.06)

STATION CONTROL TAG FORM

nationalgrid

STATION CONTROL TAG FIELD SWITCHING ORDER - Continued			
TIME		SWITCH PERSON	OPERATION
ISSUED	EXECUTED		

RETURN STATION CONTROL TAG SHEET WITH TAGS TO LOCAL SUPERVISION
RETAIN LOCALLY FOR THREE (3) YEARS

NGUSES (02/05)

6.5.4 Contractor Permission to Work Form

CONTRACTOR PERMISSION TO WORK FORM
(Filled out by the FCC)

nationalgrid

DATE ______ LINE / STATION No ______ SYSTEM OPERATOR ______

In accordance with National Grid Clearance and Control procedures the following devices in the following locations are tagged for:

NAME OF AUTHORIZED PERSON: ______

LOCATION:	DEVICE:	INSTALLED	REMOVED
1			
2			
3			
4			
5			
6			
7			

☐ Additional Devices on back of sheet

☐ Contractor informed to begin work: Date: ______ Time: ______

By: ☐ Phone ☐ Fax ☐ In Person ☐ Other: ______

The Contractor may proceed to test de-energized and ground (if applicable) in accordance with all OSHA, Federal, state and local safety procedures for testing and grounding. Appropriate ground lead size shall be used as directed for specific sites.

CONTRACTOR COMPLETION OF WORK

(Filled out by the Contractor)

I Certify that All Grounds have been removed, the workers and equipment are in the clear, and the devices listed above may have the tags removed and be returned to service.

SIGNED:	COMPANY:
DATE:	TIME:

By: ☐ Phone ☐ Fax ☐ In Person ☐ Other: ______

fl30080 (01.06)

CONTRACTOR PERMISSION TO WORK FORM
(Filled out by the FCC)

nationalgrid

LOCATION:	DEVICE:	INSTALLED	REMOVED
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

RETURN CONTRACTOR PERMISSION TO WORK FORM WITH TAGS TO LOCAL SUPERVISION
RETAIN LOCALLY FOR THREE (3) YEARS

REMARKS:

7602060 (02.05)

Liberty Utilities	Doc. # LU-EOP G014		
Electric Operating Procedure	**04-01-15**	**General**	
Clearance and Control	**Revision #**	**1.0**	**Page: 71 of 79**

6.5.5 Customer Work Notification Form

CUSTOMER WORK NOTIFICATION FORM nationalgrid

This form shall be used when general clearances can not be maintained by customers on circuits energized at primary voltage and shall establish and document the meeting, discussions, job brief, and the customer contact requirements.

______________________ NATIONAL GRID AUTHORIZED PERSON NAME

______________________ NATIONAL GRID CONTACT NUMBER

☐ CLEARANCE NUMBER: ______________

☐ PRT (NAME): ______________

______________________ LINE / APPARATUS

Grounds Location (s)

____

____

____

Ground Device Identification Ticket (s)

____

____

____

CUSTOMER SECTION and CONTACT INFORMATION:

______________________ CUSTOMER NAME / RESPONSIBLE PERSON / CONTRACTOR / AGENCY

______________________ DATE

______________________ STREET ADDRESS

______________________ TELEPHONE NUMBER

______________________ CITY / TOWN / VILLAGE

______________________ EMERGENCY 24/7 TELEPHONE NUMBER

I am requesting that national**grid** de-energize and ground the electrical conductors at:

☐ ______________ CUSTOMER INITIALS ______________________ (Location where work will be performed)

☐ ______________ CUSTOMER INITIALS I understand that if there any changes required or if the work is completed, I will contact the national**grid** contact number listed above and inform them of these changes.

______________________ CUSTOMER SIGNATURE

______________________ DATE

CUSTOMER WORK COMPLETION SECTION:

☐ ______________ CUSTOMER INITIALS I acknowledge that all work has been completed and I will treat all line/apparatus as energized as of this date.

______________________ CUSTOMER SIGNATURE

______________________ DATE

N00061 (09/08)

6.5.6 Red Tag Sample

Electromark
6188 W. PORT BAY ROAD
WOLCOTT, NY 14590 PH# 800-295-8247
WWW.ELECTROMARK.COM

FILE:PUBLIC/ART/ PROOFS2/SAP PROOFS/23187404 10
EM PART NO.: CUST. PART NO.:

PRODUCT TYPE: ☐ LABEL ☐ SIGN ☒ TAG ☐ OTHER
MATERIAL: 10 MIL POLYESTER
LAMINATE: 1 MIL POLYESTER SELF LAM FLAP
ADHESIVE:
COLOR: RED, BLACK AND WHITE FRONT AND BACK

DATE: 7/10/13 REVISION: 1-11/7/13
ARTIST: DB PROOF: 23187404 10
CUSTOMER: LIBERTY UTILITIES

SELF LAMINATING FLAP
☒ 1 SIDE ☐ 2 SIDE
CORNER TYPE
☒ ROUND ☐ SQUARE ☐ CROPPED
☐ VARIABLE LEGEND
☐ 2 SIDED
☐ SLIT LINER
☒ HOLES ☐ SLOTS

☐ STRING LOOPED OPEN END
☐ STRING CLOSED KNOTTED END
☐ GROMMET/EYELET
☐ WIRE ☐ TIE WRAP
☐ NO ATTACHMENTS
☐ PERFORATION
☐ SEQUENTIAL NUMBERED

*UNLESS NOTED OTHERWISE, ELECTROMARK WILL DETERMINE THE PANTONE COLORS FOR THIS ITEM

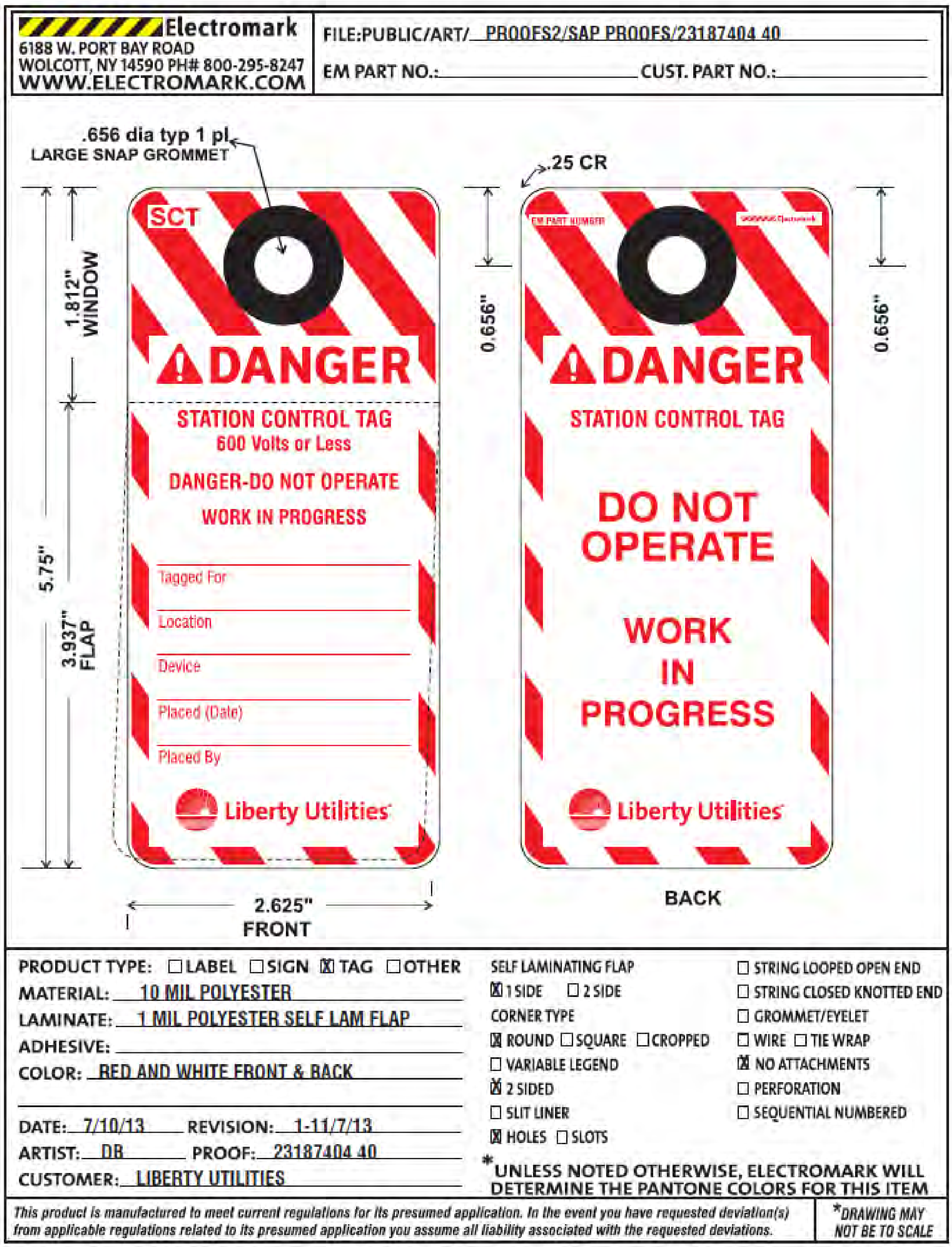
This product is manufactured to meet current regulations for its presumed application. In the event you have requested deviation(s) from applicable regulations related to its presumed application you assume all liability associated with the requested deviations.

**DRAWING MAY NOT BE TO SCALE*

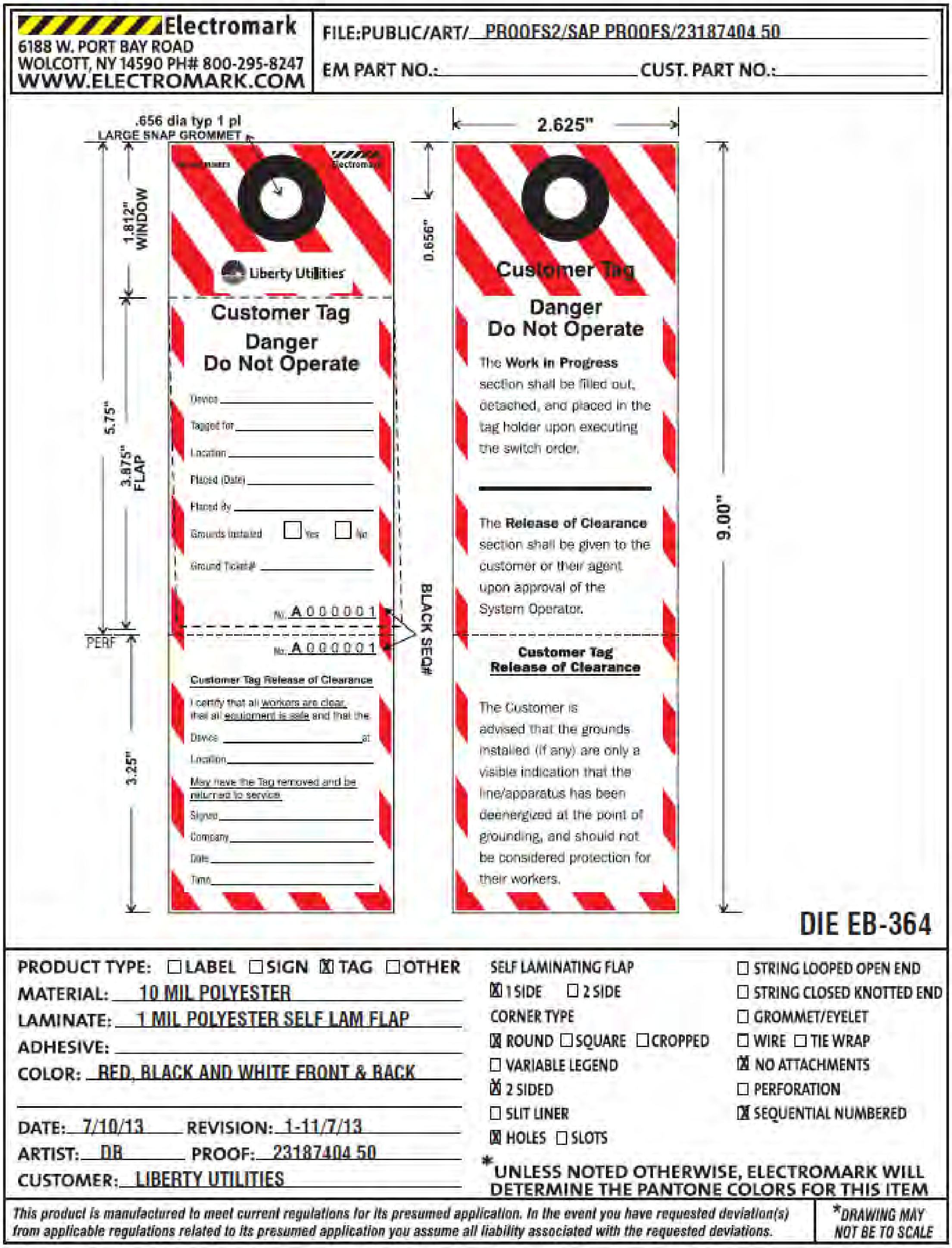
6.5.7 Non-Reclose Assurance Tag Sample

6.5.8 HOLD Tag Sample

6.5.9 Station Control Tag Sample



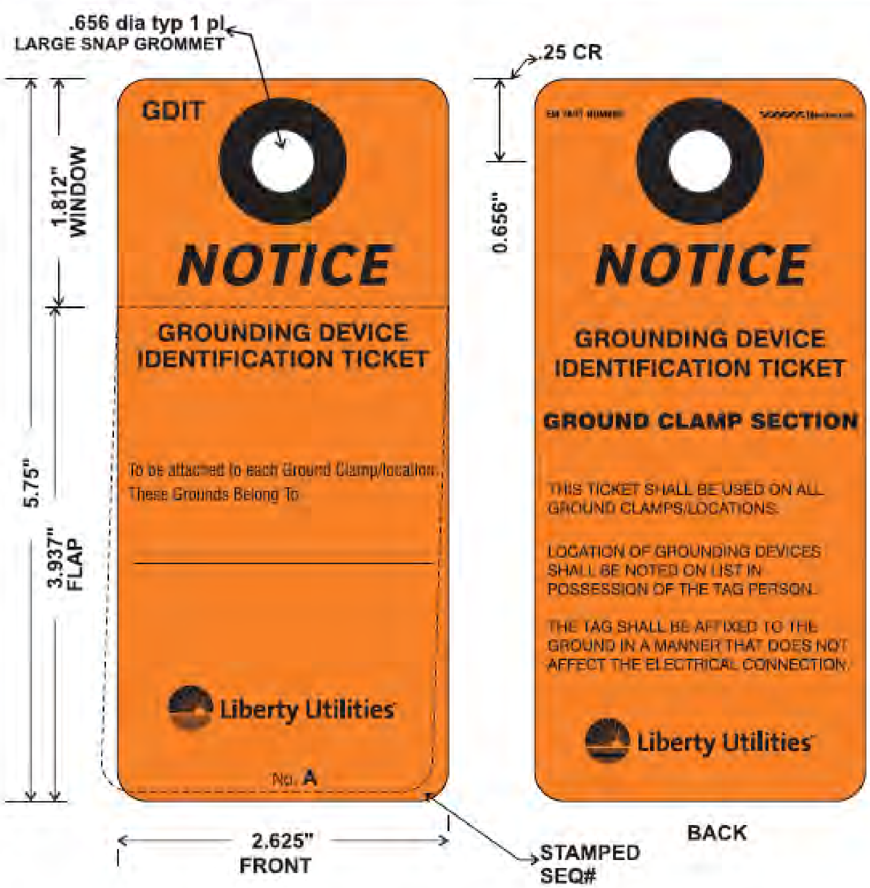
6.5.10 Customer Tag Sample



6.5.11 Ground Device Identification Ticket Sample

Electromark
6188 W. PORT BAY ROAD
WOLCOTT, NY 14590 PH# 800-295-8247
WWW.ELECTROMARK.COM

FILE:PUBLIC/ART/ PROOFS2/SAP PROOFS/23187404 60
EM PART NO.: ______ CUST. PART NO.: ______



NOTE:16" WEATHER-PROOF STRING INCLUDED WITH THIS ORDER

DIE EB-365

PRODUCT TYPE: ☐LABEL ☐SIGN ☒TAG ☐OTHER
MATERIAL: 10 MIL POLYESTER
LAMINATE: 1 MIL POLYESTER SELF LAM FLAP
ADHESIVE:
COLOR: ORANGE, BLACK, FRONT & BACK

DATE: 7/10/13 REVISION: 1-11/7/13
ARTIST: DB PROOF: 23187404 60
CUSTOMER: LIBERTY UTILITIES

SELF LAMINATING FLAP
☒1 SIDE ☐2 SIDE
CORNER TYPE
☒ROUND ☐SQUARE ☐CROPPED
☐VARIABLE LEGEND
☒2 SIDED
☐SLIT LINER
☒HOLES ☐SLOTS

☒STRING LOOPED OPEN END
☐STRING CLOSED KNOTTED END
☐GROMMET/EYELET
☐WIRE ☐TIE WRAP
☒NO ATTACHMENTS
☐PERFORATION
☒SEQUENTIAL NUMBERED

*UNLESS NOTED OTHERWISE, ELECTROMARK WILL DETERMINE THE PANTONE COLORS FOR THIS ITEM

This product is manufactured to meet current regulations for its presumed application. In the event you have requested deviation(s) from applicable regulations related to its presumed application you assume all liability associated with the requested deviations.

*DRAWING MAY NOT BE TO SCALE

6.5.12 Worker Placard Sample

Electromark
6188 W. PORT BAY ROAD
WOLCOTT, NY 14590 PH# 800-295-8247
WWW.ELECTROMARK.COM

FILE:PUBLIC/ART/ PROOFS2/SAP PROOFS/23187404 70

EM PART NO.: CUST. PART NO.:

PRODUCT TYPE: ☐ LABEL ☐ SIGN ☒ TAG ☐ OTHER
MATERIAL: 10 MIL POLYESTER
LAMINATE:
ADHESIVE:
COLOR: RED, BLACK & WHITE, FRONT & BACK

DATE: 7/10/13 REVISION: 1-11/7/13
ARTIST: DB PROOF: 23187404 70
CUSTOMER: LIBERTY UTILITIES

SELF LAMINATING FLAP
☐ 1 SIDE ☐ 2 SIDE
CORNER TYPE
☐ ROUND ☐ SQUARE ☐ CROPPED
☐ VARIABLE LEGEND
☐ 2 SIDED
☐ SLIT LINER
☒ HOLES ☐ SLOTS

☐ STRING LOOPED OPEN END
☐ STRING CLOSED KNOTTED END
☐ GROMMET/EYELET
☐ WIRE ☐ TIE WRAP
☒ NO ATTACHMENTS
☐ PERFORATION
☐ SEQUENTIAL NUMBERED

*UNLESS NOTED OTHERWISE, ELECTROMARK WILL DETERMINE THE PANTONE COLORS FOR THIS ITEM

This product is manufactured to meet current regulations for its presumed application. In the event you have requested deviation(s) from applicable regulations related to its presumed application you assume all liability associated with the requested deviations.

*DRAWING MAY NOT BE TO SCALE

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
04/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G016		
Electric Operating Procedure	12-01-2017	General	
Equipment Elevated Voltage Testing	Revision #	1.1	Page: 1 of 9

INTRODUCTION

This Electric Operating Procedure outlines the company requirements for equipment elevated voltage testing associated with Liberty Utilities Distribution System assets and facilities. This procedure will provide guidance to Liberty Utilities personnel or contractors on elevated voltage testing procedures, test equipment, and corrective action requirements for elevated voltage findings.

PURPOSE

This procedure applies to all Liberty Utilities personnel or contractors who may be involved with or responsible for the testing of facilities designated by this EOP for equipment elevated voltage.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies, & Codes
   A. Update procedures as necessary
   B. Provide field support and training upon request.
2. Electric Operations
   A. Ensure the equipment elevated voltage testing as outlined in this EOP is implemented.
   B. Provide qualified personnel to complete equipment elevated voltage testing.
   C. Ensure that qualified personnel performing testing are trained in this procedure
   D. Ensure approved test equipment is used and in good working order.
3. Employee or Contractor
   A. Demonstrate the understanding of the procedure.
   B. Comply with the requirements of the procedure.
4. Liberty Utilities Learning and Development
   A. Provide appropriate training on procedure when requested.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules
Testing Equipment Operation Instructions
Bulletin # 4-26 Touch Potential Street Light Poles

DEFINITIONS

Stray Voltage: “Stray Voltage” means voltage conditions on electric facilities that should not ordinarily exist.

Stray Voltage Testing: The process of checking an electric facility for stray voltage using a device capable of reliably detecting and audibly and/or visually signaling voltages in the range of 6 to 600 volts.

Proximity Detection Unit: A low voltage hand held detector used to test exposed metallic surfaces and conductors for the presence of low voltage from 6V to 600V.

Equipment Elevated Voltage Inspector: The individual performing the equipment elevated voltage inspection.

Handheld Computer: An electronic Data recording device that is used in the field to create a record of conditions found.

Equipment Elevated Voltage: An A.C. rms voltage difference between utility equipment and the earth, or to nearby grounded facilities that exceeds the lowest perceptible voltage levels for humans.

Finding: Any confirmed voltage reading on an electric facility or streetlight greater than or equal to 1V measured using a volt meter and a 500 ohm shunt resistor.

Mitigation: Corrective actions performed by the utility to address the stray voltage finding.

DOCUMENT CONTENTS

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1.0 FACILITIES WHERE EQUIPMENT ELEVATED VOLTAGE TESTING/DOCUMENTATION IS REQUIRED

1.1 Company Owned Street Lights

1.1.1 Testing will be performed during each outage investigation notification and the data will be recorded for each instance.

1.2 Overhead Distribution Facilities

1.2.1 Wood distribution poles require testing to be completed on metallic risers in conjunction with the distribution patrol program covered by LU-EOP D004.

1.2.2 Documentation is only required on metallic risers found to be at an elevated voltage requiring repair. Testing data is not required for a facility that is found to be operating as designed.

1.3 Underground Facilities

1.3.1 Testing for equipment elevated voltage shall be done while completing scheduled inspections of underground equipment covered by LU-EOP UG006, Underground Inspection and Maintenance. The following items are to be tested on a five year cycle, padmount transformers, switchgears, and metallic handhole covers.

1.3.2 Testing for equipment elevated voltage shall be completed on underground facilities while completing working inspections covered by LU-EOP UG006. The metallic items to be tested are manholes covers, vault covers, handhole covers, splice box covers, junction box covers, padmount transformers, switchgear, and submersible equipment covers.

1.4 Daily Job Site Test Requirements

1.4.1 Each job site where Liberty Utilities personnel or its contractors complete a work assignment shall be tested for equipment elevated voltage at the end of the work day or the completion of the assignment. **This testing requirement is considered good utility practice and does not require specific documentation**.

a. In a storm situation, where mutual aid is required, testing by other than Liberty Utilities personnel will not be required.

1.5 Exemptions

1.5.1 A completely fenced in area where access is denied to the general public and where access is only achieved by climbing a fence. Good judgment is required by the tester in these scenarios.

2.0 TEST EQUIPMENT

2.1 A hand held device (proximity detection unit) that is capable of detecting voltage from 6 volts to 600 volts.

2.2 A portable AC digital high impedance volt meter must have the ability to take readings with and without an input load impedance of 500 ohms.

2.3 The handheld devices utilized must be certified by an independent test laboratory as being able to reliably detect voltages of 6 – 600 volts. The following units have been certified:

2.3.1 HD Electric model LV-S-5 (5-600 volts).

Fluke 85
Fluke 87
Fluke 170 series or equivalent
Fluke 175
Fluke 177
Fluke 179
Fluke 187
Fluke 189

3.0 TEST PROCEDURE

3.1 Job Briefing

3.1.1 At minimum, the following information must be communicated to all personnel at the beginning of each shift for equipment elevated voltage testing:

a. Structures are never to be touched with a bare hand while performing the tests, only the voltage detector or meter probe is to be used to make contact with the facilities.

b. Appropriate PPE must be worn.

c. Each individual needs to be aware of his/her surroundings at all times.

d. Make sure to observe all traffic before entering a street, either at intersections or any other point.

e. Traffic safety vest (DOT Compliant Class II) is to be worn at all times when exposed to traffic. Be aware that when bending down, the visibility benefits of the traffic safety vest are diminished.

f. Obey all traffic control devices.

g. When working in the street, face oncoming traffic whenever possible.

3.2 Measurements for voltages will be performed in accordance with the following:

3.2.1 Initial measurements for the presence of voltage shall be made using a certified proximity detection unit as noted in the testing equipment certified equipment list in Section 2.0, 2.3.

a. To verify the proper operation of the proximity detector, follow operating instructions for the particular certified unit being utilized, this is to be done daily.

b. After verification that the detection unit is working, approach the area/equipment to be tested. The proximity detector will illuminate prior to touching the area/equipment being tested if voltage is present. If the proximity detector does not illuminate in close proximity to the area/equipment touch the area/equipment to be tested with the probe of the unit.

3.2.2 If this test detects voltage, repeat the test with the portable AC voltmeter (The 500 ohm. Resistor is NOT used in this initial test):

a. Measurements with a portable AC voltmeter shall be taken on clean bare metallic surface (structure, ground wire, etc.)

b. When using a portable AC voltmeter, connection shall be made to suitable neutral or ground source with the common (black) lead.

1. In locations where the neutral or ground point is at a distance in excess of the voltmeter lead length, the connection to the neutral/ground shall be made with up to 25’ of # 16 stranded copper lead wire (covered), the other end of which shall be securely connected to the negative (black) probe of the meter. When using such “extension leads” appropriate care shall be taken in the placement of such leads so as to not create a physical hazard to workers, pedestrian or vehicular traffic.

2. In locations where a system ground is not available, or the existing ground registered voltage upon the proximity test, a metal rod shall be firmly embedded into the earth to a depth of no less than 6” to create a ground reference point for the measurement to be taken. An alternate method is available for obtaining a ground reference point utilizing an aluminum plate in lieu of driving a ground rod. The reference point should be as close as practicable to the facility being tested to simulate an equipment elevated voltage situation (3’ to 4’.) On occasion longer leads may be necessary to find undisturbed earth (up to 25’.)

c. The “live” meter probe lead shall then be placed into contact with the structure under inspection to determine the voltage.

1. Voltages readings greater than 30 volts shall be recorded in the database for the site.

2. For voltage readings less than 30 volts, install a 500 ohm input load impedance resistor on the volt meter. Take another voltage measurement and record this voltage in the database for the site.

4.0 CORRECTIVE ACTION REQUIREMENTS FOR ELEVATED VOLTAGE FINDINGS

If an equipment elevated voltage condition is found and verified by the Test Procedure in Section 5.0, the site is to be guarded until made safe by Company personnel or if municipally owned, made safe by the owner or company. Guarded for the purpose of this EOP is defined as guarded by a person or a protective barrier that prevents public contact if the equipment elevated voltage found is greater than 4.5 volts. **If the voltage measures less than 4.5 volts and is found to be consistent with system operation design (no visual evidence of a problem upon review) no further action is required.** If the voltage measures greater than 4.5 volts and less than 8 volts it can either be guarded in person or by a protective barrier that prevents public contact, contact your supervisor for required action. It is expected that sound judgment shall be utilized in this application. If the voltage measurement is greater than 8 volts it must be guarded by an equipment elevated voltage inspector or a Company employee that has been trained to stand by on energized facilities; and immediate response is required using the notification in section 4.3 below

4.1 In the event of an elevated voltage finding on an electric facility or streetlight during the stray voltage Test Procedure, all publicly accessible structures and sidewalks within a minimum 30 foot radius of the electric facility or streetlight must be tested for stray voltage.

4.2 The following notification process for personnel to respond shall be utilized.

4.2.1 Notification:

a. Liberty Utilities (New Hampshire) Emergency Dispatch and Scheduling Center – 1-603-216-3620

4.2.2 Inform the operator that this is an equipment elevated voltage call, giving inspector name, company (if not Liberty Utilities), unique ID, address where problem is identified, facility number, circuit number , ownership, type of equipment, voltage found and whether they are physically guarding or leaving the site after flagging and installing a protective barrier. Liberty Utilities personnel or designee will be assigned to respond.

4.3 Temporary repairs may be used to correct the equipment elevated voltage thereby removing the need to guard the site.

4.4 Permanent repairs to the equipment shall be made within 45 days of the occurrence.

4.5 The Stray Voltage Tester/Equipment elevated Voltage Inspector may detect a minimal voltage level that is attributable to the design of the facility and not the result of an improper condition, no corrective action is required in this instance.

4.6 The individuals conducting the equipment elevated voltage tests on street light standards shall have a supply of “Angel guards” available for installation if the cover is missing or wires are found to be exposed to the public at the time of testing. Angel guards shall only be installed after the testing of the street light standard is complete and 1) there is no indication of equipment elevated voltage above 1 volt, or 2) repairs have been completed to correct the equipment elevated voltage.

4.7 The equipment elevated voltage inspector shall report any potentially hazardous conditions found on Liberty Utilities facilities seen visually during the survey process.

4.8 Customer Owned Equipment

4.8.1 Where the Company finds equipment elevated voltage above 1 volt and identifies its source as customer-owned equipment, the Company shall guard the site and notify the customer or a responsible person, as appropriate, that a potentially hazardous situation exists. The Company shall advise the customer or responsible person that the cause of the equipment elevated voltage must be immediately remedied.

4.8.2 Company personnel are encouraged to work with the customer to determine and rectify the problem. If the customer agrees to accept the Company's assistance, the Company may charge a reasonable cost for this effort.

a. The Company may temporarily remove a customer's meter or take such other actions as are appropriate and necessary to protect the public.

5.0 DATABASE REQUIREMENTS

5.1 The database in use shall be easily searchable for information and reporting.

5.2 Information fields required to be completed for facilities:

Survey Date
Contractor
GIS ID/Asset # (Unique ID)
Facility Type
Owner
Feeder/Circuit
Line #
Pole/Structure/Equipment ID
Street Name
Inspectors Name
GPS Taken
Equipment elevated Voltage Test Required
Voltage Found Y/N
Voltage Measurement
Type of Equipment (See Appendix A)
Immediate Action Taken
Person Notified
Permanent Repair Date
Person that made repair

6.0 TYPE OF EQUIPMENT – APPENDIX A

6.1 Read and follow the manufacturer's operating instructions for testing and operation of the unit.

TYPE	CODE	EQUIPMENT DESCRIPTION
Distribution	910	Pole
	911	Regulator
	912	Sectionalizer
	913	Recloser
	914	Ground
	915	Guy
	916	Riser
	917	Switch Handle Mechanical Operated
	929	Distribution – Other (use comments)
Underground	950	Handhole
	951	Manhole
	952	Switchgear
	953	Transformer
	954	Vault – Cover/Door
	969	Underground – Other (use comments)
Street Light	970	Handhole
	971	Standard
	979	Street light – Other (use comments)

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	1.0	Initial Version of Liberty Utilities document Updated from National Grid document to be NH Specific.	Robert J Johnson
12/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G018		
Electric Operating Procedure	12-01-2014	General	
Phasing and Rotation Procedures for Overhead & Underground Personnel on Circuits Above 600 Volts	Revision #	1.0	Page: 1 of 16

INTRODUCTION

This EOP provides the proper procedures to be used by all Overhead and Underground Electric Distribution Operations personnel to perform phasing and/or rotation on Overhead and Underground Distribution circuits and equipment above 600 volts.

PURPOSE

The purpose of this procedure is to provide safe work methods and procedures that shall be used by all OH and UG Electric Distribution Operations employees when performing phasing and/or rotation on circuit conductors, switching devices, or other circuit equipment above 600 volts. Whenever routine or emergency work is performed on a circuit or equipment which has the potential of/or currently is paralleling with either the same circuit or another circuit and that work may result in a change to the phasing and/or rotation of that circuit or equipment, phase and/or rotation verification shall be performed. Phasing and/or rotation testing shall be done at a location on the circuit or equipment prior to the start of work and again at the same location at the completion of work. If, due to an interruption of the circuit, phasing and/or rotation can not be accomplished prior to the start of work it shall be performed at the conclusion of work.

When any new overhead or underground lines or equipment are installed that create a sectionalizing point where a circuit may be paralleled with either itself or another circuit, that new location shall be phased. If phasing cannot be established due to a difference in phase angle relationship of the circuits; then rotation shall be performed. Any open loop, switch or equipment, that can be utilized to perform paralleling of a circuit to it or to another circuit that is **NOT** in phase, shall be clearly labeled with a sign stating **"NOT IN PHASE"**. The proper equipment to accomplish this labeling is available from Materials Management; the sign for use on overhead is Std Item P22P, Item ID 8830-8002214 and the sign for underground installations is Std Item P22P1, Item ID # 8830-9202444.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide appropriate guidance to field personnel when requested for a specific work related task.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   A. Demonstrate an understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.
   C. It is the workers responsibility to read and fully understand and follow the manufacturer's instruction manual and specifications before operating any equipment.

REFERENCES

LU - EOP G014 - Clearance and Control

Liberty Utilities Employee Safety Handbook and Procedures

OSHA 1910.269

DEFINITIONS

Circuit: A conductor or system of conductors through which an electric current is intended to flow.

De-energized: Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps or other means. Note: De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

Electrically Isolated: All switches, jumpers, taps or other means through which known sources of electrical energy may be supplied to the particular lines and equipment have been opened.

In Phase: An expression used when the electrical value measured between two-phase conductors of either the same or a different electrical system results in an approximate 0 voltage.

Person In Charge of Work: A qualified person responsible for the work to be performed.

Phasing: An electrical testing procedure that is used to determine the phase angle relationship between the phase conductors at an open point to phases of either the same circuit or to a different electrical circuit.

Primary Voltage: All distribution circuit cables or conductors energized at 4, 15, 23, or 34.5 kV.

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Rotation: Caused by the direction of rotation of the generator. Phase rotation is determined by the order in which three alternating electromotive forces of the same frequency and differing in time phase by 120 electrical degrees succeed each other. Changing the position of any two wires in a three-wire system once outside the generator may reverse rotation

Shall: The word shall is to be understood as mandatory.

Should: The word should is understood as recommended

System Operator: An authorized person, who directs, controls, monitors, and operates the electric system and its associated apparatus.

TRAINING

A written request should be submitted to Learning and Development by user group whenever training is required.

DOCUMENT CONTENTS

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1.0 SAFETY

1.1 All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and all appropriate Liberty Utilities Electric Operating Procedures.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 If there is more than one worker assigned to the task, the employee in charge of the work shall conduct a written job brief with the employees involved prior to the start of each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

1.4 Only approved test instruments/equipment shall be utilized by employees for the purpose of performing phasing and rotation checks on overhead and underground transmission and distribution circuits and equipment. Refer to your supervisor for approved tools and equipment.

1.5 All switching, tagging and testing shall be done in accordance with LU - EOP G014 Clearance and Control.

2.0 GENERAL INFORMATION

2.1 Whenever a switching/tie point exists, or is being constructed on a circuit that would allow for conductors on that circuit to be paralleled with conductors from either the same circuit, or another circuit operating at the same voltage that point must be checked to verify that there is a proper phase relationship between the phase conductors. When a switching/tie point is established the following two phase relationships may occur:

2.1.1 **IN PHASE** - The phases have the same voltage and angular displacement and may be paralleled together with out an interruption. Tie points that are in phase may be closed together without an interruption but factors such as feeder loading, conductor capacity and voltage regulation devices must be considered and reviewed prior to performing the switching.

2.1.2 **OUT OF PHASE** – The phase angle displacement between the circuits is not compatible, but the circuit voltage and the rotation of the phases of each circuit were tested and the phase conductors are arranged so that rotation of the phase conductors is the same on each side of the tie point. This configuration requires that the circuit or a portion of the circuit be de-energized and isolated before this tie point may be closed to energize the conductors. Tie points that are not in phase but have been verified as having the same rotation shall be marked with a sign stating **"NOT IN PHASE"**.

3.0 PHASING PROCEDURE

3.1 Phase verification shall be performed on all new installations, or on any existing installations when work is being performed that could result in an improper phase relationship at either an existing tie point or a newly created tie point

3.2 The following two different styles of devices may be used to perform the phase verification check:

3.2.1 Electronic (wireless) phase verification device – this device may be used to verify phase identification on circuits meeting the following requirements:

a. On effectively grounded circuits when the voltage of the circuits is either known or proven to be the same nominal voltage. It is mandatory that a verification of voltage be conducted with a voltmeter across any open point unless the open is positively known to be an extension of the same circuit conductors or from another circuit that is fed from the same substation bus and/or transformer.

b. On non-effectively grounded circuits that are fed from the same circuit, substation bus and/or transformer. Voltmeter readings are recommended, but not required on non-effectively grounded circuit conductors that are positively known to be either an extension of the same circuit or fed from the same substation bus and/or transformer. These conductors will be the same nominal circuit voltage and if operating with an accidental ground on a phase; the ground will always be on the same phase of each circuit.

c. On non-effectively grounded circuits that feed from different transformers, substation bus or substations it is mandatory that a digital or analog voltage tester is used to verify both phase to ground and phase to phase voltage readings and that a ground does not exist on a phase conductor on both of the circuits (ground check) prior to phasing with an electronic phase verification test device.

NOTE: Electronic (wireless) phase verification devices transmit a radio signal to the receiver unit that will interpret the signal to determine if the phase conductors are both at the same angular displacement. CAUTION: These style devices cannot distinguish a difference in voltage levels of the conductors. Users must be sure that the conductors on each side of the open are fed from circuits of the same nominal voltage level.

3.2.2 A digital or analog voltage tester (phasing tester) – this device may be wireless or hard wired with a digital or analog voltage display; it may be used on effectively grounded wye, and all non-effectively grounded circuits (uni-grounded, ungrounded and delta).

3.3 The phasing process shall be performed at an open switch or open loops on overhead circuits and at an approved switch, isolation device or test point that will allow safe access to the appropriate live parts on underground circuits.

3.4 To test for proper phasing across an open point using an electronic (wireless) phase verification device, the circuit conductors on each side of the open must be from circuits of the same nominal voltage. This phasing may be accomplished across a previously established open tie point where it was originally verified that the circuit voltages on each side of the open point were the same, or by using a digital or analog voltage tester and verifying that the conductors on each side of the open are from circuits of the same nominal voltage class. Once the voltage across the open point has been established the following process will be utilized to determine correct phasing:

3.4.1 The manufacturer's instructions for proper use of each specific device must be used. Each manufacture uses different combinations of lights, buzzers, beepers and sirens to alert the user to a correct and incorrect phase relationship.

3.4.2 Place the transmitter on each of the conductors on each side of the open point to verify a presence of voltage on each conductor (recognizes energized conductor, but does not measure a level of voltage).

3.4.3 Place the transmitter on the first conductor to be phased and place the receiver on any one of the conductors on the other side of the open. The receiver shall be placed on each of the conductors on the opposite side of the open from the transmitter.

a. Record which conductor gave a positive response of "in phase" and which conductors gave a response of being "out of phase".

3.4.4 Move the transmitter to a different conductor, if present, on the same side of the open point and then place the receiver on each of the phase conductors on the opposite side of the open point.

a. Record which conductor gave a positive response of "in phase" and which conductors gave a response of being "out of phase".

3.4.5 Move the transmitter to the last remaining conductor, if present, on the same side of the open point and then place the receiver on each of the phase conductors on the opposite side of the open point.

a. Record which conductor gave a positive response of "in phase" and which conductors gave a response of being "out of phase".

3.4.6 If each of the phase conductors on one side of an open point give a positive identification as to being "in phase" with a phase conductor on the opposite side of the open point, the conductors may be considered as "in phase" and used as a tie point to parallel circuits, when required.

3.5 When using a digital or analog voltage tester the following voltage readings shall be verified:

3.5.1 Workers shall measure and record the voltage readings on each side of the open tie point from phase to ground source and from phase to phase on all effectively grounded and non-effectively grounded circuits unless the open is positively known to be an extension of the same circuit conductors or from another circuit that is fed from the same substation bus and/or transformer.

3.5.2 If the open tie point is being fed from conductors that have been positively identified as an extension of the same circuit conductors or from another circuit that is fed from the same substation bus and/or transformer worker can skip steps number3.5.3 through 3.5.4, c-3 and go directly to 3.5.5 of this process.

3.5.3 The phase to ground source readings shall be accomplished by performing the following:

a. On effectively grounded (wye) circuits the measurement for the phase to ground source readings shall be accomplished by reading from each phase conductor to the neutral of the circuit.

b. On non- effectively grounded (Ungrounded Wye, uni-grounded or delta) circuits the phase to ground source readings shall be taken from each phase conductor to an existing secondary neutral or downground, if available, at the work structure. If a secondary neutral or downground does not exist at the work structure a temporary ground rod shall be driven and utilized as the ground source.

3.5.4 On non-effectively grounded (Ungrounded Wye and Delta) circuits, when the phase to ground source voltage readings are taken they also accomplish the task of checking the phase conductors for an accidental ground. The process of checking ungrounded wye and delta circuits for an accidental ground on a phase conductor is a mandatory step in the phasing process.

a. The phase to ground source readings on an ungrounded wye or delta circuit that does not have an accidental ground on any of the phase conductors will read approximately the phase to phase value of voltage divided by 1.73.

b. If one of the phases of an ungrounded wye or delta circuit does have an accidental ground on it then the phase to ground source reading for that phase will vary anywhere between 0 volts and the nominal phase to ground source voltage for that circuit. The lower the value of resistance for the accidental ground on the phase conductor the closer the reading will be to 0 volts.

1. The phase to ground source voltage readings on the other phase conductors of an ungrounded wye or delta circuit that has one phase conductor grounded will elevate to approximately the same voltage as the nominal phase to phase voltage for that circuit. The closer that the accidentally grounded phase reading approaches 0 volts the closer the remaining phases of the circuit will produce phase to ground readings approaching the same level as the phase to phase readings.

c. If a ground is detected on one of the phase conductors on only one side of the open tie point it is permissible to continue with the phasing process. If a ground is detected on a conductor on each side of the open tie point the following additional details must be reviewed before continuing the phasing process:

1. If the conductors/circuits on each side of the open tie point are fed from either the same circuit, or a different circuit that originates from the same substation bus, the phasing process may continue.
2. If the conductors/circuits on each side of the open tie point are fed from different substation bus, substations or transformer banks one of the circuits must have work done to find and remove the ground condition from the circuit.
3. When a ground is detected on an ungrounded wye or delta circuit, during routine or emergency work, tests to find and correct the problem causing the ground shall be conducted within a reasonable time.

3.5.5 Voltage readings shall be taken from one phase conductor on one side of the open point to all phase conductors on the opposite side of the open point. This process shall continue until all of the phase conductors on one side of the open point have been tested to all phase conductors on the opposite side of the open point. A reading of approximately 0 volts between a phase conductor on one side of the open point to a phase conductor on the opposite side of the open for each of the phases at the test point must be achieved in order for the circuit conductors to be paralleled.

NOTE: When taking voltage readings across an open switch or loop the reading may not be 0 volts. Voltage measurements up to approximately 10% of either the normal circuit phase to ground voltage on a Wye System or10% the phase to phase voltage on a Delta System may be encountered and should not present a problem. If voltage readings are higher than this guidelines consult a Supervisor for further direction.

3.5.6 On Ungrounded Wye or delta circuits that do **NOT** originate from the same substation bus the voltage readings from any one of the phases on one side of the open point to any of the phases on the opposite side of the open may not provide voltage readings that allow the employee to positively determine if the circuits are in the correct phase relationship (may observe readings that are much lower than expected up to readings that are higher than the normal phase to phase voltage of the circuit). When this circumstance occurs the employee must proceed with the following additional steps:

a. Close any one of the switches, install a temporary cutout and jumper or use a jumper that can be applied with hot stick methods to tie any phase on side #1 of the open to any phase on side #2 of the open. This closed switch or jumper will create a physical tie (reference) between the two different circuits.

b. Test the voltage between the remaining phases on side #1 of the open to the remaining phases on side #2 of the open. If the voltage readings observed are within the proper voltage limits so that the worker is assured that the remaining phases are in the correct phase relationship; these remaining phases may be closed to establish the parallel. If the voltage readings observed indicate that the phases are not in the correct phase relationship then the testing operation shall continue.

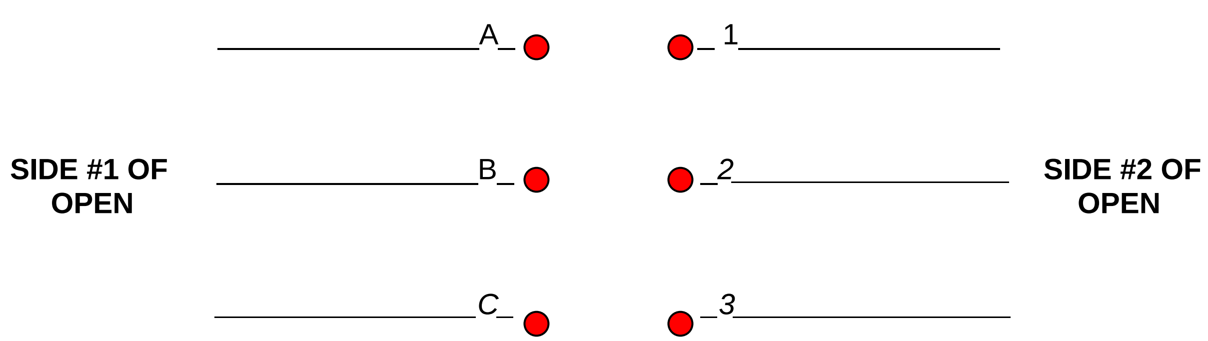
c. Open the switch or remove jumper and then repeat the procedure by closing the same phase on side #1 of the open to either of the remaining phases on side #2 of the open. Once this connection has been made, perform the voltage tests on the remaining phase conductors to verify if conductors are in phase. If the voltage readings observed are within the proper voltage limits so that the worker is assured that the remaining phases are in the correct phase relationship; these remaining phases may be closed to establish the parallel. If the voltage readings observed indicate that the phases are not in the correct phase relationship then the testing operation shall continue.

d. Open all switches or remove all jumpers and then repeat the procedure by closing the same phase on side #1 of the open to the last remaining phase on side #2 of the open. If the voltage readings observed are within the proper voltage limits so that the worker is assured that the remaining phases are in the correct phase relationship; these remaining phases may be closed to establish the parallel. If proper voltage readings between the phase conductors can not be achieved after doing this three-step procedure the circuits will not phase.

4.0 PHASING GUIDELINE

4.1 This phasing guideline provides an example for the appropriate readings that shall be performed to conduct phase testing.

4.1.1 The switch, open loops or open tie point shall be temporarily assigned markings as shown below to assist in the phasing process. Theses markings may be removed once the phasing and/or rotation process is complete.



4.2 VOLTAGE READINGS:

SIDE #1

A to GRD. ________________ B to GRD__________________ C to GRD. ________________

A to B ____________________ B to C ____________________ A to C ___________________

SIDE #2

1 to GRD.__________________ 2 to GRD.__________________ 3 to GRD. ________________

1 to 2 _____________________ 2 to 3 _____________________ 1 to 3 ___________________

NOTE: When performing the phase to ground readings on Ungrounded Wye and Delta circuits, if the voltage reading on one phase is observed to be low or close to 0 volts and the voltage reading on the remaining phases when read phase to ground reads close to the nominal phase to phase voltage of the circuit that is an indication that the circuit has an accidental ground on a phase.

FROM SIDE #1 TO SIDE #2

A to 1 _____________________ A to 2 _____________________ A to 3 ___________________

B to 1 _____________________ B to 2 _____________________ B to 3 ___________________

C to 1 _____________________ C to 2 _____________________C to 3 ___________________

RESULTS

A - PHASE GOES TOGETHER WITH ________________________

B - PHASE GOES TOGETHER WITH ________________________

C - PHASE GOES TOGETHER WITH ________________________

4.3 If the voltage readings that are recorded do not do not indicate the circuits are in phase or do not seem to make sense these readings, if all filled in, can be reviewed by Distribution Engineering to determine if there is a possibility that changing of the transformer bank wiring may allow the circuits to phase.

5.0 ROTATION

5.1 Any Lines or equipment serving three-phase customers that have any work performed on them that could result in the established phasing and or rotation of equipment being changed and the physical configuration (radial feed) of the circuit does not allow for phase testing to be performed shall have rotation verified.

5.2 When work is performed on a circuit or section of the circuit that does not tie to either itself or to another circuit and that work could result in a change to the phase configuration of that system the rotation must be verified prior to connecting customer load. Rotation shall be performed and documented on the load side of the work area prior to the work being performed. After the work is complete the rotation should be rechecked at the same location to verify that it is correct. Verification of rotation may be done on the secondary side of an existing three-phase transformer bank or customer equipment. The same location shall be utilized to perform the check before the start of work and the re-check of rotation after work is complete.

5.3 When it is necessary to perform work on a three phase transformer and/or three-phase customer secondary service equipment and that work could result in a change to the phase configuration of that circuit, the rotation shall be verified. Verification of rotation may be done on the secondary side of an existing three-phase transformer bank or customer equipment. Whichever location is chosen to perform the rotation testing the same location shall be utilized to perform the check before the start of work and the re-check of rotation after work is complete.

5.4 Liberty Utilities has several different test devices that are approved for use to verify rotation on secondary level voltages; there are differences in the designs of these devices, and the labeling and color coding of the test equipment leads. When rotation of a circuit or equipment is performed utilizing one specific style of tester, the re-check verification after work is complete shall be performed with the same style or a proven compatible test device.

6.0 ROTATION EXAMPLE

6.1 The following is an example of use for the AB Chance Phase Rotation Tester (similar approved testers can be used) on a 4800-volt Delta circuit. There are other testers that are approved, and can be used. The AB Chance Phase Rotation Tester can also be used on Wye circuits. This tester is a portable device that is designed to easily and safely determine the rotation of a circuit, the phase relationships between circuits and for measuring voltages on a circuit from phase to phase or phase to ground on circuits up to and including 80 kV when equipped with the appropriate resistors.

6.2 The AB Chance Phase Rotation Tester (or similar tester) must be equipped with two universal hot sticks and appropriate number of resistor extensions on both the meter and reel probes for the circuit being worked. The Meter scale shall be read in accordance with the resistor extension being used.

VOLTAGE	EXTENSION CAT. #	No. OF EXTENSIONS	SCALE READING
0-15 kV	N /A	0	Direct
16-48 kV	H18764	21" - 1 – each stick	X3
48-80 kV	H18762	32" – 1 - each stick	X5

6.3 On Ungrounded Wye or Delta circuits, check each phase to ground. If one phase of an Ungrounded Wye or Delta circuit is grounded, use the other two phases to conduct the test. On Wye systems or on Ungrounded Wye or Delta systems that do not have an accidental ground on a phase any two of the phases may be used. Which ever two phase conductors are used on one side of the open point the same two corresponding phase conductors must be used on the other side of the open.

6.4 Connect a ground lead securely to a ground source and to the grounding (capacitor) terminal behind the meter.

6.5 Select the two phases to be used to perform the test. (In our example we use phase #1 and phase #2.)

6.6 Touch the meter probe to one phase and the reel probe to the other phase; record the reading on the meter. In this example we place the meter probe on phase #1 and the reel probe on phase #2, a voltage reading of approximately 6000 volts is recorded.

6.7 Using the same two phases, reverse the meter and the reel probes. Record the reading on the meter. In this example we now place the meter probe on phase # 2 and the reel probe on Phase #1, a voltage reading of approximately 4500 volts is recorded.

6.8 The value of the readings determines the sequence of the phase rotation, therefore, taking the readings that were achieved the rotation goes from the higher reading to the lower reading to the untouched phase. (Therefore in our example when the meter probe was on phase #1, higher meter reading of 6000 volts, to the lower meter reading on phase #2 of 4500 volts to the phase that was not used, phase #3 we have determined the rotation of this circuit to be from 1-2-3.)

6.9 To prove your results repeat the test using two other phases. (In our example we used phase #1 and phase #2 to conduct the tests for the recheck you could use phase #2 and Phase #3 or phase #1 and phase #3.

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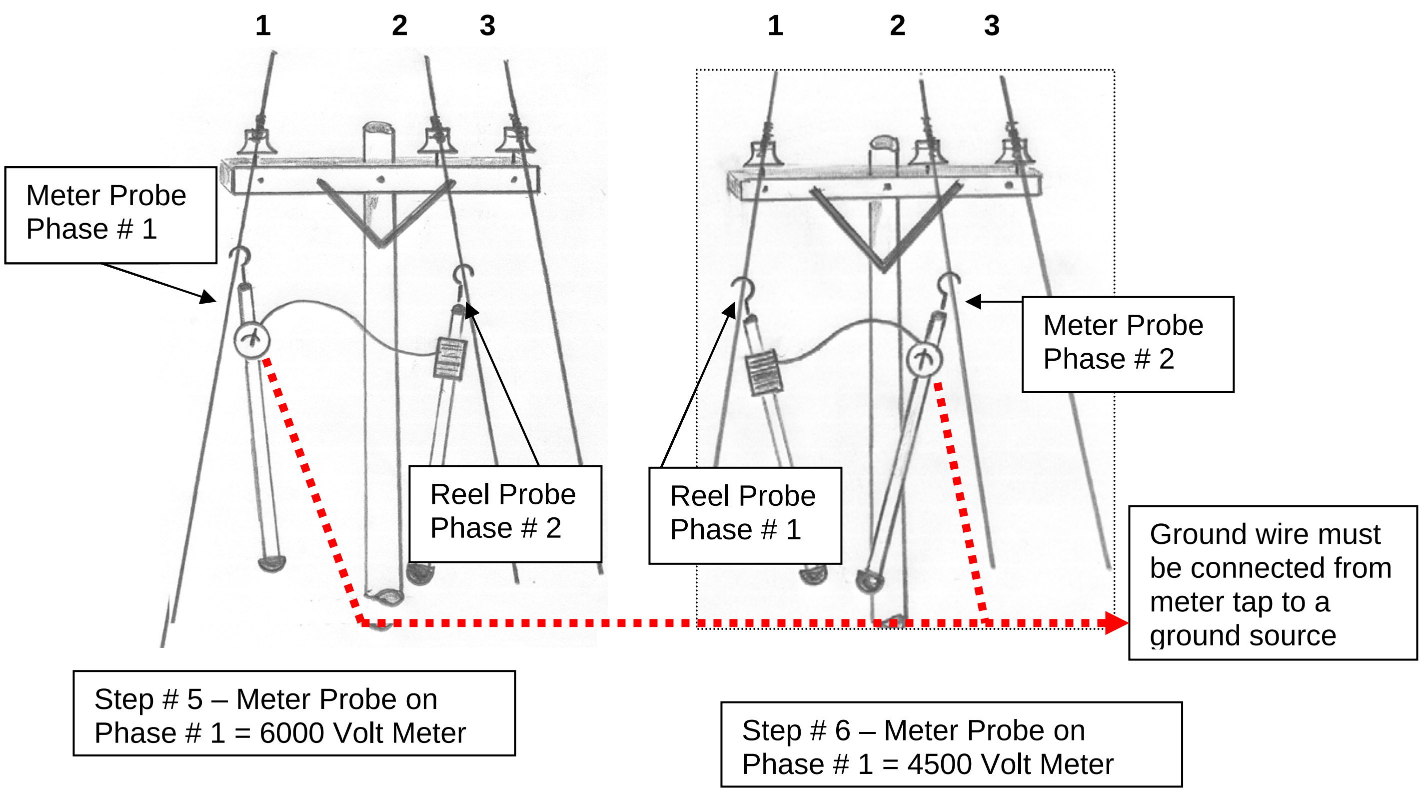
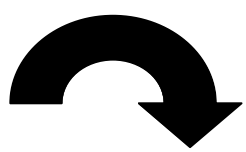
PRIMARY ROTATION EXAMPLE - 4800 VOLT DELTA (Wye would work the same)

5 KV CIRCUIT **SAME CIRCUIT**



ROTATION = Highest reading phase-to- Lowest reading phase-to- untouched phase

Example Results (see step #7) - in our example when the meter probe was on phase #1, higher meter reading (6000 volts), to the lower meter reading on phase #2 (4500 volts) to the phase that was not used phase #3, we have determined the rotation of this circuit to be from 1-2-3 (clockwise).

CLOCKWISE  **1-2-3**

NOTE: When utilizing a primary phase/rotation tester such as A.B. Chance and rotation testing is performed on a Delta system the first step that should take place is to check to determine if any of the phases have either a solid or partial ground. If a phase is identified as having a ground then the two ungrounded phases shall be used to perform the rotation testing. Only the necessary length of cable to perform the test should be unreeled. The tester should be removed from the line when not in. This test does not identify specific phases, but selects the phases at the test location in a "positive sequence."

7.0 SPECIAL CASES

7.1 When the design of a switch or isolating device does not allow for access to the appropriate live parts of the switch contacts or the cable/bus attachment connection point to allow an employee to perform the phasing procedure across an open, then an **EXCEPTION APPROVAL** shall be requested from Engineering Standards, Policies, and Codes and/or EHSS and the Program Manager Safety will review all exception requests and make the decision as to granting an exception approval. If an exception is deemed necessary a procedure will be developed and included in this procedure as an **EXCEPTION APPROVAL.**

8.0 EXCEPTION APPROVAL – PAD MOUNTED SWITCHGEAR

8.1 It has been identified that due to the switch design and the configuration of the protective barrier boards in some of the 15 kV and higher voltage pad mounted switchgear it is either very difficult or impossible to access the contacts and /or bus work on both sides of the switch to accomplish phase testing. If phase testing must be performed in a pad mounted switchgear that restricts access the following work procedures shall be followed:

8.1.1 **NEW INSTALLATIONS -** Prior to pad-mounted switchgear being installed the switch and/or the bus assembly shall be checked to determine if adequate access can be achieved to accomplish phasing across the open switch. If adequate access cannot be accomplished all of the following steps shall be performed:

a. Manufactures phasing diagram shall be checked.

b. Verify that the phase position labeling at each position and in each compartment is present.

c. Testing shall be conducted to verify that the manufactures phase position labeling is correct. A megger or a continuity style tester shall be used to perform this testing.

d. When this unit is installed and energized phase testing may now be performed by contacting the lower cable to switch connection point in the compartment with the switch closed to the respectively labeled lower cable to switch connection point in the compartment with the switchblades open. This procedure shall be repeated to verify that all three phases are in the proper-labeled position. (See attached example)

8.1.2 EXISTING EQUIPMENT - If work is performed at a switchgear or on cable that is terminated at a switchgear which has the capability of paralleling with the same circuit or another circuit and the type of work performed could result in a change of phase positioning phase verification shall be performed. If due to the design of the switch and/or the configuration of the protective barrier boards, phase testing across the contacts of the switch or the bus work attached to the high side of the switch cannot be performed, the following steps shall be followed:

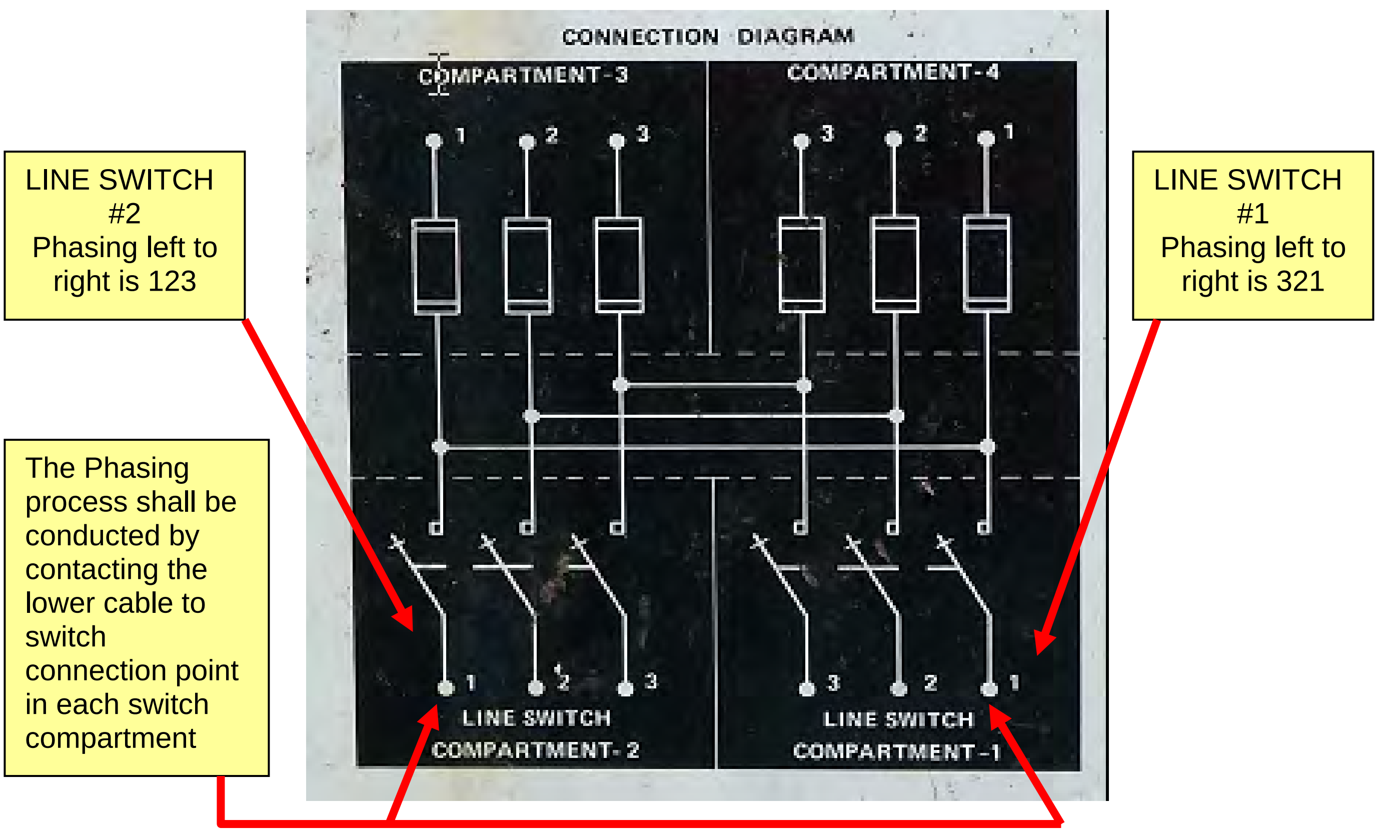
a. Review the Manufactures diagram for phase configuration.

b. Verify that the phase position labeling at each position and in each compartment is present and agrees with the Manufacture's diagram.

c. Phase testing may now be performed by contacting the lower cable to switch connection point (terminal pad) in the compartment with the switch closed to the respectively labeled lower cable to switch connection point (terminal pad) in the compartment with the switchblades open. This procedure shall be repeated to verify that all three phases are in the proper-labeled position (See attached example).

9.0 PAD MOUNT SWITCHGEAR PHASING EXAMPLE

9.1 The phasing diagram below from PMH-9 switchgear shows the phase orientation in each of the compartments. The high side "Line" switches in the pad mounted switchgear are arranged in a 123-to- 321configuration.



9.2 The phasing in this style switchgear cannot be accomplished by reading across the open switch, switch connection points or attached bus due to the design of the switch and/or the configuration of the protective barrier boards. When phasing is performed in this style switchgear the phasing will be done on the lower cable to switch connection point Terminal pad) in the compartment with the switch closed to the respectively labeled lower cable to switch connection point (terminal pad) in the compartment with the switch blades open.

10.0 PARALLELING UNGROUNDED WYE OR DELTA CIRCUITS

10.1 Whenever workers are paralleling non-effectively grounded (ungrounded wye or delta) distribution circuits that originate from either a different transformer bus from within the same substation, or from two different substations testing for a grounded phase on each circuit **MUST** be performed prior to conducting circuit phasing, or closing any devices to parallel the circuits. To perform proper phasing on non-effectively grounded circuits the phase conductors should be clear of any grounds; however in emergency situations circuits may be phase checked and tied together provided there **SHALL** not be a ground on more than one phase of one of the circuits. Tests to find and correct the problem causing the ground on the non-effectively grounded circuit shall be performed shortly (within a reasonable period of time) after the emergency situation has concluded.

11.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2014	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G019		
Electric Operating Procedure	**03-01-2015**	**General**	
Test Devices and Testing Procedures Before Performing Work on De-Energized, Tested De-Energized and Grounded Distribution Circuits.	**Revision #**	**1.0**	**Page: 1 of 7**

INTRODUCTION

This document identifies approved testing devices to be used and details specific steps that shall be taken to test distribution circuits BEFORE de-energized before installing grounds.

PURPOSE

This procedure identifies and describes the available test devices and testing procedures used to verify the absence of system voltages on overhead distribution circuits.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate guidance when requested.
2. Electric Distribution Operations
   - A. Ensure that the procedures in this EOP are implemented.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide procedure revision input as necessary.
3. Employees
   - A. Demonstrate the understanding of the procedures in this EOP.
   - B. Comply with the requirements of this procedure.
   - C. It is the workers responsibility to read, understand, and follow the manufacturers instruction manual and specifications before using any test device.

COORDINATION

Not Applicable

REFERENCES

Code of Federal Regulations 29 CFR 1910.269 (m) (3) (v). OSHA

Liberty Utilities Employee Safety Handbook

LU-EOP G005.00 Testing Tools and Insulated Equipment

LU-EOP G014 Clearance & Control

DEFINITIONS

Minimum Approach Distances (MAD) – The closest point of approach to energized lines or equipment by a qualified employee or by any conductive object, without the use of insulating gloves, sleeves, or portable protective devices.

TRAINING

Provided by the appropriate Liberty Utilities L&D training program when requested.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

All work shall be performed by qualified workers in accordance with the Liberty Utilities Employee Safety Handbook rules as well as all applicable Liberty Utilities EOPs utilizing appropriate safe work methods.

All appropriate Personal Protective Equipment, including, but not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures. Rubber gloves or rubber gloves and sleeves as well as all other appropriate PPE equipment and FR clothing shall be worn when testing circuits or equipment and during the installation of grounds

The person in charge shall conduct a written Job Brief with the employees involved before they start each job. The briefing shall cover at a minimum the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and Personal Protective Equipment requirements.

Rubber gloves of the appropriate class and sleeves shall be worn as required.

During work, barriers or other appropriate protection as required shall be installed where required to protect workers.

All the procedures shall be performed in accordance with accepted safe work practices using approved tools and equipment. Refer to your supervisor to verify approved tools and equipment.

2.0 TESTING A CIRCUIT DE-ENERGIZED

2.1 Circuits or apparatus shall be isolated, shall have a Clearance/Personal Red Tag issued and tested de-energized with approved testers before the application of grounds. The testing of the circuit or apparatus shall be continuous. If there is an interruption in the sequence of events from testing to placing of the grounds, including either additional actions being performed or any delay in the application of the grounds, the circuits/apparatus shall be tested again before the circuit/apparatus is considered de-energized and then grounded. All circuits/apparatus shall be tested de-energized at each location before grounds are applied. Grounds are to be installed ONLY at the test point.

2.2 Approved test devices shall only be attached to insulated extension stick(s). The stick(s) shall be of appropriate length to maintain the required Minimum Approach Distance from ungrounded conductors to any portion of the employee's body.

2.3 Properly maintained and inspected insulated sticks of sufficient length to enable the worker to maintain adequate working clearance required by Liberty Utilities safety rules shall be used to position the approved test device for testing circuits/apparatus before applying the conductor end of the grounding leads. All workers shall visually inspect the stick surface for defects and clean the stick with approved materials prior to use as necessary. Sticks which are damaged or have outdated inspection stickers shall not be used.

2.4 All tests shall be conducted on a bare conductor or a bare switch/test point.

2.5 Workers should be aware that delta circuits pose a unique hazard. There may be circumstances when a conductor is down and a voltage test indicates zero potential difference when testing phase to ground and in fact not be isolated and de-energized from the known sources(s). Test all phases at each location.

2.6 It is the worker's responsibility to read and fully understand the manufacturer's instruction manual before using any of the devices listed in this document.

2.7 If you DO NOT understand how to correctly use any of the devices described in this EOP, you shall <u>STOP AND GET ASSISTANCE</u>.

2.8 All of the above shall be in accordance with accepted safe work practices using approved equipment as set forth herein. Only approved tools and test equipment shall be used to perform this procedure. Refer to your supervisor to verify approved tools and equipment.

2.9 **The general 3-step procedure is as follows:**

2.9.1 **Step 1.** <u>Prove the Tester</u> - the tester must be tested against a known live source, if readily available, of the same voltage and configuration as the circuit to be tested de-energized. Following this method will give the person conducting the test an indication of how the tester will perform in testing the circuit. If using a portable or self test feature, such as found on the Salisbury or other similar testers, be extremely careful to select the proper selector switch position for the self test to be performed. The selector switch must then be changed to the appropriate voltage level for which the tester will be applied. Failure to set to the proper range will result in a false test.

2.9.2 **Step 2.** <u>Test the Circuit</u> - Test the circuit by slowly moving the tester **<u>perpendicular to and in proximity</u>** to the circuit being tested OR until contact is made depending on the tester being used. Refer to the descriptions for individual testers as some testers are most sensitive when only in proximity to an energized circuit. TEST ALL PHASES OF THE CIRCUIT. Try to avoid testing at a point that has sharp edges as proximity testers will indicate energized due to electric field concentrations at these locations. Again proving the tester on a known source will be a good indication as to how the tester will operate and minimize the chance of having a false indication.

2.9.3 **Step 3.** <u>Retest the Tester</u> - Repeat step A.

2.10 If, after following the manufacturer's recommended instructions for use, an employee testing a circuit, conductor or equipment as de-energized encounters an indication or voltage reading with <u>ANY</u> type test device, that does not allow them to positively distinguish the difference between a "false positive" and "nominal" circuit voltage a <u>"SAFETY STOP</u>" SHALL be conducted. The employee shall proceed using one of the following processes to ensure the circuit/conductor is isolated and de-energized:

2.10.1 The circuit, conductor or equipment shall be re-tested with another multi-range voltage detector, either of the same style or a different style. Work shall not proceed until a positive verification has been made that the circuit is de-energized from its sources and absent of “nominal” voltage.

2.10.2 The circuit, conductor or equipment shall be tested with an approved voltmeter, appropriate for the voltage level being tested. Work shall not proceed until a thorough understanding that the readings that have been observed indicate the circuit, conductor or equipment is de-energized from its nominal voltage source.

2.10.3 If the voltage readings on the circuit, conductor or equipment can not be positively identified a Supervisor/ Manager shall be contacted. A visual review of all isolating points and potential sources shall be conducted to verify proper isolation. If after a review of isolation points and potential sources the circuit is determined to be clear of “nominal voltage” grounds may be applied.

3.0 MULTI-RANGE VOLTAGE DETECTORS (MRVD)

Analog/Digital Meters

3.1 AB Chance MRVD Field Intensity Tester Cat # C4030979, 1-40kV

3.2 White Safety Voltage Detector VDAH0300, 4kV-500Kv, phase to phase

3.3 White Safety Voltage Detector/Capacitance test point, 0-40kV VDA040C

3.4 HD Electric DVI-100, single point digital voltage indicator, 0.1kV - 99kV

3.5 HD Electric DVI-500, single point digital voltage indicator, auto-ranging indicator from 0.1kV-9.9kV and from 10kV-500kV

Audio/Visual Indicators

3.6 HD Electric Tag 200 testers. Up to 69kV phase to phase

3.7 Salisbury Tester, 240V to 230kV or 240V to 345kV

3.8 AB Chance Super Tester 2.4kV to 345kV Un-Shielded or Bare Conductor. No longer available for purchase. Existing testers are approved for use.

3.9 Always consult the manufacturer’s specifications and instructions prior to utilizing any MRVD.

3.9.1 Prove the Tester – Using the manufacturer’s instructions.

3.9.2 Test the Circuit - Set range selector switch to correct position on voltage to be tested. Contact should be made perpendicular to conductor being tested.

3.9.3 Prove the Tester - Repeat step A.

4.0 PHASING TESTERS / METERS

(Phasing meters voltage range may be increased using the proper additional pairs of the extension resistors per the manufacturer)

Analog Meters

4.1 AB Chance Phasing Meter Cat # H1876-7, measures voltage to 48kV will measure voltage to 80kV with add on resistors (phase to phase or phase to ground)

Digital Meters

4.2 Hasting Phase Tell Digital Phasing Meter Cat # 6702, 0-40kV digital volt meter will measure to 240kV with add on resistors.

4.3 White Safety Line Model PD500W Cordless Phasing Tool

4.4 HD Digi-Volt 80, 0-80kV with add on resistors

4.5 Always consult the manufacturer’s specifications and instructions prior to utilizing any testers/meters.

4.5.1 Prove the Tester - On a known live source or with a portable test device.

4.5.2 Test the Circuit - The tester is placed in contact with the conductor.

4.5.3 Prove the Tester - Repeat step A.

5.0 KNOWN SOURCE TESTER

HD PT-DET Tester for determining proper operation of Tag and DVI voltage detectors White Safety Line model number PA25TB6.

A portable known live source device for testing the operation of MRVD”S and High Voltage Phasing Meters is now available for use. This device may be used where field conditions dictate additional meter testing.

6.0 Test Devices No Longer Approved for Use (As of June 4, 1997)

6.1 Condeser Stick Tester – 23kV thru 115kV

6.2 Glowtector Tester – 23kV thru 115kV visual indicator, neon tube

6.3 Hot Line Indicator – 2.4kV to 115kV Un-shielded or bare conductor, Bodendieck HL4

6.4 Buzzhead Tester (As of September 1, 2006) – 230kV & 345kV, AB Chance audible tester

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
03/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

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INTRODUCTION

The purpose of this procedure is to provide direction for identifying and labeling secondary and neutral conductors in service boxes, meter sockets, URD, UCD and traditional manhole and duct systems before connecting to a live source and to provide direction for taking, checking and verifying rotation on three phase secondary services. This procedure applies to all overhead and underground secondary service connections.

PURPOSE

This procedure applies to all Liberty Utilities personnel or contractors who may be involved with or responsible for working on distribution secondary systems.

ACCOUNTABILITY

1. Standards, Policies, & Codes
   A. Update procedures as necessary
   B. Provide field support and training upon request.
2. Electric Operations
   A. Ensure the components of the procedure are implemented.
   B. Ensure that qualified personnel performing this work are trained in this procedure.
   C. Ensure approved equipment is used and in good working order.
   D. Provide revision input as necessary.
3. Employee or Contractor
   A. Demonstrate the understanding of the procedure.
   B. Comply with the requirements of the procedure.
4. Learning and Development
   A. Provide appropriate training on procedure when requested.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules
Liberty Utilities Construction Standards
National Electric Code – Latest Version
LU-EOP G019 Test Devices and Testing Procedures Before Performing Work on De-Energized, Tested De-Energized and Grounded Distribution Circuits.

DEFINITIONS

Continuity Tester: Electrical test equipment used to determine if an electrical path can be established between two points; that is if an electrical circuit can be made. The circuit under test must be completely de-energized prior to connecting the apparatus.

De-energized: Disconnected from all known sources of electrical supply by open switches.

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Equipment Ground: Conductor used to connect the non-current carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor.

Line of Demarcation: Defines the point between company and customers equipment ownership.

Main Disconnect: A device by which an electrical system can be disconnected from its source of power.

Meter Socket: An enclosure that contains line and load receiving blade terminals that serves as the point on the electric distribution system for metering electric power.

Multimeter: An instrument for measuring potential differences in volts.

Neutral Conductor: A system conductor other than a phase conductor that provides a return path for current to the source. Not all systems have a neutral conductor. An example is an ungrounded delta system containing only three energized phase conductors.

Parallel Conductors: Two or more sets of wires or cables originating at the same point and terminating at the same point.

Rotation: Caused by the direction of rotation of the generator. Phase rotation is determined by the order in which three alternating electromotive forces of the same frequency and differing in time phase by 120 electrical degrees succeed each other. Changing the position of any two wires in a three-wire system once outside the generator may reverse rotation.

Rotation Meter: An instrument that indicates phase rotation.

Secondary: Utility wiring energized at 600 volts or below.

Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premise served.

Service Point: The point of connection between the facilities of the serving utility and the premises wiring, i.e. the demarcation point between Liberty Utilities ownership and customer owned service cable.

TRAINING

Provided by appropriate Liberty Utilities training program upon request.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any applicable Liberty Utilities EOP's utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 All overhead and underground secondary cables and conductors shall be considered energized until proven to be de-energized.

1.4 Class O rubber gloves or higher shall be worn when working on energized secondary cables and conductors.

1.5 Only approved test instruments found in LU-EOP G019 shall be used to determine if a cable is de-energized. The employee in charge shall conduct a written job brief with the employees involved before they start each job.

1.6 The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

2.0 IDENTIFICATION OF SERVICE CONDUCTORS AND NEUTRAL MARKINGS

2.1 If a neutral or grounded conductor of a service entrance is covered, it shall be identified with the color white.

2.2 Equipment ground wires are to be identified by green markings only.

2.3 It is important to note that it may be necessary for electricians to use "color coding tape" to identify single conductor wires within multi-conductor cables to meet requirements of state codes. Changing colors of white or green wires by any means is strictly forbidden by the NEC (National Electric Code).

***NOTE**: There are some existing practices that are utilized in areas within Liberty Utilities to use specific tape color markings to identify the service voltage level of an installation. This practice may continue, but this Procedure does NOT address the assignment of specific color tapes to designate or differentiate the different classes of service level voltages.*

3.0 TEMPORARY MARKING OF SECONDARY CABLES

3.1 Underground secondary and service cables shall be clearly labeled with colored tape markings (colors other than white, grey or green) to denote which phase they are. There are two acceptable methods that may be utilized to identify/mark the individual phase conductors. Employee's may utilize either of the following methods as long as they have been trained on, are familiar with and understand the use of the markings:

3.1.1 Use a different color of tape (colors other than white, grey, or green) to identify each of the phase conductors. The color of tape that is chosen to indicate a specific phase will be used on all sub-conductors within that phase group when the parallel conductors exist.

3.1.2 Use any one color of tape (colors other than white, grey, or green) and place one tape mark for phase conductor one, two tape marks for phase conductor two, and three tape marks for phase conductor three. If the installation consists of parallel conductors each sub-conductor within each phase grouping shall be marked with identical markings.

NOTE: *Insulated neutral conductors may be marked in production by the manufacturer with yellow longitudinal stripes on the insulation to designate it as the neutral conductor. If the neutral conductor does not have markings from the manufacturer the only tape color that shall be utilized to identify this conductor is WHITE.*

3.2 URD secondary cables consist of cross linked polyethylene insulated aluminum conductors, triplexed together, suitable for installation in ducts or direct buried. The neutral is designated, in production by the manufacturer, by 3 yellow stripes placed longitudinally along the insulation. The phase conductors shall be designated utilizing either of the above mentioned accepted methods. (3.1.1 or 3.1.2)

3.3 A table of underground supply conductors that feed streetlights can be found in section 46 of the Liberty Utilities Underground Standards Book.

3.4 Refer to sections 35.16.20, 44.23 and 45.15.20 in the Liberty Utilities Underground Construction Standards for proper labeling of secondary cables.

4.0 IDENTIFICATION AND VERIFICATION OF CONDUCTORS AT THE SERVICE CONNECTION POINT

CAUTION: *Never use a continuity tester on any cables or conductors that may be energized, or between supply and customer neutrals. Always check operation of the continuity tester and multimeter before and after every use.*

4.1 To minimize hazards to workers and prevent damage to equipment and property when connecting services, the conductors and equipment shall be checked to determine that there is no backfeed voltage and neither a phase to ground nor a phase to phase short exists. A multimeter and continuity tester shall be used to test the service as follows:

4.2 Normal capacity services (1 conductor per leg)

4.1.1 Verify customer main disconnect off (open) and electric meter removed from meter socket.

4.1.2 Use multimeter to test for voltage across the line terminals and from line to ground at the meter socket. Voltage should not be present. If voltage is present, do not proceed until the source of the voltage has been identified and eliminated.

4.1.3 Verify by prints or other means that there is not a handhole, company or customer owned, between the service point and meter socket. If a handhole is present, open and visually inspect that the cables are properly connected.

4.1.4 Use multimeter to test for voltage back-feed between conductors at service point. Voltage should not be present. If voltage is present do not proceed until the source of the voltage has been identified and eliminated.

4.1.5 Jumper across line side phase terminals of meter socket and check for continuity on the conductors at service point, Continuity should exist between phases. No continuity between identified phase conductors and the identified neutral conductor shall exist.

4.1.6 Remove jumper(s) at the meter socket; verify the conductors at the service connection point for non-continuity (phase to phase and phase to ground), if no continuity is found between each of the phases and between each phase and the neutral, connect service neutral and phase conductors to energize the service conductors to line side of meter socket.

5.0 IDENTIFICATION AND VERIFICATION OF CONDUCTORS AT THE METER SOCKET PRIOR TO SETTING METER

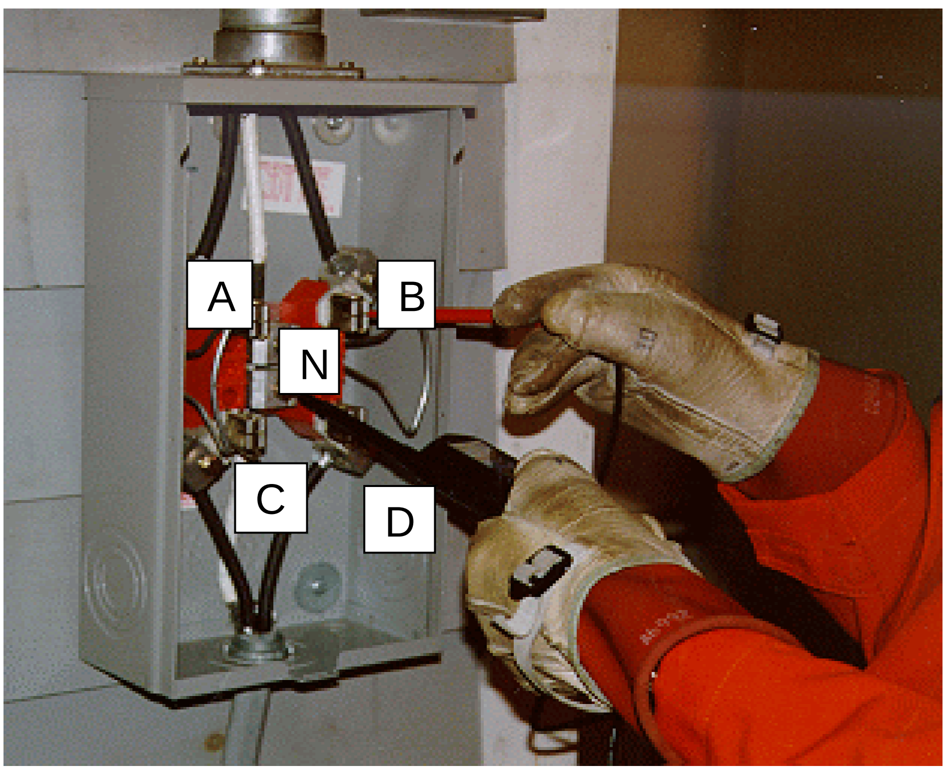
5.1 Verify the customers main disconnect is (open) off.

5.2 Measure the line side (source) voltage from line jaw to neutral and line jaw to line jaw as depicted below.

5.3 Use a multimeter to test for voltage back-feed on the load side of the meter socket by testing from load jaw to neutral and load jaw to load jaw as depicted below. If voltage is found on open load jaw(s), do not proceed until the source of the voltage has been identified and eliminated.

5.4 Check for potential grounds on load side of meter by testing from the energized line jaw to load jaw on each phase in the meter socket as depicted in Diagram A below.

DIAGRAM A



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Source	**A-N = 120V**	**B-N = 120V**	**A-B = 240V**
Backfeed	**C-N = 0V**	**D-N = 0V**	**C-D = 0V**
Grounded	**A-C = 0V**	**B-D = 0V**	

5.5 Once you have successfully completed your source, backfeed and ground test you must check for potential phase to phase short. Do not perform this test out of sequence. The check for a phase–to-phase short shall be performed by using either of the following two methods:

5.5.1 Energizing Load Terminal Method

a. Install a jumper from the top to the bottom terminals on the left side of the meter socket. See Figure1, the reading on the other side of the socket should read zero volts.

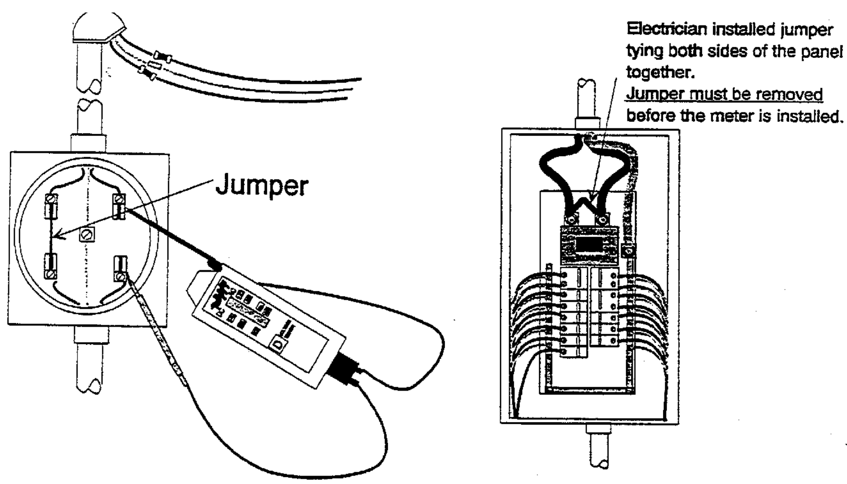
b. The meter may now be set after this last step has been performed and it has been verified that no phase to ground or phase to phase shorts exist.

c. If you get a reading of 240 volts, this means there is a line-to-line short circuit. Place a plastic cover over the meter socket until the problem is resolved. This is especially important to check when there is an upgrade from a 2 wire to a 3 wire service. The electrician may have left a jumper tying both sides of the service together. The jumper must be removed.

Do not install the meter.

***NOTE:** Prior to connecting any customer load or setting a meter, voltage shall be verified to be within the Liberty Utilities established guidelines.*

FIGURE 1



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5.5.2 Ground Load Terminal Method

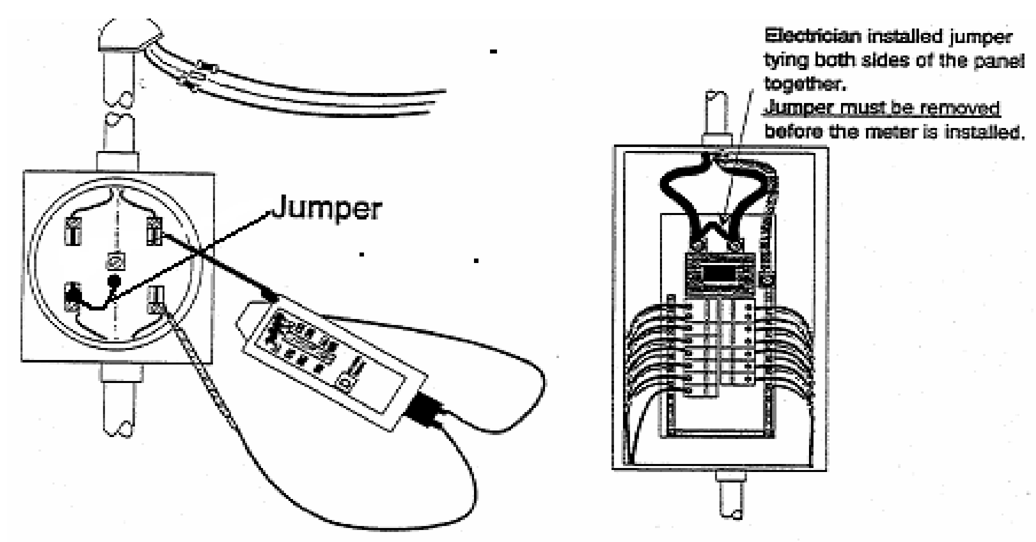
a. Install a jumper wire from the neutral conductor to one of the load side phase terminals. See Figure 2. Verify that the connection to ground on the load side terminal is a good connection by reading from an energized line side terminal to the grounded load side terminal; you should get a 120 volt reading. After verifying the ground is good on the grounded load side terminal check from an energized line side terminal to the remaining ungrounded load side terminal(s).Your reading on the other ungrounded load side terminals should read zero volts. The meter may now be set after this last step has been performed and it has been verified that no phase to ground or phase to phase short circuits exist.

b. If you get a reading of 120 volts, this means there is a line-to-line short circuit. Place a plastic cover over the meter socket until the problem is resolved. This is especially important to check when there is an upgrade from a 2 wire to a 3 wire service. The electrician may have left a jumper tying both sides of the service together. The jumper must be removed.

Do not install the meter.

NOTE: *Prior to connecting any customer load or setting a meter, voltage shall be verified to be within the Liberty Utilities established guidelines.*

FIGURE 2



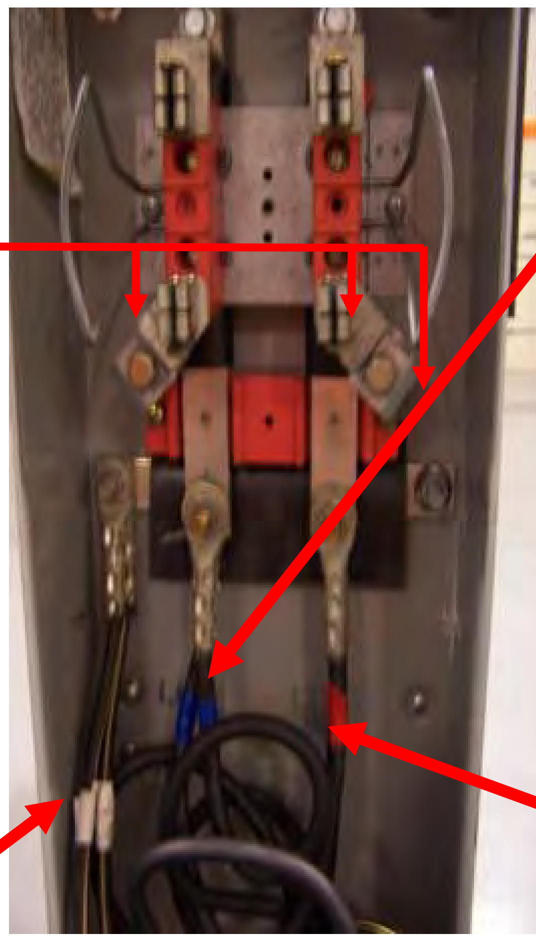
<u>6.0 IDENTIFICATION AND VERIFICATION OF PARALLEL SERVICES (2 OR MORE CABLES OR CONDUCTORS PER LEG)</u>:

6.1 Verify the customer main disconnect is open (off) and the electric meter is removed from socket.

6.2 Visually check neutral and phase conductors identified and connected together at line side of meter socket. All sub-conductors that are grouped and attached to a common neutral or phase connection point shall the have identical markings. The illustration below shows an example of a single-phase UG service with two conductors per phase. The illustration shows marking of the conductors with the different colors of tape.

The <u>LOAD</u> side conductors have been removed for clarity. These wires would also be checked and verified to be installed properly as part of this check.

Two phase conductors are marked with <u>BLUE</u> tape and connected to one of the line side phase positions.



The Two Neutral conductors are identified with <u>WHITE</u> tape and connected properly to the neutral buss position

Two phase conductors are marked with <u>RED</u> tape and connected to one of the line side phase positions.

6.3 At the service connection point, use a voltmeter to test for voltage back-feed between cables or conductors. Voltage should not be present. If voltage is present do not proceed until the source of the voltage has been identified and eliminated.

6.4 At the service connection point one of the two following methods shall be used to verify that the conductors that have been marked as part of either a phase group or a neutral group are correct. Either of the two methods will verify the conductors identified as a group are correct and prove that a phase-to-ground or a phase-to-phase short does not exist on the conductors.

NOTE: *Employee's may utilize either of the following methods as long as they have been trained on, are familiar with and understand the use of the method.*

6.4.1 Continuity Test Method

a. A continuity tester shall be utilized to check for continuity between all of the similarly marked conductors of that conductor (phase or neutral) grouping. Check for continuity between each of the sub-conductors in any one conductor group. You should get a continuity reading between these conductors.

b. Use a continuity tester to check between each of the phase and neutral groups. Check for continuity from one of the conductors in the neutral grouping to one of the conductors in each of the phase groups. No continuity should be found between the neutral and any phase group or between any conductors in opposite phase groupings. If continuity between opposite phase conductors or a phase conductor and the neutral is detected do not proceed until the problem is resolved.

c. Use proper temporary insulation and isolation practices at the energized service connection point on all phase conductors and then connect all the neutral conductors.

d. Using proper temporary insulation and isolation practices connect each of the sub-conductors identified and marked within a phase group to the same energized system phase conductor. Caution shall be utilized after any one of the sub-conductors in a phase group has been connected to an energized phase conductor; all the remaining sub-conductors in that phase group are now energized.

e. After the neutral and phase conductors have all been connected a proper test, as outlined above in step "V", shall be conducted before any current rated meter is installed.

NOTE: *Prior to connecting any customer load or setting a meter, voltage shall be verified to be within the Liberty Utilities established guidelines.*

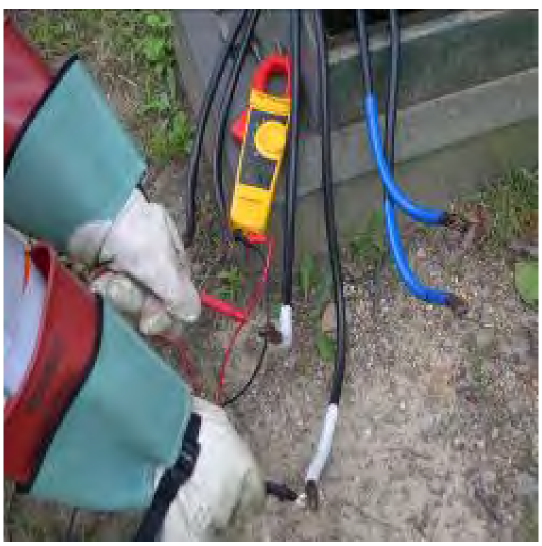
EXAMPLE: Identification or Verification of Conductors Using a Continuity Tester at the Service Connection Point

The following chart and pictures # 1 and # 2 are an example of how a continuity check should be performed at the service connection point prior to energizing a service. The example depicts a single phase parallel service consisting of two service conductors for each phase and neutral. The conductors have been marked using different colors of tape, an examination of the meter channel has been conducted and the meter is not installed.

Continuity Results

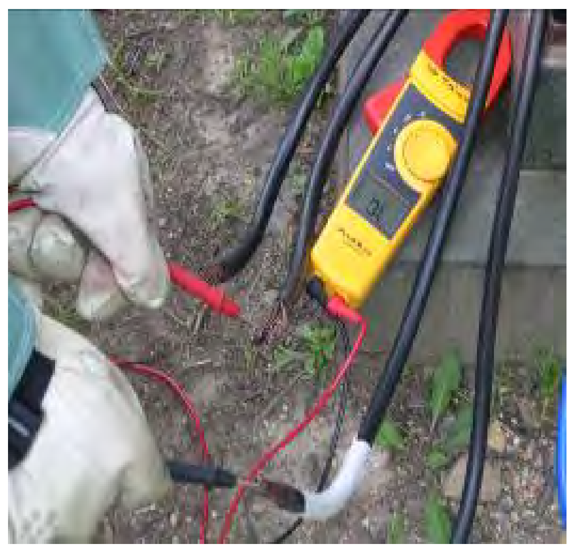
White to White 0.0 ohms - Continuity Audible Tone (see picture 1)	White to Black = Open Link – No Continuity White to Black = OL (see picture 2)	White to Blue = Open Link – No Continuity White to Blue = OL
Black to Black 0.0 ohms - Continuity Audible Tone	Black to White = Open Link – No Continuity Black to White = OL	Black to Blue = Open Link – No Continuity Black to Blue = OL
Blue to Blue 0.0 ohms - Continuity Audible Tone	Blue to White = Open Link – No Continuity Blue to White = OL	Blue to Black = Open Link – No Continuity Blue to Black = OL

Picture 1



Same Conductors 0.0 ohms
Audible Tone
Continuity

Picture 2



Opposite Conductors Open Link
OL
No Continuity

6.4.2 Voltage Test Method (see following table for reference)

NOTE: *Energized System (source) Conductors can consist of energized transformer bus bars, source conductors or energized secondary bus (crabs) depending on the location of the source.*

NOTE: *A typical single phase parallel service consists of (2) neutrals and (4) hot legs. For demonstration purposes in this EOP neutrals are WHITE, set #1 is BLUE and set # 2 is BLACK. It is understood that some parallel services may deviate from this typical scenario and the same steps laid out below shall be followed for all subsequent sets of cables. This process that is detailed below works for both OH and UG parallel services and although the most typical installation is to parallel two sets of conductors this process is appropriate for services containing any number of parallel service conductors.*

a. Use proper temporary insulation and isolation practices at the energized service connection point on phase conductors and connect the neutral conductors.

b. Take a voltage reading from one of the energized system (source) conductors to all of the sub-conductors of the new installation (all BLUE and all Black). A voltage reading should not be detected between the energized system conductor and any of the newly installed phase sub-conductors. If a voltage reading is detected a test needs to be conducted to determine if any of the service conductors is shorted to neutral or earth. DO NOT continue until this problem has been resolved.

c. After all of the phase sub-conductors have been verified as not being shorted to neutral or earth; connect one of the sub-conductors marked as part of a conductor group (BLUE or set # 1) to an energized system phase conductor (source). Caution shall be utilized once any sub-conductor within a phase group has been energized; all the remaining sub-conductors within that phase group should now be energized. Use a multi-meter or voltage meter and measure for voltage between the not yet connected energized sub-conductor and neutral to verify that voltage is present and the conductor has been properly marked.

d. Now measure from the energized system (source) conductor to the same color BLUE group marked leg (s), a zero no voltage reading shall be present on all like marked legs in that group.

e. Connect all like marked legs (BLUE or set #1) to the coinciding energized systems (source) conductor.

f. After all of the sub-conductors in one phase group have been connected to an energized system phase conductor, the sub-conductors of any additional phase groups (BLACK or set #2) of the new installation may be tested and connected to the appropriate energized system phase conductor. The same procedure for testing and connection of the sub-conductors that was outlined in the steps above shall be followed. If at any time during the testing of the conductors a voltage reading indicating a phase to ground or phase to phase short exists all work shall stop until the problem is resolved.

g. After the neutral and phase conductors have all been connected, a proper test, as outlined above in section 5 shall be conducted before any current rated meter is installed.

NOTE: *Prior to connecting any customer load or setting a meter, voltage shall be verified to be within the Liberty Utilities established guidelines.*

EXAMPLE: Identification or Verification of Conductors Using a Multi-meter or Voltage Meter at the Service Connection Point:

The following chart and pictures are an example of how multi-meter or voltage meter check should be performed at the service connection point prior to energizing a service. The example depicts a single phase parallel service consisting of two service conductors for each phase and neutral.

STEP	TEST POINTS	RESULTS
a	**Connect all neutrals WHITE to neutral bus**	**0 - VOLTS**
b	**Measure voltage from Energized (source) sub-conductors to all isolated (unconnected) BLUE and BLACK sub-conductors**	**0 - VOLTS**
c	**(1) Connect one isolated BLUE sub-conductors to energized (source) sub-conductor and (2) test for phase to ground voltage on all remaining unconnected BLUE legs**	**ENERGIZED Phase-to-ground 120 volts**
d	**Test for a zero voltage reading from energized (source) sub-conductors to all remaining BLUE sub-conductors if a zero voltage is read proceed to step e**	**ENERGIZED**
e	**Connect all remaining Isolated BLUE sub-conductors to the same energized (source) sub conductor**	**0 - VOLTS**
f	**Follow all above steps for all remaining set(s) of unconnected sub-conductors (BLACK)**	**ENERGIZED**


Step (a)


Step (b)


Step (c) (1)


Step (c) (2)

Step (d)

Step (e)

NOTE: *The tape color coding in the example pictures and charts of section 6 are for Illustration purposes only. Either method stated in section 3 of this document can be used for this purpose. It is important to note that it may be necessary for electricians to use "color coding tape" to identify conductors. This may be performed to meet requirements of their state codes.*

<u>7.0 ROTATION OF THREE PHASE SECONDARY SERVICES</u>

7.1 Safety Precautions:

7.1.1 All 240 volt three phase services that have a 208 volt leg, (wild leg) must be identified and marked with ORANGE (NEC requirement) tape. Never swap the 208 volt leg (wild leg) to reverse rotation.

7.1.2 Before leaving the job site, always check with the customer and make sure all their equipment is operating properly.

7.1.3 When taking rotation, only use an approved rotation meter like the Knopp K-3 rotation meter (see picture below) or other approved rotation meter.

7.2 **Installation of new three phase secondary service.**

7.2.1 Check customers main switch open.

7.2.2 Energize new service.

7.2.3 Verify correct secondary voltage with approved meter.

7.2.4 Rotation is not required. Customer is responsible for rotation.

7.3 **Replacing an existing three phase pad mounted or three phase overhead transformer bank.**

7.3.1 Verify that both primary and secondary voltages from both the existing and new transformer name plates match.

7.3.2 Measure correct secondary voltage and document.

7.3.3 Take, record, and mark rotation at line of demarcation for future reference.

7.3.4 Verify customer's main switch is open.

7.3.5 Replace transformer ('s)

7.3.6 Energize new transformer ('s), measure correct secondary voltage.

7.3.7 With same rotation meter verify previous rotation is correct.

7.4 **Changing or replacing three phase secondary service.**

7.4.1 Measure correct secondary voltage at the line of demarcation and document.

7.4.2 Take and mark rotation at the line of demarcation.

7.4.3 Verify customer's main is open.

7.4.4 Replace and energize the new 3 phase service.

7.4.5 Measure correct secondary voltage.

7.4.6 With the same rotation meter verify previous rotation is correct at the line of demarcation.

7.5 **Customer replacing existing three phase service.**

7.5.1 No rotation is required. The customer is responsible for proper rotation.

7.5.2 Check for correct voltage and proper operation of customer's equipment before leaving the job site.

7.6 **Pole mounted or Pad mounted three phase transformers(s) damaged, rotation not known.**

7.6.1 DO NOT ENEGIZE THE SERVICE CABLE WHEN WORK IS COMPLETE IF MAIN BREAKER CANNOT BE OPENED.

7.6.2 Make necessary repairs to damaged transformers and equipment.

7.6.3 Before energizing check and verify the customer's main switch open.

7.6.4 Make arrangements to have customer available to check rotation of their equipment before energizing service.

7.6.5 With customer main open, energize service and check correct secondary voltage.

7.6.6 Verify with customer that rotation is correct before leaving the job site.

7.7 **Conversions**

7.7.1 For rotation procedure during conversions, refer to LU-EOP D010 section IV.

8.0 APPROVED TOOLS USED TO IDENTIFY SECONDARY/SERVICE CABLES

8.1 There are a variety of approved testers and multimeters that are appropriate for performing the functions listed in the above procedures, any tool that is used to perform these tasks must be appropriate for the task and listed as approved by the Company. If unsure if appropriate tool is being used contact your supervisor.

Exception approvals:
It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate supervisor in their respective department, the Manager of Work Methods, Distribution Engineering Services and a Manager of Corporate Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

9.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	1.0	Initial Version of document. Converted from National Grid document.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities		Doc. # LU-EOP G022	
Electric Operating Procedure	12-01-2017	General	
Substation Security Entry, Notification, and Documentation Requirements	Revision #	1.1	Page: 1 of 15

INTRODUCTION

Homeland Security and other agencies consider increased oversight of both entry and departure of electric substations a prudent practice.

Liberty Utilities is committed in ensuring effective security practices are in place in order to protect substation workers, substation assets, and to prevent the physical disruption to the infrastructure that may result in serious social and economic consequences.

PURPOSE

The purpose of this procedure is to outline the process that Liberty Utilities employees are required to follow in order to be compliant with NERC Cyber Security Standards, OSHA 1910.269, and Liberty Utilities Employee Safety Handbook and Procedures for Liberty Utilities owned electric distribution substations.

These specific requirements must be followed to manage, control, monitor, and log access to substation and substation controlled areas by personnel that have been approved to enter substations.

The procedure outlines the access, notification, and documentation requirements that shall be followed by all Liberty Utilities personnel and Liberty Utilities employed contractors who enter Liberty Utilities Electric Substations to meet NERC Cyber Security Standards, EHSS Procedures, and Substation O&M Procedure requirements.

ACCOUNTABILITY

CQ&EM Standards, Policies, and Codes, Electric Distribution Operations, Substation O&M, and Engineering personnel shall ensure that requirements or this procedure are followed.

All Liberty Utilities personnel and Liberty Utilities employed contractors who enter Liberty Utilities Electric Substations shall comply with this procedure.

All personnel in Liberty Utilities Control Center shall comply with the requirements of this procedure.

COORDINATION

Compliance, Quality, & Emergency Management (CQ&EM)

REFERENCES

Liberty Utilities EHSS Procedures and Liberty Utilities Employee Safety Handbook

NERC CIP-006-(R1) Cyber / Physical Security Standard

Substation Maintenance Procedure SMP-400.14.2

Substation Maintenance Procedure SMP499.10.2 Substation Work Area Identification

DEFINITIONS

Blockout Blade: A device inserted into standard cores used to prevent the insertion of a standard key.

Extractor Key: A number controlled key used to remove Blockout Blades from lock cores.

DOCUMENT CONTENTS

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1.0 OVERVIEW

1.1 Physical access controls have been implemented for Liberty Utilities New Hampshire Substations. All access into and out of any substation shall be conducted and monitored through proper notification procedures. Substation access and notification is performed by contacting the Control Center and through the use of electronic means such as card readers, if so equipped.

1.2 When using card readers to gain access into substations, Liberty Utilities employees or Liberty Utilities employed contractors are still required to contact the Control Center.

1.3 Entry or work within the substation perimeter fence shall only require notification of the Control Center.

1.4 For entry or work inside the station control house, access into and out of the substation control house shall be recorded in the logbook. At a minimum, information to be recorded shall indicate the name of the person(s) entering the substation, their business purpose, their company affiliation, time in, and time out.

1.5 Visitors shall be escorted at all times and their visit reported as outlined in this procedure.

2.0 PERSONNEL ENTERING SUBSTATIONS - QUALIFICATIONS

2.1 Authorized

2.1.1 A Liberty Utilities Employee

a. EHA Trained
b. NERC-CIP trained and PRA (Personal Risk Assessment) completed to enter NERC-CIP designated substations.

2.1.2 A Liberty Utilities Employed Contractor

a. Must be qualified by Liberty Utilities management
b. NERC-CIP trained and PRA completed to enter NERC-CIP designated substations.

2.2 Non-Authorized

2.2.1 A Liberty Utilities Employee

a. Without EHA, NERC-CIP, or PRA documentation
b. Must be escorted
c. Special entry notifications SHALL be followed

2.2.2 A Liberty Utilities Employed Contractor

a. Without qualified training for substation work, NERC-CIP, or PRA documentation
b. Must be escorted
c. Special entry notifications SHALL be followed

2.2.3 Visitors (Refer to Section 10 in this document)

a. Any outside vendor, contractor, person visiting or performing work in substations that are not authorized shall be escorted at all times

b. Only those personnel who have been previously authorized unescorted access clearance on their ID can act as an escort. When escorting visitors the escort must closely monitor the visitor in a manner sufficient to observe whether the visitor is engaged in any activities other than those for which access was granted. No more than five (5) persons can be assigned to one (1) escort.

3.0 SUBSTATION PERIMETER GATES

3.1 Extended Driveway Pipe Type, Chain, or Fence Panel Gates

3.1.1 Shall be kept secured (locked) at all times when the substation is unattended. When gates are closed and locked, the gap between substation entrance gate leafs shall be less than 4 inches.

3.1.2 May be left open during the time work activities are being conducted at the substation but shall be secured upon completion of the work and the substation is left unattended.

a. V&O Inspections

b. Equipment Maintenance

c. Construction Activities

3.1.3 May be left in the open and secured position for snow plowing during the winter months

a. November through March

3.2 Main Substation Truck Gates and Person Gates

3.2.1 Shall be kept secured (locked) at all times when the substation is unattended. When gates are closed and locked, the gap between substation entrance gate leafs shall be less than 4 inches.

3.2.2 May be left open when crews are working inside the substation as long as the gates can be continuously visually monitored during the work activity.

3.2.3 Shall be closed and locked when work activity is such that continuous visual monitoring cannot be performed and there is a possibility of unauthorized entry.

4.0 SUBSTATION ENTRY AND NOTIFICATION REQUIREMENTS

4.1 Entering **ANY** Substation Yard Only

4.1.1 Authorized personnel shall contact the Control Center when entering any Liberty Utilities Substation yard.

4.1.2 Entry or work within the substation perimeter yard shall only require notification of the Control Center. See Appendix A for Control Center's contact number.

4.1.3 If a crew (multiple individuals) is entering the yard, the crew lead shall notify the Control Center of entry to the facility.

4.1.4 Notification of the local Security contact numbers IS NOT required.

4.1.5 If the main gate is equipped with an electronic card reader and a crew (multiple individuals) is entering such facility, only one person is required to present their Liberty Utilities issued ID to the card access reader.

4.1.6 No requirement to enter control house and sign in the substation entry logbook.

4.2 Departing the Substation Yard

4.2.1 When departing a substation yard Liberty Utilities electric substation at the end of the work activity, all Liberty Utilities personnel and Liberty Utilities employed contractors shall notify the Control Center of their departure. If a crew (multiple individuals) is leaving such a facility the crew lead shall notify the Control Center of departure of the facility.

5.0 SUBSTATION CONTROL HOUSE ENTRY AND NOTIFICATION REQUIREMENTS

5.1 Entry into and out of **ANY** substation control house shall be recorded in the substation entry logbook.

5.1.1 At a minimum, information to be recorded shall indicate the name of the person(s) entering the substation, their business purpose, their company affiliation, time in, and time out.

5.2 If the substation control house is equipped with electronic card readers, ALL employees with Liberty Utilities issued ID cards entering the substation control house must present their ID to the card reader prior to entering.

5.2.1 Entry into the substation control house shall also be recorded in the substation entry logbook.

6.0 CONTROLLED ACCESS AREAS

6.1 NERC designated site access will be controlled by the use of electronic card access systems. Only those employees and contractors that have been previously approved for unescorted access to these sites will have access programmed on their photo ID access card.

6.2 In addition, these NERC sites have been posted with a sign depicting it as a “Controlled Access Area” and employees and contractors shall follow the entry, notification, control, monitoring, and log in requirements in this procedure.

Liberty Utilities Emergency Dispatch Contact Number – 603-216-3620
15 Buttrick Rd. Londonderry, NH

6.3 Since the list of NERC designated sites are “Confidential” they will not be available for distribution. Contact the Director of Electric Operations for further information.

7.0 CONTROL BUILDING ACCESS WITH ELECTRONIC SECURITY SYSTEMS

7.1 Control Building doors regulated by NERC CIP standards shall have Blockout Blades inserted into the cores to prohibit key entry. These doors shall be identified with a decal above the lock stating, “No Key Entry”. All entry into these buildings must be by Card Reader only.

7.2 For substations equipped with card readers, DO NOT use a key to enter the substation. Opening any door with a key will send an alarm to security and shall be investigated and reported. For this reason NERC CIP designated control house doors are also equipped with Blockout Blades and a No Entry Sign to prevent the use of keys and to remind those requiring access to use their ID Badge to gain access by using card readers.

7.3 Control Building doors regulated by NERC CIP standards shall have Blockout Blades inserted into the cores to prohibit key entry. These doors shall be identified with a decal above the lock stating, “No Key Entry”. All entry into these buildings must be by Card Reader only. Sponsors may request Extractor keys to these cores for qualified personnel to be used only in emergency circumstances.

7.4 For station equipped with card readers, DO NOT piggy-back behind others when entering the substation control house. Every person entering the control house must card in.

7.5 When working in substation control house equipped with card readers, the doors and operable windows must remain closed and locked at all times so persons entering can be logged appropriately through the card reader.

7.6 In rare circumstances when the doors must be temporarily left open and the system disarmed to prevent “standing alarms”, the person disarming the system takes over the responsibility for controlling, monitoring, and logging access to the substation control house. This person must be able to have the open door in their line of sight at all times to ensure unauthorized individuals are not accessing the area. This person is also responsible for re-arming the system when leaving the facility. (Security will receive an alarm for any doors that are open when the security system is armed.)

7.7 AMAG SYSTEM

7.7.1 To disarm the alarm system press *1 on the card reader keypad, then present your ID to the card reader. The accompanying LED display will change from red to green to reflect the system is disarmed.

7.7.2 Doors without card readers (contact alarm only) are not to be used at all unless the system is disarmed.

7.7.3 For work activities that are in close proximity of the motion detectors located above the door OR for work that requires continuous entry into the control building, the crew leader should disarm the alarm. The person disarming the alarm assumes the responsibility to monitor all personnel entering the control building.

7.7.4 The card access system continues to operate even though the system is disarmed. Anyone entering the control house is required to present their ID to the card reader to electronically log access even when the system is disarmed and the door propped open. No piggybacking is allowed.

7.7.5 To re-arm the system press *2 on the card reader keypad then present your card to the card reader. The LED display will change from green to red to reflect the security system is now armed.

7.8 INFOGRAPHICS SYSTEM

7.8.1 There is no disarming feature with this system.

8.0 EXITING CONTROL HOUSE DOOR WITH ELECTRONIC SECURITY SYSTEMS

8.1 When exiting a control house equipped with electronic card readers, employees must be aware of the exiting requirements.

8.2 These doors are equipped with a "REX" or Request to Exit PIR that is usually mounted above the door and functions similar to a motion detector.

8.3 The function of the REX is to shunt the door contact. It basically tells the system to ignore the door alarm because someone is exiting.

8.4 As a person approaches the door, the REX, acting as a motion detector, clicks on and a green LED light appears and shunts the alarm.

8.5 Do not linger near the door. Failure to exit while the LED light is green, a "Door Forced Open" alarm will be triggered when the door is actually opened

8.6 As Corporate Security observes trends in alarms, adjustments to the REX settings may be performed to better reflect the timing that the green light stays on.

9.0 SUBSTATION ENTRY DOCUMENTATION REQUIREMENTS

9.1 Substation Yard Entry

9.1.1 Entrance only to the Substation Yard DOES NOT require entry in the Substation Logbook

9.2 Substation Control Building Entry

9.2.1 Each Liberty Utilities Substation control building shall contain a Substation Entry Logbook to document ALL entry to substation control house.

9.2.2 Only ONE Substation Entry Logbook shall be provided for each substation control house

9.2.3 Substation Entry Logbook shall be clearly identified as such

9.2.4 May be used for documenting switching operations and other maintenance/trouble activities if a separate Substation Maintenance Logbook is not provided

9.2.5 Individuals entering/departing the substation control house shall record name, purpose for entry, time of entry, and time of departure

9.2.6 When individuals enter/depart the substation control house as a crew, the crew leader shall ensure the crew members have been logged in or logged out as required

9.2.7 Shall be provided and maintained by local substation organization

9.2.8 Substation log books shall be retained for a period of three years

9.3 Substation Maintenance Logbook

9.3.1 A substation control house may also have a separate logbook designated as Substation Maintenance Logbook

9.3.2 Used for capturing equipment maintenance activities, Switching operations, Clearances issued, relay targets, and other alarms and equipment related issues

9.3.3 Not to be used for documenting employee, contractor, visitor entrance to the substation control house.

10.0 SUBSTATION VISITORS

10.1 General Requirements for Substation Entry.

10.1.1 General Substation entry by visitors may not require the use of FR clothing.

10.1.2 The following items must be performed prior to entering the substation:

a. Follow SMP 400.14.2 – Substation Security and Section 5.1 Employee Safety Handbook for access to or entering substations.
b. Follow SMP 499.30.2 Substation Personal Protective Equipment.
c. Identify the hazards for entering the substation with the visitor.
d. Perform a hazard assessment identifying if and what level of FR clothing is appropriate for the work being performed during the visit.
e. Record the hazards identified and the requirements discussed and being followed on the job brief.

10.2 Unqualified escorted individuals who require entry to a substation

10.2.1 Follow the General Requirements for Substation Entry.

10.2.2 Must be escorted at all times by a qualified person.

10.2.3 Must have on the following minimum PPE to enter a substation yard:

a. Hard Hat.
b. Safety Glasses with side shields.
c. Sturdy work boot or shoe.

10.2.4 Based on the Hazard Assessment, the following additional PPE may be required:

a. Natural Fiber clothing
b. Appropriate rated FR clothing per SMP 499.30.2.
c. Work shoe that meets ASTM F2413 standard for impact and compression.

10.3 Liberty Utilities employees who require entry to a substation

10.3.1 Follow the General Requirements for Substation Entry (Section 5 – Substations Liberty Utilities Employee Safety Handbook).

10.3.2 Hard Hat

10.3.3 Safety Glasses with side shields.

10.3.4 Work shoe that meets ASTM F2413 standard for impact and compression, and EH rated.

10.3.5 Natural fiber clothing.

10.3.6 Based on the Hazard Assessment, the following additional PPE may be required:

a. FR rated clothing per SMP 499.30.2.

11.0 SUBSTATION ENTRANCE PROCEDURE WITH TRANSGARD ELECTRIC FENCE

10.1 Go to the fence entrance gate that has a disconnect switch and voltage meter (Some Substations have two fence entrances).

10.2 Turn disconnect switch to the off position.

10.3 Visually check red LED beacon ***OFF***.

10.4 Visually check voltage meter on control cabinet at 0 kVolts.

10.5 Fence is now de-energized and safe to enter.

10.6 Open door to entrance, ***CAUTION*** high step.

10.7 Step is removable, if causes a problem.

10.8 It's safe to resume work.

This is a picture of a Substation with two gates, this gate has a warning light only no disconnect switch.

12.0 SUBSTATION EXITING PROCEDURE WITH TRANSGARD ELECTRIC FENCE

12.1 When work is completed and ready to leave substation.

12.2 Make sure all step plates are put back in, fence is back together, and entrance gates are closed.

12.3 Turn disconnect switch to the ***ON*** position.

12.4 Red LED beacons should be energized.

12.5 Voltage Meter on control cabinet should pulse between 8-10 kVolts.

12.6 If fence doesn't read 8-10 kVolts call local O&M Department.

12.7 Fence is now energized back in service.

13.0 SITE DUAL USE AND STORAGE REQUIREMENTS

13.1 The use of substation yards for non-critical activities, such as construction equipment storage, contractor staging, or personal vehicle parking, should be avoided where possible. Areas designated for electrical apparatus storage or construction material staging shall be clear of all electrical hazards and identified by designated storage area signs. Refer to SMP499.10.2 Substation Work Area Identification for details.

14.0 SUBSTATION PARKING REQUIREMENTS

14.1 Parking inside electric substation perimeter fencing by Liberty Utilities employees or Liberty Utilities employed contractors driving personally owned vehicles (POV) is not allowed.

15.0 SUBSTATION TROUBLE RESPONSE

15.1 Trouble Workers or other qualified employees are normally dispatched to a substation based on trouble alarms.

15.2 Individuals responding to the substation incident shall make a concerted effort to differentiate normal electromechanical failures from malicious acts.

15.2.1 For Normal Substation Alarms

a. Standard substation response protocols shall be followed to conduct an assessment of the alarm(s) received.

b. Based on the field observations, standard isolation and/or restoration practices are to be followed.

15.2.2 Malicious activity has transpired or is assumed.

a. Priority should be to return the substation to normal functionality while preserving forensic evidence where possible.

b. Control Center shall notify substation management and Company Security immediately. Additional notifications shall be made by the Control Center and Substation Management per existing protocols to assemble the required personnel to begin system restoration efforts. Notification to substation management is normally conducted through the System Operator.

16.0 TRAINING

16.1 Initial Training

16.1.1 Electric Operations Management shall review this EOP with all the appropriate electric personnel and contractors.

16.2 Refresher Training

16.2.1 Refresher training will be conducted as necessary, generally during Annual Expert Training (AET). Electric Operations supervision shall review this EOP with all new personnel entering the departments.

17.0 RESPONSIBILITIES

17.1 CQ&EM, Standards, Policies, and Codes

17.1.1 Update Procedure as necessary.

17.2 Electric Operations Management

17.2.1 Ensure Log Books are maintained at each Liberty Utilities Substation.

17.2.2 Ensure LU employees and LU employed contractors comply with the requirements of this EOP.

17.2.3 Maintain a list of personnel approved to enter substations.

17.2.4 Submit Substation Key Requests Forms to Liberty Utilities Director of Electric Operations to coordinate with National Grid.

17.3 Liberty Utilities Control Center (National Grid during transition)

17.3.1 Liberty Utilities Control Centers should log reported entry/departure from substations, and report to appropriate supervision and/or System Security any known violations of this policy.

17.4 EHSS Security

17.4.1 Issue ID badges

17.4.2 Maintain Database of approved LU employees and LU employed contractors with access to substation controlled areas.

17.4.3 Provide periodic database print outs to Liberty Utilities Management.

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Electric Operating Procedure	**12-01-2017**	**General**	
Substation Security Entry, Notification, and Documentation Requirements	**Revision #**	**1.1**	**Page: 14 of 15**

18.0 APPENDIX A – NE ≥ 69kV TRANSMISSION CONTROL CENTER NOTIFICATION CONTACT NUMBERS – National Grid

National Grid Transmission Control Room All lines and Substations 69kV and Above	
Bay State North Granite State Bay State South	**Bay State West Ocean State**
866-258-0157 800-423-6029 508-389-2492 508-366-8393	866-870-4358 800-423-6029 508-389-4212 508-366-8393

19.0 APPENDIX B – NE < 69kV DISTRIBUTION CONTROL CENTER NOTIFICATION CONTACT NUMBERS – National Grid

National Grid Distribution Control Centers			
NE North Contacts		NE South Contacts	
North Shore		Capital	
Toll Free	877-247-3606	Toll Free	877-247-3610
Alternate	(508)389-3726	Alternate	(508)389-3730
Merrimack Valley and Granite State		Coastal	
Toll Free	**877-247-3607**	Toll Free	877-247-3611
Alternate	**(508) 389-3727**	Alternate	(508)389-3731
Central		Southeast	
Toll Free	877-247-3608	Toll Free	866-411-3812
Alternate	(508) 389-3728	Alternate	(508)389-3733
Western		South Shore	
Toll Free	877-247-3609	Toll Free	866-411-5599
Alternate	(508) 389-3729	Alternate	(508)389-3734

Liberty Utilities NH Emergency Dispatch Contact Number – 603-216-3620
15 Buttrick Rd. Londonderry, NH

20.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
12/01/2017	1.1	Updated for System Use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G023		
Electric Operating Procedure	01-01-2017	General	
Inspection of Electric Facilities Following an Earthquake	Revision #	1.1	Page: 1 of 4

INTRODUCTION

This procedure applies to all Liberty Utilities personnel that are required to inspect and patrol electric facilities in the event an earthquake is perceived and/or reported in your location.

PURPOSE

The purpose of this EOP is to give instructions on inspections and reporting of Liberty Utilities electric facilities after an earthquake is perceived and/or reported in your location.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies and Codes
   - A. Update procedures as necessary.
2. Electric Distribution Operations
   - A. Ensure that the procedures in this standard are implemented.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide procedure revision input as necessary.
3. Liberty Utilities Employees and Contractors
   - A. Demonstrate the understanding of the procedures in this standard.
   - B. Comply with the requirements of the procedures in this standard.
   - C. It is the workers responsibility to read and fully understand and follow the vendor's instruction manual and specifications before using any test device.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules
Substation Maintenance Procedure 400.87.2

DEFINITIONS

Damage:

– "Damage" means any impact or exposure that results in the need to repair an underground facility due to the weakening or the partial or complete destruction of the underground facility, including, but not limited to, the protective coating, lateral support, corrosion control, or the housing for the line, device, or underground facility.

Distribution Inspector: An employee that has been trained to identify deficiencies or non-standard construction conditions on Liberty Utilities distribution facilities.

Emergency: A sudden or unexpected occurrence involving a clear and imminent danger demanding immediate action to prevent or mitigate loss of, or damage to, life, health, property, or essential public services.

Inspect: An assessment of Liberty Utilities facilities for the purpose of determining the condition of the facility and any associated components.

TRAINING

Training to be provided by appropriate Liberty Utilities training program, progression training and AET as indicated. This shall be provided by Learning and Development.

DOCUMENT CONTENTS

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1.0 SAFETY

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any applicable Liberty Utilities EOP's utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 Before each job begins for a crew of two or more, and whenever working conditions change, a documented job brief shall be conducted by the crew leader/chief, person in charge of the work, or supervisor to review hazards, precautions, procedures, energy sources/control, and personal protective equipment requirements. All members are required to sign or initial the documented job brief.

1.4 Appropriate rubber gloves shall be worn by persons opening or unlocking a padmount transformer, submersible vault, and/or switchgear: They shall wear Class 2 gloves. (Liberty Utilities Employee Safety Handbook 2.11.17 (j).

2.0 GUIDELINES FOR WHEN AN INSPECTION SHOULD BE MADE

The following guidelines are for your assistance in determining when an inspection must be made.

2.1 When the magnitude of the earthquake is reported to have been 4.0 or higher as measured on the Richter scale and facilities are within a 75 mile radius of the reported epicenter.

2.2 When the earthquake, as determined by Director Electric Operations or designee, might have caused damage or abnormal conditions at or on Liberty Utilities facilities within your area.

2.3 When so ordered by a higher authority.

3.0 INSPECTIONS

The facilities designated below shall be visually inspected as soon as personnel can be mobilized in the case of a 4.0 or higher event.

3.1 ALL Electric Substations: equipment, structures, foundations, buses and insulators shall be visually inspected.

3.1.1 All affected substations shall have an infrared inspection conducted as soon as practicable.

4.0 REPORTING

Any abnormal conditions, emergency situation or indication of change which might result in an abnormal condition or potential damage shall be reported to the Director of Electric Operations and/or Manager Electric Operations, Substation O&M supervisor.

4.1 The following items shall be included in the report.

4.1.1 Inspection start time and date.

4.1.2 Facilities inspected.

4.1.3 Geographic description of the area inspected.

4.1.4 All abnormal conditions, equipment/structures, change or emergency condition.

NOTE: Should an emergency condition be discovered, appropriate action to safeguard life, property and the integrity of the electrical system shall be taken.

4.1.5 All conditions or indications which may require engineering, or other evaluation.

4.1.6 Completion time and date of the inspection.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G025		
Electric Operating Procedure	12-01-17	General	
Utilizing a Digger Derrick to Remove Poles	Revision #	1.1	Page: 1 of 6

INTRODUCTION

This procedure applies to all Liberty Utilities employees or Liberty Utilities employed contractor (workers) that utilize a Digger Derrick to remove poles during construction and maintenance activities.

PURPOSE

The purpose of this procedure is to provide information and the proper work methods for utilizing a Digger Derrick to remove (pull) poles or pole butts. Liberty Utilities Digger Derricks have protection systems that are intended to protect the unit from being overloaded. Even with these protection systems in place, Digger Derricks can still be damaged if the operator overrides or disengages these protection systems. Improper use of the Digger Derrick can lead to winch line failures and boom damage.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support and training upon request.
2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.
3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules
ANSI A10.31-1995 Section 4.11.2
ALTEC Owner's Manual
TELECT Owner's Manual

TRAINING

Provided by Liberty Utilities Learning & Development Training Program upon request.

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Utilizing a Digger Derrick to Remove Poles	**Revision #**	**1.1**	**Page: 2 of 6**

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PROCEDURE

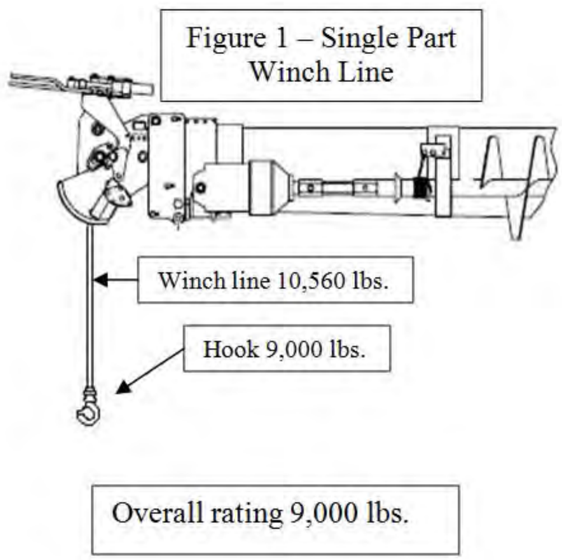
1.0 DETERMINING THE WEIGHT OF THE LOAD

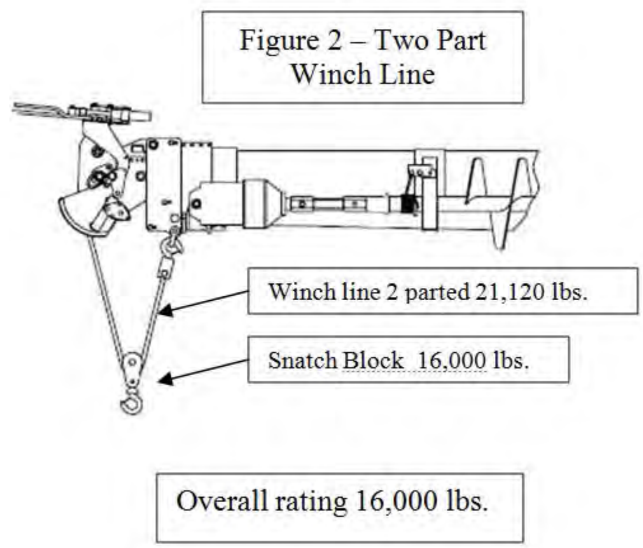
The operator should determine the weight of the pole (Load) to be removed. Average pole weights in pounds are listed in the table below:

POLE LENGTH (Feet)	CENTER OF GRAVITY (Measured in feet from butt)	AVERAGE WEIGHT IN POUNDS					
	FULL LENGTH TREATED SOUTHERN YELLOW PINE POLES						
		CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6
20		-----	-----	-----	-----	330	284
25		-----	-----	674	573	490	422
30		-----	-----	921	784	660	550
35	16	1567	1343	1155	1004	862	742
40	18.5	1884	1622	1403	1219	1059	921
45	20.5	2222	1911	1664	1444	1274	1114
50	22	2585	2214	1925	1687	1494	-----
55	23	2990	2590	2245	1945	-----	-----
60	14 & 45	3755	3260	2820	2450	-----	-----
65	14 & 47.5	4265	3695	3205	-----	-----	-----
70	15 & 50	4805	4170	3610	-----	-----	-----
	FULL LENGTH TREATED WESTERN RED CEDAR POLES						
30		-----	-----	645	540	440	370
35	16	1055	880	750	660	570	495
40	17.5	1320	1145	970	790	705	615
45	19.5	1585	1365	1145	1010	880	-----
50	21.5	1760	1585	1365	1230	1145	-----
55	23	2025	1760	1540	1410	-----	-----

The Digger Derrick's Load Chart should be used to determine the lifting capabilities of the equipment based on boom angle, load radius and boom extension. The values listed in the Load Charts for Liberty Utilities Digger Derricks are based on stability. These load charts vary from manufacturer to manufacturer and from model to model. It is important that the operator review's the load chart prior to lifting the load so that the Digger Derrick can be positioned to safely pick the load.

Liberty Utilities currently purchases a 5/8 diameter x 70' winch line (item ID 8830-9202210) with a 10,560 lbs. working load limit. ANSI requires the use of a multiple part winch line for loads that exceed the winch line rated working load capacity. Liberty Utilities Digger Derricks are equipped with a Crosby Utility hook that has a 9,000 lbs. capacity and a snatch block with a 16,000 lbs. capacity for two-parting the line (see figures below). Two-parting the lined doubles the working load limit of the winch line. A two-part line shall be used when the load exceeds the working load limit (W.L.L.) of the single part line and are less than 16,000 lbs. (8 tons capacity of the snatch block) (refer to manufacturer markings on the snatch block for actual W.L.L). Special arrangements should be made by supervision for loads that exceed 16,000 lbs.





2.0 LIFTING OF LOADS

Loads being lifted must not exceed the lowest rating of the following:

- Load capacity from the load chart (Figure 1) for the boom angle (Figure 2), load radius and boom position (i.e. retracted, intermediate, etc.)(Figure 3).
- Winch line rated capacity multiplied by the number of parts of line.
- Hook, shackle, sling or chain rated capacity.

Section 11.6 of the Employee Safety Handbook contains information on working loads for shackles. Hooks should be stamped by the manufacturer with their working load rating (stamped rating may be by manufacture code).

Do not use the auger as a stiff leg to remove a pole or pole butt using the winch line.

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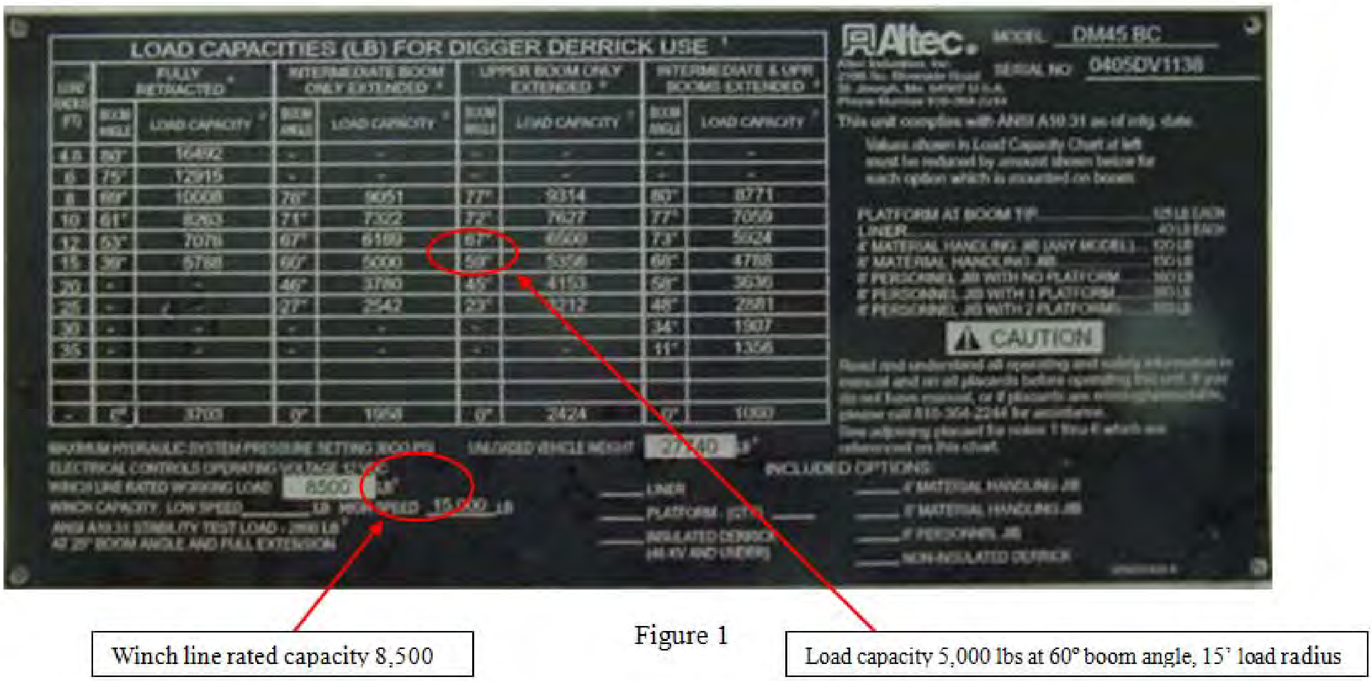

Figure 1

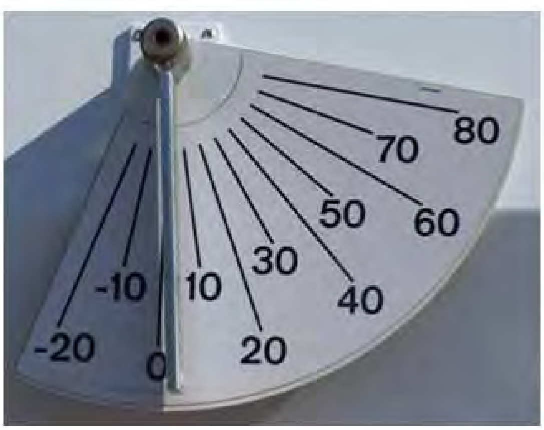

Figure 2

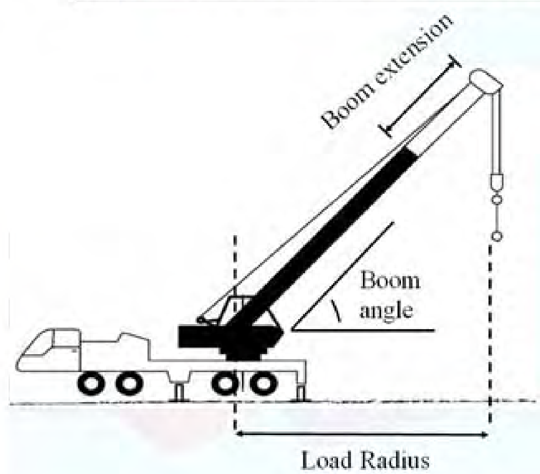

Figure 3

3.0 DETERMINING IF LOAD IS WITHIN RATED CAPACITY WITH ALTEC DIGGER DERRICK.

Digger Derricks supplied by Altec can be used to remove poles by following Altec's Boom Raise Capacity Test procedure listed below from Altec's operators manual. Depending on the boom angle, load radius and boom position, the boom hydraulics may exceed the ratings of the hook, shackle or a single part winch line. Be sure to appropriately rig the load so that all components are within their rated capacity for the hydraulic system prior to

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conducting the boom raise capacity test. An example would be:
A corner mount digger with the vehicle positioned with a 6 ft. load radius and a boom angle of 75° would have a capacity of 12,915 lbs. that would exceed the single part winch line rating of 10,000 lbs. and the hook rating of 9,000 lbs. This set up would require a two part winch line. Utilizing an eight ton rated snatch block and two parting the line would bring this load within the ratings of all of the components.

Boom Raise Capacity Test:

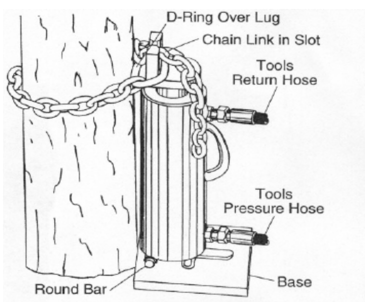
The lift cylinder is designed to lift loads within the rated capacity of the hydraulic system, regardless of boom angle or extension. This feature provides an easy way for the operator to determine if a load is within the rated capacity of the hydraulic system. The operator simply attempts to lift the load slightly by shifting the boom control handle to the Raise position. If the load can be lifted in this manner, rated capacity of the hydraulic system is not being exceeded. If stability has been maintained, then the load may then be winched up to the required position. Maintain control of the load at all times. If it is necessary to extend the booms with a load, and then perform the boom raise capacity test and consider stability along several points of the extension. If, while performing the Boom Raise Capacity Test, the outriggers of the digger derrick lose contact with the ground, the procedure shall be stopped.

TELELECTS AND PITMAN MODELS are not to be used for this procedure!

4.0 USE OF OPTIONAL POLE PULLER TO FREE UP POLE PRIOR TO LIFTING (All Manufacturers)

A pole puller shall be used to break the pole loose from the ground when the pole has not been excavated around the base or when the Altec Boom Raise Capacity Test has been stopped. When using a pole puller, the ground around the pole or pole butt should be level where the pole puller will be positioned for it to operate correctly. Shoveling may be required to level the ground where the pole puller will be positioned. If ground cannot be made level or if it is in an area with soft soil, blocking may be required. If pole is set in sidewalk or pavement, the concrete or pavement should be broken away from pole base before continuing with the procedure.

Figure 1



Note: If excavation is required (shovel in ground) a Dig Safe notification will be required.

Procedure for using a pole puller:

1. Make sure the pole to be pulled is within the Digger Derricks load capacity.
2. Position pole puller next to the base of the pole (as shown in figure 1), wrapping chain around pole in the retracted position.

3. Taking the vehicle's load chart into consideration, position the digger derrick over pole that is being pulled and attach winch line above the balance point to control the pole once it is broken loose from the ground.
4. Wrap chain tightly around the pole and insert the free end in the slot on the pole puller ram.
5. Attach auxiliary hose from the vehicle to the pole puller.
6. Extend the pole puller to break pole from the ground. Take slack of winch line to maintain control of the pole at all times. If the pole is still set in the ground, retract the pole puller cylinder and repeat process. In some difficult soil conditions, you may need to dig around the pole to loosen from the ground.
7. When the pole is loose from the ground, detach chain of pole puller and remove pole puller from area.
8. Remove the pole using the winch raise and boom up functions of the Digger Derrick.

5.0 INSPECTION OF WINCH LINES AND BOOM

Operators should inspect the Digger Derrick boom and winch lines before each use with a thorough visual inspection. Pay particular attention to the winch line checking for cuts, abrasions and any wear, including the eye of the rope and the hook or shackle that is being used. Any defects found on any item needs to be replaced before performing any job.

All accessories (thimble, nylite spool and shield, and hook or shackle), must be at the same or greater rating than the rope being used.

REVISION HISTORY

Date	Rev #	Description	Lead/Author
02/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
12/01/2017	1.1	Updated for System Use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G026		
Electric Operating Procedure	12-01-2017	General	
Mechanized Equipment Grounding	Revision #	1.1	Page: 1 of 13

INTRODUCTION

Operation of vehicles or equipment near energized lines and equipment may create hazards due to electric field induction, magnetic field induction, and direct contact with energized lines or equipment. These effects may be reduced by grounding and/or isolating the vehicle or equipment.

PURPOSE

The purpose of this procedure is to provide the appropriate methods required for grounding and/or barricading before working on or near energized overhead and underground distribution, sub-transmission and transmission lines. The procedure addresses all mechanized equipment working in or near an energized source where the hazards due to electric or magnetic field inductions exist or the potential of an accidental contact with energized equipment / wire may occur.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies and Codes
    A. Update procedure as necessary.
    B. Provide Electric Distribution Operations field support and training upon request.
2. Electric Distribution Operations
    A. Ensure the components of the procedure are implemented.
    B. Ensure Electric Operations personnel are trained in this procedure.
    C. Provide procedure revision input as necessary.
3. Liberty Utilities Employees and Contractors
    A. Demonstrate the understanding of the procedure.
    B. Comply with the requirements of the procedure.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

OSHA 1910.269 (p) 4 Operations Near Energized Lines or Equipment.

OSHA 1926.416

OSHA 1910.333

NESC 2012 edition

IEEE Standard 1048 2003 IEEE Guide for Protective Grounding of Power Lines

ANSI Z535.5-2002

ASTM Designation: F855-97

LU-EOP G013 Excavation Notification Requirements

DEFINITIONS

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Barricade: A physical obstruction such as tapes, screens or cones intended to warn and limit access to a hazardous area.

Barrier: A physical obstruction that is intended to prevent contact with energized lines and equipment.

Effectively Grounded: Being connected to the earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the building up of voltages that may result in undue hazard to connected equipment or to persons.

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Touch Potential: The voltage difference between an object which the worker may touch and the earth upon which the worker is standing. This voltage difference could be hazardous and could result from energization, induction or faults.

Step Potential: The voltage difference between two points on earth's surface, separated by a distance of one pace (assumed to be one meter/approximately 3 feet) in the direction of the maximum voltage gradient. This potential difference, if great enough, could be dangerous to a worker.

Exposed – Not isolated or guarded.

Isolated: An object that is not readily accessible to persons unless special means of access are used.

Guarded: Protected by personnel, covered, fenced, or enclosed by means of suitable covers or casings, barrier rails, screens, mats, platforms, or other suitable devices in accordance with standard barricading techniques designed to prevent dangerous approach or contact by persons or objects.

Tolerance Zone: - If the diameter of the underground facility is known, the distance of one-half of the known diameter plus two feet, on either side of the designated center line or, if the diameter of the underground facility is not known, two feet on either side of the designated center line.

TRAINING

Training to be provided by appropriate Liberty Utilities training program, progression training and AET as indicated. This shall be provided by Learning and Development.

DOCUMENT CONTENTS

Table of Contents

1.0 SAFETY REQUIREMENTS

1.1 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.2 The employee in charge of the work shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, atmospheric testing and ventilation and personal protective equipment requirements.

1.3 During work, barriers or other appropriate protection shall be installed to protect adjacent conductors.

1.4 All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Refer to the tool catalog for a listing of approved equipment.

2.0 GENERAL GUIDELINES FOR ALL APPLICATIONS (OVERHEAD AND UNDERGROUND)

2.1 All ground connections shall be made on a bare metal surface and shall be clean and wire brushed before installing connection.

2.2 All ground leads shall be fully extended or uncoiled.

2.3 All ground connections shall be checked prior to each use.

2.4 When installing a ground clamp or grounding mechanized equipment to a grounding element, the use of Class 2 rubber gloves is required. And, if the relevant minimum approach distances cannot be maintained for a particular voltage, the use of live line tools shall be used.

2.5 Temporary driven grounds shall be installed at a location away from the workers on the ground and barricaded.

2.6 Follow procedure LU-EOP G013 Excavation Notification Requirements when installing any ground rods.

3.0 OVERHEAD EQUIPMENT APPLICATION

3.1 When a qualified employee needs to operate mechanized equipment near energized lines or apparatus, the equipment shall be operated so that the minimum approach distances listed in the tables below are maintained from exposed energized lines/apparatus. This can be accomplished in most cases by repositioning the mechanized equipment or by displacement or relocation of the affected energized lines or apparatus. Insulated aerial equipment being used within its dielectric rating and operated by a qualified employee is exempt from this requirement.

OSHA MINIMUM APPROACH DISTANCES

No employee shall approach or take any conductive object closer to exposed, energized parts than the distances listed below: (For phase to ground and phase to phase clearance:)

Minimum Approach Distance: The closest point of approach to energized lines or equipment by a qualified employee, or by any other conductive object, without the use of insulating gloves, sleeves or portable protective devices, shall be in accordance with the table below.

DISTANCE

Nominal Voltage[1]	Phase to Ground[2]	Phase to Phase
0.50 - 0.300 kV	Avoid contact	Avoid contact
0.301 - 0.750 kV	1.09 ft.	1.09 ft.
0.751 - 5.0 kV	2.07 ft.	2.07 ft.
5.1 - 15.0 kV	2.14 ft.	2.24 ft.
15.1 - 36.0 kV	2.53 ft.	2.92 ft.
36.1 - 46.0 kV	2.76 ft.	3.22 ft.
46.1 - 72.5 kV	3.29 ft.	3.94 ft.
72.6 - 145.0 kV	3.71 ft.	4.66 ft.
145.1 - 169.0 kV	4.27 ft.	5.38 ft.

[1]Employers may use the minimum approach distances in this table provided the worksite is at an elevation of 3,000 feet or less. If employees will be working at elevations greater than 3,000 feet above mean sea level, the employer shall determine minimum approach distances by multiplying the distances in this table by the correction factor in table 2B corresponding to the altitude of the work.

[2]Employers may use the phase-to-phase minimum approach distances in this table provided that no insulated tool spans the gap and no large conductive object is in the gap.

Below are tables (2B & 2C) to use to calculate Minimum Approach Distance, if working at elevations greater than 3000ft

ALTITUDE CORRECTION FACTOR

Altitude Above Sea Level (ft.)	Correction Factor (A)
0 to 2,952	1.00
2,952 to 3,937	1.02
3,938 to 4,921	1.05
4,922 to 5,905	1.08
5,906 to 6,889	1.11
6,890 to 7,874	1.14
7,875 to 8,858	1.17
8,859 to 9,842	1.20
9,843 to 11,811	1.25
11,812 – 13,779	1.30
13,780 – 15,784	1.35

3.2 A designated qualified employee other than the equipment operator shall observe the approach distance to exposed lines and apparatus and give timely warnings before the minimum approach distance, shown in the relevant table above, is reached. When the minimum approach distance cannot be maintained, in order to accomplish the work, the written job brief must document the reasons for the encroachment on the minimum approach distances and the operation shall comply with at least one of the following:

3.2.1 The energized lines exposed to contact shall be covered with approved Insulating products/barriers that will withstand the type of contact that might be made.

3.2.2 The equipment shall be insulated for the voltage involved and repositioned so that its uninsulated portions cannot approach the lines or equipment any closer than the minimum approach distances.

3.2.3 Each employee shall be protected from hazards that might arise from equipment contact with energized lines. The measures used shall ensure that employees will not be exposed to hazardous differences in potential by:

a. Using the best available ground to minimize the time the line remains energized;

b. Bonding equipment together to minimize or eliminate potential differences;

c. Providing ground mats to extend areas of equipotential;

d. Employing portable insulating protective equipment or barricades to guard against any remaining hazardous potential differences.

4.0 OVERHEAD GROUNDING ELEMENTS

4.1 Ground element choices in order of priority are:

4.1.1 System neutral conductor or cable

4.1.2 Substation ground, structure ground

4.1.3 Ground wire connected to ground rod and bonded to system neutral (down ground)

4.1.4 An existing guy anchor rod under tension and that is not newly installed.

4.1.5 Temporary driven ground rod (8' length driven fully into the soil)

5.0 GROUNDING OF OVERHEAD EQUIPMENT

5.1 **All wire trailers and pulling/tensioning equipment**

5.1.1 When operating this equipment near energized lines, the equipment shall be grounded to a ground element. The equipment/work area shall be barricaded to protect the workers and the public from dangerous touch and step potentials. Appropriate rated rubber gloves and EH rated overshoes shall be worn by the operators.

Three reel spacer cable trailer with axle grounds

Single reel trailer 2/0 grounding set

AB Chance Cat # SA600-3147 or
MacLean Power Systems

Three reel trailer 2/0 grounding set

AB Chance Cat # SA600-3149 or
MacLean Power Systems

5.2 Three reel trailer grounding set installation:

5.2.1 The three rotators are put onto the arbors as the wire reels are being mounted located approximately two feet from each wire reel. Each three foot ground cable should be connected from the bare wire tail (stripping of conductor may be necessary) of each wire reel to one of the ball studs on the rotator installed on each arbor. Next, connect the ten foot ground cable lead to the second ball stud on the rotators to whichever bus bar is chosen depending on where the grounding element is located. Then connect the fifty foot ground cable lead from the bus bar to the ground source. The single reel trailer grounding should be done in a similar fashion utilizing the approved single reel trailer grounding set.

5.2.2 Running or stringing grounds can be used in place of arbor reel grounds when installing new conductors. These grounds connect the new conductor to the trailer which connects to a ground element. **The preferred method is the arbor rotating ground method.**

5.3 Digger Derrick Trucks:

5.3.1 If it has been determined that adequate insulate/isolate products could not be installed to withstand the type of contact that might be made during the operation of the digger derrick with any uninsulated portions (winch line is not tested and cannot be considered insulated for voltages involved) operating within the relevant minimum approach distances, a written job brief must detail the reasons for the encroachment on minimum approach distances and the following requirements shall be done. The digger derrick shall be attached to the best available ground element at the work site. (See Section 3 Grounding Elements) Bond equipment together to minimize or eliminate potential differences and provide ground mats to extend areas of equipotential. If there is exposure to the public (near a sidewalk or in a parking lot for example) the vehicle shall be barricaded. It is strongly recommended that the equipment should always be barricaded to prevent ground personnel from making inadvertent contact with the equipment.

5.3.2 Contact with the vehicle while the boom or suspended load is in the energized area shall be avoided while standing on the ground. However, when situations require contact with the digger derrick from the ground, class 2 rubber gloves and EH rated overshoes must be worn. Added safeguards such as insulating pole guards shall be used when setting poles within the relevant minimum approach distances.

5.3.3 The operator of the digger derrick shall utilize the following methods to protect themselves in case of accidental contact with energized lines:

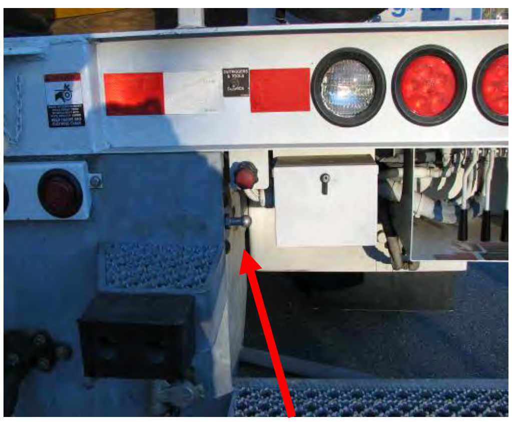
a. Operate controls from the truck platform of the digger derrick.

b. If controls are not being operated from the truck platform the operator shall wear Class 2 rubber gloves and EH rated overshoes.

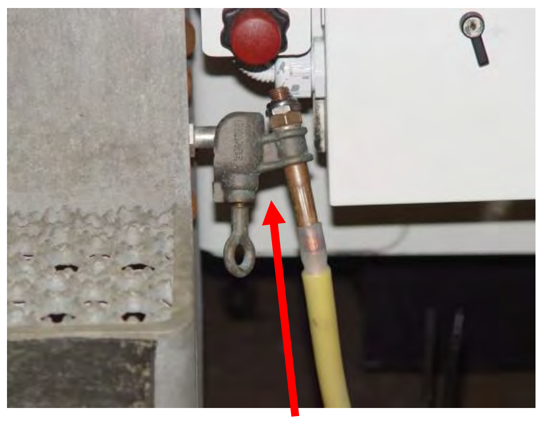
c. Stand on an equipotential mat bonded to the truck.

d. Avoid contact to equipment with unprotected portions of their body.

Grounding of Digger Derrick



Ground Ball Stud
Located rear of digger derrick



Ball Socket Ground Clamp

Ground Cable Assembly Located in front till on passenger side of vehicle
Visual inspection of ground connection to frame on this style of ground is required to insure the integrity of the ground connection.

Use a Liberty Utilities approved 2/0 Cu Ground Cable Assembly 50' length -
AB Chance Assembly # SA600-3027 or MacLean Power Systems part #BT-Q-2/0Y-50
to connect from ball stud ground connection on vehicle to the chosen ground element.

5.4 Additional mechanized equipment

5.4.1 The following mechanized equipment when operating within the relevant minimum approach distances shall follow the approved methods described in this procedure; insulated aerial equipment rated below the circuit voltage level, cranes with booms, trucks with derricks, loaders, uninsulated telescopic and articulating aerial lifts, personnel lifts, scissor lifts, high reach forklifts, tractors with side booms and any other similar equipment.

<u>6.0 UNDERGROUND EQUIPMENT APPLICATION</u>

6.1 While pulling Cable with a conductive steel winch line and the steel winch line will be within reasonable proximity and a possibility of contact exists with an energized shielded cable, above 1000V up to 46kV and energized unshielded cables below 1000V, the cable pulling equipment shall be grounded and barricaded. This requirement applies when pulling cable in a manhole & conduit, URD or UCD systems.

6.2 Each employee shall be protected from hazards that might arise from equipment contact with energized cables. The measures used shall ensure that employees will not be exposed to hazardous differences in potential by:

6.2.1 Using the best available ground to minimize the time the line remains energized.

6.2.2 Bonding equipment together to minimize or eliminate potential differences.

6.2.3 Providing ground mats to extend areas of equipotential.

6.2.4 Employing portable insulating protective equipment or barricades to guard against any remaining hazardous potential differences.

7.0 UNDERGROUND GROUNDING ELEMENTS

7.1 Underground Grounding Element Choices in order of priority:

7.1.1 Manhole ground grid (has ground rod)

7.1.2 Primary neutral in manhole

7.1.3 Secondary neutral in manhole

7.1.4 Substation / structure ground grid

7.1.5 Ground rod with down ground - which is connected to system neutral (non delta distribution area)

7.1.6 Street light ground rod (connected to the rod)

7.1.7 Anchor rod under tension, not new, not rusty (or clean off rust)

7.1.8 Temp ground rod (driven - 8' min)

Manhole Ground Grid (7.1.1)

Cable Truck Grounded to Ground Grid

8.0 GROUNDING OF UNDERGROUND EQUIPMENT

8.1 Underground Lines Pulling Equipment and Powered Reel Trailers

8.1.1 Cable Winch Trucks and powered reel trailers shall be attached to the best available ground element at the work site. (See section 7 Grounding Elements) Bond equipment together to minimize or eliminate potential differences. The equipment/work area shall be barricaded to protect the workers and the public from dangerous touch and step potentials. Appropriate rated rubber gloves and EH rated overshoes shall be worn by the operators.

8.1.2 Avoid contact with the winch truck or powered reel trailer while grounded. However, when situations require contact with the winch truck or reel trailer from the ground, class 2 rubber gloves and EH rated overshoes shall be worn.

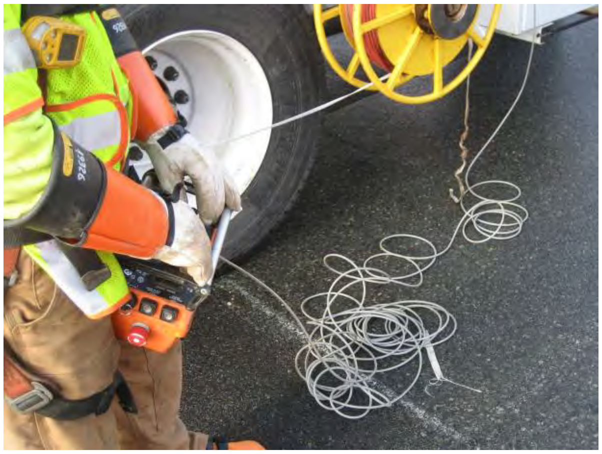
8.1.3 The operator of the cable winch truck or the reel trailer shall utilize the following methods to protect themselves in case of accidental contact with energized cables:

a. Where possible use wireless remote controls to operate the equipment.

b. If using hard wired controls (including foot pedals) or operating the controls on the truck the operator shall wear Class 2 rubber gloves and EH rated overshoes.

c. Stand on an equipotential mat bonded to the truck.

d. Avoid contact to equipment with unprotected portions of their body.

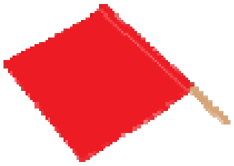


Wired Pendant Using Rubber Gloves

9.0 BARRICADING

9.1 Barricading a vehicle or equipment provides a physical and visual obstruction, warning the public and workers of possible danger. The barricade should be positioned so that no hazardous voltage exists outside the barricade and will prevent unauthorized entrance into the potentially hazardous area. No one should enter the barricaded area while the vehicle or equipment is operating and has a risk of contacting energized lines or apparatus. A barricade should be set up using a minimum six foot perimeter, if possible, around the vehicle or equipment providing isolation from the vehicle or equipment for the public and workers. If the six foot perimeter would impede traffic flow or create a greater hazard for the pedestrians, then a lesser perimeter is allowable, but a worker must be positioned to ensure that contact is avoided. The use of safety cones, safety flags, red barricade tape, and/or retractable barriers should be used to construct this barricade. The following is examples of a method of barricading:

<u>Item ID's</u>
Safety Cones - #8830-8002231
Retractable barrier - #8830-5460815
Flags - #8830-8002050
Danger Barrier Tape - #8830-0811225



10.0 EXCAVATING EQUIPMENT

10.1 Prior to excavating, cables and other buried utilities in the immediate vicinity shall be located, per LU-EOP G013 Excavation Notification Requirements. Mechanized equipment should not be used to excavate in close proximity, within the tolerance zone (2 feet either side of center line), of energized buried lines. When excavating in close proximity of energized cables within the tolerance zone, the hand digging method utilizing hand tools equipped with handles made of a nonconductive material and Class 2 rubber gloves, flame retardant clothing, and EH rated overshoes shall be used.

10.2 Uninsulated mechanized excavating equipment (backhoes, earth borers, excavators, vacuum trucks, trenchers, diggers, and any other similar equipment) that could possibly contact an energized underground cable or apparatus shall be grounded and barricaded utilizing approved methods described in this procedure.

11.0 ELECTRIC AND MAGNETIC FIELD INDUCTION

11.1 Voltages can be induced on vehicles and equipment that are in proximity to energized lines due to electric and magnetic field induction. If these vehicles and equipment are not in the work area and cannot possibly make contact with energized lines or equipment, they may be grounded with a discharge (static) ground cable to drain off these induced voltages.

12.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
12/01/2017	1.0	Updated for System Use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G027		
Electric Operating Procedure	**04-01-2015**	**General**	
Code Blue Emergency System Activation	**Revision #**	**1.0**	**Page: 1 of 6**

INTRODUCTION

The Code Blue Emergency System is designed to allow workers in the field the ability to broadcast an emergency condition and request assistance in obtaining ambulance, rescue, or police service to the scene of any company accident.

PURPOSE

This procedure applies to all field personnel, as well as anyone who operates a company radio.

ACCOUNTABILITY

1. Distribution Engineering Services
   A. Update procedure as necessary.
   B. Provide appropriate personnel guidance when requested.
2. Electric Distribution Operations
   A. Ensure that all field workers are trained in the Code Blue/AVLS procedure.
   B. Ensure that field workers receive refresher training annually (during the Bucket Rescue/Climbing Qualification refresher training or as appropriate).
   C. Provide revision input as necessary.
3. Liberty Utilities Employees, System Operators, and Dispatchers
   A. Demonstrate an understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

Liberty Utilities IT Business Support – Code Blue Testing Procedure

DEFINITIONS

Code Blue Emergency System: An emergency rescue system that uses company radios to alert Liberty Utilities employees that a worker is stricken and automatic vehicle locators to show the exact geographic spot where ambulances and/or other assistance will be sent.

AVLS: Automatic Vehicle Locating System – A system that provides satellite tracking of company vehicles equipped with an Automatic Vehicle Locating transmitter.

EDCC: Emergency Dispatch and Control Center, New Hampshire, 603-216-3612, -3613, or -3614.

TRAINING

Annual Training Required.

DOCUMENT CONTENTS

Table of Contents

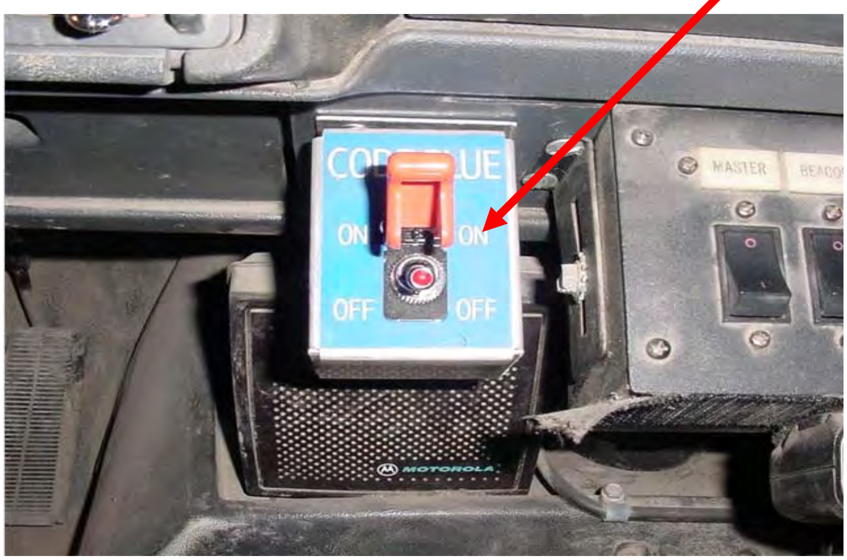
1.0 CODE BLUE EMERGENCY SYSTEM ACTIVATION

In the event of an emergency situation, the Field Worker shall activate the code blue emergency system.

Vehicles equipped AVLS:

1.1 Lift the protective cover of the Code Blue Switch.

1.2 Then place the toggle switch to the "On" position



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Electric Operating Procedure	04-01-2015	General	
Code Blue Emergency System Activation	Revision #	1.0	Page: 4 of 6

1.3 Wireless Code Blue Transmitter:

1.3.1 In trucks equipped with a Code Blue wireless transmitter, the transmitter should be placed on the field workers belt or vest especially when they are in the elevated position. The field worker activates the wireless Code Blue transmitter pressing the Code Blue activation button as shown below:

In the event of an accidental Code Blue activation, the field worker should immediately reset the transmitter (press both reset buttons, see above) and call the EDCC at 603-216-3612 or -3614. If a telephone is not available, the field worker should use a company radio to notify EDCC of the accidental activation.

2.0 CODE BLUE EMERGENCY RADIO ANNOUNCEMENT

2.1 **IN ALL CODE BLUE EMERGENCY SITUATIONS**, the field worker shall use the mobile radio and state three times:

CODE BLUE

CODE BLUE

CODE BLUE

2.2 Then provide the following information to the EDCC.

2.2.1 The complete address (street and town)

2.2.2 The vehicle number

2.2.3 Any significant landmarks or cross streets

2.2.4 Identification of ROW and nearest access (if applicable)

2.2.5 The type of accident and number of people injured

Dispatch should repeat back to crew – **"This is Dispatch; we have a CODE BLUE at "Location". All crews in area please respond. Please keep radio clear for emergency notifications".**

2.3 If radio communication is not available, the field worker shall initiate an alternate emergency notification procedure as discussed and documented in the pre-job briefing such as cell phone, radio communication with another company vehicle, or land line telephone.

Once a Code Blue Emergency has been declared over the radio all other radio traffic shall stop until EDCC has provided notification that the Code Blue situation has ended.

3.0 FAILURE OF SYSTEM OPERATIONS DISPATCH TO RESPOND TO CODE BLUE

3.1 In the event that a code blue is not acknowledged by the EDCC, another vehicle that hears the Code Blue can relay the Code Blue information to the EDCC via mobile radio. If assisting, provide your vehicle number and state the truck number for which you are reporting a Code Blue, along with the complete Code Blue information.

4.0 VEHICLES WITHIN THE VICINITY OF CODE BLUE EMERGENCY

4.1 Vehicles within the vicinity of the Code Blue Emergency may proceed to the Code Blue location to provide assistance after notifying the base that you are moving to the Code Blue location. When arriving at the Code Blue location, pay particular attention to any unsafe conditions such as:

4.1.1 Live wires on the ground.

4.1.2 Hazardous atmospheres in manholes, station control buildings, or any other confined space location.

5.0 NOTIFICATION TO RESCUE SERVICES

EMERGENCY DISPATCH and CONTROL CENTER (EDCC) NH

5.1 Acknowledge a code blue emergency situation and collects the following information from the field.

5.1.1 The complete address (street and town)

5.1.2 The vehicle number

5.1.3 Any significant landmarks or cross streets.

5.1.4 Identification of ROW and nearest access (if applicable)

5.1.5 The type of accident and number of people injured.

5.2 Repeat back to crew – **"This is Emergency Dispatch; we have a CODE BLUE at "the Location". All crews in area please respond. Please keep radio clear for emergency notifications".**

5.2 Collects information from the AVLS equipped vehicles.

5.3 Calls the City or Town Emergency services to respond to the scene of the Code Blue Emergency – only if requested by crew or if there is no response from the crew who reported the Code Blue.

5.4 Notify Supervisor (or on-call Supervisor) of Code Blue situation.

5.5 Standby to offer direction or assistance and monitor radio to hear field updates.

5.4 Provide notification over the company radio when Code Blue Emergency has ended by stating - **"All clear"**.

6.0 Responder/AVLS System Testing

6.1 The EDCC group is responsible for maintaining and conducting Responder/AVLS system tests quarterly. The test includes both hardwired Responder/AVLS vehicles transmitters and the wireless code blue Responder/AVLS transmitters and should be conducted in all the Liberty Utilities service areas. If any issues arise while performing Responder/AVLS system tests create a Help Desk ticket at helpdesk.libertyutilities.com and notify your supervisor.

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
4/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G028		
Electric Operating Procedure	**01-01-2017**	**General**	
Wood Pole Condition Assessment	**Revision #**	**1.1**	**Page: 1 of 8**

INTRODUCTION

This procedure applies to all Liberty Utilities employees or Liberty Utilities employed contractor (workers) whose work involves climbing a wood pole or performing work that would put added stresses on the pole.

PURPOSE

The purpose of this procedure is to outline the requirements for Liberty Utilities employees or Liberty Utilities employed contractors to properly assess the general condition of a pole prior to climbing or performing work that would put added stresses on the pole. It is a good utility practice to inspect the pole to be worked and the adjacent poles anytime the proposed work will put added stresses on the pole.

All appropriate PPE, which includes, but is not limited to, hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook.

All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and applicable Work Procedures, utilizing all appropriate safe work methods.

Before work begins a "pre-job brief" shall be conducted to identify the boundaries of the work area, the work methods to be used and all hazards associated with the job.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support and guidance when requested.
2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.
3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules

OSHA 1910.269 App D

OSHA 1910.268(n) (3)

American Wood Preservers Standards

Lineman's Quick Reference on Wood Safety

DEFINITIONS

Suspect Pole: A pole that is considered to have some pole defect (shell rot, insect damage, mechanical damage, etc.) that may reduce the pole strength but has not been inspected by a qualified pole inspection contractor.

Reject Pole: A pole that has been inspected and evaluated by a qualified pole inspection contractor to meet the NESC for strength and failed but may be a candidate for reinforcement and supplemental treatment.

Priority Pole: A pole that has been inspected and evaluated by a qualified pole inspection contractor to meet the NESC for strength and failed. It cannot be reinforced and no further groundline treatment is supplied.

TRAINING

Provided in Liberty Utilities training programs for effected personnel and/or as requested.

DOCUMENT CONTENTS

1.0 VISUALLY ASSESSING THE GENERAL CONDITION OF A WOOD POLE

1.1 A visual inspection must be completed prior to climbing a wood pole or performing work that would put added stresses on the pole. The visual inspection should take an overall look at the pole to assess its general condition and to look for any obvious defects. Obvious defects may include but are not limited to, shell rot, surface decay, insect damage, holes, large checks, horizontal cracks, excessive knots, twist in pole, burn marks, mechanical damage and soil conditions (soft, wet or loose). Workers should pay particular attention to the ground line area looking for buckling or unusual angle with respect to the ground. On all poles that the visual inspection showed any signs of aging, cracking or deterioration a sounding test inspection and/or probe test shall be conducted. Buckling and odd angles may indicate that the pole has rotted or is broken.

1.2 Additionally, a thorough pole top inspection must be conducted to evaluate such things as:

1.2.1 The condition of all equipment on the pole especially potted porcelain cutouts or switches;

1.2.2 The condition of the crossarms and pole top with particular attention to any signs of decay;

1.2.3 Any non-standard construction hazards.

1.3 Poles should not be climbed that contain horizontal cracks perpendicular to the grain of the wood, deep vertical cracks that go the center of the pole, large hollow spots or woodpecker holes that weaken the pole.

2.0 DETERMINING INFORMATION FROM THE POLE BRAND MARKINGS

2.1 The ANSI standard requires that wood utility poles are marked with the following information:

2.1.1 Supplier's code or trademark

2.1.2 Pole size and class

2.1.3 Plant and year of treatment pole species and preservative used

2.2 In addition to this information, the standard requires that the poles be marked at a set distance from the butt to ensure that the marking can be read easily after the pole is placed in service. Unless otherwise stated in a purchase order, marking on poles <50 ft long must be located 10 ft ± 2 inches from the butt end and the marking is located 14 ft ± 2 inches from the butt end for poles > 55 ft in length. Liberty Utilities's standards require that the marking be placed on the pole at 6 ft ± 2 inches above groundline for a properly set pole regardless of length.

2.3 Generally speaking workers can utilize the location of the brand marking on the pole to determine if the pole has been set to the proper depth (pole height/10 plus 2 ft), per Standards (Pole marking could be at 4ft ± 2 inches or at 6 ft ± 2 inches above grade for a properly set 40 ft pole). There are some exceptions to this rule of thumb.

CPT – Manufacturer information - Cahaba Pressure Treating

SPN08 – Southern Pine (SP), Copper Napthenate (N), 08 lbs./ft^3 of treatment chemical

B598 – Treating Plant Alabama (B), Month/Year of manufacturing (5/98)

3/45 – Size and Class of pole 45 ft Class 3

Note: Some poles treated with Copper Naphthenate prior to 1995 have failed prematurely. These poles are decaying from the inside out and cannot be detected visually or by routine hammer test. Failures have occurred at locations other than the groundline (i.e. pole top, telephone attachment height). Extreme caution must be used when working on or near these poles (refer to Attachment A - Copper Naphthenate Safety Alert for additional information).

3.0 SOUNDING INSPECTION

3.1 Sounding inspections are performed by striking the pole with a hammer and listening for differing sounds and feeling the rebound of the hammer off the pole. Sounding inspections are very subjective depending on the person performing the inspection and their experience with conducting this type of inspection. Workers should practice on sounding a known "sound" pole to develop a feel and an ear for the "sound" pole.

3.2 Workers should start the sounding inspection of a pole at the groundline and go around the entire pole then continue this sounding up the pole as far as the employee can reach. Workers should be listening for hollow sounds, clapping of wood or a dull, drum like sound. These types of sounds would be signs of the possibility of decay and further inspection would be required.

4.0 PROBE TEST

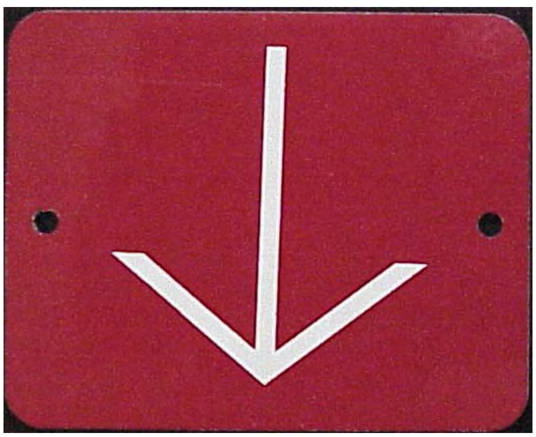
4.1 A large screwdriver, pointed metal bar or similar object (probes) should be used to probe around the base of the pole near the ground line to check for areas of decay on all poles that the visual inspection showed any signs of aging, cracking or deterioration. Take the screwdriver/probes and prod into the pole at the groundline. If the screwdriver/probe penetrates the pole easily, the pole should be considered "suspect".

Warning: You should never attempt to climb a pole that produced "suspect" results from a sounding inspection or a probe test unless the pole has braced or supported before climbing, then securely guyed.

5.0 DEFECTIVE POLE MARKINGS/TAGS

5.1 Reject Poles: Poles that have been inspected and evaluated by a qualified pole inspection contractor to meet the NESC for strength and failed but may be a candidate for reinforcement and supplemental treatment will be classified as "Reject poles" and marked with the tag on the left below.

5.2 Priority Poles: Poles that have been inspected and evaluated by a qualified pole inspection contractor to meet the NESC for strength, failed, cannot be reinforced and to which no further groundline treatment is supplied will be classified as a "Priority pole" and marked with the tag on the right below.



Reject Pole Tag

Priority Pole Tag

6.0 SAFE WORK PRACTICES

6.1 The following are examples of the safe practices to be followed in work on structures, along with all other safe work procedures which a specific job may require:

6.1.1 Before climbing, workers shall satisfy themselves that a pole or structure is strong enough to support them safely.

6.1.2 Structures that are questionable shall be braced or supported before climbing, then securely guyed.

6.1.3 Existing anchor guys shall be checked before climbing structures.

6.1.4 All unguyed dead-end poles shall be securely guyed, braced or supported before work is started.

6.1.5 Before working on a structure on which the stress is to be substantially changed, adequate guying (preferably in four directions), bracing, lashing or support shall exist.

7.0 PERFORMING WORK ON "SUSPECT", REJECT OR PRIORITY POLES

7.1 Operations personnel performing work on "suspect", reject or priority poles should preferably work from a bucket truck, whenever practical, and proper precautions should be taken such as securing the pole by ropes, guys, holding the pole with a digger derrick or by setting a new pole along side the "suspect", reject or priority pole. When a new pole has been set next to the defective pole, the new pole shall be lashed to the defective pole (refer to NG-EOP D005 – Distribution Pole Lashing). All work on the defective pole should be performed from the new pole or from a bucket truck.

7.2 Whenever a "suspect", reject or priority pole (defective pole) is inaccessible by line equipment (line truck, digger derrick or track vehicle), adequate guying (preferably in four directions), bracing, lashing or support shall exist before work is performed. Before climbing, employees should be satisfied that the pole has been secured/supported enough to safely support them if the structure has to be climbed.

8.0 ATTACHMENT A - SAFETY ALERT

SAFETY ALERT

Premature Failure of Copper Naphthenate Treated Wood Poles

Distribution poles in the Watertown, Ogdensburg, Potsdam and Malone districts are failing prematurely. Poles are decaying from the inside out and cannot be detected visually or by routine hammer tests at the base of the pole. Deterioration is occurring well above the ground line, on the upper part of the pole.

We estimate that approximately 4500 poles were purchased and installed in the Northern Region prior to the 1998 Ice Storm. Unknown pole quantities have also been placed by Joint Owners; e.g., Alltel, throughout NM service territory.

Copper Naphthenate treated poles have the letter 'N' on the third line of the pole stencil as shown below.

- CPT indicates the manufacturer, Cahaba Pressure Treating Plant. Other manufacturer markings such as TLCOB may be encountered.
- B593 means that the pole was manufactured in Alabama in May of 1993. Dates will vary. No link has been established between the decayed poles and the month of manufacturing.
- SPN08 – This is the marking that determines that the pole was treated with Copper Naphthenate. The SP means Southern Pine, N means Copper Naphthenate. 08 means that the pole as treated to a retention level of 0.08 lbs. of elemental Copper/cubic foot of wood. Other treatment retention levels of 06 (SPN06) and 04 (SPN04) may be encountered. It may be possible that other species of poles other than Southern Pine were used.
- 3-45 means a Class 3 pole, 45 ft. long.

IF YOU ENCOUNTER THESE POLES, EXTREME CAUTION MUST BE USED.

- Inspect brand markings prior to climbing or performing maintenance.
- Identify Copper Naphthenate poles (marked with the 'N') as DANGER pole. Place red tag pointing towards the top of the pole to inform others.
- Fill out Copper Naphthenate Inventory Management Document (attached).
- Notify supervision immediately.
- If removed from service, save deteriorated poles (Law Department request).
- Supervision - Notify Mike Abbott, T&D Work Methods – 315-428-5340 in Syracuse.

9.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
01/01/2014	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
01/01/2017	1.1	Updated for System use	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G030		
Electric Operating Procedure	**12-01-2015**	**General**	
Primary Circuit Overvoltage Incidents	**Revision #**	**1.0**	**Page: 1 of 12**

INTRODUCTION

Liberty Utilities vision is to be a world-class safety organization, with zero injuries every day. This EOP will provide guidance to employees when they encounter de-energized Distribution Circuits that have experienced specified types of "overvoltage" incidents.

PURPOSE

The purpose of this document is to provide workers with a procedure for responding to specific types of overvoltage incidents that may occur on distribution conductors or circuits and to provide guidance as to the appropriate inspections that should be conducted, notifications for assistance and for re-energization procedures of the affected circuit/customers.

ACCOUNTABILITY

1. Standards, Policies and Codes
   A. Update procedure as necessary.
   B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements.

2. Electric Distribution Operations
   A. Ensure that all components of this EOP are understood and implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   A. Demonstrate an understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

COORDINATION

Not Applicable.

REFERENCES

LU-EOP G014 Clearance and Control
LU-EOP D002 Overhead Distribution and Sub-Transmission Personal Protective Grounding
Liberty Utilities Employee Safety Handbook
OSHA 1910.269

DEFINITIONS

Circuit: A conductor or system of conductors through which an electric current is intended to flow.

De-energized: Free from any electrical connection to a source of potential difference and from electrical charges. Not having a potential difference from that of earth.

Note: The term is used only with reference to current-carrying parts which are sometimes alive (energized).

Electrically Isolated: All switches, jumpers, taps or other means through which known sources of electrical energy may be supplied to the particular lines and equipment have been opened.

Incident Commander: The designated responsible person to take charge of and coordinate all activities and departments during an incident.

Main Disconnect: A device by which an electrical system can be disconnected from its source of power.

Meter Socket: An enclosure that contains line and load receiving blade terminals that serves as the point on the electric distribution system for metering of electric power.

Overvoltage: A level of voltage that is above the nominal high range of voltage on a conductor, or piece of electrical equipment for any given circuit.

Person In Charge of Work: A qualified person responsible for the work to be performed.

Primary Voltage: All distribution circuit cables or conductors energized at 4, 15, 23, or 34.5 kV.

Qualified Person: A person knowledgeable in the construction and operation of electric generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premise served.

Shall: The word shall is to be understood as mandatory.

Should: The word should is understood as advisory.

System Operator: An authorized person, who directs, controls, monitors, and operates the electric system and its associated apparatus.

TRAINING

Provided in Liberty Utilities L&D training Programs for effected personnel and or as requested.

DOCUMENT CONTENTS

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1.0 SAFETY

1.1 All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and all appropriate Liberty Utilities Electric Operating Procedures.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 If there is more than one worker assigned to the task, the employee in charge of the work shall conduct a written job brief with the employees involved prior to the start of each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

1.4 Only approved test instruments as specified by Supervisor or Manager and LU-EOP G019 - Test Devices and Testing Procedures before Performing Work on De-Energized, Tested De-Energized and Grounded Distribution and Sub-Transmission Circuits shall be used to test a circuit, conductor or equipment as de-energized.

1.5 All switching, Tagging and Testing shall be done in accordance with LU-EOP G014 Clearance and Control.

2.0 GENERAL INFORMATION

2.1 “Overvoltage” conditions may occur routinely on a primary distribution circuit because of many different incidents such as switching transients, phase to phase, or phase to ground conductor faults, voltage regulation events, lighting, etc., these incidents are usually very short duration and of minor consequence to the operation of our Electrical Distribution System. This EOP is to address specific overvoltage conditions that are caused by the following incidents:

2.1.1 Contact to a lower voltage distribution conductor or circuit from a conductor/conductors of a higher voltage transmission, sub-transmission, or distribution circuit that is either overbuilt or crossing the lower voltage primary distribution circuit conductors.

2.1.2 A single phase outage to the primary side of a Wye-Delta three-phase step-down transformer bank with an outage or unbalance on the secondary (load) side.

2.1.3 Energization of customer load from a step-up or step-down transformer with incorrect voltage tap settings that results in abnormal high voltage to the company secondary and customer’s equipment.

Note: This EOP does not address overvoltage incidents that occur when a transmission, sub-transmission or distribution conductor/circuit contacts either a secondary conductor or service wire.

2.2 An overvoltage condition to the primary distribution system caused by one of the above listed incidents may result in the normal operating voltage on the primary conductors of a circuit to elevate to a level high enough above the normal operating ranges for that circuit and for a long enough duration that damage to customer or utility electrical equipment may be experienced. When an increased voltage exposure may have been experienced, a work plan to survey Company electrical equipment and metering for possible damage prior to re-energization of the circuit following an overvoltage incident should be developed.

2.3 These overvoltage incidents may cause discoloration and failure of the electronic circuitry in Company electronic style meters. There is a built in surge arrester located across the hot terminals (phase-to-phase) in these electronic meters that is designed to suppress voltage surges and protect the internal circuitry of the meter should a lower level of overvoltage occur. When overvoltage incidents occur related to the three types of incidents listed above, the overvoltage surges may result in voltages that are above the rating of this internal lightning arrester; this can result in failure of the lightning arrester, discoloration of the meter shell and meter registration failure.

2.4 The following three examples will explain the three distinct different types of overvoltage incidents that this EOP is addressing:

2.4.1 EXAMPLE #1: An incident has occurred where a phase conductor from a 34.5 kV sub-transmission circuit has made contact with a phase conductor on an under built 4800 volt Delta distribution circuit. To estimate the approximate overvoltage that was imposed on the 4800 volt Delta distribution circuit conductors you would need to know the phase angle relationships of both the 34.5 kV and the 4800 volt Delta circuits along with information regarding which phases of each circuit were involved in the contact. The resulting voltage to the 4800 volt Delta distribution circuit will be highest when the conductor form each of the circuits is180 degrees out of phase. When this type of contact occurs the level of increased voltage to the primary distribution conductor would be restricted (clamped) due to the following:

(a). The lightning arrester protection for the distribution system primary conductors, electrical equipment and transformers, if installed per the Liberty Utilities Distribution Standards is designed to restrict (clamp) the maximum voltage rise of the 4800 volt Delta distribution circuit during any overvoltage incident to approximately 10 kV.

(b). The increased voltage on the distribution system primary conductors could result in the transformer's core becoming saturated and restricting the full level of overvoltage output on the secondary system.

2.4.2 EXAMPLE #2: A motor vehicle accident has occurred on a 4.8 kV three-phase circuit that is being fed from a Wye-Delta step down transformer bank. One of the phases of the 4.8 kV circuit is down one section away from the step down bank and is burning. The accident has caused one of the fuses on one of the phases feeding the high side of the step-down bank to blow and de-energize one of the 7.6 kV phases feeding the transformer bank. The loss of this phase without closing the neutral by-pass switch on the wye-delta step down bank causes the customers on the 4.8 kV side of the step down bank to experience a high voltage surge. The level of overvoltage on the 4.8 kV transformers is dependent on the secondary load connected to the two remaining energized transformers in the step-down bank. If the load is equally balanced on the 4.8 kV load side of each transformer the resulting secondary voltage on the 4.8 kV transformers will be less than the normal 120 volt legs. If there is a severe imbalance and one transformer is carrying a large load and the other is carrying almost none, there will be a shift in voltage on the transformers in proportion to the imbalanced load.

2.4.3 EXAMPLE #3: A line crew has installed a new dual ratio 2,400/7,620 transformer on a 7,620/13,200Y distribution circuit. The internal mechanical tap selector switch did not change to 7,620 volt tap setting, it remained on the 2,400 volt setting. What would the approximate overvoltage to the nominal 120 volt secondary be?

$$\text{Transformer Coil Ratio} = \frac{\text{Primary voltage of current transformer tap setting}}{\text{Lowest nominal output voltage of transformer}}$$

$$\text{Transformer Coil Ratio} = \frac{2400 \text{ volts}}{120 \text{ volts}} = \frac{20}{1} = \text{20-to-1}$$

AND

$$\text{Overvoltage to nominal 120 volt secondary} = \frac{\text{Actual primary voltage applied to transformer}}{\text{transformer coil ratio}}$$

$$\text{Overvoltage to nominal 120 volt secondary} = \frac{7620}{20} = 381 \text{ volts}$$

(a). Therefore; any customers that may have been connected to the secondary net of this transformer when it was energized would have seen their nominal secondary voltage of 120/240 volts increase to approximately 381volts phase to ground and 762 volts phase to phase. This voltage may damage customer electrical and electronic equipment, but it will not damage customer service entrance equipment or wiring.

(b). The formula above may be used to calculate the approximate overvoltage for other voltage specific incidents.

2.5 The level of overvoltage that may result from each of the three examples listed above may cause damage to Company electronic meters, motors and 120 volt electrical equipment, but the overvoltage levels from these type incidents should not elevate to a level that would cause failure of service entrance equipment or wiring.

2.5.1 Using these examples as guidance, employees must review the details of each overvoltage incident, determine the cause and evaluate the approximate maximum voltage rise that may have occurred on 120 base for the secondary hot leg, customer's service entrance, or customer equipment connected to this lower voltage primary distribution circuit.

3.0 RESPONSIBILITIES AND NOTIFICATIONS

When workers encounter an electric interruption that was caused by, or involved with an incident due to one of the above listed overvoltage conditions to the electrical distribution circuit and that overvoltage may have caused damage to Liberty Utilities owned and maintained electrical equipment (e.g. lightning arresters, transformers, overhead wires and meters) an inspection shall be conducted. This first inspection shall be titled "The Initial Inspection", and include all Company electrical equipment and Company meters within a 1000 feet of the problem source that caused the overvoltage, or to the first customer connected to the circuit in any direction of the overvoltage source, whichever is greater ("Initial Inspection").

When the initial inspection has been completed the person in charge shall contact the System Operator and inform him/her of all findings. The System Operator, after evaluating the information reported by the field, may elect to complete repairs and restore the circuit to service, or may require that notifications and additional inspections as defined within this procedure be conducted prior to re-energization of any customers. The System Operator is responsible to direct the procedures that shall be utilized by the field workers for the switching and tagging methods to be used for repair and restoration of the conductor/circuit. All switching to isolate the damaged area will be completed prior to implementation of this procedure, and restoration to customers isolated from the damage will take priority. If the initial survey indicates damage to any Company electrical equipment, but there are no apparent signs of discoloration or damage to Company metering devices, the repair to or isolation of the damaged equipment and re-energization of the circuit may proceed following established accepted safe work practices.

3.1 If the initial survey indicates damage or discoloration to Company electrical metering devices within the initial inspection zones the following notifications shall be made:

3.1.1 The person in charge of the work at the incident location shall contact the System Operator to request notification of the responsible Supervisor or on call supervisor if off hours for the location of the incident. The following information will be provided to the System Operator:

(a). Location of incident (feeder number, street/road name, town/city, pole number and a house # in general area.)
(b). Details regarding overvoltage problem
(c). Observed or suspected equipment damage
(d). Approximate repair times
(e). Additional field resources if necessary

3.2 The Supervisor or their designee will determine the necessary plan of action for repairs, inspections and re-energization of the circuit after discussions with the person in charge of work at the incident and/or a site visit to the incident to access the problem. If, after compiling all the facts, the Supervisor feels additional resources or notifications are necessary, these notifications shall be made through the System Operator.

3.2.1 The Supervisor will contact the System Operator and provide an update including any additional details regarding the overvoltage Incident. The EDO Performance Supervisor shall verify that the System Operator has all of the appropriate information as required in section 4.2.1. Specific emphasis should be given to the following information:

(a). The location and number of the protective device that operated or was operated to interrupt the portion of the circuit affected by the overvoltage condition

(b). The exact location for the source of the overvoltage incident (feeder number, street/road name, town/city, county and pole number).

3.2.2 The System Operator and the Supervisor will discuss the work practices and procedures that will be utilized for switching, tagging, and restoration of the circuit.

(a). The System Operator will be responsible to either direct all switching activities for the restoration of the conductor/circuit or may delegate the switching and restoration of the conductor/circuit to the Supervisor.

1. If the System Operator retains the responsibility for directing all switching and restoration activities, the Supervisor will coordinate all field repair activities and communicate with the System Operator regarding the completion of repair and approval for re-energization of repaired sections of the circuit.

2. If the System Operator delegates approval for switching and restoration activities to the Supervisor the Supervisor shall notify the System Operator as switching and restoration activities are complete for any portion of the circuit.

3.3 If an incident on the distribution on the distribution system involves significant damage to Company and/or Customer equipment and will require coordination of efforts from multiple departments to facilitate restoration of service the EDO Performance Supervisor will be designated as the “Incident Coordinator” and will be the responsible person in charge of work to coordinate all work activities. When multiple departments are involved in an overvoltage incident, no portion of the interrupted circuit will be restored until communications from each department’s “person in charge of work” has been made to the Incident Coordinator notifying him/her that all work in that zone/section has been completed, workers are in the clear and have been advised to treat the circuit as energized.

3.3.1 Incidents that result in damage to Company metering devices will require coordination with the Metering Department. The Supervisor shall notify the Meter Supervisor.

3.3.2 ALL incidents that result in damage to customer service equipment, customer premise wiring or customer electrical equipment requires notification of the Liberty Utilities Claims Department (Legal Department). The Company has hired a Claims Consultant to oversee the investigation of any incident or event that may result in claims against the Company. In the event of such incident or event, the Consultant will dispatch to the scene forensic investigators on behalf of the Company, whose purpose is to collect potential evidence to defend or resolve any claims that may arise out of the incident or event. Company personnel should cooperate fully with any of the Consultant's claims investigators. When the claims department has been notified of an incident then the Manager or Director of Electric Operations should be notified.

3.4 The Metering Supervisor will contact the "Incident Coordinator" to discuss the scope of the overvoltage incident and coordinate the resources that will be needed to conduct an inspection of Company metering or customer service entrance for possible damage prior to re-energization of customer's service.
If damage was found at the customer service entrance notification to the local wire inspector or AHJ (Authority Having Jurisdiction) to coordinate any repairs necessary.

3.4.1 The Metering Supervisor may contact the System Operator to obtain any additional information regarding the customer count on any specific isolation device.

(a). When given the appropriate information the System Operator can provide customer counts from Responder for the number of customers feeding from a specific isolation device on the circuit. This information will help the Supervisor analyze the scope of the work and number of field Metering Service personnel that will be needed for the inspection process.

(b). A query shall be made by the Metering Supervisor or their designee to provide a comprehensive list of all customers and meter numbers that exist downstream on a distribution circuit or tap from a given isolation point, pole number, or customer address.

4.0 INSPECTION PROCESS

If damage to Company owned and maintained electrical equipment has been observed within the initial inspection zone, the following additional inspection zones and processes will be established:

4.1 Electric Operations Line Workers: A visual inspection of all Company owned and maintained electrical equipment shall be conducted by line workers to check for signs of damaged electrical equipment (e.g. lightning arresters, transformers, regulators, capacitors, switches and overhead wires). The damaged area will be divided into zones as described below. Restoration of the affected circuit shall be under the direction of the System Operator or their designee.

4.1.1 If the overvoltage exposure was due to contact of a distribution voltage circuit/conductor with a higher voltage transmission, sub-transmission or distribution circuit/conductor the inspection zone shall extend 1000 feet in any direction from the end of the initial inspection zone, or to the first customer in each direction if there are no customers within the a 1000 feet zone.

(a). If damage from the overvoltage incident is evident to Company electrical equipment within this zone the process shall be expanded an additional 1000 feet. This process shall be continued by expanding into additional 1000 feet zones until a full zone is identified as having no damage to Company electrical equipment (except for discoloration of Company meters).

(b). No portion of the interrupted circuit shall be re-energized until either a 1000 foot zone is found absent of damage to Company electrical equipment (except for discoloration of Company meters), or a zone between two isolation devices is found to be absent of damage to Company electrical equipment (except for discoloration of Company meters).

(c). No device shall be operated to re-energize a portion of a circuit that was interrupted due to a circuit overvoltage until permission has been received from the System Operator or their designee.

4.2 Electric Operations Line Workers Performing Company Meter Inspections: If due to the limited magnitude of the affected overvoltage area, or lack of availability of Metering Services Representatives, the Operations Supervisor utilizes Line Workers to conduct the inspection for discoloration or damage to Company metering devices, the same procedures as listed below for Metering Services Representatives shall be followed by the Line Workers. All findings and documentation will be reported to the Operations Supervisor.

4.3 Metering Service Representatives: If MS personnel are notified and summoned, an inspection of Company metering devices shall be conducted to look for signs of damage or discoloration to Company metering devices. The zones for inspection will be set up the same as that stated above for Line Workers. The Metering Services Supervisor, when applicable, will coordinate this process and direct the Metering Services Representatives as to the scope of the inspections

that should be performed.
When the inspection process in any zone has been completed and the only damage that is observed is discoloration of Company meters the inspection process may be discontinued. The following guidelines shall be utilized by Metering Services Representatives for the inspection Process:

4.3.1 Inspect the Company metering device; look for discoloration, signs of burning or melting.

4.3.2 If no damage or discoloration is observed to the meter, no additional inspections are required.

4.3.3 If damage is observed to the Company meter, remove the metering device from meter channel and inspect the meter channel; look for melted or broken insulators, burnt or arced contacts, or melted insulation.

(a). If any damage is observed to the customer meter channel the Customer Metering Services Supervisor shall be notified. The Customer Metering Supervisor will make the notifications to the customer regarding any repairs and/or electrical inspections that will be required prior to re-energization of the service.
(b). The Customer Service Supervisor will contact the Incident Coordinator with all pertinent information regarding a service that has been identified as defective and/or in need of repair to arrange to have taps cut clear prior to the circuit re-energization.

4.3.4 If damage is found to the Company meter, but no other damage to the meter channel is observed the Metering Services Representative may replace the meter.

4.4 The Metering Service representatives will report to the Metering Services Supervisor providing a list detailing all findings of damage to Company meters or customer meter channels within each individual zone and acknowledge that all meter installations within the zone have been inspected and are clear for re-energization or have been identified as needing repairs and have been reported.

4.4.1 The Metering Services Supervisor will be responsible for notification to the Incident Coordinator as each zone is cleared for re-energization.

4.4.2 The Incident Coordinator will communicate to the Metering Services Supervisor when the circuit or a portion of the circuit is re-energized.

4.4.3 The Metering Services Supervisor will notify all Metering Service representatives that the circuit or a portion of the circuit has been re-energized.

4.5 When inspections have been completed in a specific work zone and no additional damage other than discoloration of Company meters has been observed the inspection process shall be discontinued and the following notification made:

4.5.1 Metering Services Representatives notify the appropriate Metering Services Supervisor.

4.5.2 Metering Services Service Supervisor notifies “Incident Coordinator”.

4.5.3 Electric Operations Line Workers notify the “Incident Coordinator”.

NOTE: **This inspection process is not intended to inspect, log or report damaged customer owned electrical or electronic equipment other than damaged meter channels that would preclude the customer from being re-energized. The Company Claims Department or their designee may perform this.**

5.0 DOCUMENTATION

All pertinent information regarding the “Overvoltage Incident” will be assembled by the following disciplines and copies provided to the incident coordinator who will assemble all documents and file those in the appropriate Department office for reference:

5.1 Electric Operations System Control and Emergency Dispatch – to provide:

5.1.1 Trouble Outage report

5.1.2 Copy of appropriate GIS or feeder Index map indicating the following information:

(a). Overvoltage source or contact location.
(b). Isolation device that operated or was operated to isolated the problem.
(c). Area effected by the overvoltage incident.
(d). Outage restoration details (switch, location & time)

5.2 Electric Operations Supervisor – to provide:

(a). Damaged Company electrical equipment.
(b). Electrical Operations Lineworkers work timesheets.
(c). Any field trouble reports generated.

5.3 Metering Services Representatives – to provide:

(a). Meter replacement information (defective meter number, replacement meter number, customer’s name and address) to Metering Services Supervisor.
(b). Completed meter removal tag with defective meter
(c). Completed Meter Installation form

5.4 Metering Services Supervisor – to provide:

(a). Meter replacement information (defective meter number, replacement meter number, customer's name and address).

(b). List of any customers that were re-energized with temporary repairs

(c). List of any Customer's that were Not re-energized, and are in need of repair.

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP G033		
Electric Operating Procedure	**12-01-2017**	**General**	
Re-Energization of Circuits	**Revision #**	**1.1**	**Page: 1 of 6**

INTRODUCTION

This procedure provides direction to Control Center Operations and field personnel (section 5.1) with respect to re-energizing circuits. This procedure describes what needs to be considered when determining whether to re-energize a circuit or first conduct a line patrol.

It is the responsibility of System Control to use their good judgment and consult with field personnel as necessary to assess the circumstances and make a determination on why the circuit tripped, and whether the line needs patrolling prior to attempting to re-energize.

This procedure applies to all sub-transmission and distribution circuits on the Liberty Utilities System. Any reference to circuits or lines includes sub-transmission and distribution lines, unless stated otherwise.

PURPOSE

The purpose of this procedure is to guide decisions with respect to re-energizing circuits.

ACCOUNTABILITY

1. Standards, Policies and Codes
   A. Update procedure as necessary.
   B. Provide appropriate guidance when requested.
2. System Control/Electric Distribution Operations
   A. Ensure the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.
3. Employees
   A. Demonstrate the understanding of this procedure.
   B. Comply with the requirements of this procedure.

REFERENCES

Liberty Utilities Employee Safety Handbook and Safety Rules
LU-EOP G014 Clearance and Control

TRAINING

Provided in Liberty Utilities training programs for effected personnel and/or as requested.

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The following procedures must be used when making the determination on how to proceed with re-energizing circuits:

1.0 CIRCUITS WITH AUTO-RECLOSING

1.1 If there is a Non Reclose Assurance (NRA) on the reclosing relay or Hot Line Tag on the circuit breaker or pole top recloser, contact the Authorized Person (s) holding the NRA to determine if any Liberty Utilities personnel or Contractors may have caused the circuit to trip.

1.1.1 If they have caused the trip:

a. Make arrangements for emergency assistance and/or repairs, if necessary.

b. Obtain permission from the Authorized Person (s) holding the NRA to re-energize and confirm all Liberty Utilities and/or Contractor personnel are clear of the circuit.

c. Re-energize the circuit.

1.1.2 If they did not cause the trip:

a. Monitor trouble calls, 911 calls, and all available information (EMS Alarms, SCADA) for the “cause” of the circuit lockout.

b. If there is no evidence of a fault, the circuit may be re-energized within a reasonable period of time of the **trip;** otherwise a ***Risk Assessment*** must be conducted. **For purposes of this procedure, the Control Center will use 10 minutes as guideline for determining a reasonable timeframe but conditions may dictate a different timeframe.**

1.2 If there is <u>**no**</u> Non Reclose Assurance (NRA) in place on the circuit and the circuit has tripped, reclosed, and locked out, the System Operator should consult with known field

personnel in the areas when possible and complete a ***Risk Assessment*** (*see **Risk Assessment** of this procedure)* to determine whether the trip was likely due to a temporary fault on the line, or whether the line should be patrolled before attempting to re-energize.

1.3 If the circuit has tripped and has not completed the normal reclosing cycle,

a. Monitor trouble calls, 911 calls, and all available information (EMS Alarms, SCADA) for the “cause” of the circuit lockout.

b. Consider if any Liberty Utilities personnel or Contractors may have caused the circuit to trip.

c. If there is no evidence of a fault, the circuit may be re-energized within a reasonable period of time of the **trip;** otherwise a ***Risk Assessment*** must be conducted. **For purposes of this procedure, the System Control will use 10 minutes as guideline for determining a reasonable timeframe but conditions may dictate a different timeframe.**

2.0 <u>CIRCUITS WITHOUT AUTO-RECLOSING</u>

2.1 If there is a Non Reclose Assurance (NRA) on the circuit, contact the Authorized Person (s) holding the NRA to determine if any Liberty Utilities personnel or Contractors may have caused the circuit to trip.

2.1.1 If they have caused the trip:

a. Make arrangements for emergency assistance and/or repairs, if necessary.

b. Obtain permission from the Authorized Person (s) holding the NRA to re-energize and confirm all Liberty Utilities and/or Contractor personnel are clear of the line.

c. Re-energize the line.

2.1.2 If they did not cause the trip:

a. Monitor trouble calls, 911 calls, and all available information (EMS Alarms, SCADA) for the “cause” of the circuit lockout.

b. Determine if any Liberty Utilities personnel or Contractors may have caused the circuit to trip.

c. If there is no evidence of a fault, the circuit may be re-energized within a reasonable period of time of the **trip;** otherwise a ***Risk Assessment*** must be conducted. **For purposes of this procedure, the Control Center will use 10 minutes as guideline for determining a reasonable timeframe but conditions may dictate a different timeframe.**

2.2 If there is **no** Non Reclose Assurance (NRA) in place on the circuit:

2.2.1 The System Operator shall complete a ***Risk Assessment***
2.2.2 If re-energizing the circuit was successful, consider the need for a circuit patrol to confirm the integrity of the line.
2.2.3 If re-energizing the circuit was unsuccessful, the System Operator shall consult with field personnel to complete a patrol of the line.

3.0 <u>MAJOR STORM EVENTS (HURRICANES, TROPICAL STORMS, ICE/WET SNOW STORMS)</u>

3.1 It is permissible to re-energize ***Transmission and Sub Transmission Circuits*** when <u>**one or more**</u> of the following criteria are met and a ***Risk Assessment*** has been conducted:

3.1.1 A circuit has tripped and failed to reclose in its normal reclosing process.

3.1.2 A circuit has been sectionalized and re-energizing the circuit is paramount to providing a source to one or more substations.

3.1.3 The line has been patrolled and reported as being ready for service.

3.2 It is permissible to re-energize ***Distribution Circuits*** when <u>**one or more**</u> of the following criteria are met:

3.2.1 The entire feeder including all side taps has been patrolled and reported as being ready for service.

3.2.2 The feeder mainline has been patrolled and unpatrolled side taps are opened to isolate faulted or potentially faulted areas and the section of the feeder to be energized is reported as being ready for service.

3.2.3 A risk assessment with field personnel determines that no further isolation or patrols are required due to lack of storm damage to distribution equipment in the area. (This may be considered after loss of source to a station or stations for instance)

4.1 When a ***Risk Assessment*** is required to determine how to proceed with re-energizing a circuit, the following (<u>but not limited to</u>) should be considered:

4.1.1 Weather caused a temporary fault on the line. (Lightning, wind, ice or snow building up on the lines)

4.1.2 Salt spray and insulator contamination.

4.1.3 Birds or animals may have caused a temporary fault.

4.1.4 Indications that it was a transient or temporary fault.

4.1.5 No power for traffic lights, street lighting, for medical facilities and emergency response, public conveyance systems, elevators, heating and ventilation systems, etc.

4.1.6 SCADA information, equipment alarms or protective relay information provide insights into the nature or location of the fault that caused the line to trip.

4.1.7 Time of day and location of the line or suspected fault area.

4.1.8 Road crossings, sidewalks, developed areas or places where the public are known to gather.

4.1.9 Indications of a public contact or that Liberty Utilities crews or Contractors may have caused the fault.

4.1.10 Calls have been received from emergency personnel or the public indicating that an accident has occurred in the vicinity of the line.

4.1.11 There is a risk of causing equipment damage or line failure by re-energizing a possible fault condition.

4.1.12 Consult with known field personnel for additional insights to the potential cause and to determine if a patrol is required prior to re-energizing the circuits.

4.1.13 Added due diligence is required prior to re-energizing a circuit if it has significant underground circuit sections, significant double circuit sections, or if it has an under-built line that has also tripped.

4.1.14 Once the Risk Assessment is complete, the System Operator will determine whether to reenergize the circuit or initiate a line patrol.

4.1.15 If the decision was to re-energize the circuit without a patrol and it was successful, consider a line patrol to confirm the integrity of the line.

5.0 <u>LINE PATROLS</u>

5.1 Individuals meeting the below classifications are authorized to direct and or perform Restoration Patrols:

5.1.1 Rated/Qualified Line Worker/Mechanic

5.1.2 Qualified Electric Operations Supervisor

5.1.3 Restoration Crew Supervisor and/or Field Construction Coordinator

5.1.4 Qualified Electric Operations Engineer

Note: Individuals shall be an Authorized Person and have all of the following qualifications:

a. Shall be an employee or contractor working for Liberty Utilities.
b. Shall be trained in and knowledgeable of the Clearance and Control Procedure.
c. Shall have appropriate knowledge of the type of apparatus included in the Patrol.
d. Shall have the ability to direct the performance of the work to be done.

5.2 In order to ensure an accurate and effective patrol, the individual or crew should have the following materials with them:

5.2.1 Accurate Feeder/Circuit Map

5.2.2 Geographic Map or knowledge of the area

5.2.3 Circuit Single Line / Index Diagram

5.3 In situations where Feeder/Circuit/Index maps are not available, circuit open points must be verified with the System Operator prior to initiating the patrol to ensure full understanding of circuit configuration.

5.4 Patrollers must ensure any abnormal conditions which may exist that could result in an electrical fault or hazardous situation are identified, cleared and/or isolated. (All LU-EOP GO14 procedures shall be followed).

5.5 Personnel shall put reclosing ***Off***, if arriving at a station/recloser where the breaker/recloser is Open.

5.6 When locations on a circuit exist where extreme conditions (flood, swamp, deep ravine, etc.) render impacted areas impassable or otherwise not feasible to physically patrol, the use of binoculars, aerial patrol or best utility practice is an acceptable method to verify circuit integrity.

5.7 In order to expedite restoration of as many customers as possible, isolate (cut clear) problem areas on the three phase main line or single phase taps, especially those single phase taps requiring long off road patrols. (All LU-EOP GO14 procedures shall be followed)

5.8 Contact the System Operator when the assigned patrol is completed and report all portions of circuit that are available to be energized.

6.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
03/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson
12/01/2017	1.1	Updated for System use.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D001		
Electric Operating Procedure	**12-01-2013**	**Overhead**	
Cutouts Open/Enclosed Type	**Revision #**	**1.0**	**Page: 1 of 8**

INTRODUCTION

This procedure will provide information and the appropriate work methods for employees that are required to perform any work (primary or secondary) at a pole, structure or vault that has open or closed type porcelain style cutouts at that location. All distribution equipment has a limited life expectancy and over time failure of any equipment is inevitable. Adherence to proper procedures shall always be utilized to minimize the risk of any hazard that could occur from a failure.

PURPOSE

This EOP will apply to all qualified workers who may perform work on or near exposed energized equipment.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies and Codes
   A. Update procedure as necessary.
   B. Provide personnel guidance and assistance as requested.
2. Electric Distribution Operations
   A. Ensure all components of the procedure are implemented.
   B. Ensure Operations personnel are trained in this procedure.
   C. Provide revision input as needed.
3. Employee or Liberty Utilities contractor
   A. Demonstrate an understanding of the procedure.
   B. Comply with all requirements of the procedure.
4. Liberty Utilities Learning and Development
   A. Provide appropriate training on the procedure as requested.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
OSHA 1910.269
NESC 2012 edition
All applicable Liberty Utilities Procedures

DEFINITIONS

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Barricade: A physical obstruction such as tapes, screens or cones intended to warn and limit access to a hazardous area.

Barrier: A physical obstruction that is intended to prevent contact with energized lines and equipment.

Effectively Grounded: Being connected to the earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the building up of voltages that may result in undue hazard to connected equipment or to persons.

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity

Exposed – Not isolated or guarded.

Isolated: An object that is not readily accessible to persons unless special means of access are used.

Guarded: Protected by personnel, covered, fenced, or enclosed by means of suitable covers or casings, barrier rails, screens, mats, platforms, or other suitable devices in accordance with standard barricading techniques designed to prevent dangerous approach or contact by persons or objects

Shall: The word “shall” indicates provisions that are mandatory

Should: The word “should” indicates provisions that are normally and generally practical for the specified conditions

TRAINING

Training to be provided by appropriate Liberty Utilities training program, progression training and AET as indicated. This shall be provided by Learning and Development.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All appropriate Personal Protective Equipment **(PPE),** which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable procedures.

1.2 The employee in charge of the work shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, procedures involved, special precautions, and PPE Requirements.

2.0 BACKGROUND OPEN AND ECLOSED TYPE FUSED CUTOUTS

2.1 The general design of cutouts has undergone modification over time. This procedure is intended to highlight the progression and limitation resulting in the transition from enclosed style cutouts, to banded style cutouts, to potted style cutouts, and finally polymeric style cutouts.

2.2 Enclosed cutouts are designed to enclose the fuse tube with top, bottom and center mounting assemblies cemented into the cavity in the porcelain body. Banded style cutouts have the center mounting pin, top, and bottom assemblies U bolted to the porcelain fuse body. Potted style cutouts have the top, bottom and center mounting assemblies cemented into a cavity in the porcelain body. The Polymeric cutout is designed using an internal fiberglass rod with attachments either bolted or molded to the rod with a covering of polymeric material (silicone rubber and/or EDPM).

2.3 The failure mode of each type of cutout differs; however, all have a finite life expectancy. General failure modes (but not limited to) for the different types of cutouts are as follows:

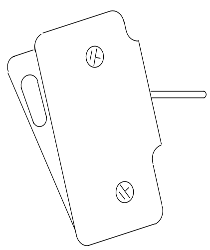
2.3.1 Enclosed type cutouts fail due to internal contamination/tracking and porcelain breakage.

2.3.2 Banded type cutouts fail when the fuse tube burns up.

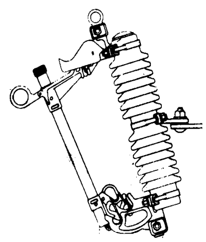
2.3.3 Potted type cutouts fail due to tracking, cracking, and porcelain breakage.

2.3.4 The failure mode for Polymeric type cutouts has not been fully established, but may be via leakage, tracking or **the internal fiberglass rod can break if the cutout is dropped from an elevated position.**

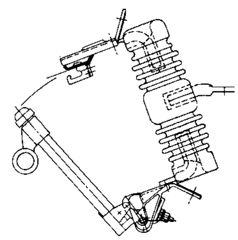
Enclosed Porcelain



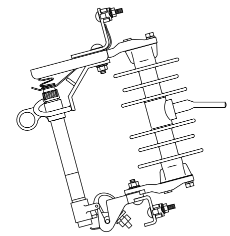
Banded Cutout



Potted Cutout



Polymeric



Due to the mechanical failure mode and potential hazard associated with potted porcelain cutouts, Liberty Utilities is no longer purchasing this style of cutout. Liberty Utilities's preferred cutout style is the polymeric style. These materials have performed well in electrical testing, and do not exhibit the mechanical failure mode seen in the potted porcelain cutouts.

3.0 JOB SITE HAZARD EVALUATION

3.1 Whether the job entails routine line work, operating a cutout, replacing a cutout, or work on or near a cutout due to an emergency situation, **a thorough inspection of the pole(s) and the pole top(s) shall be conducted and documented on a written job brief. Any defective equipment found as part of the job site hazard evaluation shall be repaired or replaced.** At a minimum, the following items shall be reviewed, evaluated and discussed during the job hazard evaluation:

3.1.1 All appropriate PPE , which includes, but is not limited to hard hat; eye protection, flame retardant clothing, and rubber gloves and sleeves shall be utilized as required by the Liberty Utilities Employee Safety Handbook and all applicable procedures.

3.1.2 Insulating protective equipment such as rubber blankets, line hose and fiberglass barrier guards shall be utilized as required.

3.1.3 Minimum approach distance and proximity of equipment to be worked on.

3.1.4 The condition and location of all cutouts on the pole(s) with particular attention to the tap lead length and possible items or grounds that could be contacted during a cutout failure.

3.1.5 Condition of the cutout (inspect for cracks or fractures, tracking evidence or discolored connections).

3.1.6 The condition of the crossarms and pole top with particular attention to any signs of burning.

3.1.7 Any hazards from non-standard construction. Spacing and clearance.

3.1.8 Delta system or potential back-feed.

Upon completion of the Job Site Evaluation the qualified worker shall take the necessary precautions to eliminate, avoid or mitigate any foreseeable or unforeseeable hazards. The qualified worker will be prepared to take additional electrical safeguards, including the use of approved hot stick/live line equipment, the use of additional line and equipment cover-up, the placement of circuits or portions of circuits on non-reclosing/hot line tag, or the de-energization of customers, circuits, or parts of circuits, in order to safely complete the work.

4.0 WORK PROCESS REQUIREMENTS

4.1 Liberty Utilities' policy is to replace **ALL** manufacturers' potted porcelain style cutouts. The replacement of both good and defective potted porcelain cutouts will be accomplished as part of any work performed on poles or structures. Specific conditions and work requirements for cutout replacements are listed below:

4.1.1 Prior to performing routine or emergency work **in the primary area**, **ALL** potted porcelain cutouts on poles or structures shall be thoroughly inspected for visible hazards and replaced. Additional precautions shall be taken if defects were identified as part of the inspection process.

4.1.2 Prior to performing routine or emergency work **in the secondary area, ALL** potted porcelain cutouts on the poles or structures shall be thoroughly inspected for visible hazards. A defective cutout shall be replaced prior to work being performed. When no apparent defects are visible the cutout shall be replaced, provided equipment, material, and crew qualifications allow. Work can proceed at or below the secondary level using class O gloves only when no apparent cutout defects or hazards associated with the cutout are found.

4.1.3 Cut and kick pole work shall require a thorough inspection of the potted porcelain cutouts. If the inspection reveals that the potted porcelain cutout is defective, then the cutout shall be replaced prior to the cut and kick process.

4.1.4 In the rare case where a defective cutout of any type is **NOT** immediately replaced, **NO WORK** shall be performed at this pole or structure. The worker (authorized person) shall immediately report the condition to the system operator and notify their immediate supervisor. A hold tag shall also be placed at the location per NGEOP G014 and the cutout shall be scheduled for replacement within 48 hours.

4.1.5 Overhead potted porcelain or overhead enclosed porcelain cutouts (100 amp or 200 amp, shall **NEVER (except as noted below for indoor or inside applications)** be used as a visible open for isolation or grounding requirements. In situations where a potted porcelain or overhead enclosed porcelain cutout (100 amp or 200 amp, will not be replaced, either removal of a high side lead from that device or another approved isolating device shall be utilized to establish an approved isolation point for the grounding requirements under NGEOP G014 Clearance and Control.

4.1.6 Enclosed porcelain cutouts **only,** located **indoors or inside** underground facilities such as vaults or enclosures may be used as a visible open for isolation or grounding requirements under NGEOP G014 Clearance and Control and only after a thorough inspection of the cutouts has been completed

4.1.7 Enclosed porcelain disconnects (400/600 amp "dead blade" type) are approved for use as a visible open and may be utilized as a visible open for the purpose of isolation or grounding requirements under NGEOP G014 Clearance and Control. Historical data has shown that due to the differences in construction (size, clearance between contacts and porcelain mass) between the enclosed porcelain disconnect and the enclosed porcelain cutout that this device does **NOT** present the problems or failure history similar to the smaller designed 100 amp and 200 amp enclosed porcelain cutout.

100 amp and 200 amp enclosed porcelain cutouts shall NEVER be used as a visible open for isolation or grounding requirements under EOP G014 Clearance and Control (except in UG applications such as indoor vaults and enclosures).

400/600 amp Solid Blade Disconnects – Are allowed to be utilized as a visible open for the purpose of isolation or grounding requirements under EOP G014 Clearance and Control.

4.1.8 When the requirement to replace potted porcelain cutouts (impact safety to the worker or public, or) compromises system continuity (storm restoration), or customer business continuity, work may proceed, provided a thorough inspection of the cutout shows no apparent defects.

4.1.9 Replacement of energized primary cutouts requires a minimum of two qualified workers.

4.1.10 Cutouts may be **de-energized and energized** by a single worker using approved hot stick/live line tools as shown below in the single worker excerpt from Standard 29 CFR 1910.269 (1) (ii) – A, B, C.

a. Routine switching of circuits, if the employer can demonstrate that conditions of the site allow this work to be performed safely.

b. Work performed with hot stick/live-line tools if the employee is positioned so that he or she is neither within reach of nor otherwise exposed to contact with energized parts, and

c. Emergency repairs to the extent necessary to safeguard the general public.

4.1.11 Jumpers of any type shall **NOT** be used to keep underground risers, transformers, or transformer banks energized for the purpose of changing potted porcelain cutouts. Skinning or making any type of mechanical connection to any portion of either the line or load side leads of underground risers, transformers, or transformer banks to keep them energized for the purpose of changing potted porcelain cutouts is **NOT** allowed.

4.1.12 Where practical, approved 15kV jumpers can be utilized for bypassing a cutout when replacing main line cutouts or cutouts feeding tap lines. (Jumpers shall not be placed on cutout tap conductors).

4.1.13 Refer to the Liberty Utilities Employee Safety Handbook and applicable procedures to determine when it may be necessary to place a circuit or portion of a circuit on non-reclosing/hot line tag and obtain a NRA.

5.0 CUTOUT REMOVAL/REPLACEMENT

5.1 Removal

5.1.1 All exposed energized conductors, grounds and neutrals within reaching and falling distance shall be insulated with rubber protective cover-up or guarded.

5.1.2 The cutout fuse holder shall be opened and removed. (The condition of the cutout and the results of the inspection will dictate whether this can be done safely).

5.1.3 When disconnecting the cutout from an energized circuit by means of a conducting wire, employees shall remove the source end first from the source conductor. (Note: delta transformer configurations will have both source and load connection points energized with door removed). Care shall be taken to control any loose lead from contacting conductors, parts or equipment that is at a different potential. The alternate method is to remove the source lead from the cutout body using approved hot stick/live line tools (the method is dictated by configuration and condition of installation). The lead shall be controlled at all times.

5.1.4 The method of removal and replacement of the lead shall be discussed in detail during the documented Job Brief. All leads shall be kept as short as possible and controlled.

5.1.5 After removal and prior to replacing the new cutout, the position of the cutout shall also be evaluated to ensure that the mounting location is in the least hazardous space. **Cutout spacing for the future use of the Load Buster Tool shall be considered on all three phase installations.**

5.2 Replacement

5.2.1 Install the load side lead first and then install the source side lead, keeping the tap lead controlled and as short as possible.

5.2.2 Depending on the configuration of the pole top construction, remove insulated protective cover-up and/or barriers.

5.2.3 Install the fuse holder in the cutout and close using an approved hot stick/live line tool. If a line jumper has been applied, remove the jumper after closing the cutout.

6.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D002		
Electric Operating Procedure	**11-01-2015**	**Overhead**	
OH Distribution and Sub-Transmission Personal Protective Grounding	**Revision #**	**1.0**	**Page: 1 of 21**

INTRODUCTION

This procedure provides grounding methods to protect workers from voltages that might develop in the work area during de-energized maintenance of overhead distribution and sub transmission lines.

PURPOSE

The purpose of this procedure is to provide for appropriate steps required for personal protective grounding for workers performing work on or near de-energized overhead distribution and sub-transmission lines. The procedure will address the necessary steps for proper application and placement of personal protective grounds on Wye and Delta systems, both single and three phase configuration. This procedure shall be used for voltages up to and including 46 kV, for work on structures and aerial-lift work.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate guidance to field personnel when requested for a specific work related task.
2. Electric Distribution Operations
   - A. Ensure that the procedures in this EOP are implemented.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.
3. Liberty Utilities Employees and Contractors
   - A. Demonstrate an understanding of the procedures in this EOP.
   - B. Comply with the requirements of the procedures in this EOP.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

OSHA 1910.269 (n) Grounding for the protection of employees

NESC ANSI C2 20012

Liberty Utilities OH and UG Distribution Construction Standards

LU - EOP G014 - Clearance and Control

LU - EOP D001 – Cutouts Open/Enclosed Type

LU - EOP G026 – Mechanized Equipment Grounding

DEFINITIONS

Barricade - A physical obstruction such as tapes, cones, or A-frame type wood or metal structures intended to provide a warning about and to limit access to a hazardous area.

Barrier - A physical obstruction that is intended to prevent contact with energized lines and equipment, or to prevent unauthorized access to a work area.

Bracket Grounds Equipotential - Two or more sets of short circuiting master grounds installed between the work area and all sources of energization and as close as practical to the work area. A personal protective ground jumper and a cluster bar shall be attached to all pole(s) or structure(s) in between the bracket grounds to any phase upon which work will be performed or clearance violated.

Bracket Grounds Non-Equipotential - Two or more sets of short circuiting master grounds installed between the work area and all sources of energization and as close as practical. Class #2 Rubber Gloves shall be worn.

Circuit: A conductor or system of conductors through which an electric current is intended to flow.

Cluster Bar: A device that is clamped around the pole(s) or structure(s) below the lowest work position.

Dead: Isolated, red tagged, tested de-energized and grounded.

De-energized: Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps or other means. Note: De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

Electrically Isolated: All switches, jumpers, taps or other means through which known sources of electrical energy may be supplied to the particular lines and equipment have been opened.

Energized (alive, live): Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Equipotential Grounding: A personal protective ground jumper and a cluster bar are attached at the work site to all pole(s) or structure(s) to any phase upon which work will be performed or clearance violated. Equipotential grounding shall always include at least one set of master grounds (point of work) or multiple sets of master grounds between the work site and all known sources (bracket grounding).

Equipotential Zone: A physical region where the electric potential (voltage) is effectively the same at every point within that region.

Guarded: Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats, or platforms, designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects.

Master Grounds: Is a term used to describe a set of grounds that provide a three-phase short circuiting effect and are connected to a ground source. They SHALL be adequately sized so as to be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

Non-Equipotential Grounding: Work performed between bracketed grounds where personal protective grounds are not used to establish an equipotential zone. All work shall be performed utilizing Class 2 gloves.

Personal Protective Grounds(s): A system of cables, cluster bar(s), grounding conductor(s), and ground electrode(s) connected around a work area on a pole/structure. The minimum size for personal protective grounds is 2/0 copper.

Person In Charge of Work: A qualified person responsible for the work to be performed.

Point of Work Grounds: A set(s) of grounding jumpers and a cluster bar applied at the pole or structure where work is to be done.

Primary Voltage: All distribution circuit cables or conductors energized at 4, 15, 23, or 34.5 kV.

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Shall: The word shall is to be understood as mandatory.

Should: The word should is understood as recommended.

Step Potential: The voltage difference between two points on the earth's surface separated by a distance of one pace (assumed to be three feet) in the direction of maximum voltage gradient. This voltage difference could become dangerous when current flows through the earth upon which the worker is standing, particularly under fault condition.

System Operator: An authorized person, who directs, controls, monitors, and operates the electric system and its associated apparatus.

Touch Potential: The voltage difference between an object which the worker could touch and the earth upon which the worker is standing. This voltage difference could result from induction or fault conditions and could be dangerous.

TRAINING

A written request should be submitted to Learning and Development by user group whenever training is required.

SCOPE

1.0 <u>OVERHEAD DISTRIBUTION AND SUB-TRANSMISSION GROUNDING</u>

1.1 Pre-Job Briefing (Tailboard Conference)

1.1.1. The person in charge shall conduct a written pre-job briefing with the workers involved before they start the job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions (i.e., grounding, insulate and isolate, site evaluation and setup, etc), Clearance and Control procedure and PPE requirements.

1.1.2. Additional job briefings shall be held if significant changes, which might affect the safety of the employees, occur during the course of the work.

1.2 <u>Personal Protective Equipment (P.P.E.)</u>

1.2.1. All PPE, including flame retardant clothing and class 2 rubber gloves (and sleeves where required) must be worn when testing, installing or removing personal protective grounds.

1.3 <u>Switching</u>

1.3.1. Before grounding is performed, all switches, disconnects, jumpers, taps and other means through which *known* sources of electric energy may be supplied shall be opened and red tagged by a qualified worker under the direction of an authorized employee.

1.3.2. The switching point shall provide a clear visible open and shall be rendered inoperable, unless not permitted by its design. (Note: oil switches, sectionalizers and reclosers shall have the leads removed in order to provide a clear visible open, unless disconnect switches are present). Consult NG-USA EOP D001 for guidance on use of enclosed porcelain cutouts or potted porcelain cutouts as an approved open for isolation or grounding requirements under Clearance and Control, LU-EOP G014.

1.4 Tagging

Tagging shall be done in accordance with LU-EOP G014 and the Liberty Utilities Employee Safety Handbook rules.

1.5 Testing

1.5.1. Prior to the application of any personal protective grounds, the circuit to be worked on must be tested for the presence of voltage using an approved potential detector.

1.5.2. The line worker must verify the detector is in operating order prior to and after testing for voltage.

1.5.3. Minimum approach distances as specified in the Liberty Utilities Employee Safety Handbook must be maintained during the testing.

1.5.4. Testing the line for voltage shall be done at the point where the grounding devices are to be attached. Test all phases of the circuit to be worked on. A test shall be conducted at each location that grounds are installed.

1.5.5. Personal protective grounds shall be installed immediately after testing the circuit. If the grounding process is interrupted, a retest shall be performed prior to the installation of grounds.

1.6 Grounding

1.6.1. All lines and equipment, regardless of voltage, will be considered energized unless such lines and equipment have been de-energized (isolated), tested for absence of normal voltage with an approved voltage tester and grounded with approved grounding devices.

1.6.2. Temporary protective grounds will be arranged in such a manner as to create an equipotential zone and to protect the worker from any hazardous voltages that could occur under the following conditions:

- Accidental re-energization of the line.
- An energized line accidentally contacting the line.
- Back-feed from emergency or auxiliary power supplies.
- Electromagnetic induced voltages caused by load or fault currents in an adjacent line.
- Electrostatic voltages caused by capacitive coupling to adjacent lines.

1.6.3. Ground Leads - Approved protective grounds no smaller than 2/0 Copper (minimum size) shall always be used to protect the worker. Any time the size of the Aluminum or Copper circuit conductor is equal to or smaller than the 2/0 protective ground lead. The 2/0 protective ground lead will be sufficient to handle available fault current on that conductor. All distribution and sub-transmission circuits in New Hampshire have an available fault current within the limits of the rated capacity of one 2/0 copper grounding conductors. Approved ground set should be used for all protective grounding applications and home-made ground sets utilizing hot line clamps SHALL NOT used. Down grounds or equipment ground conductors SHALL NOT be used as a ground lead. If not sure of approved grounds ask your Supervisor or Program Manager, Standards, Policies, and Codes.

1.6.4. Parallel Ground Leads – If, in the future, fault current that is available on a specific feeder or at a specific work location exceeds the rated capacity of one 2/0 copper grounding conductor, multiple grounding leads consisting of either 2/0 or 4/0 copper grounding conductors shall be paralleled to achieve the necessary fault current capability. When two or more copper grounding cables are paralleled the cables shall be of equal conductor size, length and ground clamp design. When parallel grounding cables are utilized they shall be attached so that the respective clamps are side by side in very close proximity to each other.

1.6.5. Personal Protective Ground Sets - The recommended minimum ground set for distribution overhead line vehicle consists of 3-6’, 2-8’, 2-10’ and 2-40’ *approved* 2/0 copper grounding leads with clamps and 1-cluster bar. It is not necessary to have the 40’ leads in the absence of delta circuits. The same connecting parts and components should be employed for all cables. The cable should be of equal cross-section.

1.6.6. Grounding Procedures

1.6.6.1. Grounding through fused disconnects, transformers, regulators, reclosers and sectionalizers is NOT allowed. Grounding through a solid blade switch or disconnect is allowed provided the switch or disconnect is in the closed position and continuity is maintained. Though not required, a Hold Tag may be applied to maintain this continuity per Liberty Utilities EOP G014.

1.6.6.2. Temporary personal protective grounds shall be placed only after the circuit has been isolated, red tagged, and tested de-energized, at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.

1.6.6.3. All personal protective grounds shall be applied using live line tools and class 2 rubber gloves maintaining minimum approach distances. The ground end clamp of the personal protective ground lead SHALL always be connected first and removed last. The connection between the cluster bar and neutral shall be made using class 2 rubber gloves (sleeves where required) only.

1.6.6.4. The conductor on which the personal protective ground is to be installed shall be wire brushed to remove all surface oxidation. The personal protective ground clamp shall then be applied snugly on the conductor, rotated back and forth on the conductor and then tightened fully. Dirty surfaces and/or loose joints result in high resistance connections. The heat generated from the flow of high fault current through an improper connection may result in softening of the metal surfaces at the jaw/conductor interface, with a loss of clamping force. Low contact resistance (clean and tight) will prevent the clamps from being “blown off” by mechanical forces.

1.6.6.5. Personal protective ground leads shall be installed as short, straight and direct as possible. Personal protective grounds, if slack, should be tied off with a rope to avoid possible personal injury should the leads whip under fault conditions. Leads should not be coiled or taped. When workers are installing grounds, the leads should not contact the workers body, pole, structure, cross arm, or pole hardware and equipment.

1.6.6.6. Workers shall not be nearer than 15 feet from the base of the structure on which work is being performed, except when serving workers on the structures. If contact is necessary to the work structure or components of the structure, class 2 rubber gloves shall be used.

1.6.6.7. Workers ascending or descending a pole or non-metallic structure below the equipotential zone (cluster bar) while protective grounds are attached at that pole or structure must use class 2 rubber gloves.

1.6.7. <u>Grounding Elements</u>

1.6.7.1 Grounding element choices in order of priority are:

- System neutral
- Equipment ground rod
- Existing Guy anchor rod under tension (Newly installed anchors cannot be used as a ground source due to disturbed soil and poor ground continuity)
- Temporary driven ground rod (firmly embedded in the soil 8’ feet)
- If the work structure has a permanently installed down ground and equipment ground rod, this equipment ground rod may be utilized for the ground source. All ground sources at the work area shall be bonded together. If a temporary driven rod is installed as a ground source at a work structure that has a permanently installed equipment

ground, the two ground source elements must be bonded together to minimize step potential hazards.

- Delta and 3-wire Wye circuits that have equipment grounds that are not connected to the neutral conductor shall be bonded to the equipotential grounding if there is any exposure to the worker in the elevated work position to these grounds or equipment connected to them.
- Poles or structures that have an ungrounded guy wire, that do not have insulated guy breakers that will protect the worker from exposure to an earth potential path while in the work position, shall have a bond placed between the equipotential grounds and the guy wire. When it is necessary to place a bond on an insulated guy wire, that bond shall be installed on the earth side of the insulated breaker.
- The ground source for a delta or 3-wire Wye circuit that is located on a pole or structure that has a neutral conductor from another 4-wire Wye system shall be the neutral of that 4-wire system.
- When temporary driven ground rods are installed at a work location that does not have a permanent equipment ground, the temporary ground rod shall be installed approximately 8 feet from the base of the pole, in a location away from the workers on the ground.
- Always follow proper dig safe/dig safely procedures when installing any ground rods.

1.6.8 Cluster Bar Attachment

1.6.8.1. Attach a cluster bar on the pole below the working position, leaving adequate working space above it. Connect the cluster bar to the common neutral or shield wire, if present, on Wye or Delta systems. If there is no common neutral or shield wire, install a grounding jumper from a suitable ground element to the cluster bar.

1.6.8.2. When the work is being performed with an insulated aerial device the position of the cluster bar should be below the neutral conductor. *(Figure 11)*

1.6.8.3. When a worker is climbing and will be physically working from the structure, a cluster bar should be positioned approximately three (3) feet below the worker's feet.

1.6.8.4. The cluster bar is required on all wooden poles that are to be climbed, or when working from an aerial lift where the pole is within reaching distance of the worker.
1.6.8.5. The cluster bar is not required when working from an aerial lift and the pole is not within reaching distance of the worker.

1.6.9. Grounding Methods

There are two approved methods that may be utilized to establish an equipotential zone for personal protective grounding.

1.6.9.1. Point of Work Grounding (equipotential grounding)

1.6.9.1.1. This is the preferred method of grounding and shall be utilized for all situations where it is practical. Point of work grounds are a set(s) of personal protective grounding jumpers and a cluster bar, applied at the pole or structure where the work is to be done. These grounds shall be arranged on the conductor in such a manner, so that the work is always being performed within 6 feet of the ground clamp connection. When utilizing the point of work grounding method the ground leads should always be placed, when practical, to the station source side of the work structure. *(Figures 1, 2, 3, & 8)*

1.6.9.2. Sequence of Installation

1.6.9.2.1. Point of Work

1) *Wye with a common neutral or shield wire. (Figures 1&8)*
2) *Delta with a secondary neutral or shield wire. (Figures 3&8)*
3) *Wye or Delta without a secondary neutral or shield wire. (Figure 2)*

1.6.9.3. Bracket Grounds

This method shall be utilized for situations such as conversions and storm problems. It allows work to be performed on multiple structures that are located between the bracket grounds.

1.6.9.3.1 Bracket Grounds (Equipotential) *(Figures 4&6)*

The recommended method of bracket grounding that is to be utilized for all situations where it is practical; is to place bracket grounds at locations as close as practical on each side of the work area with a maximum separation of two miles.
At any work structure within the brackets, the worker shall establish an equipotential zone by installing a grounding jumper from the cluster bar or neutral to any phase upon which work will be performed or clearance will be violated.

1.6.9.3.2. Bracket Grounds (No Equipotential) *(Figures 5&7)*
The optional method to be utilized when an equipotential zone is not being established is to place bracket grounds as close as practical to the work area (preferably at adjacent structures) with a maximum separation of one mile.

The following requirements must be met to utilize bracket grounds (no equipotential):

1. The worker(s) shall have "bracket grounds" properly installed so that there

is always a set of grounds between the worker and any known source.
2. Class 2 rubber gloves shall be worn when an equipotential zone is not established at the point of work.
3. The worker must utilize safe work practices to avoid contact to unprotected portions of their body with phase wires, neutrals, ground wires, guy wires, or other apparatus that may be at earth potential.

4. There can be no other energized circuits on the same structure.

OR

When there are other energized circuits on the same structure, such as an **OVER BUILT** transmission or sub-transmission or an **UNDER BUILT** (15kV or less), special precautions must be adhered to protect against the specifics of each of the different potential hazards.

When working on an **OVER BUILT** circuit which has been isolated, tagged, tested and bracket grounded and the worker wants to perform work within the bracket grounded area without the use of an equipotential zone when an **UNDER BUILT** circuit of 15 kV or less exists on the same pole or structure the following requirements shall be met:

a. The worker shall utilize Class # 2 rubber gloves sleeves and appropriate rubber cover-up any time they are working on or within the minimum approach distance of the energized **UNDER BUILT** circuit.

b. To perform work on the **OVER BUILT** bracket grounded circuit from a pole or structure that the worker is physically climbing, Class # 2 rubber gloves, sleeves and appropriate cover-up shall be utilized while climbing through the energized **UNDER BUILT** circuit. Class # 2 rubber gloves and sleeves **SHALL** remain on while work is being performed on the bracket grounded **OVER BUILT** circuit in this scenario.

c. To perform work on the **OVER BUILT** bracket grounded circuit from an insulated aerial device at a pole or structure, between the bracket grounds, that has an energized **UNDER BUILT** circuit to which minimum work clearances can be maintained, the worker may utilize Class # 2 rubber gloves and practice safe work practices to avoid contact to unprotected portions of their body with phase wires, neutrals, ground wires, guy wires or other apparatus. If minimum approach distances cannot be maintained from the **UNDER BUILT** circuit, then Class # 2 rubber gloves, sleeves and appropriate cover-up, shall also utilized on the bracket grounded **OVER BUILT** circuit.

When working on an **UNDER BUILT** circuit which has been isolated, tagged, tested and bracket grounded and the worker wants to perform work within the bracket grounded area without the use of an equipotential zone when an energized **OVER BUILT** circuit exists on the same pole or structure the following requirements must be met:

a. All conductors on the **OVER BUILT** circuit shall be inspected to be in good condition and attached to standard insulators and hardware in the sections between the bracket grounds on the **UNDER BUILT** circuit.

b. To perform work on an **UNDER BUILT** bracket grounded circuit either from a pole or structure that the worker is physically climbing or from an insulated aerial device at a pole or structure, between the bracket grounds, that has an energized **OVER BUILT** circuit, the worker may utilize Class # 2 rubber gloves and practice safe work practices to avoid contact to unprotected portions of their body. Minimum approach distances **<u>SHALL</u>** be maintained from the energized **OVER BUILT** circuit, phase wires and electrical equipment during performance of work on or near the de-energized bracket grounded **UNDER BUILT** circuit.

NOTE: If an accidental energization occurs to the de-energized bracket grounded circuit from inside the bracket grounds this may generate hazardous voltages on the conductors within the bracket grounded area. Workers that are utilizing the "Bracket Grounded – No Equipotential Zone" method of work <u>MUST</u> utilize safe work practices to avoid contact to unprotected portions of their body.

1.6.9.4 <u>Bracket Grounding (no equipotential, system isolation)</u>

When performing work on a de-energized conductor without personal protective grounds (equipotential) at the point of work and working without class #2 gloves and sleeves, ALL of the following conditions must be satisfied:

NOTE: This section may only be used when there is no possible back feed from any source, such as transformers.

1. The line is physically disconnected from every possible source (i.e. open loops, open switches with the leads removed from one side, a section of wire removed etc.). On the structure where the loops are opened, grounds shall not be left on <u>both</u> sides of the open loops, as this will cause continuity through the ground leads.

2. There can be no static/shield wires, counterpoise wires, neutrals, messengers or communications cables that provide a conductive current path from any portion of an energized circuit into the de-energized section of the circuit that has been isolated. When working on circuits that have static wires or counterpoise wires this method shall NOT be utilized unless the continuity of the static wire or counterpoise wire can be isolated (opened) at the same location that the conductor open loops are created. Proper procedures shall be utilized when opening any static/shield wire, counterpoise, or neutral conductor.

3. Bracket grounds shall be installed as close as practical, preferably on adjacent structures on the isolated line. The maximum distance between the bracket grounds shall be four miles. All work must be performed so that the worker always has a set of grounds

between them and any known source. If the scope of the work covers an area larger than four miles an additional set or sets of master grounds shall be installed so that no work location is more than two miles from a set of master grounds.

4. There are no paralleling energized lines on the same structure or in the same right-of-way.

5. There are no crossings with energized circuits within isolated section of line to be worked.

1.7 Downed conductors

Downed conductors must be handled utilizing one of the following methods:

NOTE: Whenever workers are handling downed conductors on the ground they shall wear all appropriate PPE including EH rated overshoes.

1.7.1. No Equipotential Zone / Circuit Isolated / Circuit Grounded

1.7.1.1. The circuit shall have bracket grounds installed on both sides of the work area. The bracket grounds shall be placed as close as practical to the work zone, preferably on adjacent Structures. (Figure 9) (Maximum distance between the bracket grounds shall not exceed one mile)

1.7.1.2. All employees that will contact the conductor shall wear class 2 rubber gloves, **EH rated overshoes** and all other appropriate PPE as specified by the Liberty Utilities Employee Safety Handbook. A 2/0 cu jumper shall be installed across the open ends of any conductor that is broken and requires splicing. The jumper shall be installed using live line tools and class 2 rubber gloves.

Caution must be utilized to prevent contact of unprotected body parts to the conductor.

1.7.2. Circuit Isolated / Equipotential Zone Established At Work Site

1.7.2.1. The circuit shall have bracket grounds installed on both sides of the work area. The bracket grounds shall be placed as close as practical to the work zone, preferably on adjacent structures (Maximum distance between the bracket grounds shall not exceed two miles) (Figure 10)

1.7.2.2. When working from the ground a jumper shall be installed across the open ends of any conductor that is broken that requires splicing. The jumper shall be installed using live line tools and class #2 rubber gloves. The worker shall utilize all required PPE as stated in the Liberty Utilities Employee Safety Handbook.

1.7.2.3. A grounding mat shall be installed at the work site and connected to a ground source. This ground source may be a permanent ground rod, anchor rods, or a temporary installed driven ground rod. A ground lead shall be installed from the grounding mat to the conductor that is being spliced. This lead shall be applied to the conductor with a live line tool and class 2 rubber gloves. The worker shall utilize all required PPE as stated in the Liberty Utilities Employee Safety Handbook.

NOTE: The worker must keep their body and all tools on the grounding mat while splicing or contacting the conductor.

1.7.2.4. The jumper shall be removed from the conductor utilizing live line tools and class #2 rubber gloves. The ground connection from the grounding mat to the conductor shall be removed with live line tools and class #2 rubber gloves before the worker steps off the grounding mat.

2.0 REMOVAL OF PROTECTIVE GROUNDS

2.1. Grounds will be removed in the reverse order of installation. The ground lead will be removed from the phase end first using class 2 rubber gloves and a live line tool. Remove the ground clamps from the conductor end first and then remove the clamp from the ground end last. The ground clamp attached to the system neutral can be removed by hand, using class 2 rubber gloves.

2.2. The worker shall avoid handling the ground lead while the conductor end is being removed. The disconnected ground lead should be isolated from nearby energized lines or equipment before disconnecting the ground end to avoid accidental energization.

3.0 CARE and INSPECTION OF GROUND SETS

3.1. Care - Grounds shall not be thrown into the bottom of the truck with other equipment or with equipment piled on top of them. Ground sets shall be cleaned and stored in such a way as to protect them from physical damage and from sources of contamination. They shall be stored in canisters or protective bags and kept in a dry location.

3.2. Inspection - Before each use, grounds shall be given a visual inspection. The cables shall be carefully examined to detect broken strands and other physical damage to the cable, particularly near the clamps and other areas of frequent flexing. Particular attention must be given to maintaining tight clean connections between the cable and the ferrule, and between the ferrule and the grounding clamp. Grounding clamps need to be inspected and repaired when necessary. If a defective clamp cannot be repaired, it should be discarded and replaced. Serrated jaws should be cleaned frequently and replaced when they become worn or damaged. Worn threads on clamping bolts render a clamp useless.

4.0 GROUNDING OF VEHICLES/EQUIPMENT

Liberty Utilities, LU-EOP G026, Mechanized Equipment Grounding provides direction on the appropriate methods that are required for grounding and/or barricading of mechanized equipment before working on or near energized overhead and underground distribution, sub-transmission and transmission lines

In addition to those guidelines when workers are working with mechanized equipment on or near de-energized overhead distribution or sub-transmission circuits where there is a possibility that the vehicle/equipment or attachment to the vehicle/equipment may become accidentally energized all of the following work practices shall be utilized:

4.1. Workers should avoid contact to all equipment that is grounded or bonded to the de-energized circuit and the work site grounds. All tools and equipment needed for the work operation shall be removed from the vehicle/equipment before the work begins. Any worker contacting the vehicle/equipment shall wear class 2 rubber gloves, EH rated over shoes and avoid any accidental contact with the vehicle/equipment to unprotected parts of their body.

4.2. All non-insulated vehicle/equipment or an insulated vehicle/equipment being used above its dielectric rating which could possibly become accidentally energized shall meet the following requirements:

1. Vehicle/equipment shall be connected to the best available ground to minimize the time the lines remain energized
2. Bond vehicle/equipment together to minimize potential differences
3. Providing ground mats to extend areas of equipotential, and/or employing insulating protective equipment or barricades to guard against any remaining hazardous potential differences.

Note: All appropriate LU-EOP's and/or any applicable safety rules contained within the Liberty Utilities Employee Safety Handbook shall be adhered to.

EXCEPTION APPROVAL:

It is expected that additional special cases (i.e., storm emergencies/field conditions) will be identified that may require clarification, exception or a revision to this procedure. Agreement and approval will be required by concurrence of Operating Department Supervision and Safety. If concurrence cannot be achieved among these parties, they will seek concurrence of the Directors of Engineering and/or Electric Operations or their designees.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
11/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Figure #1

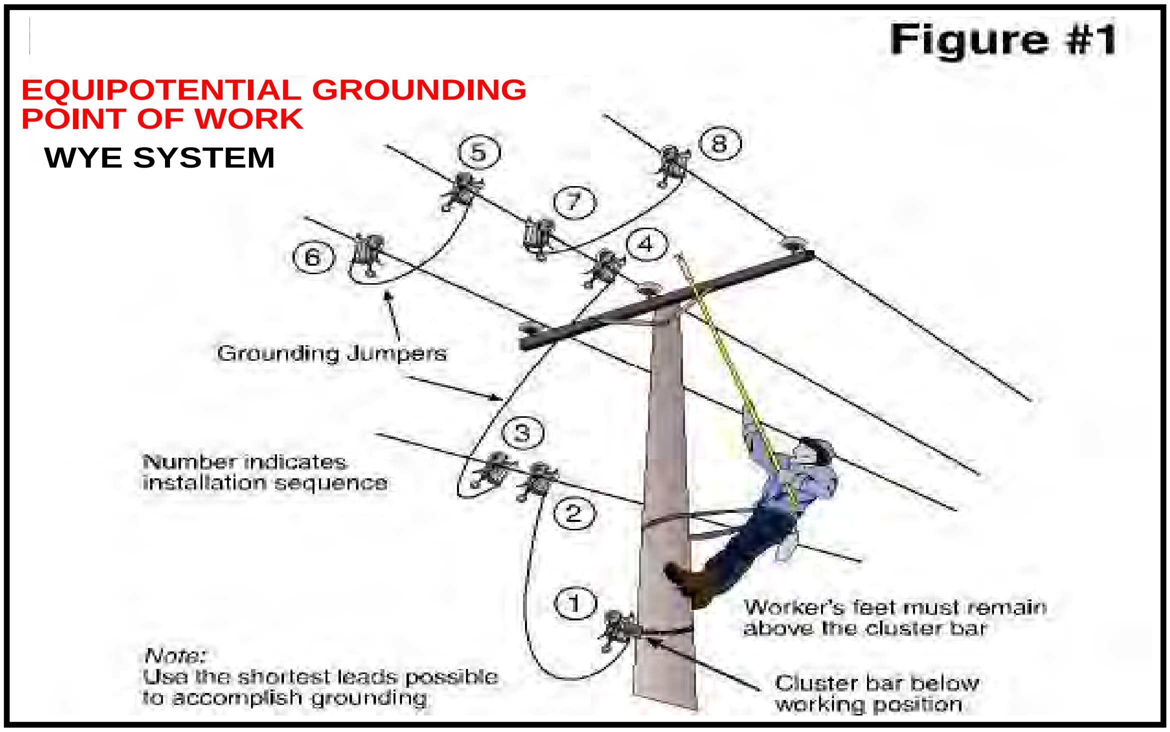
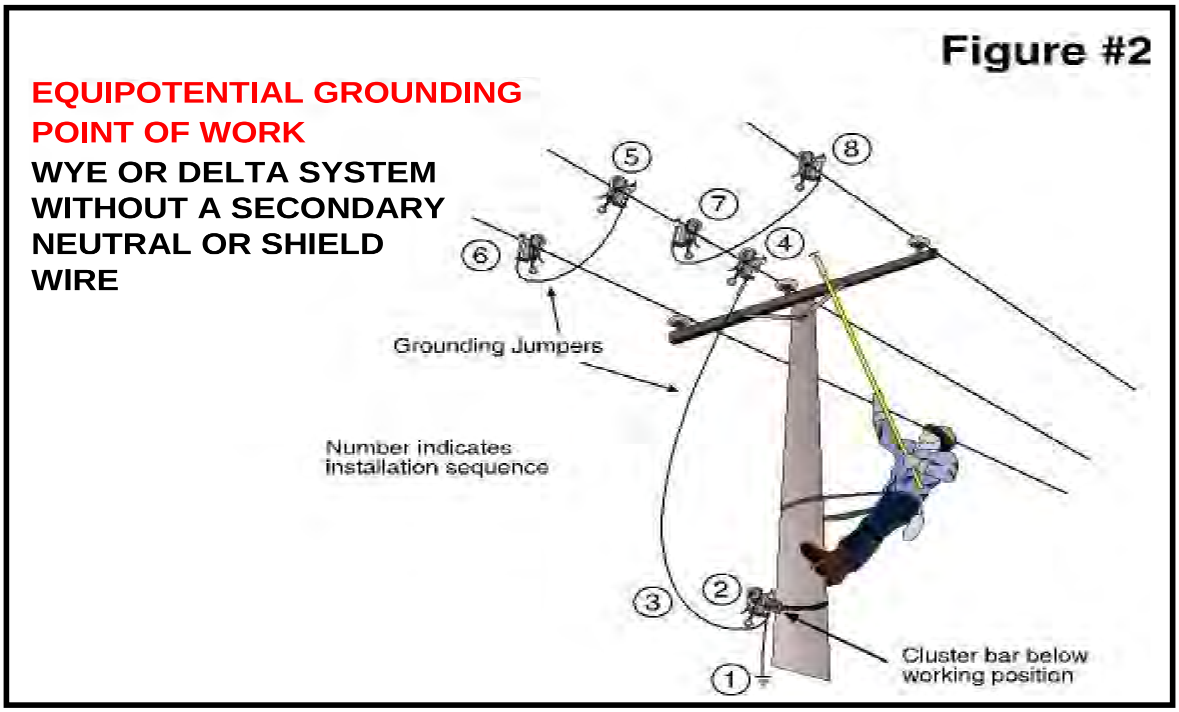


Figure #2



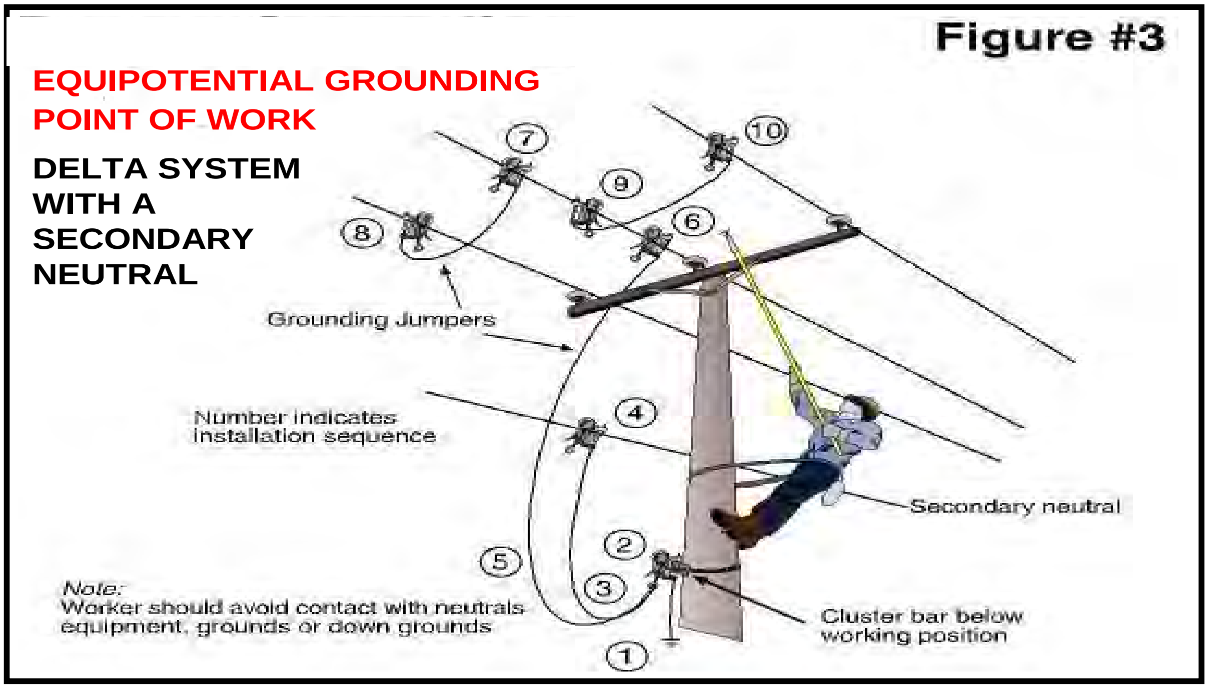


Figure #3
EQUIPOTENTIAL GROUNDING
POINT OF WORK
DELTA SYSTEM
WITH A
SECONDARY
NEUTRAL
Grounding Jumpers
Number indicates installation sequence
Secondary neutral
Note:
Worker should avoid contact with neutrals equipment, grounds or down grounds
Cluster bar below working position
1
2
3
4
5
6
7
8
9
10

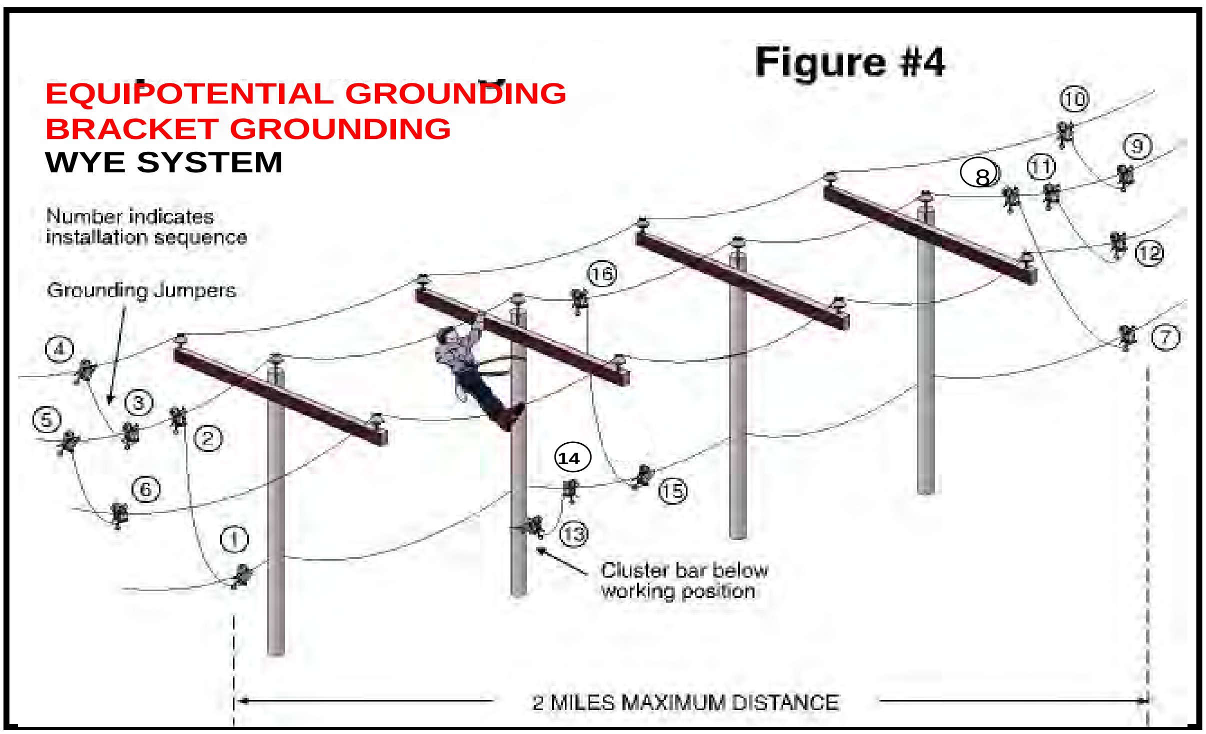
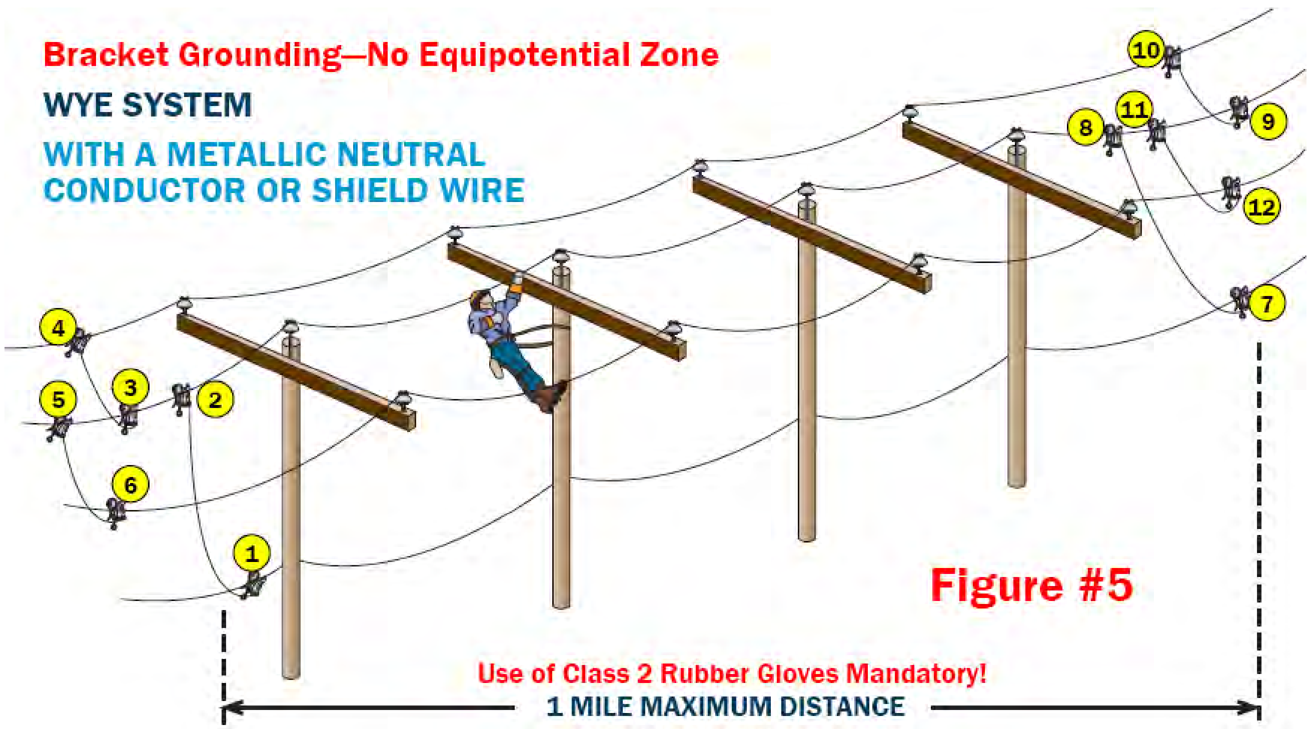


Figure #4
EQUIPOTENTIAL GROUNDING
BRACKET GROUNDING
WYE SYSTEM
Number indicates installation sequence
Grounding Jumpers
Cluster bar below working position
2 MILES MAXIMUM DISTANCE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


Bracket Grounding—No Equipotential Zone
WYE SYSTEM
WITH A METALLIC NEUTRAL CONDUCTOR OR SHIELD WIRE
1
2
3
4
5
6
7
8
9
10
11
12
Figure #5
Use of Class 2 Rubber Gloves Mandatory!
1 MILE MAXIMUM DISTANCE

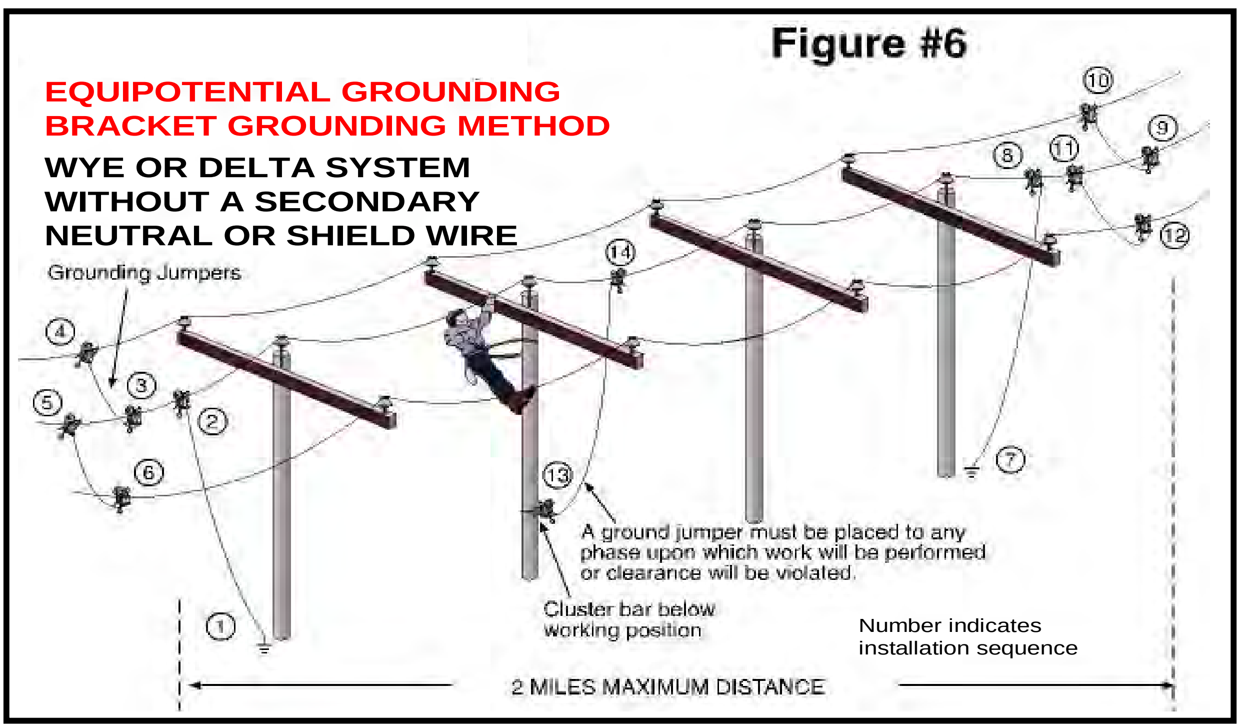


Figure #6
EQUIPOTENTIAL GROUNDING
BRACKET GROUNDING METHOD
WYE OR DELTA SYSTEM
WITHOUT A SECONDARY
NEUTRAL OR SHIELD WIRE
Grounding Jumpers
1
2
3
4
5
6
7
8
9
10
11
12
13
14
A ground jumper must be placed to any phase upon which work will be performed or clearance will be violated.
Cluster bar below working position
Number indicates installation sequence
2 MILES MAXIMUM DISTANCE

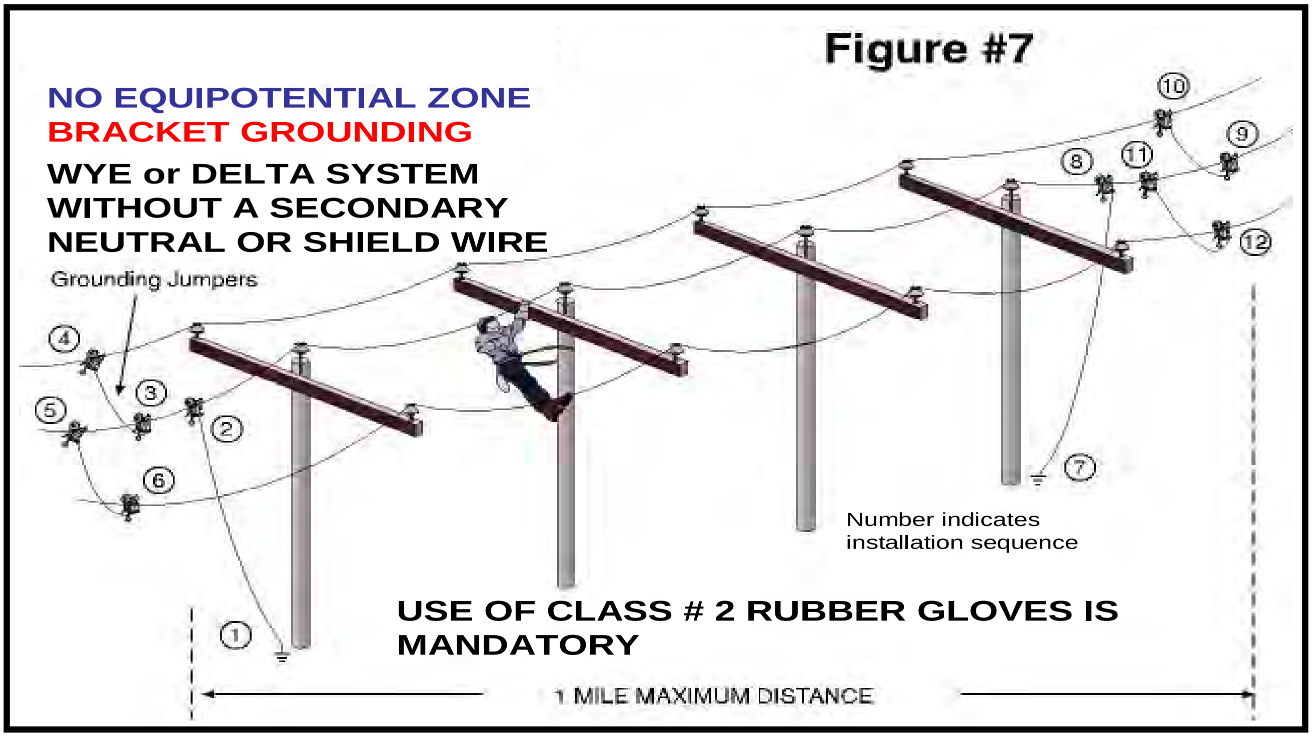


Figure #7
NO EQUIPOTENTIAL ZONE
BRACKET GROUNDING
WYE or DELTA SYSTEM
WITHOUT A SECONDARY
NEUTRAL OR SHIELD WIRE
Grounding Jumpers
1
2
3
4
5
6
7
8
9
10
11
12
Number indicates installation sequence
USE OF CLASS # 2 RUBBER GLOVES IS MANDATORY
1 MILE MAXIMUM DISTANCE

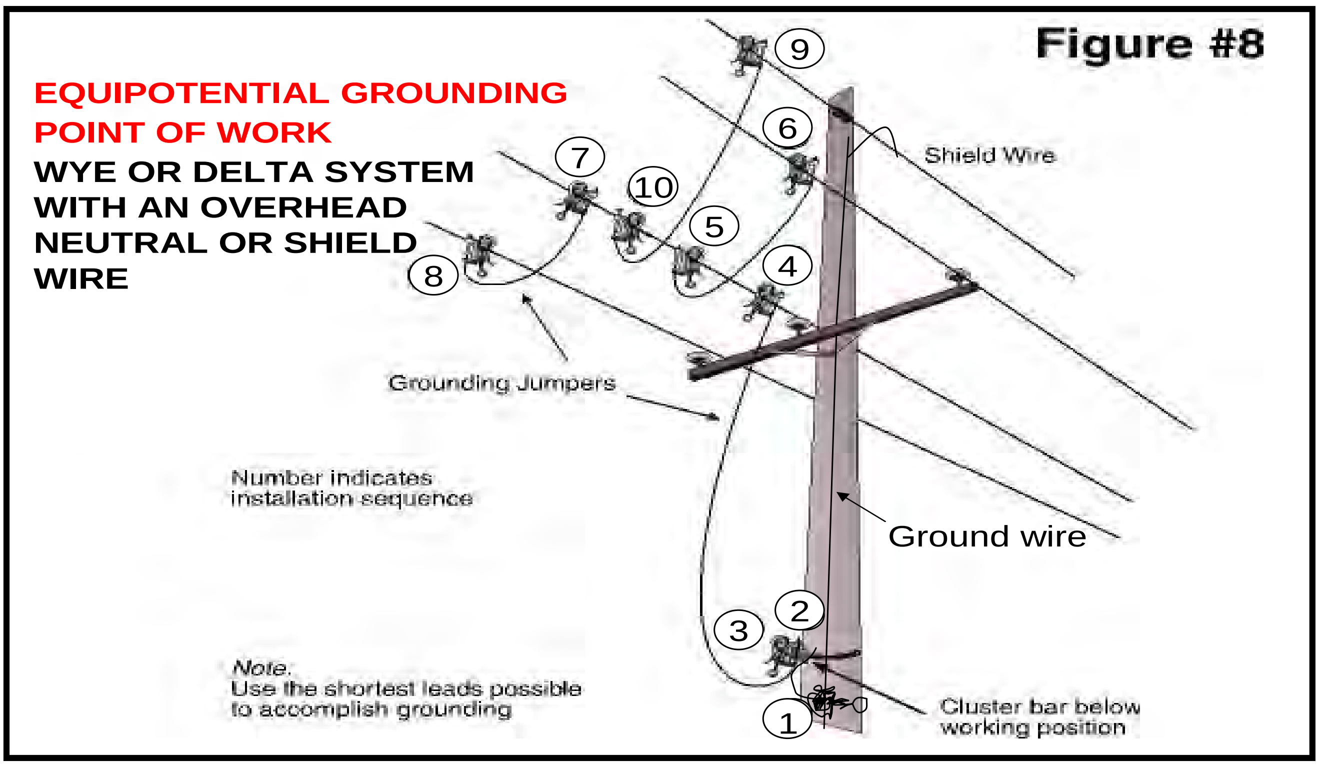


Figure #8
EQUIPOTENTIAL GROUNDING
POINT OF WORK
WYE OR DELTA SYSTEM
WITH AN OVERHEAD
NEUTRAL OR SHIELD
WIRE
1
2
3
4
5
6
7
8
9
10
Shield Wire
Grounding Jumpers
Number indicates installation sequence
Ground wire
Note.
Use the shortest leads possible to accomplish grounding
Cluster bar below working position

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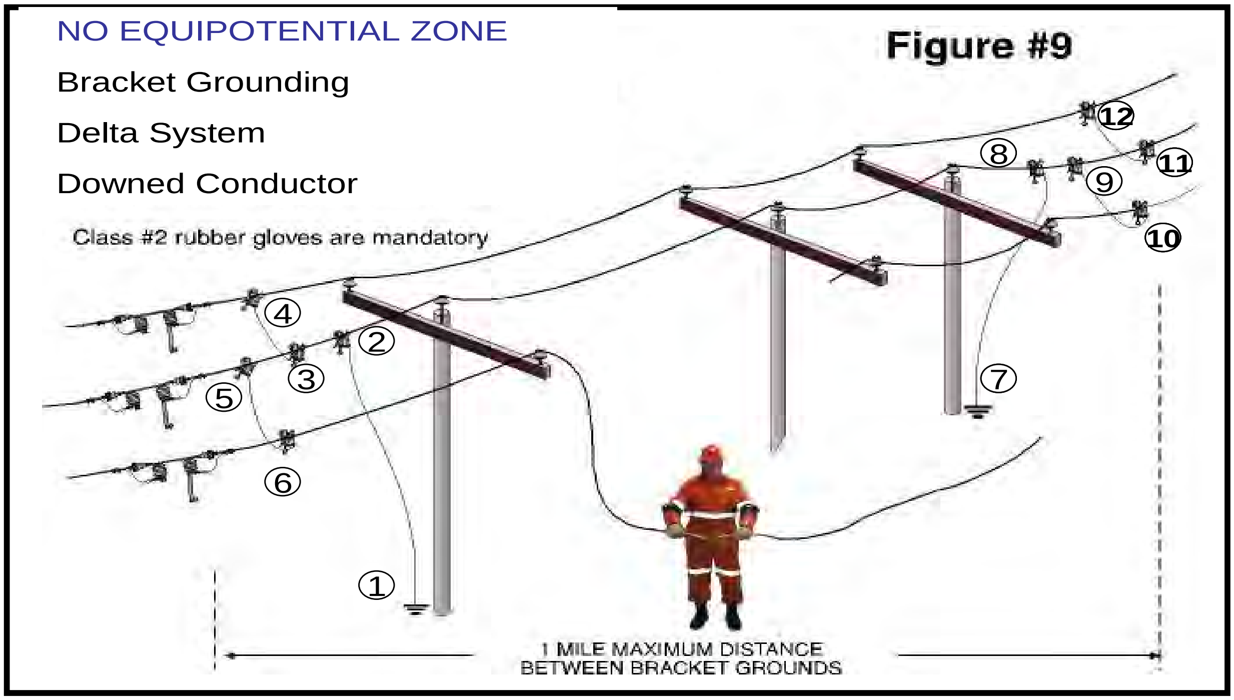


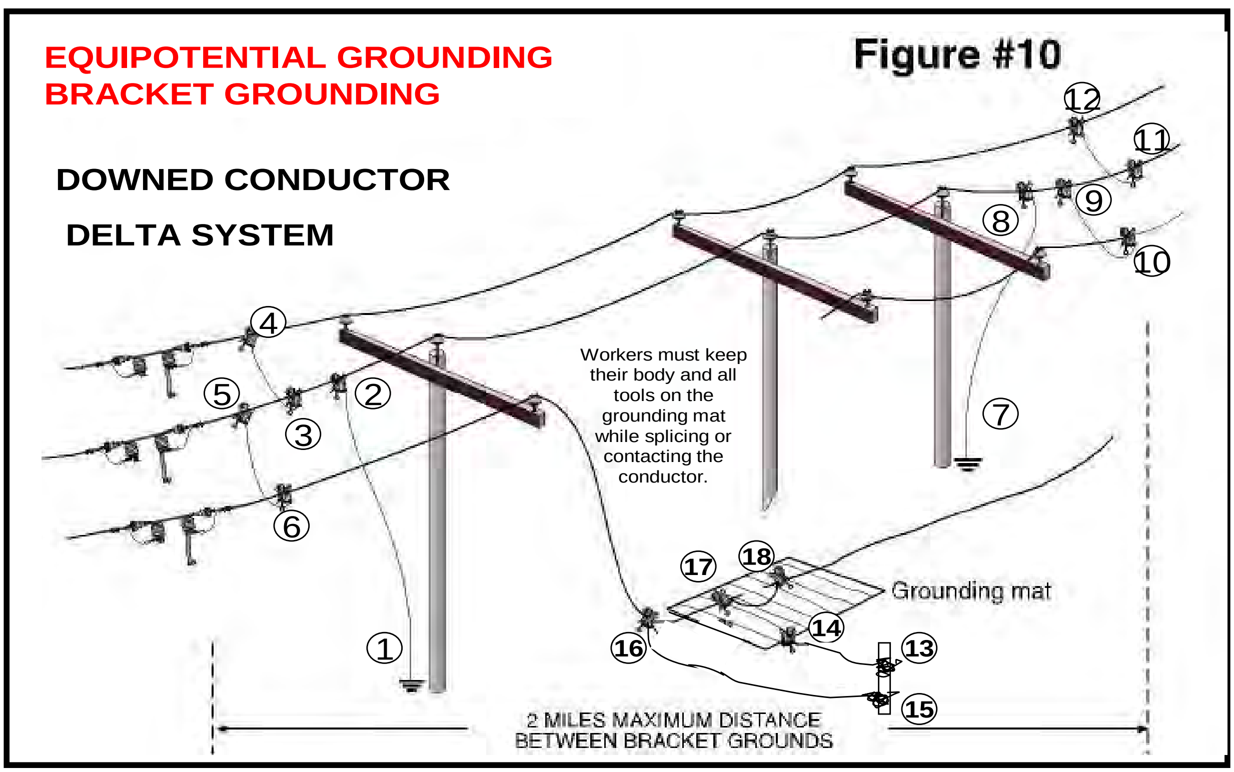


FIGURE # 11

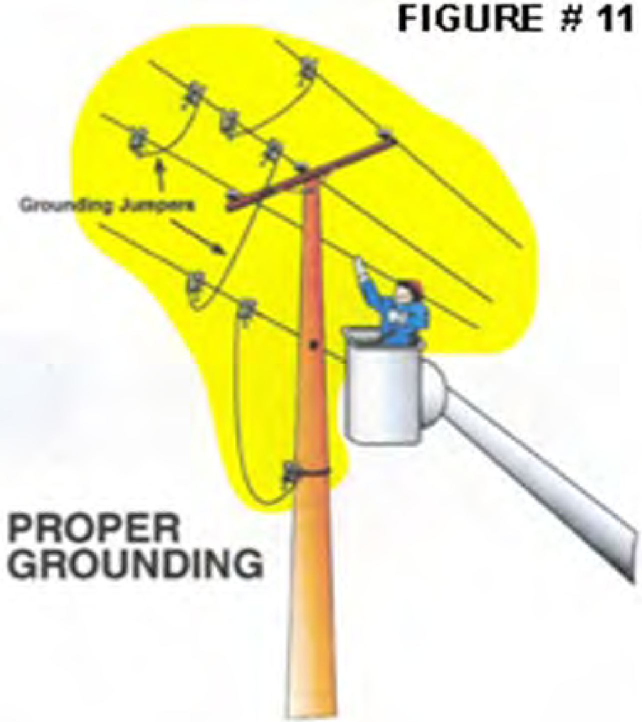
Equipotential Grounding

Grounding procedures are the same whether the worker is on the structure or working from an aerial device.

When working mid-span from an aerial device and contact with a pole or structure cannot be made, an equipotential zone is not necessary at that work location.

Caution should be used by a worker in the elevated position so that the worker does not bridge a neutral and a grounded conductor.

Note: Use the shortest leads possible to accomplish grounding.



<table>
<tr><td colspan="1">Liberty Utilities</td><td colspan="3">Doc. # LU-EOP D003</td></tr>
<tr><td>Electric Operating Procedure</td><td>09-01-2013</td><td colspan="2">Overhead</td></tr>
<tr><td>Single and Three Phase Step Type Voltage Regulators</td><td>Revision #</td><td>0</td><td>Page: 1 of 21</td></tr>
</table>

INTRODUCTION

This Electric Operating Procedure outlines the procedures for installing and removing step-type line voltage regulators from service in wye and delta configurations, adjusting secondary voltage output levels, and methods for safely paralleling regulators..

PURPOSE

This procedure applies to all Liberty Utilities personnel who may be required to install, remove, or operate step-type pole mounted overhead distribution voltage regulators.

ACCOUNTABILITY

1. Standards, Policies, & Codes
   A. Update procedures as necessary
2. Electric Operations (Line Dept.)
   A. Operates line voltage regulators.
   C. Makes repairs or corrects non-standard deficiencies.
   D. Complete TOA notification process to Regional Control when necessary.
3. Protections and Telecom Relay and Control
   A. Assist Operations when installing/removing regulators if necessary.
   B. Complete TOA notification process to Regional Control when necessary.
4. Distribution Design
   A. Create and Maintain accurate GIS records that identifies the line voltage regulator and its install date, location, and control and bypass switch numbers.
5. Engineering Maps & Records
   A. Maintain accurate Circuit and Index Feeder Maps of line voltage regulators and their location.

COORDINATION

Electric Distribution Operations, O&M Operations, and Protection and Telecom Operations

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
Liberty Utilities Overhead Construction Standards – Section 15
Manufacturer's Installation, Operating, and Maintenance manuals for the specific equipment to be inspected and maintained
EOP GO14 Clearance and Control
SMP 404.01.2 Substation Maintenance Procedure (Step Voltage Regulator)

DEFINITIONS

GIS – Geographic Information System. The GIS system provides an asset register that graphically illustrates our distribution/transmission facilities and their operating characteristics.

Live Line Tool - An insulated stick for use on energized equipment, usually carried on vehicles, or stored in buildings or control houses for everyday use. Tools such as shotgun sticks, switch sticks, universal sticks, telescopic sticks, etc., are live line tools.

Qualified Person – A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and / or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Step-Type Voltage Regulator - Step type voltage regulators raise or lower the incoming primary voltage by 10% and the regulator tap changers divide the 10% raise or lower voltage into 16 individual steps. Each step on a regulator adds 5/8 % of the maximum raise or lower voltage to the primary circuit.

TOA – Transmission Outage Application used to schedule, document and coordinate system outages for New England and New York.

TRAINING

Liberty Utilities Technical Training will provide training upon request.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook rules as well as all applicable Liberty Utilities EOPs utilizing appropriate safe work methods.

All appropriate Personal Protective Equipment, including, but not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

The person in charge of the work shall conduct a written Job Brief with the employees involved before they start each job. The briefing shall cover at a minimum the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and Personal Protective Equipment requirements.

Rubber gloves of the appropriate class shall be worn as required.

During work, approved barriers or other appropriate protection as required shall be installed where required to protect workers.

All the procedures shall be performed in accordance with accepted safe work practices using approved tools and equipment. Refer to the approved Tool and Equipment Catalog for a listing of approved equipment.

2.0 GENERAL OPERATING INFORMATION

2.1 Conduct a **thorough pole top inspection** to evaluate such things as:

2.1.1 The condition of all equipment on the pole paying particular attention to porcelain cutouts or switches

2.1.2 The condition of the cross arms and pole top looking for any signs of burning

2.1.3 Any non-standard construction hazards

NOTE: Any proposed paralleling of feeders and associated switching and/or regulator adjustments shall first be discussed with the System Operator.

3.0 VERIFYING REGULATOR(S) IN NEUTRAL

3.1 Regulator By-pass switches must not be operated to place an energized voltage regulator on or off line until the regulator is placed in the NEUTRAL position, and the manual/automatic control circuit has been switched off. The fuse (fig. 2) or circuit breaker (fig. 1) on the front of the control panel may be removed or opened as an additional protection. Verification of the neutral position must be completed by one of the three methods below:

3.1.1 Properly working neutral light AND properly working position indicator.

3.1.2 Properly working neutral light AND Neutral Position Regulator Voltmeter (NPRV).

3.1.3 Properly working position indicator AND Neutral Position Regulator Voltmeter (NPRV).

Never install or remove a regulator from service unless it is in neutral and motor controls are turned off. If the regulator is not run to neutral, dangerous circulating currents can develop causing catastrophic equipment failure.

Always remember: <u>Manual – Neutral - Off</u>

3.1.4 Newer types of regulators are equipped with CT and PT switches mounted in the back of the control panel (fig. 5 and 6). If so equipped, the CT switch should be closed and the PT switch opened for additional protection.

3.2 The Neutral Position Regulator Voltmeter (NPRV) is a specially designed voltmeter used for measuring the voltage **<u>between the source (S) and load (L) bushings</u>** on distribution voltage regulators. It can be used to check for the neutral position of the regulator before operating the regulator by–pass switch. **THE NPRV MUST BE TESTED BEFORE AND AFTER IT IS USED.** Follow the manufacturer's operating instructions and look for the lowest deflection or null point on the meter. See section 6 for NPRV use.

3.3 When regulators are equipped with a neutral indicator light and used in conjunction with the position indicator or NPRV, the light is considered a dependable indicator. If the light does not illuminate to indicate the neutral position, either the bulb is burnt out, the bulb circuit is defective, (report this to the appropriate supervisor) or the regulator is not in the neutral position. When the neutral indicator light does not light, the Neutral Position Regulator Voltmeter (NPRV) and the position indicator (fig. 3) shall be used to test that the step type pole mounted regulator is in the neutral position.

3.4 Manually raise and lower the regulator in order to verify that the Neutral Indicator Light and/or the Position Indicator are working properly. Return to neutral once verification is complete. Exercise caution when raising and lowering the regulator so as not to exceed lower and upper secondary voltage output limits (see 9.3.2).

NOTE: Regulator position indicators (fig. 3) have been known to get out of adjustment and not indicate correctly, so we require more than one source to check for neutral.

Fig. 1

Fig. 2

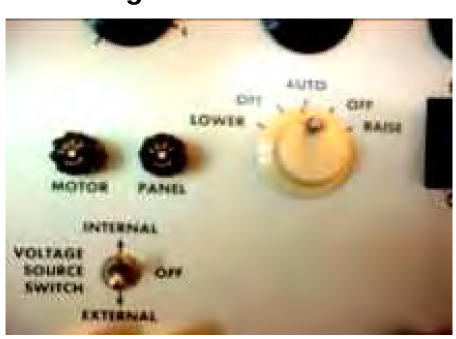

Fig. 3

3.5 DO NOT OPERATE THE REGULATOR BY-PASS SWITCH IF THERE IS ANY DOUBT THAT THE REGULATOR IS <u>NOT</u> IN THE NEUTRAL POSITION OR IF THERE IS ANY INDICATION THAT THE REGULATOR MAYBE DAMAGED (i.e. damaged by-pass arrestor). DE-ENERGIZE THE FEEDER IF NECESSARY, REMOVE REGULATOR LEADS, AND THEN OPERATE THE BY-PASS SWITCH AND REMOVE THE REGULATOR FROM SERVICE.

NOTE*: THE NPRV MUST NEVER BE USED ON INDUCTION TYPE REGULATORS (check name plate). TO REMOVE INDUCTION TYPE REGULATORS FROM SERVICE AN INTERRUPTION OF SERVICE MAY BE REQUIRED. GENERALLY INDUCTION REGULATORS ARE LARGER AND MAY BE FOUND IN SUBSTATIONS*.

<u>4.0 INSTALLING AND REMOVING LEADS</u>

4.1 Always remember to connect the tank ground before any other lead is installed.

4.2 **All leads <u>must</u> be kept in the clear** when they are directly connected between the primary conductor and the regulator bushings by using **Insulated Hangers** (fig. 4) when either installing or removing them. **ALL** the leads will be energized when one or more leads are attached to the energized primary conductor.

Fig. 4

4.3 When **<u>installing</u>** the leads connected directly from the regulator bushings to the primary conductor:

4.3.1 The **Source Load (SL)** lead is installed **first.**

4.3.2 The **Source lead (S)** is installed **second**.

4.3.3 The **Load (L)** lead is installed **last**. The regulator must be in neutral and off before this connection is made.

4.4 When **removing** the leads connected directly from the regulator bushings to the primary conductor:

4.4.1 The **Load (L)** lead is removed **first**

4.4.2 The **Source (S)** lead is removed **second**

4.4.3 The **Source Load (SL)** lead is removed **last**.

4.5 When **removing** leads to Delta connected regulator(s) connected to an S&C regulator by-pass switch:

4.5.1 **OPEN** by-pass switch **first**

4.5.2 The **Source Load (SL)** lead is removed **second** (regulator is now de-energized)

4.5.3 Remove **Source (S)** and **Load (L)** leads **last**.

5.0 CT AND PT SWITCHES IN REGULATOR CONTROL

5.1 The CT shorting switch and the PT disconnect switch, if so equipped, are located inside the control cabinet behind the main panel. (Fig. 5 and 6)

5.2 It is recommended that the CT switch be closed and the PT switch be opened, if so equipped, when either energizing or de-energizing a regulator. This will prevent an inrush of current especially if it is being reverse feed.

5.3 The control cable must be connected on all regulator installations prior to energizing.

5.4 If the control cabinet is equipped with a CT shorting switch, **do not disconnect the control cable** from an energized regulator's position indicator or from the control cabinet. This will create an open CT circuit and high voltage from the open CT may be present. Warning decals are placed on or near the control cable terminations if it is so equipped (Fig. 7 and 8) or a check inside the control cabinet can be done (Fig. 5 and 6).

5.5 Extreme caution must be used when working inside the control cabinet of an energized regulator as the PT disconnect switch and CT shorting switch may not de-energize all the components in the control cabinet. Only a qualified technician should perform work inside the control cabinet on an energized regulator.

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Fig. 5

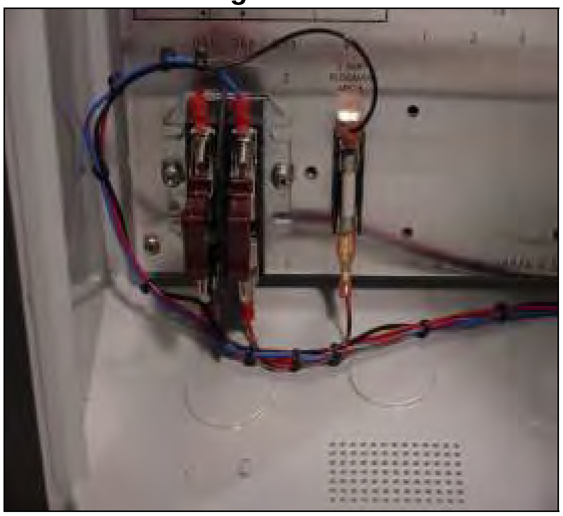


Fig. 6

Fig. 7

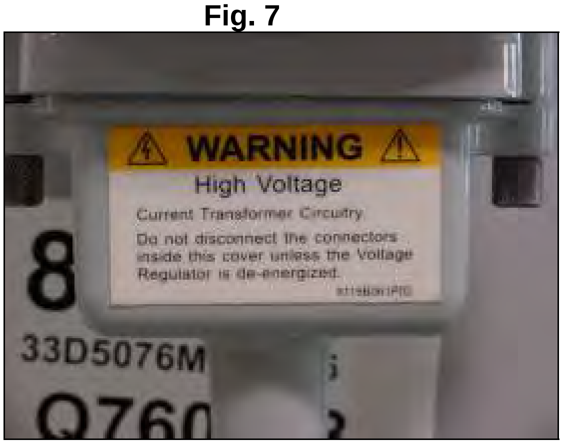


Fig. 8

6.0 NEUTRAL POSITION LINE VOLTAGE VOLTMETER

6.1 Read and follow the manufacturer's operating instructions for testing and operation of the unit.

6.2 The NPRV **shall** be used wearing rubber gloves and all other required Personal Protective Equipment.

6.3 The NPRV **shall** be attached to an approved and properly tested live line tool of sufficient length to provide the required minimum approach distance for the voltage being worked

6.4 The NPRV **shall** be visually inspected for damage and moisture before use.

6.5 The NPRV **shall** only be used to take voltage measurements between the **Source (S) and Load (L) bushings** or leads as it is only rated for 3kv (Fig. 9).

6.6 The NPRV **shall** be tested before and after it is used.

6.7 The NPRV **shall not** be tested on primary voltage. (Phase to phase or phase to ground)

6.8 On the new style NPRV, (Fig. 10) a self test is done when turned on.

6.9 On the old style NPRV, use the battery test to check for deflection of the meter (Fig 11).

6.10 The NPRV **shall** be stored properly in a dry, clean location to avoid damage.

6.11 Determine the best location to position the NPRV in order to read the voltage between the Source (S) and Load (L) bushings or the Source (S) and Load (L) leads of the regulator. Contact must be made between the bushing terminals or the leads attached to these terminals and the NPRV electrodes. **Care must be taken not to short any wires or bushings to ground or each other. (Fig 9)**

6.12 Place the regulator control in manual and operate the regulator to the neutral position as shown on the regulator position indicator (Fig. 3).

6.13 Place the electrodes of the NPRV between the S and L bushings or S and L leads, using caution not to bridge between ground or another phase with the electrodes, and confirm the regulator is in neutral.

6.14 Operate the regulator manually in either direction to confirm the electrical connection of the NPRV. The NPRV reading should increase as the position indicator leaves neutral.

6.15 Return the regulator back to neutral as indicated by the NPRV.

6.16 **If the readings of the NPRV and the regulator neutral position indicator do not agree, and you don't have a light, on the Neutral Indicator Light, notify the appropriate supervision before proceeding any further.**

6.17 A malfunctioning NPRV must be removed from service, tagged and returned for repair or replacement as soon as possible.

Fig. 9

Test Across <u>Source and Load</u> bushings or leads <u>only</u>

Fig. 10

New Style
Self test when turned on

Fig. 11

Old Style
Battery test

<u>7.0 REMOVING REGULATOR(S) FROM SERVICE</u>

7.1 This section refers to regulators with the leads connected directly to the primary conductor and with a disconnect by-pass switch (D5) or a cut-out by-pass switch (C43).

7.2 When removing regulators from service and the removal of the leads will de-energize the regulator windings, **the sequence for installing or removing the leads is important.**

7.3 Visually inspect the regulator for any signs of damage; leaking oil, burnt oil smell, a damaged position indicator, or a damaged exterior by-pass arrester, if so equipped (fig.12).

__NOTE__: IF THE BY–PASS ARRESTER IS DEFECTIVE, OR ANY OTHER DAMAGE OR DEFECTS ARE OBSERVED, DO NOT OPERATE THE TAP CHANGER CONTROL. The circuit may have to be de-energized to remove the regulator from service.

7.4 To place the regulator into the neutral position:

7.4.1 Place the control mechanism to the **MANUAL** position.

7.4.2 Raise or lower the tap changer as needed to run the tap changer to the **NEUTRAL** position.

7.5 Most regulators are equipped with a neutral indicator light that will indicate that the regulator is in the neutral position. Manually raise and/or lower the regulator to verify that the neutral indicator light and the position indicator are working properly and return to neutral when verification is complete.

7.6 THE NEUTRAL POSITION SHALL BE CHECKED USING THE NEUTRAL POSITION REGULATOR VOLTMETER (NPRV) IF EITHER THE NEUTRAL INDICATOR LIGHT OR THE POSITION INDICATOR CANNOT BE CONFIRMED TO BE PROPERLY WORKING.

NOTE: Regulator position indicators are sometimes out of adjustment (fig. 3).

7.7 Turn the control mechanism from the manual position to the **OFF** position.

REMEMBER: MANUAL - NEUTRAL – OFF

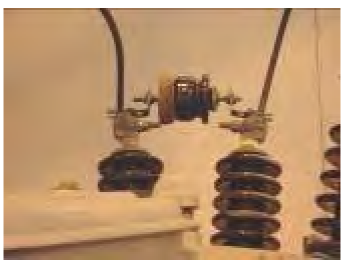
7.8 For added protection, the fuses or circuit breakers on the front of the control panel may be removed or turned off. On newer control panels, the CT switch may be closed and the PT switch opened. This will disable, **not de-energize,** the control panel.

7.9 Visually inspect the by-pass switch(s) for any defects.

7.10 Close the by–pass switch using an appropriate length switch stick.

7.11 Remove the regulator leads following the appropriate sequence for lead removal.

Fig. 12



8.0 PLACING REGULATOR(S) IN SERVICE

8.1 This section refers to regulators with the leads connected directly to the primary conductor and with a disconnect by-pass switch (D5) or a cut-out by-pass switch (C43).

8.2 When placing regulators in service and the installation of the leads will energize the regulator windings, **the sequence for installing the leads is important.**

8.3 Visually inspect the regulator for any damage; leaking oil, burnt oil smell, a damaged position indicator, or a defective exterior by-pass arrester, if so equipped (Fig. 12).

8.4 Always connect the tank grounds first.

8.5 THE REGULATOR MUST BE IN THE NEUTRAL POSITION BEFORE EITHER THE REGULATOR BY–PASS SWITCH IS OPERATED OR THE L (LOAD SIDE) LEAD IS CONNECTED.

8.6 The control panel must have power to it so the manual control can be operated. The power can be obtained either from the primary source, internal source, (fig. 15) or from a 120 volt external source connected to the external source terminals (fig. 16) on the front of the control panel (fig. 13 and 14).

8.7 When obtaining power for the control panel from the primary source, the common (SL) lead shall be put on first, making sure that the Source (S) and Load (L) leads are in the clear on temporary insulated hangers, and then install the Source (S) lead. Do not connect the load lead until it is proven that the regulator is in neutral.

8.8 When using an external voltage source, the voltage source switch must be in the external position and the leads must have the proper polarity (hot wire, ground wire).

8.9 Before energizing the regulator the CT switch should be closed and the PT switch opened. This will prevent a possible in rush of current that may damage the regulator.

8.10 After the regulator windings have been energized, the PT switch can be closed and the CT switch opened.

8.11 Place the control knob to the **MANUAL** position.

8.12 Raise or lower the tap changer as needed to verify that the regulator is in the **NEUTRAL** position.

8.13 Turn the manual control knob to the **OFF** position.

REMEMBER: MANUAL - NEUTRAL – OFF

8.14 For added protection the fuses or circuit breakers on the front of the control panel may be removed or turned off. This will disable the control panel but not de-energize it.

8.15 If the leads are connected directly to the primary conductor, install the Load (L) lead after the regulator has been proven to be in the neutral position and the control is in the off position.

8.16 Visually inspect the by-pass switches for any defects.

8.17 Open the by–pass switch using an appropriate length insulated stick and Load Buster Tool, if the switch is equipped.

8.18 Check the secondary output voltage and adjust the voltage accordingly and place the control in the auto position.

8.19 DO NOT OPERATE THE BY–PASS SWITCH IF THERE IS ANY DOUBT THAT THE REGULATOR IS <u>NOT</u> IN THE NEUTRAL POSITION.

Fig. 13

Fig. 14

Fig. 15

Fig. 16

9.0 ADJUSTING THE SECONDARY VOLTAGE OUTPUT

9.1 At times it may be necessary to manually raise or lower the secondary output voltage on a step type pole mounted regulator.

9.2 ANY PROBLEM WITH THE AUTOMATIC TAP CHANGER MUST BE REPORTED TO A SUPERVISOR AS SOON AS POSSIBLE. LEAVE THE TAP CHANGER IN THE OFF POSITION AND NOTIFY THE SUPERVISOR OF THE PROBLEM.

9.3 To adjust the voltage output:

9.3.1 Visually inspect the regulator.

9.3.2 Check the secondary output voltage at the voltage test terminals on the front of the control panel (fig.17). The high and low limits for secondary voltage are; 123V to 114V NY, and 126V to 114V NE, Nominal is 120V.

9.3.3 If the voltage level has to be raised or lowered:

a. Place the control knob from the **AUTO** position to the **MANUAL** position:

b. **Raise or Lower** the tap changer, while checking the voltage level at the test terminal:

c. Continue to **Raise or Lower** the tap changer until the proper voltage is reached:

d. Turn the control knob to the **OFF** position when complete.

e. Notify the local supervisor/engineer that the regulator is in the off position.

Fig. 17

10.0 REGULATOR CONFIGURATION

10.1 Effectively Grounded Circuits (Wye)

10.1.1 The preferred 3 phase method of installation on effectively grounded circuits is to install each regulator onto a separate pole eliminating unnecessary congestion and allowing for a quicker replacement and re-energization during an outage. When installing or removing leads from regulators, all leads must be in the clear and secured to insulated hangers. Wye connected single or 3 phase regulators must always have the Source Load (SL) bushing solidly connected to ground.

Regulators cannot be operated in the wye connection with the bank-neutral isolated (i.e. floating). Without an effectively grounded connection to the system neutral, the wye connection is hazardous, as the individual and independent voltage control of each phase can cause unequal turn ratios between phases, resulting in shifting of an isolated neutral with extreme distortion of phase voltages. Any exception to this should be reviewed by planning/engineering.

10.2 Not Effectively Grounded Circuits (Delta)

10.2.1 There are two methods of installation of regulators on not effectively grounded circuits. The regulators can be either connected closed delta (3 regulators) or open delta (two regulators). Whether the regulators are installed in either the open or closed delta configuration, the regulators must be placed in the neutral position before operating any of the regulator by-pass switches. When installing or removing leads from regulators in the open or closed delta configuration, all leads must be in the clear and secured to insulated hangers. A voltage will exist on all leads with any one lead installed.

10.2.2 When using two regulators in an open delta connection, the location shall be relatively balanced and the high and low voltage phases shall be determined through a preliminary load/voltage monitoring check by planning/engineering. It is critical that the field should install the regulation on the phases determined by planning/engineering. Normally, the line voltage regulators in the Open Delta configurations are connected to the high and low voltage phases. The remaining phase will increase by ½ the total of the two regulated phases added together.

For illustration purposes only, an example of this would be:

10.2.3 Phase (1-2) 121 volts

10.2.4 Phase (2-3) 119 volts

10.2.5 Phase (1-3) 113 volts

In this example, the two phases you would regulate are the high phase, Phase (1-2) and the low phase, Phase (1-3). If you add 1 volt to Phase (1-2) and 6 volts to Phase (1-3), Phase (2-3) would increase by ½ the total of (1-2) and Phase (1-3) added together or 3.5 volts (1 + 6 = 7, ½ x 7 = 3.5). Phase (1-2) would increase to 122 volts, Phase (2-3) would increase to 122.5 volts and Phase (1-3) would increase to 119 volts.

11.0 PARALLELING REGULATORS

11.1 Prior to any proposed paralleling of circuits and associated switching, a discussion shall be conducted with the System Operator so that there is a complete understanding of the feeder configuration and any impacts the proposed switching will have on the feeder regulation.

11.2 Some regulator installations are uni–directional, (again check the name plate) and can only be fed from one direction. These installations may have to be taken off line or placed in neutral and switched off if the source side is reversed as can happen during switching operations. All new regulator installations and many existing installations are bi–directional and can be fed from either direction.

11.3 The exact choice of which work method to use when paralleling line voltage regulating devices together depends on:

11.3.1 Whether one or more regulating devices are involved in the parallel

11.3.2 The impedance in the loop to be paralleled (near substations)

11.3.3 The resulting voltage conditions

11.3.4 Are they connected the same? (open delta/closed delta)

11.3.5 Type A regulators (exciting winding connected to the source voltage bushing) or Type B regulators (exciting winding connected to the load voltage bushing) (refer to name plate)

Do not attempt to parallel line voltage regulators off neutral if one regulator bank is connected closed delta and the other is connected open delta.

12.0 PARALLELING REGULATORS NEAR SUBSTATIONS

12.1 There are three work methods for paralleling feeders that involve line voltage regulation. Proper work methods for paralleling line voltage as determined by the System Operator should be adhered to in order to prevent dangerous high circulating currents. These work methods are:

12.1.1 Neutral-off

12.1.2 Matching steps

12.1.3 Matching voltages

12.2 Paralleling by setting regulators to Neutral-Off

12.2.1 The preferred method for paralleling line voltage regulators is neutral and off. When directed by the System Operator to parallel feeders that involve regulation by neutral and off, set the line voltage regulators in the Manual position, run them to the neutral position and turn them off. Refer to Section 4 of this EOP for detailed procedures to verify neutral position.

12.3 Paralleling by Matching Steps

12.3.1 When directed by the System Operator to parallel feeders that involve regulation by matching steps, turn the regulators to manual and run the regulators to the desired step and turn the regulator off. Never parallel Type A and Type B regulators that are in close proximity together by matching steps. Paralleling regulators of different types on any step other than neutral can result in significant circulating current if the loop impedance is small (regulators close together). Notify the System Operator if directed to parallel feeders involving different types of regulators that are in close proximity.

12.4 Paralleling by Matching Voltages

12.4.1 When directed by the System Operator to parallel by matching voltages, line voltage regulators should be adjusted so that the measured voltages are equal. To adjust the voltages, turn the regulator controls to Manual, adjust the voltages (raise or lower as needed), so that the measured secondary voltages are within 0.5 volts. Secondary voltages should only be taken with a true rms voltmeter, the Fluke 12 is not a true rms meter and should not be used to take secondary voltage readings to parallel line voltage regulators by matching voltages (refer to EOP G016 Elevated Equipment Voltage Testing Section IV for approved true rms voltmeters).

12.5 General Guidelines for Paralleling of feeders involving line voltage regulations with the regulation and tie switch used for the parallel within 1 mile of the station

Paralleling regulators fed from:	**Work Method**
Open Delta configurations tied to closed Delta	Neutral – Off
Same station with same Distribution bus	Neutral – Off or Matching Steps*
Same station, different Distribution bus, with open source bus tie	Neutral – Off or Matching Voltages
Same station different Distribution bus, with closed source bus tie.	Neutral – Off or Matching Steps*

* Never match steps between a Type A and Type B regulators.

13.0 PARALLELING REGULATORS MORE THAN ONE MILE APART

13.1 Prior to paralleling feeders that have line voltage regulation a check of the line voltage regulators involved shall be made to determine if the regulators are bi-directional or uni-directional (determined by checking information in the regulator control panel and/or the manufacturer's operating instructions located in the regulator control box).

13.2 When paralleling feeders that contain line voltage regulation from two different stations or feeders originating from the same station when the feeder regulation and the tie switch are more than a mile from the substation, a determination shall be made if any of the regulators will be reverse fed. If the regulators will be reverse fed, the reverse fed regulators shall be put in the manual position (tied down) prior to the parallel being made. Once the parallel has been made, the reverse fed regulators should be run in manual to neutral. The parallel will then be broken and the voltage checked at the reverse fed regulators to determine the final settings of these reverse fed regulators.

Reminder that there may not be enough load on the feeder for a bi-directional regulator to automatically reverse and the bi-directional regulator may need to be reversed manually.

14.0 S&C REGULATOR BY-PASS SWITCH

14.1 The S&C Regulator By-pass switches must not be operated to place a voltage regulator on or off line until the regulator is placed in the **NEUTRAL** position, and the manual/automatic control circuit has been switched off.

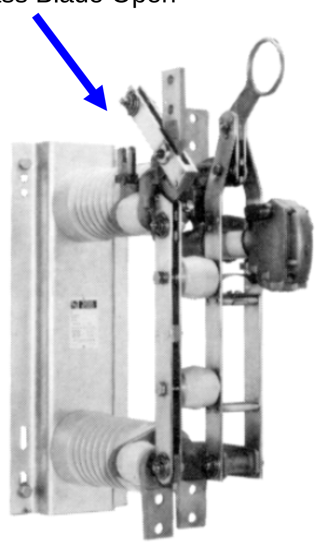
REMEMBER: MANUAL – NEUTRAL - OFF

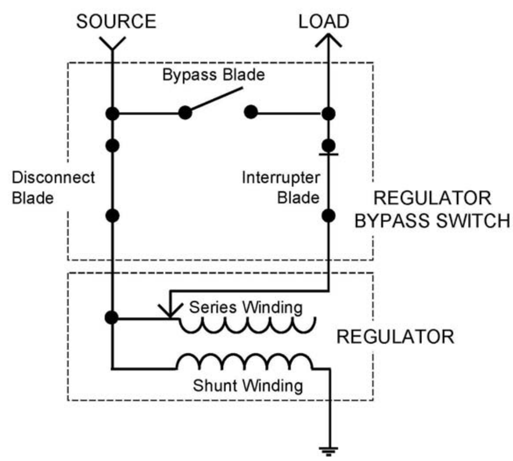
14.2 By-Pass Switch in CLOSED Position

14.2.1 The Switch is closed, voltage regulator is energized. By-Pass blade is open, disconnect blade and interrupter blade are closed, Fig. 18.

By-Pass Blade Open

Figure 18



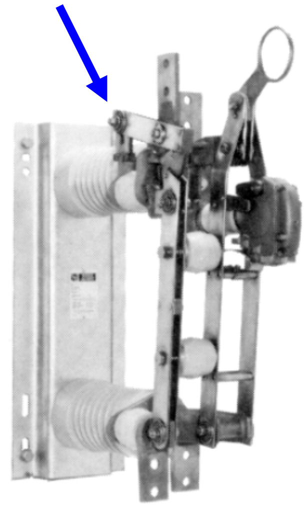


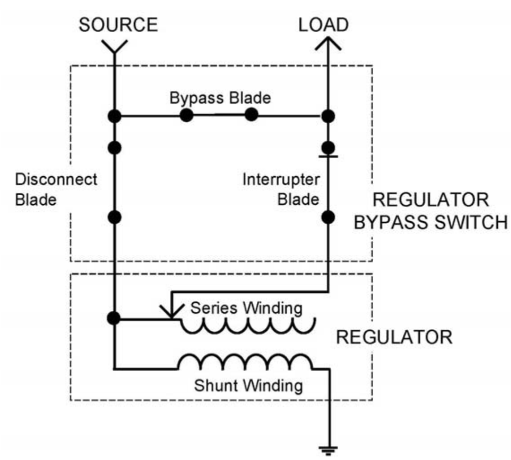
14.3 By-Pass Switch OPENING Sequence

14.3.1 Switch in early stage of opening stroke. By-Pass blade has closed making a direct connection between source and load. Disconnect blade and interrupter blade are still closed, Fig 19

By-Pass Blade Closed

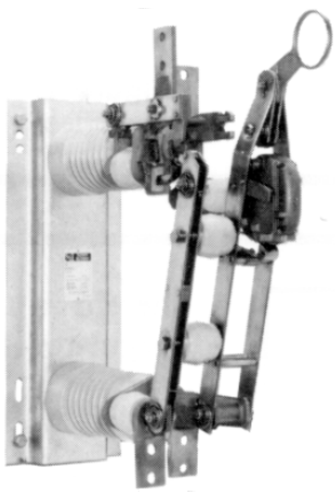
Figure 19

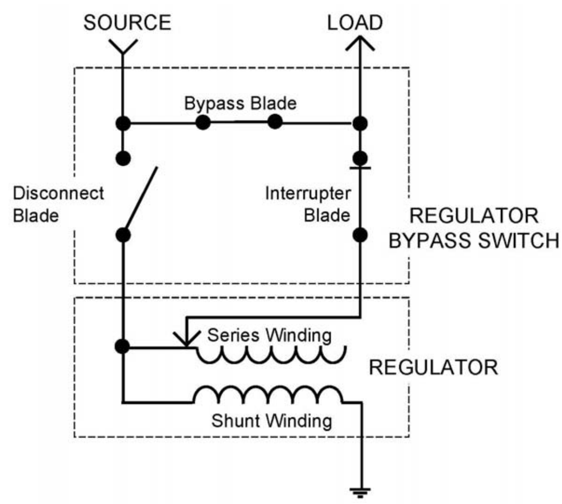




14.3.2 Switch in later stage of opening stroke. Disconnect blade has opened, but voltage regulator shunt winding is still energized through the interrupter blade, Fig 20.

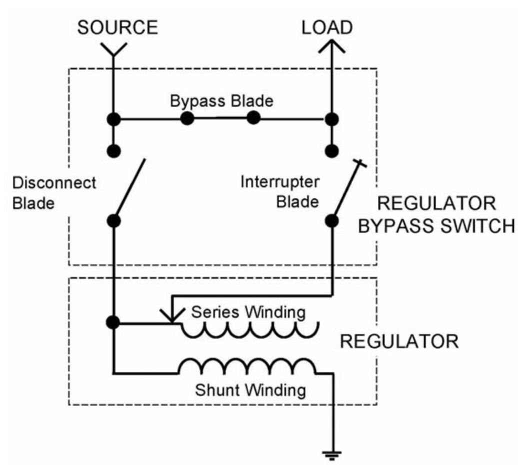
Figure 20





14.3.3 Switch fully open. Voltage regulator magnetizing current interruption has taken place within the interrupter with no external arc or flame. Voltage regulator is de-energized and By-Passed, Fig 21.

Figure 21



15.0 INSTALLING NEW REGULATORS WITH S&C BY-PASS SWITCH USING AN INTERNAL VOLTAGE SOURCE (SYSTEM VOLTAGE)

With the regulator(s) and by-pass switch(s) installed on pole(s) or a platform, the following steps outline the procedure for connecting the leads from the regulator to the by-pass switch and to the primary to place regulator in service.

15.1 Visually inspect the regulator for any damage; leaking oil, a damaged position indicator, or a damaged exterior by-pass arrester, if so equipped (fig.12).

15.2 If necessary, install in-line insulator (I7) to separate source and load on primary circuit. Do not cut open primary conductor.

15.3 OPEN the by-pass switch (by-pass is blade closed)

15.4 If regulator control is equipped, check CT switch CLOSED and PT switch OPEN in control

15.5 After the regulator windings are energized Close the PT switch and Open the CT switch

15.6 Connect tank to ground (wye and delta)

15.7 Connect source and load side leads to regulator bushings and bottom of by-pass switch

15.8 Connect SL lead to ground (Wye) or SL lead to primary (Delta)

15.9 Connect load side lead to top of by-pass switch and park lead on Insulated Hanger on load side of (I7) insulator

15.10 Connect source side lead to top of by-pass switch and primary conductor on source side of (I7) insulators.

15.11 CLOSE by-pass switch energizing regulator

15.12 Check and verify regulator to be in neutral and off

15.13 OPEN by-pass switch de-energizing regulator

15.14 Connect load side lead to primary conductor paralleling primary and bypass blade

15.15 Check current in load and source leads to be at least 30% of primary

15.16 Cut open loop over primary insulator (I7) breaking parallel between primary and by-pass blade

15.17 CLOSE by-pass switch energizing regulator. Regulator is in service.

15.18 If control line voltage compensation is set, check voltage and place regulator in auto.

CAUTION: When the by-pass switch is OPEN on a Delta connected regulator(s) and the Source Load (SL) lead is connected, the Source (S) and Load (L) leads from the regulator bushings to the bottom of the by-pass switch will remain energized.

16.0 INSTALLING NEW REGULATORS WITH S&C BY-PASS SWITCH USING AN EXTERNAL VOLTAGE SOURCE

Installing new regulators and checking them to be in neutral with an external source can be accomplished before they are transported to the job, at the work site before they are hung on the pole or on the pole before they are connected to the primary circuit.

With the regulator control properly connected, check that the control PT switch is closed if equipped. Place the voltage source control switch to the OFF position and connect the120V power source or generator making sure the polarity is connected correctly to the control then switch to the "External" position. Verify the regulator to be in neutral using the neutral light and position indicator. Turn control switch to OFF and disconnect power source.

With the regulator(s) verified in the neutral position and in manual OFF, OPEN the By-Pass switch and connect the regulator leads to the By-Pass switch and primary circuit. With the regulator in manual, neutral and OFF, CLOSE the By-Pass switch to place regulator in service. If control line voltage compensation is set, check voltage and place regulator in auto

17.0 REGULATOR REPLACEMENT

17.1 If it is determined that a regulator needs to be removed from the pole for repair or replacement due to damage, deterioration, or obsolescence, refer to Section 15 of the Overhead Distribution Standards for replacement options.

18.0 VISUAL AND OPERATIONAL INSPECTION

18.1 Visual and Operational Inspection shall be completed annually. Refer to SMP 404.01.2 Substation Maintenance Procedure (Step Voltage Regulator) Section 4

19.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	0	Initial Version of document Update from National Grid document to be NH Specific	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D004		
Electric Operating Procedure	**09-01-2013**	**Overhead**	
Distribution Line Patrol and Maintenance	**Revision #**	**0**	**Page: 1 of 7**

1.0 PURPOSE

The purpose of this document is to outline the requirements for inspection and maintenance activities, to electric operations personnel, associated with Liberty Utilities Overhead Distribution System feeders. Also, to furnish information and guidance to Liberty Utilities employees in establishing or sustaining a continuing program of effective, ongoing Overhead Distribution lines inspection and maintenance. This program is designed to both provide for a safe and sustainable distribution system and improve system reliability.

2.0 SCOPE

This program applies to all personnel involved with or responsible for the inspection and repair of Overhead (OH) Distribution Lines facilities. It will outline inspection and maintenance activities for overhead distribution lines assets, inspection cycles, and data collection. Procedures will be included detailing an inspection priority system that will identify and provide for timely condition-based replacement of any visibly damaged or deteriorated asset prior to the next inspection cycle.

3.0 DEFINITIONS

NESC: National Electric Safety Code

Patrol: A walking/vehicle assessment of Liberty Utilities distribution facilities for the purpose of determining the condition of the facility and its associated components.

Hand Held Computer: A *Windows*® based data recording device that is used in the field to create a record of conditions found.

Desktop Computer: A personal computer that is connected to the Liberty Utilities network that is used to download the Hand Held Computer and retrieve the information in the form of reports.

Distribution Inspector: An employee or contractor that has been trained to identify deficiencies or non-standard construction conditions on Liberty Utilities facilities.

4.0 REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
NESC Section 21 Part 214 A
LU-EOP UG006 Underground Inspection and Maintenance
LU-EOP G016 Equipment Elevated Voltage Testing

5.0 RESPONSIBILITY

Roles and Responsibilities are outlined in the "Procedure" section of this document

6.0 PROCEDURE

6.1 General

The Overhead Distribution Maintenance Program was designed to provide for a patrol and subsequent maintenance of each distribution feeder once every five (5) years. The patrols are conducted by a Distribution Inspector identifying all required maintenance on a Windows® based hand held computer. The maintenance items identified through this patrol are separated into four priority levels 1, 2, 3, and 4. The problem codes identified default to the appropriate priority level. The default priority level can be adjusted by the individual

performing the inspection based on actual field conditions.
These priority levels are defined as follows:

Level 1- An identified facility/component or tree condition that must be repaired/replaced within 1 week.

Level 2 - Identified facility/component condition that must be repaired/replaced within 1 year.

Level 3 – Identified facility/component condition that must be repaired/replaced within 3 years.

Level 4 – This priority category is to collect inventory information on actual field conditions to be used by Electric Planning Engineering.

All Level 1 priority conditions identified in the field shall be called in by the Distribution Inspector as follows:

- Notification:
  Liberty Utilities (New Hampshire) Emergency Dispatch and Scheduling Center - 1-603-216-3620
- Detailed information to be provided to NH Emergency Dispatch
  - Identify yourself as individual performing Distribution feeder inspections for Liberty Utilities and your work reporting area.
  - Details of the *Level 1* Priority condition:
    - Problem found
    - Town, Street, Feeder No., and Pole No.
    - Street address and any additional information that would assist in finding the location of the problem.
    - If you are standing by or have secured the location.
- Notification to area Electric Operations Supervisor or Electric Operations Manager.

6.2 Distribution Patrol

6.2.1 Distribution Patrols are conducted by a Distribution Inspector that has been trained to identify deficiencies or non-standard construction conditions on Liberty Utilities facilities. Distribution patrols are scheduled in such a manner that each distribution feeder is examined in the field once every five (5) years. The patrols shall be completed by March 31. The most current Distribution Patrol schedule can be found in the Distribution Maintenance Program data base (RPT 1310 Feeder Patrol Status). New Distribution Feeders added to the system will be incorporated through our Geographic Information System (GIS) system and added to the appropriate inspection cycle. If the Distribution Inspector finds unmapped facilities from the information supplied from GIS, the inspector shall add the information into the Windows® based hand held computer for maintenance tracking purposes LU- EOP G011, Preparation and Distribution of Electric Facilities Records, identifies the correct procedure for updating GIS records, if needed.

6.2.2 Distribution Patrol data is recorded by the Distribution Inspector on a Windows® based hand held computer and downloaded to the Distribution Maintenance Program. The Distribution Inspector shall also complete maintenance code 118, stencil installed and maintenance code 220, guy wire marker, maintenance code 660, switchgear missing nomenclature, maintenance code 681, transformer missing nomenclature, and maintenance code 745, enclosure missing nomenclature if found deficient upon inspection while at the site. Maintenance Codes are shown on the Distribution Field Survey Worksheet #LU0236 (Page 7). The Distribution Field Survey Worksheet can be used by the field to record maintenance items and is used for informational purposes only. The latest distribution maintenance codes are downloaded to the Hand Held Computer each time there is a change that affects the maintenance code table contained in the Distribution Maintenance Database. Printed copies of the latest maintenance code tables may be obtained by running a report on the look up tables from the Distribution Maintenance Database.

6.2.3 The Windows® based hand held computer is to be used as the primary vehicle for recording maintenance problems in the field. There may be times where it is not practicable to use the hand held computer. In these cases, the person performing the inspection should record the information on the Distribution Field Survey Worksheet #LU0236).

Once complete, the Distribution Field Survey Worksheet information must be input into the Distribution Maintenance Database by the inspector, clerk, or supervisor or their designee.

6.3 Equipment to be Inspected and Maintenance Codes

Wood Pole Mounted Street Light
Poles
Crossarms
Insulators
Primary
Transformers
Capacitor
Regulator
Recloser
Switches
Down Grounds
Guy
Anchor
Secondary
Service
ROW
GIS
Spacer Cable
Cutout
Risers
Switchgear
Padmount Transformers
Enclosures

Liberty Utilities	Doc. # LU-EOP D004	
Electric Operating Procedure	**09-01-2013**	**Overhead**
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DISTRIBUTION FIELD SURVEY WORKSHEET

Liberty Utilities

REGION	DISTRICT	EMPLOYEE ID	DATE
FEEDER	TAX DISTRICT/TOWN	MAP #	
LINE # / ROUTE #	POLE #/SUFFIX #		
LOCATION			
# MAIN LINE CATV ATTACHMENT 1 2 3 4 5	# MAIN LINE TELEPHONE ATTACHMENT 1 2 3 4 5	STREET LIGHT ATTACHED ☐ Yes ☐ No	

WOOD POLE MOUNTED STREET LIGHT	P/Q	SECTIONALIZER	P/Q	CUTOUT	P/Q
098 1,2,9 (NR) ☐ Street Light Hazard Cond.	/	180 1,2,9 (NR) ☐ Oil Weeping	/	280 1,2,9 (R) ☐ Defective Cutout	/
099 2,9 (NR) ☐ Not Bonded	/	181 1,2 (R) ☐ Bushings Broken/Cracked	/	281 2 (R) ☐ Potted Porcelain	/
POLE		182 2,9 (R) ☐ Missing Ground Wire	/	282 4 (NR) ☐ Banded Porcelain	/
106 3 (NR) ☐ Dbl Wood-NG Trnsf Req'd	/	183 4 (NR) ☐ Control Cab Height/Ground	/	283 4 (NR) ☐ Enclosed	/
107 4 (NR) ☐ Dbl Wood-Tel Trnsf Req'd	/	184 3,9 (R) ☐ Improper/Missing Bond	/	284 4 (NR) ☐ Non Porcelain	/
108 4 (NR) ☐ Dbl Wood-CATV Trnsf Req'd	/	185 3,9 (R) ☐ Animal Guard Missing	/	285 4 (NR) ☐ Hybrid	/
110 1,2,9 (R) ☐ Broken/severely damaged	/	186 3,9 (R) ☐ LA Blown/Missing/Improper	/	286 4 (R) ☐ SpurTap Not Fused	/
111 1,2,3,4 (RP) ☐ Visual Rotting Grd Line	/	**RECLOSER**		289 4 (NR) ☐ Other	/
113 3 (NR) ☐ CuNap Treated Bthmark Yr	/	190 1,2,9 (NR) ☐ Oil Weeping	/	**RISER**	
114 2,4 (R) ☐ Woodpecker Holes	/	191 1,2 (R) ☐ Bushings Broken/Cracked	/	290 1,2,3,9 (NR) ☐ Improp Cable Supp/Term	/
115 1,2,3,9 (NR) ☐ Riser Guard Req'd	/	192 2,9 (R) ☐ Missing Ground Wire	/	291 2,9 (R) ☐ Improper/Missing Bond	/
116 1,2,3,4 (RP) ☐ Visual Rotting Pole Top	/	193 4 (NR) ☐ Control Cab Height/Ground	/	292 3,9 (R) ☐ Animal Guard Missing	/
117 1,2 (NR) ☐ Leaning Pole	/	194 3,9 (R) ☐ Improper/Missing Bond	/	293 2,3,9 (R) ☐ LA Blown/Missing/Improper	/
118 P (NR) ☐ Stencil / Correction Req'd	/	195 3,9 (R) ☐ Animal Guard Missing	/	**INFRARED**	
119 4 (NR) ☐ Bird's Nest	/	196 2,3,9 (R) ☐ LA Blown/Missing/Improper	/	400 1,2,3,9 (R) ☐ Problem - Switch	/
CROSSARM		**SWITCH**		401 1,2,3,9 (R) ☐ Problem - Cutout	/
120 1,2,4,9 (R) ☐ Damage Arm	/	203 1,2 (R) ☐ Gang Oper'd Defective	/	402 1,2,3,9 (R) ☐ Problem - Splice	/
121 1,2,4 (NR) ☐ Loose/Defective Pins	/	204 1,2,3,9 (R) ☐ Single Phase Defective	/	403 1,2,3,9 (R) ☐ Problem - Other	/
122 3,9 (NR) ☐ Wooden Pine 13.2kv	/	205 3,9 (R) ☐ Improper/Missing Bond	/	**HANDHOLES**	
123 1,2,4 (R) ☐ Loose Brace, Hrdwr	/	207 3,4,9 (R) ☐ LA Blown/Missing/Improper	/	600 1,2,9 (NR) ☐ Broken/Damaged/Unsecured	/
124 1,2,4,9 (R) ☐ Damage Dbl Crossarm	/	208 2,9 (NR) ☐ Handle Not Bonded	/	602 P (NR) ☐ Missing Nomenclature	/
125 1,2,4,9 (R) ☐ Damage Alley Arm	/	**GROUND**		603 1 (R) ☐ Secondary Needs Repair	/
127 1,2,9 (R) ☐ Primary On Arm	/	210 1,2,9 (R) ☐ Wire Broken/Loose	/	604 4 (NR) ☐ Other (use comments)	/
INSULATOR		211 1,2,9 (R) ☐ Hazard Condition	/	**SWITCHGEAR**	
130 1,2 (R) ☐ Broken/Cracked/Flashed	/	212 3,4 (NR) ☐ Guard Req'd	/	651 1,2,3,9 (R) ☐ Barrier Brkn/Dmgd/Unsec	/
131 1,2,9 (R) ☐ Floating	/	213 3,4 (NR) ☐ Non Standard	/	652 1,2 (NR) ☐ Base Broken/Damaged	/
132 3,4 (NR) ☐ I7 Aluminum Capped	/	214 3,9 (NR) ☐ Not Bonded to Neutral	/	654 2,9 (R) ☐ Cable Not Bonded	/
133 3,9 (R) ☐ Non-Standard Voltage	/	**GUY**		656 2,9 (R) ☐ Door Broken/Damaged	/
134 3,4 (NR) ☐ AL Cap Assoc w/Switch/Fuse	/	220 P (NR) ☐ Guy Wire Marker	/	657 F (NR) ☐ Excessive Vegetation	/
PRIMARY		221 2,9 (NR) ☐ Not in Compliance w/Code	/	659 2,9 (R) ☐ Missing Ground	/
140 1,2,9 (R) ☐ Insuff. Grnd Clearance	/	222 3,9 (NR) ☐ Excessive Slack	/	660 P (NR) ☐ Missing Nomenclature	/
141 1,2,3,9 ☐ Damaged Cond/Brkn Strands	/	223 1,2,3,9 (R) ☐ Broken Wire	/	661 4 (NR) ☐ Other	/
142 1, F (NR) ☐ Limbs on Primary	/	225 4 (NR) ☐ Guy not Bonded/Isolated per Standards	/	662 4 (NR) ☐ Rusted/Paint Peeling	/
145 1,2,3,9 (R) ☐ Dmg'd Stirups/Connector	/			**PAD TRANSFORMER**	
146 2,3 (R) ☐ Improper Sag	/	**ANCHOR**		672 1,2,3,9 (R) ☐ Bushing Broken/Cracked	/
147 4 (R) ☐ LA Missing Transition	/	226 1,2,3,9 (NR) ☐ Req'd - Jt. Owned	/	673 1,2,P (R) ☐ Door Broken/Damaged	/
148 4 (R) ☐ LA Missing End of Line	/	227 1,2,3,9 (NR) ☐ Req'd - Sole NG	/	675 1,2 (R) ☐ Elbows/Terminator/ Tracking/Burned	/
149 3,9 (R) ☐ LA Blown	/	**SECONDARY**			
TRANSFORMER		231 1,F (NR) ☐ Limb on Secondary	/	676 F (NR) ☐ Excessive Vegetation	/
150 1,2,9 (NR) ☐ Oil Weeping	/	232 1,2 (NR) ☐ Improper Sag	/	680 2,9 (R) ☐ Missing Ground	/
151 1,2 (R) ☐ Bushings Broken/Cracked	/	234 1,2,3,9 (NR) ☐ Floating	/	681 P (NR) ☐ Missing Nomenclature	/
152 2 (R) ☐ Missing Ground Wire	/	**SERVICE**		684 1,2,9 (NR) ☐ Oil Weeping	/
153 2,4 (R) ☐ LA Blown/Missing/Improper	/	240 1 (NR) ☐ Ins. Loose from House	/	685 1,2,3,4,9 (NR) ☐ Pad Broken/Damaged	/
155 4 (R) ☐ Animal guards required	/	241 1,F (NR) ☐ Limb on Service	/	686 4 (NR) ☐ Protection (Ballards)	/
156 3,9 (NR) ☐ Non Std Install of Gap	/	243 1 (NR) ☐ Non Std/Unsecured	/	687 4 (NR) ☐ Rusted/Paint Peeling	/
157 2,9 (R) ☐ Improper/Missing Bond	/	**ROW**		**ENCLOSURES**	
CAPACITOR		250 F (NR) ☐ Brush/Tree/Washout	/	740 1,2,3,4,9 (R) ☐ Base Broken/Cracked	/
160 1,2,9 (NR) ☐ Oil Weeping	/	**GIS**		741 1,2,3,9,P (R) ☐ Door Brkn/Dmgd/Unsec	/
161 1,2,9 (R) ☐ Bulging	/	260 4 (NR) ☐ Map Doesn't Match Field	/	742 1,2,3,9 (R) ☐ Elbows Tracking/Burned	/
162 1,2 (R) ☐ Bushings Broken/Cracked	/	261 4 (NR) ☐ Pole/Line Numbering Error	/	743 F (NR) ☐ Excessive Vegetation	/
163 2,9 (NR) ☐ Missing Ground Wire	/	262 4 (NR) ☐ Equip/Hardware/Missing	/	744 2 (NR) ☐ Missing Ground	/
164 2,9 (NR) ☐ Blown Fuse	/	263 4 (NR) ☐ Equip Removed in Field, Remove From GIS	/	745 P (NR) ☐ Missing Nomenclature	/
165 3,9 (NR) ☐ Improper/Missing Bond	/			746 4 (NR) ☐ Rusted/Paint Peeling	/
166 3,9 (R) ☐ Animal Guard Missing	/	269 4I (NR) ☐ Other GPS/GIS Errors	/	**POLE INSPECTION**	
167 3,9 (R) ☐ LA Blown/Missing/Improper	/	**SPACER CABLE**		801 1,2,3,4,9 (NR) ☐ Identified Priority Pole	/
168 4 (NR) ☐ Control Cab Heigh/Ground	/	270 1,2,3,9 (R) ☐ Damaged/Missing Spacer	/	802 1,2,3,4,9 (NR) ☐ Identified Reject Pole	/
REGULATOR		271 1,2,3,9 (R) ☐ Bracket Damage	/	803 4 (NR) ☐ Excessive Checking	/
170 1,2,9 (NR) ☐ Oil Weeping	/	272 3,9 (R) ☐ Bracket Not Bonded	/	804 4 (NR) ☐ Climbing Inspection	/
171 1,2 (R) ☐ Bushings Broken/Cracked	/	273 3,9 (R) ☐ Messenger Not Bonded	/		
172 2,9 (R) ☐ Missing Ground Wire	/	274 3,9 (R) ☐ Messenger Guard Missing	/		
174 4 (NR) ☐ Control Cab Height/Ground	/	276 3,9 (R) ☐ Uncovered Splice	/	**KEY**	
175 3,9 (R) ☐ Improper/Missing Bond	/			P/Q = Priority / Quantity	
176 3,9 (R) ☐ Animal Guard Missing	/			NR = Maint. Code May Not Direct Affect Reliability	
177 3,9 (R) ☐ LA Blown/Missing/Improper	/			R = Maint. Code May Affect Reliability	
				RP = Maint. Code May Affect Reliability and Has Specific Program to Place to Address	

Comments:

6.4 Distribution Maintenance Data Base

6.4.1 The Distribution Maintenance database consists of information collected in the field down loaded from the Windows® based hand held computer and data gathered from other sources entered from the desktop computer. The Windows® based hand held computer can be down loaded to any Liberty Utilities desk top computer that is connected to the network by an employee that has been authorized to perform this function. The Distribution Maintenance database is used by various departments throughout Liberty Utilities to generate maintenance reports and cost estimates.

6.4.2 The Distribution Maintenance database contains information to be used by are conducted by a Distribution Inspector that has been trained to be used by Distribution Planning to track maintenance codes that may affect reliability (R), or may not directly affect reliability (NR).

6.5 Maintenance Schedule

6.5.1 Maintenance activities are scheduled by priority Levels. All “Level 1 Priority” conditions identified must be repaired/corrected within 1 week. All “Level 2 Priority” conditions identified must be repaired/corrected within 1 year. All “Level 3 Priority” conditions must be repaired within 3 years. Level 4 Priority is for inventory purposes only.

6.5.2 Once the Distribution Feeder is completed in the Distribution Maintenance Database or 21 days have elapsed since the inspection, the Level 2 and Level 3 Priority maintenance codes are downloaded into STORMS. Expense maintenance work goes straight to scheduling while the capital work goes to Distribution Design. Level 1 Priority maintenance codes are communicated by the Distribution Inspector directly to the field operations group for the area where the feeder is located.

6.6 Completion of Maintenance Codes

6.6.1 Level 1 priority maintenance codes completion process

- Distribution Inspector contacts NH Emergency Dispatch providing information on the Level 1 maintenance item and fills out a Level 1 Priority Report Form (page 10).
- Emergency Dispatch generates a PowerOn order from Dispatch Control.
- Supervisor captures PowerOn ID# and details for Level 1 maintenance item status. Inspections Supervisor tracks Level 1 maintenance status with operations ensuring that the Level 1 item is completed within 1 week. Supervisor closes out the Level 1 maintenance item in the Distribution Maintenance Database by adding the PowerOn ID # number to maintenance record.

6.6.2 Level 2 and Level 3 priority maintenance codes are completed in the Distribution Maintenance database once the 699 requirement is completed in STORMS for the work request associated with the maintenance code.

ALL MAINTENANCE WORK IS TO BE COMPLETED PER LIBERTY UTILITIES DISTRIBUTION STANDARDS.

ALL MAINTENANCE WORK PERFORMED THAT WAS IDENTIFIED ON THE WORK ORDER OR DISCOVERED DURING THE REPLACEMENT/REPAIR/CORRECTION OF THE ORIGINAL MAINTENANCE PROBLEM MUST BE LISTED ON THE DATABASE AND THEN CLOSED OUT WHEN COMPLETE.

<u>Level "1" & Elevated Voltage Priority Report Form</u>

Any Level "1" Priority or Elevated Voltage condition found must be called into Dispatch.

Feeder:________________________________

Line #:________________________________

Pole #:________________________________

Closest Meter #:______________________________

Street Address: ________________________

City/Town: ___________________________

Level "1" Priority/Elevated Voltage condition found.

____

____

Call Dispatch to inform that this is either an Elevated Voltage call or an Inspection issue.

Dispatcher notified: _____________________

Date/Time: ____________________________

Inspector: ______________________________

7.0 TRAINING

Liberty Utilities Technical Training will provide training upon request.

8.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear, Hi-Vis and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and any additional requirements specified in referenced Liberty Utilities procedures.

10.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	0	Initial Version of document	Robert J Johnson

INTRODUCTION

Pole lashing can generally be associated with two types of pole replacement. The first type is the setting of a new pole in a newly excavated hole adjacent to the existing pole and lashing the two together. (Provide additional support to an existing damaged pole until wires and equipment can be transferred). The second type is removing the existing pole butt out of its hole so a new pole can be set in the same hole/location. This second type of pole replacement is used when replacing a jointly owned pole carrying underground risers or pole mounted equipment and should not create a construction hardship to transfer each parties equipment.

PURPOSE

This EOP will address the proper way to lash two poles together.

ACCOUNTABILITY

This procedure applies to all personnel involved with the lashing of double poles.

1. Distribution Engineering Standards, Policies, and Codes
   A. Update procedures as necessary.
   B. Provide Electric Distribution Operations field support and training upon request.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.

3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this standard.
   C. It is the workers responsibility to read and fully understand and follow the vendors instruction manual and specifications before using any test device or equipment.

REFERENCES

National Electrical Safety Code
Liberty Utilities Employee Safety Handbook and Procedures
OSHA 1910.269
NJUNS (National Joint Utilities Notification system)
JO Pole Agreements and IOP

DEFINITIONS

Cut and Kick: A method of setting a new pole in the same hole as the existing pole. This is achieved by cutting the existing pole just above ground line, removing old pole butt, and placing the new pole in the existing hole.

TRAINING

Provided by Liberty Utilities Learning & Development Training Program.

DOCUMENT CONTENTS

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PROCEDURE

1.0 LIMITATIONS

1.1 The use of pole lashing is limited by the facility loading (wire & equipment), type (dead end, angle, etc), and condition of the replaced pole (pole rot, CuNap pole treatment, etc). These factors shall be evaluated during the pre-job brief and a decision made as to the ability to safely support the old pole by lashing to the new pole. An engineering study has determined that lashing poles maintains class “C” construction and meets Liberty Utilities standards. Lashing does not meet class “B” construction, (i.e. railroad crossings or the traveled way of a limited access highway).

1.2 Poles replaced due to motor vehicle accidents or general maintenance (rotted or CuNap poles) and poles that meet class “B” construction, will be transferred at the time of set, unless the situation is deemed unsafe due to weather conditions or other circumstances. Local supervision will oversee this decision.

2.0 TIME CONSTRAINTS

2.1 At This time, New Hampshire does not have a time constraint law in place. Liberty Utilities will follow “in accordance with good utility practice” a company constraint that requires double poles to be removed within 6 months. This requirement applies to all facilities on the pole (telephone, cable, alarm, etc).

2.2 Design Engineering is responsible for getting the job ready for Construction. And the Electric Operations Coordinator sends job to Operations to have the job completed within the required time frame. Operations will return double pole field activity report with job package to the Operations Coordinator.

2.3 The NJUNS system is used to keep track of double poles in New Hampshire.

3.0 POLE LIFECYCLE MANAGEMENT

3.1 The National Joint Utilities Notification system (NJUNS) application is a web-based database application used by utility, telephone, CATV and private companies for tracking double pole installations and providing transfer obligation notices to attaching parties, thereby streamlining the management of joint use poles. By agreements among the pole owners, this system is used in New Hampshire.

3.2 Over the life of each double pole tracked in NJUNS, information is entered into the system;

3.2.1 When the double pole is set

3.2.2 Any facilities are transferred

3.2.3 The last piece of wood is removed

3.3 Information on pole sets and removals is entered by the pole owning electric and telephone companies. Information on transfers of facilities is entered by electric companies, telephone companies, cable operators, telecommunications service providers and some fire departments. Transfer information for most fire departments and all private attaches' are entered by the pole owners.

3.4 The NJUNS application allows all parties to eliminate communication inefficiencies by accessing the same data.

3.5 To access the database go to:

(http://www.njuns.com)

4.0 POLE SET AND REMOVAL

4.1 A pre-job brief must be held to evaluate site conditions such as pole loading, guying, pole top equipment, equipment and tools needed to perform the task, and work area protection.

4.2 The first step in the process is to secure the existing pole with the digger's pole guides (guides cannot be used alone) just under the secondary position.

4.3 A properly rated pole chain, or steel sling, must then be attached just above the pole's balance point, taking into consideration pole height, class, and equipment loading. Using the winch up function, slight upward pressure should be placed on the pole and the pole should then be cut just above ground line. The pole can then be lifted slightly and moved away from the remaining pole butt, so as not to impede the removal of the pole butt. The digger holding the pole will continue to hold the pole, or the pole will be secured through additional guying.

4.4 The existing pole butt is then removed from the hole and an inspection of the existing hole is conducted for obstructions, proper size and depth. A new pole is then installed /set in the existing hole using proper cover-up and guards. Once the new pole is installed /set, the old pole is moved as close as practical to the newly set pole and set on blocking.

5.0 POLE LASHING

5.1 The lashing of the two poles is done at a minimum of two locations, 4' to 6' from the ground-line, and between the CATV and telephone attachments, (see figures 1 & 2). The preferred method of lashing two poles together is to use the approved lashing wire (Item ID #8830-5998430) at both the upper and lower positions. Polyethylene polyester rope (Item ID #8830-8020562) can be used for a third point of lashing if crew deems it necessary for added support, but can be no smaller than ½."

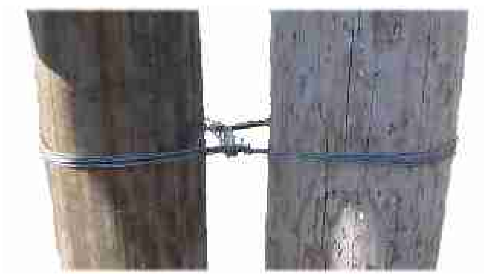

Figure 1

Figure 2

5.2 The installation of steel lashing wire entails making an eyelet at one end of the wire, looping the wire around the pole once and feeding the tail of wire through the eyelet, then wrapping the wire a minimum of 6 times around both poles and cinching the wire tightly to prevent movement of the cut pole (see Figure 1).

5.3 The installation of the rope (third option only) is shown in Figures 3, 4 & 5 and described as follows:

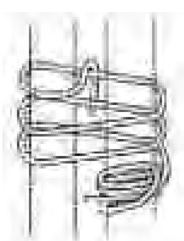

Figure 3

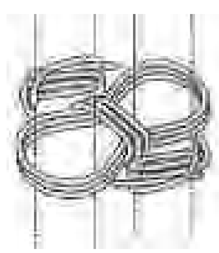

Figure 4

Figure 5

5.4 A rolling hitch should be attached to the more stable of the two poles, (figures 3, 4 & 5) the number of turns required is:

6 turns with ½ inch rope
4 turns with ⅝ inch rope
3 turns with ¾ inch rope

5.5 Pass the working end of the rope between the poles so that when you pull down it will bend around your wrappings and not unravel. Make 3 to 4 half hitches to secure rope.

6.0 SAFETY

6.1 Safety to employees as well as the general public must not be compromised. The condition of the pole, clearance over road crossings, and the weight of other utilities should all be contributing factors in the decision to cut and kick a pole. Always perform your job brief before performing each job. Follow all Liberty Utilities safety rules including proper PPE, Dig Safe notifications, work area protection, proper cover-up, and the use of non-reclosing assurance where applicable.

7.0 DOUBLE POLE FIELD ACTIVITY FORM

Double Pole Report Form

01/31/13

One Form per Pole

Submitted by: ______________________ Date: ______________________

Pole Location & Identification

Liberty Utilities Pole # ______________
Street ___________________________
Municipality ______________________
Tel Pole # (if known) ______________

Pole Ownership

sole owned [ ] joint owned [ ]
pole set type: side set [ ] cut & kick [ ]

Special Site Restoration Req'd? yes [ ] no [ ]

asphalt [ ] concrete [ ] grass [ ] brick [ ]
Other [ ] please describe

Double Pole Condition and Remaining Attachee Information (required transfers to new pole)

Electric transfers complete? yes [ ] no [ ]
Pole been topped? yes [ ] no [ ]
Butt removed? yes [ ] no [ ]

Fairpoint transfer req'd? yes [ ] no [ ]
Municipal transfer req'd? yes [ ] no [ ]
type: fire [ ] traffic [ ] sign [ ] other [ ]

Cable Co transfer req'd? yes [ ] no [ ]
Cable Co name ______________________
Fiber company transfer req'd? yes [ ] no [ ]
Fiber Co name ______________________
Fiber company transfer req'd? yes [ ] no [ ]
Fiber Co name ______________________
Other attachments? (describe) ____________

Comments:

WR # ______________________

Pole set date ______________________
Pole removal date ______________________

Operation Support Use Only

Data Input by: PLM / NJUNS Record ID:

Instructions: Complete a form for *each* pole replacement. Answer all questions. Input info to NJUNS. www.njuns.com

Transfer and pole removal work is time sensitive - do not delay submittal

Liberty-Energy Confidential 10/21/2014 Page 1

REVISION HISTORY

Date	Rev #	Description	Lead/Author
02/01/2015	0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

INTRODUCTION

This procedure will apply to all Liberty Utilities personnel that are required to install, remove or troubleshoot Step-down/Step-up Transformer(s).

Step-down/Step-up transformers are frequently used where:

Immediate conversion is not economically justified.
Immediate conversion to a higher voltage is required.
To relieve load from a lower voltage distribution circuit.

PURPOSE

This document details specific steps that shall be followed when Step-down/Step-up transformer(s) are installed or removed or when troubleshooting Step-down/Step-up transformer(s).

ACCOUNTABILITY

1. Standards, Policies, and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate guidance when requested.
2. System Control/Electric Distribution Operations
   - A. Ensure that the procedure in this EOP is implemented.
   - B. Ensure that all personal are trained in this procedure.
   - C. Provide procedure revision input as necessary.
3. Employees
   - A. Demonstrate the understanding of this procedure.
   - B. Comply with the requirements of this procedure.

COORDINATION

N/A

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
Liberty Utilities OH Construction Standards

DEFINITIONS

Overvoltage: A level of voltage that is above the nominal high range of voltage on a conductor, or piece of electrical equipment for any given circuit.

Person In Charge of Work: A qualified person responsible for the work to be performed.

Primary Voltage: All distribution circuit cables or conductors energized at 4, 15, 23, or 34.5 kV.

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Shall: The word "shall" indicates provisions that are mandatory.

Should: The word "should" indicates provisions that are normally and generally practical for the specified conditions.

TRAINING

Provide line personnel with training, through progression schools and as necessary.

DOCUMENT CONTENTS

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1.0 SAFETY

1.1 All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and all appropriate Liberty Utilities Electric Operating Procedures.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 If there is more than one worker assigned to the task, the person in charge of the work shall conduct a written job brief with the employees involved prior to the start of each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

1.4 It is possible that a transformer may be installed with the incorrect voltage rating, or in the case of a dual rated transformer, set on the wrong voltage. The energizing of customers at the wrong voltage can have catastrophic and costly results. Therefore, it is imperative that all precautions be taken to ensure that the voltages on Step-down/Step-up transformers are correct when installed. In addition, when three-phase Step-down/Step-up banks are involved, phase rotation and relation must also be checked.

2.0 GENERAL INFORMATION

2.1 The procedure for checking Step-down/Step-up transformer(s) installations is as follows:

2.1.1 Compare operating diagrams with construction drawings to verify the accuracy of the voltages shown on the construction drawing, if available.

2.1.2 Verify nameplate voltages and polarity on the transformer(s) with the voltages on the construction drawings.

2.1.3 If the transformer(s) are dual rated, check to insure that the switch or tap is placed on the proper voltage setting to match the voltage which it will be connected to. Do not assume that since the switch or tap is on the proper setting, that the output voltage is correct. The switch or tap may not have made the proper internal connection. Continue with the following steps to insure that the voltages are correct.

2.1.4 The Step-down/Step-up transformer(s) installation should be wired in accordance with the Liberty Utilities Overhead Construction Standard Section 14. After the installation is wired, but prior to connecting to the source circuit, the source voltages shall be verified.

a. Delta

1. Measure all phase-to-phase and phase to ground voltages (to verify no grounded phase) and phase orientations on the load side of the transformer(s).

2. Compare results with the construction drawing.

b. Wye

1. Measure all phase-to-phase and phase-to-neutral voltages and phase orientations on the load side of the transformer(s).

2. Compare results with the construction drawing.

2.1.5 It is critical that the phase orientation is known at the installation location in order to decide which Standard drawing should be utilized in order to correctly wire the bank.

2.1.6 If the voltages measured in (2.1.4) agree with the construction drawing, the transformer(s) may be connected to the source circuit.

2.1.7 Prior to connecting the transformer(s) to the load circuit, the output voltage of the transformer(s) and the load circuit voltage must be verified.

2.1.8 If the load side circuit of the step-down/step-up transformer(s) is to be paralleled with another energized circuit, the phase relation of the transformer(s) and/or rotation must be verified to match the other energized circuit. The phase relation of transformer(s) and load circuit will not always be the same and, therefore, cannot always be paralleled.

2.1.9 In the case of a three phase step-down/step-up transformer installation, if the load circuit of the transformer bank is not in phase with the existing load circuit, then rotation of the two circuits must be performed. Any existing tie points need to be identified as in-phase or out-of-phase.

2.1.10 Any existing tie points that are identified as not in-phase must have the phase conductors on each side of the switch configured so that the rotation will be the same on each side of the switch.

3.0 INSTALLATION

3.1 Step-Down/Step-Up Transformers Connections

	Secondary feeder – 3 Phase			
	3 Phase, 3 Wire feeders of 2400 or 4800 Delta		3 Phase, 4 Wire of 4160, 8320, 12470, 13200 or 13800 Volts Wye	
Primary Feeder – 3 Phase	Transformer Primary Voltage Rating	Transformer Connection	Transformer Primary Voltage Rating	Transformer Connection
12470 Volts Wye 4 wire	7200/12470 Y	Wye-Delta	7200/12470 Y	Wye-Wye
13200 Volts 3 Wire	13800/23900 Y (at 95% Taps)	Delta-Delta	13800/23900 Y (at 95% Taps)	Delta-Wye
13200 Volts Wye 4 Wire	7620/13200 Y (1) 13800/23900 Y (2) (at 95% Taps)	Wye-Delta Delta-Delta	7620/13200 Y (1) 13800/23900 Y (2) (at 95% Taps)	Wye-Wye Delta-Wye
13800 Volts 3 Wire	13800/23900 Y (at 100% Taps)	Delta-Delta	13800/23900 Y (at 100% Taps)	Delta-Wye
13800 Volts Wye 4 wire	7970/13800 Y (1) 13800/23900 Y (2) (at 100% Taps)	Wye-Delta Delta-Delta	7970/13800 Y (1) 13800/23900 Y (2) (at 100% Taps)	Wye-Wye Delta-Wye
23000 Volts 3 Wire	22900	Delta-Delta	22900	Delta-Wye
23000 Volts Wye 4 Wire	13800/23900 Y (at 100% Taps)	Wye-Delta	13800/23900 Y (at 100% Taps)	Wye-Wye
34500 Volts Wye 4 Wire	-	-	19920/34500 Y	Wye-Wye

3.2 Neutral Connections

3.2.1 Single Phase

a. Grounded Wye-Delta connections shall have the transformer high side neutral bushing connected to the system neutral and connected to a driven ground.

b. Grounded Wye – Grounded Wye connections shall have both the high and low side neutrals bushings connected together, connected to system neutral, and connected to driven ground.

c. Delta – Wye connections shall have the low side neutral bushing connected to the low side feeder neutral and to a driven ground.

3.2.2 Three Phase

a. Wye-Delta connections shall have the high side neutral bushings connected together and not connected to (floating) from the common/secondary neutral and ground. The neutral bushings connections shall be kept away from the pole and connected to the top side of the neutral disconnect switch (i.e. not stapled or in contact with any ground source).

b. Wye-Wye connections shall have both the high and low side neutrals connected together, connected to the system neutral, and connected to a driven ground.

c. Delta-Wye connections shall have the low side neutral bushing connected to the low side feeder neutral and to a driven ground.

3.3 Floating Wye-Delta Step-down/Step up Transformer Installation/Operation recommendations

3.3.1 Consistency in installations and conformance with the construction standards needs to be followed.

3.3.2 Proper secondary (low voltage) load balancing can improve the voltage supply quality during normal and abnormal events, ***significantly reducing over voltages*** from occurring. The maximum allowable current unbalance should <u>not be greater than 25%</u>, which has been determined through experience and independent research. The current unbalance is determined by measuring the current of each of the three legs and then calculating the percent current unbalance using the following formula:

$$\text{Percent current unbalance} = \frac{\text{Maximum current difference in any leg from average current}}{\text{Average current}} \times 100$$

Single-phase line-to-neutral load shall not be installed between the high side single-phase fuse cutout/disconnects and the step-down/step-up bank (Note: the cutouts/disconnects on the high side, may be a section away.)

3.3.3 For new construction: a solid blade cutout shall be installed between the floating high side neutral bushings and the common neutral and/or ground. The cutout blade should be removed and secured to the pole. This cutout will be used to temporarily ground the floating Wye neutral for routine single phase switching of the high side fuses/disconnects or main line single phase switching that feeds the step-down/step-up transformer(s). This cutout shall be closed prior to any routine single phase switching being performed to energize or de-energize the transformers. **The cutout shall be open for normal operations with the blade removed and secured to the pole**)

For existing construction: where a solid blade grounding cutout has not been previously installed between the floating high side neutral bushings and the common neutral and/or ground, a solid blade cutout shall be installed between the floating high side neutral bushings and the common neutral and/or ground. This cutout will be used to temporarily ground the floating Wye neutral for routine single phase switching of the high side fuses/disconnects or main line single phase switching that feeds the step-down/step-up transformers. This cutout shall be closed prior to any routine single phase switching being performed to energize or de-energize the transformers. **The cutout shall be open for normal operations with the blade removed and secured to the pole**)

3.3.4 High side arresters shall be removed from the transformer tanks and installed on the Wye **source side** of the fused cutout/disconnects. The reason for removing the arresters from the tank is to prevent the failure of the arresters when a fuse blows on the wye source side of the transformers causing a neutral shift that causes the voltage on the load side to rise above the maximum operating withstand voltage of the arrester. Low side arresters can remain on the transformers.

3.3.5 Fuse only the high side of step-down transformers.

3.3.6 There may be specific instances where a high side three-phase circuit interrupter (recloser) may be required. Each installation will need to be evaluated to determine if such a device is necessary due to inadequate protection from fuses on the high side of the bank.

3.3.7 There may be specific instances where a low side gang operated loadbreak switch may be required instead of single-phase disconnects to disconnect load from the step-down/step-up transformer.

4.0 PHASING

4.1 When step-down/step-up transformers are installed, they establish new voltages and phase rotations (Systems). It is desirable to identify phases on these systems and to understand the phase rotation and position so they may be paralleled with other systems of the same voltage.

4.1.1 If two such systems are to be paralleled, the voltage, rotation, and phase position must be the same.

4.1.2 Larger (over 100 kVa) step-down/step-up transformers should not normally be loaded over 100% of nameplate rating. In emergency situations with supervisor approval, a step down/step up transformer may be loaded to greater than 100%. When temporarily overloading a step down/step up bank, it should be monitored with an infrared camera. Overloading will significantly reduce the service life of the transformers.

5.0 SWITCHING FLOATING WYE-DELTA INSTALLATIONS

5.1 Normal Operations

5.1.1 The neutral grounding switch, if available, shall be closed prior to any routine single phase switching being performed to energize or de-energize the source side fused cutouts on the step-down/step-up bank or on the main line circuit feeding the step-down/step-up bank. Closing the neutral grounding switch will provide a temporary path between the floating neutral bushings and the ground to reduce the possibility of overvoltages from occurring during the switching operations. Failure to ground the floating Wye may result in overvoltages on the system that can approach twice the normal operating voltages depending on the load balance at the time of the switching.

5.1.2 A neutral grounding switch shall be installed at existing locations prior to normal switching, if it does not exist.

5.1.3 The neutral grounding switch **shall be opened after the switching has been completed for normal operations**. A loadbreak tool shall be used to open the neutral grounding switch. Failure to open the neutral grounding switch will result in the transformer acting as a grounding bank, individualizing the transformers, causing the transformer to burn out.

Remember: Step-down – Door Down (blade down/open) under normal operating conditions.

5.2 Emergency Operations

5.2.1 Under emergency conditions that endanger life or property a qualified person working for Liberty Utilities may open the step-down/step-up transformer without grounding the floating Wye.

5.2.2 A step-down bank shall be immediately taken out of service if a high or low side phase is lost. See Section 6.0 Operations for sequence of switching.

6.0 TROUBLESHOOTING FOR EMERGENCY SWITCHING ON FLOATING WYE-DELTA INSTALLATIONS

6.1 Open phase/fuse condition found on the Wye side with no corresponding open fuse or wire down on the Delta side.

6.1.1 Open the remaining high side cutouts/disconnects as soon as possible to avoid causing additional damage.

6.1.2 Troubleshoot cause of the open.

6.1.3 If there is no apparent cause for the open high side fuse, you must troubleshoot the transformer bank. Never close a grounding switch without troubleshooting the bank in this situation.

a. If one of the transformers in the three phase bank is found defective, contact the Control Center to determine if the load on the circuit could be temporarily supplied by making the existing bank an Open Wye – Open Delta configuration.

b. A Neutral grounding switch must be closed if present or a neutral grounding switch installed and closed before energizing the transformers in the Open Wye – Open Delta configuration. This temporary condition shall be left closed/connected for the duration of the Open Wye – Open – Delta configuration.

6.1.4 Before reenergizing the transformer, close the neutral disconnect or install a solid blade neutral disconnect between floating neutral and the common neutral and close.

6.1.5 Once switching has been completed and the transformers are operating in the Floating Wye – Delta configuration, open and remove the solid blade and secure to the pole.

6.2 Open phase/fuse condition found on the Wye side with corresponding open fuse or wire down on the Delta side.

6.2.1 Open the remaining high side cutouts/disconnects as soon as possible to avoid causing additional damage.

6.2.2 Troubleshoot cause for open

6.2.3 Before reenergizing the transformer, close the neutral disconnect or install a solid blade neutral disconnect between floating neutral and the common neutral and close.

6.2.4 Once switching has been completed, open and remove the solid blade and secure to the pole.

6.3 Open fuse condition or wire down found on the Delta side only with the transformers still operating.

6.3.1 With neutral grounding switch available:

a. Disconnect the load side by use of a three phase device or when one fuse is blown by opening the remaining low side cutouts/disconnects, if available.

b. Close the neutral disconnect

c. Open the high side cutouts/disconnects.

d. Troubleshoot cause for open.

e. Before reenergizing the transformer, close the neutral disconnect or install a solid blade neutral disconnect between floating neutral and the common neutral and close.

f. Once switching has been completed, open and remove the solid blade and secure to the pole.

6.3.2 With no neutral grounding switch

a. Open the following in order of preference:

1. Disconnect the load side by use of a three phase device or open the remaining low side cutouts, if available.

2. Open three phase source side device, if available to isolate transformer bank and load.

3. Contact System Control to operate a three phase device to isolate transformer bank or the load. Then operate high side switch to isolate transformer bank. Contact System Control to reenergize three phase device to restore any customers that are not included with the outage. Customer interruptions can be reduced by positioning at the transformer bank, if time allows.

4. Open high side fuse/disconnects. This is the option of last resort. When this option is chosen, potential damage due to overvoltage conditions may be minimized by accomplishing this task as quickly as possible.

Remember: In an emergency situation that endangers life or property, a qualified person can open the high side fuses.

b. Open the high side cutouts/disconnects

c. Troubleshoot cause for open.

d. Before reenergizing the transformer, close the neutral disconnect or install a solid blade neutral disconnect between floating neutral and the common neutral and close.

e. Once switching has been completed, open and remove the solid blade and secure to the pole.

6.4 Energizing a Floating Wye-Delta step-down/step-up bank from the Delta side.

6.4.1 If the step-down/step-up bank is energized to fed from the Delta side (tying feeders, etc.) the neutral disconnect needs to be closed or a neutral disconnect installed if one is not present prior to back feed. This temporary condition shall be left closed/connected for the duration of the back feed.

Remember: Step-Up – Door Up (blade closed) under back feed conditions.

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
03/01/2014	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D009		
Electric Operating Procedure	01-01-2019	Overhead	
Vise Grip Short Circuiting Bonding Cables	Revision #	1.0	Page: 1 of 4

INTRODUCTION

This EOP applies to all Liberty Utilities employees that work at the secondary voltage level (1000 volts or less) that might have equipment become energized due to customer activity (backfeed). This would apply to both overhead and underground service and secondary connections at the transformer.

PURPOSE

The purpose of this procedure is to provide an additional option for protection from 'Backfeed' to personnel working on a line or piece of equipment that has already been properly de-energized, tested de-energized and grounded, per EOP D002. An example for the use of vise grip short circuiting bonding cables would be during voltage conversions.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support upon request.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.

3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

LU-EOP G019 Test Devices and Testing Procedures Before Work De-Energized, Tested De-Energized and Grounded Distribution Circuits

LU-EOP G014 Clearance and Control

LU-EOP D002 OH Distribution and Sub-Transmission Personal Protective Grounding

DEFINITIONS

Backfeed: Energizing an otherwise de-energized circuit by a power source other than the de-energized power source.

Secondary: Utility wiring energized at 600 volts or below.

Bonds: An electrical connection from one conductive element to another for the purpose of minimizing potential differences or providing suitable conductivity for fault current or for mitigation of leakage current and electrolytic action.

TRAINING

Provided by Liberty Utilities Learning and Development during progression schools, or by request.

DOCUMENT CONTENTS

Table of Contents

1.0 BONDING CABLES

1.1 Bonding cables are not considered personal protective grounds. They are Short Circuiting cables that provide another means of protection for the worker from secondary backfeed caused by customer activities, e.g. generators.

1.2 The vise grip clamp ends of the Bonding Cables are to be attached to the secondary bushing or conductor of the OH/UG transformer and the secondary neutral or ground.

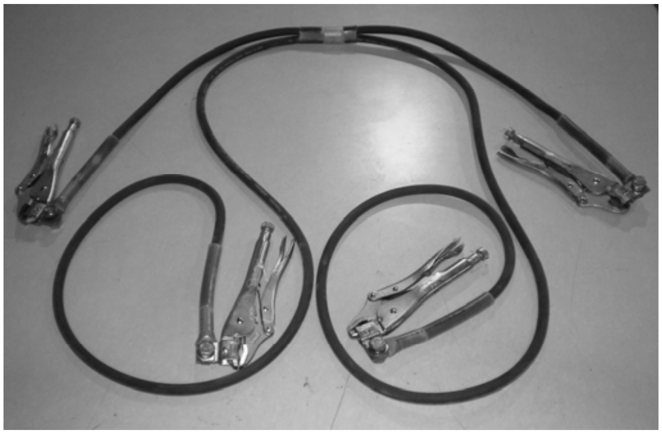
1.3 There is no requirement in Liberty Utilities' Clearance and Control rules (LU-EOP G014) to tag (GDIT) the bonding cables or document their location as they are not considered to be personal protective grounds. The bonding cables should be removed immediately after completing work for which they were applied.

2.0 DESCRIPTION OF VISE GRIP BONDING CABLES

2.1 3 Grip Set – two 24 inch leads and one 5 foot lead. Stores Item ID #8830-0810922 - Mfg. # 133040-SLP

2.2 4 Grip Set – two 24 inch leads and two 6 foot lead. Stores Item ID #8830-0810923 - Mfg. # 133040-1-SLP

2.1 - 3 Grip Set, 2-24" & 1-5ft 1/0 cables



2.2 - 4 Grip Set, 2-24" & 2-6ft 1/0 cables

3.0 TESTING AND GROUNDING

3.1 Before Secondary Vise Grip Short Circuiting Bonding Cables can be applied, the Primary (>600V) line or equipment to be worked on must first be isolated and properly tagged per LU-EOP G014, tested de-energized and grounded per LU-EOP D002.

4.0 TEST FOR SECONDARY VOLTAGE

4.1 A test for voltage shall be done using an approved voltage tester before applying the short circuiting bonding cables. This is necessary because there is the possibility that a secondary breaker on a transformer may be open or a primary transformer fuse may be blown there by allowing voltage to be present on a transformer due to customer activities, e.g. generators.

5.0 APPLICATION OF BONDING CABLES

5.1 Inspect the vise grip clamps and cables before using. Remove any damaged or defective vise grip short circuiting bonding cables from service and tag them for proper disposal.

5.1.1 Vise grips should be clean and work freely. Jaws should be wire brushed and free of contaminants.

5.1.2 Cables should be inspected for cuts and frays.

5.2 Adjust vise grip clamp so that it clamps tight and is securely fastened to the secondary connections at the transformer

5.3 When installing Vise Grip Short Circuiting Bonding Cables the bond to the ground or neutral shall be installed first and removed last.

6.0 RUBBER GLOVES

6.1 Appropriate rubber gloves (sleeves where required) shall be worn when testing for secondary voltage and for the application of the short circuiting bonding cables.

7.0 OTHER APPLICATIONS

7.1 Authorization must be received from Corporate Safety and Health, Distribution Engineering Services, and Customer Operations, before Vise-Grip Short Circuiting Bonding Cables may be used for other applications.

8.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
01/01/2019	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

<table>
<tr><td rowspan="1">Liberty Utilities</td><td colspan="3">Doc. # LU-EOP D011</td></tr>
<tr><td>Electric Operating Procedure</td><td>09-01-2013</td><td colspan="2">Overhead</td></tr>
<tr><td>Inspection/Maintenance and Installation of Distribution Line Reclosers</td><td>Revision #</td><td>0</td><td>Page: 1 of 14</td></tr>
</table>

INTRODUCTION

This procedure applies to all personnel who are responsible for the installation, and inspection and maintenance of distribution line reclosers.

PURPOSE

The purpose of this procedure is to specify the inspection and maintenance requirements and the installation process for distribution line reclosers located outside of the substation.

ACCOUNTABILITY

1. Overhead Electric Division Operations (Line Dept)
   - A. Performs visual inspection and battery test/replacement of Recloser and Control with Trouble Worker (NE Only).
   - B. Performs pre-approved switching order when required.
   - C. Makes repairs or corrects non-standard deficiencies identified by inspections.
   - D. Assists Relay and Control personnel (PTO) when necessary to commission recloser or install/reinstall protective functions and replace control.
   - E. Complete TOA notification process to Regional Control when necessary.

2. Substation Operations, Maintenance and Construction
   - A. Performs visual inspection and battery test/replacement of Recloser and Control (NY&NE).
   - B. Complete TOA notification process to Regional Control when necessary.

3. Protections and Telecom Relay and Control
   - A. Provides the necessary resources to:
     1. Assists Electric Operations (Line Dept) during installation of recloser if requested.
     2. Performs commissioning of recloser.
   - B. Sets protective functions supplied by Electric Assets Field Engineering
   - C. Corrects protective functions that are non-operable or outside acceptable parameters.
   - D. Performs Control Diagnostic Testing
   - E. Complete TOA notification process to Regional Control when necessary.

4. Electric Operations Field Engineering
   - A. Provide recloser settings
   - B. Evaluate diagnostic data

5. Distribution Design
   - A. Maintain accurate GIS records with Recloser size (560 or 800 amp), install date, location; and bypass, control, and sectionalizing switch numbers.

6. Engineering Records
   - A. Maintain accurate Circuit and Index Feeder Maps showing location of line reclosers.

COORDINATION

Electric Distribution Operations, O&M Operations, and Protection and Telecom Operations

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
Liberty Utilities Overhead Construction Standards – Section 12
Manufacturer's Installation, Operating, and Maintenance manuals for the specific equipment to be inspected and maintained
EOP GO14 Clearance and Control
SMP 401.07.2 Substation Maintenance Procedure (Station and Line Reclosers)
Work Methods Bulletin #12-06 – Temporary use of Hot Line Clamp/Vice Connectors Prior to Making Permanent Primary Connections.

DEFINITIONS

Bypass Switch – Disconnect switch used to by-pass recloser to remove from service.

Qualified Person – A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Recloser – Circuit breaker with self-contained relaying.

TOA: An acronym used in the formal application for requesting outages or for other work on lines or apparatus through the System Operator. (Transmission Outage Application).

TRAINING

Liberty Utilities Technical Training will provide training upon request.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All appropriate PPE, which includes but is not limited to, hard hat, safety glass/eye protection, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Safety Manual.

1.2 All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and applicable Work Procedures, utilizing all appropriate safe work methods.

1.3 All work zone traffic protection and equipment shall conform to applicable federal, state, and local requirements.

1.4 Liberty Utilities Safety Handbook Traffic control requirements shall be adhered to at all work locations on public and private roads.

1.5 Before work begins a “Job Brief” shall be conducted to identify the boundaries of the work area, the work methods to be used and all hazards associated with the job.

1.6 When required, Clearance and Control procedures shall be followed while conducting work outlined in this EOP.

2.0 PROCESS

2.1 Electric Operations (EO) throughout Liberty Utilities utilizes different qualified workers from different departments to perform routine inspections and maintenance of distribution class line reclosers. Electric Operations is responsible for determining which work group(s) complete the inspection and maintenance requirements contained in this EOP.

2.2 The inspection and maintenance requirements in this EOP are closely aligned with Substation Maintenance Procedures (SMP) which contain similar requirements for inspection and maintenance of stations reclosers.

2.3 Inspection and Testing Schedule

2.3.1 The recloser visual inspection is completed annually. Control battery replacement and testing is done as part of the visual inspection. The visual inspection requirement and battery testing and replacement procedure is in Section 3.0.

2.3.2 The control diagnostic testing is to be done as needed and is in Section 4.0.

2.3.3 Overhead line reclosers are a relatively maintenance free device and their operating duty generally extends beyond their in-service life. Conditions that may require a recloser replacement include:

a. Physical Condition of the unit

b. Obsolescence

c. As Needed – Event occurred such as lightning strike, animal contact, MVA, etc. and recloser sustains damage

2.3.4 In cases where the recloser is found to be defective early in its service life, the manufacturer should be contacted for warranty coverage. There is a one year Manufacturer's Warranty that covers product defects.

3.0 INSPECTION OF CONTROL AND RECLOSER

3.1 The purpose of the visual inspection is to identify broken/damaged equipment, deficiencies or non-standard conditions. The control battery test/replacement and certain operations checks and information recording is also part of the inspection. Conditions requiring immediate repair shall be reported to the responsible work group for repair/correction. The qualified person will complete the recloser inspection information on the Control and Recloser Inspection Form (LU0308), Appendix B, and retain the inspection record locally.

3.2 Materials Required for Inspection:

3.2.1 Inspection data from last inspection including the manufacture date of the control battery in the recloser control.

3.2.2 Binoculars

3.2.3 Battery load tester (Cooper Form 3&3A Controls only)

3.2.4 Ladder to access control

3.2.5 New batteries and switchboard lamps

3.2.6 Control and Recloser Inspection form (NG0308)

3.3 The Visual inspection shall include the following:

3.3.1 Check pole for correct recloser and bypass switch numbers

3.3.2 Check for abnormal noise

a. If there is any abnormal noise, move away to a safe location and notify the dispatch center and your supervisor.

3.3.3 Check bushings for:

a. Surface contamination, dirt, rust, salt, etc.

b. Evidence of tracking

c. Chipped or cracked porcelain

d. Discoloration of or heat rising from bushing connections (overheating)

e. Leaking oil

f. Animal guards

1. Proper guard

2. Proper installation

3.3.4 Check Arresters for:

a. Proper arresters (distribution class polymer housed MOV, metal oxide varistor)

b. Arrestors properly connected and bonded to down ground

c. Faulted arrestor, disconnector blown on bottom of arrestor, needs replacing

d. Animal guards

1. Proper guard (insulating top cap)

2. Proper installation (secured over top live terminal)

3.3.5 Check Control Cabinet Condition for:

a. Cabinet securely locked with padlock

b. Door gasket condition/deterioration

c. Paint condition / presence of rust

d. Evidence of moisture or water

e. Missing insect screens

f. Cabinet ground – connected to pole down ground, wire proper size

g. Missing knockout covers and/or amphenol caps

h. Control cable secure, properly covered, and in good condition

i. Check recloser tank for:

j. Oil leaks

k. Deteriorating paint / presence of rust

l. Check for proper control cabinet height

3.3.6 Check Control Cabinet Operations for:

a. Position (open / closed) indicator correct

b. Check recloser status lights (open / closed) correct / illuminated

1. Check mechanical indicator for agreement with indicating lights and recloser mechanism position.

c. Check recloser loop scheme status correct and auto (if applicable)

d. Heaters operating (may be off above 40 degrees outside temperature)

e. Control voltage & fuses

f. Reclosing On

g. Ground Trip On

h. Check Hot line tag off

1. Do not operate without Control Center authorization

i. Control Lights Illuminate

1. Air Vents and filters clean, unobstructed

3.3.7 Record recloser operations counter

3.3.8 Record peak load readings

3.3.9 Record recloser & control location and identifying information on inspection form

3.3.10 Check control battery:

a. Replace control battery if more than 5 years old. The manufacture date is noted on battery. Record battery date on inspection form.

b. Replacement battery shall be load tested after installation

c. Reading battery voltage with a voltmeter will not detect marginal batteries, a load must be applied

d. McGraw Cooper Form 3 or 3A controls require the use of the Batteries Plus Battery Load Tester (fig. 5) or a 25 watt 10 ohm resister (fig. 6) used with a Fluke 170 series multimeter.

 1. Normal voltage without load is between 26 and 28 volts
 2. Maximum voltage drop under load should not exceed 3 volts
 3. Voltage level under load should not be less than 23 volts

e. Cooper Form 4, 5 and 6, and G&W Viper Schweitzer SEL651R controls incorporate an internal battery load test feature

 1. Do not apply an external load test
 2. Load test with the control panel battery test function
 3. These controls have automatic daily test feature and low battery voltage warning indicator light

f. Controls equipped with Telemetrics have low battery voltage alarm through EMS to alert Control Center

g. Replace any battery which fails the load test

IMPORTANT - Cooper Form 3 and 3A control protective functions, including placement of the recloser in the non-reclose position for worker protection, will not properly operate if the control battery is fully discharged or its capacity under load is inadequate.

If during the process of the inspection, the recloser is found to be inoperable, the qualified worker shall notify the Regional Control Center.

4.0 CONTROL DIAGNOSTIC TESTING

Control diagnostic testing will be done as needed. The Control Diagnostic testing frequency will be determined by Electric Operations if, for example, miss-operations are suspected or protective settings need to be changed. Miss-operations may be suspected as a result of customer inquiries regarding an abnormally high frequency of interruptions or a high number of operations recorded during an inspection. Protective settings may need to be changed if, for example, the circuit is reconfigured. In some cases the control may need to be removed in order to conduct tests. The recloser control test data will be stored in the database.

4.1 Initial test of protection settings, store in database

4.2 Perform subsequent testing of control settings for:

 4.2.1 Firmware updates

 4.2.2 Changes to protective settings

 4.2.3 If deemed necessary

5.0 PLACING RECLOSER IN SERVICE

5.1 The G&W Viper-S vacuum type line recloser is tested to meet or exceed standard requirements at the factory after it is assembled. The quality test procedures insure the recloser is service-ready when shipped. A detailed factory test report is shipped with every recloser. Prior to shipping, every G&W Viper goes through full testing that includes:

1. Dielectric AC withstand per ANSI 37.74/60
2. CT polarity test
3. Resistance test
4. TCC test
5. Complete mechanical characteristic test – 50 operations
6. Secondary wiring test
7. 100% x-ray on every module
8. 100% corona testing on every module

NOTE: G&W Viper reclosers should be transported with mechanism in OPEN position.

5.2 When installing a recloser perform the following service ready checks prior to placing in service.

5.2.1 Recloser has been installed per Liberty Utilities Overhead Construction Standards, Section 12

5.2.2 Recloser and By-pass switch are properly identified

5.2.3 Control cabinet is at proper height and grounded, a ground grid is installed if lower than 8ft.

5.2.4 Control cables are properly attached and secure

5.2.5 Protection settings loaded in control and tested

5.2.6 Recloser checked for:

1. Bushings not cracked, broken or damaged, bushing seals ok
2. No signs of damage to recloser mechanism cabinet or tank
3. No weeping or leaking oil, if applicable
4. Recloser cabinet or tank, arrestors, control and junction box properly grounded (wye or delta)
5. Animal guards in place, do not tape, use cable tie UP21T if necessary

5.3 Placing recloser in service.

5.3.1 Service ready checks in Section 5.2 have been completed and no problems identified.

5.3.2 By-pass switches are in Closed position

5.3.3 Load and Source leads are parked on insulated hangers, PT's (frame or pole mounted) are connected and cutouts open

5.3.4 Pull manual trip handle down locking out recloser (opens internal contacts)

5.3.5 Connect source leads **first**, Load leads **second**

5.3.6 Close cut-out energizing PTs, AC supply power is present at control and ok

5.3.7 Reset the manual trip handle to the Closed position and Close recloser from the Control (making parallel between recloser and primary conductor)

5.3.8 Verify that control indicates recloser is Closed

5.3.9 Check source and load leads with an ammeter to have approximately 30% of the primary amperes

5.3.10 Place control in Non-Reclose and Open the By-pass switch (Do Not operate without Control Center authorization)

5.3.11 Turn off Non-Reclose function, return to Normal operation

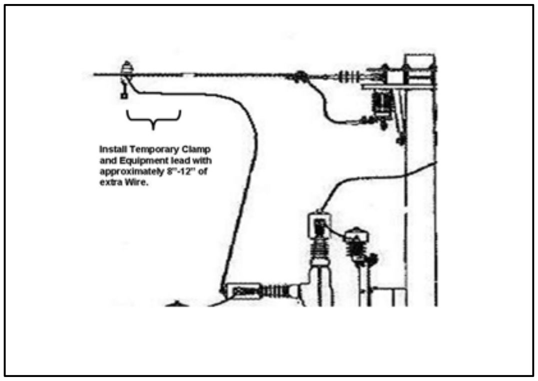
5.4 Follow the Recloser Commissioning Procedure for reclosers equipped with Telemetric Remote Telemetry Module (RTM, RTM-II) dated 12/21/2010 prior to placing the recloser in service.

5.5 Follow the steps in section 5.2 & 5.3 when re-installing a Cooper or other oil filled recloser. Pay particular attention on these units for the porcelain bushings not to be cracked or broken and the tank for weeping or leaking oil. Do not energize if either is found.

5.6 The following illustrates a method for making an initial temporary connection to energize a recloser with a live-line/hot stick using either a hot line clamp/vice connector or the Ampact "piggy back" clamp to maintain worker clearance from the initial temporary connection. When using this work practice, workers shall **NOT** pick up circuit load current. The recloser shall be verified to be in the open position.

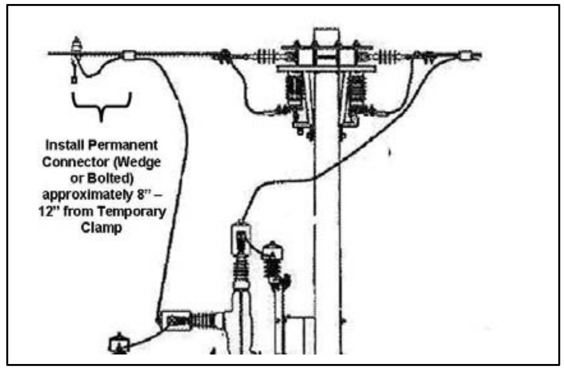
5.6.1 Step one.

Workers should measure the length of the equipment lead to the position on the conductor where the permanent connection is to be made. An additional length of approximately 8" to 12" of additional conductor should be added to allow the temporary use of a hot line clamp/vice connector. The temporary connector may now be applied to the energized conductor approximately 8" to 12" beyond where the permanent connection will be made.



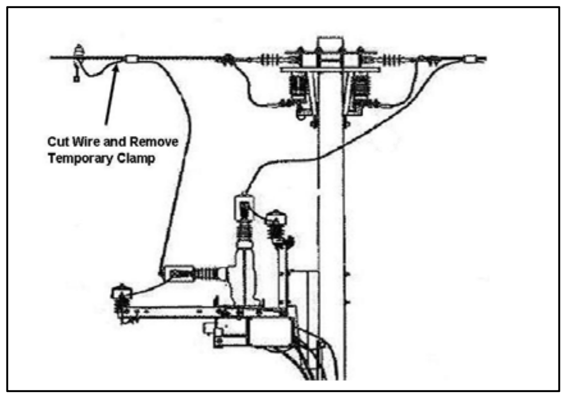
5.6.2 Step two.

Apply appropriate Insulate and Isolate practices. The worker may now ascend to the position where the permanent connection will be made, shape the primary equipment lead to position it and remove all unnecessary slack in the wire. Use either a bolted or a fired on wedge connector to complete the permanent connection.



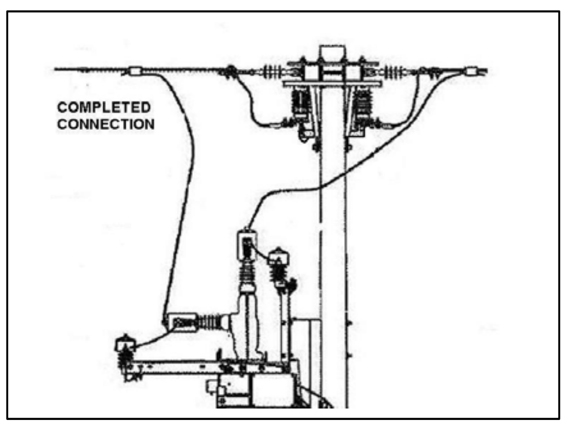
5.6.3 Step three.

The excess conductor to the hot line clamp/vice connector should now be cut and the temporary hot line clamp/vice connector may be removed from the primary conductor.



5.6.4 Step four.

Completed connection.



6.0 APPENDIX A - RECLOSER BATTERY INFORMATION

To order Cooper Power Systems and G&W Viper distribution recloser control batteries contact Batteries Plus at ph# 603-685-0293.

Description	Model Number
Form 3A, 24V-1.2AMP-Hour Minimum NICAD Rechargeable Battery Pack.	KITNATLGRID1
Form 4C, 24V-8 AMP-Hour Minimum Lead Acid Rechargeable Battery Pack.	KITNATLGRID2
Form 6/Form 5 Non-Swing Panel, 24V-13AMP-Hour Minimum Lead Acid Rechargeable Battery Pack.	KITNATLGRID3
G&W Viper-S Schweitzer Control SEL651R	XE16

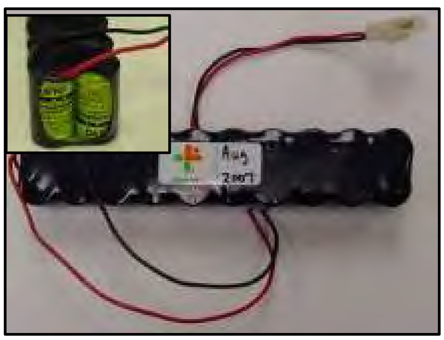


Figure 1 – Form 3A Battery

Figure 2 - Form 4C Battery Pack

Figure 4 – G&W Vacuum 12V XE16X

Figure 3 – Form 5 & Form 6 (2 batteries required)

Figure 5 – Batteries Plus tester

Figure 6 – 25 watt, 10ohm resister used with Fluke

7.0 Appendix B – Control and Recloser Inspection form #LU0308 (04/13)

Liberty Utilities

VISUAL INSPECTION OF RECLOSER & CONTROL	(Check / inspected)
☐ Check for correct Recloser & Bypass Switch Number (matches GIS and Index map) ☐ Check recloser for no Abnormal Noise ☐ Check Recloser Bushings for: o No surface contamination o No evidence of tracking o No chipped or cracked porcelain o No discoloration of or heat rising from bushing connections o No leaking oil o Animal guards, proper guard & properly installed ☐ Check Arrestors for: o Disconnector not blown (bottom of arrestor) o Bonded to down ground wire o Animal guards installed properly ☐ Check Control Cabinet Condition for: o Proper Height >8feet if no ground grid o Control door Locked o Door gasket in good condition, seals properly o Paint not deteriorating/rust o No moisture or water in control o No missing insect screens o Cabinet grounded o No missing knockout covers o Control cable secure/covered/good condition	☐ Check recloser tank for no Oil Leaks ☐ Check Control Cabinet Operations for: o Status Light (open/closed) Correct, matches recloser mechanism position. o Loop scheme status correct and auto (if applicable) o Heaters Operating o Reclosing On o Ground Trip On o Control Voltage and Fuses ok o Air Vents and Air Filters ok o Control Lights Illuminate Record Operations Counter: ______________ Record load readings (peak): Phase A________ Phase B_______ Phase C________ Record Battery Manufacture's Date: ____________ Record Telemetrics DNP ID #: ______________ (if equipped) ☐ Load Tested Battery, Form 3& 3A with load tester ☐ Load Tested battery from control, Form 4,5,6, & Schweitzer control
COMMENTS/CORRECTIONS REQUIRED	
Inspected By:	Reviewed By:

NG#0308 4/13

Line & Pole #
Circuit Number
Recloser Manuf.
Control Type
Control Serial #
Street/Road
Date

8.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	0	Initial Version of document Update from National Grid document to be NH Specific	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D012		
Electric Operating Procedure	**06-01-2015**	**Overhead**	
Installing and Removing OH Conductors	**Revision #**	**1.0**	**Page: 1 of 17**

INTRODUCTION

This EOP provides the requirements and steps needed to follow when installing, sagging and removing overhead conductors.

PURPOSE

This procedure is to provide the appropriate work methods required for installing and removing overhead conductors.

ACCOUNTABILITY

1. Standards, Policies and Codes
    A. Update procedure as necessary.
    B. Provide appropriate guidance to field personnel when requested for a specific work related task.
2. Electric Distribution Operations
    A. Ensure that all procedures in this EOP are understood and implemented.
    B. Ensure that all personal are trained in this procedure.
    C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.
3. Liberty Utilities Employees and Contractors
    A. Demonstrate the understanding of the procedures in this EOP.
    B. Comply with the requirements of the procedures in this EOP.
    C. It is the workers responsibility to read and fully understand, and to follow the manufacturer’s instruction manual and specifications before operating equipment.

REFERENCES

IEEE Standard 1048 2003 IEEE Guide for Protective Grounding of Power Lines
Liberty Utilities Employee Safety Handbook
Liberty Utilities Overhead Distribution Construction Standards
NESC 2012 edition
LU-EOP D002 OH Distribution and Sub Transmission Personal Protective Grounding
LU-EOP G026 Mechanized Equipment Grounding
Liberty Utilities Bulletin #11-02 (Installing, Removing or Re-Positioning of Conductors)
Liberty Utilities Bulletin #12-09 (Basket Style Grips for OH Conductor Pulling)
OSHA 1910.269 & 333 (p) Operations near Energized Lines or Equipment.
OSHA 1926.955 (C&D)
The Lineman’s and Cableman’s Handbook (Ninth Edition)

TRAINING

Provided in appropriate Liberty Utilities L&D training programs for personnel and as requested

DEFINITIONS

Aerial Device: Any device, extendable, articulating or both, which is designed to position personnel and/or handle materials.

Barricade: A physical obstruction such as tape, screens, or cones, intended to warn and limit access to a hazardous area.

Barriers: A physical obstruction that is intended to prevent contact with energized lines, equipment or to prevent unauthorized access to work area. Rigid barriers, rubber blankets, arc suppression blankets, and/or blast blankets are used to protect adjacent equipment from damage.

Bend Radius: The radius of the bend (designated as a multiple of product diameter) at which a wire product can be safely bent without significantly affecting its ability to function.

Bond: An electrical connection from one conductive element to another for the purpose of minimizing potential differences or providing suitable conductivity for fault current or for mitigation of leakage current and electrolytic action.

Conductor: A material, usually in the form of a wire, cable, or bus bar suitable for carrying an electric current.

Dead: Isolated, tagged, tested de-energized and grounded.

Equipment Ground: Conductor used to connect the non-current carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor.

Exposed: Not isolated or guarded.

Finger Line: A lightweight line that is placed over the traveler with both ends extending to the ground. It is used to thread the end of the pilot or pulling line and eliminates the need for a worker to re-ascend the structure to perform the task.

Guarded: Protected by personnel, covered, fenced, or enclosed by means of suitable covers or casings, barrier rails, screens, mats, platforms, or other suitable devices in accordance with standard barricading techniques designed to prevent dangerous approach or contact by persons or objects.

Leader: The person in charge of the job site and operation (crew chief, lead splicer, etc.) The Leader's responsibilities include but are not limited to:

- Pre-job safety and assignment brief
- Job site safety for crew members
- Public safety near the work area
- Equipment requirements
- Positioning of equipment
- Assignment of tasks
- Communication needs and responsibilities between crew members
- Returning the equipment in a safe and clean condition
- Adherence to Liberty Utilities policies

Minimum Approach Distance: The closest point of approach to energized lines or equipment by a qualified employee or by any conductive object, without the use of insulating gloves, sleeves, or portable protective devices. **NOTE:** Table R-6 in OSHA 1910.269 defines the Minimum Approach Distances to be followed by a qualified employee while working near energized lines and equipment.

Pilot Line: A lightweight line used to install the pulling line through the travelers. Pilot lines can be installed with finger lines or with the aid of a helicopter (transmission) on new construction. During the planning stage of reconductoring projects, the existing conductor is often considered to serve as the pilot line. Prior to the pulling operation, the existing conductor must be inspected and assessed to ensure that the conductor is free of damage and is capable of enduring expected stresses.

Phasing: The procedure for determining the electrical relationship of one phase conductor to another between three phase electrical circuits and three phase transformer banks

Pulling / Bull Line: Line used to pull in conductor. Can refer to any type of line but usually refers to line on a pulling machine.

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Shall: The word shall is to be understood as mandatory.

Should: The word “should” indicates provisions that are normally and generally practical for the specified conditions.

Traveling Grounds/Running Grounds: Ground device installed on moving conductor while installing or sagging operations are completed.

Traveler/ Stringing Block: Device conductor travels through during installation.

Zone of Protection: An area defined by opened protective points which isolate all known energy sources. This area is created by isolating, de-energizing and tagging every protective point of isolation from all forms of external sources of energy that could create a hazard for workers.

DOCUMENT CONTENTS

Table of Contents

1.0 Safety Requirements

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and all appropriate Liberty Utilities EOP's utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 The employee in charge shall conduct a written "Job Brief" with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

1.4 Rubber gloves of the appropriate class shall be worn until the conductor is proven to be isolated, red tagged, tested de-energized and grounded.

1.5 During work, barriers or other appropriate protection shall be installed to protect workers and adjacent conductors.

1.6 All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Check with your supervisor for a listing of approved equipment.

2.0 Site selection

2.1 When selecting a site for installing and removing conductors, the following shall be considered:

2.1.1 Accessibility, Traffic

2.1.2 Puller capacity, Length and size of the conductor, Availability of dead ends

2.1.3 Placement of pullers, tensioners, reel stands, reel winders, rope machines

2.1.4 The ability to provide an adequate grounding system

2.2 Terrain Evaluation - Analyze the terrain to determine if there are areas of impaired ground clearance. If such areas exist precautions must be taken to protect personnel and conductors. Other unusual terrain features may dictate special conditions.

3.0 Equipment Inspection

All equipment shall be inspected prior to any conductor installation.

3.1 Some of these are but not limited to: Ropes, Travelers, Conductor reels, Line jacks, Grips, Portable radios

3.2 Specific attention should be given to the conductor reel / cable drum. If any wood decay is apparent, especially around the central core where the arbor is connected, **do not use** the reel. If it is deemed unsafe, have your supervisor or manager return it to supplier.

4.0 Selection of Equipment

The proper sizing of puller and use of tensioner type is critical to; the condition of the installed conductor, time of installation and safety of the crew.

4.1 Puller Sizing formulas

$$T_1 = \frac{WL^2}{8D} = \text{Tension in (1) Span}$$

$$TMAX = \frac{T_1}{.98^N} = \text{Pulling Tension}$$

- W = Weight of conductor, per foot in lb.
- L = Span (average) in feet
- D = Stringing sag in feet off horizontal
- N = Number of supports in pull

- .98 is efficiency of each support

4.2 The following link can be used to calculate pulling tension and ensure the selection of properly sized equipment with sufficient capacity; Conductor Stringing Calculator

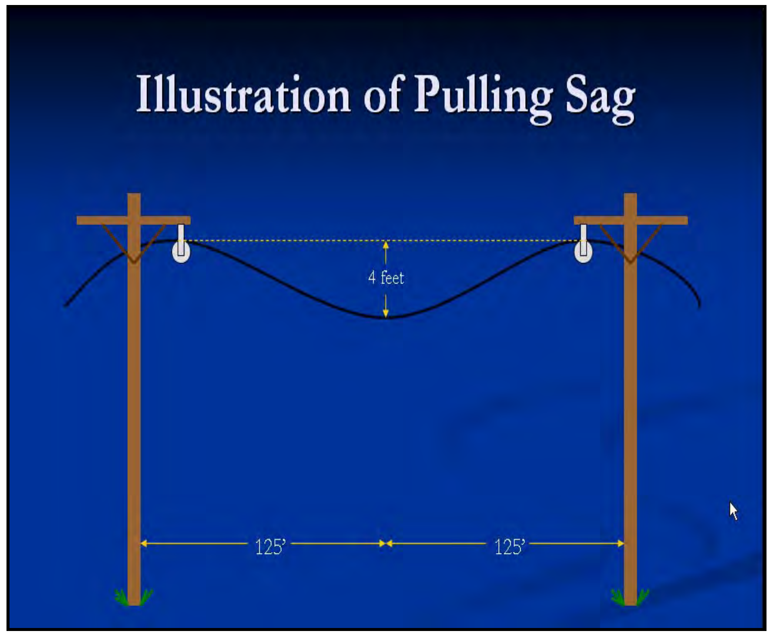
4.3 **Example of Tension Calculation**

$$T_1 = \frac{WL^2}{8D} \qquad W = .5 \quad (336\ \text{ACSR}) \quad L = 250 \quad D = 4'$$

$$T_1 = \frac{.5 \times 250^2}{8 \times 4} = \frac{62{,}500}{32} \times .5 = \frac{31{,}250}{32} = 977$$

$$T_{MAX} = \frac{T_1}{.98^N} = \frac{977}{.67} = 1{,}458 \text{ Lbs. Pulling Tension}$$

Based on 5,000' pull (20 poles)



5.0 Positioning of Equipment

Puller should be positioned at a distance of 3 times the height of the first traveler from the base of the pole. (i.e. 30' height = 90' from pole).

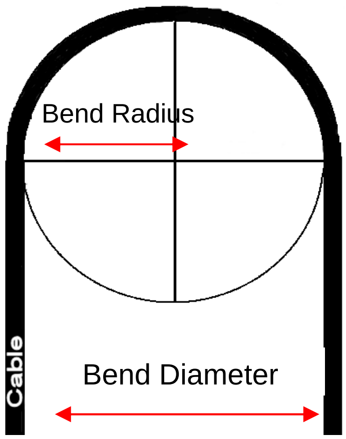
5.1 In Some cases this distance is unattainable and the puller needs to be moved closer to pole.

5.2 Two methods maybe used to off set the angle of conductor at first pole

a. Larger Traveler on first pole

b. Installation of another bull wheel to lessen angle

5.3 The angle of conductor at any traveler, especially the first and last traveler, must never exceed the minimum bend radius of the conductor being installed



Bend Radius = 12 x OD (outside diameter of conductor)

1/0 Bare alum = .398 OD x 12 = 4.776”	**1/0 Covered alum =.728 OD x 12 = 8.74”**
336 Bare alum = .666 OD x 12 = 8.00”	336 Covered alum = .937 OD x 12 = 11.25”
477 Bare alum = .793” OD x 12 = 9.52”	**477 Covered alum = 1.362” OD x 12 = 16.4”**

6.0 Clearance Considerations

Review all sections of the circuit where work will be performed to determine if there are any other conductors normally energized above 600 volts that are parallel to or cross the spans on which the work will be performed. If any such conductors are found that during the performance of the required work tasks may result in an encroachment of the required NESC clearances between the circuit conductors, the following practices shall be adhered to:

6.1 Vertical and horizontal measurements shall be taken between the conductors being worked and any other identified conductors where an encroachment of required clearances may occur.

6.2 The job brief will include these measurements, a discussion regarding any conductor parallel to or crossing the conductors being worked and the details of methods to be used to prevent against accidental contact.

6.3 If the conductor being installed, removed or re-positioned crosses over other conductors that are energized in excess of 600 volts a non-reclose assurance will be applied if the design of the protective devices so permits.

6.4 A member of the crew will be assigned as the “Safety Observer” to monitor NESC approach distances anytime movement of such conductor takes place within the span where a parallel or crossing exists.

6.5 Unless impractical, barriers or insulated protective cover-up rated for the voltage of the conductor to which it is applied shall be required on all distribution and sub-transmission circuit conductors that are either in parallel or crossing over or under a conductor that is being installed, removed, or re-positioned if the movement of that conductor could create an NESC clearance violation between the circuits.

6.6 Sub-transmission and transmission circuits that are energized above the voltage rating of existing insulated protective cover-up should use barriers, when practical, to protect against inadvertent contact to conductors that are either in parallel or crossing over or under a conductor that is being installed, removed, or re-positioned if the movement of that conductor could create an NESC clearance violation between the circuits. Insulated protective cover-up that does NOT have a voltage rating for the voltage level of the conductors/circuit being worked may be installed and utilized on either energized or de-energized conductors to act as either mechanical protection or to assist as visual enhancement to identify the conductor.

6.7 Sub-transmission or transmission conductors that do not have insulated protective cover-up applied for a visual marker shall utilize approved portable markers, whenever possible, as an aid to the Safety Observer and/or crew workers to help visually enhance the conductor and identify the distance between the conductor being moved and any other circuit parallel to or crossing the effected spans.

NOTE: The following is an example of an approved portable marker that can be applied to a conductor. This device has provisions to be applied with a hot stick tool and may be applied to directly to energized or de-energized distribution, sub-transmission or transmission conductors.

7.0 Protective Grounding

7.1 The conductors (covered and bare) must be grounded while being installed.

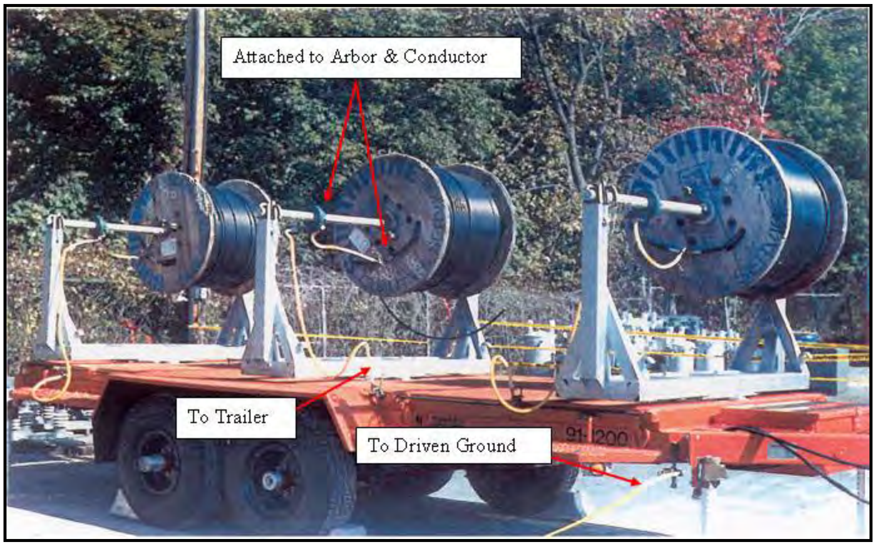
7.1.1 Each **bare** conductor shall be grounded so that at no point along the conductor is it more than two miles from a ground.

7.1.2 Traveling grounds on bare wire shall be utilized at tensioner (Device must be secured with rope to trailer, pole or structure to prevent device from moving with conductor).

7.1.3 When **covered** wire is being installed grounding rotators must be used. The ground shall remain in place until the conductor installation is complete between dead-ends. The grounds shall be removed as the last phase of aerial cleanup.

Three reel trailer 2/0 grounding set
AB Chance Cat # SA600-3147
Or MacLean Power Systems

Rotating Grounds Installed



NOTE: Rotating Grounds (attached to arbor) are the only acceptable method of grounding covered conductor during installation

7.2 When a temporary ground source needs to be established, the choices in order of priority are:

7.2.1 System Neutral

7.2.2 Equipment ground rod

7.2.3 Existing Guy anchor rod under tension (Newly installed anchors can not be used as a ground source due to disturbed soil and poor ground continuity)

7.2.4 Temporary driven ground rod firmly embedded in the soil 8' feet.

NOTE: *The use of Temporary Screw Type Ground Rods is not approved for use at Liberty Utilities.*

7.3 Follow all excavation notification requirements for the area of the work when installing a driven ground rod (see LU-EOP G013)

<u>8.0 Tensioned Conductor Installation</u>

The process of installing overhead distribution line conductors in a manner which keeps the conductors off the ground, clear of vehicular traffic and other structures that might damage the conductors and clear of energized circuits is called tension stringing. Tension stringing to reconductor existing lines provides a means to keep the new conductor under control and prevent it from contacting the energized conductors.

This is the preferred method of installation.

8.1 The new conductors that are being installed are to be effectively grounded for the protection of the workers (see previous section)

8.2 Distribution line conductor installation requires the installation of conductor stringing blocks (travelers) to permit pulling conductors in under tension.

8.3 When installing the stringing blocks, a lightweight rope called a finger line (tag line) is normally placed in the traveler.

8.3.1 The finger line must be long enough to reach the ground on both sides of the traveler and must be tied off 8' above grade to keep them out of reach of the general public.

8.3.2 The finger lines are used to pull the pilot line through the traveler from the ground.

8.4 Pilot lines are a lightweight rope needed to pull in the pulling line through the travelers.

8.4.1 A pilot line winder (take-up reel) may be used to provide power to pull in the conductor pulling line from the reel at the pulling machine through the travelers back to the wire reel.

8.5 Tension is kept on the pulling line or bull line to prevent contact with objects on the ground or other existing facilities.

NOTE: Pilot lines may be installed for distribution line stringing by using the spider system.

8.6 The energized conductors must be kept isolated from the new conductors being installed.

8.6.1 Hot extension arms may be used to provide clearance for new conductors.

8.6.2 The new conductors being installed adjacent to energized wires shall be grounded and controlled to prevent energization by accidental contact with energized wires.

8.7 If the conductor being installed or removed crosses over a line energized at more than 600 volts, the **automatic reclosing** features of the station breaker or line recloser shall be put in the non-reclose (manual) position, if so equipped; (i.e., a non-reclose assurance NRA must be obtained if it is available on the circuit).

8.8 Reel handling equipment, including pulling and braking (tensioning) machines, shall have ample capacity, operate smoothly, be in safe operating condition and be leveled aligned and appropriately anchored.

8.9 The conductors should be pulled directly from the cable reel on the tensioner (unless tension is above the cable reels strength, in which case a bull wheel is required), using the pulling line, through the stringing blocks, back to the pulling machine take up reel without touching the ground.

8.10 Conductor pulling tension should not exceed 35 percent of conductor breaking strength (NESC Rule 261H1b).

8.11 The distribution designer who selects the materials should furnish guidance to the field whenever it is required.

For example, the distribution designer should furnish break strength of conductor and stringing sags at 32°F/0°C, 60°F/15°C, and 90°F/32°C (see section 6 Primary Conductors Liberty Utilities Construction Standards). Designer should indicate the spans that should be checked for sag whenever ruling span or slack span sag is needed.

8.12 Care must be exercised to ensure that conductors do not become kinked, twisted, abraded or damaged.

8.13 Proper grips for wire size and type shall be utilized with swivel connector to prevent twisting of grip during wire run and weakening strength of grip. There are many types of basket style conductor pulling grips and different types are used for overhead and underground operations. Refer to the grip manufacturer's selection charts to determine what size and type of grip to use depending upon the application.

8.13.1 A smooth grip (no teeth or rough edge) that may damage the integrity of the conductor covering shall be utilized on covered wire.

8.13.2 Do not run Grips or swivels over bull-wheels while under tension

8.14 Pulling swivels must be used with all types of conductor pulling grips. Refer to the manufacturer's selection charts (see below) to determine the proper size and type of swivel.

Grip Sizing Chart (Kellem)

Model No.	Color Code	Diameter Range, Inches		Max. Working Load Lbs.	Approx. Breaking Strength	Eye Dia. Inches	Mesh Length	Dia. Over Cable & Grip Add to Cable or Rope Dia - Inches	Use With Swivel*
		Conductor Diameter	Rope Diameter						
1037	Black	.19 - .37	.25 - .65	1,300	6,500	0.218	24	0.200	A-18
1038	Green	.38 - .62	.50 - .90	2,800	14,000	0.375	36	0.280	B-40
1039	Red	.63 - .87	.75 - 1.10	4,000	20,000	0.437	48	0.360	B-75
1040	Blue	.88 -1.12	1.00 - 1.50	6,120	30,600	0.500	60	0.500	C-100
1041	Yellow	1.13 -1.37	1.25 - 1.70	9,350	46,800	0.625	76	0.625	D-160
1042	Aluminum	1.38 -1.90	1.50 - 2.10	13,300	66,500	0.750	89	0.750	D-300

8.14.1 All swivels should be inspected prior to and after a pulling operation and removed from service if any defects are found.

8.14.2 Swivels are to be stored out of the elements.

8.15 Pulling line size must be checked against calculated pulling tension of each wire pull for proper sizing. Pulling line should be closely checked for fraying during the payout to attach to conductor portion of the wire run.

8.16 Reliable communications must be maintained between the operators of the pulling equipment, the reel or tensioning equipment and the person following the conductor (i.e. radios, cell phones etc.).

8.17 The person in charge of the work or their appointee shall follow the conductor at the point of attachment between the pull line and conductor, in order to catch and prevent any hang ups at the travelers. The person in charge shall advise operators of puller and tensioner of pulling sag to maintain control of conductor.

8.18 Each pull shall be snubbed (caught off) or dead ended at both ends before any subsequent pull begins.

8.19 For pulls up to 500 lbs. the spider system may be utilized to install distribution conductors under tension utilizing the spider system pilot line and truck capstan.

8.20 For pulls in excess of 500 lbs. a puller tensioner shall be employed. (See formulas and calculator above in ‘selection of equipment’ section).

9.0 Banding

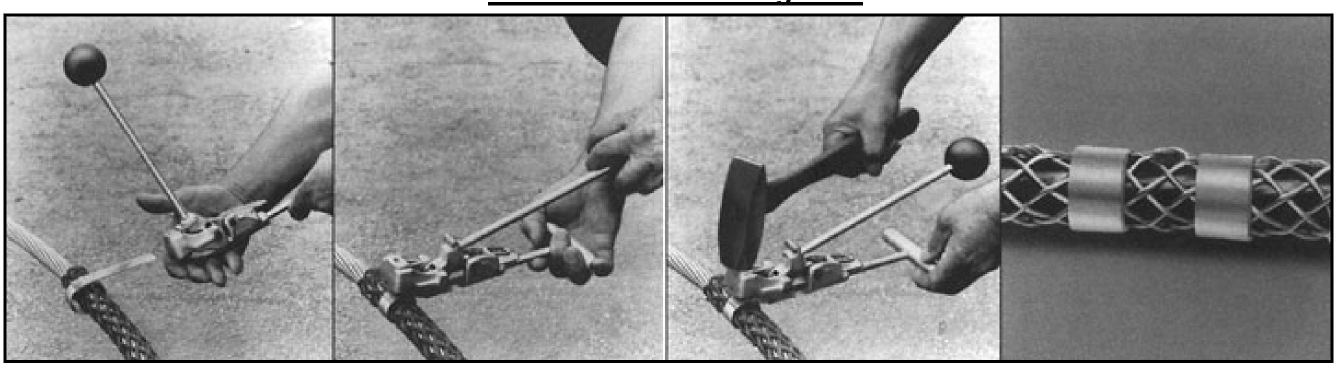
Banding is required for Maximum reliability and to guard against accidental release. Bands are applied over the tail of Pull Grips to prevent the mesh from being stripped or pulled loose. Also, it ensures full gripping action by locking the mesh of the tail in tight contact with the cable or rope.

9.1 Band the tail end of the pulling grip once installed.

9.2 Two “Punch-Lok” bands shall be installed at 1” and 2” from the tail end of the grip for maximum grip performance and to guard against accidental release.

9.3 Tape over bands and the tail end of the grip to provide a smooth transition from the grip to the conductor also preventing catching of any running blocks during the pulling operation.

“Punch Lok” Banding Tool



- “Punch Lok” tool, Hubbell Cat #20320048
- 3/8” band for conductors smaller than 336.4Kcmil Hubbell Cat # (20320050, 51)
- 5/8” band for conductors 336.4 kcmil and larger Hubbell Cat # (20320052, 53, 54)
- 3/8” band adaptor needed for 3/8” banding with tool, Hubbell Cat #D229

- Banding Removal Tool, Hubbell Cat #D-550 (below)

10.0 Slack Conductor Installation

10.1 Slack conductor stringing is limited to short lengths of line operating at distribution voltage utilizing methods that would prevent scuffing or scratches of conductors being installed.

10.2 This method is utilized on new construction in rural areas (example; adding four sections of primary and secondary to new house set back off street).

10.3 Reels of wire can be mounted on an appropriate vehicle or an approved trailer in such a manner that the reels are free to rotate.

10.4 The ends of the conductors are anchored and the vehicle is then driven along the route of the line, allowing the conductors to unwind/pay out as the reels are moved forward. Thus the conductors are not dragged along the ground; avoiding scratching or damaging conductors.

10.5 Once the conductor is past a pole or structure it can be placed on the structure. This method of paying out and then lifting a conductor from the ground in congested urban areas may not be practical or where there is danger of contacting an energized circuit.

10.6 When a conductor is pulled up into an energized area from the ground using a hand line or tag line, the line must be properly positioned on the structure and a link stick installed on the hand line to protect the person on the ground using the pulling line.

10.7 Conductors shall be raised one at a time to their final position.

10.8 The old conductors may be removed in reverse order treating them as if energized until they are clear of the energized area.

11.0 Transfer or Removal of Conductor

11.1 Conductor Transfer - is when conductors are transferred from one structure to another structure or when the position of a conductor is changed on an existing structure there are three work methods that may be utilized to accomplish this work:

11.1.1 Treating the conductor as energized, adhering to all live conductor work practices and utilizing all appropriate PPE and rubber protective cover-up

11.1.2 De-energized and grounded, providing equi-potential grounding at all work locations. Grounds shall be placed so that any conductor that a worker can contact at a work location is at the same potential as any equipment that they can contact while in the process of their work. Workers on the ground who must handle a conductor that is still connected to conductors or equipment that are a part of the electrical system shall wear appropriate PPE. (Refer to LU-EOP D002, OH Distribution and Sub-Transmission Personal Protective Grounding)

11.1.3 If it is a bare pole with no conductors or foreign wires attached to a pole with energized conductors, it may be considered dead.

11.2 Conductor Removal – When it is necessary to remove a conductor that was once a part of the electrical system one of the following two work methods shall be adhered to:

a. Treat the conductor as energized, adhering to all live conductor work practices and utilizing all appropriate PPE and/or rubber protective cover-up.

b. The conductor may be worked as de-energized if it meets all of the following requirements:

c. The conductor(s) that is being removed shall be disconnected from all normal primary sources.

d. There are no crossings or parallels with energized conductors.

e. It is a bare pole with no conductors or foreign wires attached to a pole with energized conductors.

f. The conductor(s) that is being removed shall have grounds applied so that no point along the conductor is more than 2 miles from a ground

g. Any conductor being removed that is still in an elevated position shall have a minimum of one ground.

h. Work will be coordinated so that all workers perform any conductor removal by working toward the protective ground. This protective ground shall be removed as the last step in the conductor removal process.

12.0 Equipment

12.1 Spider system

12.2 Pulling/Tension Machines

12.3 Wire Trailers with Brake

12.4 Reel stands

12.5 Travelers / Running Blocks

12.6 Extension Arms

12.7 Hoists

12.8 Grips

12.9 Grounding devices

a. Running Grounds
b. Rotating Grounds
c. Ground Rods
d. Personal Grounds
e. Ground Grids
f. Equipment Grounds
g. Vehicle Grounds
h. Structure grounds

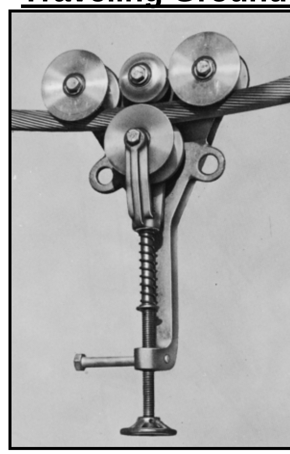
12.10 Communication Equipment

a. Portable radios
b. Fixed radio in vehicle
c. Cell phone

Spider Reels

Puller/Tensioner

Traveling Grounds

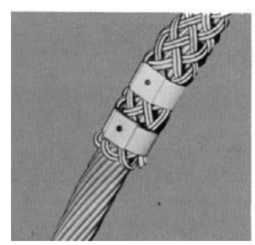


Running Block

Pulling Line

Basket Style Pulling Grips

Banding

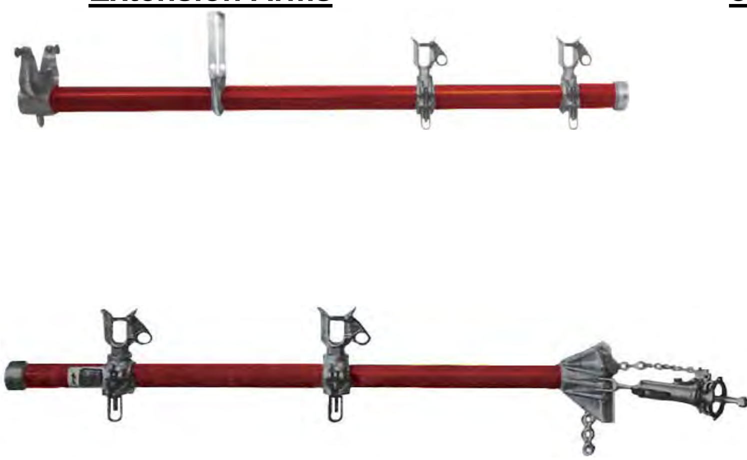


Portable Radio

Coffing Hoists

Strap Hoist

Extension Arms



50' Equipment Grounding Lead

13.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
06/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

INTRODUCTION

The purpose of this EOP is to establish a safe and consistent procedure for the installation, splicing, terminating and removal of pre-lashed aerial cable. This procedure applies to all personnel involved in the installation, splicing, terminating, removal and maintenance of lashed aerial cable.

All work will be performed in accordance with the Liberty Utilities Employee Safety Handbook, utilizing all appropriate safe work methods and procedures. Only qualified workers may perform work on or near exposed energized parts.

ACCOUNTABILITY

1. Standards, Policies and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate personnel guidance when requested for specific work related task.

2. Electric Distribution Operations
   - A. Ensure that all procedures in this EOP are understood and implemented.
   - B. Ensure that all personal are trained in this procedure.
   - C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   - A. Demonstrate the understanding of the procedures in this EOP.
   - B. Comply with the requirements of the procedures.
   - C. It is the workers responsibility to read and fully understand, and to follow the manufacturer’s instruction manual and specifications before operating equipment.

REFERENCES

Liberty Utilities Employee Safety Handbook
Liberty Utilities Construction Standards (Overhead and Underground)
Manufacturer’s Instructions (Sherman & Reilly, Inc.)
LU-EOP G014 Clearance and Control
Liberty Utilities Bulletin #12-09
LU-EOP G026 Mechanized Equipment Grounding

DEFINITIONS

Aerial Device: Any device, extensible, articulating or both, which is designed to position personnel and/or handle materials.

Bracket Grounds: Two or more sets of “Master Grounds” in the same configuration installed so that there is ALWAYS a set of Master Grounds on each side of the work location between the worker and any known source of energization. These master grounds SHALL be placed as close as practical to the work location, preferably on adjacent structures.

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Conductor: A material, usually in the form of a wire, cable, or bus bar suitable for carrying an electric current.

Drum puller: A machine, equipped with an engine which drives the drum mechanically and/or hydraulically, designed to pull conductor during conductor stringing operations. It may be equipped with synthetic fiber rope or wire rope to be used as the pulling line.

Exposed: Not isolated or guarded.

Leader: The person in charge of the job site and operation (crew chief, lead splicer, etc.) The Leader's responsibilities include but are not limited to:

Pre-job safety and assignment brief
Job site safety for crew members
Public safety near the work area
Equipment requirements
Positioning of equipment
Assignment of tasks
Communication needs and responsibilities between crew members
Returning the equipment in a safe and clean condition
Adherence to Liberty Utilities policies and procedures

Minimum Approach Distance: The closest point of approach to energized lines or equipment by a qualified employee or by any conductive object, without the use of insulating gloves, sleeves, or portable protective devices.

Note: Table R-6 in OSHA 1910.269 defines the Minimum Approach Distances to be followed by a qualified employee while working near energized lines and equipment.

Shall: The word shall is to be understood as mandatory.

Should: The word "should" indicates provisions that are normally and generally practical for the specified conditions.

Splice: A connection between distribution cable and another section of cable or a cable lug or a cable termination including live end caps.

Tension site: The work area where the tensioner, reel stands and anchors are located.

Zone of Protection: An area defined by opened protective points which isolate all known energy sources. This area is created by isolating, de-energizing and tagging every protective point of isolation from all forms of external sources of energy that could create a hazard for workers.

TRAINING

Provided by appropriate Liberty Utilities L&D training program

DOCUMENT CONTENTS

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1.0 GENERAL

1.1 This EOP provides direction in the installation, splicing, terminating and removal of lashed aerial cable. All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and appropriate EOP's and Bulletins. Only approved tools and equipment shall be used.

1.2 All aerial cable now purchased by Liberty Utilities is pre-assembled with a messenger already installed with the phase conductors. Aerial cable is typically utilized for station get aways or where adequate clearance to ground or clearance to buildings cannot be obtained with open wire or spacer cable construction. Factory assembled shielded aerial cable has a grounded metallic sheath and requires similar clearance to that specified for secondary, rather than for primary conductors. The metallic sheath shall be bonded across each splice and at each termination.

2.0 EQUIPMENT

Wire Puller

Aerial Cable Trailer (with tensioner)

Large Block

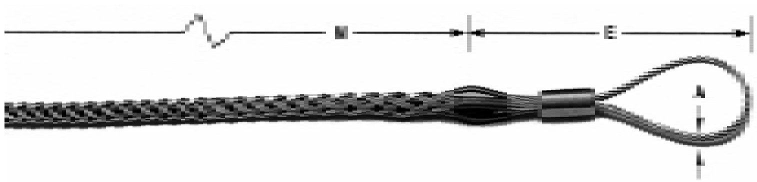
Shall be used as the first and last block to minimize bending radius

Aerial Cable Block

Attached at all structures between first and last large blocks

Swivels

Shall use two swivels attached back to back



Kellem Grip

Shall be properly sized for messenger

NOTE: *Refer to Work Methods Bulletin #12-09 for proper grip selection and banding instructions. It is required that when pulling any type of wire overhead that the grip shall be banded to prevent accidental loss of conductor during pulling operations.*

3.0 INSTALLATION OF CABLES

3.1 Great care shall be exercised in the review of the job design specifically: accessibility and traffic, proper pulling and tensioning equipment, supporting structures and associated hardware required to properly install aerial cable.

3.2 Establish a route plan and calculate average span lengths and total route distance. Special attention shall be given to the length of pull as related to the amount of cable on the reel, in order to efficiently install cable and minimize cable waste.

3.3 Proper blocks, swivels, grips, tools and methods prevent messenger and phase conductor damage and result in longer system life. Proper stringing hardware and methods prevent bracket breakage, the likelihood of poles being pulled out of line during installation and messenger contact with energized conductors during installation. All equipment shall be inspected prior to any conductor installation. Some of these are but not limited to, pulling line, travelers, cable reels, line jacks, grips and portable radios.

3.4 Verify the class and condition of all poles involved in the installation of aerial cable and verify all clearances.

3.5 The process of installing aerial cable in a manner which keeps the cables off the ground, clear of vehicular traffic, communications cable and other structures that might damage the cables is called tension stringing. Tension stringing to reconductor new lines provides a means to keep the new cables under control. **This is the preferred method of installation.**

3.6 Reliable communications must be maintained between the operator of the pulling equipment and the reel tensioning equipment (i.e. radios, cell phones etc.) The person in charge of the work or their appointee shall follow the cable at the point of attachment between the pull line and cable, in order to catch and prevent any hang ups on the blocks.

Pre-lashed aerial cable should be pulled in and sagged as follows:

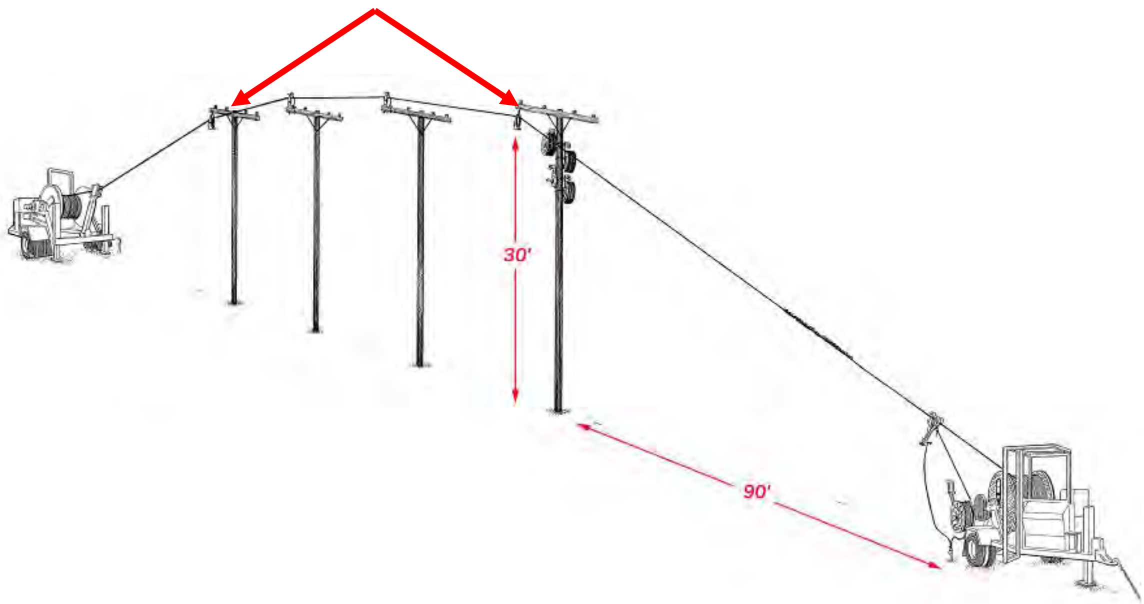
3.7 Aerial cable shall be installed at a minimum of 16 inches below the existing secondary conductor at the pole, 12 inches below the secondary conductor at mid span, 30 inches above communication cable at the pole (40” for Fairpoint) and 12 inches above communication cable at mid span.

3.8 Use appropriate size aerial blocks at every pole (blocks shall have ½ inch clearance on either side of cable and be at least ½ inch deeper than cable bundle width. Blocks should be anchored such that all downward pressure is on the pole.

3.9 The cable reel and pulling machine shall be a minimum of 3 times the height of the first block away from the first pole to minimize bending radius. If the 3 to 1 ratio cannot be met large blocks shall be used at the first and last structures to minimize over bending of the cable. Adhere to the minimum bending radius of 8 times the outside diameter.

If the 3 to 1 ratio cannot be met, large blocks shall be used at these locations

Diagram showing 3 to 1 ratio of equipment to first block



3.10 There shall be provisions for tensioning the cable reel in order to keep constant tension on the messenger throughout the pull to keep cable under control.

3.11 Attach pulling line to proper sized grip and attach to messenger only. Taper cable on pulling end to enable smooth transition through blocks. Use back to back swivels to help prevent rolling of cable.

3.12 Pull in the cable using sufficient tension (see pulling tension data on pages 8/9) so that the cable is not bent sharply at any block and is in contact with rollers at all times. The messenger should come off the reel on the bottom of the cable bundle and in and out of the roller on the bottom of the cable bundle.

3.13 Install temporary head guys to handle tension from individual pulls. Guys can be removed after a new run has been spliced together and the tension is on messenger. Aerial cable is wound on the reels with extra messenger beyond cable on either end to facilitate installation and splicing. Be sure to consider this when picking, pulling and dead ending cable.

3.14 Make sure to overlap cable by at least ten feet in either direction at splicing point to facilitate proper spacing of joints as well as proper neutral cut back per Standard fig. I on page 16-315 of Overhead Construction Standards.

3.15 Inspect dead ends, angles, and guys. If guys have slipped or seriously cut into the wood, tighten, replace, or repair the fittings.

3.16 Reduce the tension to the values specified (Section 16.6 Aerial Cable Sag/Tension Data, Liberty Utilities Overhead Constructions Standards), clamp the messenger at each pole and complete the dead ends.

Calculating Pulling Tension:

3.17 The proper sizing of puller and tensioner is critical to the condition of the installed cable, time of installation and safety of the crews. The following two formulas (T1 and Tmax combined) calculate the appropriate pulling tension needed.

Puller Sizing formulas

$T_1 = \frac{WL^2}{8D}$ = Tension in (1) Span

$TMAX = \frac{T_1}{.98^N}$ = Pulling Tension

- W = Weight of cable, per foot in lb.
- L = Span (average) in feet
- D = Stringing sag in feet off horizontal
- N = Number of supports in pull
- .98 is efficiency of each support

Example: For 15kV EPR (JCN), copperweld messenger, copper binding tape, 1000 ft. reel (NOTE: This is an example of the current type and voltage rating cable we now purchase. Please refer to the Overhead Construction Standards, section 16 for weights of other types and classes of aerial cable.)

$T_1 = \frac{WL^2}{8D}$

W= 5.01 lbs.
L= 135 feet
D= 2.5 feet
N=8 (supports)

$T_1 = \frac{5.01 \text{ x } 135(2)}{8 \text{ x } 2.5} = \frac{91307.25}{20}$ = 4565 lbs. (1) Span

$Tmax = \frac{T_1}{.98^N} = \frac{4565}{.85}$= 5365 lbs. Pulling Tension for 7 Sections

Note: *Number of supports (N) and average span length (L) are for calculating this example only.*

Refer to Section 16 in the Liberty Utilities Overhead Construction Standards for final sagging and tensioning instructions. Aerial cable construction drawings are located in the back of Section 16.

4.0 SPLICING AND TERMINATING OF AERIAL CABLE

4.1 There are many types of aerial cable presently in service throughout the Liberty Utilities territory. Liberty Utilities purchases aerial cable pre-assembled from the factory that is rated 15kV through 35kV, EPR insulated, jacketed concentric neutral, 3 phase construction with an EHS copperweld messenger held together with a covered copper binding tape. The 7/16" messenger shall be spliced with the appropriate automatic splice; however with the 9/16" messenger the appropriate compression connector must be used.

4.2 Older aerial cables have a copper tape metallic shield and can be jacketed or unjacketed. Every effort shall be made to splice these with a cold shrink kit. If a cold shrink splice cannot be installed, refer to Underground Construction Standards for proper splice selection.

4.3 Because of the proximity to other energized OH conductors a capacitive or inductive charge may build on the unbonded aerial cable. Workers shall use a low resistance approved test device to verify de-energized/test/dissipate any possible capacitive charge before splicing.

4.4 On newly installed aerial cable, splices shall be cold shrink. For installation of the splice on concentric neutral cable, follow the instructions in Section 36.2.10 (Underground Construction Standards). For grounding and bonding of the splice on concentric neutral cable, follow Section 36.7.20. For installation of the splice on copper tape shielded cable follow the instructions in Section 36.2.30. For grounding and bonding the splice on copper tape shield cable follow Section 36.7.90 (Underground Construction Standards). Splices shall be staggered to a minimum of 5 feet apart per fig. I on page 16-315 of Overhead Construction Standards. Each splice is to be externally bonded. Connect the bond wires exiting the splice to the messenger wire and/or other grounded conductor and bond cable lashing to messenger per instructions in Section 16 of Overhead Construction Standards. The outer jacket contained in the splice kit is not UV resistant and must be replaced with two UV resistant silicon outer jackets overlapped (Std Item UR49D).

4.5 When all installation of cable, conductor and messenger splicing is complete, bond the messenger of the factory assembled shielded aerial cable to the secondary or common neutral at each transformer, at the ends of each secondary and elsewhere to provide a bond on every fourth pole.

4.6 On newly installed cable, terminations shall be cold shrink. For installation on concentric neutral cable follow the instructions in 37.1.50. For installation on copper tape shielded cable follow the instructions in 37.1.60.

4.7 Refer to Section 16 - Aerial/Spacer Cable of the Liberty Utilities Overhead Construction Standards for proper selection of splices and terminations.

5.0 SAFETY

5.1 When operating any equipment near energized lines, the equipment shall be grounded to a ground element. The equipment/work area shall be barricaded to protect the workers and the public from dangerous touch and step potentials. Appropriate rated rubber gloves and EH rated overshoes shall be worn by the operators.

5.2 Underground cables shall be effectively grounded. Short circuiting grounds of an approved type shall be installed at the nearest convenient point on each side of the work location, or an approved method for working on ungrounded cables shall be followed.

5.3 A full body harness, with shock absorbing lanyard, shall be worn when employees are working from aerial lifts and bucket trucks. An approved attachment point shall be used for the lanyard; the approved attachment point shall not be part of the fiberglass bucket. Fall protection is not required when employees access or exit an aerial bucket in the cradled position or work on the truck. (Liberty Utilities Employee Safety Handbook Section 1.20.9)

5.4 In situations requiring rubber gloves, gloves shall be donned before the employee leaves the ground and shall be worn until the employee returns to the ground (commonly referred to as "ground to ground" or "cradle to cradle"). (Liberty Utilities Employee Safety Handbook Section 2.11.16)

5.5 Any exceptions to wearing rubber gloves for specific jobs not listed in the Safety Manual are permitted only with the dated, written approval of a Director of Operations. (Liberty Utilities Employee Safety Handbook Section 2.11.21)

Rubber Glove Exceptions: (Liberty Utilities Employee Safety Handbook, 2.11.20)

5.5.1 2.11.20 - e. You are working in an equipotential zone.

5.5.2 2.11.20 - g. You are working with de-energized cable terminations, stress cones, and similar devices which require a high degree of manual dexterity in the application of tape insulation, tape maybe applied bare handed provided the following conditions are adhered to:

a. Secondaries and primaries are covered with rubber protective equipment to a degree that accidental contact is improbable.

b. Taping is done from a position that excludes any possibility of contact with exposed energized equipment.

NOTE: *This exception in the Liberty Utilities Employee Safety Handbook Section 2.11.20 - g is for the application of insulating tape only. Any additional exception will need a Director of Operations approval per the Liberty Utilities Employee Safety Handbook Section 2.11.21.*

6.0 REMOVAL OF AERIAL CABLE

6.1 Aerial Cable Removal – When it is necessary to remove a cable that was once a part of the electrical system one of the following two work methods shall be adhered to:

6.1.1 Treat the cable as energized, adhering to all live conductor work practices and utilizing all appropriate PPE and/or rubber protective cover-up.

6.1.2 The cable may be worked as de-energized if it meets all of the following requirements:

a. The cable(s) that is being removed shall be disconnected from all normal primary sources.

b. There are no crossings or parallels with conductors energized above 600 volts.

c. The cables(s) that are being removed shall have grounds applied so that no point along the conductor is more that 2 miles from a ground.

d. Any cable being removed that is still in an elevated position shall have a minimum of one ground.

e. Work will be coordinated so that all workers perform any cable removal by working toward the protective ground. This protective ground shall be removed as the last step in the cable removal process.

Exception approvals:

It is recognized that situations arise that are not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Program Manager Standards, Policies and Codes and a Manager of EHSS or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
06/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D015		
Electric Operating Procedure	**12-01-2014**	**Overhead**	
Fiber Optic Cable	**Revision #**	**1.0**	**Page: 1 of 10**

INTRODUCTION

This electric operating procedure provides information, instructions and work methods for qualified line workers, working on pole tops in the primary supply space with (ADFO) All- Dielectric Fiber Optic cables attached.

PURPOSE

This procedure applies to all qualified workers, who may perform work on fiber optic cable in the primary supply space.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support upon request.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.

3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

COORDINATION

Not Applicable

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
Liberty Utilities Overhead Construction Standards, Section 17 – Joint Use
National Electrical Safety Code
O.S.H.A.29 CFR 1910.269

DEFINITIONS

Fiber Optic Cable: Contains multiple glass or plastic strands, called fibers, using light pulses to carry information down the line. The light pulse may be created using light emitting diodes or lasers.

Dielectric: Insulating material or a very poor conductor of electric current

ADFO: All-Dielectric Fiber Optic communication cables

ADMS: All-Dielectric Messenger Supported

ADMMS: All-Dielectric Metallic Messenger Supported

ADSS: All-Dielectric Self Supporting

QUALIFIED WORKERS (as defined in 1910.269): Workers shall be trained in and familiar with the safety related work practices, safety procedures and other safety requirements that pertain to their respective job assignments. Workers shall also be trained in and familiar with any other safety practices, including applicable emergency procedures (such as pole top/bucket rescue). Qualified workers shall be trained and competent in: skills and techniques necessary to distinguish exposed live parts, determining nominal voltage of exposed live parts, knowledge of minimum approach distances.

Proper use of precautionary techniques, use of PPE including insulating and shielding materials and properly rated insulated tools for working on or near energized parts of electrical equipment.

TRAINING

All Liberty Utilities employees who are required to install, remove, and transfer fiber optic cable will be trained on this procedure.

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Liberty Utilities	Doc. # LU-EOP D015		
Electric Operating Procedure	**12-01-2014**	**Overhead**	
Fiber Optic Cable	**Revision #**	**1.0**	**Page: 4 of 10**

1.0 SAFETY REQUIREMENTS

All appropriate PPE, which includes but is not limited to, hard hat, safety glass/eye protection, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Procedures. All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and applicable Work Procedures.

Before work begins a "Job Brief" shall be conducted to identify the boundaries of the work area, the work methods to be used and all hazards associated with the job.

Use caution when handling Fiber Optic Cable. With fiber optics, lasers operate in the infrared range and the beam is invisible to the eye. Viewing an optical beam does not cause pain. The iris of the eye will not close involuntary as when viewing a bright light. Permanent eye damage may result.

CAUTION: DO NOT LOOK DIRECTLY INTO THE ENDS OF THE FIBERS!

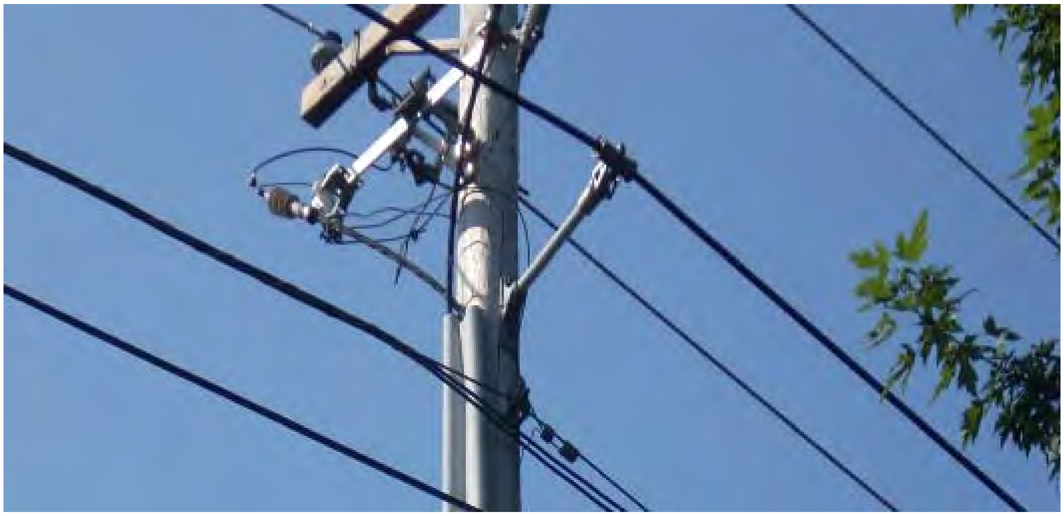
The fibers inside the sheath are glass and are no larger in diameter than a human hair. Never handle a damaged cable without gloves. The glass slivers are small and not easily seen. Medical attention may be necessary.

2.0 TYPES OF FIBER OPTIC CABLE AND LOCATION ON POLE

Per Liberty Utilities requirements, **only ADFO cable is approved for installation in the supply space.** An ADFO cable may be **ADSS** (all-dielectric self-supporting) cable that is supported by an internal dielectric line or may be **ADMS** (all-dielectric messenger supported) cable that is supported by a separate dielectric line. The key distinguishing feature of this type of cable is that the **entire cable assembly including the messenger is all-dielectric**.

In general, an ADFO cable must be attached to the pole with a 12 inch minimum separation in any direction from the electric neutral or secondary cables and at least 30 inches of separation from any primary electric supply cable or other energized part. A 12 inch vertical separation between the AFDO cable and the electric neutral or secondary cables at the pole is required. Where this is not possible, the owner of the communications cable may install the ADFO cable on an extension bracket to obtain the 12 inch minimum separation from the neutral or secondary cable. (Reference Construction Standards Section 17)

Workers installing and maintaining fiber optic cables in the supply space are required by NESC and OSHA to be "Qualified Workers". (See definition)



(**ADSS**) All-Dielectric Self Supporting Fiber Optic Cable with Extension Bracket

The other type of fiber optic cable, an effectively grounded cable, is a communications cable that is supported on a metallic messenger (ADMMS) and is effectively grounded throughout its length. Liberty Utilities does not allow the installation of any communications cables with a metallic component in the supply space. This type of metallic messenger supporting fiber cable is typically located in the communications space below the secondary cable on the pole.

(ADMMS) All-Dielectric Metallic Messenger Supported

The ADFO has been installed in underground systems as well as the overhead. In underground applications there is no messenger and the owning companies contact information is identified using the same tag as the overhead.

3.0 OWNER IDENTIFICATION OF FIBER OPTIC CABLE

Company ownership identification tags should be installed at all pole attachments and manhole / handhole entry and exit points. The tags are typically orange in color and will have the owning company's name and / or phone number on the identification tag. (See pictures below)

If no identification exists at the pole, check the adjacent poles for an ownership tag and / or phone number attached.

4.0 TRANSFERRING FIBER OPTIC CABLE

Liberty Utilities crews are routinely assigned to transfer ADFO in the supply space as part of the Job Card work activities. If it is not practical to transfer the ADFO in the supply space due to complex hardware or multiple attachments the crew should notify their supervisor and make a note on the job card indicating the company name and contact information listed on the tag located at the pole attachment.

The communications companies have qualified workers who will respond to our requests for transfers.

Common ADFO hardware typically assigned to transfer as part of a Job Card include the following brackets and accessories:

ADSS Rubber Clamp Insert and Metal Clamp

ADSS Plastic Clamp

Extensions Bracket

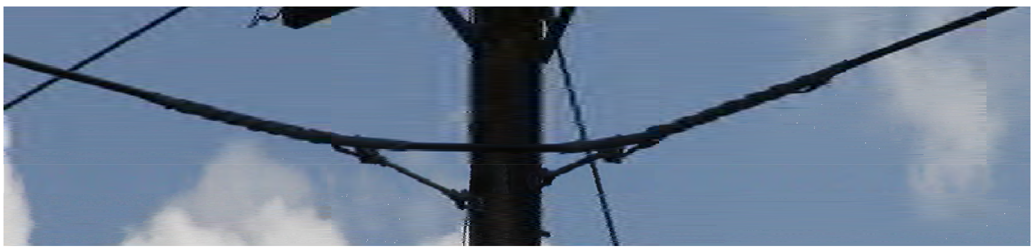
Cautions when transferring ADFO:

Do's

4.1 When transferring or floating, always try to protect the fiber optic cable.

4.2 If necessary to hold any strain on the cable, tie a pulling hitch over a fiber optic armor wrap if one is already attached to the cable.

4.3 Fiber optic armor wraps similar to our guy wraps may be used if it is necessary to hold a fiber optic cable.



Fiber Optic Armor Wrap

Don't's

4.4 Push the fiber optic cable with a bucket. If room is needed to work on the pole, float the cable.

4.5 Use any conventional wire grip on any fiber cable.

4.6 Compress any fiber optic with ropes, tools, poles or buckets.

4.7 Exceed minimum bending radius (20 times the cable diameter).

4.8 Move any fiber optic cable if it has been burned. You may break undamaged fibers.

Report any fiber optic cable damage to the Liberty Utilities Emergency Dispatch and Scheduling Operator.

4.9 Types of damage are:

4.9.1 Parted Cable

4.9.2 Partial damage to the sheath: This type of damage can exist in the form of cuts, holes, or kinks (caused by pole damage, fuse blowing next to cable, excessive heat, or tree damage.

4.9.3 Open Fiber: This may not be evident unless the cable is cut (I.e., an impact to the cable could break the glass fibers inside the jacket).

4.9.4 Signal Deterioration: This can be caused by severe bends in the cable so always avoid making a sharp bend or kink in the cable.

5.0 NOTIFICATION

ADFO attachments should have a tag indicating the companies name and or a phone number to be contacted for any work needed by the communications company identified. Owning companies have "Qualified Workers" available to respond to Liberty Utilities requests and emergencies 24/7.

If you need to contact the owning company during an emergency, or to report damaged fiber optic cable, then notify the **Emergency Dispatch and Scheduling** and provide the communications companies' information noted at the attachment along with a brief description of the condition. The **Emergency Dispatch and Scheduling** will notify the communications company of the situation.

6.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2014	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP D016		
Electric Operating Procedure	**01-01-2014**	**Overhead**	
Installing Wood Poles	**Revision #**	**1.0**	**Page: 1 of 16**

INTRODUCTION

This work method applies to special multipurpose vehicle-mounted machines, commonly known as digger-derricks. These machines are primarily designed to accommodate components that dig holes, set poles, and position materials and apparatus.

PURPOSE

This EOP will address the proper procedure for the installation of new distribution wood poles.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support upon request.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.

3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.

REFERENCES

ANSI/ASSE A10.31-1995
OSHA 1910.269
Liberty Utilities Employee Safety Handbook and Procedures
Work Methods Bulletin #10-22
Work Methods Bulletin #10-24
Work Methods Bulletin #11-02
Work Methods Bulletin #12-01
Work Methods Bulletin #12-08
Work Methods Bulletin #12-19
LU - EOP D005 - Distribution Pole Lashing
LU - EOP G006 - Requirements for Loading and Hauling Poles
LU - EOP G013 - Excavation Notification Requirements
LU - EOP G025 - Utilizing a Digger Derrick to Remove Poles
LU - EOP G026 - Mechanized Equipment Grounding
The Lineman's and Cableman's Handbook (Tenth Edition)
Altec Operators Manual

DEFINITIONS

Barricade: A physical obstruction such as tapes, screens or cones intended to warn and limit access to a hazardous area.

Barrier: A physical obstruction that is intended to prevent contact with energized lines and equipment.

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Exposed: Not isolated or guarded.

Guarded: Protected by personnel, covered, fenced, or enclosed by means of suitable covers or casings, barrier rails, screens, mats, platforms, or other suitable devices in accordance with standard Barricading techniques designed to prevent dangerous approach or contact by persons or objects.

Minimum Approach Distance: The closest point of approach to energized lines or equipment by a qualified employee, or by any other conductive object, without the use of insulating gloves, sleeves or portable protections devices, shall be in accordance with the Minimum Approach Distance table.

Non-Reclose Assurance (NRA): A formal statement from the System Operator to an Authorized Person to perform work on, or near, designated energized lines or apparatus after all its reclosing devices. Including SCADA/EMS, are disabled and tagged.

Shall: The word shall is to be understood as mandatory

Step Potential: The voltage difference between two points on earth's surface, separated by a distance of one pace (assumed to be one meter/approximately 3 feet) in the direction of the maximum voltage gradient. This potential difference, if great enough, could be dangerous to a worker T011, D002, G026

TRAINING

Provided in appropriate Liberty Utilities L&D training programs for personnel and as requested.

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1.0 SAFETY

1.1 Always conduct a Pre Job Brief and Hazard Assessment.

1.2 The operator should never leave the controls while a load is suspended.

1.3 During pole loading or unloading operations, do not stand between the pole pile, the loading and transporting equipment or a fixed object.

1.4 Do not stand or walk on pole pile if it all possible.

1.5 All winch ropes and hoisting accessories shall be inspected prior to each use and replaced as necessary.

1.6 Use pole LIFTING tongs if possible to make the first pick on the pole to enable attachment of an approved rated pole lifting chain or sling.

1.7 Do not stand or pass beneath suspended loads.

1.8 Workers should be aware to keep all body parts from under a suspended load.

1.9 Section 3.6 of the Liberty Utilities Employee Safety Handbook entitled Line installation and Removal states the following:

1.9.1 When setting or removing a pole, do not allow the pole to contact exposed energized conductors.

1.9.2 Wear appropriate rubber gloves when setting, moving, or removing a pole near an exposed energized overhead conductor.

1.9.3 Do not contact the pole with un-insulated parts of your body.

1.9.4 Attend or physically guard pole holes.

2.0 Excavation Notification Requirements

2.1 Call 811

2.2 LU-EOP G013 applies to all Liberty Utilities Operation Personnel who move or remove earth, rock or other materials in or on the ground by use of mechanized equipment or by blasting, including, but not limited to digging, auguring, backfilled, drilling, grading, plowing in, pulling in, trenching and tunneling.

3.0 Before you operate

3.1 Read your manufacturer's operation manual before digging. Make sure you are aware of and have received instruction in the location, function and proper use of winch, boom, rotation and auger controls. If there is no manual with the machine—get one. Study it before you start work. If there is something in the manual you don't understand, ask your supervisor to explain it to you.

3.2 **Daily Preoperational Inspection,** Inspect the unit at the beginning of each work day before going out on the job. Potential service and safety problems may be detected by inspecting the unit every day. If any problem is found, including oil leaks or improper operation, stop and have the problem corrected before placing the unit in service.

3.3 Inspect the auger windup cable/rope each day. If the cable/rope shows signs of wear replace it immediately. A worn windup cable/rope could fail causing a free swinging auger. A free swinging auger could cause death or serious injury.

3.4 Position the truck on a firm surface before operating the auger.

3.4.1 Always use wheel chocks and parking brake.

3.4.2 A digger Derrick shall not be used on a slope of more then 5º unless appropriate measures are taken to level the unit.

3.4.3 The outriggers shall be extended as directed in manufacturer's operating manual.

3.4.4 Always have the outriggers in view when they are being extended or retracted, it maybe necessary to use a signal person to watch them.

3.4.5 Always set outriggers on the down hill side first to level unit.

3.4.6 Use outrigger pads on all unpaved surfaces, asphalt pavement, and other soft surfaces.

3.5 The digger derrick shall be attached to the best available ground at the work site to minimize the time the lines remain energized in the case of accidental contact OR the vehicle is to be barricaded to prevent contact by ground personnel.

3.5.1 Barricading a vehicle or equipment provides a physical and visual obstruction, warning the public and workers of possible danger.

3.5.2 The barricade shall be positioned so that no hazardous voltage exists outside the barricade and will prevent unauthorized entrance into the potentially hazardous area.

3.5.3 No one should enter the barricaded area while the vehicle or equipment is operating and has a risk of contacting energized lines or apparatus without wearing Class 2 rubber gloves and EH rated shoes.

3.5.4 A barricade shall be set up using a minimum six foot perimeter, if possible, around the vehicle or equipment providing isolation from the vehicle or equipment for the public and workers.

3.5.5 If the six foot perimeter would impede traffic flow or create a greater hazard for the pedestrians, then a lesser perimeter is allowable, but a worker Shall be positioned to ensure that contact is avoided.

3.5.6 The use of safety cones, safety flags, red barricade tape, and/or retractable barriers shall be used to construct this barricade. See Liberty Utilities EOP G026 for further explanation.

3.6 There shall be a **traffic control plan** for the movement of vehicles in areas where there are also workers conducting other tasks. Drivers, workers on foot, and pedestrians shall be able to see and understand the routes they are to follow.

Note: Refer to Liberty Utilities Safety Procedure - Work Zone Traffic Control

4.0 Releasing Auger (Raised)

All personnel shall be clear of the area before stowing or un-stowing the auger

4.1 Make sure the digger is in low speed.

4.2 Elevate the boom to at least a 45 degree angle. (Should the auger become free, the swing would be minimal, eliminating the chance of injury or damage).

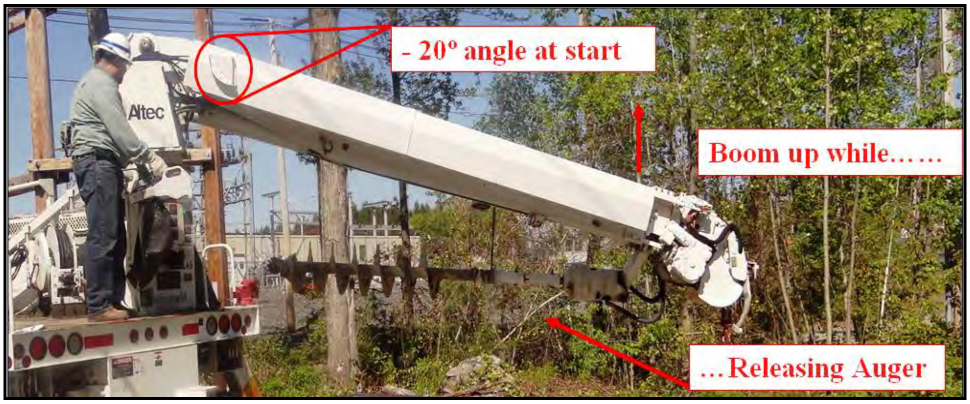
4.3 Move the auger control slightly to the clean or dig side (depending on the direction of windup) to relieve the weight from the stow latch and retract stow latch completely.

4.4 Unwind and lower the auger until it is in the vertical position.

4.5 Remove the windup strap from the auger.

5.0 Releasing Auger (Lowered)

Method used when conditions do not allow for the raising of boom



5.1 Make sure digger is in low speed.

5.2 Lower the boom to at least -20 º degree angle. (Should the auger become free, the swing would be minimal and auger would hit the ground first thus eliminating the chance of injury or damage).

5.3 Move the auger control slightly to the clean or dig side to relieve the weight from the stow latch and retract stow latch completely.

5.4 Unwind and lower the auger while raising the boom until the auger is in the vertical position.

5.5 Remove the windup strap from the auger.

6.0 Stowing Auger

All personnel shall be clear of the area before stowing or un-stowing the auger

6.1 Rotate the boom to a position that will allow the boom and auger to clear all obstacles when the digger is stowed.

6.2 Fully retract the intermediate boom before stowing the auger. With the intermediate boom partially extended, the auger may hit and damage the auger stow bracket.

6.3 Lower the boom and point of the auger to the ground.

6.4 Attach the loop at the end of the auger windup sling onto the auger lug.

6.5 Move the digger speed switch to “Low.

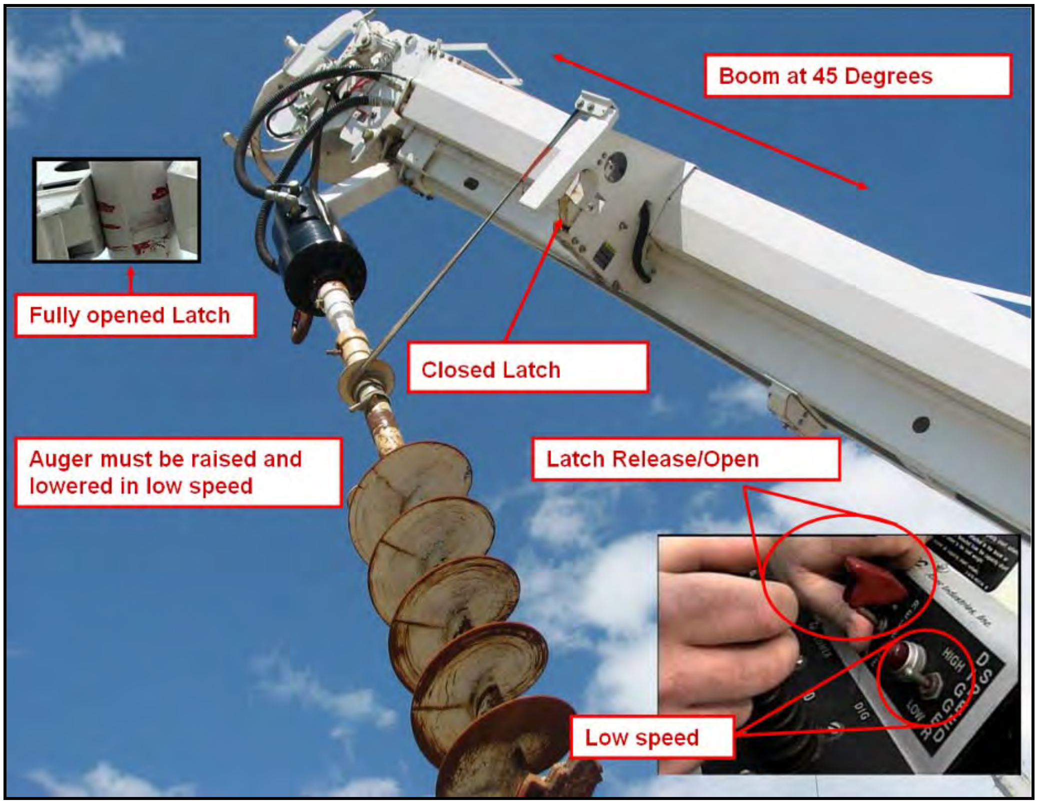
6.6 Operate the digger hand control slightly in the Dig position and raise the booms. Make certain the sling continues to wrap around the auger tube below the cable guide dish.

6.7 Continue rolling the auger up slowly using the digger control. When the auger tube is close to the auger stow bracket, use the auger release switch to retract the auger latch while the auger tube enters the auger stow bracket.

6.8 Close the auger latch once auger is in the stow position.

6.8.1 Do not stow auger with latch closed. Running the auger over latch while stowing will cause damage to the control piston by forcing latch open and the piston to forcibly retract.

6.8.2 You may have to operate the throttle at high speed to maintain the pressure to operate the digger and latch at the same time.



7.0 Digger Operation

Once the digger is unstowed, the intermediate boom and rotation controls may be used to position the digger.

7.1 Pole hole depth is 10% of pole length plus 2 feet, with a minimum depth of 5 feet

(Example a 40' pole x 10% = 4' + 2' = 6' hole depth)

7.2 Digging is most efficient when a relatively steady downward force is kept on the auger. Do this by jogging the boom hand control to the Lower position while operating the digger hand control. Coordinate the boom and digger controls to exert various amounts of force and speed as needed for soil conditions.

7.3 Too much downward force with the boom lower function may cause the auger to corkscrew into the ground. This means the auger acts like a screw, rather than cutting the soil loose for the flighting to pick up. If the auger begins to corkscrew, shift the digger hand control to the clean position. Back the auger out of the hole until normal digging can be resumed. Corkscrewing the auger creates great stress on the boom. It is especially important to avoid corkscrewing the auger when it is positioned at a side angle to the boom. This may cause side loading to develop on the boom.

7.4 Use the lower boom, rotation, and intermediate boom extend functions to follow the auger as it advances into the ground.

7.5 Maintain alignment of the hole and the auger shaft.

7.6 When the auger is loaded with soil, raise the auger above the ground with the auger turning slowly.

7.7 Move the digger clean switch back and forth. This will normally remove the soil from the auger. The operator may also move the digger speed switch to the high position and use the foot throttle to remove the soil. The use of a spade shovels to remove soil from auger, maybe necessary.

8.0 Lifting & Setting Poles

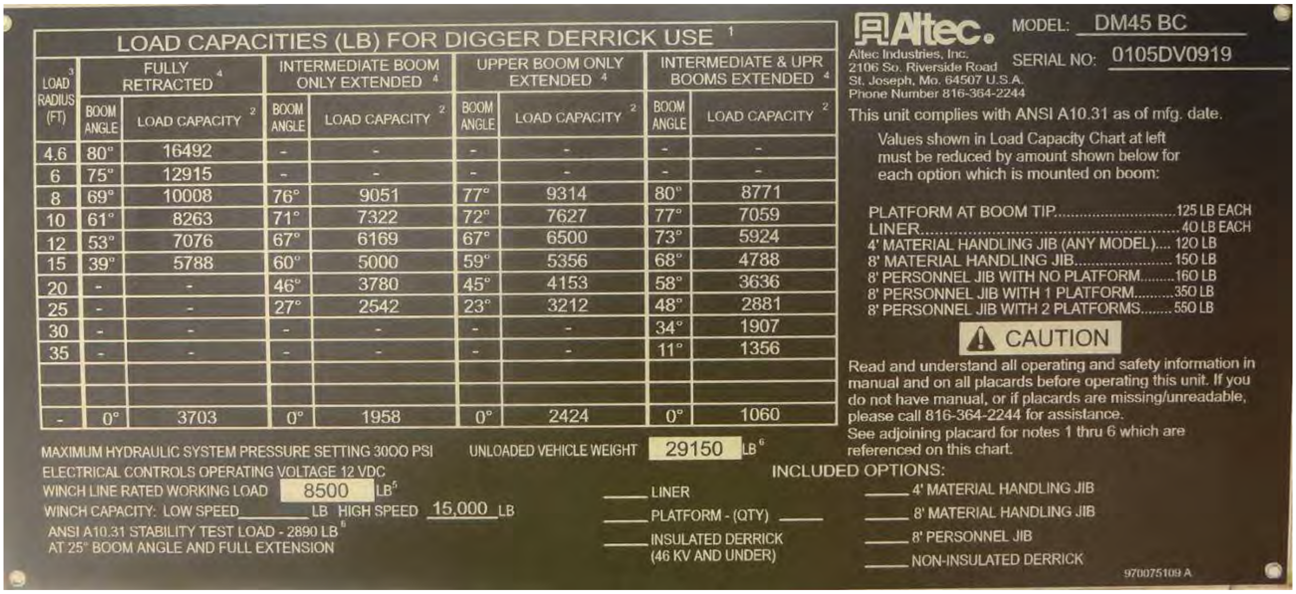
8.1 To position a pole to be set on the ground, the pole should be lifted on balance and guided from the ends by co worker.

8.2 The operator shall determine the weight of the pole (Load) to be lifted. Average pole weights in pounds are listed in the table below:

POLE LENGTH (Feet)	CENTER OF GRAVITY (Measured in feet from butt)	AVERAGE WEIGHT IN POUNDS					
	FULL LENGTH TREATED SOUTHERN YELLOW PINE POLES						
		CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6
20		-----	-----	-----	-----	330	284
25		-----	-----	674	573	490	422
30		-----	-----	921	784	660	550
35	16	1567	1343	1155	1004	862	742
40	18.5	1884	1622	1403	1219	1059	921
45	20.5	2222	1911	1664	1444	1274	1114
50	22	2585	2214	1925	1687	1494	-----
55	23	2990	2590	2245	1945	-----	-----
60	14 & 45	3755	3260	2820	2450	-----	-----
65	14 & 47.5	4265	3695	3205	-----	-----	-----
70	15 & 50	4805	4170	3610	-----	-----	-----
	FULL LENGTH TREATED WESTERN RED CEDAR POLES						
30		-----	-----	645	540	440	370
35	16	1055	880	750	660	570	495
40	17.5	1320	1145	970	790	705	615
45	19.5	1585	1365	1145	1010	880	-----
50	21.5	1760	1585	1365	1230	1145	-----
55	23	2025	1760	1540	1410	-----	-----

8.3 The Digger Derrick's Load Chart shall be used to determine the lifting capabilities of the equipment based on boom angle, load radius and boom extension. The values listed in the

Load Charts for Liberty Utilities Digger Derricks are based on stability. These load charts vary from manufacturer to manufacturer and from model to model. It is important that the operator review's the load chart prior to lifting the load so that the Digger Derrick can be positioned to safely pick the load.



LOAD CAPACITIES (LB) FOR DIGGER DERRICK USE [1]

LOAD RADIUS (FT) [3]	FULLY RETRACTED [4]		INTERMEDIATE BOOM ONLY EXTENDED [4]		UPPER BOOM ONLY EXTENDED [4]		INTERMEDIATE & UPR BOOMS EXTENDED [4]	
	BOOM ANGLE	LOAD CAPACITY [2]	BOOM ANGLE	LOAD CAPACITY [2]	BOOM ANGLE	LOAD CAPACITY [2]	BOOM ANGLE	LOAD CAPACITY [2]
4.6	80°	16492	-	-	-	-	-	-
6	75°	12915	-	-	-	-	-	-
8	69°	10008	76°	9051	77°	9314	80°	8771
10	61°	8263	71°	7322	72°	7627	77°	7059
12	53°	7076	67°	6169	67°	6500	73°	5924
15	39°	5788	60°	5000	59°	5356	68°	4788
20	-	-	46°	3780	45°	4153	58°	3636
25	-	-	27°	2542	23°	3212	48°	2881
30	-	-	-	-	-	-	34°	1907
35	-	-	-	-	-	-	11°	1356
-	0°	3703	0°	1958	0°	2424	0°	1060

MAXIMUM HYDRAULIC SYSTEM PRESSURE SETTING 3000 PSI
ELECTRICAL CONTROLS OPERATING VOLTAGE 12 VDC
WINCH LINE RATED WORKING LOAD 8500 LB[5]
WINCH CAPACITY: LOW SPEED ________ LB HIGH SPEED 15,000 LB
ANSI A10.31 STABILITY TEST LOAD - 2890 LB[6]
AT 25° BOOM ANGLE AND FULL EXTENSION

UNLOADED VEHICLE WEIGHT 29150 LB[6]

Altec. MODEL: DM45 BC
Altec Industries, Inc.
2106 So. Riverside Road
St. Joseph, Mo. 64507 U.S.A.
Phone Number 816-364-2244
SERIAL NO: 0105DV0919

This unit complies with ANSI A10.31 as of mfg. date.

Values shown in Load Capacity Chart at left must be reduced by amount shown below for each option which is mounted on boom:

PLATFORM AT BOOM TIP.............................125 LB EACH
LINER...40 LB EACH
4' MATERIAL HANDLING JIB (ANY MODEL).... 120 LB
8' MATERIAL HANDLING JIB...................... 150 LB
8' PERSONNEL JIB WITH NO PLATFORM.........160 LB
8' PERSONNEL JIB WITH 1 PLATFORM..........350 LB
8' PERSONNEL JIB WITH 2 PLATFORMS........550 LB

CAUTION

Read and understand all operating and safety information in manual and on all placards before operating this unit. If you do not have manual, or if placards are missing/unreadable, please call 816-364-2244 for assistance.
See adjoining placard for notes 1 thru 6 which are referenced on this chart.

INCLUDED OPTIONS:
_____ LINER
_____ PLATFORM - (QTY) _____
_____ INSULATED DERRICK (46 KV AND UNDER)
_____ 4' MATERIAL HANDLING JIB
_____ 8' MATERIAL HANDLING JIB
_____ 8' PERSONNEL JIB
_____ NON-INSULATED DERRICK

970075109 A

8.4 For lifting, installing or removing wood poles, a properly sized wire rope sling or a chain sling are the only slings approved for use. Below are item IDs for stocked slings. Additional wire rope and chain slings can be ordered from an approved supplier (i.e 3/8" Grade 100 chain or a 5/8" wire rope slings bulletin #12-19).

Item ID # 8830-0811177
(5FT X 1/2IN)

Item ID #8830-0811175
(3/8IN. X 5FT)

Not Stocked
5/8" Chain Sling 4' or 5' Reach

8.5 Rigging shall utilize appropriately rated and the least number of shackles/components as possible (i.e. Crosby Hook, Shackle, etc).


Examples of Correct use of Rigging


Incorrect Uses

8.6 A pole shall be picked at slightly over center to maintain weight on pole butt and allow the pole to be erected to vertical position.

8.7 Where hazards to employees exist, tag lines or other suitable devices shall be used to control loads being handled by hoisting equipment. (1926.953(d)

8.8 Special attention shall be taken when erecting pole with winch as winch line can bundle up and cause the pole to slip or 'jump' down.

8.8.1 As you power up, make sure the rope winds evenly and tightly on the drum. This prevents the outer wraps from drawing into the inner wraps or stacking on one side thus binding and damaging the line, it also avoids shock loads.

8.8.2 Shock loads can momentarily far exceed the winch and rope ratings.

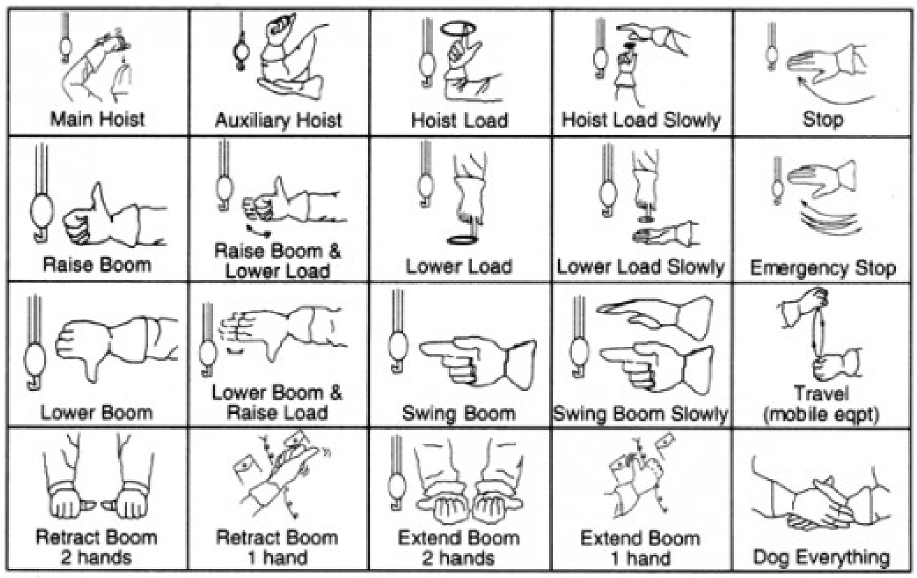
8.8.3 To fix an uneven stack, lower pole back to ground and reposition line in drum, then continue erecting pole.

8.8.4 Once pole is suspended in the vertical position and butt is off the ground, worker on ground will manipulate pole into pole guides on boom.

8.8.5 Once in the pole guides, the equipment operator has complete control of the pole.

8.8.6 Visual hand signals and voice commands by the worker on the ground is now utilized to guide the operator to set pole in the hole.

OSHA Hand Signals



8.8.7 Once pole is over hole, with butt slightly in, the operator will lower pole with winch line.

8.8.8 The brand marks are now located so that the bottom of the brand mark will be 6 feet above the standard ground line with a pole set of 10% plus 2 feet. (See Standards Bulletin # 12-01)

Length of Pole, ft	Ground Line Distance from Butt, ft	Bottom of Brand Mark from Butt, ft
30	5	11
35	5.5	11.5
40	6	12
45	6.5	12.5
50	7	13
55	7.5	13.5
60	8	14
65	8.5	14.5
70	9	15

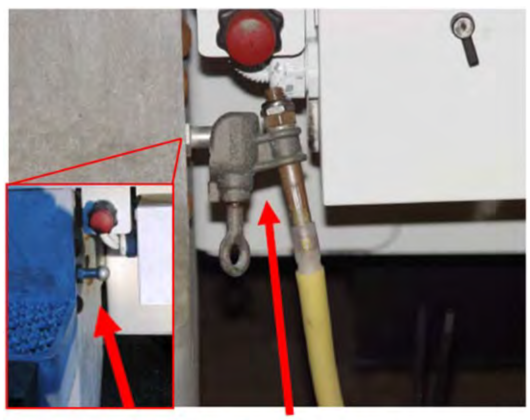
8.9 With butt sitting securely on bottom of hole, the operator with guidance from worker on ground will position pole to the plumb position.

8.10 After the pole is properly faced and lined in, the hole is backfilled and tamped.

9.0 Working around Energized Conductors

9.1 A Digger Derrick working near energized conductors **SHALL ALWAYS BE CONSIDERED ENERGIZED.**

9.2 The digger truck must be barricaded or grounded with an approved ground lead connection on the vehicle grounding stud before the boom is un-stowed or elevated and ground to the system neutral, a driven ground rod or an existing anchor rod in that order.



Ball Socket Ground Clamp

9.3 The operator of the digger derrick shall utilize the following methods to protect themselves in case of accidental contact with energized lines:

9.3.1 Operate controls from the truck platform of the digger derrick.

9.3.2 If controls are not being operated from the truck platform the operator shall wear Class 2 rubber gloves and EH rated overshoes.

9.3.3 Stand on an equi-potential mat bonded to the truck.

9.3.4 Avoid contact to equipment with unprotected portions of their body.

9.4 When setting, removing, or moving a pole near energized lines, employees shall use protective equipment to prevent electrical injury and the reclosure shall be put in the non-reclose (manual) position as conditions dictate.

9.5 When a qualified employee needs to operate mechanical equipment near energized lines or apparatus, the equipment shall be operated so that the minimum approach distances listed in the tables below are maintained from exposed energized lines/apparatus. This can be accomplished in most cases by repositioning the mechanical equipment or by displacement or relocation of the affected energized lines or apparatus. Insulated aerial equipment being used within its dielectric rating and operated by a qualified employee is exempt from this requirement.

MINIMUM WORKING APPROACH DISTANCES FOR VEHICULAR AND MECHANICAL EQUIPMENT

Voltage	OSHA Phase to Ground	General[1]
.05 – 1.0 kV	Avoid Contact	Avoid Contact
1.1 – 15.0 kV	2 feet 1 inch	10 feet
15.1 – 36.0 kV	2 feet 4 inches	10 feet
36.1 – 46.0 kV	2 feet 7 inches	10 feet
46.1 – 72.5 kV	3 feet	10 ft. to 10 ft. 8 in
72.6 – 121 kV	3 feet 2 inches	10 ft. 8 in to 12 ft. 4 in
138 – 145 kV	3 feet 7 inches	12 ft. 8 in to 13 feet
161 – 169 kV	4 feet	13 ft. 8 in to 14 feet
230 – 242 kV	5 feet 3 inches	15 feet to 16 feet
345 – 362 kV	8 feet 6 inches	24 ft. 8 in to 25 ft. 4 in
500 – 550 kV	11 feet 3 inches	37 ft. 8 in to 41 ft. 4 in
765 – 800 kV	14 feet 11 inches	59 ft. 8 in to 61 ft. 4 in

[1]General clearances are for unqualified equipment operators.
Up to 50 kV, the approach distance is 10 feet. Thereafter, add 4 inches of approach distance for every 10kV

9.6 Employees shall keep clear of equipment located within minimum approach distances of primary conductors.

9.7 Workers shall wear appropriate rated rubber gloves when setting, moving, or removing a pole near an exposed energized overhead conductor.

9.8 Workers shall hold pole away from their body whenever guiding pole.

9.9 The worker most at risk while setting a pole in a live circuit is the worker controlling the pole butt.

9.10 Pole Guards, Line Hose and other Barriers shall be utilized when working around energized conductors.

10.0 Clean up and disposal of Spoils

10.1 Excess soil shall be left a few inches above ground level to allow for settling around pole, remaining soils shall be removed.

10.2 All remains from old pole shall be returned to the platform and disposed of in wood recycling bins.

11.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
01/01/2014	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG001		
Electric Operating Procedure	**09-01-2013**	**Underground**	
Infrared Non-Contact Thermometer Inspection Requirement for Underground Equipment	**Revision #**	**1.0**	**Page: 1 of 5**

INTRODUCTION

This procedure establishes work practices for infrared, non-contact thermometer inspection of distribution voltage separable connectors in underground operations.

IR Guns (infrared, non-contact thermometers) can identify faulty or failing separable connectors if the connector is carrying electric current. The IR gun can detect heat generated by a poor, current carrying connection.

An infrared inspection of separable components is required before work begins in a manhole, vault, enclosure, padmounted transformer or subsurface transformer.

PURPOSE

The purpose of this Electrical Operating Procedure (EOP) is to provide information on the Liberty Utilities requirements for the use of the IR gun approved for use on Electric Distribution System.

ACCOUNTABILITY

This procedure applies to all personnel involved with the operation and maintenance of separable underground connectors including 200 amp loadbreak or dead break elbows, 600 amp modular T bodies and pre-molded H and Y connectors.

1. CQ&EM, Standards, Policies, and Codes
   A. Update procedures as necessary.
   B. Provide Electric Distribution Operations field support and training upon request.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.

3. Liberty Utilities Employees or Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.
   C. It is the workers responsibility to read and fully understand, and follow the vendor's instruction manual and specifications before using any test device.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

Liberty Utilities Construction Standards

Manufacturers Operating Instructions

National Grid Work Methods Bulletin # 06-21

DEFINITIONS

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Conductor: A material, usually in the form of a wire, cable, or bus bar suitable for carrying an electric current.

Enclosed space: A working space, such as a manhole or vault that has limited means of egress or entry, that is designed for periodic employee entry under normal operating conditions, and that under normal conditions does not contain a hazardous atmosphere, but that may contain a hazardous atmosphere under abnormal conditions.

Infrared Inspection: An inspection conducted to detect abnormal heating conditions associated with separable connectors. An infrared inspection is required before work begins in an enclosed space, enclosure, padmounted transformer or padmounted switchgear.

Manhole: A subsurface enclosure that personnel may enter used for the purpose of installing, operating, and maintaining submersible equipment and cable.

Separable insulated connector: A fully insulated and shielded system for terminating and electrically connecting an insulated power cable to electrical apparatus, other power cables, or both, so designed that the electrical connection can be readily established or broken by engaging **or** separating the connector at the operating interface.

Shall: The word shall is to be understood as mandatory.

Should: The word should is to be understood as advisory.

Vault: An enclosure, above or below ground, which personnel may enter and which is used for the purpose of installing, operating, or maintaining equipment, wiring or both.

TRAINING

Provided by appropriate Liberty Utilities Training Program

DOCUMENT CONTENTS

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1.0 SAFETY

All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any applicable Liberty Utilities EOP's utilizing all appropriate safe work methods.

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

The employee in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

Follow all manufacturers' instructions while using the infrared heat gun.

2.0 HAZARDS

1. The laser light used to aim this device can damage eyesight. Never point the unit at another person or yourself. Avoid direct exposure via reflective materials such as glass or mirrors.

2. Components not carrying current produce no heat. Defects will not be identified. A normal temperature reading does not guarantee the equipment is free of defects. Take all necessary precautions and use added safeguards as appropriate.

3. This unit is not insulated. Never touch energized equipment during the inspection.

3.0 PROCEDURE

1. Complete all entry requirements and a visual hazard inspection before beginning an infrared temperature inspection on the underground distribution equipment in the manhole, vault, enclosure or transformer.

2. Inspect each separable connector. Compare the connector temperature to the temperature of the cable on the same phase. Connectors with elevated temperature may indicate a connector defect.

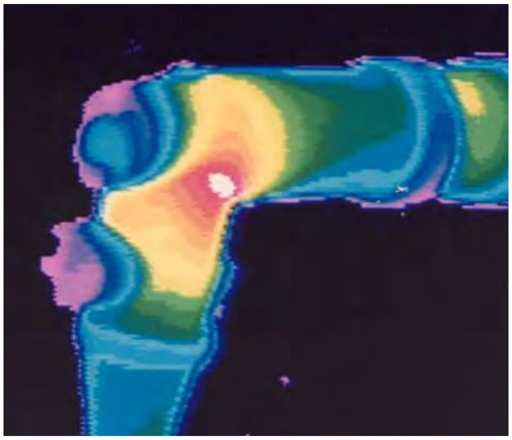
Manhole Application

Shoot connector and associated cable

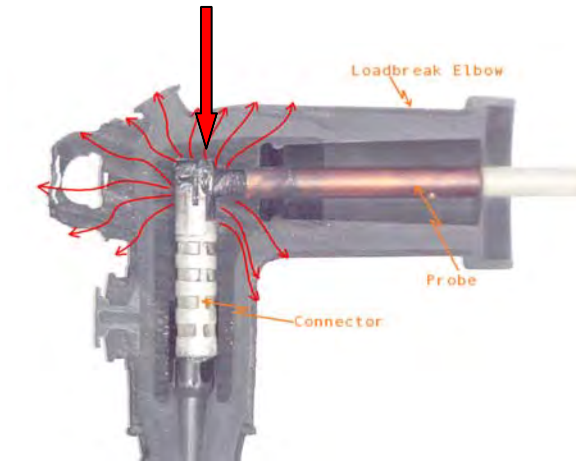
3. Use the following table to compare connector temperature rise to cable temperature.

Delta Temp ° F	Work Conditions
Less than 10 ° F	Normal, begin work, may operate elbows
11 to 20 ° F	Do not operate elbows. Schedule component repairs and use added safeguards as appropriate
More than 20 ° F	Schedule immediate repairs as soon as possible. Stability and reliability concern.

Liberty Utilities	Doc. # LU-EOP UG001		
Electric Operating Procedure	09-01-2013	Underground	
Infrared Non-Contact Thermometer Inspection Requirement for Underground Equipment	Revision #	1.0	Page: 5 of 5



Defective 200 amp Elbow IR scan



Elbow cutaway showing defect

Actual temperature read out screen

4.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG002		
Electric Operating Procedure	**12-01-2014**	**Underground**	
Underground Cable Installation and Removal for Manhole and Duct Systems	**Revision #**	**1.0**	**Page: 1 of 10**

INTRODUCTION

The purpose of this procedure is to establish the proper work methods for installing and removing power cables between manholes, vaults, heavy duty handholes (splice boxes) and risers in a traditional manhole and duct system. This guide is intended to outline industry accepted practices and techniques considered the safest and most practical ways to do installations and removals without damaging the cable.

PURPOSE

The purpose of this procedure is to establish consistent work practices across all regions to safely and efficiently perform the installation and removal of power cable within traditional duct and manhole systems.

This procedure applies to all personnel involved with the installation or removal of primary or secondary cable in traditional manhole and duct systems. This procedure must be followed prior to and during any cable installation or removal operation.

ACCOUNTABILITY

1. Standards, Policies and Codes
   A. Update procedure as necessary.
   B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements.
2. Electric Distribution Operations
   A. Ensure the components of the procedure are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide revision input as necessary.
3. Liberty Utilities Employees or Contractors
   A. Demonstrate an understanding of the procedures in this EOP.
   B. Comply with the requirements of this procedure.
4. Learning & Development
   A. Provide appropriate training on procedures in this EOP.

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

Liberty Utilities Underground Construction Standards – Section 35

Manufacturers Operating Instructions

LU-EOP G026, UG011, UG013

Liberty Utilities Safety Enclosed Space Procedure

DEFINITIONS

Leader: The person in charge of the job site and operation (crew chief, lead splicer, etc.) The Leader's responsibilities include but are not limited to:

Pre-job safety and assignment brief
Job site safety for crew members
Public safety near the work area
Equipment requirements
Positioning of equipment
Assignment of tasks
Communication needs and responsibilities between crew members
Returning the equipment in a safe and clean condition
Adherence to Liberty Utilities policies

Feed Manhole: The name given the manhole from which cable is installed (fed) during pulling operations.

Pulling Manhole: The name given the manhole into which the cable is pulled during installation operations, and out of which the cable is pulled during removal operations.

Light duty handhole: 17x30 inch cover, polymer concrete, with fiberglass flared sidewalls, used for secondary services (600 volts and below) for buildings or street lighting.

Heavy duty rectangular handhole: 26 inch cover, where the ultimate use of the handhole, including the number, size, voltage and type of cables/conductors to be installed, meets the following criteria:

1. Use of single conductor cables.
2. Secondary mains and services requiring immediate locations in the cable run, or additional space in the handhole, for cable pulling, due to duct length, or, for service laterals.
3. Primary services (13.8 kV maximum) from either an underground or overhead system requiring additional locations in the cable run for cable pulling due to duct length.

Vault: An enclosure, above or below ground, which personnel may enter and which is used for the purpose of installing, operating, or maintaining equipment, wiring or both.

TRAINING

Provided by appropriate Liberty Utilities training program.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with all Liberty Utilities Safety Procedures, Liberty Utilities Employee Safety Handbook and Liberty Utilities Electric Operating Procedures utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear, non entry rescue equipment and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 The employee in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, atmospheric testing and ventilation and personal protective equipment requirements.

1.4 During work, barriers or other appropriate protection shall be installed to protect adjacent conductors.

1.5 All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Refer to the tool catalog for a listing of approved equipment.

1.6 Prior to pulling operations all tools and equipment shall be inspected for defects. Any defective equipment shall be removed from service and repaired/replaced before pulling operations begin.

1.7 Prior to pulling operations, check any cable for moisture and possible damage. Do not install any cable which has been damaged or contains moisture that can not be eliminated. Before installing any baskets or cages, assure that the ends of the cable are sealed in order to prevent water migration into the conductor.

2.0 GENERAL JOB SITE SETUP

2.1 Job Brief: Before each job begins for a crew of two or more, and whenever working conditions change, a documented job brief shall be conducted by the leader, person in charge of the work, or the supervisor to review hazards, precautions, procedures, energy sources/control, and personal protective equipment requirements. All crew members are required to sign or initial the documented job brief.

2.2 Communication: The means of communication between the workers shall be two way radios, cell phone, voice, or agreed upon hand signals. During the pre-job brief the leader and crew members will agree on the appropriate communication method to be used. When the line of sight between manholes is impaired, radio communication or use of another similar device is required (ex. Cellular phone).

2.3 Pulling equipment: Only equipment designated for installing or removing cable - cable handling trailer or truck, cable trailer, winch, capstan hoist, or other company-accepted equipment - shall be used.

2.4 Pulling equipment will be arranged so that the pull into/out of the duct will be as straight as possible. Where a straight alignment of equipment is not possible, the angle of the pull is to be kept at a minimum to reduce equipment strain and cable damage. Please refer to the Underground Standards Book sections for Cable Installation (35.10), Bending Radius (35.10.10), Duct Sizing / Jam Ratio (35.10.20) and Pulling Tension (35.10.30) for further information.

2.5 Pulling Operations: In order to prevent injury in the event of a breakage of the winch rope or pulling equipment, all personnel shall maintain a safe and reasonable distance from the winch rope during pulling operations. No person shall be in the pulling manhole or vault when cable is being pulled in or out using rigging methods. Rigging includes, but is not limited to, the use of pulleys, pulling eyes, jamb skids, saint louis, blocks, sheaves or rollers. (Employee Safety Handbook 4.4.3)

2.6 Non-Entry Rescue: Entrants working in manholes shall employ the non-entry rescue procedures developed by the Company. Entrants shall wear an approved full body harness and shall be connected to the rescue device unless the leader or supervisory verbal waiver is obtained. If the leader or supervisor decides that tethering the employees in the manhole will introduce a greater hazard, the verbal waiver shall be issued and the pole rescue method of non-entry rescue shall be utilized. Authorization through the verbal waiver to work un-tethered shall be documented on the job brief form.

2.7 Vehicles: A vehicle in gear (cable truck, splicing van, bucket truck or pickup truck) is **not** an accepted method of installing or removing cable. Only equipment rated for cable installation or removal (bed winches, cable trailers, capstans, etc.) shall be used to install or remove cable.

3.0 RIGGING

3.1 If rigging is utilized the following is the preferred rigging hierarchy:

3.1.1 Pulling eyes that are determined to be part of the original manhole construction and are inspected to ensure they are in good condition prior to pulling operations.

3.1.2 Jamb skids with Quadrant Block.

3.1.3 Duct eyes.

3.1.4 Four bolt temporary anchor, anything less is unacceptable.

3.2 When using methods listed above added safeguards such as barriers and/or blast blankets should be considered to protect adjacent cable and equipment.

NOTE: If rigging is utilized no personnel shall be allowed to remain in the pulling manhole during cable installation and removal operations.

4.0 CABLE REMOVAL

Preparation for Cable Removal:

4.1 In both the feed and pulling manholes, fireproofing, bonds, fairleaders and splices shall be removed.

4.2 When existing de-energized cables that end in a manhole, vault or heavy duty handhole need to be shortened to facilitate the removal of cable, an identification tool shall be used. Identification tools such as a high visibility plastic ring that can be slid down the cable as cuts are made can be found in the Liberty Utilities tool catalog. Cutting shall start at the cut end and follow in short sections towards the duct end, leaving enough cable to install a rated chain, nylon sling, or other approved equipment around the cable to be removed. LU-EOP UG013 shall be followed during initial identification of the cable end that needs to be shortened. If at any time the cable being shortened cannot be followed with the identification tool (ex. plastic ring), all cuts shall be made remotely using an approved guillotine cutter from outside the manhole, vault or heavy duty handhole until the plastic ring can be utilized.

4.3 In the feed manhole attach rope to cable to be removed for future duct availability.

4.4 Cable will be removed one section at a time.

4.5 Additional safeguards or barriers shall be installed to protect adjacent equipment if necessary.

4.6 Strain should be gradually applied on the winch rope in steps until cable to be removed begins to move.

4.7 Once the cable has been determined to been broken free from the duct, there are two methods that can be used for cable removal: coil cable on a reel using power reel cable trailer, or cut removed cable into lengths for disposal.

4.8 Pick up all tools and equipment from work area, return and properly secure all materials on vehicles before leaving job-site.

5.0 DUCT PREPARATION FOR CABLE INSTALLATION

5.1 Inspect the duct mouths for sharp edges that may damage the new cable.

5.2 Dirt and debris affect the new cable installation process. Prove the duct with fiberglass duct rods, brushes and/or mandrels. A rigid type mandrel (cleaning, boring or testing) is sized to have a mandrel diameter 1/4 to 1/2 inch (6 to 13mm) less than the diameter of the duct to be mandrelled.

5.3 When fiberglass duct rods/snakes are used, they shall be installed in a direction to minimize hazard to the crew members and to prevent equipment damage. A crew member shall be positioned at the receiving end when rodding ducts to safeguard against accidental equipment damage. Any live equipment that could be contacted by the rodding device shall be protected by barriers or additional safeguards, such as wood blocks or arc blankets.

6.0 CABLE INSTALLATION

6.1 The leader, or in some situations due to the complexity of the pull, Underground Engineering will decide which manhole is to be the pulling manhole and which is to be the feed manhole. The following are some guidelines that should be considered when making this choice:

6.1.1 Pulling cable from the manhole that is farthest from any offsets or bends.

6.1.2 Feeding into a riser.

6.1.3 Pulling from the least congested manhole.

6.1.4 A downhill pull is preferred.

6.2 At the feed manhole the use of a cable trailer, reel handling truck/trailer or other company-accepted equipment is required. Only equipment designated for cable pulling may be used.

6.3 At the pulling manhole a winch equipped vehicle, capstan, power reel trailer/truck, or a self-powered winch (tugger) is required. Only equipment designated for cable pulling may be used.

6.4 In the feed manhole personnel may guide and lubricate the cable during the feeding operation. Use of feed tubes (commonly known as a “pea-shooter” or an “elephant trunk”) should be considered in most pulling operations.

6.5 The feed reel will be positioned as close to the feed manhole opening as possible and in line with the pull. The feed trailer will be secured with jacks and chocks as required. Match the pay-out speed to the pulling speed to minimize pulling tension.

6.6 Generously lubricate the cable as it enters the duct or feed tube. Cable lubrication reduces cable friction up to 70 percent.

6.7 Avoid any jerking motions in the pulling process. Jerking motions can cause equipment damage and cable stress.

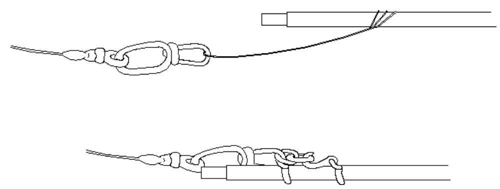
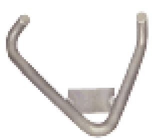
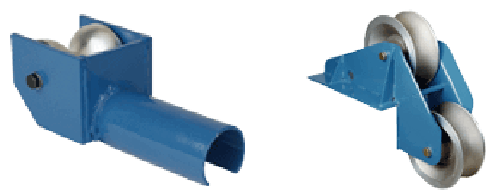
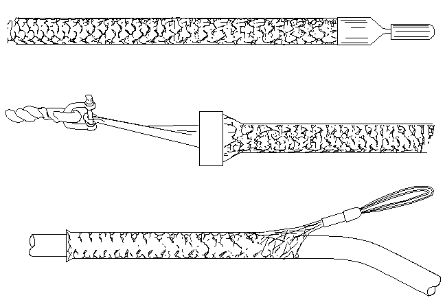
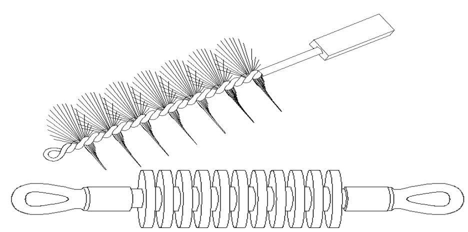
6.8 Pull the cable until it emerges from the duct in the pulling manhole. A sufficient amount of cable should be pulled into the manhole for proper racking and splicing standards. The use of slack baskets to pull in additional cable for splicing may be utilized.

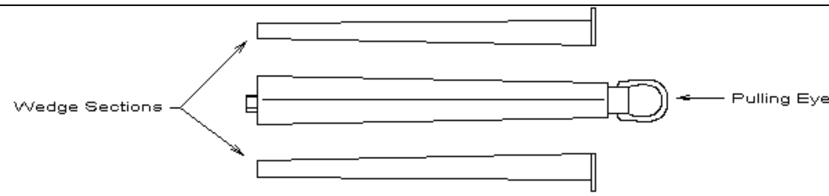
6.9 At the feed manhole, cut the cable. Be sure to leave a sufficient amount for proper racking and splicing standards.

6.10 Seal both ends of the cable and rack as high as possible. Wipe off any lubricant and/or dirt on the new cable.

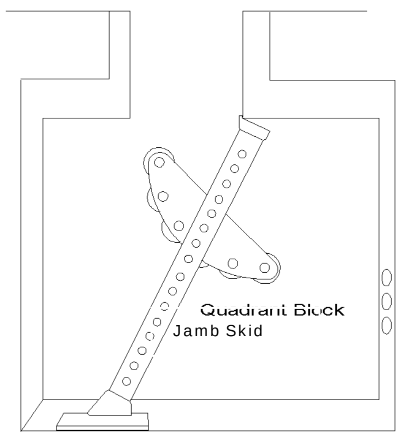
6.11 Pick up all tools and equipment from the work area, return and properly secure all materials on vehicles before leaving job-site.

7.0 CABLE PULLING/RIGGING EQUIPMENT

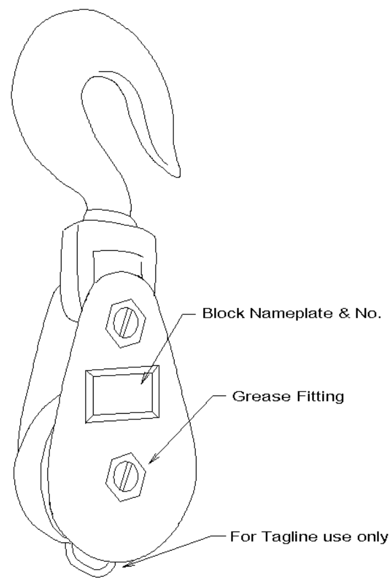
 Duct Rod/Snake	 Lubricants
 Shackles/Steel Chains	 Nylon Slings/Chain
 Manhole Pulling Eyes	 Duct Bells/Cable Guides
 Pulling Baskets/Grips	 Duct Brushes/Mandrels



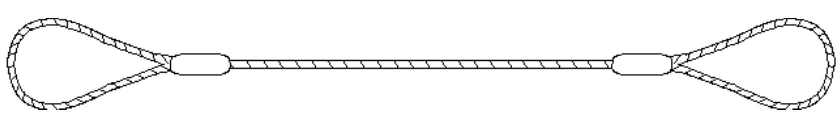
Duct Eye/St. Louis



Jamb Skid with Quadrant Block



Steel Block



Steel Sling

 Fairleaders	 Swivels
 Steel Shoes	 Feed Tubes

Exception approvals:
It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager\Superintendent of their respective department, the Manager of Work Methods - Standards, Policies and Codes and a Manager EHSS or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

8.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
12/01/2014	1.0	Initial Version of document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG004		
Electric Operating Procedure	04-01-2015	Underground	
Distribution Cable Dielectric Testing	Revision #	1.0	Page: 1 of 10

INTRODUCTION

Equipment and recommended procedures for testing distribution cables have undergone significant changes during the past decade. This is particularly the case for extruded dielectric (XLPE and EPR insulated) cables. Research and utility experience have shown that the DC Hypot testing can damage service aged extruded dielectric cables. This damage, in turn, results in subsequent failures that would not otherwise have occurred. This finding, in combination with the development of new types of cable test equipment, has led to changes in requirements for testing distribution cables.

PURPOSE

This procedure is intended to describe the current practice for performing field tests on all types of shielded distribution cables that are now in use by Liberty Utilities. This procedure applies to the testing of all shielded distribution cables, rated from 1kV up to and including 46kV. All types of cable insulation materials are included.

Previously, testing of aged extruded insulated cables has been restricted, especially for 1970's vintage XLPE. This restriction was due to the damage that DC testing could inflict on these types of cables if they were developing water trees. Use of DC for diagnostic testing on these cables is still restricted; see Tables 5 & 6 below. The new technology AC test sets (VLF) do not inflict this type of damage on extruded insulations. Diagnostic testing may be performed on these cables without damage, especially if alternative test methods or voltages are used. See Alternative Test Methods below or contact Distribution Engineering Services for assistance and guidance.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate guidance to field personnel when requested for a specific work related task.

2. Electric Distribution Operations
   - A. Ensure that the procedures in this EOP are implemented.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   - A. Demonstrate an understanding of the procedures in this EOP.
   - B. Comply with the requirements of the procedures in this EOP.
   - C. It is the workers responsibility to read and fully understand and follow the manufacturer's instruction manual and specifications before operating any equipment.

COORDINATION

Not applicable.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
OSHA 1910.269
IEEE Standard 400 - "Guide for Field Testing of Shielded Power cable Systems Using Very Low Frequency (VLF)"
Von Corporation Arc Reflection System

DEFINITIONS

Acceptance Testing: A field test made after cable system installation, including terminations and joints, but before the cable system is placed in normal service. All components must be new, never energized at system voltages. This test is intended to detect installation damage and to show any defects or errors in installation of other system components.

Diagnostic Test: A testing procedure used during the operating life of a cable system. It is intended to determine and locate degradation that may cause cable and accessory failure. Cables are de-energized specifically to allow this testing procedure to be done. The test is conducted for 60 minutes and is sometimes called a Maintenance Test or Withstand Test.

DC Hypot: A testing method utilizing DC voltage.

Far End: The opposite end of a cable segment from the Test End.

Grounded: Intentionally connected to earth through a ground connection.

Installation Test: A testing procedure conducted after cable installation, but before jointing (splicing) or terminating. This is not a routine test, but rather a test performed if indications are such that the cable may have suffered damage from shipping, storage or pulling into ducts. This test is conducted for 60 minutes.

Pick Up Test: A testing procedure applied to a cable circuit which has been repaired or modified. This test is intended to locate gross problems which will most likely cause immediate failure of the circuit. This test is conducted for 5 minutes.

Shall: The word shall is to be understood as mandatory.

Should: The word should is to be understood as advisory.

Tan Delta Test: A Diagnostic Test Method performed with the VLF test set, similar to a Doble Power Factor test. This test is conducted for 60 minutes.

Test End: The end of a cable segment where the test equipment is connected.

Very Low Frequency (VLF): A testing method utilizing low frequency AC voltage. Test frequencies of 0.01 to 0.1 Hertz are available. Liberty Utilities utilizes 0.1 Hertz. The capability of the VLF test set is limited by the test voltage and the capacitance of the cable, which changes with cable length.

Voltage Testing: Testing when applied voltages result in voltages greater than 50 volts. This includes but not limited to Fault Finder, Power Factor, Insulation Resistance measurements, TTR, Hi-Pot, or System Voltages, etc. Appropriate minimum approach distances shall be maintained within the area under test.

TRAINING

A written request should be submitted to Learning and Development by user group whenever training is required.

DOCUMENT CONTENTS

Table of Contents

1.0 SAFETY

All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any applicable Liberty Utilities EOP's utilizing all appropriate safe work methods.

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

The employee in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

2.0 PREPARATION TO TEST

Switching, Tagging, Grounding & Preparation to Test:

Before starting any cable testing activities, cable circuits must be properly switched out, tagged and grounded according to applicable Liberty Utilities rules. Refer to the Liberty Utilities Employee Safety Handbook and LU - EOP G014, "Clearance and Control".

After the circuit is switched out, tagged and grounding is complete, prepare all cable terminals for testing. This includes the removal of taps to lightning arresters, cleaning the terminations, checking the integrity of the shield ground bonds at all terminations and removal of taps to OH systems or devices. Removal of the taps is not mandatory, but the best test results will be obtained if taps are removed. If taps are not removed, the test results will have to be interpreted accordingly. The test will record the leakage of the insulating devices on the taps. Thorough cleaning of the insulating devices which are connected to the tap will reduce the negative effect of such devices on the test results. Once all preparation work is complete on both ends of the cable(s) to be tested, all grounds on the far end (away from the end where the test equipment is to be connected) may be removed.

3.0 TESTING

Connect the test equipment on the first phase to be tested, then remove the ground on that phase. Always use appropriate procedure to remove grounds. The other phases of the circuit, which are not being tested, should remain grounded at the test end.

Once the test is complete on the first phase, turn off the test equipment, operate the ground switch which is integral with the test equipment (if so equipped) and then re-install the ground on that phase, using appropriate procedures. Switch the test lead to the next phase and repeat the process for each of the other phases as needed.

NOTE: If using DC testing, do not operate the grounding switch in the test equipment, or install a ground on the termination, until the residual voltage on the cable is less than 40% of the highest test voltage that had been applied. Grounds SHALL remain on the cable for a minimum of 4 times the test time. (IE: If the test voltage was applied for 15 minutes, the grounds shall remain on the cable for 60 minutes.) The cables shall be grounded continuously for this length of time to allow the trapped charges – which are typical of DC testing – to be reduced as far as possible.

VLF Test Capability:

The capabilities of the VLF test sets are limited by the test voltage and cable capacitance. Cable capacitance changes with length of the cable, limiting the length of cable that can be tested at one time. The test set calculates the capacitance of the cable to be tested before beginning the test. If the capacitance is too high, the test set will not perform the test. Refer to Table 1 below for approximate cable lengths which can be tested. These lengths are calculated using an average cable capacitance of 100pF/ft.

Table 1

Voltage Class KV	Maximum Test Voltage KV	Approximate Cable Length FT
5	10	150,000
15	20	60,000
25	31	35,000
35	44	25,000
46	57	10,000

Determination to Test:

The determination as to when to test cable is left up to the operating divisions. Recommendations from Distribution Engineering Services are listed below. If a decision is made to conduct testing, choose the appropriate Test Procedure, Test Method, Test Voltage and Test Times from the Tables below.

Step I: Test Procedure Selection:

The Test Procedure is based upon the Type of System, as listed in Table 2. Cable systems are broken up into 2 types, Conventional UG and URD. Conventional systems are characterized by being installed in ducts and manholes and / or cables larger than #2. These are prevalent in dense load areas (cities) and industrial complexes. URD (Underground Residential Distribution) systems have mostly single phase transformers and serve residences. Some of these systems are direct buried and some are in ducts with handholes and pull boxes.

Refer to Table 2 to select the test procedure:

Table 2

Type of System	Acceptance Testing	Installation Testing	Diagnostic Testing	Pick Up Testing
Conventional UG	Recommended[1]	Optional[2]	Optional	Recommended[3]
URD	Optional	None Required	Optional	Optional

Footnotes for Table 2:

1. Required for feeder get away and main line cables.
2. To be considered only if the condition of the ducts, or the difficulty of pulling indicate possible compromise of cable integrity.
3. Unless weather conditions prohibit testing.

Step II: Test Method Selection:

The Test Method is selected based upon:

1. Type of insulation on the cables
2. Has any portion of the cable segment been electrically energized?

The DC Hypot Test Method shall never be used on cables which have been electrically energized (except cables which are 100% PILC), unless no other Test Method is available. If the DC Hypot test method must be used on electrically aged cables, use only the Pick Up Test Procedure.

Refer to Tables 3, 4, 5 & 6 to select the test method:

Table 3

Acceptance Testing	VLF	DC Hypot	5KV Meggar
100% XLP	Yes	Yes	Yes
100% EPR	Yes	Yes	Yes
100% PILC	Yes	Yes	Yes

Table 4

Installation Testing	VLF	DC Hypot	5KV Meggar
XLP	Yes	Yes	Yes
EPR	Yes	Yes	Yes
PILC	Yes	Yes	Yes

Table 5

Diagnostic Testing	VLF	DC Hypot	5KV Meggar
100% XLP	Yes	No	Yes
100% EPR	Yes	No	Yes
100% PILC	Yes	Yes	Yes
Mixed – Any Type	Yes	No	Yes

Table 6

Pick Up Testing	VLF	DC Hypot	5KV Meggar
100% XLP	Yes	No[1]	Yes
100% EPR	Yes	No[1]	Yes
100% PILC	Yes	Yes	Yes
Mixed – Any Type	Yes	No[1]	Yes

Footnotes for Table 6:

1. May be used only if a VLF test set is not available

Step III: Determine Test Voltage:

The Test Voltage to be used is determined by three factors:

1. The insulation rating of the cable segment to be tested
2. The type of test procedure to be used
3. The test method used

Be sure not to exceed the lowest cable insulation rating in the segment being tested. When performing an Acceptance Test, always determine the test voltage based on the insulation rating of the cable, not the system voltage on which the cable will be operated. All test voltages are phase to ground.

For Diagnostic and Pick up Testing, the actual test voltage shall be determined by operating conditions/ requirements. The maximum voltage shall never be exceeded. However, if desired, the test voltage can be lowered depending on the actual electric system which the cable is connected to. A cable which passes a test conducted with the maximum voltage can be expected to operate without further issue for a minimum of 2 years. A cable which passes a test with the reduced voltages will be expected to be energized successfully; however the long term reliability will be unknown.

Refer to Tables 7 through 9 to select the test voltage:

Acceptance Test:

Table 7

Cable Voltage Class KV	VLF KV AC rms	DC Hypot KV DC
5	10	28
15	20	56
25	31	80
35	44	100
46	63	132

Installation Test:

Table 8

Cable Voltage Class KV	VLF KV AC rms	DC Hypot KV DC
5	9	28
15	18	56
25	27	80
35	39	100
46	54	132

Diagnostic & Pick Up Test – Minimum Test Voltages:

The minimum test voltage is determined depending on the voltage which is expected to be impressed on the cable during operation. This takes into account higher than normal energizing voltage due to switching surges, lightning storms, faults on the system, etc. Different calculations are performed depending on whether the system is solidly grounded or ungrounded / ineffectively grounded.

1. Solidly grounded systems:
   a. The minimum test voltage shall be 125% of the normal phase to ground voltage of the system. For example on a 13.8/7.97kV Wye system, the minimum test voltage would be 1.25 X 7970V = 9962.5V. Round this up to a test voltage of 10kV.
2. Ineffectively grounded systems:
   a. These systems include true delta, delta with high impedance grounding bank, resistance / reactance grounded Y and single point grounded Y. The minimum test voltage shall be 100% of the phase to phase voltage. This voltage is used since a phase shift does occur in these systems during a phase to ground fault. Depending on the fault & fault duration, this shift can result in as much as phase to phase voltage being impressed on the cable insulation of the unfaulted phases.

Table 9

Operating Voltage KV	Minimum Test Voltage KV AC rms
4.16 / 2.4 Grd Y	3
11.5 Delta or Uni Grounded	12
12.47 / 7.2 Grd Y	9
13.2 / 7.62 Grd Y	10
13.8 / 7.97 Grd Y	10
13.8 Delta or Uni Grounded	14
23.0 Delta	23
34.5 / 19.9 Grd Y	25
34.5 Delta or Uni Grounded	35
46 Delta or Uni Grounded	46

Diagnostic & Pick Up Test – Maximum Test Voltages

Table 10

Voltage Class KV	VLF KV AC rms	DC Hypot KV DC
5	7	3.5
15	16	11
25	23	19
35	33	28
46	45	37

Step IV: Determine Test Duration:

The test duration is determined by:

1. The Test Procedure
2. Test Method.

Refer to Table 10 for Test Duration. All times are in minutes.

Table 11

Test Type	VLF	DC Hypot	5KV Meggar
Acceptance Test	60	15	1
Installation Test	60	15	1
Diagnostic Test	60	15	1
Pick Up Test	5	5	1

Alternative Testing Programs:
There are many variations in cable systems, age & types of cable, need for testing, need for data to evaluate the reliability of a cable system. With all these differences, there may be a need to design a specific test program for a given situation. The VLF with Tan Delta test is very flexible and a test can be designed for a cable that will not exceed the system operating voltage, yet some information on the integrity of the cable can be gathered.

If a unique cable test program is needed, consult Engineering with the specifics of the situation. A testing sequence will be designed around the situation.

Results:
Contact Engineering if assistance is needed for interpretation of cable test results.

Test Equipment:
Approved / existing VLF test equipment is supplied HV Diagnostics.
Existing DC Hypot equipment is manufactured by various companies. No new DC Hypot test equipment shall be purchased at Liberty Utilities.

Contact UG Engineering Standards if new cable test equipment is needed.

4.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
04/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG006		
Electric Operating Procedure	**09-01-2013**	**Underground**	
Underground Inspection and Maintenance	**Revision #**	**0**	**Page: 1 of 7**

1.0 PURPOSE

The purpose of this document is to outline the requirements for inspection and maintenance activities, to electric operations personnel, associated with Liberty Utilities Underground Distribution facilities. Also, to furnish information and guidance to Liberty Utilities employees in establishing or sustaining a continuing program of effective, ongoing Underground Distribution facilities inspection and maintenance. This program is designed to both provide for a safe and sustainable distribution system and improve system reliability.

2.0 SCOPE

This program applies to all personnel involved with or responsible for the inspection and repair of Underground (UG) Distribution Lines facilities, Underground Residential developments (URDs), and Underground Commercial Developments (UCDs). It will outline inspection and maintenance activities for underground distribution lines assets, inspection cycles, and data collection. Procedures will be included detailing an inspection priority system that will identify and provide for timely condition-based replacement of any visibly damaged or deteriorated asset prior to the next inspection cycle.

3.0 DEFINITIONS

Desktop Computer: A personal computer that is connected to the Liberty Utilities network that is used to download the Hand Held Computer and retrieve the information in the form of reports.

Distribution Inspector: An employee or contractor that has been trained to identify deficiencies or non-standard construction conditions on Liberty Utilities facilities.

Elevated Equipment Voltage Test: An A.C. rms voltage difference between utility equipment and the earth, or to nearby grounded facilities that exceeds the highest perceptible voltage levels for humans.

Hand Held Computer: A *Windows*® based data recording device that is used in the field to create a record of conditions found.

Hand-Hole: An enclosure identified for use in underground systems, provided with an open or closed bottom, and sized to allow personnel to reach into, but not enter, for the purpose of installing, operating, or maintaining equipment or wiring or both.

Infrared Inspection: An inspection conducted to detect abnormal heating conditions associated with separable connectors. An infrared inspection is required before work begins in an enclosed space, enclosure, padmounted transformer or padmounted switchgear.

Manhole: An enclosure identified for use in underground systems, provided with an open or closed bottom, and sized to allow personnel to enter, for the purpose of installing, operating, or maintaining equipment or wiring or both.

NESC: National Electric Safety Code

Patrol: A walking/vehicle assessment of Liberty Utilities distribution facilities for the purpose of determining the condition of the facility and its associated components.

Secondary Splice Box: An enclosure identified for use in underground systems. A secondary splice box may be required where the customer's number of secondary cables exceeds the maximum allowed amount on the transformer.

Service Box: See Hand-hole

Submersible Equipment: Electric equipment such as transformers and switches that, are generally located within a Hand-hole, Manhole, or Vault.

URD: Underground Residential Distribution

UCD: Underground Commercial Distribution

Underground Distribution Facilities: Manholes, vaults, hand-holes and service boxes, padmounted equipment and the components and equipment contained in these structures. (See GENERAL INFORMATION).

User: An individual who the program administrator has authorized to use the inspection reporting program.

Vault: An enclosure, above or below ground, which personnel may enter and which is used for the purpose of installing, operating, or maintaining equipment or wiring or both.

4.0 REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
NESC Section 31 Part 313 A
LU-EOP D004 Distribution Line Patrol and Maintenance
LU-EOP UG001 Infrared Non-Contact Thermometer Inspection Requirement for Underground Equipment
LU-EOP G016 Equipment Elevated Voltage Testing

5.0 RESPONSIBILITY

Roles and Responsibilities are outlined in the "Procedure" section of this document

6.0 PROCEDURE

6.1 General

The Underground Distribution Maintenance Program was designed to provide for a patrol and subsequent maintenance of each underground distribution facility once every five (5) years. The patrols are conducted by a Distribution Inspector identifying all required maintenance on a Windows® based hand held computer. The maintenance items identified through this patrol are separated into four priority levels 1, 2, 3, and 4. The problem codes identified default to the appropriate priority level. The default priority level can be adjusted by the individual performing the inspection based on actual field conditions.

These priority levels are defined as follows:

Level 1- An identified facility/component or tree condition that must be repaired/replaced within 1 week.

Level 2 - Identified facility/component condition that must be repaired/replaced within 1 year.

Level 3 – Identified facility/component condition that must be repaired/replaced within 3 years.

Level 4 – This priority category is to collect inventory information on actual field conditions to be used by Electric Planning Engineering.

All Level 1 priority conditions identified in the field shall be called in by the Distribution Inspector as follows:

- Notification:
  Liberty Utilities (New Hampshire) Emergency Dispatch and Scheduling Center - 1-603-216-3620
- Detailed information to be provided to NH Emergency Dispatch
  - Identify yourself as individual performing Distribution feeder inspections for Liberty Utilities and your work reporting area.
  - Details of the *Level 1* Priority condition:
    - Problem found
    - Town, Street, Feeder No., and Pad, Handhole, or Pole No.
    - Street address and any additional information that would assist in finding the location of the problem.
    - If you are standing by or have secured the location.
- Notification to area Electric Operations Supervisor or Electric Operations Manager.

6.2 Distribution Patrol

6.2.1 Inspection of designated underground equipment will be scheduled in such a manner that each designated Underground Facility will be examined once every five years. These patrols shall be completed by March 31h of the fiscal year. One-fifth of all metallic handholes, padmount transformers and switchgear shall be inspected annually. The metallic handhole covers shall be opened for a visual inspection. An external visual inspection shall be completed on the padmount transformers and switchgear. Additionally all separable components in the metallic handholes are to be inspected by infrared. Refer to LU-EOP UG001 - Infrared Non-Contact Thermometer Inspection Requirement for Underground Equipment for infrared procedure. A "Level 1 Priority" shall be assigned to a temperature gradient greater than 20º, although it is recognized that consideration must be taken as to whether a customer outage will occur at this time and the negative impact the outage could have on the customer. This may require scheduling an outage with the customer within one week to satisfy this requirement. A "Level 2 Priority" shall be assigned to a temperature gradient between 10º and 20º. A "Level 3 Priority" shall be assigned to a temperature gradient less than 10º. Also, an elevated equipment voltage test shall be completed at each location, refer to LU-EOP-G016 - Equipment Elevated Voltage Testing.

6.2.2 A working inspection on underground facilities is required for all manholes, vaults, handholes, splice boxes, junction boxes, padmount transformers, switchgear and submersible equipment, each time a crew performs work at one of these facilities. The format for data collected shall follow this EOP. All separable components in these facilities are to be inspected by infrared. Additionally an elevated equipment voltage test shall be completed at each location, refer to LU-EOP-G016 - Equipment Elevated Voltage Testing.

6.2.3 The Electric Operations group is responsible to create the patrol schedule for their area for the designated underground facilities. The Distribution Inspector uses a hand held computer to record district, employee ID, feeder number, structure ID number, GPS location, line number, comments and maintenance problem codes. The Distribution Inspector, while patrolling or crew while inspecting, shall also complete the following maintenance codes if found deficient upon inspection, 602 – Handhole missing nomenclature, 617 – manhole missing nomenclature, 639 - network transformer- missing nomenclature, 660 – switchgear missing nomenclature, 681 – transformer missing nomenclature, and 707 – vaults improper nomenclature. The Distribution Inspector will input the code into the Windows® based handheld as required, as well as completing the work unit in the handheld upon field completion while at the site. If the Inspector finds unmapped facilities from the information supplied from GIS, refer to LU-EOP G011, Preparation and Distribution of Electric Facilities Records, for required procedure for corrections. Crews performing working inspections are to follow the same protocol for inspections by using either a handheld data entry unit or paper inspection logs requiring data entry by the inspector, clerk, or supervisor or their designee.

6.3 Equipment to be Inspected and Maintenance Codes

This EOP requires the visual inspection of the following facilities as designated above for New Hampshire which require opening, and may require pumping on some items to assure a proper inspection:

- Manholes
- Vaults
- Handholes – non-fiberglass
- Splice boxes – non-fiberglass
- Junction boxes – non-fiberglass
- Pad mount transformers
- Pad mount switchgears
- Submersible equipment
- Handholes – fiberglass do not require opening
- Splice boxes – fiberglass do not require opening
- Junction boxes – fiberglass do not require opening
- Street Light Standards (Metallic, Fiberglass, and Wood)

Maintenance Codes are shown on the Underground Field Survey Worksheet (Table 1). The Underground Field Survey Worksheet can be used by the field to record maintenance items and is used for informational purposes only. The latest maintenance codes are downloaded to the Hand Held Computer each time there is a change that affects the maintenance code table contained in the Underground Maintenance Database. Printed copies of the latest maintenance code tables may be obtained by running a report on the look up tables from the Underground Maintenance Database.

INSPECTION PROGRAM AND MAINTENANCE CODES
TABLE 1

UNDERGROUND FIELD SURVEY WORKSHEET

DATE:	INSPECTOR NAME:	EMPLOYEE ID
DIVISION	DISTRICT	FEEDER:

TOWN:	STREET:	POLE, MANHOLE, VAULT #	SUFFIX #

Handhole		Manhole		Net Protect		Net XFMR's		Switchgear		Transformer	
Vault		Trench		Submersible		Pull Box		Other		Equipment #	

MANHOLES, HANDHOLES, VAULT STRUCTURES
Water (in hole) Yes No

EV Test Required: Yes No Voltage Action Taken: Repaired De-energized
EV Found Voltage: Yes No

Gas Monitor Readings		Alarm Setting
Lower Explosive Limit (LEL)		10% or above
Oxygen (0_2)		% below 19.5, above
Carbon Monoxide (CO)		33 ppm
Hydrogen Sulfide (H_2S)		10 ppm

GIS	P/Q	SWITCHGEAR	P/Q
260 **4** (NR) GIS map doesn't match field	/	657 **F** (NR) Excessive vegetation	/
261 **4** (NR) GIs Pole/line numbering in error on GIS	/	659 **2** (R) Missing ground	/
262 **4** (NR) GIS equip/hardware missing in GIS	/	660 **P** (NR) Missing nomenclature	/
263 **4** (NR) GIS equip removed in field, remove from GIS	/	661 **4** (NR) Other	/
269 4 (NR) GIS Other GPS/GIS Errors	/	662 **4** (NR) Rusted/Paint Peeling	/
HANDHOLES		TRANSFORMER	
600 **2** (NR) Broken/damaged/unsecured	/	672 1,2,**3** (R) Bushing Broken/Cracked	/
602 **P** (NR) Missing nomenclature	/	673 1,**2**,3 (R) Door Broken/damaged/unsecure	/
603 **1** (R) Secondary needs repair	/	675 1,2,**3** (R) Elbows/tracking/burned	/
604 **4** (NR) Other (use comments)	/	676 **F** (NR) Excessive vegetation	/
MANHOLE		680 **1** (R) Missing Ground	/
610 2 (NR) Ground rods missing	/	681 **P** (NR) Missing nomenclature	/
611 **2** (R) Cable/Joint leaking	/	682 **4** (NR) Mud/debris	/
612 **2** (NR) Cables bonded/grid defective	/	684 1,**2** (NR) Oil Weeping	/
614 1,2,3,**4** (NR) Cracked/broken	/	685 1,2,3,**4** (NR) Pad broken/damaged	/
615 **3** (R) Fire proofing	/	686 **4** (NR) Protection (ballards) damage	/
616 **4** (NR) Improper grade	/	687 **4** (NR) Rusted/Paint peeling	/
617 **P** (NR) Missing nomenclature	/	688 1,**2** (NR) Pad Pushed Off Base	/
620 **2** (NR) Rerack	/	TRENCH	
621 1,2,3,**4** (NR) Ring/cover repair/replace	/	690 **1** (R) Exposed Cable	/
622 1,**4** (NR) Roof condition – use comments	/	692 **4** (NR) Path – Sunken	/
623 1,**4** (NR) Chimney Condition – comments	/	VAULTS	
624 **4** (NR) Manhole needs cleaning	/	700 **2** (NR) Cable missing bond	/
625 **1** (R) Secondary needs repair	/	702 1,2,3,**4** (NR) Cracked/broken	/
626 4 (NR) No Holes in Manhole Cover	/	703 1,2,**4** (NR) Damaged/broken cover	/
NETWORK PROTECTOR		704 1,2,**4** (NR) Damaged/broken door	/
630 **2** (R) Barriers broken/damage	/	705 1,**2**,4 (NR) Damaged/broken ladder	/
632 **1** (R) Oil leak	/	706 1,2,3,**4**,P (NR) Improper grade	/
633 **2** (NR) Worn/damaged gasket	/	707 4,**P** (NR) Improper nomenclature	/
NETWORK TRANSFORMER		708 **4** (NR) Light not working	/
635 **2** (R) Bushing Broken/cracked	/	712 **4** (NR) Sump pump broken	/
637 **2** (R) Low oil	/	713 **1** (R) Secondary needs repair	/
638 **1** (NR) Missing ground	/	SUBMERSIBLE EQUIPMENT	
639 **P** (NR) Missing nomenclature	/	720 1,2,3,**4** (R) Excess Corrosion	/
642 1, **2** (R) Oil Weeping	/	721 1,2,3,**4** (R) Physical damage	/
643 **4** (NR) Rusted/paint peel	/	722 1,**2** (R) Leaking	/
SWITCHGEAR		ANODES	
651 1,**2**,3 (R) Barrier broken/damaged/unsecure	/	730 **3** (R) Missing	/
652 1,2,**3** (NR) Base broken/damaged	/	731 **3** (NR) Need replacement	/
654 **2** (R) Cable not bonded	/	KEY	
656 1,**2**,3 (R) Door Broken/Damaged	/	PQ = Priority Quantity	
		NR = Maint.Code May Not Directly Affect Reliab.	
		R = Maint. Code May Affect Reliability	
		RP = Maint. Code May Affect Reliab. and Has Specific Program to Place to Address	

Comments:

NG-0244 7/09

6.4 Distribution Maintenance Data Base

6.4.1 The Distribution Maintenance database consists of information collected in the field down loaded from the Windows® based hand held computer and data gathered from other sources entered from the desktop computer. The Windows® based hand held computer can be down loaded to any Liberty Utilities desk top computer that is connected to the network by an employee that has been authorized to perform this function. The Distribution Maintenance database is used by various departments throughout Liberty Utilities to generate maintenance reports and cost estimates.

6.4.2 The Distribution Maintenance database contains information to be used by are conducted by a Distribution Inspector that has been trained to be used by Distribution Planning to track maintenance codes that may affect reliability (R), or may not directly affect reliability (NR).

6.5 Maintenance Schedule

6.5.1 Maintenance activities are scheduled by priority Levels. All “Level 1 Priority” conditions identified must be repaired/corrected within 1 week. All “Level 2 Priority” conditions identified must be repaired/corrected within 1 year. All “Level 3 Priority” conditions must be repaired within 3 years. Level 4 Priority is for inventory purposes only.

6.5.2 Once the Underground Distribution Circuit/Feeder is completed in the Underground Maintenance Database or 21 days have elapsed since the inspection, the Level 2 and Level 3 Priority maintenance codes are downloaded into STORMS. Expense maintenance work goes straight to scheduling while the capital work goes to Distribution Design. Level 1 Priority maintenance codes are communicated by the Distribution Inspector directly to the field operations group for the area where the feeder is located.

6.6 Completion of Maintenance Codes

6.6.1 Level 1 priority maintenance codes completion process

- Distribution Inspector contacts NH Emergency Dispatch providing information on the Level 1 maintenance item and fills out a Level 1 Priority Report Form (page 10).
- Emergency Dispatch generates a PowerOn order from Dispatch Control.
- Supervisor captures PowerOn ID# and details for Level 1 maintenance item status. Inspections Supervisor tracks Level 1 maintenance status with operations ensuring that the Level 1 item is completed within 1 week. Supervisor closes out the Level 1 maintenance item in the Distribution Maintenance Database by adding the PowerOn ID # number to maintenance record.

6.6.2 Level 2 and Level 3 priority maintenance codes are completed in the Distribution Maintenance database once the 699 requirement is completed in STORMS for the work request associated with the maintenance code.

ALL MAINTENANCE WORK IS TO BE COMPLETED PER LIBERTY UTILITIES UNDERGROUND DISTRIBUTION STANDARDS.

ALL MAINTENANCE WORK PERFORMED THAT WAS IDENTIFIED ON THE WORK ORDER OR DISCOVERED DURING THE REPLACEMENT/REPAIR/CORRECTION OF THE ORIGINAL

MAINTENANCE PROBLEM MUST BE LISTED ON THE DATABASE AND THEN CLOSED OUT WHEN COMPLETE.

7.0 TRAINING

Liberty Utilities Technical Training will provide training upon request.

8.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear, Hi-Vis and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and any additional requirements specified in referenced Liberty Utilities procedures.

10.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	0	Initial Version of document	Robert J Johnson

INTRODUCTION

This procedure applies to all personnel involved with or responsible for working in and around conventional distribution underground systems.

PURPOSE

The purpose of this procedure is to provide requirements for recording the installation or removal of primary voltage splices on the electric distribution cable system due to failure. Additionally this document will record the failure of equipment associated with underground cable systems i.e. switchgear, vacuum switches, transformers and network protectors. This procedure applies to all underground primary cable connections and network secondary connections, in a conventional manhole and duct system.

All changes to primary voltage splices will be recorded by field crews using procedures and forms described in this EOP. A comprehensive inventory record of cable splices on the electric distribution system is required to track product reliability and insure proper workmanship practices.

ACCOUNTABILITY

1. CQ&EM, Standards, Policies and Codes
   - A. Update procedure as necessary.
   - B. Provide Electric Distribution Operations field support and training upon request.
2. Electric Distribution Operations
   - A. Ensure the Underground Trouble/Splice Logs and Trouble/Splice System as outlined in this EOP is implemented properly and timely.
   - B. Provide qualified personnel - electric mechanic, line constructor, splicer, or any other person who actually performs the splicing work as the individuals required to complete the Trouble/Splice Log consistently and accurately.
   - C. Ensure Electric Operations personnel are trained in this procedure.
   - D. Provide procedure revision input as necessary.
3. Liberty Utilities Employees and Contractors
   - A. Demonstrate the understanding of the procedure.
   - B. Comply with the requirements of the procedure.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

LU-EOP UG006 Underground Inspection and Maintenanace

DEFINITIONS

Primary Voltage: All distribution cable energized at 4, 13, or 23kV.

Splice: A connection between distribution cable and another section of cable or a cable lug or a cable termination including live end caps.

Underground Trouble/Splice System: This application and database maintains the permanent record of primary splices. In order to determine the reliability of primary splices, this database contains important data relating to individual splices; such as splice manufacturer, the date of installation and individual completing the splice.

Underground Trouble/Splice Log: This paper form is used by operating crews to document the work required and the as-built condition of splicing connections on distribution feeders. A sample of the paper form is located in section 3.1 of this EOP.

TRAINING

Provided by the appropriate Liberty Utilities training program

DOCUMENT CONTENTS

Table of Contents

1.0 RESPONSIBILITY FOR COMPLETING TROUBLE/SPLICE LOG

Work Completion – The electric mechanic, line constructor, splicer, or any other person who actually performs the splicing work is required to complete the Underground Trouble/Splice Log with the as-built conditions. If a manhole number is not available, to properly capture the work location, it may be necessary on the back of the Underground Trouble/Splice Log to provide a sketch and description of the work that was conducted. This will provide Operating Supervision/Clerical Support with better direction on where the work was preformed.

Filing Completed Report – Engineering Planning/Clerical Support will enter the paper Trouble/Splice Log Form into the UG Trouble/Splice System database. The Trouble/Splice Log Form will be scanned and stored in Folder with Engineering Documents.

2.0 DOCUMENT RETENTION

The Trouble/Splice Log database will represent our permanent record driven by a paper form.

3.0 INSTRUCTIONS FOR COMPLETING TROUBLE/SPLICE LOG

Where work is being performed in more than one manhole additional Trouble/Splice Logs will be needed for each manhole location.

FIELD	**DESCRIPTION**
Name	Individual who is completing splice construction
Employee ID	The Employee ID of the individual completing splice construction
Date	Date of splice installation
Circuit Number	The electric circuit (Feeder) that is being worked on
Voltage	The Voltage Class of the circuit being worked on
From Location	The address or street location where the work is being performed. This should include structure number and suffix (if it exists) i.e., Main Street, Manhole 456
To Location	The address of street location where the work is extending to. This should include structure number and suffix (if it exists) i.e., Main Street, MH 457
Reason for Splicing	Document the reason for doing the splicing i.e., failure, new business, reliability
Trouble Failed	Document what failed i.e., cable, splice, switch, terminator, transformer, Network Protector, Other
Failed/Removed Cable	Document what type and size of cable was removed. Also document number, manufacturer and type of joints being removed
Installed Cable/Splice	Document what type and size of cable was Installed. Also document number, manufacturer and type of splice being installed.

3.1 Underground Trouble / Splice Log

Liberty Utilities

Underground Trouble / Splice Log

Name:	Emp ID:
Name:	Emp ID:
Name:	Emp ID:
Date:	
City/Town:	
Other:	Other:
Circuit:	Voltage:

☐ 5 kV Class ☐ 15 kV Class ☐ 25 kV Class ☐ 35 kV Class ☐ Network Sec
☐ Other:
Reason for work: ☐ Failure ☐ New Business ☐ Reliability

From Location Street: ______ *Manhole/Pole:* ______ *Suffix:* ______

To Location Street: ______ *Manhole/Pole:* ______ *Suffix:* ______

*Trouble Failed (*Explain In Notes)*
☐ Cable ☐ Joint ☐ Switchgear ☐ Terminator ☐ Transformer ☐ Other
☐ Network Protector ☐ Vacuum Switch ☐ Oil Fused Cutout
☐ *Manhole Cover Dislodged ☐ *Gas Found ☐ None
Notes ______

Failed / Removed Cable / Splice
☐ EPR ☐ VC ☐ PILC ☐ XLP ☐ Other: ______
Size
☐ Cu ☐ Al ☐ 1/C ☐ 3/C
☐ #2 ☐ 1/0 ☐ 4/0 ☐ 350 ☐ 500 ☐ 750 ☐ 1000
☐ Other: ______
Joint/Termination
☐ 200A Premold ☐ 600A H or Y ☐ Cold Shrink ☐ Hand Applied Lead
☐ Hand Applied Non Lead ☐ Heat Shrink Straight ☐ Heat Shrink Y ☐ Heat Shrink Trif
☐ T-Body Manufacturer: ______

Installed Cable / Splice
☐ EPR ☐ VC ☐ PILC ☐ XLP ☐ Other: ______
Size
☐ Cu ☐ Al ☐ 1/C ☐ 3/C
☐ #2 ☐ 1/0 ☐ 4/0 ☐ 350 ☐ 500 ☐ 750 ☐ 1000
☐ Other: ______
Joint/Termination
☐ 200A Premold ☐ 600A H or Y ☐ Cold Shrink ☐ Hand Applied Lead
☐ Hand Applied Non Lead ☐ Heat Shrink Straight ☐ Heat Shrink Y ☐ Heat Shrink Trif
☐ T-Body Manufacturer ______

4.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
01/01/2013	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG011		
Electric Operating Procedure	**03-01-2015**	**Underground**	
Underground Electric	**Revision #**	**1.0**	**Page: 1 of 13**

INTRODUCTION

Underground construction, reconstruction, relocation, maintenance and emergency work in the vicinity of exposed energized cables or equipment shall be performed in accordance with this EOP.

PURPOSE

The purpose of this procedure is to provide the appropriate safe work methods and procedures that shall be utilized by employees when working on or around underground electric facilities.

ACCOUNTABILITY

1. Standards, Policies, and Codes
   A. Update procedures as necessary.
   B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements.
2. Electric Distribution Operations
   A. Ensure the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.
3. Employees
   A. Demonstrate the understanding of the procedure.
   B. Comply with the requirements of the procedure.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

LU-EOP G013 Excavation Notification Requirements

LU-EOP G016 Elevated Equipment Voltage Testing

LU-EOP UG001 Infrared – Non-Contact Thermometer Inspection Requirement for

Underground Equipment

LU-EOP UG002 Cable Installation and Removal Manhole and Duct System

LU EHSS Procedure – Enclosed Space Entry 8810-100-200-007

LU EHSS Procedure – Asbestos Abatement General Spec 8810-200-200-001

REFERENCES (cont'd)

OSHA 1910.269

(e) Enclosed Spaces

(t) Underground electrical installations

OSHA 1926.956

(b) Work in Manholes

Trenching and Excavating

National Electrical Safety Code 2012 Edition

DEFINITIONS

Attendant: An employee assigned to remain immediately outside the entrance to an enclosed or other space to render assistance as needed to employees inside the space.

Barricade: A physical obstruction such as tape, cones, or A-frame type wood or metal structures intended to provide a warning about and to limit access to a hazardous area.

Barrier: A physical obstruction which is intended to prevent contact with energized lines or equipment or to prevent unauthorized access to a work area.

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Dead: Isolated, tagged, tested de-energized and grounded.

De-energized: Free from any electrical connection to a source of potential difference and electric charge; not having a potential different from that of the earth.

Enclosed space: A working space, such as a manhole or vault that has limited means of egress or entry, that is designed for periodic employee entry under normal operating conditions, and that under normal conditions does not contain a hazardous atmosphere, but that may contain a hazardous atmosphere under abnormal conditions.

Energized: Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Hazardous Atmosphere: An atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from an enclosed space), injury, or acute illness from one or more of the following causes: Flammable gas, or vapor, or mist in excess of 10 percent of its lower flammable limit (LFL); Airborne combustible dust at a concentration that meets or exceeds its (LFL); Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent; Atmosphere concentration of any substance for which a dose could result in employee exposure in excess of its dose or permissible exposure limit; Any other atmospheric condition that is immediately dangerous to life or death.

Manhole: A subsurface enclosure which personnel may enter and which is used for the purpose of installing, operating and maintaining submersible equipment or cable.

Vault: An enclosure, above or below grade, which personnel may enter and which is used for the purpose of installing, operating, or maintaining equipment or cable.

TRAINING

Provided by appropriate Liberty Utilities Learning & Development training program.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any Liberty Utilities EOP's utilizing all appropriate safe work methods.

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

The employee in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

All underground cables shall be considered energized until the cable is isolated, tagged, tested de-energized and grounded.

If at any time a cable that is thought to be de-energized and grounded proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted and the System Operator shall be notified.

Rubber gloves of the appropriate class shall be worn until the cable is proven to be isolated, tagged, tested de-energized and grounded.

A primary or secondary neutral system shall not be opened on an energized circuit. When it is necessary to rearrange neutral conductors on an energized circuit, the neutral circuit shall be maintained using a jumper of the equivalent size.

During work, barriers or other appropriate protection shall be installed to protect adjacent conductors.

All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Refer to the tool catalog for a listing of approved equipment.

When work is to be performed in an enclosed or confined space, the entrant shall wear an approved full body harness and tether. The entrant shall be connected to the rescue device unless the crew leader/chief or supervisory waiver is obtained. The rescue device will be placed at the entrance. Authorization to work un-tethered shall be documented on the job brief form. All entrants will follow the approved Liberty Utilities Non-Entry Rescue Procedure.

2.0 ENCLOSED SPACES

2.1 Safe Work Practices

2.1.1 Employees must apply safe work practices before entering an enclosed space. All employees, entrants and attendants, shall have annual recertification in the non-entry rescue procedure.

2.2 Training

2.2.1 Employees who enter enclosed spaces or who serve as attendants shall be trained in the hazards of enclosed space entry procedures, enclosed space rescue procedures and CPR.

2.3 Non-Entry Rescue Equipment:

2.3.1 Employees shall use provided non-entry rescue equipment to ensure the prompt and safe rescue of entrants from the enclosed space (Reference Enclosed Space Entry 8810-100-200-007 and Work Method Bulletin #09-05).

2.4 Evaluation of Potential Hazards:

2.4.1 An evaluation shall be completed in order to determine the presence of any hazardous conditions before removing the entrance cover by:

a. Checking for elevated temperatures within the space.

b. Cracking the cover seal to release any pressure present.

c. Air monitor for the potential for a hazardous atmosphere. The internal atmosphere shall be checked with a multi-gas meter.

2.4.2 Flame shall not be used on or around manhole covers before testing for explosive atmospheres has been completed.

2.5 Removal of Covers:

2.5.1 When covers of manholes, handholes, or vaults are removed from enclosed spaces, the opening shall be promptly guarded by a railing, temporary cover, barrier, rescue device or attendant intended to prevent an accidental fall through the opening and to protect employees working in the space from objects entering the space.

2.5.2 Approved lifting devices shall be used to open or remove covers.

2.5.3 The covers shall be placed clear of vehicular and pedestrian traffic and coned/barricaded off as necessary.

2.6 Hazardous Atmosphere:

2.6.1 Employees may not enter any enclosed space while it contains a hazardous atmosphere. An enclosed space must have the atmosphere tested, by a qualified person using a calibrated direct reading instrument, before any employee is allowed to enter an enclosed space.

2.6.2 The atmospheric testing shall be performed at various levels within the enclosed space. After the employee enters, additional sampling shall be taken high, low, in corners, in seams, near ducts, and at other potential sources of leakage.

2.6.3 Continuous monitoring shall be in use any time an employee is in an enclosed space.

2.6.4 Reevaluation shall be done after shift changes, breaks, or when conditions have changed.

2.7 Calibration of Test Instruments:

2.7.1 Test instruments used to monitor atmospheres in enclosed spaces (multi-gas meters) shall be kept in calibration and good working condition. The Liberty Utilities standard requires that the meter measure oxygen, combustibles, carbon monoxide, and hydrogen sulfide (See Standards Bulletin #03-23). The meter shall be taken out of service if it is past its calibration due date, fails to successfully complete its self diagnostic check, goes into continuous alarm, or the user believes that the meter is not working properly.

2.8 Ventilation and Monitoring:

2.8.1 If flammable gases or vapors are detected or if an oxygen deficiency is found, forced air ventilation shall be used to maintain oxygen at a safe level and to prevent a hazardous concentration of flammable gases and vapor from accumulating. Continuous monitoring must also take place.

2.8.2 A continuous monitoring program to ensure that no increase in flammable gas or vapor concentration occurs may be followed in lieu of ventilation, if flammable gases or vapors are detected at safe levels.

2.8.3 Continuous power ventilation shall be used at all times when an employee is performing a lead splice, using an open flame, using solvent, or welding.

2.9 Specific Ventilation Requirements:

2.9.1 A safe atmosphere shall exist before employees are allowed to enter the work area by using continuous forced air ventilation. The forced air ventilation shall be so directed as to ventilate the immediate area where employees are present within the enclosed space and shall continue until all employees leave the enclosed space.

2.9.2 Continuous power ventilation shall be required in all instances where test monitoring indicates a hazardous work space contains or has the potential to contain a hazardous atmosphere and continuous power ventilation alone is sufficient to keep the space safe for entry.

2.10 Air Supply:

2.10.1 The air supply for the continuous forced air ventilation shall be from a clean source and may not increase the hazards in the enclosed space.

2.11 Open Flames:

2.11.1 If open flames are used in enclosed spaces continuous power ventilation shall be used. A continuous monitoring program shall be in place.

2.11.2 Employees shall not smoke in manholes.

2.11.3 Where open flames must be used in manholes or vaults, extra precautions shall be taken to ensure adequate ventilation.

2.11.4 When a torch or open flame is used (as in heat shrink splicing) in proximity to a visibly exposed gas or other line(s) that transport flammable material, adequate air space or a barrier shall be provided to protect the gas or line(s) that transport flammable material from the heat source.:

3.0 UNDERGROUND ELECTRICAL INSTALLATIONS

3.1 Hazard Assessments:

3.1.1 A hazard assessment shall be conducted when first entering manhole or vault. The assessment must include a visual inspection for electrical abnormalities on all equipment and work areas prior to the start of work. The hazard assessments and electrical abnormalities shall be fully discussed and documented during the job brief. An infrared inspection of separable components is required before work begins in an enclosed space (refer to LU-EOP UG001 Infrared – Non-Contact Thermometer Inspection Requirement for Underground Equipment).

3.2 Daily Job Site Test Requirements:

3.2.1 Each job site where Liberty Utilities personnel or its contractors complete a work assignment shall be tested for elevated equipment voltage at the end of the work day or the completion of the assignment. This testing requirement is considered good utility practice and does not require specific documentation.

3.3 Access:

3.3.1 A ladder shall be used to enter and exit a manhole or subsurface vault exceeding four feet in depth. No employee may climb into or out of a manhole or vault by stepping on cables or hangers.

3.4 Raising and Lowering Materials into Manholes or Vaults:

3.4.1 Equipment used to lower materials and tools into manholes or vaults shall be capable of supporting the weight to be lowered and shall be checked for defects before use. The materials and tools being lowered shall be mechanically secured to the lowering device such that they cannot be accidentally dislodged. Before tools or materials are lowered into the opening for a manhole or vault, each employee working in the manhole or vault shall be clear of the area directly under the opening.

3.4.2 Furnaces and hot materials on the surface shall be placed so they do not to tip into the hole. The worker in the hole should be warned to stand clear before hot material is lowered, and lowering shall not proceed until person below is ready.

3.4.3 Torches and Furnace

a. Only employees trained and qualified in the use of torches and a furnace are permitted to operate them (See Work Methods Bulletin #08-24).

b. Do not light a torch or a furnace within an enclosure such as in a manhole, truck cabs, empty barrels which may contain an atmosphere containing flammable vapors and/or gases. Do not use a windbreak that is enclosed on all sides.

c. When using a torch in a manhole adequate continuous power ventilation shall be provided for employees and combustion.

d. Never leave a torch unattended or in a location where it could cause a fire.

e. Do not use cold or wet ladles when handling molten metals. Preheat and dry ladles before they are used.

3.5 Attendants for Manholes and Vaults:

3.5.1 While work is being performed in a manhole or vault, an employee with first-aid training, CPR training and emergency non-entry rescue procedures shall be immediately available outside the enclosed space to render emergency assistance. That person is not precluded from performing other duties outside the enclosed space if these duties outside the enclosed space do not distract the attendant from monitoring employees within the space.

3.5.2 The attendant may not enter the manhole or vault under any circumstances unless another attendant is available on-site.

3.5.3 There shall be effective communications between the employees in the manhole or vault and the attendant.

3.6 Communication:

3.6.1 The means of communication between the workers shall be two-way radios, voice, or agreed upon hand signals. During the pre-job brief the leader and crew members will agree on the appropriate communication method to be used. When the line of sight between manholes is impaired, radio communication or use of another similar device is required (ex. cellular phone).

3.7 Tanks of Liquefied Petroleum Gas: (see Work Methods Bulletin #08-24)

3.7.1 All propane tanks used shall have a guard around the valve.

3.7.2 A propane tank shall not be used in an excavation, manhole, vault, confined space, or enclosed space. The tank shall be secured so they will not be knocked or pulled into an excavation, manhole, vault, confined space, or enclosed space.

3.7.3 The length of hose shall be long enough to keep the tank out of the work space.

3.8 Duct Rods:

3.8.1 When duct rods/snakes are used, they shall be installed in a direction presenting the least hazard to employees. An employee shall be stationed at the far end of the duct line being rodded to ensure that the required minimum approach distances are maintained. Any live equipment that could be contacted by the duct rods/snakes shall be protected by barriers or additional safeguards, such as wood blocks or arc blankets. Employees shall avoid being in manholes where power-driven rodding equipment is in operation.

3.9 Energized Cable or Equipment:

3.9.1 Energized cables in service which are protected by metal sheath (intact) or by concentric neutral cable with protective covering shall not be considered “exposed parts”.

3.9.2 Physical protection of the sheath shall be provided without such practices as piling rubble on cable or hanging tools and equipment on cable.

3.9.3 Employees that can be exposed to energized parts or equipment in the work area shall be protected by:

a. An adequate insulating barrier consisting of portable rubber protective equipment (blankets, hoses, hoods, etc.)

b. A substantial barrier which ensures required minimum safe working clearances.

c. Workers will wear all appropriate personal protective equipment during installation.

d. To the extent possible, suitable protective covering of grounded parts in work areas shall be employed if exposed live parts are within reach.

3.10 Moving Cable:

3.10.1 Minimal movement of energized cables shall be undertaken only if deemed safe to do so through a documented job brief and a thorough hazard assessment of the cables.

3.10.2 If energized cables must be moved, employees shall:

a. Inspect the cables carefully for defects

b. Consider the age of the cables and splices etc.

c. Wear appropriate class rubber gloves

d. The recloser may be put into the manual position

e. Consider added safeguards and alternative methods

3.10.3 Energized cables must be protected during cable removal and installation in manholes using appropriate added safeguards.

3.11 Defective Cable:

3.11.1 When a cable in a manhole has one or more abnormalities that could lead to or be an indication of an impending fault, the defective cable shall be protected from the possible effects of a failure by installing blast blankets or the cable shall be de-energized before any employee may work in the manhole.

NOTE: Abnormalities such as oil or compound leaking from cable or joints, broken cable sheaths or joint sleeves, hot localized surface temperatures of cable or joint sleeves that are swollen beyond normal tolerances are presumed to lead to or be an indication of an impending fault. Precautions shall be taken to install protective barriers and schedule repairs ASAP.

3.12 Primary Cable and/or Splice Failure:

3.12.1 When a manhole or vault contains a known primary cable and/or splice failure in a specific manhole or vault, said manhole or vault shall not be entered for inspection or work until the affected primary cable has been isolated and red tagged, a Clearance or PRT issued, and grounds applied per Employee Safety Handbook 2.10.7. If the manhole or vault must be entered to establish the Clearance or PRT, the manhole or vault shall not be entered until the source(s) of the circuit are isolated and red tagged.

3.13 Grounding:

3.13.1 Underground cables shall be effectively grounded. Short circuiting grounds of an approved size and type shall be installed at the nearest convenient point on each side of the work location, or; an approved method of working on ungrounded cables shall be followed. (Reference LU-EOP G014 – Clearance and Control)

3.14 Phasing:

3.14.1 When work is in progress, grounds can be removed (in accordance with the appropriate clearance and control rules) long enough to identity phase orientation, and then reapplied. The approved class of rubber gloves shall be worn during this operation.

3.15 Asbestos Removal:

3.15.1 When removing asbestos in a manhole, handhole, and vault or on a riser pole the asbestos shall be removed per the Liberty Utilities EHSS Procedure - Asbestos Abatement General Spec 8810-200-200-001.

3.16 Trenching and Excavating:

3.16.1 Before an excavation or trenching begins, the Dig Safe organization shall be contacted per LU-EOP G013 Excavation Notification Requirements. At sites not controlled by Dig Safe the appropriate underground facility owner shall be contacted.

3.16.2 During excavation or trenching, in order to prevent the exposure of employees to the hazards created by damage to dangerous underground facilities, efforts shall be made to determine the location of such facilities and work conducted in a manner designed to avoid damage.

3.16.3 Before using open flames in an excavation in an area where combustible gases or liquid may be present, such as near a gasoline service station, the atmosphere of the excavation shall be tested and found safe or cleared of the combustible gases or liquids.

3.16.4 Trenching and excavation operations shall comply with the following requirements:

a. Surface encumbrances

b. Underground installations

c. Access and egress

d. Means of egress from excavations

e. Exposure to vehicular traffic

f. Exposure to falling loads

g. Warning systems for mobile equipment

h. Hazardous atmospheres

i. Emergency rescue equipment

j. Protection from hazards associated with water accumulation

k. Stability of adjacent structures

l. Protection of employees from loose rock or soil

m. Inspections

n. Fall protection

Before trenching or excavating takes place a careful review should be completed of Liberty Utilities Employee Safety Handbook – Section 1.17.

3.16.5 When an employee is required to perform tasks in trenches or excavations where a cave-in hazard exists or the trench or excavation is in excess of 5 ft in depth, shoring, sloping, or shielding methods shall be used to provide employee protection.

3.16.6 When underground facilities are exposed (electric, gas, water, telephone etc.) they should be identified and shall be protected by barriers as necessary to avoid damage.

3.16.7 Where multiple cables exist in an excavation, cables other than the one being worked on shall be protected by barriers as necessary.

3.16.8 Cables and other buried utilities in the immediate vicinity shall be located, to the extent practical, prior to excavating.

3.16.9 When using guided boring or directional drilling methods, existing utilities should be exposed by the personnel performing the boring operation where the bore path crosses such facilities.

3.16.10 Hand tools used for excavating in the vicinity of energized supply cables shall be equipped with handles made of nonconductive material.

3.16.11 Mechanized equipment should not be used to excavate in close proximity to cables and other buried utilities.

3.16.12 If a gas or line that transports flammable material is broken or damaged, employees shall:

a. Leave the excavation open.

b. Extinguish flames that could ignite the escaping gas or fuel.

c. Notify the proper authority.

d. Keep the public away until the condition is under control.

3.17 Construction and Maintenance of Underground Structures and Conduit Lines

3.17.1 When pulling cable, workers shall stand clear of pulling lines on heavy pulls. Pulling lines shall be kept clear of contact with energized parts or equipment. The use of ARC blankets and protective barriers is recommended (refer to LU–EOP UG002 Cable Installation and Removal Manhole and Duct System).

3.17.2 Until the exact location of underground power circuits is known, employees using jackhammers, bars, shovels or similar tools are required to wear the appropriate rubber gloves, FR clothing, EH rated shoes and EH rated overshoes.

3.17.3 Before excavating near a conduit bank containing live cable, duct occupancy shall be checked at each adjacent hole, and conduit locations as shown, and maps shall be verified by field checks.

3.17.4 Stripping conduit and concrete envelope from sections of a duct bank containing live cable shall be undertaken only when required, and with great care. Concrete and conduit shall be chipped away at one point initially by the use of hand tools.

3.17.5 When cable is exposed (sheath/concentric/jacket) inserts of suitable size, shape and material shall be placed inside conduit, in each direction from the point of opening, such that chipping of concrete and conduit along the conduit line may precede using pneumatic tools without danger of damaging the cable.

3.17.6 All required PPE as well as appropriate rubber gloves shall be worn, along with EH rated shoes, EH rated overshoes and flame retardant clothing when using pneumatic or hand tools in excavations near live cables. Suitable approved protective guards shall be used to protect exposed conductors in the work area.

3.17.7 All protruding reinforced steel onto and into which employees could fall against shall be guarded to help reduce the hazard of impalement or injury.

3.17.8 Employees should not work underneath concrete buckets or any other suspended loads or hazards.

4.0 EXCEPTION APPROVALS

It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Program Manager of Engineering Standards, Policies, and Codes and a Manager of Corporate Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
03/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG012		
Electric Operating Procedure	09-01-2013	Underground	
Procedure for Operating Underground Residential Distribution	Revision #	0	Page: 1 of 14

INTRODUCTION

This procedure applies to all personnel involved with or responsible for working on Underground Residential Distribution systems.

PURPOSE

The purpose of this procedure is to provide information to safely work on Underground Residential Distribution systems (URD's). Subjects covered in this Electric Operating Procedure (EOP) include all operational aspects associated with Underground Residential Distribution.

ACCOUNTABILITY

1. Standards, Policies and Codes
    A. Update procedure as necessary.
    B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements.
2. Electric Operations
    A. Ensure the components of the procedure are implemented.
    B. Ensure workers are trained in this procedure.
    C. Provide revision input as necessary.
3. Employees and Contractors working for Liberty Utilities
    A. Demonstrate the understanding of the procedure.
    B. Comply with the requirements of the procedure.

REFERENCES

Liberty Utilities Employee Safety Handbook

Liberty Utilities Construction Standards

Manufacturers Operating Instructions

Liberty Utilities Electric Operating Procedures

LU-EOP D002 Overhead Distribution and Sub-Transmission Personal Protective Grounding

NG-EOP G014 Clearance and Control

LU-EOP G016 Elevated Equipment Voltage Testing

LU-EOP G021 Connecting Secondary Services

LU-EOP UG001 Infrared Non-Contact Thermometer Inspection

Standards Bulletin #08-02 Capacitive Tests Points & Grounding

Work Methods Bulletin #10-01 200A Feed-Thru with a Deadbreak & Loadbreak Bushing Insert

DEFINITIONS

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Dead: Isolated, red tagged, tested de-energized and grounded.

De-energized: Free from any electrical connection to a source of potential difference and from electrical charges. Not having a potential difference from that of earth. Note**:** The term is used only with reference to current-carrying parts which are sometimes alive (energized).

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Hand-Hole: An enclosure identified for use in underground systems, provided with an open or closed bottom, and sized to allow personnel to reach into, but not enter, for the purpose of installing, operating, or maintaining equipment or wiring or both.

One-call notification system: Any organization among whose purposes is establishing and carrying out procedures to protect underground facilities from damage due to excavation and demolition, including but not limited to, receiving notices of intent to perform excavation and demolition and transmitting the notices to one or more member operators of underground facilities in the specified area. The one-call notification system serving Massachusetts, New Hampshire and Rhode Island is Dig Safe System, Inc., which can be contacted at 888-DIG-SAFE (888-344-7233) or www.digsafe.com. ***811*** can also be called from anywhere within the United States and your call will be routed to the correct one-call notification center.

Shall: The word “shall” indicates provisions that are mandatory.

Underground Residential Distribution (URD): URD construction methods are typically used for residential areas. They consist of buried cables, either direct buried or in ducts, with pad-mounted or subsurface transformers.

TRAINING

Provided by appropriate Liberty Utilities training program.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any Liberty Utilities EOP's utilizing all appropriate safe work methods. All the procedures shall be worked using approved tools and equipment. Refer to the tool catalog for a listing of approved tools.

1.2 All primary underground cables shall be considered energized until the cable is isolated, red tagged, tested de-energized and grounded.

1.3 If at any time a cable that is thought to be de-energized and grounded proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted immediately and the System Operator shall be notified.

1.4 Rubber gloves of the appropriate class shall be worn until the cable is proven to be isolated, red tagged, tested de-energized and grounded.

1.5 A primary or secondary neutral system shall not be opened on an energized circuit. When it is necessary to rearrange neutral conductors on an energized circuit, the neutral circuit shall be maintained using a jumper of the equivalent size.

1.6 During work, barriers or other appropriate protection shall be installed to protect adjacent cables. Where multiple cables exist in an excavation, cables other than the one being worked on shall be protected.

1.7 If there is a need to make repairs in a trench to a faulted primary cable without de-energizing the adjacent energized primary cables the following shall be adhered to.

1.7.1 All required PPE as well as appropriately rated rubber gloves and EH rated overshoes shall be worn until all energized primary cables are located in the trench.

1.7.2 All energized primary cables in the work area shall be protected from the adjacent primary cables.

1.7.3 Excavation by hand may be needed to locate the energized primary cables. Hand tools used for excavating in the vicinity of the energized primary cables shall be equipped with handles made of nonconductive material. Appropriate rated rubber gloves and EH rated overshoes shall be worn.

1.7.4 If any energized primary cable in the trench needs to be moved the cables shall be moved with an approved live line / hot stick tool. The energized primary cables shall be inspected for defects. Appropriate rated rubber gloves and EH rated overshoes shall be worn.

1.7.5 All energized primary cable shall be covered with rubber and/or arc suppression blankets. If the energized primary cable will be moved during the installation of the blankets the blankets shall be applied with appropriate rubber gloves or with appropriate rubber gloves and an approved live line/hot stick tool. EH rated overshoes shall be worn.

1.7.6 After the faulted primary cable in the trench is repaired the covering (rubber and/or arc suppression blankets) used shall be removed. If the energized primary cable will be moved during the removal of the covering the covering shall be removed with appropriate rubber gloves or with appropriate rubber gloves and an approved live line / hot stick tool. EH rated overshoes shall be worn.

2.0 GENERAL

2.1 All equipment, devices and material used in any underground applications must be kept clean and free from any contamination.

2.2 Any elbow or bushing insert, including feed-thru devices, not in use must be protected from contamination through the use of the appropriate insulating cap or placed on a clean feed-thru parking stand or single parking stand device.

2.3 Protect all cables and terminations from physical damage.

2.4 Before any work is started, an infrared inspection of separable components is required in a manhole, vault, enclosure, pad-mounted transformer or subsurface transformer as outlined in LU-EOP UG001.

2.5 Any exposed energized part shall be kept clear of grounded equipment until tested de-energized.

2.6 The specifications for the approved elbow grounds can be found in the Liberty Utilities (National Grid) Grounding Catalog.

3.0 SECONDARIES AND SERVICES

3.1 Before connecting any underground secondary or service in the pad-mounted transformer compartment or URD secondary handhole, the secondary or service must be tested clear of grounds and shorts. Always use caution when connecting services that are in parallel (Refer to LU-EOP G021 Connecting Secondary Services).

4.0 CABLE LOCATION, IDENTIFICATION AND TAGGING

4.1 Cables and or equipment to be worked on shall be positively identified by identification tags, duct location charts, maps, or other approved means and shall be isolated from all sources of supply.

4.2 All cables, primary, secondary and services, shall have identification tags per Underground Standards Section 45.15.

4.3 Where more than one phase of an Underground Residential Distribution cable is installed in an area, only the phase supplying the transformer shall be brought through the transformer enclosure. Enclosures used for sectionalizing and switching may have all phases installed in them.

5.0 EXCAVATING

5.1 Before excavating or trenching begins, follow NG-EOP G013 Excavation Notification Requirements. This will require notifying the appropriate one call notification system.

6.0 DEADBREAK ELBOW

6.1 To isolate and/or restore a section of cable or a transformer deadbreak elbows must be de-energized before they can either be removed from the bushing insert or installed onto the bushing insert.

6.2 Deadbreak elbows and deadbreak bushing inserts shall both be changed to loadbreak components when possible.

6.3 A deadbreak feed-thru device and bushing (per section 6.6.1) should be attained before de-energizing the deadbreak elbow.

6.4 Procedure for de-energizing and testing at the riser pole.

6.4.1 Whether the job entails routine line work, operating a cutout, replacing a cutout, or work on or near a cutout due to an emergency situation, a thorough inspection of the pole and pole top shall be conducted and documented on a written job brief. As per LU-EOP D001 Cutouts Open / Enclosed Type all manufacturers' potted porcelain style cutouts on poles and structures shall be thoroughly inspected for visible hazards and replaced.

6.4.2 To de-energize, open the disconnect switch or fuse using a "Loadbuster" tool.

6.4.3 After opening the disconnect switch, or if the fuse has operated, the load side tap of the disconnect switch must be tested de-energized and grounded per NG-EOP G014 Clearance and Control.

6.5 Procedure for de-energizing and testing at a padmount transformer or enclosure.

6.5.1 If the padmount transformer or enclosure has loadbreak capabilities follow section 7.

6.6 Procedure at a transformer enclosure containing deadbreak elbows.

6.6.1 When work at the riser pole or at the location with load capabilities has been completed the following procedure shall be used to test, remove and isolate deadbreak elbows.

a. To properly test de-energized, ground and place a signal trace on a cable that has a 200A 15kV non-loadbreak elbow, Elastimold makes a feed-thru device that can support a deadbreak bushing insert and a loadbreak bushing insert.

- The feed-thru device is part number K1601WFT.
- The deadbreak bushing insert is part number K1501A1.
- The loadbreak bushing insert is part number 1601A4.
- The feed-thru device and dead-break bushing insert can be purchased through an Elastimold representative or Graybar, Manchester, NH
- The loadbreak bushing insert is available through the storeroom (Item ID 8830-2014963, Standard Item UR36B). Follow the Elastimold installation instructions to properly install the deadbreak insert and loadbreak bushing insert into the feed-thru device.

b. Install a clean feed-thru device with a deadbreak bushing insert and a loadbreak bushing insert onto a parking stand position.

c. The transformer secondary shall be tested de-energized at the secondary connections or at the service entrance using an approved voltage tester.

d. The primary cable shall be tested above the concentric neutrals to see if it is carrying load. This is accomplished using an approved ammeter, attached to an approved live line / hot stick tool, at the base of the deadbreak elbow. Below are two of the approved ammeters. This tool is from SensorLink and HD Electric Halo 1 or 2 (shown below).

e. If the deadbreak elbow has a capacitive test point follow section 8 to determine if the cable is energized.

f. If the tests from steps c., d. and e. prove the cable to be de-energized, then remove the deadbreak elbow from the transformer using an approved elbow removal tool. Place the elbow on the deadbreak bushing insert of the feed-thru device. A deadbreak elbow shall not be placed on a loadbreak position of a feed-thru device.

g. After the elbow has been placed on the feed-thru device, test the cable using an approved voltage tester attached to an approved live line / hot stick tool. An approved bushing adapter shall be installed on the voltage tester and this shall be inserted into the open bushing of the feed-thru device.

h. If the circuit tests de-energized install the ground end clamp of an approved elbow ground to the system neutral then install the elbow ground into the open bushing of the feed-thru device.

i. The primary bushing of the transformer shall then be tested de-energized.

6.7 After the cable section or the transformer has been isolated, the remaining portions of the circuit may be energized following proper procedures and rules.

6.8 Restoring the circuit to normal:

6.8.1 When work has been completed on the section of cable or transformer the circuit must be de-energized at the riser pole using a “Loadbuster” tool or at a location with loadbreak capabilities.

6.8.2 After the disconnect (cutout) has been opened the load side tap of the disconnect shall be tested de-energized using an approved tester attached to an approved live line / hot stick tool. If the circuit was de-energized with a loadbreak elbow follow section 7.0.

6.8.3 Isolated sections or transformers shall now be restored to their normal positions using an approved elbow connector tool.

6.8.4 After all the connections have been placed back to their normal position, close the disconnect (cutout) at the riser pole or follow the loadmake procedure per section 7.0 returning the circuit back to normal.

7.0 LOADBREAK ELBOW

7.1 Ratings

7.1.1 All components are rated to make and/or break load up to 200 amps. All 35 kV elbows shall be operated de-energized.

7.2 Identification

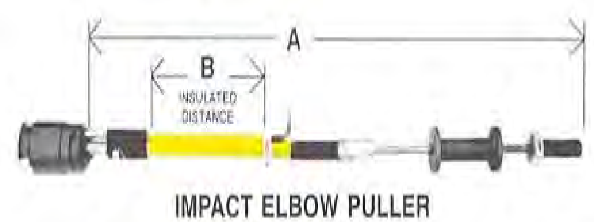
7.2.1 A Loadbreak elbow can be identified by a white plastic band around the elbow body, or a yellow band (older style). If there are no loadbreak bands visible check the elbow body for the word “LOADBREAK” embossed during manufacturing.

7.2.2 A loadbreak bushing insert can be identified by a bright yellow, white, or red (pink) nose opposite the transformer tank.

7.3 Loadbreak Procedure

7.3.1 Remove the protective caps from a clean Feed-thru device or Parking-stand and install on a stand-off position inside the transformer compartment using an approved live line / hot stick tool.

7.3.2 Attach an approved elbow connector tool to the loadbreak elbow. Other approved elbow connector tools are available in the tool catalog on the infonet. Below (picture to the left) is a picture of the Hastings URD elbow connector tool that attaches to an approved live line / hot stick tool. An impact style elbow connector tool is available for elbows that are difficult to remove. The picture to the right is the Hastings Impact Style Elbow Puller.



7.3.3 Without exerting any pulling force rotate the elbow slightly in a clockwise direction. Hold in this position when pulling the elbow. Note: Never turn counterclockwise as this will loosen the bushing well insert. Withdraw the elbow with a fast, firm, straight motion. Be careful not to place the elbow in contact with or near any grounded surface.

7.3.4 Install the elbow on the previously installed Feed-thru or Parking-stand device.

7.4 Load make Procedure

7.4.1 Attach the elbow connector tool to the loadbreak elbow that is to be removed from the feed-thru or parking-stand device.

7.4.2 Withdraw the elbow with a fast, firm, straight motion.

7.4.3 Place the elbow over the bushing inserting the white arc follower portion of the probe into the bushing and immediately thrust the elbow onto the bushing with a fast, firm, straight motion with sufficient force to latch the bushing onto the bushing insert. Ensure the band of the bushing is covered fully by the elbow.

7.4.4 Do not install (close) an elbow into a known fault. If an elbow is unintentionally installed (closed) into a fault, both the loadbreak elbow, bushing insert and probe shall be changed.

7.5 Testing & Grounding

7.5.1 Install a clean loadbreak feed-thru device onto the parking stand bracket.

7.5.2 Insert the loadbreak elbow onto the feed-thru device using an approved live line / hot stick tool.

7.5.3 After the elbow has been inserted onto the feed-thru device, perform a direct test on the cable using an approved voltage tester attached to an approved live line / hot stick tool. An approved bushing adapter shall be installed on the voltage tester and this shall be inserted into the open bushing of the feed-thru device.

7.5.4 If the circuit tests de-energized install the ground end clamp of an approved elbow ground to the system neutral then install the elbow ground into the open bushing of the feed-thru device.

8.0 CAPACITIVE TEST POINTS

8.1 Capacitive test points on dead front equipment are only to be used to indicate that a cable is energized.

8.2 They shall not be used to test a cable as de-energized in preparation for grounding. These test points can be used for indicating live cable only. A direct test shall be performed to prove a cable is de-energized (refer to section 7.5.3).

8.3 These tests points are not 100% reliable in all applications, especially when used on 5kV systems. If a voltage is indicated with the capacitive test point, this reading is normally correct. However, if the test point indicates no voltage, this reading is not always correct. There is a real possibility that there is voltage on the cable in spite of the capacitive test point indication of no voltage.

8.4 Appropriate minimum approach distances must be maintained for all unshielded equipment at all times unless the equipment is isolated, red tagged, test de-energized and grounded. This includes the removal and replacement of the capacitive test point cap if this test point is used.

9.0 D.C. HI-POT FAULT TESTING METHOD

9.1 The D.C. Hi-Pot Adapter is a simple and effective tool for determining the presence of a fault in underground residential distribution systems up to 35 kV. The adapter converts an AC source voltage to a pulsating DC voltage which is used to charge the conductor being tested to a level equal to the operating voltage. A short length of cable will charge in seconds while a long cable may require a minute or more. If the cable being tested has no grounds or faults, the meter will initially increase as the cable charges, but will drop back to near zero when a full charge is reached. A grounded or faulted cable will not fully charge, preventing the meter from dropping back to near zero. Most cables will continue to have a small neutral discharge even though a ground is not present. The longer the section of cable, the larger the discharge will be.

9.1.1 This tool can be used on URD circuits that are direct buried or in conduit. This tool shall not be used to locate a fault in a manhole and duct system.

9.1.2 This tool shall be used to test a cable following repairs and before energizing. The section of cable repaired is the only part of the circuit that needs to be tested.

9.1.3 This tool will not pinpoint the exact location of a fault; it will allow the user to identify a bad section of cable and sectionalize in order to restore power to an area.

9.1.3 After the bad section of cable has been identified and isolated, and power restored to area, the VON Arc Reflection System unit is the Liberty Utilities preferred method to be used for fault locating and to pinpoint the exact location of a fault. To operate the VON unit you must be trained in its operation and follow the manufacturer’s instructions.

9.2 If the location of the fault is not readily identifiable, the cables and equipment shall be sectionalized and tested starting at the source.

9.3 Locating the faulted cable can be performed with an approved voltage tester using the appropriate D.C. Hi-Pot adapter attached and following the manufacturers operating procedure. Note: Use the adapter with the proper voltage rating.

9.4 The DC Hi-Pot Adapter is the preferred tool for locating faulted cables in URDs. Isolating (split & shoot) the cable from the riser pole to first mini-pad transformer and closing the riser fuse, is an optional method that is allowed only after a hazard assessment evaluation has been completed and the job brief has been updated. This assessment should take into consideration if fault indicators have been installed, and checking for operational status, disconnecting of arresters, weather, construction, age, and operations history of URD. The use of additional PPE (earmuffs, face shield, etc.) and telescopic switch stick should be considered during the job brief.

9.5 The cable being tested shall be isolated at both ends during the entire fault testing method.

9.6 A primary system voltage source must be available to perform the D.C. Hi-Pot testing.

9.7 All riser pole arresters and pad-mounted arresters at open or end positions that are effected shall be disconnected before using the fault testing method.

9.8 Method from Riser Pole

9.8.1 Step 1: Isolate the cable from the first pad-mounted transformer or enclosure to the riser pole. Place the cable to be tested on a feed-thru device. The three position feed thru is the preferred device.

9.8.2 Step 2: Install the D.C. Hi-Pot adapter on the end of the meter probe of the phasing meter.

9.8.3 Step 3: Install the hook probe on the adapter to connect to the system voltage source.

9.8.4 Step 4: Install the hook probe to the reel probe of phasing meter in order to connect to the cable terminator at the riser.

9.8.5 Step 5: Attach the reel probe to the cable in question, and then contact the meter probe to the primary source.

9.8.6 If the cable being tested has no grounds or faults, the meter will initially increase as the cable charges, but will drop back to near zero when a full charge is reached. A grounded or faulted cable will not fully charge, preventing the meter from dropping back to near zero.

9.8.7 Discharge the Cable

a. Step 1: Disconnect both probes of the phasing tool from all conductors.

b. Step 2: Remove the bushing adapter, if present from the reel probe.

c. Step 3: Connect the metal hook to the reel probe.

d. Step 4: Attach the reel probe to an appropriate ground, and then contact the meter probe to the test cable in order to discharge the cable.

e. THE TESTED CABLE SHALL BE PROPERLY DISCHARGED TO A GROUND SOURCE AFTER EACH TEST. FAILURE TO DO SO CAN RESULT IN INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT.

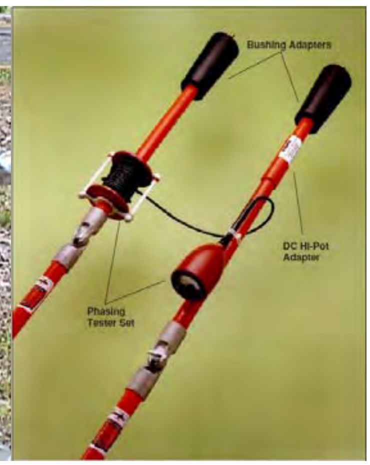
9.9 Method from Pad-Mounted Equipment

9.9.1 Step 1: Isolate both ends of the cable section to be tested being sure any lightning arrestors are disconnected. Place the cable to be tested on a feed-thru device. The three position feed-thru is the preferred device.

9.9.2 Step 2: Install the D.C. Hi-Pot adapter on the end of the meter probe of the phasing meter.

9.9.3 Step 3: Install the required connecting device (e.g., bushing adapter) onto the D.C. Hi-Pot adapter in order to connect with the system voltage source.

9.9.4 Step 4: Install the required connecting device (e.g., bushing adapter) onto the reel probe of the phasing meter in order to connect the cable to be tested.



9.9.5 Step 5: Install the meter probe to the live primary bushing and the reel probe to the cable to be tested. A short length of cable will charge in seconds, while a very long section of cable may require one or two minutes**.**

9.9.6 If the cable being tested has no grounds or faults, the meter will initially increase as the cable charges, but will drop back to near zero when a full charge is reached. A grounded or faulted cable will not fully charge, preventing the meter from dropping back to near zero.

9.9.7 Discharge the Cable

a. Step 1: Disconnect both probes of the phasing tool from all cables.

b. Step 2: Remove the bushing adapter, if present from the reel probe.

c. Step 3: Connect the metal hook to the reel probe.

d. Step 4: Attach the reel probe to an appropriate ground, and then contact the meter probe to the test cable in order to discharge the cable.

e. THE TESTED CABLE SHALL BE PROPERLY DISCHARGED TO A GROUND SOURCE AFTER EACH TEST. FAILURE TO DO SO CAN RESULT IN INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT.

9.10 Method for Ungrounded Faults

9.10.1 If erroneous readings are suspected, verify the results as follows:

9.10.2 Verify and ground the other end of cable that has been isolated.

9.10.3 The cable shall be isolated, red tagged, tested de-energized per NG-EOP G014 Clearance and Control before grounding any cable.

9.10.4 Retest the cable as per sections 9.8 and 9.9.

9.10.5 If the cable test fails to see the grounded condition, then the cable has an open point somewhere in the section because it was unable to "see" the ground at the far end. This condition is possible in Underground Residential Distribution installed in conduit.

10.0 EXCEPTION APPROVALS

It is recognized that situations may arise that are not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Manager of Standards, Policies and Codes and/or a Manager of Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

11.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2013	0	Initial Version of document. Updated National Grid document to be applied to Liberty Utilities.	Robert J Johnson

INTRODUCTION

The purpose of this procedure is to provide instruction on the proper identification of Underground Distribution Cable(s) in order to prevent incidents that may occur as a result of working on the wrong cable which may be energized, and when a live voltage test and grounds cannot be applied at the point of work, such as a cable(s) in a trench or manhole/vault. This procedure shall be used whenever cable insulation must be breached to perform work, and it is not possible to test de-energized and apply grounds without cutting into the cable insulation. The proper identification of abandoned cables in a manhole and duct system is also included in this procedure.

Prior to working on Underground Distribution Cables at voltages above 1000V and up to 46kV the cable shall be, isolated, red tagged, tested to be de-energized and grounded as applicable in accordance with LU-EOP G014, positively identified and guillotined at the point of work to ensure it is not energized.

PURPOSE

This procedure applies to all work performed on underground distribution cables at voltages above 1000V and up to 46kV. This EOP does not cover working on energized cables operating at or below 1000 volts. This EOP does not cover Preassembled Lashed Aerial Cable.

ACCOUNTABILITY

1. Standards, Policies and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements.
2. Electric Distribution Operations
   - A. Ensure the procedures in this EOP are implemented.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide procedure revision input as necessary.
3. Employees
   - A. Demonstrate the understanding of the procedure.
   - B. Comply with the requirements of the procedure.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

OSHA 1910.269 paragraph (t) (5) “Multiple Cables”

Positive Cable Indentification Truck Manual

DEFINITIONS

Barriers: A physical obstruction that is intended to prevent contact with energized lines or equipment or to prevent unauthorized access to work area. Rigid barriers, rubber blankets and arc suppression blankets are used to protect adjacent equipment from damage.

Bonding: The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed (IEEE-100). The electrical interconnecting of conductive parts, designed to maintain common electrical potential (NESC).

Cable Fault: Is a defect in the insulation of the cable which results in an electric failure.

Dead: Isolated, red tagged, tested de-energized and grounded.

De-energized: The absence of normal operating voltages associated with the operation of the system or control circuit. Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth. Note: The term is used only with reference to current-carrying parts, which are sometimes energized (alive). Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means. Note: De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

Effectively Grounded: Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having current carrying-capacity to limit the build-up of voltages to levels below that which may result in undue hazard to persons or to connected equipment.

Energized (Alive, live): Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Grounded: Intentionally connected to earth through a ground connection.

Guillotine: Tool used to intentionally cut the cable through the conductor to prove de-energized from a remote location. Only an approved, properly grounded hydraulic guillotine cable cutter or a grounded eight foot insulated ratchet cable cutter shall be used.

Isolated: Not readily accessible to persons unless special means for access are used. Disconnected from all sources of electrical supply by open switches, disconnects, jumpers, taps, or other means and absent from nominal voltages.

Personal Protective Grounds: Is a term used to describe a set of grounds that provide a short circuiting effect and are connected to a ground source. They shall be adequately sized so as to be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault. The grounds are installed as directed by the Clearance Person and applied for the protection of workers.

Underground Distribution Cables: Cables for use in the Company underground system are available in a variety of types. Examples are: Medium Voltage Cables (Non-URD), URD Primary Cables, Reduced Diameter Cables, Replacement Cable for Paper Insulated Lead Covered (PILC) Cables, Special Use Cables (Jacket Concentric Neutral & PILC), Obsolete Cables (Concentric Neutral& Drain Wire Shield), Submarine Cable and River Cable.

TRAINING

Provided by the appropriate Liberty Utilities Learning and Development training program.

DOCUMENT CONTENTS

Table of Contents

1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and all appropriate Liberty Utilities Electric Operating Procedures.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 The employee in charge of the work shall conduct a written job brief with the employees involved prior to the start of each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

1.4 All underground cables shall be considered energized until proven to be de-energized and grounded.

1.5 **If at any time a cable is thought to be de-energized and grounded and proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted immediately and the System Operator shall be notified.**

1.6 Rubber gloves of the appropriate class shall be worn per the Employee Safety Handbook. Rubber gloves shall be worn when guillotining cable and in the application of electrical signal tracing test equipment/leads.

1.7 During work, barriers or other added safeguards shall be installed to protect adjacent conductors.

1.8 Only approved test instruments shall be used to determine if a cable is de-energized.

1.9 At the work site, cable to be worked on shall be proven to be de-energized by being guillotined from outside the manhole, vault, handhole or trench or tested by other approved methods, before work is begun. The use of testing equipment requires the use of the approved class of rubber gloves.

1.10 All initial guillotine cuts of each cable to be worked on shall be performed from a safe position outside a manhole, vault, handhole or trench. Only an approved, properly grounded hydraulic guillotine cable cutter or a grounded eight foot insulated ratchet cable cutter shall be used. Where the cut will be made, adjacent cables shall be covered with a rubber insulating or arc suppression blanket, or be protected by barriers.

2.0 APPLICABILITY

2.1 This procedure applies to all work performed on underground distribution cables at voltages above 1000V and up to 46kV. This EOP does not cover working on energized cables operating at or below 1000 volts. This EOP does not cover Preassembled Lashed Aerial Cable. If the cable to be work upon does not meet the above criteria then the cable is not applicable to this EOP.

3.0 RESEARCH RECORDS, FIELD SURVEY & EVALUATION

3.1 All available data shall be used to properly identify the cable to be worked on. Relying on a cable tag or any single indication is an inadequate method to affirmatively identify a cable.

3.2 Research all available records and perform a complete and thorough field survey and evaluation. The identification of the cable(s) to be worked upon shall be completed by reviewing all of the following:

3.2.1 System prints and one-line drawings

3.2.2 Cable tags

3.2.3 Duct location

a. If available duct configuration sketches (duct views) shall be used when verifying cables.

b. In areas that don't have duct configuration sketches when the survey of the cable (abandoned or energized) is conducted, duct configuration sketches (duct views) shall be developed. The duct locations, the circuit number of each cable and the relative position of each duct on each wall of the manhole/vault shall be documented for each consecutive manhole/vault. If another crew needs to complete the survey or is going to cut any of the cables the sketches shall be passed on to that crew and be included in their job brief.

3.2.4 Cable size, configuration, dimensions, foot markings

4.0 CLEARANCE & CONTROL

4.1 The cable to be worked shall be isolated, red tagged, tested de-energized and grounded per LU-EOP G014, Clearance and Control. The cables shall be effectively grounded using an approved personal protective ground set in accordance with Liberty Utilities grounding procedures. Reference LU-EOP G014, Clearance and Control, and the appropriate Protective Grounding EOP where applicable.

4.1.1 If the cable is not isolated per LU-EOP G014 it may be an abandoned cable. If it is follow Section 5.

4.1.2 If the cable is isolated per LU-EOP G014 and it is determined grounds are present, visible and can be visually traced to the point of work follow Section 6.

4.1.3 If the cable is isolated per LU-EOP G014 and it is determined the cable needs a minor repair and there is no breach in the insulation follow Section 7.

4.1.4 If the cable is isolated per LU-EOP G014 and it is determined the cable needs to be de-energized to relocate the cable in a trench, manhole, handhole or vault follow Section 8.

4.1.5 If the cable is isolated per LU-EOP G014 and it is determined the configuration of the system allows an electronic signal trace follow Section 9.

4.1.6 If the cable is isolated per LU-EOP G014 and needs to be identified with a fault follow Section 10.

4.1.7 If the de-energized lead covered cable is isolated per LU-EOP G014 and needs to be identified when an electrical signal trace is impossible follow Section 11.

5.0 IDENTIFY ABANDONED CABLES

5.1 Research all available records and perform a complete and thorough field survey and evaluation per Section 3.

5.2 The exposed abandoned cable ends to be worked on shall be tested de-energized before installing test and bonding leads. Rubber gloves shall be worn when testing the cable de-energized. The abandoned cable shall be tested de-energized before shortening any cable to facilitate the removal of that cable. Refer to LU-EOP UG002 when existing de-energized cables that end in a manhole and duct system need to be shortened to facilitate the removal of that cable. In the rare case the abandoned cable ends cannot be located follow the exemption clause in section 12.0.

5.3 The proper identification of the de-energized abandoned cable(s) shall be made by electrical means using an electrical signal tracer, such as the use of a TIMCO or Hipotronics device. **A Hipotronics device shall only be used on three phase circuits, not on single phase circuits.** Each de-energized abandoned cable(s) that will be cut shall be positively identified.

5.4 Once positive identification has been determined, or the exemption clause applied, guillotine the initial cut of each identified intact continuous cable from outside the manhole, vault, handhole or trench using an approved tool. Note: To avoid guillotine damage to adjacent circuits, secure the guillotine from within the manhole, handhole or vault or from above the manhole, handhole or vault as needed. Rubber gloves shall be worn when guillotining the cable(s).

5.5 If a cable will not be guillotined at the same time that the cable is identified, install the appropriate positive cable identification tag. The tag is only valid for a maximum of 14 days. After this time period the cable shall be re-identified with an electrical signal tracer before the initial cut. The tag shall be filled out completely and secured to the cable with a nylon cable tie. Contact your supervisor or stores person for the appropriate positive cable identification tag.

6.0 DETERMINE IF GROUNDS ARE PRESENT, VISIBLE AND CAN BE VISUALLY TRACED TO THE POINT OF WORK

6.1 If cutting a cable at the point of work where protective ground placement is visible and cable identification can be visually verified the cable would not have to be identified by an electrical signal tracer.

6.2 **If cables cannot be visually traced back and protective grounds are not visible, then an electrical signal trace shall be performed.** Follow Section 9 of this EOP.

6.3 If the ground(s) are present, visible **and can be visually traced back to** the point of work, guillotining of the cable would not be necessary.

6.4 The Job Brief shall indicate the crew is proceeding without performing the electrical signal tracing step.

7.0 DETERMINE IF THE CABLE NEEDS A MINOR REPAIR AND IF THERE IS NO BREACH IN THE INSULATION

7.1 If the cable is de-energized to make a repair to the outer jacket or sheath, the cable shall be properly identified by electrical means. Follow Section 9 of this EOP.

7.2 If the cable cannot be properly identified by electrical means follow the exemption clause in Section 12 of this EOP.

7.3 If repairs are needed to the outer jacket or lead sheath of a cable that does not have a breach in the cable insulation, the cable is not required to be guillotined.

8.0 DETERMINE IF THE CABLE NEEDS TO BE DE-ENERGIZED TO RELOCATE THE CABLE IN A TRENCH, MANHOLE, HANDHOLE OR VAULT

8.1 If a cable is de-energized to relocate the cable in a trench, manhole, handhole or vault, the cable shall be properly identified by electrical means per Section 9 of this EOP but is not required to be guillotined.

8.2 If the cable cannot be properly identified by electrical means follow the exemption clause in Section 12 of this EOP.

9.0 IDENTIFY DE-ENERGIZED CABLES

The preferred method to positively identify all de-energized cables prior to guillotining is outlined below.

9.1 The proper identification of the de-energized cable(s) shall be made by electrical means using an electrical signal tracer, such as the use of a TIMCO or Hipotronics device. **A Hipotronics device shall only be used on three phase circuits, not on single phase circuits.** Each de-energized cable(s) that will be cut shall be positively identified or the exemption clause in Section 12 applied.

9.2 Once positive identification has been determined guillotine the initial cut of each identified cable from outside the manhole, vault, handhole or trench using an approved tool. Note: To avoid guillotine damage to adjacent circuits, secure the guillotine from within the manhole, handhole or vault or from above the manhole, handhole or vault as needed. Rubber gloves shall be worn when guillotining the cable(s).

9.3 If a cable will not be guillotined at the same time that the cable is identified, install the appropriate positive cable identification tag. The tag is only valid for a maximum of 14 days. After this time period the cable shall be re-identified with an electrical signal tracer before the initial cut. The tag shall be filled out completely and secured to the cable with a nylon cable tie.

10.0 IDENTIFY CABLE IN THE EVENT OF A FAULT

10.1 Cable identification shall be made utilizing an electrical signal tracer whenever possible. In cases where it is not possible to utilize an electrical signal tracer due to the condition of the faulted cable and or test results are inconclusive, proceed using the visible identification method.

10.2 Visible Identification Method: To verify a visible cable fault an employee shall see exposed conductor strands or damage to the cable insulation, which can and shall be verified by a flash generated by a signal generator (thumper) at the point of origin of the fault. If the fault is not visible by seeing exposed conductor strands and damage to the cable insulation an employee shall use a signal generator (thumper) to verify the fault by generating a visible flash and/or audible thump at the origin of the fault.

10.3 However, if a faulted cable cannot be identified by a signal generator, an electrical signal tracer or by visual means, due to the configuration of the system or location of the fault, the crew leader or crew chief shall determine if it is safe to guillotine the cable without first identifying the cable as outlined in this EOP. This shall be documented on the Job Brief.

10.4 If the faulted cable that needs to be guillotined is lead cable:

10.4.1 The lead sheath can be removed, a voltage test performed within the manhole/vault or trench and then guillotined from outside the manhole/vault or trench.

10.4.2 The cable can be guillotined from outside the manhole/vault or trench without chipping lead.

10.4.3 Follow Section 11 of this EOP when chipping lead or removing a lead sleeve.

10.5 If the faulted cable that needs to be guillotined is a cable type other than lead the only option is to guillotine the cable from outside the manhole/vault or trench.

11.0 IDENTIFY DE-ENERGIZED LEAD COVERED CABLES WHEN AN ELECTRICAL SIGNAL TRACE IS IMPOSSIBLE

For cables operating above 1000V, guillotining is the preferred method to prove lead cables to be de-energized. This portion of the procedure can be used to positively identify de-energized lead cable when it cannot be identified electrically. This portion of the EOP is for lead covered cable at voltages above 1000V and up to 46kV. Appropriate rated rubber gloves shall be used for the voltage level of the lead cable being tested de-energized. All other parts of this EOP are applicable. If at any time a cable that is thought to be de-energized and grounded and proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be immediately contacted and the System Operator shall be notified.

11.1 Removing lead to test cables de-energized

11.1.1 Removing lead at voltages above 1000v and up to 5kV:

a. Remove the appropriate length of lead for the voltage class across the test area. The lead removal requirements should match the splicing dimensions whenever possible.

b. Perform a voltage test with an approved proximity test device.

c. Remove any shielding tapes and perform a voltage test on the insulation.

d. Cut steps into the paper/rubber insulation checking for voltage after each cut.

e. Perform a voltage test on the conductor with an approved proximity test device.

f. The initial cut shall be with an approved, properly grounded hydraulic guillotine cable cutter or a grounded eight foot insulated ratchet cable cutter from a safe position outside the manhole/vault or trench.

11.1.2 Removing lead at voltages of 15kV, 25kV, 35kV and 46kV:

a. Appropriate rated rubber gloves shall be used for the voltage level of the lead cable being tested de-energized.

b. Remove the appropriate length of lead for the voltage class across the test area. The lead removal requirements should match the splicing dimensions whenever possible.

c. Perform a voltage test with an approved proximity test device.

d. Remove any shielding tapes and perform a voltage test on the insulation with an approved proximity test device.

e. The initial cut shall be with an approved, properly grounded hydraulic guillotine cable cutter or a grounded eight foot insulated ratchet cable cutter from a safe position outside the manhole/vault or trench.

11.2 Removing a lead sleeve to break down and test splice de-energized

11.2.1 Removing a lead sleeve at voltages above 1000v and up to 5kV:

a. Remove the lead splice sleeve.

b. Remove enough filling compound to expose the individual phases.

c. Perform a voltage test with an approved proximity test device.

d. Remove any shielding tapes and perform a voltage test on the insulation.

e. Cut steps into paper/rubber insulation checking for voltage after each cut.

f. Perform a voltage test on the conductor with an approved proximity test device.

g. The initial cut shall be with an approved, properly grounded hydraulic guillotine cable cutter or a grounded eight foot insulated ratchet cable cutter from a safe position outside the manhole or vault.

11.2.2 Removing a lead sleeve at voltages of 15kV, 25kV, 35kV and 46kV:

a. Appropriate rated rubber gloves shall be used for the voltage level of the lead cable being tested de-energized.

b. Remove the lead splice sleeve.

c. Remove enough filling compound to expose the individual phases.

d. Perform a voltage test with an approved proximity test device.

e. Remove any shielding tapes and perform voltage test on the insulation with an approved proximity test device.

f. The initial cut shall be with an approved, properly grounded hydraulic guillotine cable cutter or a grounded eight foot insulated ratchet cable cutter from a safe position outside the manhole or vault.

12.0 EXEMPTION CLAUSE

Only after all procedural steps have been exhausted to electrically identify the underground distribution cable(s) may this exemption apply.

12.1 The purpose of this EOP is to properly identify the circuit by electrical means using an electrical signal tracer, such as the use of a TIMCO or Hipotronics device per Section 9 of this EOP.

12.2 However, if the circuit cannot be identified by electrical means, due to the configuration of the system, the crew leader or crew chief shall determine if it is safe to guillotine the cable without first identifying the circuit by electrical means. **Without the ability to perform cable identification by electrical means, the crew leader or crew chief must rely solely on the actions taken per section 3.0 to verify the cable is correctly identified.**

12.3 Examples of configurations where it may be impossible to identify a circuit by electrical means include circuits that contain Oil Fused Cutouts or Oil Switches and portions of an underground circuit that have a live end seal. The job brief shall be used to document that the crew is proceeding using this exemption.

12.4 If the cable that needs to be guillotined is lead cable:

12.4.1 The lead sheath can be removed, a voltage test performed within the manhole/vault or trench and then guillotined from outside the manhole/vault or trench.

12.4.2 The cable can be guillotined from outside the manhole/vault or trench without chipping lead.

12.4.3 Follow Section 11 of this EOP when chipping lead or removing a lead sleeve.

12.5 If the cable that needs to be guillotined is a cable type other than lead the only option is to guillotine the cable from outside the manhole/vault or trench.

13.0 DECISION TREE – Exhibit A

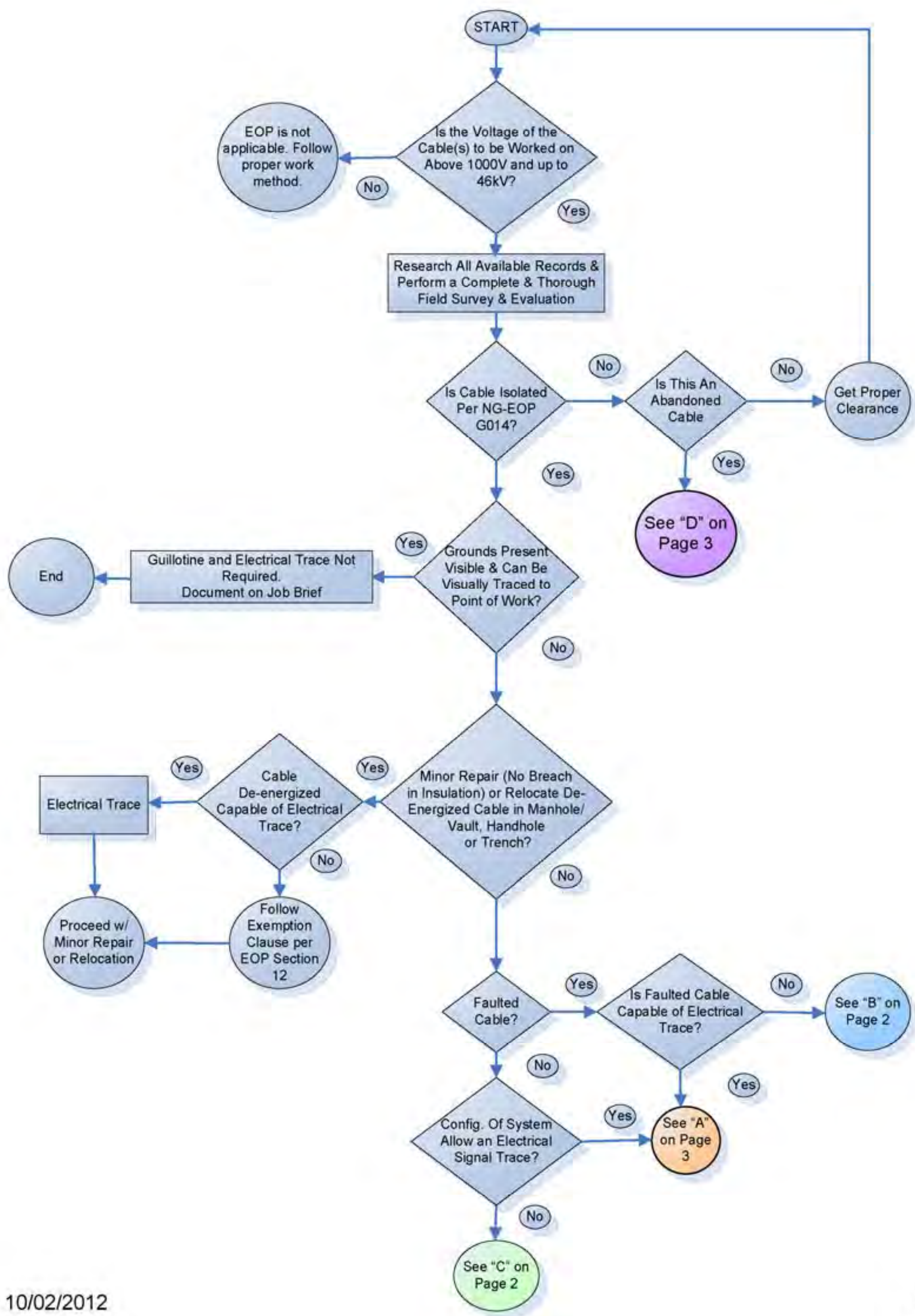
The decision tree is not all inclusive and shall be used as a job aid for this EOP. Employees shall be knowledgeable of the full content and requirements of this EOP.

14.0 EXCEPTION APPROVALS

It is recognized that situations may arise that are not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Program Manager Engineering Standards, Policies, and Codes and a Manager of Corporate Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

Liberty Utilities	Doc. # LU-EOP UG013		
Electric Operating Procedure	**03-01-2015**	**Underground**	
Positive Identification of De-Energized UG Cables	**Revision #**	**1.0**	**Page: 12 of 15**

Exhibit A



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LU-EOP UG013 – Positive Identification of De-Energized UG Cables	Originating Department: Standards, Policies, & Codes	Author: Robert J Johnson

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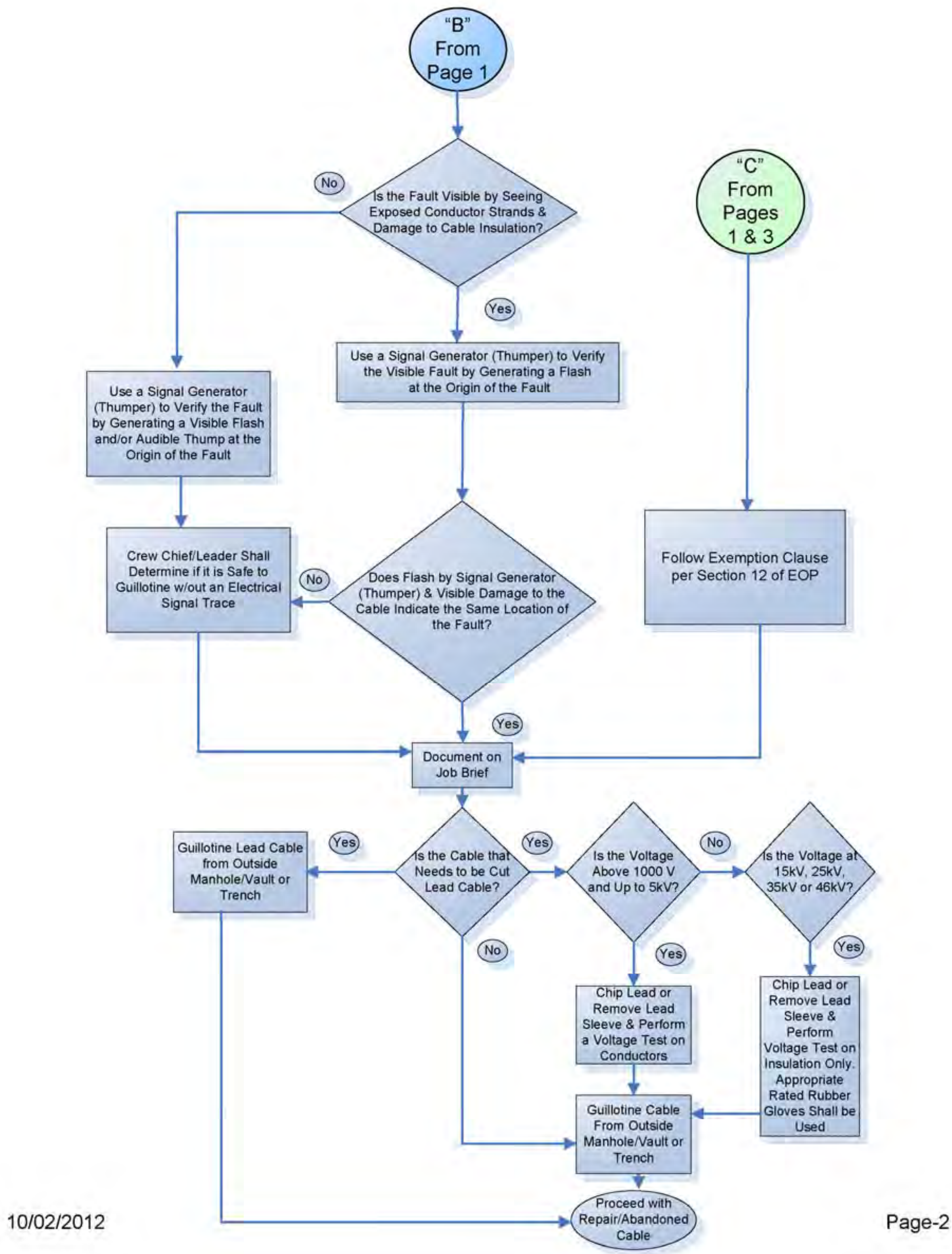
Liberty Utilities	Doc. # LU-EOP UG013		
Electric Operating Procedure	**03-01-2015**	**Underground**	
Positive Identification of De-Energized UG Cables	**Revision #**	**1.0**	**Page: 13 of 15**



Liberty Utilities	Doc. # LU-EOP UG013		
Electric Operating Procedure	**03-01-2015**	**Underground**	
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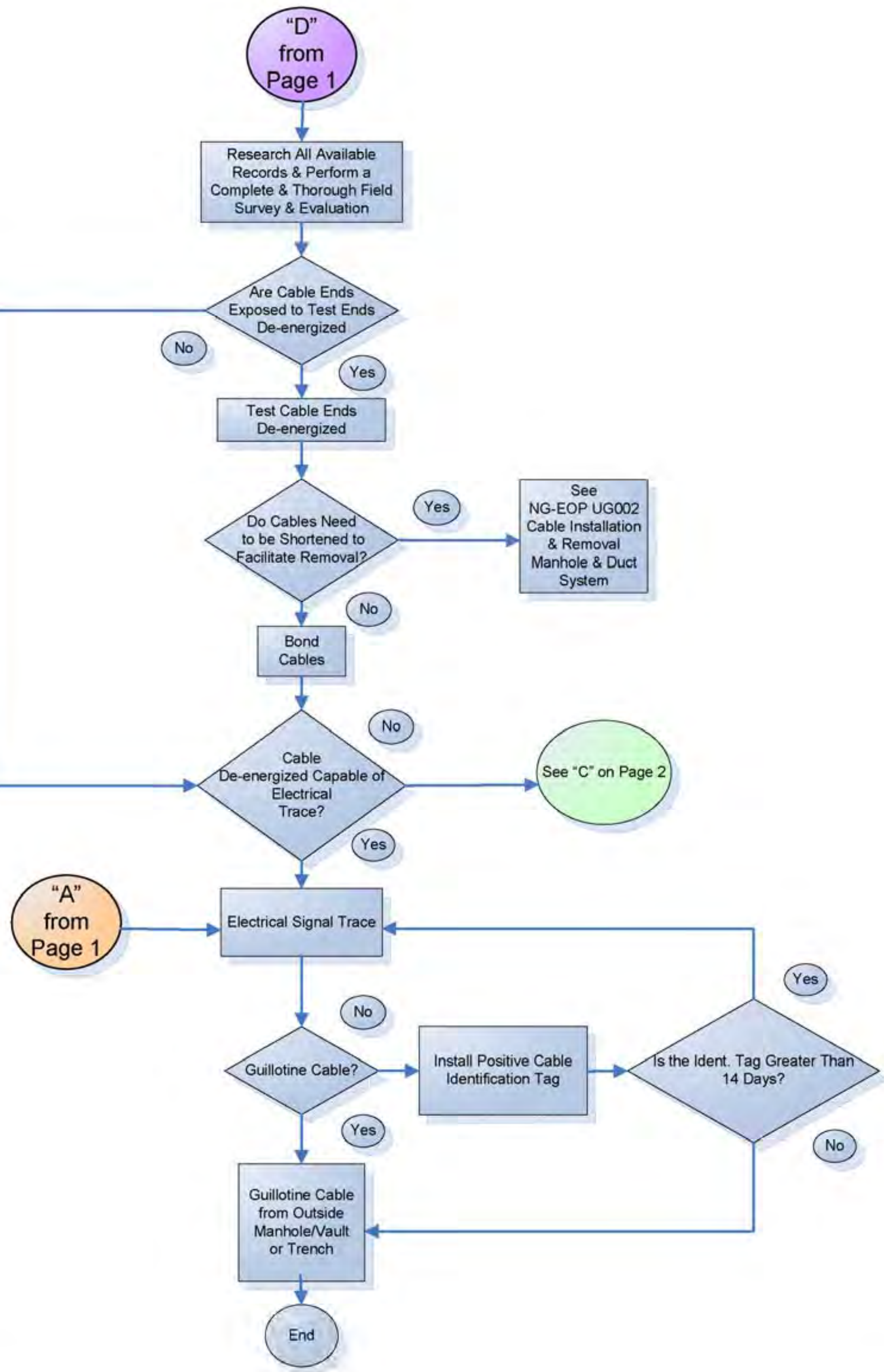

10/02/2012 Page-3

15.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
03/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

INTRODUCTION

This Electrical Operating Procedure (EOP) establishes a consistent method, practice, and preferred tool for identifying and marking primary cables across the underground systems of Liberty Utilities, as well as other acceptable tools for phase identification.

PURPOSE

This procedure applies to all personnel involved with the installation, splicing and terminating of primary underground cable.

ACCOUNTABILITY

1. Standards, Policies and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support upon request.
2. Electric Distributions Operations
   A. Ensure the components of the procedure are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.
3. Liberty Utilities Employees and Contractors
   A. Demonstrate the understanding of the procedure.
   B. Comply with the requirements of the procedure.
   C. It is the workers responsibility to read, understand, and follow the vendors instruction manual and specification before operating any equipment.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures
EOP UG002 Cable Installation and Removal Manhole and Duct System
EOP G021 Overhead and Underground Secondary Connections
Liberty Utilities Distribution Construction Standards
Manufacturers Operating Instructions
Work Methods Bulletin # 09-04

DEFINITIONS

Cable: A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

Conductor: A material, usually in the form of a wire, cable or bus bar suitable for carrying an electric current.

Continuity Tester: Electrical test equipment used to determine if an electrical path can be established between two points; that is if an electrical circuit can be made. The circuit under test must be completely de-energized prior to connecting the apparatus.

Grounded: Intentionally connected to earth through a ground connection.

In Phase: An expression used when the electrical value measured between two-phase conductors of either the same or a different electrical system results in an approximate 0 voltage.

Neutral Conductor: A system conductor other than a phase conductor that provides a return path for current to the source. Not all systems have a neutral conductor. An example is an ungrounded delta system containing only three energized phase conductors.

Phasing: An electrical testing procedure that is used to determine the phase angle relationship between the phase conductors at an open point to phases of either the same circuit or to a different electrical circuit.

Primary Voltage: All distribution circuit cable or conductors energized at 4, 15, 23 or 35 kV.

Secondary: Utility wiring energized at 600 volts or below.

Voltage Testing: Testing when applied voltages result in voltages greater than 50 volts. This includes but not limited to Fault Finder, Power Factor, Insulation Resistance measurements, TTR, Hi-Pot, or System Voltages, etc. Appropriate minimum approach distances shall be maintained within the area under test.

TRAINING

Provided in appropriate Liberty Utilities L&D training programs for personnel and as requested

Liberty Utilities	Doc. # LU-EOP UG014		
Electric Operating Procedure	03-01-2015	Underground	
Phase Labeling of Newly Installed or Existing Primary Underground Cables Including Aerial Cable	Revision #	1.0	Page: 3 of 7

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1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any Liberty Utilities EOP's utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment (PPE), which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 The employee in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and PPE requirements.

1.4 All underground cables shall be considered energized until the cable is isolated, red tagged, tested de-energized and grounded.

1.5 If at any time a cable that is thought to be de-energized and grounded proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted and the System Operator shall be notified.

1.6 Rubber gloves of the appropriate class shall be worn until the cable is proven to be isolated, red tagged, tested de-energized and grounded.

1.7 During work, barriers or other appropriate protection shall be installed to protect adjacent conductors.

1.8 All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Refer to your supervisor for approved tools and equipment.

2.0 GENERAL

2.1 Phase identification of electrical conductors at all open points will ensure that there is no difference of potential when closing switches or connecting cables. Improper phase identification may damage the equipment involved, cause circuit interruptions, or lead to employee injuries.

3.0 PHASE MARKING OF PRIMARY CABLES

3.1 Always identify the correct phase marks on newly installed underground cable or when working on existing underground cables in manholes, vaults, URD's and UCD's. Temporary phase markings (colored tape markings of any color other than white, grey or green) shall not take the place of permanent phase markings with plastic tags and holders (Std Item. UP21). Individual tags are available with a variety of numbers and phrases and can be found in stores. Refer to the Liberty Utilities Underground Standards Book Sections 35.16.10, 45.15 and 44.23 (Cable Tags) for proper use of cable tags. **<u>Always</u>** verify phase markings on existing underground cable!

3.2 Identification of Multiple Phase Conductors at the Splicing or Termination Point:

3.2.1 Newly installed cables shall be properly identified by verification of the manufacturers phase markings stamped on the cable jacket. Temporary phase markings (colored tape markings of any color other than white, grey or green) shall be installed on each end of the cable before splicing or terminating and shall match the manufacturers phase markings. The placement of temporary phase marks emphasizes that the employee verified the manufacturer's phase marks. This will make the phases easily identifiable.

Employees may utilize either of the following methods as long as they have been trained on, are familiar with and understand the use of the markings:

3.2.2 Use a different color of tape (colors other than white, grey or green) to identify each of the phase conductors. The color of tape that is chosen to indicate a specific phase shall be used on all sub-conductors within that phase when parallel conductors exist.

3.2.3 Use any one color of tape (colors other than white, grey or green) and place one tape mark for phase conductor (1) or A, two tape marks for phase conductor (2) or B, and three tape marks for phase conductor (3) or C. If the installation consists of parallel conductors each sub-conductor within each phase grouping shall be marked with identical markings.

Note: All primary triple wound underground cable now ordered by Liberty Utilities shall have the phase markings A phase or 1, B phase or 2, and C phase or 3 clearly marked on the cable jacket.

CAUTION: If at any time the temporary phase marks do not match the manufacturer's phase marks, the job should be stopped until the situation is rectified.

3.2.4 Newly installed cables without manufacturers phase marks, or existing cables without manufacturers phase markings shall be identified by means of a continuity test or other electronic means to properly determine each phase. Only approved Liberty Utilities test equipment may be used to identify phases. Each of the individual cables must be identified with temporary phase marks (colored tape markings of any color other than white, grey or green)

Employees may utilize either of the following methods as long as they have been trained on, are familiar with and understand the use of the markings:

3.2.5 Use a different color of tape (colors other than white, grey or green) to identify each of the phase conductors. The color of tape that is chosen to indicate a specific phase shall be used on all sub-conductors within that phase when parallel conductors exist.

3.2.6 Use any one color of tape (colors other than white, grey or green) and place one tape mark for phase conductor (1) or A, two tape marks for phase conductor (2) or B, and three tape marks for phase conductor (3) or C. If the installation consists of parallel conductors each sub-conductor within each phase grouping shall be marked with identical markings.

CAUTION: Always identify the correct phase markings when installing any new underground cable or when working on an existing underground cable. Temporary phase markings shall not take the place of permanent phase markings. Always verify phase markings on existing underground cables.

4.0 SOME TYPICAL TOOLS USED FOR PHASE IDENTIFICATION ACROSS LIBERTY UTILITIES TERRITORY.

It is the workers responsibility to read and fully understand the manufacturer's instruction manual before using any of the devices listed in this document.

Tools used for phase identification of primary cables:

4.1 HD Electric Cable identification tool (PF-50)

4.1.1 This tool identifies the correct phases of de-energized and discharged cables. It consists of a transmitter and receiver that are designed to be handheld or can be used with hot sticks. The PF-50 can test a mile of cable. Red LED's on both units indicate that the PF-50 units are connected to the same cable. **This is the preferred tool for phase identification to be used at Liberty Utilities.**

4.2 Continuity tester flashlight

4.2.1 The continuity tester flashlight consists of a flashlight and two leads. Circuits ending in remote positions can be tested using two circuit continuity testers in series. Connect the black lead of one tester to the cable to be identified and the red lead to ground. A continuous circuit is signaled when both testers light. Although this tool is still being used in some areas it is no longer being manufactured.

4.3 Timco

4.3.1 This unit is powered by 120 volts A.C. or batteries and allows the user to identify cables. It works by sending a series of pulses along the conductor of the cable to be identified and uses the cable sheaths to complete the circuit back to the instrument.

4.4 Megger

4.4.1 A Megger is a portable, self contained instrument designed to give rapid and accurate measurement of insulation resistance and/or presence of a grounded condition on the conductor. It can also be used to identify phases by sending voltage along the conductor of the phase to be identified with a ground attached to that phase. If the Meggar shows that phase grounded it is correctly identified.

4.5 Hipotronics PTC-2 Cable Identifier and Phase Tracer

4.5.1 This unit runs on 120 volts A.C. The current transmitter puts a series of low voltage (less than 30 volts) D.C. pulses along the conductors. A battery powered detector is used in a manhole or trench, or the far end of the cable to identify phases by the number of pulses.

Note: All phases shall be tested against each other to verify that they have been properly identified. i.e. A phase to A phase (correct), A phase to B phase (incorrect), A phase to C phase (incorrect) and so on for B and C phase.

Exception approvals:

It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Program Manager of Work Methods, Engineering Services and a Manager of Corporate Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
3/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG016		
Electric Operating Procedure	10-01-2015	Underground	
Padmounted Switchgear	Revision #	1.0	Page: 1 of 24

INTRODUCTION

The purpose of this procedure is to provide for appropriate operation of 15kV PMH style pad-mounted switchgear, and other padmount units, up to 34.5kV. Areas addressed are operation of the switch mechanism, proper grounding techniques, de-energization, removal and replacement of fuses, removal and replacement of barriers, installation of cable, inspection of units, the use of insulated barrier boards and working within switch and fuse compartments. Metal enclosed pad-mounted switchgear are designed for use in underground distribution, both residential and commercial. The design offers a combination of switches and fuses for sectionalizing and protection of circuits.

This procedure is to be utilized for S&C Mark III, Mark II and PMH style switchgear, EEI switchgear (units with integral fuse interruption capability), PME Dead Front Switchgear, Cooper Dead-front Switchgear Liberty Utilities owned pad-mounted unit, and metal enclosed customer owned switchgear up to 34.5kV S&C Mark II pad mounted switchgear. S&C Mark II switchgear are equipped with non load break fuse mountings. Use of the Loadbuster tool to open the fuses in S&C Mark II switchgear is not allowed. The fuse compartment shall be de-energized by either opening the line side switch(es) feeding the fuse compartment or de-energizing the complete switchgear from another location prior to opening any of the fuses. When S&C Mark II switchgear are encountered in the field the fuse side shall be tagged with a “DANGER-DO NOT OPERATE ENERGIZED” (Electromark tag NIM151-J-P9-GH4) and identified on operating maps. The tags can be purchased through Power Sales Group, Inc. at 1-978-535-9800. The closing (load-making) of the fuses is permitted with the switchgear energized.)

Only qualified workers may perform work on or near exposed energized parts.

All work will be performed in accordance with any and all Liberty Utilities Employee Safety Handbook rules and/or Liberty Utilities EOP’s utilizing all appropriate safe work methods.

All appropriate Personal Protective Equipment, which includes, but is not limited to, hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

Class #2 Rubber gloves shall be worn when performing any of the following functions on pad-mounted switchgear: Unlocking or opening any compartment doors, operation of any switches or fuses, testing, installing or removing grounds, removing or installing barriers.

The employee in charge shall conduct a job briefing with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

Per Work Methods Bulletin #11-10, Padlocks for Liberty Utilities Owned Pad-Mounted Equipment, Liberty Utilities requires energized pad-mounted equipment be continuously secured with a short shank padlock (a Penta head bolt by itself does NOT replace the need for a padlock). The only exception to this requirement is when pad-mounted equipment is attended by a qualified Liberty Utilities employee or representative. When the equipment is unsecured an attendant must be in a position to prevent unauthorized entry.”

Refer to LU-EOP G018 for the procedure to phase PMH style pad-mounted switchgear.

PURPOSE

This procedure shall apply whenever personnel perform work on pad-mounted switchgear.

ACCOUNTABILITY

1. Engineering Standards, Policies, and Codes
   A. Update procedures as necessary.
   B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements

2. Electric Distribution Operations
   A. Ensure that the procedures in this standard are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   A. Demonstrate the understanding of the procedures in this standard.
   B. Comply with the requirements of the procedures in this standard.
   C. It is the workers responsibility to read and fully understand and follow the vendors instruction manual and specifications.

REFERENCES

Code of Federal Regulations 29CFR1910.269 (I) working on or near exposed energized parts
National Electric Safety Code
Liberty Utilities Employee Safety Handbook
Liberty Utilities Underground Construction Standards
Liberty Utilities Distribution Standards Material Specifications
Liberty Utilities LU-EOP D009
Manufacturer Instructions
Liberty Utilities Work Methods Bulletin #05-28
Liberty Utilities Work Methods Bulletin #11-10
Liberty Utilities Work Methods Bulletin #08-19
Liberty Utilities Work Methods Bulletin #03-05
Liberty Utilities Work Methods Bulletin #04-22
Liberty Utilities Work Methods Bulletin #05-16
Liberty Utilities Work Methods Bulletin #06-03
Liberty Utilities Work Methods Bulletin #06-05
Liberty Utilities Work Methods Bulletin #13-17

DEFINITIONS

Barrier: A physical obstruction that is intended to prevent contact with energized lines, equipment or to prevent unauthorized access to work area. Rigid barriers, rubber blankets, arc suppression blankets, and/or blast blankets are used to protect adjacent equipment from damage.

Clearance (for work): Permission to an Authorized Person to perform specified work within a zone of protection.

Clearance Person: The person holding the Clearance.

Dead: Isolated, red tagged, tested de-energized and grounded.

Dead-Front (switchgear): Without live parts exposed to a person on the operating side of the equipment.

De-energized: Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means. **Note:** De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Fuse Grappler Tool: By design, this tool helps remove, install and operate power fuses and barriers in padmount switchgear. It is made to be attached to an insulated universal stick.

Live-Front (switchgear): With live parts exposed to a person on the operating side of the equipment.

Minimum Approach Distance (M.A.D.): The closest point of approach to energized lines or equipment by a qualified employee or by any conductive object, without the use of insulating gloves, sleeves, or portable protective devices. **Note:** Table R-6 in OSHA 1910.269 defines the Minimum Approach Distances to be followed by a qualified employee while working near energized lines and equipment.

Qualified Person: A person knowledgeable in the construction and operation of electric power generation, transmission, substation, and/or distribution apparatus involved along with the associated hazards in specific duties pertaining to electric operations.

Shall: The word shall is to be understood as mandatory.

Should: The word "should" indicates provisions that are normally and generally practical for the specified conditions.

Underground Commercial Distribution (UCD): An underground electrical supply system using at-grade transformers and switchgear to serve commercial or industrial customers.

Underground Residential Distribution (URD): URD construction methods are typically used for residential areas. They consist of buried cables, either direct buried or in ducts, with pad-mounted or subsurface transformers.

TRAINING

Provided by the appropriate Liberty Utilities training program.

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1.0 PMH, MARK II AND MARK III STYLE PAD-MOUNTED UNIT:

Per S&C operating instructions a Grappler tool **shall** be used when installing and removing barrier boards, opening and closing fuses or lifting fuses in or out of their cradle on the following S&C live-front switchgear (PMH, Mark II and Mark III). The only exceptions to the use of the Grappler tool are with S&C PME style dead-front, Vista switchgear and note below. Follow the manufacturer's instructions and LU-EOP UG016 when operating these units.

NOTE: **Exception to using the Grappler tool to remove or install barrier boards:**

The first requirement is to always follow the manufacturer's recommendations by using the Grappler tool. In the case that the barrier board has a missing, broken or flattened tab and the Grappler tool cannot be used, it is acceptable to use an approved live line / hot stick tool to lift the barrier board from the bottom, away from the energized switchgear components to a point outside of Minimum Approach Distance and with appropriately rated rubber gloves lift the board off the tabs and remove from the switchgear. If possible the board should be replaced with a new board (item id 9306440 for fuse side barrier board and item id 9306441 for switch side barrier board) with working tabs (item id 9306439) or the original board shall be turned around so the good tab is facing out. If the tab is operable the Grappler tool shall be used to re-install the board. If the tab is not operable, the board may be installed with appropriately rated rubber gloves and an approved live line / hot stick tool in the reverse order of removing while continuing to maintain Minimum Approach Distance.

1.1 Opening/Inspection of Units

1.1.1 Class #2 rubber gloves shall be worn when unlocking and opening compartment doors.

1.1.2 Verify that the unit is properly bonded to ground.

1.1.3 Verify that you are at the correct location. Check the switchgear number, switch number and compartment location.

1.1.4 Verify the manufacturer, model and type.

1.1.5 S&C Mark II Switchgear have additional hazards and operating instructions discussed in the Introduction section of this document. S&C Mark II Switchgear can be easily identified by the nameplate information. Many S&C Mark II Switchgear units also have two hasps, one top and one bottom, to lock the compartment doors instead of one penta head bolt latching mechanism. A qualified employee shall not continue until they have a thorough understanding of the limitations and special instructions for this type of switchgear.

1.1.6 Conduct a visual inspection of the barrier boards for signs of deterioration, tracking and contamination.

1.1.7 When the switchgear is opened for any reasons the following inspections shall be conducted:

a. The condition and integrity of the doors, panels and locking fixtures shall be checked. Ensure that penta bolts are installed and tight. Ensure that locks are installed.

b. The condition and readability of all markings shall be checked.

c. Visually check the general overall condition of the switchgear. Excessive accumulation of dirt or condensation shall be reported for future cleaning, if conditions permit the unit should be isolated, red tagged, tested de-energized and grounded and cleaned when opened.

d. Observe the barriers for proper position and condition. The barriers shall be in the vertical position unless work is being performed on the unit.

e. Inspect the slide-in barrier: look for signs of electrical activity, i.e., tracking, burning, etc., warping, mechanical or moisture damage. If there is evidence of these signs, replace the affected barriers. The S&C Mark II switchgear utilized an older style barrier board. Due to the combination of the age of the unit and the design of the barrier board a thorough inspection of the barrier boards and the switchgear shall be conducted.

f. Check for any signs of burning, flashover or tracking. These conditions shall be reported.

g. If there are signs of burning, flashover or tracking the barrier should be cleaned with denatured alcohol or other approved cleaner. Dry the barriers. Do not place the barriers on the ground or other contaminated surfaces. The barriers in S&C Mark II Switchgear shall only be wiped clean.

h. Check the condition of foundations for cracks, general deterioration, level, tipping, etc. There shall be no exposed holes above the ground. Any voids or openings between the switchgear and the top of the vault pad shall be caulked with sealing compound (STD Item S2).

1.1.8 Operation of Switch Mechanism

a. Class #2 rubber gloves shall be worn when unlocking and opening compartment doors. Verify that unit is properly bonded to ground.

b. With the compartment door braced in the open position, wearing Class #2 rubber gloves, remove the appropriate front barriers using an approved live line/hot stick tool utilizing the fuse Grappler.

c. Visually check the position of the switch by observing the switch blades. Conduct a thorough visual inspection of the switch, insulators and operating mechanism to determine any defects which may impair proper operation.

d. Re-install the barriers in the vertical position using an approved live line/hot stick tool utilizing the fuse Grappler tool, close and secure the doors.

e. Unlock and open the appropriate switch operating control panel.

f. Install the switch operating control handle and operate the switch to the desired position following the manufacturer's recommended instructions.

g. Open the cabinet and verify the switch operation by observing blade position of switch (note the blades may be energized when the switch is in the open position).

Note: The front barriers shall not be left in the diagonal position. The front barriers shall be left in their normal suspended position.

1.1.9 Procedure for Working within the Switch Compartment:

a. Option 1: Any work that cannot be performed with an approved live line/hot stick tool while maintaining proper clearances for the voltage being worked shall require the unit to be isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 – Clearance and Control.

b. Option 2: In lieu of isolating, red tagging, testing, de-energizing and grounding the entire switchgear the use of an approved insulated barrier board may be used. These boards take the place of the existing S&C barrier boards. They are designed to be installed by hand wearing class #2 rubber gloves, while not breaking M.A.D. THESE ARE FOR USE IN S&C PMH STYLE SWITCHGEAR ONLY. If working on any other type of switchgear option 1 shall be followed. See section (1.1.18) for detailed instructions for using the insulated barrier boards.

1.1.10 Procedure for Working within the Fuse Compartment:

a. Option 1: Any work that cannot be performed with an approved live line/ hot stick tool while maintaining proper clearances for the voltages being worked shall require the unit to be isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 – Clearance and Control.

b. Option 2: In lieu of isolating, red tagging, testing, de-energizing and grounding the entire switchgear the use of an approved insulated barrier board may be used. These boards take the place of the existing S&C barrier boards. They are designed to be installed by hand wearing class #2 rubber gloves, while not breaking M.A.D. THESE ARE FOR USE IN S&C PMH STYLE SWITCHGEAR ONLY. If working on any other type of switchgear option 1 shall be followed. . See section (1.1.18) for detailed instructions for using the insulated barrier boards.

1.1.11 De-Energization and Removal of Fuses - Three Phases - S&C Mark II Switchgear.

a. The following de-energization and fuse removal procedure describes equipment which requires the use of a Grappler tool attached to an approved live line/hot stick tool. Fuses in an S&C Mark II switchgear do not have load break capability and shall only be operated to the open position when they are de-energized.

b. The fuse compartment shall be de-energized by either opening the line side switch(s) feeding the fuse compartment or de-energizing the complete switchgear from another location.

c. Test the fuse compartment de-energized.

d. Remove the barrier associated with the fuse to be opened using the Grappler tool attached to an approved live line/hot stick tool.

e. Open that de-energized fuse using the Grappler tool attached to an approved live line/hot stick tool.

f. Place that barrier in the diagonal position using the Grappler tool attached to an approved live line/hot stick tool.

g. Remove that fuse from this position in the approved manner using the Grappler tool attached to an approved live line/hot stick tool.

h. Hang the barrier associated with the fuse that was removed in its normal suspended position using the Grappler tool attached to an approved live line/hot stick tool.

i. To de-energize and remove the two other fuse positions repeat steps a through h.

Note 1: The front barriers shall not be left in the diagonal position. The front barriers shall be left in their normal suspended position.

Note 2: Caution shall be used when handling fuses to ensure that contact is not made between the live parts and grounded parts of the unit. Either or both ends of the fuse or fuse holder may be energized.

Note 3: Although the procedures listed above are listed as specific to the S&C Mark II switchgear, the same procedures shall be utilized an all fuses that are not of the load break interrupting type.

Note 4: Fuses that do not have integral interrupting capability may be encountered by Liberty Utilities Employees in either customer owned or non-PMH style switchgear. Opening of any fuses in switchgear with non-integral interrupting fuses shall be accomplished following the same procedures as listed for the S&C Mark II.

1.1.12 De-Energization and Removal of Fuses - Three Phase - S&C Mark III & PMH Style Switchgear, EEI/PSI I & II Switchgear and Federal Pacific Switchgear.

The S&C Mark III & PMH style switchgear, EEI/PSI I&II switchgear and Federal Pacific switchgear have integral fuse interruption capability. When a fuse needs to be operated (opened, closed or replaced) in a switchgear the following procedure shall be followed.

a. Verify the manufacturer of the switchgear by reading the nameplate. If the switchgear is manufacturer by Federal Pacific or EEI the worker shall conduct a thorough visual inspection of the fuse compartment PRIOR to removing any barriers. If the nameplate indicates that the switchgear is an S&C Mark III proceed directly to step#2.

   1. Federal Pacific Switchgear has had failures in the fuse compartment area. An inspection of the fuse compartment area shall be conducted prior to removal of the front barriers. A check shall be made to determine that the fuses are properly in place and that there are no signs of heated or melted components in the fuse holder area.

   2. If no problems are observed the barrier board(s) may be removed and another visual inspection shall be conducted. The inspection shall be conducted with an infrared heat detector looking for hot spots in the bushing area behind the fuse holder. If any signs of heat or fatigue are found, the switchgear shall be de-energized before operating the fuses.

   3. Proceed to step c.

b. Remove the outer barrier board associated with the fuse to be opened using the Grappler tool attached to an approved live line/hot stick tool and conduct a thorough visual inspection of the fuse holder, fuse assembly inner barriers and insulators.

c. Visually make sure the fuse is securely seated in the jaw before opening fuse.

1. Check the hooks and pins in the bottom of the fuse holder are seated.
2. Check the top of the fuse holder to make sure it is fully closed and latched. If it is not fully engaged the interrupting mechanism will not operate.
3. There are two different style latching mechanisms (S&C and EEI) used on “load break” fuses, each style shall be inspected to ensure that they are properly engaged. Older versions of the Federal Pacific did not have the red indicator as an indication of full engagement. Operators shall conduct a thorough inspection.

d. Open the associated fuse using the Grappler tool attached to an approved live line/hot stick tool.

e. Place that associated barrier in the diagonal position using the Grappler tool attached to an approved live line/hot stick tool.

f. Remove that associated fuse using the Grappler tool attached to an approved live line/hot stick tool.

g. Caution shall be used when handling fuses to ensure that contact is not made between live parts and grounded parts of the switchgear. When a fuse is in the open position <u>EITHER OR BOTH ENDS OF THE FUSE AND/OR THE FUSE HOLDER MAY BE ENERGIZED.</u>

h. After the fuse has been removed re-install the barrier using the Grappler tool attached to an approved live line/hot stick tool. The front barriers shall not be left in the diagonal position. The front barriers shall be left in their normal suspended position.

i. When removal of the first fuse has been completed and the barrier re-installed either of the remaining fuses may be operated. Proceed to either of the other two fuse positions and remove the barrier board associated with the fuse to be opened. Use all of the same steps and procedures that were discussed in section 1.1.12 d-h of this EOP regarding the operation and or removal of the remaining fuses.

1.1.13 De-Energization and Removal of Fuses - Single Phase - S&C Mark II Switchgear

a. De-energize the fuse compartment by operating the line switch(es) of the switchgear.

b. Remove the barrier using the Grappler tool attached to an approved live line/hot stick tool.

c. Test de-energized.

d. Open the de-energized fuse using the Grappler tool attached to an approved live line/hot stick tool.

e. Place the barrier in the diagonal position using the Grappler tool attached to an approved live line/hot stick tool.

f. Remove this fuse using the Grappler tool attached to an approved live line/hot stick tool.

g. Place the barrier in the normal suspended position using the Grappler tool attached to an approved live line/hot stick tool.

1.1.14 De-Energization and Removal of Fuses- Single Phase - S&C Mark III & PMH style Switchgear, EEI/PSI I&II Switchgear

a. Remove the desired barrier using the Grappler tool and an approved live line/hot stick tool.

b. Make sure the fuse is securely seated in jaw.

c. Open the fuse the Grappler tool attached to an approved live line/hot stick tool.

d. Place the barrier in the diagonal position using the Grappler tool attached to an approved live line/hot stick tool.

e. Remove this fuse in the approved manner using the Grappler tool attached to an approved live line/hot stick tool.

f. Caution shall be used when handling fuses to ensure contact is not made between live parts and grounded parts of the unit. <u>EITHER OR BOTH ENDS OF THE FUSE HOLDER MAY BE ENERGIZED</u>

g. Place the barrier in the normal suspended position using the Grappler tool attached to an approved live line/hot stick tool.

1.1.15 Replacement of Blown Fuses

a. Proper cleaning of the fuse tube and muffler assembly shall be done, according to the manufacturers instructions, when replacing a fuse link.

b. Caution shall be used when handling fuses to ensure contact is not made between live parts and grounded parts of unit.

1.1.16 Grounding PMH Pad-mounted Switchgear

a. Before any work is performed on any part of the unit, that part shall be properly isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 – Clearance and Control.

b. Switchgear is equipped with facilities for both the ground clamp and the conductor clamp. Refer to supervisor or Program Manager Standards, Policies, Codes for the approved switchgear grounds

c. When work is performed on the primary side of a pad-mounted transformer that is fed from a switchgear, vise grip short circuiting cables shall be placed on the secondary side of the transformer in accordance with LU-EOP D009 – Vise Grip Short Circuiting Bonding Cables.

d. When work is performed on the primary side of a pad-mounted transformer that is fed from a switchgear, the fuse position in the switchgear will be the tag point (point of protection).

1.1.17 Pulling Cable

a. Installing or removing of any cable(s) into the switchgear shall only be done after the switchgear has been properly isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 – Clearance and Control unless the insulated barrier boards are utilized in accordance with section 1.1.18 (a) (b) and (c) of this EOP.

NOTE: Installing or removing cable *is* permitted in energized pad-mounted PMH switchgear installed on a **manhole,** insulated barriers shall be used in this application. Installing or removing cable *is not* permitted into energized pad-mounted PMH switchgear installed on a **fiberglass foundation**.

b. When new switchgear is first installed, and there are spare positions for future taps, the cable shall be terminated at the spare positions, brought out of the switchgear, capped and properly tagged for future use.

1.1.18 Instructions for use of Insulated Barrier Boards

a. The purpose of the insulated barrier boards is to allow employees to perform work in a de-energized switchgear compartment under energized bus. The existing isolating (non-insulating) S&C 15kV switchgear barrier boards shall be inserted or removed with the Grappler tool attached to an approved live line/hot stick tool. The new insulated barrier boards are inserted or removed by hand with class #2 rubber gloves while maintaining minimum approach distances (M.A.D). The insulated barriers allow work to be performed within the de-energized portion of the switchgear. Work can be performed below these boards while the rest of the switchgear bus remains energized. Any existing cables within the *de-energized portion* of the switchgear to be worked on shall be isolated red tagged, test de-energized and grounded.

b. The insulated barrier boards are ordered as a unit. The unit consists of 4 boards and a carrying case. The one large board is to be used in the switch compartment of the switchgear. The three smaller boards are to be used in the fuse compartment of the switchgear. These insulated barrier boards are rated up to 50kV and can be found in the Liberty Utilities Tool Catalog.

c. These barrier boards are **only** to be used for S&C 15kV PMH style switchgear. Before using these insulated barrier boards confirm that the switchgear to be worked on is a S&C 15kV PMH style switchgear by checking the name plate on the switchgear. Depending on the age of the switchgear the name plate may be located on the inside or outside of the door on either side of the switchgear. The insulated barrier boards shall be inspected before and after each use.

The existing S&C isolating (non-insulated) barrier boards shall be inserted or removed using the Grappler tool attached to an approved live line/hot stick tool following current procedures (pictured below).

The insulated barrier boards shall be inserted or removed by hand, wearing class 2 rubber gloves while maintaining M.A.D (pictured below)

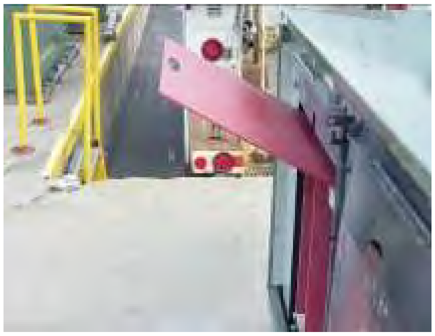
NOTE: Rubber gloves shall be worn unless the circuit is tested, de-energized, and grounded.

The following pictures show the insulated barriers boards being inserted and removed (while maintaining M.A.D) as well as a side view to show the correct positioning of boards when they are *fully* inserted.

Fuse compartment insert/remove barrier

Switch compartment insert/remove barrier


Fuse compartment barrier fully inserted


Switch compartment barrier fully inserted

Once the insulated barrier boards are inserted and the terminations are isolated, red tagged, tested de-energized and grounded, work below the insulated barrier boards can commence without the use of rubber gloves.

These are *temporary* insulated barrier boards. Because of the size and shape of these boards the switchgear doors cannot be closed when they are in use. After the work has been completed and the switchgear is to be put back normal, these boards shall be removed by hand while wearing class #2 rubber gloves and the S&C isolating barrier boards shall be re-inserted into their normal suspended position using the Grappler tool attached to approved live line/hot stick tool.

The insulated barrier boards shall be cleaned and stored in the provided carrying bag when not in use.

NOTE: The insulated boards may not be used for single phase switching applications. When working within a fuse compartment of a switchgear, all three fuses shall be opened and removed and the three smaller boards shall be installed. Opening and removing one fuse and utilizing one small insulated barrier board is not allowed.

2.0 PME DEAD-FRONT PAD-MOUNTED SWITCHGEAR

S&C's "dead-front" PME Pad-Mounted Gear features elbow-connected components. All switch and fuse components are enclosed and protected within an inner, air-insulated steel compartment that keeps out foliage, wildlife, and contaminants, and also reduces exposure to energized live parts. The three-piece roof is hinged over the cable compartments; cables can be pulled up through the opening, simplifying installation. S&C Manual PME Pad-Mounted Gear, which is available in ratings of 14.4 kV and 25 kV, permits manual switching and provides fault protection for underground distribution systems. This gear features elbow-connected encased components and accommodates separable insulated connectors.

2.1 Opening/Inspection of Units

2.1.1 Class #2 rubber gloves shall be worn when unlocking and opening compartment doors.

2.1.2 Verify that the unit is properly bonded to ground.

2.1.3 Verify that you are at the correct location. Check the switchgear number, switch number and compartment location.

2.1.4 Verify the manufacturer, model and type.

2.1.5 When the switchgear is opened for any reasons the following inspections shall be conducted:

a. The condition and integrity of the doors, panels and locking fixtures shall be checked. Ensure that Penta Bolts are installed and tight. Ensure that locks are installed.

b. The condition and readability of all markings shall be checked.

c. Visually check the general overall condition of the switchgear. Excessive accumulation of dirt or condensation shall be reported for future cleaning,

d. If conditions permit the unit should be isolated, red tagged, tested de-energized, grounded and cleaned when opened.

e. Check for any signs of burning, flashover or tracking. These conditions shall be reported.

f. Check the condition of the foundation for cracks, general deterioration, level, tipping, etc. There shall be no exposed holes above the ground. Any voids or openings between the switchgear and the top of the vault pad shall be caulked with sealing compound (STD Item S2).

2.2 Operation of Switch Mechanism

2.2.1 Class #2 rubber gloves shall be worn when unlocking and opening compartment doors and operating switch. Verify that unit is properly bonded to ground.

2.2.2 Visually check the position of the switch by observing the switch blades. Conduct a thorough visual inspection of the switch, insulators and operating mechanism to determine any defects which may impair proper operation.

2.2.3 Unlock and open the appropriate switch operating control panel.

2.2.4 Install the switch operating control handle and operate the switch to the desired position following the manufacturer's recommended instructions.

2.2.5 Open the cabinet and verify the switch operation by observing the blade position of the switch (note the blades may be energized when the switch is in the open position).

2.2.6 Remove and fold the switch-operating handle, and return the handle to its storage position. Then close and padlock the access cover.

2.3 Opening theTransFuser Mounting

2.3.1 Open the appropriate fuse termination-compartment door and secure it with the door holder. On double-door models, the adjacent door should be closed and latched to minimize exposure.

2.3.2 Using an approved shotgun stick, install a portable feed-thru or stand-off insulator on the parking stand that is directly above the cable guide of the elbow to be moved. This will ensure that once the elbow is moved, the cable will not interfere with the TransFuser Mounting. Using the approved shotgun stick, and following the elbow manufacturer's instructions for loadbreak operation, remove the 200-ampere loadbreak elbow (thus interrupting any load through the fuse to be removed), and move the elbow to the portable feed-thru or stand-off insulator.

2.3.3 When changing fuses, the 200-ampere interface need not be covered with an insulating protective cap since it will be exposed only temporarily. Operation of the TransFuser mechanism will draw the grounded drain wire inside the component compartment close to energized parts which can result in a flashover and serious injury.

If elbows are stored on feed-thru or stand-off insulators for an extended period of time, cover the 200-ampere interface with an insulating protective cap with a drain wire and connect the drain wire to the ground bail. Failure to connect the drain wire to the ground bail can result in a flashover, injury, and equipment damage. The insulated protective cap and drain wire shall be removed before operating the TransFuser mechanism. Failure to remove the cap and drain wire will interfere with operation of the mechanism.

2.3.4 Once the elbow has been moved and mounted on a feed-thru or stand-off insulator, theTransFuser mechanism may be operated. Using the approved shotgun stick, raise the mechanical interlock to unlock the TransFuser Mounting. This interlock, which cannot be lifted to the unlocked position until the elbow has been removed, guards against gaining access to the fuse while it is carrying current.

2.3.5 Secure the approved shotgun stick to the pull-ring at the lower end of the TransFuser Mounting. With an outward pull, rotate the TransFuser Mounting end-over-end to expose the fuse. Make certain that the mounting is latched before removing the shotgun stick. Then disengage the shotgun stick from the pull-ring. Using the shotgun stick, push against the top of the mounting to verify that it has securely latched. With the TransFuser Mounting latched in the open position, the fuse is de-energized, isolated from high voltage, and accessible for removal from the mounting.

NOTICE:
Do not close the switchgear door on a TransFuser Mounting in the open position with a fuse in the mounting. The door will strike the fuse pull-ring which will interfere with door closing. The door may be closed if the fuse is removed from the mounting.

2.4 Installing the Fuse in the Mounting

2.4.1 Secure the approved shotgun stick tightly to the fuse pull-ring with the fuse oriented so that the body of the fuse is below the stick. Grasp the shotgun stick with both hands (approximately 2 feet apart), placing one hand on the shotgun-stick latch mechanism.

2.4.2 Lift the fuse and lower it into the cradle of the fuse mounting.

2.4.3 With the fuse securely seated in the cradle, push the fuse forward to latch it in the closed position. Disengage the shotgun stick from the fuse.

NOTE: The dead-front style switchgear has barriers to isolate all live sources. A worker, wearing proper PPE can install or remove the fuse in the holder by hand if they choose to or use an approved shotgun stick as stated above. Operating the fuse to install or remove it from the internal area of the switchgear shall be done with an approved shotgun stick.

2.4.4 Verify that the fuse is properly latched in the fuse mounting. While holding the approved shotgun stick, push against the fuse holder assembly, and also pull on the fuse assembly by locating the ring of the stick in the opening below the pull-ring.

2.5 Closing the TransFuser Mounting

After the fuse has been installed or replaced, close the TransFuser Mounting (energize the fuse) as follows:

2.5.1 Secure an approved shotgun stick to the pull-ring at the top of the TransFuser Mounting. With an outward pull, rotate the TransFuser Mounting end-over-end to return the fuse to the component compartment. Make certain that the mounting latches in this position before removing the shotgun stick. Then disengage the shotgun stick from the pull-ring. Using the shotgun stick, push against the bottom of the mounting to verify that it has securely latched.

2.5.2 Using the shotgun stick, lower the mechanical interlock to lock the TransFuser Mounting.

2.5.3 If a protective cap was placed on the bushing interface, remove it with the shotgun stick.

2.5.4 Using the shotgun stick, move the elbow from the portable feed-thru or stand-off insulator to the bushing in accordance with the elbow manufacturer’s instructions. Remove the portable feed-thru or standoff insulator from the parking stand.

2.5.5 Close and latch the enclosure doors. Pull outward on the Penta-Latch Mechanism cover to verify that the door has latched securely, and then padlock the door.

Line Side of Deadfront Switchgear

Load Side of Deadfront Switchgear

NOTE: Installing or removing cable *is* permitted in energized pad-mounted PME dead-front switchgear installed on a **manhole or a fiberglass foundation.**

3.0 OTHER PAD-MOUNTED UNITS:

Liberty Utilities additionally owns various metal enclosed switchgear. Many of these units are "full height" as opposed to PMH style.

Before operation of these units consult single line and operating instructions.

3.1 Opening/Inspection of Units

3.1.1 Class #2 rubber gloves shall be worn when opening compartment doors.

3.1.2 Verify that the unit is properly bonded to ground.

3.1.3 Verify that you are at the correct location. Check the switchgear number, switch number and compartment location.

3.1.4 Verify the manufacturer, model and type.

3.1.5 Conduct a visual inspection of the barrier boards for signs of deterioration, tracking and contamination.

3.1.6 When the switchgear is opened for any reasons the following inspections shall be conducted:

a. The condition and integrity of the doors, panels and locking fixtures shall be checked. Ensure that Penta Bolts are installed and tight. Ensure that locks are installed.

b. The condition and readability of all marking shall be checked.

c. Visually check the general overall condition of the switchgear. Excessive accumulation of dirt or condensation shall be reported for future cleaning, if conditions permit the unit shall be isolated, red tagged, de-energized, grounded and cleaned when opened.

d. Observe the barriers for proper position and condition. The barriers shall be in the vertical position unless work is being performed on the unit.

e. Inspect the slide-in barrier: look for signs of electrical activity, i.e., tracking, burning, etc., warping, mechanical or moisture damage. If there is evidence of these signs, replace the affected barriers.

f. Check for any signs of burning, flashover or tracking. These conditions shall be reported.

g. Clean barrier with denatured alcohol or other approved cleaner. Dry the barriers. Do not place the barriers on the ground or other contaminated surfaces.

h. Check the condition of foundations for cracks, general deterioration, level, tipping, etc. There shall be no exposed holes above the ground. Any voids or openings between the switchgear and the top of the vault pad shall be caulked with sealing compound.

i. The front barriers shall be left in their normal suspended position.

3.2 Operating of Switch Mechanism

3.2.1 Class #2 rubber gloves shall be worn when opening compartment doors. Verify that unit is properly bonded.

3.2.2 Visually check the switch position by observing blades.

3.2.3 Visually check the switch mechanism, insulators and general condition to determine any defects which may impair operation.

3.2.4 Operate the switch as the manufacturers instructions indicate.

3.2.5 Verify switch operation by observing blade position of switch. (Note the blades may be energized with the switch in the open position).

3.2.6 The front barriers shall be left in their normal suspended position.

3.3 Procedure for Working in the Switch Compartment

3.3.1 Any work that cannot be performed with hot stick / live line tools while maintaining proper clearances for the voltage being worked shall cause the unit to be isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 - Clearance and Control.

3.4 Procedure for Working in the Fuse Compartment

3.4.1 Any work that cannot be performed with hot stick / live line tools while maintaining proper clearances for the voltage being worked shall cause the unit to be isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 - Clearance and Control.

3.5 De-Energization and Removal of Fuses - Three Phase Switchgear

3.5.1 De-energize the fuse compartment by operating the line switch(es) of the unit.

3.5.2 Test for de-energization.

3.5.3 Remove the barrier associated with the fuse to be opened using an approved live line/hot stick tool.

3.5.4 Open that de-energized fuse using an approved live line/hot stick tool.

3.5.5 Place that barrier in the diagonal position using an approved live line/hot stick tool.

3.5.6 Remove that fuse using an approved fuse handling tool and an approved live line/hot stick tool.

3.5.7 Hang the barrier associated with the fuse that was removed in its normal suspended position using an approved live line/hot stick tool.

3.5.8 To de-energize and remove the two other fuse positions repeat steps 3.5.3 through 3.5.7.

3.6 De-Energization and Removal of Fuses - Single Phase Switchgear

3.6.1 De-energize the fuse compartment by operating the line switch(es) of the unit.

3.6.2 Test for de-energization.

3.6.3 Remove the desired barrier using an approved live line/hot stick tool.

3.6.4 Open the de-energized fuse using an approved live line/hot stick tool.

3.6.5 Place the barrier in the diagonal position using an approved live line/hot stick tool.

3.6.6 Remove this fuse using an approved live line/hot stick tool.

3.6.7 The front barriers shall be left in their normal suspended position.

3.7 Replacement of Blown Fuses

3.7.1 Proper cleaning of the fuse tube and muffler assembly shall be performed according to the manufacturer’s instructions when replacing a fuse link.

3.7.2 Caution shall be used when handling fuses to ensure contract is not made between live parts and grounded parts of unit. <u>EITHER OR BOTH ENDS OF THE FUSE HOLDER MAY BE ENERGIZE</u>

3.8 Grounding Pad-Mounted Switchgear

3.8.1 Before any work is performed on any part of the unit, that part shall be properly isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 – Clearance and Control.

3.8.2 Facilities for both the ground clamp and the conductor clamp are provided. Approved grounds shall be used. The specifications for the approved grounds can be found in the On-Line Tool Catalog on the Infonet.

3.8.3 For work on pad-mounted transformers fed by this unit, to work on the primary side of pad-mounted transformer vise grip short circuiting cables shall be placed on the secondary side (less than 600 volts) of the transformer in accordance with LU-EOP D009 – Vise Grip Short Circuiting Bonding Cables.

3.8.4 The fuse position in the switchgear will be the protective position.

3.8.5 On the customer side all necessary opens will be tagged and grounds applied as needed.

3.9 Pulling Cable

3.9.1 Installing or removing of any cable(s) into the switchgear shall only be performed after the switchgear has been properly isolated, red tagged, tested de-energized and grounded in accordance with LU-EOP G014 – Clearance and Control.

3.9.2 When new switchgear is first installed, and there are spare positions for future taps, the cable shall be terminated at the spare positions, brought out of the switchgear, capped and properly tagged for future use.

4.0 35kV DEAD-FRONT SWITCHGEAR

Cooper 35kV switchgear are oil insulated, gang operated, two position configurations that provide open and close functionality. Key components of the switchgear are the switch blade viewing window, rotary switch handle, the vacuum load break switch and the VFI (Vacuum Fault Interrupter).

4.1 Opening/Inspection of Units

4.1.1 Class #2 rubber gloves shall be worn when unlocking and opening compartment doors.

4.1.2 Verify that the unit is properly bonded to ground.

4.1.3 Verify that you are at the correct location. Check the switchgear number, switch number and compartment location.

4.1.4 Verify the manufacturer, model and type utilizing the nameplate.

4.1.5 Conduct a visual inspection of the switch for oil leaks, signs of tracking or contamination.

4.1.6 The condition and integrity of the doors, panels and locking fixtures shall be checked. Ensure that Penta Bolts are installed and tight. Ensure that locks are installed.

4.1.7 When the switchgear is opened for any reasons the following inspections shall be conducted:

a. The condition and readability of all marking shall be checked.

b. Visually check the general overall condition of the switchgear. Excessive accumulation of dirt or condensation shall be reported for future cleaning, if conditions permit the unit shall be isolated, red tagged, tested de-energized, grounded and cleaned when opened.

c. Check for any signs of burning, flashover or tracking. These conditions shall be reported.

d. Check the condition of foundations for cracks, general deterioration, level, tipping, etc. There shall be no exposed holes above the ground. Any voids or openings between the switchgear and the top of the vault pad shall be caulked with sealing compound (item S2).

4.2 Operation of Switch Mechanism (line side)

4.2.1 Class #2 rubber gloves shall be worn when unlocking and opening compartment doors.

4.2.2 Verify that the unit is properly bonded to ground.

4.3 To open line side of switch

4.3.1 Observe the visible break switch blades through the inspection window and verify that the switch is in the closed position.

4.3.2 Move the yellow operating handle of the vacuum load break switch to the open position.

4.3.3 Unlock and open the side mounted access door protecting the visible break rotary switch handle.

4.3.4 Using an approved switching tool or the provided T Handle, rotate the rotary handle switch to the open position.

4.3.5 Observe the visible break switch blades through the inspection window and verify that the switch is in the open position.

4.4 To close line side of switch

4.4.1 Confirm that the switch blades are in the open position by observing the visible break switch blades through the inspection window and verify that the switch is in the open position.

4.4.2 Unlock and open the side mounted access door protecting the visible break rotary switch handle.

4.4.3 Rotate the rotary handle switch to the closed position.

4.4.4 Move the yellow operating handle of the vacuum load break switch handle to the closed position.

4.4.5 Confirm through the viewing window that the switch blades are in the closed position.

Note: When work is performed on the primary side of a pad-mounted transformer that is fed from a switchgear, vise grip short circuiting cables shall be placed on the secondary side of the transformer in accordance with LU-EOP D009 – Vise Grip Short Circuiting Bonding Cables.

4.5 Operation of the load side of the switch

4.5.1 The load side of the switch can be opened or closed utilizing the VFI. Vacuum Fault Interrupters provide fast, low energy arc interruption and produce no arcing by products to contaminate the insulating oil. The VFI handle has three settings: Open, Tripped and Closed.

4.5.2 Using an approved live line/hot stick tool operate the handle to the desired position:

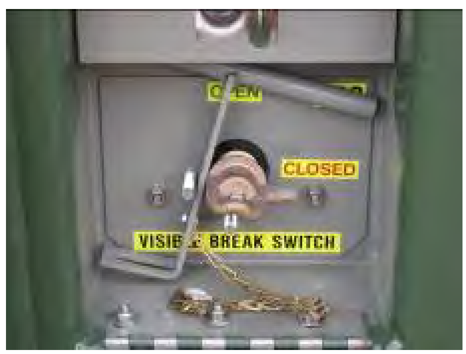
4.6 To open the VFI:

4.6.1 The VFI is opened by pulling the operation handle down to the open position. The handle may be padlocked in the open position to prevent accidental closure.

4.6.2 To reset the interrupter: After the VFI mechanism has tripped as the result of a fault condition, the mechanism must be reset before it can be closed. To reset the mechanism, firmly pull the operating handle down to towards the ground until the latch resets. After the latch has been successfully reset the VFI interrupter mechanism can be closed normally.

4.6.3 The VFI is closed by briskly pushing the handle up into the closed position.

Cooper 35kV Deadfront Switchgear



Visible Break Switch


VFI Load Side


Vacuum Load Break Switch

NOTE: Installing or removing cable *is* permitted in energized pad-mounted Cooper 35kV dead-front switchgear installed on a **manhole or a fiberglass foundation.**

<u>5.0 METAL ENCLOSED CUSTOMER OWNED SWITCHGEAR</u>

5.1 The Customer is normally responsible for performing the actual operating functions of their service equipment.

5.2 For some applications, the Company may be required to ground the customer's switchgear utilizing the provided grounding point and ground bus.

5.3 Before any work is performed on any part of the unit, the part must be properly isolated, red tagged, tested de-energized and grounded in accordance with NG-EOP G014 - Clearance and Control.

5.3.1 Facilities for both the ground clamp and conductor clamp should be provided. Approved grounds shall be used. The specifications for the approved grounds can be found in the On-Line Tool Catalog on the Infonet.

5.4 Pulling Cable

5.4.1 Installing or removing of any cable(s) into this type of switchgear shall only be performed after the switchgear has been properly isolated, red tagged, tested de-energized and grounded in accordance with NG-EOP G014 – Clearance and Control.

<u>6.0 SWITCHING PROCEDURE FOR 3 PHASE PAD-MOUNTED TRANSFORMERS FED FROM UG SYSTEMS</u>

6.1 New switching procedures for switching 3 phase pad-mounted transformers which are fed from Underground cable systems are being implemented to minimize the occurrence of the phenomenon of ferroresonance. Ferroresonance can only occur during single phase switching. When ferroresonance occurs, the voltage downstream of the switching point can increase to several times normal levels. As a result, fuses can blow, flashovers can occur, lightning arresters, cables and transformers can fail.

6.2 To minimize the possibility of ferroresonance, one of the following switching sequences will be followed when switching 3 phase pad-mounted transformers which are fed from underground cable systems:

6.2.1 Option 1 – Energizing/de-energizing to be done with a 3 phase device, i.e., loadbreak switch, MVI, circuit breaker, line recloser. This option shall only be used when it doesn't cause additional outages to other customers.

6.2.2 Option 2 – Energize/de-energize cable and transformer separately. To energize, park the elbows at the pad-mounted transformer, energize cable, then plug in the elbows. To de-energize, pull and park the elbows at pad-mounted transformer, then de-energize the cable.

6.2.3 Option 3 - Energizing/de-energizing to be done with secondary main switch closed and a minimum load of 15% of transformer rating applied.

Live-front transformers only have the choice of options 1 and 3.

IMPORTANT NOTE: Pad-mounted transformers fed from Overhead systems – riser pole to pad - with fuse cutouts located on the riser pole, can continue to be switched as in the past.

For more information about ferroresonance, contact Electric Engineering/Work Methods.

7.0 EXCEPTION APPROVALS:

It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Program Manager of Standards, Policies and Codes (Work Methods) and a Manager EHSS or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

8.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
10/01/2015	1.0	Initial Version of National Grid document. Updated from Liberty Utilities document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG017		
Electric Operating Procedure	**09-01-2015**	**Underground**	
Operation of 3 Phase Wye/Delta Padmounted Underground Transformer	**Revision #**	**1.0**	**Page: 1 of 8**

INTRODUCTION

The purpose of this EOP is to provide information on installation, switching and operation of three phase pad-mounted wye/delta transformers. When the wye winding is the source connection to the neutral H0 bushing requires special treatment. A wye/delta transformer can produce induced voltage out to the field if not switched properly. This procedure applies to all pad-mounted transformers fed from either an overhead or an underground primary system. This EOP only refers to three phase wye/delta pad-mounted underground transformers. If switching any other three phase pad-mounted transformers fed from underground systems refer to LU-EOP UG016.

PURPOSE

This procedure applies to all qualified personnel involved with the installation, switching and operation of three phase wye/delta pad-mounted transformers.

ACCOUNTABILITY

1. Standards, Policies and Codes
   A. Update procedures as necessary.

2. Electric Distribution Operations
   A. Ensure that all components of this EOP are understood and implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.

3. Liberty Utilities Employees and Contractors
   A. Demonstrate an understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.
   C. It is the workers responsibility to read and fully understand and to follow the manufacturer's instruction manual and specifications before operating equipment.

REFERENCES

Liberty Utilities Employee Safety Handbook
Liberty Utilities Safety Procedure A-105 Job Brief
Liberty Utilities UG Construction Standards
LU-EOP UG016 Pad-Mounted Switchgear

DEFINITIONS

Dead: Isolated, red tagged, tested de-energized and grounded.

De-energized: Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means. **Note:** De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc.

Electrically Isolated: All switches, jumpers, taps or other means through which known sources of electrical energy may be supplied to the particular lines and equipment have been opened.

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Grounded: Intentionally connected to earth through a ground connection.

Minimum Approach Distance: The closest point of approach to energized lines or equipment by a qualified employee or by any conductive object, without the use of insulating gloves, sleeves, or portable protective devices. **Note:** Table R-6 in OSHA 1910.269 defines the Minimum Approach Distances to be followed by a qualified employee while working near energized lines and equipment.

TRAINING

Provided by appropriate Liberty Utilities L&D training program.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any applicable Liberty Utilities EOP's utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 Before each job begins for a crew of two or more, and whenever working conditions change, a documented job brief shall be conducted by the crew leader/chief, person in charge of the work, or supervisor to review hazards, precautions, procedures, energy sources/control, and personal protective equipment requirements. All members are required to sign or initial the documented job brief (refer to Liberty Utilities Safety Procedure A-105 Job Brief).

1.4 Appropriate rubber gloves shall be worn by persons opening or unlocking a pad-mounted transformer, submersible vault, and pad-mounted switchgear.

2.0 GENERAL WYE/DELTA TRANSFORMER INFORMATION

2.1 Transformers connected wye primary and delta secondary shall have the neutral (H0 bushing) floated during normal operation. This is done to prevent backfeed and/or transformer overload in the event of a blown primary fuse that can cause equipment damage from overload. During switching operations the neutral bushing shall be grounded with a clean, approved equipment grounding elbow (UR32 - Item ID 8830-9316662) or similar device depending on the type of transformer, to prevent equipment damage due to high induced voltages or overload.

2.2 The transformer nameplate (Figure #1) is located in the secondary compartment and shall be observed before switching the transformer. The nameplate includes an internal wiring diagram. This will show the relation of the primary and secondary bushings with respect to the transformer winding.

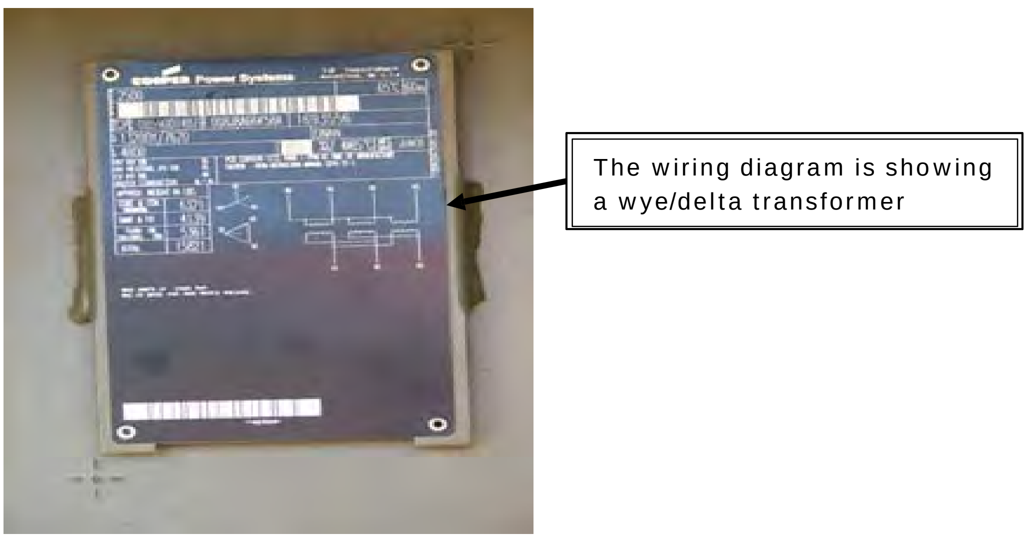


Figure #1 - Transformer Nameplate

3.0 INSTALLATION AND OPERATION OF A PAD-MOUNTED THREE PHASE WYE/DELTA TRANSFORMER

Three phase wye/delta pad-mounted transformers now purchased by Liberty Utilities are dead-front and have a dead-front H0 bushing installed to externally allow for grounding of the neutral of the wye winding when required.

3.1 Installation of a new wye/delta pad-mounted transformer with a dead-front H0 bushing when the wye is the source voltage:

3.1.1 Install the transformer on a concrete pad and connect using the appropriate work methods.

3.1.2 Permanently connect the equipment grounding elbow (UR32) to the ground grid with a compression connector. Install the equipment grounding elbow in the H0 bushing (Figure #2).

3.1.3 Install and bond a parking stand (UR38) or feed-thru device (UR29B) on the primary side of the transformer. If using a feed-thru device install an insulating cap on one of the positions. The insulating caps shall be bonded to ground.

3.1.4 Energize the transformer.

3.1.5 Test for the correct secondary voltage.

3.1.6 Apply secondary load to the transformer.

3.1.7 Remove the equipment grounding elbow, place the elbow on a parking stand or feed-thru device and install a clean insulating cap(s) on the H0 bushing and feed-thru device if present. The insulating caps shall be bonded to ground.

3.2 Installation of a new wye/delta pad-mounted transformer with *live-* front H0 bushing when the wye is the source voltage (*phase bushings are dead-front – there are a few of these in the system*):

3.2.1 Install the transformer on a concrete pad and connect using the appropriate work methods.

3.2.2 Install a #2 minimum hard drawn copper tap to the H0 bushing, leaving the end bare for grounding purposes (see Figure #4 of a dead-front transformer with live-front H0 bushing).

3.2.3 Connect a piece of covered copper wire, #2 minimum and preferably soft drawn, to the ground grid with an appropriate compression connector.

3.2.4 Install a hot line clamp (C24B) on the other end of this wire.

3.2.5 Connect the lead to the H0 bushing with the hot line clamp utilizing an approved live line / hot stick tool and all other appropriate PPE.

3.2.6 Energize the transformer.

3.2.7 Test for the correct secondary voltage.

3.2.8 Apply secondary load to the transformer.

3.2.9 Remove the lead attached to the H0 bushing tap and leave the lead in the transformer, keeping the tap attached to the H0 bushing.

3.3 Operation of a wye/delta dead-front pad-mounted transformer with a dead-front HO bushing: The neutral has to be “floating” for normal operation of a wye/delta pad-mounted transformer. If there is not a gang operated device present and single phase switching must be done, the H0 bushing (live-front and dead-front) on the three phase pad-mounted transformer shall be grounded**.**

3.3.1 Remove the insulating cap from the H0 bushing. Then remove the clean, approved equipment grounding elbow (Item ID 9316662, Figure #3) from the parking stand or feed-thru device and insert the elbow onto the H0 bushing to effectively ground the transformer.

3.3.2 Perform single phase switching as necessary.

3.3.3 When work is complete, float the neutral by pulling the equipment grounding elbow from the H0 bushing and installing it on a clean parking stand or feed-thru device.

3.3.4 Install clean insulating cap(s) on the H0 bushing and feed-thru device if present. The insulating caps shall be bonded to ground.

Figure #2 - Dead-Front Transformer, Dead-Front H0

Figure #3 - Approved Equipment Grounding Elbow

Note: This equipment grounding elbow above shall not be used for personal protective grounding purposes.

3.4 Operation of a wye/delta dead-front pad-mounted transformer with a live-front HO bushing:

The neutral has to be "floating" for normal operation of a wye/delta pad-mounted transformer. If there is not a gang operated device present and single phase switching must be done, the H0 bushing (live-front and dead-front) on the three phase pad-mounted transformer shall be grounded.

If the dead-front transformer has provisions for grounding (existing #2 minimum tap connected to live H0 bushing, existing #2 minimum lead, with a hot line clamp, connected to neutral grid with appropriate compression connector) the live-front H0 bushing of the transformer, it can be effectively grounded by connecting the hot line clamp on the existing lead in the transformer to the tap on the H0 bushing utilizing an approved live line / hot stick tool and all appropriate PPE as follows:

3.4.1 Connect the hot line clamp on the existing lead in the transformer to the tap on the H0 bushing utilizing an approved live line / hot stick tool and all appropriate PPE.

3.4.2 Perform single phase switching as necessary.

3.4.3 When work is complete, float the neutral by removing the lead attached to the H0 bushing tap. Leave the lead in the transformer, keeping the tap attached to the H0 bushing.

If there are no provisions on a wye/delta dead-front transformer to ground the live front H0 bushing with an approved live line / hot stick tool, follow the steps outlined below:

3.4.4 Disconnect the secondary load from the transformer.

3.4.5 De-energize the transformer by pulling the loadbreak elbows and installing the elbows on parking stands on the primary side of the transformer, test de-energized and ground where appropriate.

3.4.6 When the transformer is de-energized, install #2 minimum hard drawn copper tap to H0 bushing, leaving the end bare for grounding purposes.

3.4.7 Connect a piece of covered copper wire, #2 minimum and preferably soft drawn, to the ground grid with an appropriate compression connector.

3.4.8 Install a hot line clamp (C24B) on the other end of this wire.

3.4.9 Connect the lead to the H0 bushing with the hot line clamp utilizing an approved live line / hot stick tool and appropriate PPE.

3.4.10 When work is complete re-energize the transformer by plugging in the loadbreak elbows and float the neutral by removing the lead attached to the H0 bushing tap. Leave the lead in the transformer, keeping the tap attached to the H0 bushing.

A dead-front transformer with a live-front H0 bushing and a tap for grounding purposes.

Figure #4 – Dead-front pad-mounted transformer with live-front H0 bushing

If there is no H0 bushing present check the nameplate located inside the secondary compartment:

3.4.11 If the transformer is a delta high side, switch normally.

3.4.12 If the transformer has a wye connected high side with a floating neutral and delta secondary, call Underground Standards or Work Methods for proper operating instructions.

4.0 EXCEPTION APPROVALS

It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Manager of T&D Work Methods, Standards, Policies and Codes and a Manager of Corporate Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Vice President/Director level or their designee.

5.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

INTRODUCTION

Locating faults on underground electric cables over 1kV can be difficult and time consuming. It can also inflict additional damage on the cables. Traditional fault locating has utilized the capacitor discharge (thumper) method as the primary method. Research and utility experience have shown that overuse of the capacitor discharge equipment causes stress on cable systems which result in future failures. The impulse signal is similar to a lightning spike and it can inflict damage on the cable system.

Operation of the thumper unit at a voltage level that is higher than necessary and/or for long periods of time creates the opportunity for additional damage to occur. To minimize the potential for this damage, the operating voltage level of the thumper as well as the time of operation of the unit must be limited as much as possible. Other fault locating techniques should be utilized to gather as much data about the fault prior to operating the thumper.

PURPOSE

This procedure applies to fault locating activities on all shielded distribution cables, rated from 1 kV up to and including 46 kV. All types of insulation materials are included.

ACCOUNTABILITY

1. Standards, Policies and Codes
   - A. Update procedure as necessary.
   - B. Provide appropriate personnel guidance when requested for specific personal protective grounding job requirements.
2. Electric Distribution Operations
   - A. Ensure that all components of this EOP are understood and implemented.
   - B. Ensure that all personnel are trained in this procedure.
   - C. Provide feedback regarding effectiveness of the procedure and revision input as necessary.
3. Liberty Utilities Employees and Contractors
   - A. Demonstrate an understanding of the procedures in this EOP.
   - B. Comply with the requirements of the procedures in this EOP.
   - C. It is the workers responsibility to read and fully understand, and to follow the manufacturer's instruction manual and specifications before operating equipment.

COORDINATION

Not Applicable

REFERENCES

Liberty Utilities Employee Safety Handbook
OSHA 1910.269
LU EOP - UG004 Distribution Cable Dielectric Testing

LU EOP – G014 Clearance & Control

DEFINITIONS

AC Hi-pot: Testing method utilizing high potential AC voltage. Typically a very low frequency (VLF) AC voltage is utilized. The AC voltage is impressed upon the cable sample at a level and for a period of time in an attempt to determine whether the cable is fit for electrical service.

Current Trace: A method employing the burn mode. The burn current is established, and then the set is put in switch mode, which turns the burn current on and off. This establishes a traceable signal similar to the capacitive thump, but with less energy. The same magnetic detectors may be used to locate the fault. The equipment that develops this trace is called a "Thyratron".

DC Hi-pot: Testing method utilizing high potential DC voltage. The DC voltage is impressed upon the cable sample at a level and for a period of time in an attempt to determine whether the cable is fit for electrical service.

Far End: The opposite end of a cable segment from the Test End.

Hi-pot: High potential (voltage) testing equipment with either AC or DC output.

Pick Up Test Procedure: A testing procedure applied to a cable circuit which has been repaired or modified. This test is intended to locate gross problems which will most likely cause immediate failure of the circuit. This test is conducted for a minimum of 5 minutes; refer to LU EOP UG004. This is also known as a Withstand Test.

TDR: An investigative procedure called Time Domain Reflectrometry where a signal is impressed on the cable and the cable response is displayed on a video screen; commonly called 'radar'.

Test End: The end of a cable segment where the test equipment is connected.

Thumper: A cable test device which contains a large capacitor. In use, the capacitor is charged up with a DC voltage to a selected value. Then the capacitor is connected across the faulted cable, resulting in a rapid discharge of the capacitor energy across the fault in the cable. The fault is located by finding the discharge with one of the various detectors or by simply listening.

Underground Residential Distribution (URD): URD construction methods are typically used for residential areas. They consist of buried cables, either direct buried or in ducts, with pad-mounted or subsurface transformers.

Very Low Frequency (VLF): A testing method utilizing low frequency AC voltage. Test frequencies of 0.01 to 0.1 Hertz are available. Liberty Utilities utilizes 0.1 Hertz. The capability of the VLF test set is limited by the test voltage and the capacitance of the cable, which changes with cable length, refer to NG-USA EOP UG004.

Withstand Test: See definition for Pick up Test Procedure.

TRAINING

Provided by appropriate Liberty Utilities L&D training program.

DOCUMENT CONTENTS

Table of Contents

1.0 SAFETY REQUIREMENT

All work shall be performed in accordance with the Liberty Utilities Employee Safety Handbook and all appropriate Liberty Utilities EOP's.

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

The employee in charge of the work shall conduct a written job brief with the employees involved prior to the start of each job. The briefing shall cover at least the following subjects: hazard associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

All underground cables shall be considered energized until proven to be isolated, red tagged, test de-energized and grounded.

If at any time a cable that is thought to be de-energized and grounded and proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted and the System Operator shall be notified.

Rubber gloves of the appropriate class shall be worn until the cable is proven to be isolated, red tagged, tested de-energized and grounded. Rubber gloves shall be worn in the application of electronic signal tracing test equipment/leads.

Only approved test instruments shall be used to determine if a cable is de-energized.

2.0 SWITCHING, TAGGING, GROUNDING & PREPARATION FOR CABLE FAULT LOCATING

Prior to the initiation of any fault locating activities, the cable circuits must be isolated, red tagged, tested de-energized and grounded according to LU EOP G014 Clearance and Control.

After a clearance is issued and grounding is completed, prepare all cable terminals for fault locating. This includes the removal of taps to lightning arresters, checking the integrity of the shield ground bonds at all terminations and removal of taps to OH systems or devices. Removal of the taps is not mandatory, but the best results will be obtained if taps are removed. Once all preparation work is complete on both ends of the cable(s), remove all protective grounds on the far end of the cable (away from the end where the test equipment is to be connected).

3.0 CABLE FAULT LOCATING PROCESS

The objective of fault locating procedures is to pinpoint the exact location of a cable system failure. This shall be accomplished safely and in as short a time as possible while minimizing the potential for damage to good cable. The general procedure consists of five steps:

- 3.1 Investigation
- 3.2 Verification
- 3.3 Pre-locating
- 3.4 Pinpointing

3.5 Confirmation

3.1 Investigation

Investigation provides a preliminary assessment of the fault situation. It consists of determining what relay targets were activated, whether there is any damage evident in the field. Circuit maps are helpful for fault locating and should be consulted, if available to determine the feeder's configuration, length, conductor sizes, cable types, and manhole locations. When a circuit has two or more branches in parallel, the branches should be separated before beginning fault locating. If the faulted phase(s) are known the verification step can be skipped.

3.2 Verification

Verification usually consists of two parts.

3.2.1 Part 1:

After the cable circuit is isolated, red tagged, tested de-energized and grounded, the insulation resistance of each phase is measured from conductor to ground. An insulation resistance tester (Meggar™) is connected to a phase. The protective ground on the far end of the phase being tested is removed. The protective grounds should remain on the other phases. An insulation resistance tester (Meggar™) set at a maximum voltage of 1 kV shall be employed for this measurement. Next perform the test on each of the other phases. After the test is completed on a phase the protective grounds at both ends of that phase should be re-installed. The phase having the lowest resistance is presumably the faulted phase. This should be consistent with the relay targets. Knowledge of the value of the fault resistance is also useful in selecting a pre-locating method.

3.2.2 Part 2:

To verify the actual faulted phase, perform a Pick Up Test (refer to LU EOP UG 004). Perform the test on the suspected phase and note the voltage at which the fault breaks down. Next perform the test on each of the other phases. This step will confirm which phase is faulted and whether either of the other phases is also faulted. Table 1 lists the pick up test voltages to be used. All pick up tests are conducted for a minimum of 5 minutes.

The VLF is the preferred test method to determine the presence of a faulted cable, however, if a VLF test set is not available, a DC Hypot may be used. Do not exceed voltages in Table 1.

If the failure persisted for an appreciable time, i.e., the situation of a stuck breaker, it is prudent to check continuity of each phase. This can be accomplished by grounding each phase at the remote end and measuring the insulation resistance from conductor to ground at the near end. If the conductor is not burnt open, the resistance will be zero. Alternately a time domain reflectometer (TDR) may be used to compare the apparent length of the three phases in order to determine if one is burned open.

When belted cable (typically 3/C PILC) is present in the circuit, there is a possibility that there is a phase to phase fault. To determine this, measure the insulation resistance between each pair of ungrounded conductors.

Voltage Class KV	VLF KV AC rms	DC Hypot KV DC
5	7	3.5
15	16	11
25	23	19
35	33	28
46	45	37

Table 1 - Maximum Pick-Up Test Voltage

3.3 Pre-locating

Pre-locating methods include:

3.3.1 TDR (Time Domain Reflectrometry) also known as “Radar”

a. Surge arc reflection

3.3.2 Examination of Cable Route

3.3.3 Murray Loop Bridge Method

3.3.4 Voltage Ratio Method

The surge arc reflection method uses a capacitor discharge set (thumper) to produce an arc at the fault. A capacitor is charged to a high D.C. voltage. The energy stored in the capacitor is then discharged into the faulted cable. When the voltage surge exceeds the fault breakdown voltage, a flashover occurs. A TDR synchronized with the thumper can see the arc as a short circuit and indicate the distance to the fault. This method works best on cables with two ends points. This method does give useful information on cables with more than two end points by limiting the number of locations where the fault could be.

The cable route should be investigated to look for any signs of the cable fault, such as excavations, dislodged manhole covers, smoke, or dirt expelled around a manhole cover. Also, inquire if any calls from the public have been reported of smoke in the vicinity of Liberty Utilities facilities.

The process for the Murray Loop Bridge and the Voltage Ratio Method are in Appendices 3 & 4.

3.4 Pinpointing

Pinpointing consists of applying a tracer signal to the faulted cable and then finding the signal in the field. The capacitor discharge set (“thumper”) provides a traceable signal. One goes to the site indicated by the pre-location and listens for the audible “thump,” or alternately searches for the signal with a magnetic/audio detector.

An alternate method used by some areas is the current trace ("Thyratron"). This method utilizes the DC test equipment in the burn mode. After establishing the burn current place the unit in into switch mode. This mode turns the burn current on and off at a programmed interval. This current signal generates a magnetic impulse that can be sensed from above grade.

The magnetic detectors available are the TEC-X35, Megger Electromagnetic Impulse Detector and the Megger MPP1000. The TEC-X35 is a handheld detector that is capable of picking up the signal from grade, eliminating the need to pump/enter manholes. It is about the size of a small text book.

It is important to keep the discharge voltage as low as practical, no matter which method is used. With the thumper method, use only sufficient voltage to produce a clean signal – indicated by the output voltage going to zero at each discharge. With the current trace mode, set the voltage just high enough to establish the burn current. It is also important to minimize the duration of energizing the cable with either method. To minimize this time, shutdown the test set when traveling between locations.

If the fault cannot be thumped the resistance of the fault needs to be reduced. This can be accomplished by conditioning the fault. If a VLF test set is available, the fault can be conditioned to reduce its resistance using the VLF set before proceeding with other fault location activities. This fault conditioning with the VLF test set is accomplished by setting the VLF test set High Current Trip Off to "No". The objective is to create a low resistance carbonized path at the fault location. Care shall be used as it is possible to overdo the amount of burning, particularly with cross-linked polyethylene insulation. The fault could be effectively "cleared" by melting insulation into the fault path. If only a DC test set is available, then condition the fault only if the fault resistance is sufficiently high such that the pre-locating equipment is prevented from operation. Do not exceed the DC Hypot test voltages in Table 1.

3.5 Confirmation

Confirmation ideally requires that the fault be observed. Sometimes it is not possible to actually see the fault and reliance must be made on tests conducted after the section of cable containing the suspected fault is removed from the circuit.

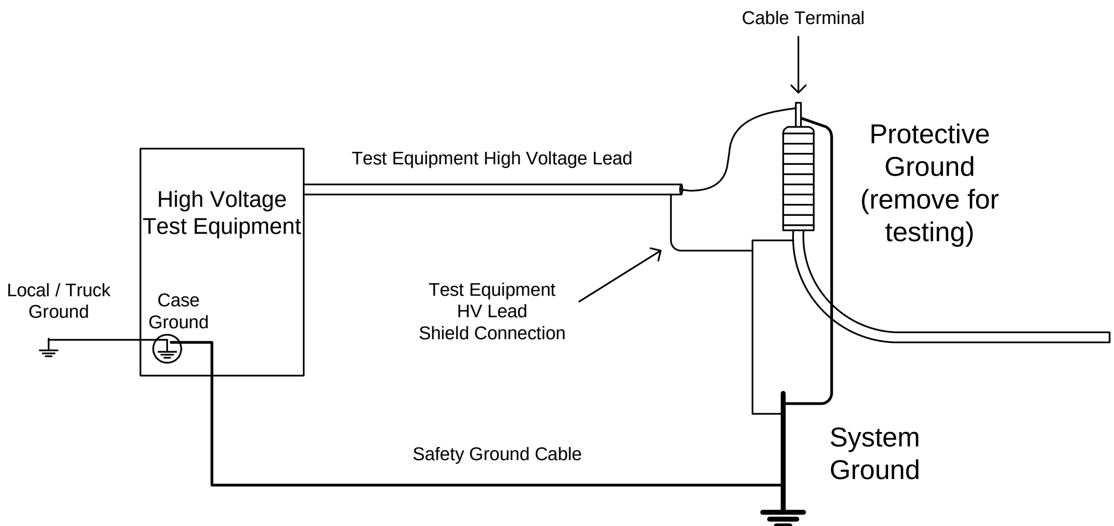
4.0 GROUNDING FOR HIGH VOLTAGE TESTS

Isolate, red tag, test de-energized and ground in accordance LU-EOP G014 Clearance and Control and the Liberty Utilities Employee Safety Handbook.

A single System Ground (see Figure 1) at the test location shall be used when performing the high voltage tests. The metallic shield or concentric neutral of the cable to be tested is connected to the System Ground. A Safety Ground Cable must connect the test equipment case ground to the System Ground. The Safety Ground Cable should have a braided or stranded #2 AWG, or larger, copper conductor capable of carrying available fault current.

A local ground (e.g. driven ground rod) is required if a pre-existing ground rod or station ground grid is not available at the Test Location. The System Ground (Truck Ground) shall always be the first connection made when setting up the test equipment.

Phase conductors not being tested should remain grounded. A protective ground should be installed on the phase being tested, except when actively testing.



Care should be taken to ensure that all ground connections cannot be accidentally disconnected. Grounding connections, which can be securely tightened, must be used. Spring loaded clip-on grounding connections are not allowed.

5.0 TEST EQUIPMENT

Standards Engineering shall be contacted prior to purchasing any new fault locating equipment. Liberty Utilities' cable fault locating vans are generally equipped with the following:

5.1 Generator

5.2 VLF - Very Low Frequency Test Set (HV Diagnostics)

5.3 Thumper - Capacitor discharge/ DC burn/DC proof test set

5.4 TDR - Time Domain Reflectometer (VON)

5.5 Thumper - Surge arc reflection and surge pulse method (VON)

5.6 TEC-X35, Megger Electromagnetic Impulse Detector #651113 and the Megger MPP1000 for use with a thumper

5.7 Murray loop bridge (Some areas) – see Appendix 3

5.8 Voltage ratio device (Some areas) – see Appendix 4

5.9 Megger Insulation Tester

5.10 Cable Locator

5.11 Clamp-on ammeter

5.12 Portable combination TDR / Thumper for URD faults (VON)

5.13 Thyratron – Current Trace

5.14 Galvanometer – Used with Thyratron

6.0 FLOW CHARTS OF CABLE FAULT LOCATING PROCEDURE

The appropriate fault locating procedure to be followed depends on the type of cable system. For fault locating purposes, distribution cable circuits can be considered to fall into one of two classifications:

Description	Flow Chart Appendix
Cable fault locating procedure for radial distribution cables	1
Cable fault locating procedure for single or three phase underground residential or underground commercial distribution cables	2

This classification recognizes the complexity of the circuit and the accessibility of terminals. A TDR synchronized with the thumper can see the arc as a short circuit and indicate the distance to the fault. This method works best on cables with two ends points. This method does give useful information on cables with more than two end points by limiting the number of locations where the fault could be.

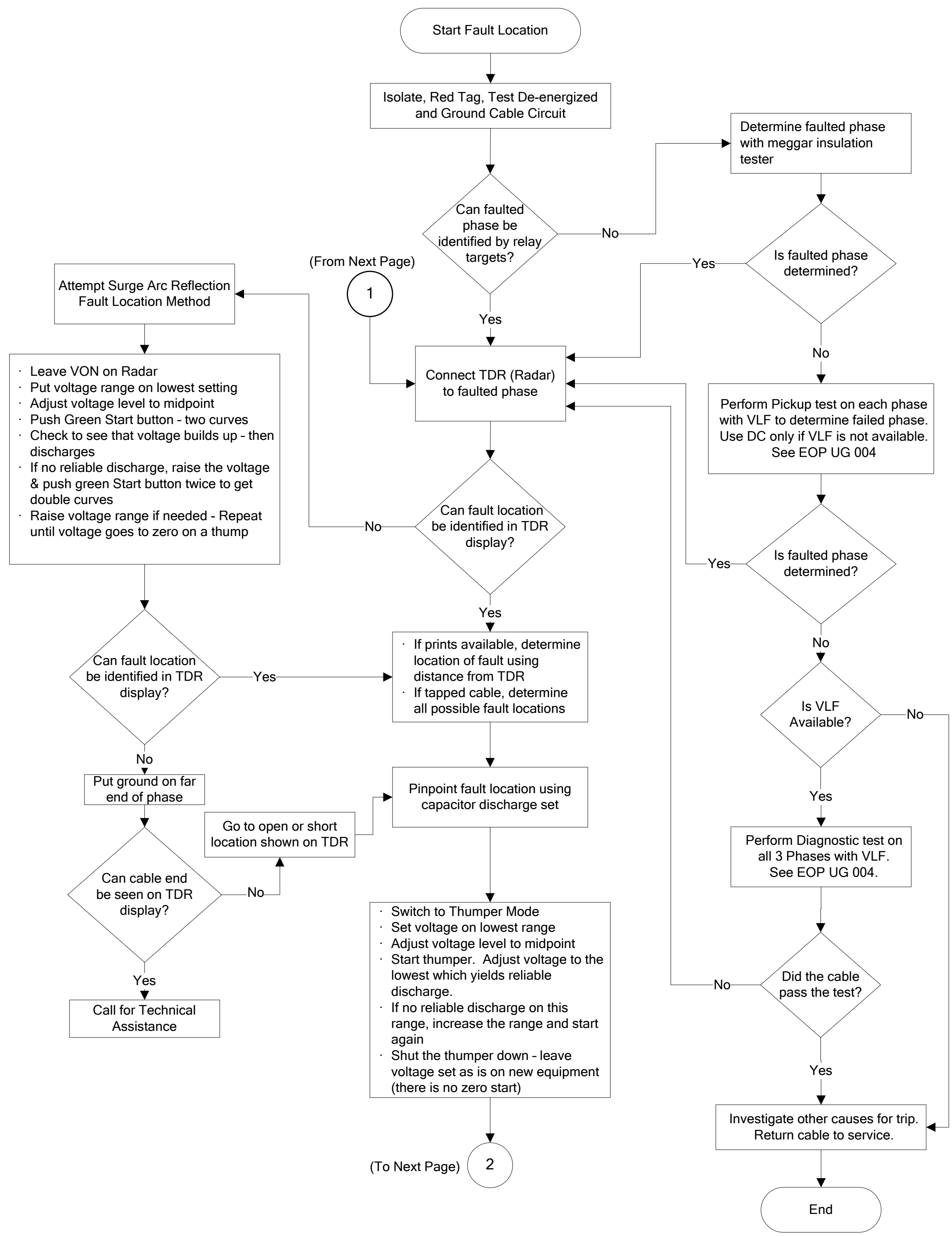
Single phase underground distribution cables (URDs), on the other hand, usually present a very simple fault locating task since they are relatively short, usually have no taps, and consist of a single cable type. For these faults, the VON portable TDR/Thumper is the recommended equipment.

The modern magnetic/audio detectors are effective at grade. The magnetic detectors available are the TEC-X35, Megger Electromagnetic Impulse Detector and the Megger MPP1000. The TEC-X35 is a handheld detector that is capable of picking up the signal from grade.

The fault location procedure is shown in the flow charts in Appendices 1 & 2, as indexed in the table above.

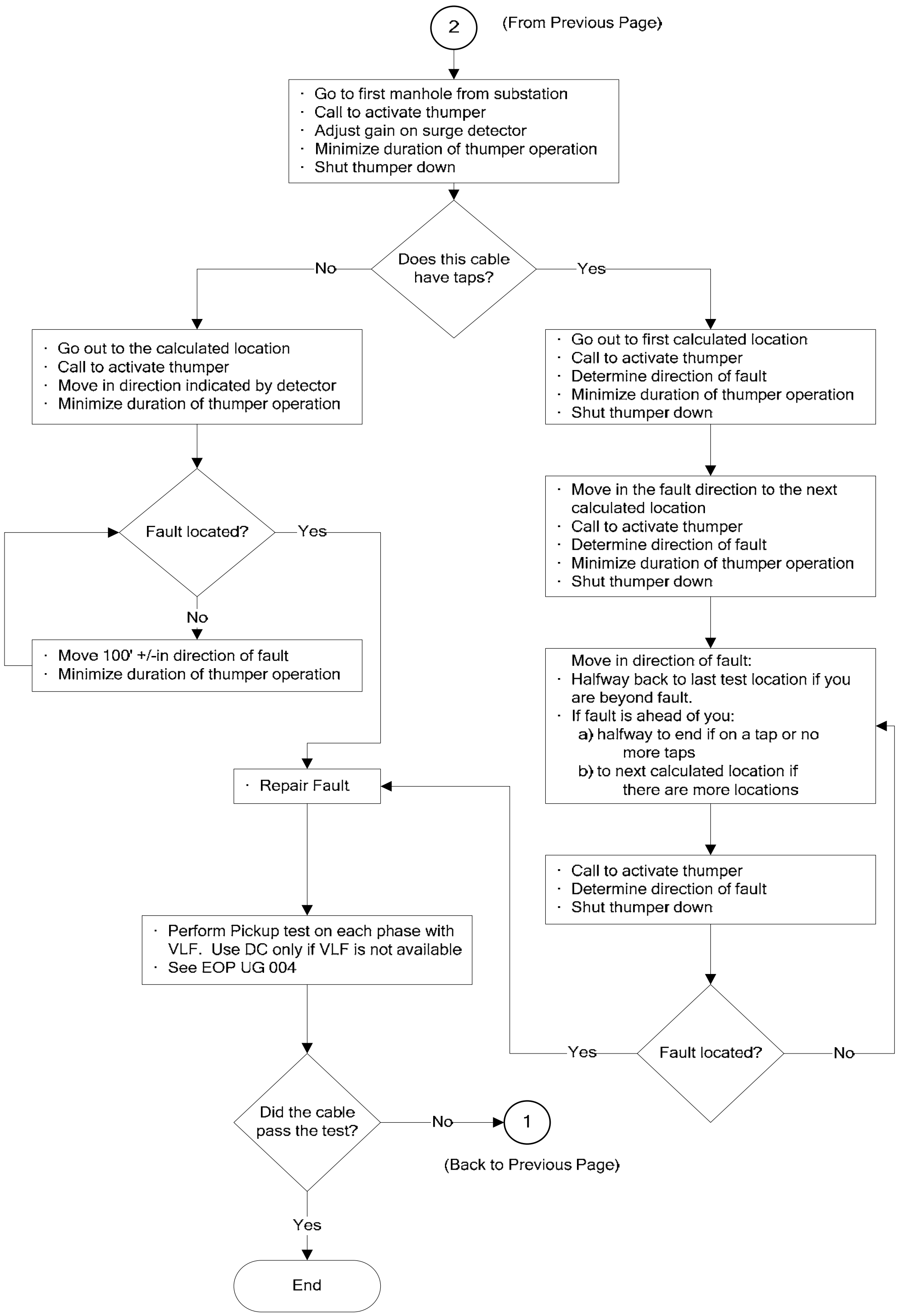
Liberty Utilities	Doc. # LU-EOP UG018		
Electric Operating Procedure	09-01-2015	Underground	
Underground Cable (over 1kV) Fault Location	Revision #	1.0	Page: 10 of 16

7.0 APPENDIX 1 - Cable Fault Locating Procedure for Radial Distribution Cables



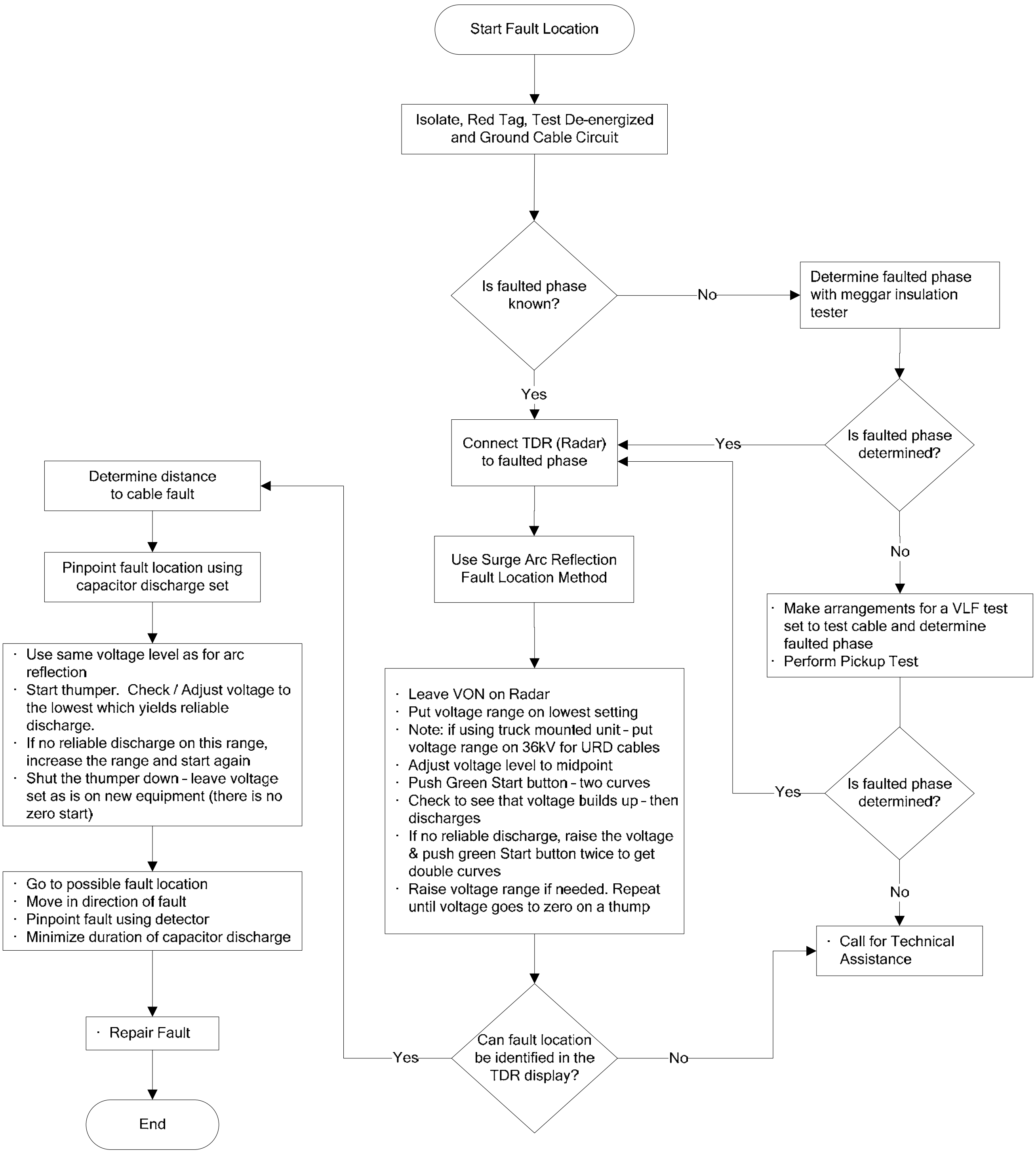
Liberty Utilities	Doc. # LU-EOP UG018		
Electric Operating Procedure	09-01-2015	Underground	
Underground Cable (over 1kV) Fault Location	Revision #	1.0	Page: 11 of 16

APPENDIX 1 (CONTINTUTED) – Cable Fault Locating Procedure for Radial Distribution Cables



Liberty Utilities	Doc. # LU-EOP UG018		
Electric Operating Procedure	09-01-2015	Underground	
Underground Cable (over 1kV) Fault Location	Revision #	1.0	Page: 12 of 16

8.0 APPENDIX 2 – Cable Fault Locating Procedure for Single or Three Phase Underground Residential or Underground Commercial Distribution Cables.



9.0 APPENDIX 3 – Murray Loop (Whetstone) Bridge

The Murray loop method is an alternative to the voltage drop method. It is not as effective as the voltage drop method for the following reasons:

9.1 Maximum precision is 1/1000

9.2 Reliable results require a fault resistance (Rf) of less than ≈ 200 ohms

Nevertheless, the Murray Loop Bridge may be successful in approximately locating a low resistance fault.

Terms:

9.1 Rb is a slide wire in the Bridge equipped with a scale calibrated from 0.000 to 1.000

9.2 Rx is the cable resistance from the near terminal to the fault

9.3 Rf is the fault resistance

9.4 G is the galvanometer in the Bridge

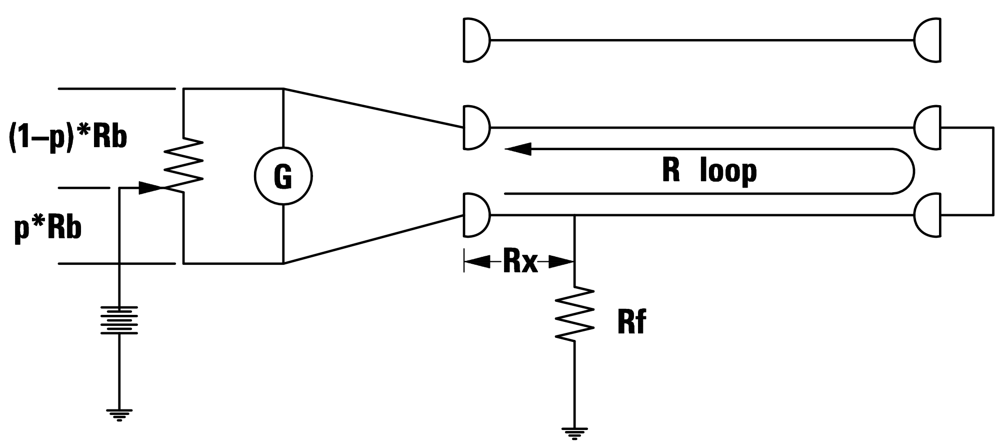
9.5 p is the reading from the slide wire when the galvanometer is balanced – range from 0.000 to 1.000

9.6 R loop is the series resistance of 2 phases of the cable and the jumper on the far end

9.7 L loop is the circuit length times 2

9.8 L1 is the distance from the termination to the fault.

Figure 1 illustrates the method. The Murray loop method requires the availability of one unfaulted conductor, which is continuous from terminal to terminal. The faulted and sound conductors are connected with a low resistance conductor at the far terminals.



The Murray loop bridge is connected between the faulted and sound conductors at the near terminal. The DC source (shown as a battery in Figure 1) can be a 12-volt automotive battery or a DC test set with its output set below 1000 volts.

NOTE:

If a DC test set is used as the DC source, the Murray Loop must be placed on an insulating rubber blanket and Class 2 rubber gloves must be worn

Resistance Rb is a slide wire equipped with a scale. At balance (indicated by a galvanometer, G):

$$\frac{p * Rb}{(1 - p) * Rb} = \frac{Rx}{Rloop - Rx}$$

Where p is the per-unit reading of the slide wire, and Rloop is the total resistance of the faulted conductor and good conductor in series.

In terms of the total circuit length:

$$L1 = p * Lloop$$

If L1 is more than 50% of L loop, then the polarity terminal of the bridge is connected to the unfaulted phase. Reverse the leads from the bridge at the terminations and take another reading. The sum of the two p readings should be approximately 1.00. If the sum varies widely from this, then there are variations in the loop resistances, making the validity of the readings questionable.

It is important to note that the bridge reading is the ratio of the distance to the fault to the total loop distance, i.e. the sum of the lengths of the faulted and the good conductor. Since the lengths of the three phases are different, due to slightly different lengths of cable at the terminals, there are three different combinations of loop distances depending on which two conductors are involved.

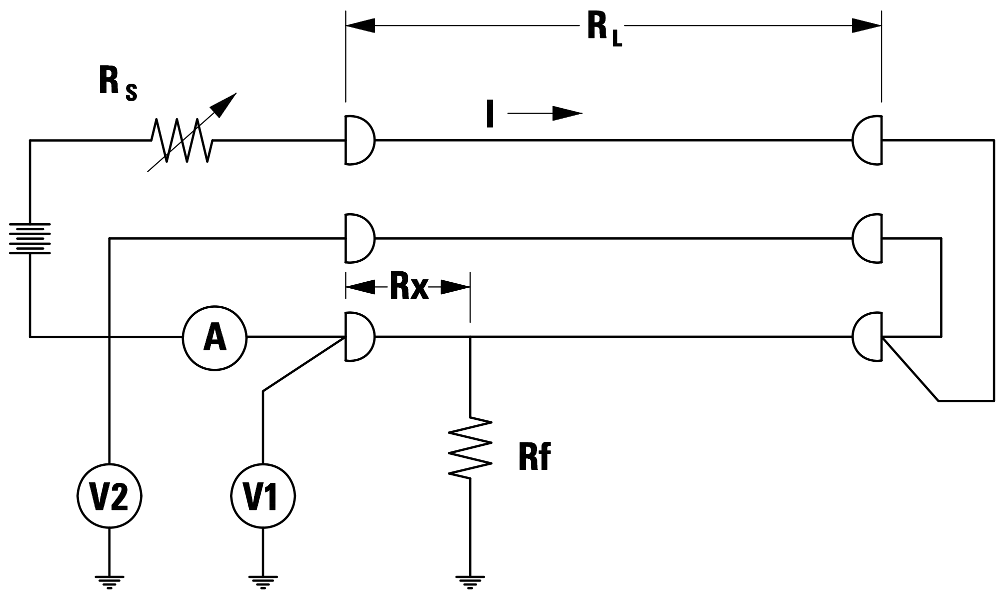
10.0 APPENDIX 4 – Voltage Ratio Method

Because of its excellent precision, even with relatively high fault resistance, the voltage ratio method may be successful if TDR related methods have not worked. The voltage ratio method is effective with fault resistances as high as one megohms. The principle of operation is illustrated in Figure 1.

The three phase conductors are connected together, as shown, at the far terminal. A direct current

(≈ 20 A) is circulated in the loop formed by the faulted conductor and one unfaulted conductor. The voltage source can be an automotive battery in series with a variable resistor. The other unfaulted conductor is used as a potential lead to permit measurement of the voltage from the faulted conductor to ground (V2) at the far terminal. The voltage to ground at the near terminal (V1) is also measured. If digital voltmeters V1 and V2 have very high resistance, the current through the voltmeters and the fault resistance Rf is negligible.

Figure 1 - Voltage Ratio Method of Fault Location



Terms:

10.1 Rs is a variable resistor to adjust loop current

10.2 Rx, equal to R1, is the cable resistance from the near terminal to the fault

10.3 Rf is the fault resistance

10.4 R2 is the cable resistance from the fault to the far terminal

10.5 A is the ammeter to read loop current

10.6 I is the loop current

10.7 p is the reading from the slide wire when the galvanometer is balanced – range from 0.000 to 1.000

10.8 RL is the resistance of 1 phase of the cable

10.9 V1 is the voltage to ground measured at the near terminal

10.10 V2 is the voltage to ground measured at the far terminal

10.11 L1 is the distance from the near termination to the fault.

10.12 L2 is the distance from the fault to the far termination.

10.13 Ltotal is the cable length from terminal to terminal

The ratio of voltages V1 to V2 is equal to the conductor resistances R1 to R2. Since the resistances, R1 and R2 are proportional to the lengths of conductors L1 and L2 respectively:

$$L1 = \frac{V1}{V1 - V2} * Ltotal$$

Where L1 is the distance from the near terminal to the fault, and Ltotal is the cable length from terminal to terminal.

The precision should approach 1/5000.

Repeat the measurement from the opposite terminal.

A Cable Dynamics Model 9100 locator, which utilizes the voltage drop method, is available in several Liberty Utilities USA Retail Company locations. If the Cable Dynamics device is not available, a satisfactory substitute can be fashioned from two digital voltmeters and a 12-volt storage battery set on a rubber-insulating blanket. A 238-foot length of #14 copper wire in series with the battery will limit the current to approximately 20 amperes.

11.0 EXCEPTION APPROVALS

It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Manager of Work Methods Distribution Engineering Services and a Manager of EHSS or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

12.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
09/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG019		
Electric Operating Procedure	**07-03-2012**	**General**	
Underground Electric Facility Locating	**Revision #**	**0**	**Page: 1 of 6**

1.0 PURPOSE

This procedure provides the requirements for the task of locating Liberty Utilities' underground electric facilities by Liberty Utilities employees or Liberty Utilities contractors.

2.0 SCOPE

This procedure was developed and implemented to provide maximum protection to underground electric facilities from third party damage by assuring accurate locations and facility verifications

3.0 DEFINITIONS

Abandoned Line or Facility: Any underground or submerged line or facility no longer in use.

Conductive/Active Locating: This is the process of locating a facility by direct connection.

Conductive attachments: Accessories used with the transmitter for direct connection. The most commonly used are red and black cables with alligator clips on the ends.

Damage:

New Hampshire – "Damage" means any impact or exposure that results in the need to repair an underground facility due to the weakening or the partial or complete destruction of the underground facility, including, but not limited to, the protective coating, lateral support, corrosion control, or the housing for the line, device, or underground facility.

Direct inductive coupling: A form of coupling, wherein the signal from the transmitter is applied to the target line by means of an inductive clamp, the jaws of the inductive clamp are spring loaded such that they may be snapped around the line. The mode is used when direct connection is not possible.

Direct connection: The preferred method of actively applying a signal onto a facility is to use direct connection. Direct connection is the process of connecting a direct lead from the transmitter to the target facility, and connecting a ground lead from the transmitter to a ground point in order to complete a circuit. This process provides the strongest signal on the line and is less likely to "bleed over" to adjacent facilities than other methods of applying a signal. This method allows a greater range of frequency and power output options. It is good practice to use the lowest frequency possible at the lowest power output possible to complete the locate.

Excavation: An operation for the purpose of movement or removal of earth, rock or the materials in the ground including, but not limited to, digging, blasting, augering, backfilling, test boring, drilling, pile driving, grading, plowing in, hammering, pulling in, jacking in, trenching, tunneling and demolition of structures. New York and Rhode Island regulations exclude the movement of earth by tools manipulated only by human power from the definition of "excavation."

Excavator: Any person proposing to or engaging in excavation or demolition work for themselves or for another person.

Facility Owner/Operator: Any person, utility, municipality, authority, political subdivision or other person or entity who owns, operates or controls the operation of an underground line/facility.

Facility: An underground or submerged conductor, pipe, or structure used in providing electric or communications service (including, but not limited to, traffic control loops and similar underground or submerged devices), or an underground or submerged pipe used in carrying, providing, or gathering gas, oil, or oil products, sewage, storm drainage, water or other liquid service (including, but not limited to irrigation systems), and appurtenances thereto.

Geographic Information System (GIS): An organized collection of computer hardware, software, and geographic data used to capture, store, update, maintain, analyze, and display all forms or geographically referenced information.

Indirect inductive coupling: A method of coupling, wherein the signal from the transmitter is applied to the target line by means of an internal antenna in the transmitter. The transmitter is placed near the line, and the signal is induced in the line. This is the least effective way to apply a signal, and it may result in bleed-over of the signal to other conductors nearby.

Inductive clamp: A device used to induce a signal onto a line without using a direct electrical connection. The jaws of the device are spring-loaded so they can be snapped around the line.

Inductive coupling: A method of applying the signal from the transmitter onto the target line without a direct connection. The two types of inductive coupling are direct and indirect.

Locate: To indicate the existence of a line or facility by establishing a mark through the use of stakes, paint or some other customary manner, that approximately determines the location of a line or facility.

Locate request: A communication between an excavator and the one-call center personnel in which a request for locating underground facilities is processed.

One-call notification system: Any organization among whose purposes is establishing and carrying out procedures to protect underground facilities from damage due to excavation and demolition, including but not limited to, receiving notices of intent to perform excavation and demolition and transmitting the notices to one or more member operators of underground facilities in the specified area. The one-call notification serving New Hampshire is Dig Safe System, Inc., which can be contacted at 888-DIG-SAFE (888-344-7233) or www.digsafe.com. 811 can also be called from anywhere within the United States and your call will be routed to the correct one-call notification center.

Passive Locating: A method of locating, wherein no transmitter is required. The current in the line is generated by electromagnetic fields in the environment such as those generated by power lines (50 or 60 Hz) and those generated by radio stations (RF). The technique is quick, but is more error prone than active locating.

Shall: The word shall is to be understood as mandatory.

Should: The word should is to be understood as advisory.

Test Holes: Exposure of a facility by safe excavation practices used to ascertain the precise horizontal and vertical position of underground lines or facilities.

Tolerance Zone: If the diameter of the underground facility in known, the distance of one-half of the known diameter plus two feet, on either side of the designated centerline or, if the diameter of the underground facility is not known, two feet on either side of the designated center line.

4.0 REFERENCES

Liberty Utilities Employee Safety handbook
Common Ground Alliance – March 2008
NHPUC Rule Chapter Puc 800 Underground Utility Damage Prevention Program
New Hampshire Excavator Manual – January 2013

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5.0 RESPONSIBILITY

Roles and Responsibilities are outlined in the "Procedure" section of this document

6.0 UNDERGROUND ELECTRIC FACILITY LOCATING

All work shall be performed in accordance with Liberty Utilities Employee Safety Handbook rules and/or any Liberty Utilities EOP's utilizing all appropriate safe work methods.

All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

The employee or contractor in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

All underground cables shall be considered energized until the cable is isolated, tagged, tested de-energized and grounded.

If at any time a cable that is thought to be de-energized and grounded proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted and the System Operator shall be notified.

Rubber gloves of the appropriate class shall be worn until the cable is proven to be isolated, red tagged, tested de-energized and grounded.

All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Refer to the tool catalog for a listing of approved equipment.

7.0 TICKET HANDLING AND LOCATE INFORMATION SYSTEMS

Liberty Utilities requires an interactive computer database application, as the primary means of receiving, processing and responding to location requests.

7.1 The system shall receive location requests from the One-Call Notification Center and automatically sends the requests to the appropriate locating group.

7.2 This system should automatically communicate the status of the location request to the Excavator by fax or phone.

8.0 ELECTRONIC LOCATING EQUIPMENT

8.1 Prior to Use Inspection - Daily

All electronic locating equipment should be inspected each day, prior to use. The inspection should include:

8.1.1 Battery strength of the transmitter and receiver.

8.1.2 Visual inspection of the conductive connection leads and inductive coupling clamp. All broken or frayed wires and damaged clamps must be repaired or replaced.

8.2 Monthly Testing

At least once per month, all electronic locating equipment should be tested for accuracy. Testing should be completed utilizing one of the following methods:

8.2.1 Conductively connecting to a "known" underground electric conductor. This may include tracer wire or an electric service whose location has been previously verified/exposed; or

8.2.2 Conductively connecting to an underground electric facility (steel or plastic with tracer wire access).

Note: Utilization of this test method requires a minimum of two separate pieces of electronic locating equipment. Each electronic locating unit utilized during this test method must produce repeatable facility location results.

9.0 DOCUMENTATION

9.1 Location Request Ticket

Requests locations will be administered by Location Request Tickets received from the One-Call Notification Center that have fields providing certain information for the employee or contractor assigned to perform the locating function. Examples are but not limited to: ticket number; geographical location; detailed location of planned excavation area; work date and time; type of work to take place; and field contact – name and phone number.

9.2 Location Status and History

The following documentation is to be provided for each location request on a system wide, standardized log sheet such as a locator's daily log sheet, which will include:

9.2.1 Locator Name

9.2.2 Date and time of locate

9.2.3 Disposition of ticket

9.2.4 Contact Information

9.2.5 Methods used to complete locate

9.2.6 Verbal agreements/conversations with the excavator

9.2.7 Variations to area of mark-out if different from ticket request (if applicable)

9.2.8 Inability to induce an electronic signal either conductively or inductively (if applicable)

9.2.9 Blasting information (if applicable)

9.2.10 Photos and/or videos (if taken at locate site)

9.2.11 Whether a special circumstance requiring additional vigilance existing (i.e., an electric substation with 100 feet, or an underground electric transmission or underground electric sub-transmission line in the vicinity of the work area).

10.0 LOCATING PROCEDURE

10.1 The locator shall utilize the available facility records at all times. The facility records indicate approximate location, number of facilities and access points for buried facilities within a requested area. The use of Liberty Utilities facility supplied records is an effective method of identifying facilities as part of the locating process.

10.2 During the course of a locating activity, a locator may become aware of an error or omission to Liberty Utilities records. Field Corrections are to be generated each time a facility record is found to be different in the field than on the Smallworld GIS Database Application per LU - EOP G011 Preparation and Distribution of Electric Facilities Records. Omission and errors may occur due to miss-drawn records, changes during construction at the job site, repair or abandonment of facilities and delays in posting new records.

10.3 The locate shall be performed in a safe manner. It is the responsibility of the locator to establish when and how the underground facility will be identified. All hazards associated with performing a locate shall be identified.

10.4 The locator shall perform a visual inspection during the locate process. The inspection should include an evaluation of the scope of the locate request and the facilities within that locate request. The locator should identify access points, identification of potential hazards and assurance that underground facilities shown on Liberty Utilities records match those at the site.

10.5 The locator shall adequately mark the facilities for the existing and expected surface conditions. Conditions which may affect markings are rain, snow, vegetation, high traffic, construction etc. The markings may include one or any combinations of the following: red paint, red chalk, red flags, and stakes with red paint, red whiskers or offsets. All locations should be marked as follows:

10.6 Guidelines for Marking UG Electric Facilities

10.6.1 Marks in the color of red are to be approximately 12” to 18” in length and 1” inch in width and separated by approximately 4’ to 50’ in distance as an example. When marking facilities the locator is to consider the type of facility being located, the terrain of the land, the type of excavation being done and the method to adequately mark the facilities for the excavator.

|← 12" to 18" →|← 4' to 50' in distance →| ↑
between marks 1" Wide

10.6.2 The following marking illustrations are examples of how a locator shall mark Liberty Utilities underground facilities.

10.6.2.1 Facility Marking: Used to mark an electric facility, the marks are placed at the boundaries of the facilities as indicated by the electronic locating equipment. The examples below indicate the proper way to mark an underground electric facility.

LU - E

10.6.2.2 Changes in direction and lateral connections are to be clearly indicated at the point where the change in direction or connection occurs with an arrow indicating the path of the facility. A radius is indicated with marks describing the arc. When providing offset markings, (paint or stakes), show the direction of the facility and distance to the facility from the markings.

10.6.3 A Liberty Utilities identifier (LU E) is to be placed at the beginning and at the end of the proposed work. In addition to the previous, subsequent operators using the same color will mark their company identifier at all points where their facility crosses another operator's facility using the same color. The maximum separation of identifiers is to be reduced to a length that can be reasonably seen by the excavator when the terrain at the excavation site warrants it.

LU E LU E LU E

10.6.4 Structures, such as vaults and manholes that are physically larger than obvious surface indications, are to be marked so as to define the parameters of the structure.

10.6.5 Termination points or dead ends are to be indicated as such.

10.6.6 When there are no Liberty Utilities underground electric facilities the locator would mark the area “Clear” preceded by LU ELECL (company identifier) in the APWA color code red for electric facilities (e.g. “LU ELEC CLEAR”).

10.6.7 All Liberty Utilities underground facilities within 15 feet of any proposed excavation area shall be located by the locator.

10.6.8 If re-marking a previously marked location, the locator shall not rely on any visible old marks. With new construction and maintenance activities, facilities can, and do, change.

10.7 All locates performed by a locator shall have a positive response to the excavator. A positive response may include one or more of the following: markings or documentation left at the job site, callback, fax or automated response system. A positive response allows the excavator to know whether all facility owners/operators have marked the requested area prior to the beginning of the excavation.

NOTE: All location requests shall be completed by the stated excavation date unless other arrangements are made with the excavator and documented by the locator. Alternative completion dates proposed by the person performing the locate shall be no longer than two working days from the original requested date unless agreed upon by both parties. All extensions shall be documented.

10.8 The locator can provide oversight (Watch Guard) to the excavator in order to assist in the location and verification of the subject facility(s).

11.0 UNVERIFIABLE FACILITIES

If an excavator contacts Liberty Utilities because they are unable to verify the location of a National Grid underground electric facility, a Liberty Utilities Electric Operations representative shall be dispatched to the site. If the representative is unable to verify the facility, one of three options must be taken:

11.1 Depending on the type and complexity of the excavation being performed, the Liberty Utilities Electric Operations representative may remain on site to provide oversight and assist the excavator in verifying or clearing the facility as the job progresses.

11.2 If the job is the type of complexity that the facility must be verified before excavation can begin a Liberty Utilities Electric Operations representative must be notified to complete the location and verification of the underground electric facility.

11.3 If the locator is confident in the location and mark out, and the electric facility is believed to be deeper than the proposed excavation, the excavator can be released to proceed, providing the tolerance zone has been observed.

12.0 LOCATIONS INVOLVING NEW CONSTRUCTION

As a method to protect newly constructed facilities from damage during the time period between its creation and the associated updated records being entered into GIS, all new installations should be painted and/or staked at the time it is energized. This shall be completed by a Liberty Utilities employee or a Liberty Utilities contractor.

A Liberty Utilities employee or Liberty Utilities contractor shall perform a visual observation of the construction site to detect any previously applied marks, which may no longer be valid. If such marks exist, the employee or contractor shall obliterate such marks to eliminate any confusion and/or inaccuracy (remove by scuffing out, painting over (black paint on pavement, grey on concrete, etc.).

13.0 LOCATIONS PERFORMED NEAR LIBERTY UTILITIES SUBSTATIONS

If a location request is within 100 feet of a Liberty Utilities electric sub-station a high profile notification is generated to Liberty Utilities Electric Operations.

13.1 Upon receipt of the location request, the locator will contact Liberty Utilities Electric Operations.

13.2 Liberty Utilities Electric Operations will review all station files for details on National Grid underground facilities.

13.3 Liberty Utilities Electric Operations shall provide access to the station facilities for the locator to directly locate underground electric facilities.

13.4 The locating and Liberty Utilities Electric Operations personnel shall work together to locate all underground electric known facilities.

13.5 If there is reason to believe there are undocumented underground electric facilities in the area, the locator or a Liberty Utilities qualified employee, will be stationed at the site to observe the excavation operation until the facilities location has been verified or until all excavation has been completed.

14.0 LOCATION REQUESTS INVOLVING UG SUB-TRANSMISSION

If it is discovered that a proposed excavation site is within **25 feet** of an underground electric transmission line or underground sub-transmission line a high profile notification is generated to Liberty Utilities Electric Operations.

14.1 Upon receipt of the location request, a Liberty Utilities appointed inspector will contact the excavator to discuss safety concerns and visit the site daily to monitor for excavation activity and renew markings until excavation begins.

14.2 Once excavation begins, a Liberty Utilities appointed inspector will be stationed at the site to observe the excavation operation whenever the active excavation is within 10 feet of the UG Sub-transmission.

14.3 If the UG Sub-transmission or UG Transmission line is exposed, a Liberty Utilities appointed inspector will inspect the electric line before backfilling and observe the backfilling process.

15.0 LOCATION REQUESTS INVOLVING PAVEMENT REMOVAL

For location requests involving pavement removal such as road milling or road base reclamation (rubblizing), all underground facilities shall be located and marked out in accordance with the provisions of Code Rule 753.

Any location request involving pavement removal should be followed up to determine the extent of the operation and the proper action can be taken.

If conditions warrant, or the excavator feels he may exceed the depth of pavement with the milling or rubblizing operation, the excavator may be required by Liberty Utilities to dig test holes to verify facility locations and/or depths. In this situation, the Company must provide guidance for the placement of these test holes. The Liberty Utilities employee and/or supervisor must review the information available, the level of confidence in the information, and provide guidance based on the job site conditions.

15.1 Guidance should be based on:

15.1.1 Depth of proposed excavation and scope of the operation.

15.1.2 Whether the facilities to be crossed are parallel or perpendicular.

15.1.3 Depth of road surface or the type of road base.

15.1.4 Liberty Utilities' past experience with the Contractor.

15.1.5 Age of the facility along with past knowledge of the facility location.

15.1.6 Grade changes since the initial installation of the facility.

15.1.7 Locating instruction indications (internal use only)

16.0 REPORTING DAMAGE TO UNDERGROUND FACILITIES

Damage to underground electric facilities is costly and could pose significant risk to Liberty Utilities employees and the general public. When an excavator causes any damage to an underground facility not owned or operated by the excavator, State laws require excavators to notify Dig Safe and NHPUC. Liberty Utilities is a member of Dig Safe. These organizations exist to protect the general public and to prevent damage to underground facilities through a member network of underground facility owners.

<u>LU EOP UG010</u> outlines the steps to take when damage has occurred to Liberty Utilities' underground electric facilities.

17.0 BLASTING OPERATIONS

When notification of intent to blast by a third party is received by Liberty Utilities, the initial staking, marking and locating shall be provided by the locating group. Upon receipt of the location request for Blasting, the locating group will contact Liberty Utilities Electric Operations. However, in addition to those guidelines the procedures given below shall be adhered to throughout the blasting operation.

Prior to blasting the following steps shall be taken, by Liberty Utilities Electric Operations, upon receipt of notification of the intent to blast to ensure that the integrity of Liberty Utilities underground electric facilities and the safety of the general public are maintained.

17.1 Liberty Utilities Operations will establish immediate contact with the contractor and arrange to hold a preliminary meeting with a representative from the organization that will be performing the blasting operation. ***NOTE**: If appropriate, a representative from Consumer Relations should also attend the meeting.*

17.2 Liberty Utilities Operations should state the following Liberty Utilities requirements at the preliminary meeting.

17.2.1 The contractor needs to provide an appropriate and valid blasting license and permit.

17.2.2 A detailed copy of excavator's blasting and construction plan.

17.2.3 A meeting will be scheduled for the purpose of reviewing plans with the excavator, to determine any potential conflicts with underground electric facilities.

17.2.4 Inform the contractor that plans are subject to a timely review by the appropriate Liberty Utilities personnel.

17.3 Liberty Utilities Electric Operations will forward a copy of the blasting plan to Electric Engineering for an analysis of the impact on Liberty Utilities underground electric facilities.

17.4 Liberty Utilities Operations obtains the results of analysis (step 12.3) and reviews with Liberty Utilities Electric Engineering, developing precautionary guidelines to safeguard underground facilities.

17.5 Liberty Utilities Electric Operations arranges, based upon the results of the analysis, a meeting to discuss one of the following scenarios:

17.5.1 Scenario 1

If the situation may be detrimental to maintaining the integrity of the underground electric facilities and the resultant welfare of the public, arrange a meeting with the excavator and appropriate Liberty Utilities Electric Operations, Consumer Relations and Electric Engineering personnel.

Discuss with the excavator the reasons why it's necessary to revise plans, and return to Step 3.

OR

17.5.2 Scenario 2

If plans are viewed to be acceptable, arrange a pre-blast meeting with the excavator and appropriate Liberty Utilities Electric Operations personnel.

17.6 Liberty Utilities Electric Operations develops, prior to pre-blast meeting, the necessary precautionary measures (see below) to be taken by Liberty Utilities Electric Operations and/or the excavator.

17.6.1 Develop plans to address any emergencies that might be expected to occur during blast.

17.6.2 Determine the need for the use of temporary protection and support of underground electric facilities during the blasting operation.

17.6.3 Determine the possibility of taking electric underground facilities out of service during blasting operation.

17.6.4 Determine the need to provide a representative or crew on a stand-by basis.

17.7 Liberty Utilities Electric Operations performs a field review of blasting plans with contractor to make certain all needs are addressed.

17.8 Liberty Utilities Electric Operations to reviews the excavator's blasting and construction schedule and deadlines

17.9 Liberty Utilities Electric Operations reviews precautionary measures to be taken to protect Liberty Utilities underground electric facilities with excavators, clarifying which measures are the responsibility of either Liberty Utilities Electric Operations or the excavator.

NOTE: As given under Code Rule 753, the excavator maintains full responsibility for requesting and maintaining the locating and staking of *facilities. The excavator also is responsible to provide temporary protection and support of electric facilities throughout the blasting operation.*

17.10 Liberty Utilities Electric Operations to coordinate with the excavator, as to the implementation schedule, the measures each party is responsible for performing. Each responsible party should designate an on site representative to be in charge of their respective operation and be responsible for establishing and maintaining on site communication.

17.11 Liberty Utilities Electric Operations finalizes, upon completing blasting activity coordination with excavator, all duties to be performed by Liberty Utilities Electric Operations.

17.11.1 Brief appropriate Liberty Utilities Electric Operating personnel as to their responsibilities during the blasting procedure and verify that all necessary equipment is ready and operational.

17.11.2 Coordinate, as warranted, with those departments whose assistance will be required throughout the blasting operation as to their duties and the implementation of activities.

17.12 During the blasting operation the following steps shall be taken by Liberty Utilities Electric Operations to ensure that the integrity of Liberty Utilities underground electric facilities and the safety of the general public are maintained.

17.12.1 Maintain a log of all pertinent activities during each blast sequence.

17.12.2 Establish contact with a designated blasting representative and performs final field review of all precautionary measures, emergency and implementation schedules. ***NOTE****: It is important, particularly at this point, that a means of communication has been established.*

17.12.3 Make sure, if an underground electric facility is to be taken out of service that all necessary feeds are maintained and all affected customers have been contacted.

17.12.4 Verify that all required protection and support for electric facilities has been properly installed and maintained.

17.12.5 Implement precautionary measures as applicable.

17.12.5.1 Verify that designated Liberty Utilities Electric Operations personnel on standby status are ready and equipped to implement emergency actions as required.

17.12.6 Perform all necessary repairs prior to the next blasting sequence.

17.13 After the blasting operation the following steps shall be taken by Liberty Utilities Electric Operations to ensure that the integrity of Liberty Utilities underground electric facilities and the safety of the general public are maintained.

17.13.1 Make contact with a representative of the excavator to make certain that all pertinent blasting activities have been completed.

17.13.2 Perform the necessary procedures to determine if the integrity of underground electric facility has been maintained.

17.13.3 Re-energize the underground electric facility and verify that all affected customers have had their service restored and their associated apparatuses are functional.

17.13.4 Verify that all essential backfill has been restored to provide adequate support and cover.

17.13.5 Perform surveillance over a reasonable time period for settlement of backfilled excavation and damage caused by other related construction activity.

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18.0 EXCEPTION APPROVALS

It is recognized that situations arise not covered by this document. In those cases the person in charge of the work shall seek concurrence on the proposed work method from the appropriate Manager of their respective department, the Manager of Standards, Polices, & Codes, Distribution Engineering Services and a Manager of Corporate Safety and Health or their designees. If concurrence cannot be reached at this level the request shall be forwarded to the Director level or their designee.

19.0 TRAINING

Provided by appropriate Liberty Utilities Learning and Development program.

20.0 REVISION HISTORY

Date	Rev #	Description	Lead / Author
07/03/2012	0	Initial version of Document	Robert J Johnson

Liberty Utilities	Doc. # LU-EOP UG021		
Electric Operating Procedure	3-01-2015	Underground	
Operations and Maintenance of Padmounted UG Equipment After a Flood Has Occurred	Revision #	1.0	Page: 1 of 11

INTRODUCTION

There are two types of underground equipment used on Liberty Utilities property: padmounted equipment for above ground use and submersible equipment located in manholes and vaults for use under water. This EOP only covers above ground padmounted equipment.

PURPOSE

The purpose of this EOP is to provide guidance in the restoration of power to de-energized padmounted equipment including switchgear, transformers, pad-mounted junction enclosures, padmounted VISTA Switchgear and primary metering cabinets and any other padmounted equipment owned by Liberty Utilities that may have sustained damage during a flood. This procedure does not cover any submersible equipment such as sub surface transformers, vacuum switches or subsurface VISTA Switchgear.

NOTE: There may be other padmounted equipment owned by Liberty Utilities that is not mentioned in this document. Please contact Underground Construction Standards for guidance on cleaning and restoration of these units.

ACCOUNTABILITY

This procedure applies to all personnel involved with the operation, maintenance and inspection of pad mounted equipment.

1. Standards, Policies, and Codes
   A. Update procedure as necessary.
   B. Provide Electric Distribution Operations field support upon request.

2. Electric Distribution Operations
   A. Ensure that the procedures in this EOP are implemented.
   B. Ensure that all personnel are trained in this procedure.
   C. Provide procedure revision input as necessary.

3. Liberty Utilities Employees and Contractors
   A. Demonstrate the understanding of the procedures in this EOP.
   B. Comply with the requirements of the procedures in this EOP.
   C. It is the workers responsibility to read and fully understand and follow the manufacturer's instruction manual and specifications before operating any equipment.

REFERENCES

Liberty Utilities Employee Safety Handbook and Procedures

Liberty Utilities Distribution Construction Standards

Manufacturers Operating Instructions

DEFINITIONS

Barrier: A physical obstruction that is intended to prevent contact with energized lines and equipment.

Clearance (for work): Permission to an Authorized Person to perform specified work within a zone of protection.

Current Carrying Part: A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current carrying parts are those not intended to be so connected.

Dead: Isolated, red tagged, tested de-energized and grounded.

De-energized: Free from any electrical connection to a source of potential difference and from electrical charges. Not having a potential difference from that of earth. **Note**: The term is used only with reference to current-carrying parts which are sometimes alive (energized).

Energized (alive, live): Electrically connected to a source of potential difference or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

Insulated: Separated from other conducting surfaces by a dielectric substance (including air space) offering a high resistance to the passage of current. **Note**: When any object is said to be insulated, it is understood to be insulated in suitable manner for the conditions to which it is subjected. Otherwise, it is to be considered un-insulated. Insulating covering of the conductors is one means of making the conductor insulated.

Protective Position: The tagged position of a mechanical or electrical device with a visible air gap that prohibits the energizing or the re-energization of a specific work area.

Shall: The word shall is to be understood as mandatory.

Should: The word should is to be understood as advisory.

Submersible Equipment: Electric equipment such as transformers and switches that, are generally located within a Hand-hole, Manhole, or Vault.

TRAINING

A written request should be submitted to Liberty Utilities Learning and Development by user group whenever training is required.

DOCUMENT CONTENTS

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1.0 SAFETY REQUIREMENTS

1.1 All work shall be performed in accordance with all Liberty Utilities Employee Safety Handbook rules and/or any applicable Liberty Utilities EOP's utilizing all appropriate safe work methods.

1.2 All appropriate Personal Protective Equipment, which includes, but is not limited to hard hat, safety glasses/eye protection, rubber protective equipment, appropriate footwear and FR clothing, shall be worn when performing work as required by the Liberty Utilities Employee Safety Handbook and applicable work procedures.

1.3 The employee in charge shall conduct a written job brief with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, Clearance and Control Procedures, and personal protective equipment requirements.

1.4 All underground cables shall be considered energized until the cable is isolated, red tagged, tested de-energized and grounded per LU-EOP G014 "Clearance and Control".

1.5 If at any time a cable thought to be dead proves to be energized, all work shall immediately stop, workers shall go to a safe position, a supervisor shall be contacted and the System Operator shall be notified.

1.6 Rubber gloves of the appropriate class shall be worn until the cable is isolated, red tagged, tested de-energized and grounded.

1.7 During work, barriers or other appropriate protection shall be installed to protect adjacent conductors.

1.8 All the procedures shall be worked in accordance with accepted safe work practices using approved tools and equipment. Refer to your supervisor for approved tools and equipment.

NOTE: The following procedures shall be performed while the switchgear, transformer, padmounted junction enclosure or primary metering cabinet are isolated, red tagged, tested de-energized and grounded.

2.0 INSPECTION BEFORE RE-ENERGIZATION OF PADMOUNTED SWITCHGEAR AFTER A FLOOD

S&C SWITCHGEAR (Live Front and Dead Front)

2.1 Manual Operated Switchgear

2.1.1 For minimal water egress (few inches)

a. Inspect base for washout, install gravel where needed.

b. Check switchgear has not shifted from base, reset if needed.

c. Check for dirt and debris that has collected and remove it.

d. Check barrier boards for moisture and sediment, if sediment is present wash them down with soap and water (dishwashing detergent), if barrier boards are swollen or broken down, they must be replaced.

e. Check live front cable terminations for positioning, if they have shifted, reposition with a minimum of 1 "clearance from barrier board.

f. Check live front cable terminations free of sediment, if dirty clean with soap and water.

g. Check switchgear insulators free of sediment, if dirty clean with soap and water.

h. Check fuses and fitting for signs of moisture, if present replace.

Use compressed air to dry out all areas of the switchgear once the checks have been completed.

NOTE: Do not use any solvent based cleaners on any part of the switchgear, this can breakdown several of the components.

For higher levels of water, below the mini-rupters the switchgear will need to have the roof removed to have a detailed inspection performed of the bus and switch mechanisms. See bulletin # 662-800 for PMH-live front style switchgear and bulletin # 665-800 for PME-dead front style switchgear found on the S&C website for further instructions. WWW.SANDC.COM

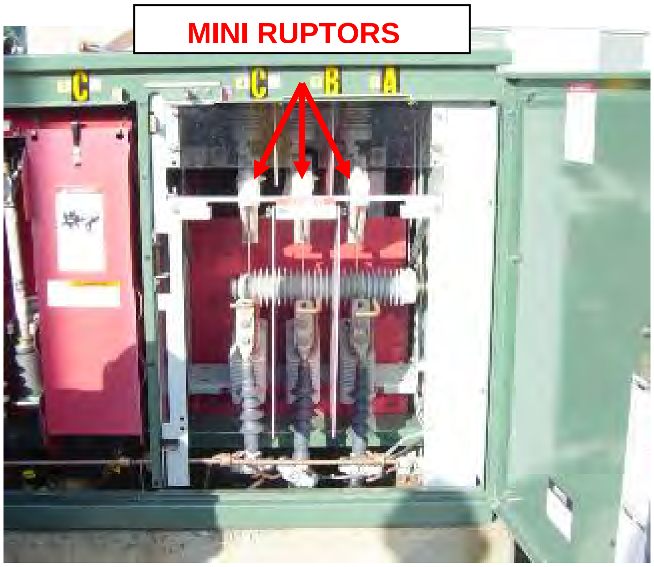
2.1.2 For water levels above the mini-rupters, have the switchgear replaced due to damage in the mini-rupters. Bring switch back to local office for a detailed inspection to repair or scrap the switchgear.

2.2 Auto Transfer Switchgear

2.2.1 For minimal water egress, follow above checks. (2.1.1)

2.2.2 For any water egress above a few inches which would impact any of the electrical controls/circuit boards, have the switch replaced and do a detailed evaluation of the switch back at the local office.

NOTE: All replacement parts and lubricants can be purchased from S&C.



S&C SWITCHGEAR (PMH-LIVE FRONT)

S&C SWITCHGEAR (PME-DEAD FRONT)

2.3 Non S&C Switchgear

2.3.1 A visual inspection shall be made. For minimal egress (few inches) the switchgear shall be cleaned and lubricated per instructions in section 2.0 of this document. For higher levels of water the switchgear should be replaced with S&C model padmounted switchgear.

3.0 INSPECTION BEFORE RE-ENERGAZATION OF 3 PHASE PADMOUNTED LIVE FRONT TRANFORMERS AFTER A FLOOD

3.1 Inspect base for washout, install gravel where needed.

3.2 Check pad mounted transformer has not shifted from base, reset if needed.

3.3 Check for dirt and debris that has collected inside the compartment area and remove it.

3.4 Check for oil sheen around transformer area.

3.5 Check for oil seeping/leaking around primary and secondary bushings.

3.6 Check for oil sheen inside primary and secondary knockout area on the concrete pad and in and around the conduits.

3.7 Check pad mounted transformer pressurized, pull oil relief valve and listen for vacuum and look for any moisture coming from the valve.

3.8 Check terminators built correctly and sealed. If sediment present, wash off sediment with water.

3.9 Check Secondary bus free of sediment, if dirty wash off with water.

3.10 Check bayonet fuses secured in well.

3.11 Remove bayonet fuses and check for signs of moisture, if okay re-install.

NOTES: 1) If the circuit that the transformer is being fed from was not manually opened a meggar and TTR test should be performed. 2) If any of the above checks on the 3 phase padmount transformer show moisture a sample of the oil should be tested for the presence of water and replaced if needed.

LIVE FRONT 3 PHASE PADMOUNTED TRANSFORMER

4.0 INSPECTION BEFORE RE-ENERGIZATION OF 3 PHASE DEAD FRONT PADMOUNTED TRANSFORMERS AFTER A FLOOD

4.1 Inspect base for washout, install gravel where needed.

4.2 Check pad mounted transformer has not shifted from base, reset if needed.

4.3 Check for dirt and debris that has collected inside the compartment area and remove it.

4.4 Check for oil sheen around transformer area.

4.5 Check for oil seeping/leaking around primary and secondary bushings.

4.6 Check for oil sheen inside primary and secondary knockout area on the concrete pad and in and around the conduits.

4.7 Check pad mounted transformer pressurized, pull oil relief valve and listen for vacuum and look for any moisture coming from the valve.

4.8 Pull and park load break elbows and check elbow for moisture and jacket seal installed properly.

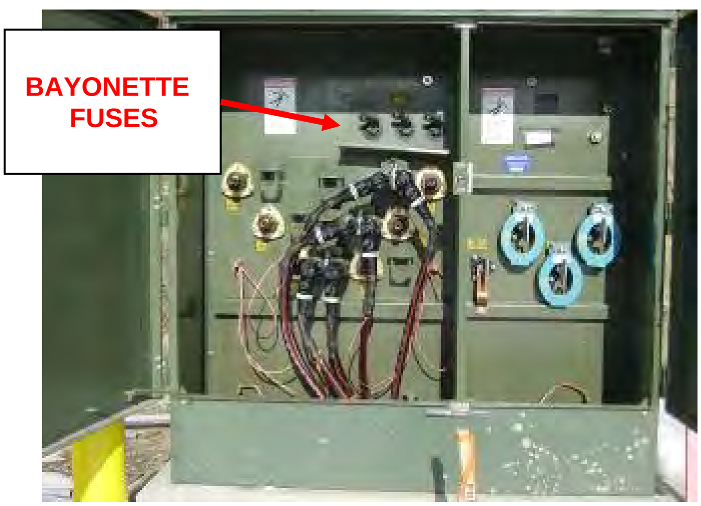
4.9 Check for moisture around the primary bushings. Check bushings properly torqued, apply lubricant and re-install elbows.

4.10 Check Secondary bus free of sediment, if dirty wash off with water.

4.11 Check bayonet fuses secured in well.

4.12 Remove bayonet fuses and check for signs of moisture, if okay re-install.

NOTES: 1) If the circuit that the transformer is being fed from was not manually opened a meggar and TTR test should be performed. 2) If any of the above checks on the 3 phase padmount transformer show moisture a sample of the oil should be tested for the presence of water and replaced if needed.



3 PHASE PADMOUNTED TRANSFORMER (DEAD FRONT)

5.0 INSPECTION BEFORE RE-ENERGIZATION OF SINGLE PHASE PADMOUNTED TRANSFORMERS AFTER A FLOOD

5.1 Inspect base for washout, install gravel where needed.

5.2 Check single phase padmount transformer has not shifted from base, reset if needed.

5.3 Check for dirt and debris that has collected inside the compartment area and remove it.

5.4 Check for any signs of oil sheens around the single phase padmount transformer and inside the box pad.

5.5 Check for oil seeping/leaking from the primary and secondary bushings.

5.6 Check mini pad transformer pressurized, pull oil relief valve and listen for vacuum and look for any moisture coming from the valve.

5.7 Pull and park load break elbows and check elbow for moisture and jacket seal installed properly.

5.8 Check for moisture in the transformer bushings. Check bushings properly torqued, apply lubricant and re-install elbows

5.9 Check secondary bus free of sediment, if dirty wash off with water.

5.10 Check bayonet fuse secured in well.

5.11 Remove bayonet fuse and check for signs of moisture, if okay re-install.

NOTES: 1) If the circuit that the transformer is being fed from was not manually opened a meggar and TTR test should be performed. 2) If any of the above checks on the mini pad show moisture a sample of the oil should be tested for the presence of water and replaced if needed.

SINGLE PHASE PADMOUNTED TRANSFORMER

Liberty Utilities	Doc. # LU-EOP UG021		
Electric Operating Procedure	**3-01-2015**	**Underground**	
Operations and Maintenance of Padmounted UG Equipment After a Flood Has Occurred	**Revision #**	**1.0**	**Page: 10 of 11**

6.0 OTHER PADMOUNTED EQUIPMENT

6.1 For padmounted Vista switchgear all components are rated to be fully submersible.

6.2 For primary metering cabinet and padmounted junction enclosure follow above instructions for three phase transformer (deadfront).

PADMOUNTED VISTA SWITCHGER

PRIMARY METERING CABINET

PADMOUNTED JUNCTION ENCLOSURE

NOTE: There may be other padmounted equipment owned by Liberty Utilities that is not mentioned in this document, please contact Underground Standards for guidance on cleaning and restoration of these units. It is understood that all field conditions might not be consistent with this document and that Operations has the ability to judge whether padmounted equipment should be replaced based on its condition or length of outage and not solely on the level of water that has occurred.

7.0 REVISION HISTORY

Date	Rev #	Description	Lead/Author
3/01/2015	1.0	Initial Version of Liberty Utilities document. Updated from National Grid document to be NH Specific.	Robert J Johnson

DISTRIBUTION
OVERHEAD & UNDERGROUND
CONSTRUCTION STANDARDS

FOREWORD

Liberty Utilities develops internal Construction Standards that are intended to provide information on the acceptable materials, techniques, and assemblies, along with representative construction drawings for building those structures used in a repetitive manner. Within these Construction Standards will be found documentation of engineering calculations required to assure that non-standard construction can be designed correctly. Also, an explanation of the reasoning behind various selections of materials and construction techniques will be included. The Company is committed to providing the most modern and inclusive Distribution Standards in a format that is both practical and straight-forward. These Standards are prepared with the intent to coordinate the interests of safety, reliability, operability, uniformity, appearance, economy and the environment. Additionally, these Standards are intended to comply in all respects with requirements of the current edition of the National Electrical Safety Code (NESC), and are supplemented by applicable rules and regulations of governing public authorities. When a conflict occurs, the most stringent rule or regulation shall prevail. Questions regarding such conflict should be referred to the Director, Electric Distribution Engineering or the CQ&EM, Standards, Policies, and Codes Department for interpretation.

Liberty Utilities produces these Construction Standards for use by the Company's construction personnel, engineers, designers and contractors for construction of the Company's distribution system. These standards are issued in two hard covered office binders; "Overhead Construction Standards" and "Underground Construction Standards”. The OH and UG Distribution Construction Standard documents will be stored on the Liberty Utilities CQ&EM SharePoint site for access by Liberty Utilities employees. For Document Control the latest version will be the document on this SharePoint site. In addition, certain Construction Standards will be issued in a permanently bound Handbook. This Handbook is intended for use by the Company’s construction personnel. For each respective binder, new or updated Standards Documents will be released and issued via the CQ&EM SharePoint site and designated as a new document. It is the responsibility of the book holders, or Managers for designated office copies, to maintain their books with the latest issued updates. Liberty Utilities Contractors will be issued a CD containing the latest version of the OH and UG Construction Standards as part of the bid process.

Employees whose work calls for the application of these Construction Standards are expected to be thoroughly familiar with them. All new construction and rebuilding shall conform to these Standards. It is not, however, intended that existing construction be changed to comply with each current issue of these Standards. When Distribution construction for special applications is not covered by these documents, those applications shall be referred to Design Engineering or Electric Standards Engineering.

Liberty Utilities recognizes and appreciates the interest and contributions made by its employees toward the establishment and improvement of construction types and methods, and the Company solicits their continued cooperation. Suggestions submitted to the CQ&EM, Standards, Policies, and Codes team should be accompanied with justification, sketches, photographs, or other exhibits in order to be given complete consideration and to ensure that the maximum benefit may be derived from them. Each submittal shall be reviewed, and the results of that review discussed with the employee suggesting the change. Utilize the Form for Change Proposals which accompanies this document.

OH Construction Standards Table of Contents

Construction Guideline for Compliance with Distribution Standards

As part of the construction audit review, questions have been raised as to when existing construction shall be brought in compliance with current Distribution Standards. The following is a general outline as to what the Company expectations are with regard to this matter.

New Construction – All new construction shall be built to current Liberty Utilities Distribution Standards.

Existing Construction – Existing construction or maintenance work (i.e., outside of complete structure replacement, reconductoring or conversions) does not require that the existing structure be brought in compliance with the current Distribution Standards provided that the work being done maintains the integrity of the original structure's construction. Safety concerns (such as clearances) or potential reliability issues at the structure shall be addressed as part of the work that is being performed.

Emergency Construction – Emergency or temporary construction does not require that the existing structure be brought in compliance with the current Distribution Standards provided that the work being done maintains the integrity of the original structure's construction. Critical safety concerns that may result in undue hazard or potential harm to Company personnel or to the general public shall be addressed as part of the emergency work that is being performed. Potential reliability issues or general safety concerns at the structure shall be reported to local supervision. Emergency or temporary construction shall be brought into compliance with Distribution Standards as soon as practical.

Note 1: During structure replacement, reconductoring, or conversion work, all minimum clearances and separations per current Distribution Standards shall be followed.

Note 2: In all cases, work being completed on any given structure shall be in compliance with Liberty Utilities Electric Operating Procedures as well as all applicable federal, state or local law / ordinance. (e.g., For the case where a driven ground rod is found to be missing on a required structure, appropriate permissions (Dig Safe, Dig Safely, etc.) must be acquired prior to correcting the situation.)

Liberty Utilities

Some examples of safety or potential reliability concerns include, but are not limited to:

- **Safety**
  - Clearances
  - Potted porcelain cutout on pole
  - Missing guy marker(s)
  - Missing structure or switch number
  - Missing equipment locks

- **Reliability**
  - Improper bonding and grounding
    - Missing or exposed ground rods
    - Street lighting
    - Metallic riser conduits
    - Guy wire (wye system)
    - Switch handles
    - Control cabinets
    - Equipment tank/mounts
    - Spacer cable supports (tangent, C and E-brackets)
    - Arresters (flexible braid utilized for arrester disconnector)
    - Secondary neutral
    - Down ground molding
  - Potted porcelain cutout on pole
  - Missing surge arrester(s)
  - Missing animal guard(s)

FORM FOR CHANGE PROPOSALS

OH & UG Construction Standards

(Submit a separate form for each proposal)

Liberty Utilities encourage and appreciate changes designed to improve construction types, work methods, and procedures. As a company we strive to be a leader in work safety and compliance with both Federal and State rules and regulations. In the interest of uniformity, this form may be used to submit proposed changes to existing company Standards and Electric Material Specifications.

Name: ____ Date: __________________
Department: ____________________________________ Location: __________________
Standard Document # (s): ____
Material Specification Document # (s): ____

Proposal: Include sketches, photos or other information useful to understanding the proposal.

Statement of problem, Reasons supporting change. Include safety, cost, reliability or other justification.

Send form to:

Robert J Johnson, MS | **Liberty Utilities (NH)** | Program Manager:Engineering, Standards,Policies, & Codes
P: 603-216-3603 | C: 508-849-8096
E: Robert.johnson@libertyutilities.com
15 Buttrick Rd. Londonderry, NH 03053

Local and responsive. We care.

Supersedes 7/07 Issue – Added additional abbreviations.

NOMINAL SYSTEM VOLTAGES

1.0 This Standard lists those system voltages presently in use within the Liberty Utilities (NH) Service Area or might incounter in National Grid (NE) areas. All voltages are 60 Hz unless otherwise noted. Non-standard service voltages are followed by an asterisk (*).

1.1 TRANSMISSION VOLTAGES

Voltage	Operating Location
46,000	MA, NH, VT, Nantucket
69,000	MA, RI
115,000	MA, NH, RI
138,000	NY
230,000	MA,
345,000	MA, NH, RI
450 kV +/- Volts DC	MA, NH

1.2 PRIMARY DISTRIBUTION VOLTAGES

1.2.10 3 Phase, 3 Wire

Voltage	BIL (kV)	Voltage Code	Operating Location
2,400Δ *	75	H	MA, NH, RI
4,160Y *	75		MA
4,800Δ	75	M	MA
13,800Δ *	95		MA, NH
23,000Y	150		MA, NH
23,000Δ	150		MA, RI

1.2.20 3 Phase, 4 Wire

Voltage	BIL (kV)	Voltage Code	Operating Location
4,160GRDY/2,400	75	J	MA, NH(1Ø), RI
8,320GRDY/4,800	75	G	MA, NH(1Ø)
12,470GRDY/7,200	95	F	MA, NH(1Ø), RI
13,200GRDY/7,620	95	L	MA, NH,
13,800GRDY/7,960	95	W	MA, RI
24,940GRDY/14,400	125	K	MA
34,500GRDY/19,900	150	T	MA, NH, RI

1.3 SECONDARY DISTRIBUTION VOLTAGES, SINGLE PHASE

1.3.10 2 Wire

Voltage
120 (Note 3)
240 (Note 3)

1.3.20 3 Wire

Voltage
120/240
120/208 (Note 1)

1.4 SECONDARY DISTRIBUTION VOLTAGES, THREE PHASE

1.4.10 3 Wire

Voltage
240 *
480 *
600 *

1.4.20 4 Wire

Voltage
208Y/120
240/120 (Note 2)
480Y/277

Notes:
1. Underground Network.
2. 240 V open or closed Delta with 120 V for lighting.
3. For lighting only.

Supersedes 1/06 Issue – Revised Footer Title Bar

These abbreviations are taken from ANSI Standard Y1.1 and other standards organizations. The asterisk (*) denotes terms deemed necessary but not acceptable or defined by the above mentioned standards. The left column lists words/phrases while the right column lists the abbreviation.

A			
ADJUST, ADJUSTING, ADJUSTABLE	ADJ	A	AMPERE
AIR BREAK SWITCH	ABS	*A/C	AIR CONDITIONER
AIR CIRCUIT BREAKER	ACB	AAAC	ALL ALUMINUM ALLOY CONDUCTOR
* AIR CONDITIONER	A/C	AAC	ALL ALUMINUM CONDUCTOR
AL CONDUCTOR STEEL REINFORCED	ACSR	AB	ANCHOR BASE
ALL ALUMINUM ALLOY CONDUCTOR	AAAC	ABS	AIR BREAK SWITCH
ALL ALLUMINUM CONDUCTOR	AAC	AC	ALTERNATING CURRENT
ALTERNATING CURRENT	AC	ACB	AIR CIRCUIT BREAKER
ALUMINUM	AL	ACSR	AL CONDUCTOR STEEL REINFORCED
ALUMOWELD	AW	ADJ	ADJUST, ADJUSTING, ADJUSTABLE
ALUMOWELD ALUMINUM CONDUCTOR	AWAC	AL	ALUMINUM
AMERICAN WIRE GAUGE	AWG	AMP	AMPERE
AMPERE	AMP, A	APPROX	APPROXIMATE
ANCOR BASE	AB	ARR	ARRESTER
AND SO FORTH	ETC	ASYM	ASYMMETRICAL
APPROXIMATE	APPROX	AUTO	AUTOMATIC
ARRESTER	ARR	AUX	AUXILIARY
ASYMMETRICAL	ASYM	AVE	AVENUE
AUTOMATIC	AUTO	AVG	AVERAGE
AUXILIARY	AUX	AW	ALUMOWELD
AVENUE	AVE	AWAC	ALUMOWELD ALUMINUM CONDUCTOR
AVERAGE	AVG	AWG	AMERICAN WIRE GAUGE
B			
BASIC INSULATION IMPULSE LEVEL	BIL	B	BLACK
BLACK	BLK, B	BIL	BASIC INSULATION IMPULSE LEVEL
BLUE	BLU, BL	BL	BLUE
BOLT	BLT	BLDG	BUILDING
BRACKET	BRKT	BLK	BLACK
BRASS	BRS	BLT	BOLT
BRITISH THEMAL UNIT	BTU	BLU	BLUE
BRONZE	BNZ	BNZ	BRONZE
BROWN	BRN,BR	BR	BROWN
BUILDING	BLDG	BRKT	BRACKET
BY PASS	BYP	BRN	BROWN
		BRS	BRASS
		BTU	BRITISH THERMAL UNIT
		BYP	BY PASS

Supersedes 7/07 Issue – Added “AB” and “BNZ”

C			
CAPACITOR	CAP	C TO C	CENTER TO CENTER
CATALOGUE	CAT	CAP	CAPACITOR
CENTER	CTR	CC	CUBIC CENTIMETER
CENTER LINE	CL	CFM	CUBIC FEET PER MINUTE
CENTER TO CENTER	C TO C	CIR	CIRCLE, CIRCULAR
CENTIGRADE	° C	CKT	CIRCUIT
CIRCLE, CIRCULAR	CIR	CL	CENTER LINE
CIRCUIT	CKT	CL	CLASS, CLASSIFICATION
CLAMP	CLP	CLF	CURRENT-LIMITING FUSE
CLASS, CLASSIFICATION	CL	CLP	CLAMP
COMPANY	CO	CNDCT	CONDUCTOR
COMPATIBLE UNIT	CU	CO	COMPANY
* COMPRESS, COMPRESSION	COMP	CO	CUTOUT
COMPLETELY SELF-PROTECTED	CSP	*COMP	COMPRESS, COMPRESSION
* CONCENTRIC	CONC	*CONC	CONCENTRIC
CONDUCTOR	CNDCT	CONN	CONNECTOR, CONNECTION, CONNECT
CONDUCTOR, MULTIPLE “EXAMPLE”	3/C	CORP	CORPORATION
* CONDUCTORS PARALLELED	CP	COV	COVER, COVERED
* CONDUCTORS TWISTED	CT	*CP	CONDUCTORS PARALLELED
CONNECTOR, CONNECTION, CONNECT	CONN	CSP	COMPLETELY SELF-PROTECTED
COPPER	CU	*CT	CONDUCTORS TWISTED
COPPERWELD	CW	CT	CURRENT TRANSFORMER
* COPPERWELD-COPPER	CCW	CTR	CENTER
CORPORATION	CORP	CU	COMPATIBLE UNIT
COVER, COVERED	COV	CU	COPPER
CROSS LINK POLYETHYLENE	XLP	CU FT	CUBIC FEET
CROSS SECTION	XSECT	CU IN	CUBIC INCH
CROSSARM	XARM	CU M	CUBIC METERS
CUBIC CENTIMETER	CC	CU YD	CUBIC YARDS
CUBIC FEET PER MINUTE	CFM	*CUST	CUSTOMER
CUBIC FEET	CU FT	CW	COPPERWELD
CUBIC INCH	CU IN	*CWCU	COPPERWELD-COPPER
CUBIC METER	CU M	CY	CYCLE
CUBIC YARD	CU YD		
CURRENT-LIMITING FUSE	CLF		
CURRENT TRANSFORMER	CT		
* CUSTOMER	CUST		
CUTOUT	CO		
CYCLE	CY		

Supersedes 1/06 Issue – Revised Footer To Reflect Page Number And Title Bar Change

D			
* DEADEND	DE	D	DEPTH
DELTA	Δ	*DB	DIRECT BURIED
DEPARTMENT	DEPT	DBL	DOUBLE
DEPTH	D	DC	DIRECT CURRENT
DIAMETER	DIA	*DE	DEAD END
* DIRECT BURIED	DB	DEPT	DEPARTMENT
DIRECT CURRENT	DC	DF	DOUGLAS FIR
DISCONNECT	DISC	DIA	DIAMETER
DISTRIBUTE, DISTRIBUTION	DISTR	DISC	DISCONNECT
DOUBLE	DBL	DISTR	DISTRIBUTE, DISTRIBUTION
DOUBLE POLE SWITCH	DP SW	DN	DOWN
DOUGLAS FIR	DF	DP SW	DOUBLE POLE SWITCH
DOWN	DN	*DPX	DUPLEX
* DUPLEX	DPX		
E			
EACH	EA	E	EAST
EAST	E	EA	EACH
* EIGHT HOLE	8H	EC	ELECTRICAL CONDUCTOR
ELBOW	ELB	EG	FOR EXAMPLE
ELECTRIC, ELECTRICAL, ELECTRONIC	ELEC	EHV	EXTRA HIGH VOLTAGE
ELECTRICAL CONDUCTOR	EC	ELB	ELBOW
EMBEDDED	EMB	ELEC	ELECTRIC, ELECTRICAL, ELECTRONIC
ENGINEER, ENGINEERING	ENGR	EMB	EMBEDDED
ENTRANCE	ENTR	ENCL	ENCLOSED, ENCLOSURE
EQUIPMENT	EQPT	ENGR	ENGINEER, ENGINEERING
EQUIVALENT	EQUIV	ENTR	ENTRANCE
ETHYLENE PROPYLENE	EP	*EP	ETHYLENE PROPYLENE
* ETHYLENE PROPYLENE RUBBER	EPR	*EPR	ETHYLENE PROPYLENE RUBBER
* EXTRA HIGH VOLTAGE	EHV	EQPT	EQUIPMENT
		EQUIV	EQUIVALENT
		ETC	AND SO FORTH

Supersedes 7/07 Issue – Added “EMB”

F			
FAHRENHEIT	° F	FC	FOOT CANDLE
FEEDER	FDR	FDR	FEEDER
FEET	FT, '	*FG	FIBERGLASS
* FIBERGLASS	FG	FIG	FIGURE
FIGURE	FIG	FLDT	FLOODLIGHT
FLOODLIGHT	FLDT	FOA	FORCED OIL W/ FORCED AIR COOLER
FOOT	FT, '	FREQ	FREQUENCY
FOOT CANDLE	FC	FT	FOOT, FEET
FOOT POUNDS	FT-LB	FT-LB	FOOT POUND
FOR EXAMPLE	EG	*FTN	FULL TENSION
FORCED OIL W/FORCED AIR COOLER	FOA		
FOUR CONDUCTORS	4/C		
* FOUR CONDUCTORS PARALLELED	4CP		
* FOUR CONDUCTORS TWISTED	4CT		
FREQUENCY	FREQ		
* FULL TENSION	FTN		
G			
GALLON	GAL	GAL	GALLON
GALLONS PER HOUR	GPH	GALV	GALVANIZED
GALLONS PER MINUTE	GPM	GALVI	GALVANIZED IRON
GALLONS PER SECOND	GPS	GALVS	GALVANIZED STEEL
GALVANIZED	GALV	GND	GROUND
GALVANIZED IRON	GALVI	GP	GENERAL PURPOSE
GALVANIZED STEEL	GALVS	GPH	GALLONS PER HOUR
GENERAL PURPOSE	GP	GPM	GALLONS PER MINUTE
GRAY	GRA, GY	GPS	GALLONS PER SECOND
GREEN	GRN	GRA	GRAY
GROUND	GND	GRN	GREEN
		GY	GRAY
H			
HANDHOLE	HH	H	HEIGHT
HARD DRAWN	HD DRN	HD	HEAVY DUTY
HARDWARE	HDW	*HD	HIGH DENSITY
HEAVY DUTY	HD	HD DRN	HARD DRAWN
HEIGHT	H	*HDPE	HIGH DENSITY POLYETHYLENE
HERTZ	HZ	*HDTR	HIGH DENSITY TRACK RESISTANT
* HIGH DENSITY	HD	HDW	HARDWARE
* HIGH DENSITY POLYETHYLENE	HDPE	HH	HANDHOLE
* HIGH DENSITY TRACK RESISTANT	HDTR	*HMP	HIGH MOLECULAR POLYETHYLENE
* HIGH MOLECULAR POLYETHYLENE	HMP	HORIZ	HORIZONTAL
HIGH PRESSURE	HP	HP	HIGH PRESSURE
HIGH PRESSURE SODIUM VAPOR	HPS	HP	HORSEPOWER
HIGH TENSION	HT	HPS	HIGH PRESSURE SODIUM VAPOR
HIGH VOLTAGE	HV	HT	HIGH TENSION
HIGHWAY	HWY	HV	HIGH VOLTAGE
HORIZONTAL	HORIZ	HWY	HIGHWAY
HORSEPOWER	HP	HZ	HERTZ

Supersedes 7/07 Issue – Added “GRN” and “HPS”

		I	
IMPEDANCE	IMPD	ID	INSIDE DIAMETER
INCANDESCENT	INCAND	I.E.	THAT IS
INCH	IN, “	IMPD	IMPEDANCE
INCHES PER SECOND	IPS	IN	INCH
INDUCTION, INDUCTANCE	IND	INCAND	INCANDESCENT
INFORMATION	INFO	*IND	INDUCTION, INDUCTANCE
INSIDE DIAMETER	ID	INFO	INFORMATION
INSTANTANEOUS	INST	INST	INSTANTANEOUS
INSULATE, INSULATING, INSULATOR	INSUL	INSUL	INSULATE, INSULATING, INSULATOR
INTERRUPT	INTRPT	INTRPT	INTERRUPT
		IPS	INCHES PER SECOND
		J	
* JOINTLY OWNED	JO	JCT	JUNCTION
* JUMPER	JMP	*JMP	JUMPER
JUNCTION	JCT	*JO	JOINTLY OWNED
		K	
KILOVAR	KVAR	K	THOUSAND
KILOVOLT	KV	KCMIL	THOUSAND CIRCULAR MILS
KILOVOLT-AMPERE	KVA	KV	KILOVOLT
KILOWATT	KW	KVA	KILOVOLT-AMPERE
KILOWATT HOUR	KWH	KVAR	KILOVAR
		KW	KILOWATT
		KWH	KILOWATT HOUR

Supersedes 1/06 Issue – Revised Footer To Reflect Page Number And Title Bar Change

L			
LARGE	LGE	L	LENGTH
LEAD COVERED	LC	*L	LUMEN
LEAD OVER HEIGHT	L/H	L/H	LEAD OVER HEIGHT
LENGTH	L	LB	POUND
LIGHT	LT	*LBK	LOAD BREAK
LIGHT EMITTING DIODE	LED	*LBS	LOAD BREAK SWITCH
LIGHTING	LTG	LBS	POUNDS
LIMITER	LMTR	LC	LEAD COVERED
* LOAD BREAK	LBK	LED	LIGHT EMITTING DIODE
* LOAD BREAK SWITCH	LBS	LGE	LARGE
* LOAD TAP CHANGER	LTC	LIM	LIMIT
LOW VOLTAGE	LV	LMTR	LIMITER
LUBRICATED, LUBRICATION	LUB	LPW	LUMENS PER WATT
* LUMEN	L	LT	LIGHT
LUMENS PER WATT	LPW	*LTC	LOAD TAP CHANGER
* LUMINAIRE	LUM	LTG	LIGHTING
		LUB	LUBRICATED, LUBRICATION
		*LUM	LUMINAIRE
		LV	LOW VOLTAGE
M			
MACRO UNIT	MU	M	THOUSAND POUNDS (GUY STRANDS)
MAINTENANCE	MAINT	MA	MILLIAMPERE
MANHOLE	MH	MAINT	MAINTENANCE
MANUFACTURE, MANUFACTURER	MFR	MATL	MATERIAL
MATERIAL	MATL	MAX	MAXIMUM
MATERIAL LIST	ML	*MBS	MINIMUM BREAKING STRENGTH
MAXIMUM	MAX	MCY	MEGACYCLE
* MEDIUM HARD DRAWN	MHD	*MEG	MEGAOHM
* MEGACYCLE	MCY	MESS	MESSEMGER
* MEGAWATT	MWT	MFR	MANUFACTURE, MANUFACTURER
* MEGAWATT HOUR	MWH	MGY	MULTIGROUNDED-Y CONNECTED
* MEGAOHM	MEG	MH	MANHOLE
* MERCURY VAPOR	MV	MH	PROBE START METAL HALIDE
MESSENGER	MESS	*MHD	MEDIUM HARD DRAWN
METAL-OXIDE VERISTER	MOV	MIN	MINIMUM
METER, METERING	MTR	MISC	MISCELLANEOUS
MILLIAMPERE	MA	ML	MATERIAL LIST
MILLION VOLT AMPERES	MVA	MOV	METAL-OXIDE VERISTER
MINIMUM	MIN	MT	MOUNT
* MINIMUM BREAKING STRENGTH	MBS	MTG	MOUNTING
MISCELLANEOUS	MISC	MTR	METER, METERING
MOUNT	MT	MU	MACRO UNIT
MOUNTING	MTG	*MV	MERCURY VAPOR
MULTIGROUNDED-Y CONNECTED	MGY	MVA	MILLION VOLT AMPERES
		*MHW	MEGAWATT-HOUR
		*MWT	MEGAWATT

Supersedes 7/07 Issue – Added "MH"

N			
NEGATIVE	NEG	N	NORTH
* NEOPRENE	NEO	NC	NORMALLY CLOSED
NETWORK	NTWK	NEG	NEGATIVE
NEUTRAL	NEUT	*NEO	NEOPRENE
* NICOPRESS	NICPRS	NEUT	NEUTRAL
NOMINAL	NOM	*NICPRS	NICOPRESS
NORMALLY CLOSED	NC	NO	NORMALLY OPEN, NUMBER
NORMALLY OPEN	NO	NOM	NOMINAL
NORTH	N	NTWK	NETWORK
NUMBER	NO, #		
O			
OBSOLETE	OBS	OBS	OBSOLETE
OHM	Ω	OCB	OIL CIRCUIT BREAKER
OIL CIRCUIT BREAKER	OCB	OD	OUTSIDE DIAMETER
ONE CONDUCTOR	1/C	*OH	OVERHEAD
OUNCE	OZ	OVLD	OVERLOAD
OUTSIDE DIAMETER	OD	OZ	OUNCE
* OVERHEAD	OH		
OVERLOAD	OVLD		

Supersedes 1/06 Issue – Revised Footer To Reflect Page Number And Title Bar Change

P			
* PAPER & LEAD	PL	P	PHASE
PARALLEL	PRL	P	POLE
* PARALLEL GROOVE	PG	*PB	PUSH BRACE
* PARTIAL TENSION	PTN	PCT	PERCENT
PEDESTRIAN	PED	PE	PHOTOELECTRIC CON
PERCENT	PCT	PE	POLYETHYLENE
PHASE	P, Ø	PEC	PHOTO ELECTRIC CONTROL
PHOTO ELECTRIC CONTROL	PEC	PECR	PHOTO ELECTRIC CONTROL RECEPTACLE
PHOTO ELECTRIC CONTROL RECEPTACLE	PECR	PED	PEDESTRIAN
PHOTOELECTRIC CONTROL	PE	PF	POWER FACTOR
PINT	PT	*PG	PARALLEL GROOVE
POINT	PT	*PISA	POWER INSTALLED SCREW ANCHOR
POLE	P	*PL	PAPER & LEAD
* POLE MOUNT	PMNT	PLD	PLATED
* POLE TOP EXTENSION	PTX	*PMNT	POLE MOUNT
POLYCARBONATE	POLYCAR	*POLY	POLYETHELENE
* POLYETHELENE	POLY,PE	POLYCAR	POLYCARBONATE
POLYVINYL CHLORIDE	PVC	PORC	PORCELAIN
PORCELAIN	PORC	POS	POSITIVE
POSITIVE	POS	POT	POTENTIAL
POST TOP	PT	PRCST	PRECAST
POTENTIAL	POT	PREFMD	PREFORMED
POTENTIAL TRANSFORMER	PT	PRESS	PRESSURE
POUND	LB	PRI	PRIMARY
POUNDS	LBS	PRL	PARALLEL
POWER	PWR	PSMH	PULSE START METAL HALIDE
POWER FACTOR	PF	PT	PINT
*POWER INSTALLED SCREW ANCHOR	PISA	PT	POINT
PRECAST	PRCST	PT	POST TOP
PREFORMED	PREFMD	PT	POTENTIAL TRANSFORMER
PRESSURE	PRESS	*PTN	PARTIAL TENSION
PRIMARY	PRI	*PTX	POLE TOP EXTENSION
PROBE START METAL HALIDE	MH	PVC	POLYVINYL CHLORIDE
PULSE START METAL HALIDE	PSMH	PWR	POWER
* PUSH BRACE	PB		
Q			
QUADRANT	QDRNT	QDRNT	QUADRANT
* QUARDUPLEX	QPX	*QPX	QUADRUPLEX
QUANTITY	QTY	QT	QUART
QUART	QT	QTY	QUANTITY

Supersedes 7/07 Issue – Added “MH”, “PEC”, “PECR”, “PED”, “POLYCAR”, “PSMH” and “PT”

Supersedes 7/07 Issue – Added “REA”, “REG” and RDWY

R			
* RADIAL, RADIUS	RAD	R	RIGHT
RAILROAD	RR	R/W	RIGHT OF WAY
* REACTANCE/RESISTANCE	X/R	*RAD	RADIAL, RADIUS
* REACTANCE	X	RC	REMOTE CONTROL
REACTOR BALLAST	REA	RCPT	RECEPTACLE
REACTOR, REACTIVE	REAC	RD	ROAD
RECEPTACLE	RCPT	RDC	REDUCE, REDUCER, REDUCING
RECLOSER, RECLOSING	REC	RDWY	ROADWAY
REDUCE, REDUCER, REDUCING	RDC	REA	REACTOR BALLAST
REFLECTOR	REFL	REAC	REACTOR, REACTIVE
* REFRACTOR	REFC	REC	RECLOSER, RECLOSING
REGULAR	RGLR	*REFC	REFRACTOR
REGULATED BALLAST	REG	REFL	REFLECTOR
* REGULATOR	REG	REG	REGULATED BALLAST
REMOTE CONTROL	RC	*REG	REGULATOR
REPORT	RPRT	RES	RESISTANCE, RESISTOR
RESISTANCE, RESISTOR	RES	REV	REVISE, REVISION
REVISE, REVISION	REV	*RGBL	RIGID BAIL
RIGHT	RT, R	RGD	RIGID
RIGHT HAND	RH	RGLR	REGULAR
RIGHT OF WAY	R/W	RH	RIGHT HAND
RIGID	RGD	RMS	ROOT MEAN SQUARE
* RIGID BAIL	RGBL	RND	ROUND
ROAD	RD	RPRT	REPORT
ROADWAY	RDWY	RR	RAILROAD
ROOT MEAN SQUARE	RMS	RT	RIGHT
ROUND	RND	RUB	RUBBER
RUBBER	RUB		

S			
SECOND, SECONDARY	SEC	S	SOUTH
SECTION, SECTIONAL	SECT	SB	SILICON BRONZE
SECTIONALIZER	SECT	*SBLT	SPLIT BOLT
SELF-SUPPORTING	SS	SD	SOFT DRAWN
SEMI-FLEXIBLE BAIL	SFB	SEC	SECOND, SECONDARY
SERIES	SER	SECT	SECTION, SECTIONAL
SERVICE	SVCE	SECT	SECTIONALIZER
SILICON BRONZE	SB	SER	SERIES
SINGLE	SGL	SFB	SEMI-FLEXIBLE BAIL
SINGLE CONDUCTOR	1/C	SGL	SINGLE
SINGLE HOLE	1H	SO	SOLELY OWNED
SINGLE PHASE	1PH, 1Ø	SOD	SODIUM
* SINGLE POLE	1P	SOL	SOLID
SINGLE POLE DOUBLE THROW	SPDT	*SP	SOUTHERN PINE
SINGLE POLE SINGLE THROW	SPST	*SPA	SOUTHERN PINE ASPHALT
SINGLE POLE SWITCH	SP SW	*SPC	SOUTHERN PINE CREOSOTE
* SINGLE STRAND EYE	SSE	*SPCA	SPACER CABLE
SIX CONDUCTORS TWISTED	6CT	*SPCT	SOUTHERN PINE-CELLON TREATMENT
SIX HOLE	6H	SPCR	SPACER
SODIUM	SOD	SPDT	SINGLE POLE DOUBLE THROW
SOFT DRAWN	SD	SPEC	SPECIFICATION
SOLELY OWNED	SO	SPPC	SOUTHERN PINE-CELLON TREATMENT
SOLID	SOL	SPST	SINGLE POLE SINGLE THROW
SOUTH	S	SP SW	SINGLE POLE SWITCH
SOUTHERN PINE	SP	*SQU	STRAIN QUADRANT
* SOUTHERN PINE ASPHALT	SPA	SS	SELF SUPPORTING
* SOUTHERN PINE CREOSOTE	SPC	*SSE	SINGLE STRAND EYE
* SOUTHERN PINE PENTA IN CREOSOTE	SPPC	SPPC	SOUTHERN PINE-CELLON TREATMENT
* SOUTHERN PINE-CELLON TREATMENT	SPCT	SST	STAINLESS STEEL
SPACER	SPCR	*SST	STRAIN STRAIGHT
* SPACER CABLE	SPCA	STA	STATION, STATIONARY
SPECIFICATION	SPEC	STD	STANDARD
* SPLIT BOLT	SBLT	STL	STEEL
STAINLESS STEEL	SST	*ST LT	STREET LIGHT
STANDARD	STD	STR	STRAND, STRANDED
STATION, STATIONARY	STA	STRN	STRAIN
STEEL	STL	*SUB	SUBSTATION
STRAIN	STRN	SUPV	SUPERVISE, SUPERVISORY
* STRAIN QUADRANT	SQU	SUSP	SUSPENSION
* STRAIN STRAIGHT	SST	SVCE	SERVICE
STRAND, STRANDED	STR	SW	SWITCH, SWITCHED
* STREET LIGHT	ST LT	SWGR	SWITCHGEAR
* SUBSTATION	SUB	SYM	SYMBOL
SUPERVISE, SUPERVISORY	SUPV	SYMM	SYMMETRIC, SYMMETRICAL
* SUSPENSION	SUSP	SYS	SYSTEM
SWITCH, SWITCHED	SW		
SWITCHGEAR	SWGR		
SYMBOL	SYM		
SYMMETRIC, SYMMETRICAL	SYMM		
SYSTEM	SYS		

Supersedes 1/06 Issue – Revised Footer To Reflect Page Number And Title Bar Change

Supersedes 7/07 Issue – Added "TBASE" and "TDROP"

T			
TANGENT	TAN	TAN	TANGENT
TEARDROP	TDROP	TBASE	TRANSFORMER BASE
TEMPERATURE	TEMP	TCC	TIME-CURRENT CURVE
TERMINAL, TERMINATOR	TERM	TD	TIME DELAY
THAT IS	I.E.	TDROP	TEARDROP
* THERMOPLASTIC	THPL	*TEA	TRIPLE EYE ANCHOR ROD
THOUSAND	K	TEMP	TEMPERATURE
THOUSAND CIRCULAR MILS	KCMIL	TERM	TERMINAL, TERMINATOR
THOUSAND POUNDS (GUY STRAND)	M	*TES	TRIPLE EYE SCREW ANCHOR
THREAD, THREADED	THD	THD	THREAD, THREADED
THREE CONDUCTOR	3/C	*THDLES	THREADLESS
* THREE CONDUCTORS PARALLELED	3CP	*THPL	THERMOPLASTIC
* THREE CONDUCTORS TWISTED	3CT	THRU	THROUGH
THROUGH	THRU	TND	TINNED
TIME-CURRENT CURVE	TCC	TPL	TRIPLE
TIME DELAY	TD	TR	TRACK RESISTANT
TINNED	TND	TRX	TRIPLEX
TRACK RESISTANT	TR	*TSE	TRIPLE STRAND-EYE
TRANSFORMER	XFMR		
TRANSFORMER BASE	TBASE		
TRANSMISSION	XSMN		
TRIPLE	TPL		
* TRIPLE EYE ANCHOR ROD	TEA		
* TRIPLE EYE SCREW ANCHOR	TES		
TRIPLE POLE DOUBLE THROW	3PDT		
TRIPLE POLE SINGLE THROW	3PST		
TRIPLE POLE SWITCH	3P SW		
* TRIPLE STRAND-EYE	TSE		
TRIPLEX	TRX		
TWO CONDUCTORS	2/C		
* TWO CONDUCTORS PARALLELED	2CP		
* TWO CONDUCTORS TWISTED	2CT		
* TWO HOLE	2H		
TWO POLE	2P		
U			
ULTRAVIOLET LIGHT	UV	*UG	UNDERGROUND
* UNDERGROUND	UG	UGY	UNGROUNDED-Y CONNECTION
UNGROUNDED-Y CONNECTION	UGY	UNIV	UNIVERSAL
UNIVERSAL	UNIV	UV	ULTRAVIOLET LIGHT
V			
VACUUM	VAC	V	VOLT
VARNISHED CAMBRIC	VC	VA	VOLT AMPERE
* VAULT	VLT	VAC	VACUUM
VERTICAL	VERT	VC	VARNISHED CAMBRIC
* VINYL	VYL	VERT	VERTICAL
VOLT	V	*VLT	VAULT
VOLT AMPERE	VA	VOL	VOLUME
VOLUME	VOL	*VYL	VINYL

W			
WATT	W	W	WATT
WATT HOUR	WHR	W	WEST
WATT HOUR METER	WHM	W	WHITE
WATTMETER	WM	W	WIDTH
WEATHERPROOF	WP	W/	WITH
WEEK	WK	W/B	WITH BRACKET
WEIGHT	WT	WD	WIDTH
WEST	W	WD	WOOD
WHITE	WHT, W	WHM	WATT HOUR METER
WIDTH	WD, W	WHR	WATT HOUR
WITH	W/	WHT	WHITE
WITH BRACKET	W/B	WK	WEEK
* WITHOUT	WO/	WM	WATT METER
WOOD	WD	*WO/	WITHOUT
WYE	Y	WP	WEATHERPROOF
		WT	WEIGHT
X			
		*X	REACTANCE
		X	STRAND
		*X/R	REACTANCE/RESISTANCE
		XARM	CROSSARM
		XFMR	TRANSFORMER
		XLP	CROSS LINK POLYETHYLENE
		XSECT	CROSS SECTION
		XSMN	TRANSMISSION
Y			
YARD	YD	Y	WYE
YARDS	YDS	Y	YELLOW
YEAR	YR	YD	YARD
YELLOW	YEL, Y	YDS	YARDS
		YEL	YELLOW
		YR	YEAR
Z			
ZINC	ZN	ZN	ZINC
* ZINC PLATED	ZP	*ZP	ZINC PLATED

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SPECIAL CHARACTERS			
1/C	ONE CONDUCTOR		
1/C	SINGLE CONDUCTOR		
1/H	ONE HOLE		
*1/H	SINGLE HOLE		
1P	ONE POLE		
1P	SINGLE POLE		
1PH	SINGLE PHASE		
1Ø	SINGLE PHASE		
2/C	TWO CONDUCTOR		
*2CP	TWO CONDUCTORS PARALLELED		
*2CT	TWO CONDUCTORS TWISTED		
*2H	TWO HOLE		
2P	TWO POLE		
3/C	THREE CONDUCTOR		
*3CP	THREE CONDUCTORS PARALLELED		
*3CT	THREE CONDUCTORS TWISTED		
3P	THREE POLE		
3P SW	TRIPLE POLE SWITCH		
3PDT	TRIPLE POLE DOUBLE THROW SW		
3PST	TRIPLE POLE SINGLE THROW SW		
4/C	FOUR CONDUCTOR		
*4CP	FOUR CONDUCTORS PARALLELED		
*4CT	FOUR CONDUCTORS TWISTED		
*4H	FOUR HOLE		
4P	FOUR POLE		
4P SW	FOUR POLE SWITCH		
4PDT	FOUR POLE DOUBLE THROW SW		
4PST	FOUR POLE SINGLE THROW SW		
6CT	SIX CONDUCTORS TWISTED		
6H	SIX HOLE		
*8H	EIGHT HOLE		
Δ	DELTA		
Ω	OHM		
Ø	PHASE		
‘	FOOT OR FEET		
“	INCH OR INCHES		
°C	CENTIGRADE		
°F	FAHRENHEIT		
#	NUMBER		

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Organizations and Documents

ORGANIZATION	ABBREVIATION
AMERICAN NATIONAL STANDARDS INSTITUTE	ANSI
AMERICAN SOCIETY OF TESTING AND MATERIALS	ASTM
AMERICAN WOOD PERSERVERS ASSOCIATION	AWPA
ASSOCIATION OF EDISON ILLUMINATING COMPANIES	AEIC
DEPARTMENT OF TRANSPORTATION	DOT
EDISON ELECTRIC INSTITUTE	EEI
ILLUMINATING ENGINEERING SOCIETY	IES
INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS	IEEE
INSULATED CABLE ENGINEERS ASSOCIATION	ICEA
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION	NEMA
NATIONAL FIRE PROTECTION ASSOCIATION	NFPA
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION	OSHA
UNDERWRITERS LABORATORY	UL
DOCUMENT	**ABBREVIATION**
ELECTRIC OPERATING PROCEDURE (National Grid)	EOP
NATIONAL ELECTRICAL CODE	NEC
NATIONAL ELECTRICAL SAFETY CODE	NESC

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DEFINITIONS

The following sources were used as a reference to define the following terms:

1. IEEE Standard Dictionary of Electrical & Electronic Terms – IEEE STD 100
2. The Lineman's and Cableman's Handbook
3. National Electrical Code
4. National Electrical Safety Code

A

AAC - (All Aluminum Conductor) A conductor made wholly of 1350 alloy aluminum.

AAAC - (All Aluminum Alloy Conductor) A conductor made wholly of 5005-H19 or 6201-T81 higher strength alloy aluminum.

ACSR - (Aluminum Conductor Steel Reinforced) A composite conductor made up of a combination of aluminum and steel wires. In the usual construction the aluminum wires surround the steel wires.

ACTUAL SPAN - The horizontal distance between two adjacent structures. The distance can be either to the structure ahead, Actual Span ahead, or to the back structure, Actual Span back. The Actual Span affects sags and clearances from the conductors to the ground.

ALIVE - Electrically connected to a source of potential difference, or electrically charged so as to have a potential difference from that of the ground. **Note:** The term "alive" is sometimes used in place of the term "current-carrying", where the intent is clear, to avoid repetitions of the longer term. (IEEE-100)

AMPACITY - The current-carrying capacity, expressed in amperes, of an electrical conductor under stated thermal conditions. (Per NESC)

ANCHOR - A device that serves as a reliable support to hold an object firmly in place. The term "anchor" is normally associated with cone, plate, screw, or concrete anchors, but terms "stub", "deadman", and "anchor log" are usually associated with pole stubs or logs set or buried in the ground to serve as temporary anchors. The latter are often used at pull and tension sites. (IEEE-100)

ANCHOR GUY MARKER - A protective cover over the guy, often a length of plastic or metal shaped to a semicircular or tubular section and equipped with a means of attachment to the guy. (IEEE-100)

ANODE - An electrode through which current enters any conductor of the nonmetallic class. (IEEE-100)

ARRESTER - See Surge Arrester

AWG - (American Wire Gauge) The standard system used for designating wire diameter, also referred to as the Brown and Sharpe wire gauge. This system is based on a direct correlation between gauge number, cross section, weight, and the DC resistance of conductors.

Supersedes 1/06 Issue – Updated Definitions To Include Overhead And Underground Terminology

B

BAY-O-NET FUSE - A pad mount transformer fuse, used to protect the line-side system from damage caused by transformer faults. Provides transformer protection from overloading and secondary fault current.

BIL - (Basic Lightning Impulse Insulation Level) A specific insulation level expressed in kilovolts of the crest value of a standard lightning impulse. (IEEE-100)

BOLLARD - A series of short posts set at intervals to delimit an area (as a traffic island) or to exclude vehicles

BONDING - The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed. (IEEE-100)

The electrical interconnecting of conductive parts, designed to maintain a common electrical potential. (NESC)

BOOST - Raise or attempt to raise voltage.

BUCK - Lower or attempt to lower voltage.

BUCKARM - A crossarm placed approximately at right angles to the line crossarm and used for supporting branch or lateral conductors or turning large angles in line conductors. (IEEE-100)

BUSHING PLUG - An interface for a transformer/switch that allows cable to be attached with an elbow connector.

C

CABLE - A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable). (OSHA, NESC, IEEE-100)

CABLE JACKET - A protective covering over the insulation, core, or sheath of a cable. (IEEE-100)

CABLE RACK - A device usually secured to the wall of a manhole, cable raceway, or building to provide support for cables. (IEEE-100)

CABLE SHEATH - A conductive protective covering applied to cables. **Note**: A cable sheath may consist of multiple layers, of which one or more is conductive. (IEEE-100)

CATHODE - An electrode through which current leaves any conductor of the nonmetallic class. (IEEE-100)

CATHODIC PROTECTION - Reduction or prevention of corrosion by making a metal, the cathode in a conducting medium by means of a direct electric current. (IEEE-100)

CIRCULAR MIL - A unit of area equal to π/4 of a square mil (= 0.7854 square mil). The cross-sectional area of a circle in circular mils is therefore equal to the square of its diamete in mils. A circular inch is equal to one million circular mils. **Note**: One mil equals 0.0001 inches. There are 1974 circular mils in a square millimeter. (IEEE-100)

Supersedes 1/06 Issue – Updated Definitions To Include Overhead And Underground Terminology

CLEARANCE - The clear distance between two objects measured surface to surface.(OSHA, NESC)

CONDUCTOR - A material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current. (OSHA)

CONDUCTOR INSULATIONS -

BR	Butyl rubber
EPR	Ethylene propylene rubber
XLPE	Cross-linked polyethylene
TRXLPE	Tree-retardant polyethylene
PILC	Paper Insulated, lead covered
VC	Varnish Cambric

CONDUCTOR, - BARE One having no covering or insulation whatsoever. (IEEE-100)

CONDUCTOR COMPACT - A round stranded conductor having all layers stranded in the same direction and successively passed through forming dies that forms the round conductor strands into a diamond-like shape. This results in a smoother, more nearly circular outer surface and effectively eliminates the void between individual wire strands.

CONDUCTOR COMPRESSED - A concentric stranded conductor which, after completion of the stranding operation, is passed through forming dies that compress the strands of the outer layer into a diamond-like shape. This results in a smoother, more nearly circular outer surface, and reduces the void between individual strands in the outer layer.

CONDUCTOR CONCENTRIC - A single straight core wire strand surrounded by one or more layers of helically wound wires in a fixed round geometric arrangement. Each layer after the first has six more strands than the preceding layer and is applied in a direction opposite to that of the layer under it.

CONDUCTOR COVERED - A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.

CONDUCTOR INSULATED - A conductor covered with a dielectric (other than air) having a rated insulated strength greater than or equal to the voltage of the circuit in which it is used. (NESC)

CONDUIT SYSTEM - Any combination of duct, conduit, conduits, manholes, handholes and/or vaults joined to form an integrated whole. (IEEE-100)

CONNECTOR - A coupling device employed to connect conductors of one circuit or transmission element with those of another circuit or transmission element. (IEEE-100)

CONTINUOUS LOAD - A load where the maximum current is expected to continue for three (3) hours or more.

CORE LOSS, TRANSFORMER - The measured power loss, expressed in watts, attributable to the material in the core and associated clamping structure of a transformer that is excited, with no connected load, at a core flux density and frequency equal to that in the core when rated voltage and frequency is applied and rated load current is supplied. (IEEE-100)

CURRENT CARRYING PART - A conducting part intended to be connected in an electric circuit to a source of voltage. **Note:** Non-current carrying parts are those not intended to be so connected. (OSHA)

Supersedes 1/06 Issue – Updated Definitions To Include Overhead And Underground Terminology

CURRENT LIMITING FUSE - A fuse that, when it is melted by a current within its specified current-limiting range, abruptly introduces a high arc voltage to reduce the current magnitude and duration. **Note:** The values specified in standards for the threshold ration, peak let-through current, and I^2t characteristic are used as the measures of current-limiting ability. (IEEE-100)

CURRENT LIMITING FUSE CARRYING - A pad mount transformer fuse that limits the potential for catastrophic failure of the transformer, due to internal faults.

CUTOUT - An assembly of a fuse support with either a fuse holder, fuse carrier, or disconnect blade. When a fuse holder or fuse carrier is used, this device is used to automatically interrupt the flow of current through any particular apparatus or instrument. (IEEE-100)

D

DEAD - Isolated, tagged, tested de-energized and grounded. (Safety Manual)

DEAD-FRONT (TRANSFORMERS & SWITCHGEAR) – Without live parts exposed to a person on the operating side of the equipment. (IEEE-100)

DEADEND GUY - An installation of line or anchor guys to hold the pole at the end of a line. (IEEE-100)

DE-ENERGIZED - The absence of normal operating voltages associated with the operation of the system or control circuits. (Safety Manual)

Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means. **Note:** De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc. (NESC)

DEMAND - The load integrated over a specific interval of time. (IEEE-100)

DISCONNECT - A device having a disconnecting blade for use as a disconnecting or isolating switch. (IEEE-100)

DUCT - A single enclosed raceway for conductors or cables. (NESC)

DUCT BANK - An arrangement of conduit providing one or more continuous ducts between two points. (IEEE-100)

DUCT SEALING - The closing of the duct entrance for the purpose of excluding water, gas, or other undesirable substances. (IEEE-100)

DUPLEX CABLE - A cable composed of two (2) insulated single conductors or one (1) insulated conductor and one (1) bare neutral conductor twisted together. (IEEE-100)

Supersedes 1/06 Issue – Updated Definitions To Include Overhead And Underground Terminology

DUTY - Continuous Duty – Operation at a substantially constant load for an indefinitely long time.

Intermittent Duty – Operation for alternate intervals of:
1) load and no load; or
2) load and rest; or
3) load, no load, and rest.

Periodic Duty - Intermittent operation in which the load conditions are regularly recurrent.

E

EFFECTIVELY GROUNDED - Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to limit the buildup of voltages to levels below that which may result in undue hazard to persons or to connected equipment. (NESC)

An alternating-current system or portion thereof may be said to be effectively grounded when, for all points on the system or specified portion thereof, the ratio of zero-sequence reactance to the positive-sequence reactance is less than three and the ratio of zero-sequence resistance to positive-sequence reactance is less than one for any condition of operation and for any amount of connected generator capacity. (IEEE-100)

ELBOW - A cable to apparatus connector.

ENCLOSED - Surrounded by case, cage, or fence designed to protect the contained equipment and limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects. (NESC)

EXTRA-HIGH VOLTAGE SYSTEM - See Voltage Systems

F

FAULT CURRENT - A current that flows from one conductor to ground or to another conductor owing to an abnormal connection (including an arc) between the two. **Note:** A fault current flowing to ground may be called a ground fault current. (IEEE-100)

FEEDER - A set of conductors originating at a main distribution center and supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two (2) types of equipment. (IEEE-100)

FEED-THRU - A device to electrically connect elbows or other accessories.

FUSE - An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it. (IEEE-100)

G

GROUND - A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth or to some conducting body of relatively large extent that serves in place of the earth. (IEEE-100)

GROUND CURRENT - Current flowing in the earth or in a grounding connection. (IEEE-100)

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GROUND GRID -	A system of grounding electrodes consisting of interconnected bare cables buried in the earth to provide a common ground for electrical devices and metallic structures. (IEEE-100)
GROUND MAT -	A system of bare conductors, on or below the surface of the Earth, connected to a ground or a ground grid to provide protection from dangerous voltages. (IEEE-100)
GROUND ROD -	A rod that is driven into the ground to serve as a ground terminal, such as a copper-clad rod, solid copper rod, or galvanized iron pipe or rod. (IEEE-100)
GROUNDING TRANSFORMER -	A transformer intended primarily to provide a neutral point for grounding purposes. **Note:** It may be provided with a Delta winding in which resistors or reactors are connected. (IEEE-100)
GUARDED -	Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats or platforms, designed to limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects. **Note:** Wires that are insulated but not otherwise protected are not normally considered to be guarded. See exceptions under applicable rules. (NESC)
GUY -	A tension member having one end secured to a fixed object and the other end attached to a pole, crossarm, or other structural part that it supports. (IEEE-100)

H

HANDHOLE -	An access opening, provided in equipment or in a below-the-surface enclosure in connection with underground lines, into which personnel reach but do not enter, for the purpose of installing, operating, or maintaining equipment or cable or both. (NESC)
HIGH VOLTAGE SYSTEM -	See Voltage Systems.

I

IMPEDANCE VOLTAGE (TRANSFORMER) -	The voltage required to circulate rated current through one of two specified windings of a transformer when the other winding is short-circuited, with the windings connected as for rated voltage operation. **Note:** It is usually expressed in per unit or percent, of the rated voltage of the winding in which the voltage is measured. (IEEE-100)
INRUSH CURRENT (TRANSFORMER) -	The maximum root-mean-square or average current value, determined for a specific interval, resulting from the excitation of the transformer with no connected load, and with essentially zero-source impedance, and using the minimum primary turns tap available and its rated voltage. (IEEE-100)
INSULATING CAP-	A cap that is used for insulating, shielding and sealing a bushing plug.
INSULATION-	That which is relied upon to insulate the conductor from other conductors or conducting parts or from ground (as applied to cable). (NESC)
INSULATOR -	Insulating material in a form designed to support a conductor physically and electrically separate from another conductor or object. (IEEE-100)
ISOLATED NEUTRAL SYSTEM -	A system that has no intentional connection to ground except through indicating, measuring, or protective devices of very high impedance. (IEEE-100)

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J

JACKET - A protective covering over the insulation, core, or sheath of a cable. (NESC)

L

LATERAL CONDUCTOR - A wire or cable extending in a general horizontal direction at an angle to the general direction of the line conductor. (IEEE-100)

LAY (CABLE) - The helical arrangement formed by twisting together the individual elements of a cable. (IEEE-100)

LIGHTNING ARRESTER - See Surge Arrester.

LIVE - See Alive.

LIVE FRONT (TRANSFORMERS & SWITCHGEAR) - With live parts exposed to a person on the operating side of the equipment.

LOAD FACTOR - The ratio of the average load over a designated period of time to the peak load occurring in that period. (IEEE-100)

LOAD LOSSES (TRANSFORMER) - Those losses which are incident to the carrying of a specified load. Load losses include I^2R loss in the winding due to load and eddy currents, stray loss due to leakage fluxes in the windings, core clamps, and other parts; and the loss due to circulating current (if any) in parallel windings, or in parallel winding strands. (IEEE-100)

LOCATION -

- Damp Location – Partially protected locations under canopies, marquees, roofed open porches, and like locations; and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses.
- Dry Location – A location not normally subject to dampness or wetness. Any location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
- Wet Location – Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids such as vehicle washing area, and locations exposed to weather and unprotected.

LOSS FACTOR - The ratio of the average power loss to the peak-load loss during a specified period of time. (IEEE-100)

LOW VOLTAGE - See Voltage Systems.

LUG - A wire connector device to which the electrical conductor is attached by mechanical pressure or solder. (IEEE-100)

LUMINAIRE - A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply. (IEEE-100)

M

MANDREL -	A tapered or cylindrical axle used to pull through conduit for inspections.
MANHOLE -	A subsurface enclosure that personnel may enter and is used for the purpose of installing, operating, and maintaining submersible equipment and cable. (NESC)
MANUAL -	Operated by mechanical force, applied directly by personal intervention. (IEEE-100)
MANUAL OPERATION -	Operated by hand without using any other source of power. (IEEE-100)
MEDIUM VOLTAGE SYSTEM -	See Voltage System.
MULTI- GROUNDED NEUTRAL SYSTEM -	A distribution system of the 4 wire type where all transformer neutrals are grounded, and neutral conductors are directly grounded at frequent points along the circuit. (IEEE-100, NESC) A system of conductors in which a neutral conductor is intentionally grounded solidly at specified intervals. A multigrounded or multiple grounded systems may or may not be effectively grounded. (NESC)

N

NAMEPLATE -	A plaque giving the manufacturer's name and the rating of the equipment to which it is attached. (IEEE-100)
NETWORK -	An aggregation of interconnected conductors consisting of feeders, mains, and services. (IEEE-100)
NEUTRAL CONDUCTOR -	The conductor that is intended to be so energized, that, in the normal steady state, the voltages from every other conductor to the neutral conductor, at the terminals of entry of the circuit into a delimited region, are definitely related and usually equal in amplitude. (IEEE-100, NESC) A system conductor other than a phase conductor that provides a return path for current to the source. Not all systems have a neutral conductor. An example is an ungrounded delta system containing only three energized phase conductors. (NESC)
NO-LOAD LOSSES -	Those losses which are incident to the excitation of the transformer. No-load (excitation) losses include core loss, dielectric loss, conductor loss in the winding due to exciting current, and conductor loss due to circulating current in parallel windings. These losses change with the excitation voltage. (IEEE-100)
NOMINAL SYSTM VOLTAGE -	See Voltage, Nominal.
NON-EFFECTIVELY GROUNDED -	An alternating-current system or portion thereof may be said to be non effectively grounded when, for all points on the system or specified portion thereof, the ratio of zero-sequence reactance to the positive-sequence reactance is greater than three and the ratio of zero-sequence resistance to positive-sequence reactance is greater than one for any condition of operation and for any amount of connected generator capacity.

NOT EFFECTIVELY GROUNDED - Not permanently connected to earth through a ground connection or connections of sufficiently high impedance and not having sufficient current-carrying capacity to prevent the building up of voltages that may result in undue hazard to connected equipment or to persons.

NOVOID X - Filling compound for G & W porcelain potheads and armored cable joint boxes.

O

OFC - Oil Fused Cutout.

OPEN WIRE - Single conductor, bare, covered or insulated, and separated by air from other conductors, e.g, not a cable.

P

PAD-MOUNTED - A general term describing equipment positioned on a surface-mounted pad located outdoors. **Note**: The equipment is usually enclosed with all exposed surfaces at ground potential. (IEEE-100)

PAD-MOUNTED TRANSFORMER - A transformer utilized as part of an underground distribution system, with enclosed compartment(s) for high voltage and low voltage cables entering from below and mounted on a foundation pad. (IEEE-100)

PARKING STAND - A bracket designed for installation on an apparatus, suitable for holding accessory devices, such as insulated parking bushing and grounding bushing. (IEEE-100)

PILC- Paper Insulated Lead Covered Cable

POLE-TYPE TRANSFORMER - A transformer that is suitable for mounting on a pole or similar structure. (IEEE-100)

POTHEAD - A device that seals the end of a cable and provides an insulated exit for the conductor or conductors. (IEEE-100)

POWER FUSE - A fuse consisting of an assembly of a fuse support and a fuse unit or fuseholder that may or may not include the refill unit or fuse link. **Note:** The power fuse is identified by the following characteristics: (1) Dielectric withstand (basic impulse insulation level) strengths at power levels; (2) Application primarily in stations and substations; (3) mechanical construction basically adapted to station and substation mounting. (IEEE-100)

PRESSURE RELIEF DEVICE - A means for relieving internal pressure in a transformer, possibly preventing explosive shattering of the tank or tank cover, following prolonged passage of fault current due to external faults or internal transformer faults. (IEEE-100)

PULLING EYE - A device that may be fastened to the conductor or conductors of a cable or formed by or fastened to the wire armor and to which a rope may be directly attached in order to pull the cable into or from a duct. (IEEE-100)

PUSH BRACE - A supporting member, usually of timber placed between a pole or other structural part of a line and the ground or a fixed object. (IEEE-100)

Q

QUADRUPLEX CABLE - A cable composed of four (4) insulated single conductors or three (3) insulated conductors and one (1) bare neutral conductor twisted together.

R

RADIAL SYSTEM - A system in which independent feeders branch out radially from a common source of supply. (IEEE-100)

RISER POLE - Pole on which overhead wires connect to underground cable.

RULING SPAN - A calculated deadend span length, which will have the same changes in conductor tension due to changes of temperature and conductor loading, as will be found in a series of spans of varying lengths between deadends. (IEEE-100)

S

SAG - The distance measured vertically from a conductor to a straight line joining its two (2) points of support. Unless otherwise stated, the sag referred to is the sag at the midpoint of the span. (IEEE-100)

SECONDARIES - Circuits 600 volts and below.

SEPARATION - The distance between two objects, measured surface to surface, and usually filled with a solid or liquid material. (NESC)

SERVICE DROP - The overhead conductors between the electric supply or communication line and the building or structure being served. (NESC)

SERVICE ENTRANCE CONDUCTORS, OVERHEAD SYSTEM – The service conductors between the terminals of the service equipment and point usually outside the building, clear of building walls, where jointed by tap or splice to the service drop. (NEC)

SERVICE ENTRANCE CONDUCTORS UNDERGROUND SYSTEM - The service conductors between the terminals of the service equipment and the point of connection to the service lateral. **Note:** Where service equipment is located outside the building walls there may be no service-entrance conductors, or they may be entirely outside the building. (NEC)

SERVICE LATERAL - The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure with adequate space, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to be the point of entrance of the service conductors into the building. (NEC)

SIDE BREAK SWITCH - A switch in which the travel of the blade is in a plane parallel to the base of the switch. (IEEE-100)

SIDEWALL PRESSURE - The crushing force exerted on a cable during installation. (IEEE-100, NESC)

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SOLIDLY - GROUNDED — Grounded through all adequate ground connection in which no impedance has been inserted intentionally. **Note:** Adequate as used herein means suitable for the purpose intended. (IEEE-100)

SPACER CABLE - A type of electric supply-line construction consisting of an assembly of one or more covered conductors, separated from each other and supported from a messenger by insulating spacers. (IEEE-100, NESC)

SPAN LENGTH - The horizontal distance of two (2) adjacent supporting points of a conductor. (IEEE-100)

SPLICE - A physical connection of two (2) or more conductors to provide electrical continuity. (IEEE-100)

SPLICE TYPES- Double Wye: also known as a double double or an H splice, splices four cables together.

Modula/Separable: A joint that is built that can be easily taken apart by mechanical means.

Normal: A splice of two similar cables.

Reducing: A type of splice that will join two different sizes of cable together.

Reducing/Transition: To splice a PILC cable to a smaller solid dielectric cable.

Transition: Splicing together PILC cable to solid dielectric cable.

Trifurcating: Splicing a 1-3/C cable to a 3-1/C cable.

Trifurcating/Transition: Splicing a 1- 3/C PILC cable to 3-1/C solid dielectric cable.

Wye: Splicing 3 cables together.

STEP-DOWN TRANSFORMER - A transformer in which the energy transfer is from a higher voltage circuit to a lower voltage circuit. (IEEE-100)

STEP-UP TRANSFORMER - A transformer in which the energy transfer is from a lower voltage circuit to a higher voltage circuit. (IEEE-100)

SUBMARINE CABLE - A cable designed for service under water. **Note:** Submarine cable is usually a lead-covered cable with a steel armor applied between layers of jute. (IEEE-100)

SUBMERSIBLE TRANSFORMER - A transformer so constructed as to be successfully operable when submerged in water under predetermined conditions of pressure and time. (IEEE-100)

SUBWAY TRANSFORMER - A submersible-type distribution transformer suitable for installation in an underground vault. (IEEE-100)

SURGE ARRESTER - A protective device for limiting surge voltage on equipment by discharging or bypassing surge current; it prevents continued flow of follow current to ground, and is capable of repeating these functions as specified. (IEEE-100)

SWEEP - A manufactured bend installed at pad mounted equipment locations.

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SWITCH -	Disconnecting or Isolation Switch -	A mechanical switching device used for changing the connections in a circuit or equipment from the source of power. **Note:** It is required to carry normal load current continuously, and also abnormal or short-circuit currents for short intervals as specified. It is required to open or close circuits either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the switch poles occurs.
	Load-Interrupter Switch -	A disconnecting or isolating switch equipped with an interrupter and designed to interrupt currents not in excess of the continuous-current rating of the switch.
	Regulator Bypass Switch -	A specific device or combination of devices designed to bypass a regulator.

T

TERMINAL - A conducting element of equipment or a circuit intended for connection to an external conductor. (IEEE-100)

TERMINAL CONNECTOR - A connector used for attaching a conductor to a lead, terminal block, or stud of electric apparatus. (IEEE-100)

TERMINAL PAD - A usually flat conducting part of a device to which a terminal connector is fastened. (IEEE-100)

TERMINATOR - An insulator used to protect each cable conductor passing through the device and provide complete external leakage insulation between the cable conductor(s) and ground.

TERMINATOR /POTHEAD - A device that seals the end of a cable and provides insulated egress for the conductor or conductors. (IEEE-100)

TIE LINE - A transmission/distribution line connecting two (2) or more power systems. (IEEE-100)

TOTAL LOSSES - The sum of the no-load and load losses, excluding losses due to accessories. (IEEE-100)

TRIPLEX CABLE - A cable composed of three (3) insulated single conductors or two (2) insulated single conductors and a bare neutral conductor twisted together. (IEEE-100)

U

ULTRA HIGH VOLTAGE SYSTEM - See Voltage System

UNGROUNDED - A system, circuit, or apparatus without an intentional connection to ground except through potential indicating or measuring devices or other very high impedance devices. (IEEE-100)

UNIGROUNDED NEUTRAL SYSTEM - A system of conductors in which one conductor is intentionally grounded solidly at a specific location, typically at the source.

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V

VAULT -	A structurally sound enclosure, including all side, top, and bottom, above or below ground where entry is limited to personnel qualified to install, maintain, operate, or inspect the equipment or cable enclosed. The enclosure may have openings for ventilation, personnel access, cable entrance, and other openings required for operation of equipment in the vault. (NESC)
VOLTAGE, - NOMINAL	A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment. See "Electric Power Systems and Equipment – Voltage Ratings (60 Hz)" (ANSI C84.1-82, IEEE-100)

VOLTAGE - SYSTEMS	Low-Voltage System -	An electric system having a maximum root-mean-square alternating-current voltage of 1000 volts or less. (IEEE-100)
	Medium Voltage System -	An electric system having a maximum root-mean-square alternating-current voltage above 1000 volts to 72,500 volts. (IEEE-100)
	High Voltage System -	An electric system having a maximum root-mean-square alternating current voltage above 72,500 volts to 240,000 volts. (IEEE-100)
	Extra-High Voltage System -	An electric system having a maximum root-mean-square alternating current voltage above 240,000 volts to 800,000 volts. (IEEE-100)
	Ultra-High Voltage System -	An electric system having a maximum root-mean-square alternating current voltage above 800,000 volts to 2,000,000 volts. (IEEE-100)

VOLTAGE TO - GROUND	For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded. For ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit. (IEEE-100)

W

WEIGHT SPAN -	Distance to the low point in the Actual Span ahead + distance to the low point in the Actual Span back. The weight span is a calculated term used to determine the vertical loading in crossarms and poles from the weight of ice coated conductors.
WIND SPAN -	½ Actual Span ahead + ½ Actual Span back. The wind span is a calculated term used to determine the transverse loading on the pole from the wind on ice coated conductors.
WOUND -	Single Wound – One cable wound on a reel. Triple Wound – Three cables in parallel wound on a reel.

Supersedes 1/06 Issue – Updated Definitions To Include Overhead And Underground Terminology

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1/1	7/12	• Added additional abbreviations	Robert Johnson	

New Standards PAge – Added notes page

 Doc. # ST. 10.00.001

Supersedes 7/09 Issue – Added Section 10.6.

10.0 GENERAL

The following STANDARDS section applies to new installation of overhead secondary conductors.

In cases where existing secondary conductors are deteriorated, clearances are doubtful, or poles need replacement, consideration should be given to rebuilding the entire secondary in accordance with these Standards.

10.0.10 Secondary "CRIB"

Secondary "CRIB" describes the overhead secondary supply conductors, typically 120/240 volt, that are supplied by a distribution transformer located near the load mid-point and that supply individual service drop cables along its route.

10.0.20 Secondary Voltages

See STANDARDS section 11 for available secondary voltages.

10.0.30 Conductors

The Standard single phase, secondary crib cable is a 1/0-3/C aluminum cable consisting of one base aluminum alloy neutral messenger and two aluminum cable covered conductors continuously wrapped around the neutral messenger. Applications for this cable include residential, industrial, commercial, and outdoor lighting.

Quadruplex cables shall be used for all 120/208 V, 277/480 V effectively grounded and 240 V and 480 V not effectively grounded secondaries.

For line currents greater than 245 amps., use 4/C 336.4 kCMIL secondary cable.

10.0.40 Conductor Location

In general, secondary conductors shall normally be installed on the street or highway side of the pole. On inside angles, it may be necessary or preferable to attach secondary conductors on the field side of the pole. "Boxing" in a pole by installing secondary cable on the opposite side from that of communication conductors should be avoided.

For rack construction, the neutral shall be located on the top spool of the rack. The grounded conductor of a 3 phase Delta secondary shall be installed in the top position on the power secondary rack. This grounded phase conductor shall not be used as a system neutral nor shall a system neutral be used as the grounded phase conductor.

When two or more secondary circuits are located on the same pole, the following order is recommended from the top: single phase secondary; 3-phase, 4 wire secondary; 3-phase, 3 wire secondary; and multiple street lighting.

All grounded neutrals (except secondary neutrals of not effectively grounded primary systems), located on the same pole shall be bonded together.

10.0.50 **Clearances**

See Section 7-Clearances for specific details.

Span taps should be made where practical to provide adequate clearance, climbing, and working space on the pole. An extension bracket (Std. Item A50E) may be used with triplex to improve clearances and climbing space, or to avoid trees.

10.0.40 **Sags and Tension**

See Pages 10-5 and 10-6 for sags and tensions.

10.0.50 **Taps and Connections**

See STANDARDS Section 5-“Connectors” for taps, connections and methods of taping connections.

10.0.60 **Tree Trimming**

Although secondary cables require a relatively small clearance from trees, they are not designed to withstand abrasion from continual contact with tree limbs.

10.0.70 **Secondary Cable Dimensions**

See STANDARDS Section 11 – “Services” – page 11-62, for secondary and service drop cable dimensional data.

Supersedes 7/09 Issue – Added paragraph 10.0.70.

10.1 SECONDARY CRIB DESIGN

Good secondary crib design is dependent on knowledge of load. Actual load checks furnish the most accurate information about existing loads and should be used whenever practical. Other tools such as GIS data are also available to accurately estimate existing loads.

Good secondary crib design also includes provisions for future load growth. Adherences to the principles in this STANDARD will result in secondary that can grow substantially without major rebuilding.

Gaps between adjacent secondary cribs should be filled in with secondary cable when the gap is less than 400-feet in length. For longer gaps, install a standard 1/0 aluminum neutral conductor only, unless future load growth is expected within the area of the gap.

Proper balance must be maintained between length of secondaries, size of conductors, loading of transformers, and overall voltage regulation in service drop, secondary, and transformer installations.

Proper secondary crib design will take into account all of the following:

10.1.10 Transformer Location – Good secondary crib design will place the distribution transformer in the physical center of the secondary crib run. Adjustments can be made to favor the electrical center of the load, or accommodate other existing pole top equipment.

10.1.20 Transformer KVA Size –A typical residential secondary crib will have one of three basic load profiles:
1. Oil or Gas Heat – 8kW diversified per residence (includes electric range, dryer, and window air conditioner units)
2. Oil or Gas Heat w/ Central Air – 10kW per residence

3. Electric Heat – 20kW per residence

The following Table provides a guide to determine the maximum number of residential customers that can be served by a secondary crib. (assumes single family homes less than 3,500 square feet and multi-family homes)

Table 1

Maximum Number of Residential Customers				
Transformer KVA Size	**Oil or Gas Heat**	**Oil or Gas Heat w/ Central Air**	**Electric Heat**	**50% Electric Heat 50% Oil/Gas Heat**
25 KVA	9	5	2	3
50 KVA	12	8	5	6

10.1.30 **Length of Secondary Crib -** Transformer KVA size, transformer location, secondary crib load, and voltage drop shall determine the length of secondary crib. For evenly distributed loads, the following Table serves as a guide to determine the approximate length of a straight, 2-way 1/0 triplex secondary to provide a 1.5% voltage drop at the ends with the transformer located in the center.

Table 2

Total KVA Load	Total Length of Secondary	Length of Secondary from Transformer to End
15 kVA	1000 feet	500 feet
25 kVA	700 feet	350 feet
50 kVA	350 feet	175 feet

10.1.40 **Voltage Drop** – Voltage drop in secondary cribs should be limited to 1.5% in areas where new load growth can reasonably be expected. In areas where new load growth is not expected, this may be increased to a maximum of 3% of nominal (120V). A voltage drop calculator is available on the Liberty Utilities Distribution Engineering Services website.

10.1.50 **Flicker** - Consider only the part of the secondary which is to be checked for flicker voltage drop. Determine the kW-Ft and the power factor for the fluctuating load. From the diagram on Page 10-9 determine the kW-Ft that will result in 1% drop.

Divide the kW-Ft by the value found and the quotient will be the percent drop as shown above. While this method is not strictly accurate, the error is in the safe side and it should serve for most problems. For more accurate results calculate load, power factor, and voltage drop before and after adding fluctuating load.

10.1.60 **Commercial or Industrial Secondaries**

In planning commercial and industrial secondaries, consider the overall voltage regulation in the service, secondary, transformer and primary rather than specifically limiting the drop in each of the parts.

The size of secondary and service wires should be determined by consideration of both voltage drop and current. Multiplex cables are recommended if current rating and voltage drops permit. Voltage drop on secondary and service should not exceed 3%. Current should not exceed the values shown in basic data for Section 6-Primary Conductors. It is generally economical to stay well below those values for everything except temporary work. In the case of intermittent loads, the above voltage limitations may be exceeded provided the resulting voltage is satisfactory.

Transformer loading should not exceed 100% of rating where the daily load factor is 100% and ambient temperature is 30°C/86°F or 0°C/32°F. However, loading may be increased 0.3% for each 1% decrease in load factor to a maximum of 115% of rating at 50% load factor. In addition, if peak loads occur at ambients other than 30°C/86°F or 0°C/32°F, loading may be increased 1% for each 1°C/34°F decrease or decreased 2% for each 1°C/34°F increase in ambient. The effects of load factor and temperature may be added to permit a maximum of 145% load with a load factor of 50% or less, at ambients of 0°C/32°F or below.

Starting currents and flicker voltage drops should be checked where applicable. Consult Pages 10-9 and 10-10 for further data on starting current and flicker limitations. Flicker should, in general, be kept below the borderline of irritation. However, avoid increasing the cost of an installation to reduce flicker if the customer should apply corrective measures to his load.

Supersedes 01/06 Issue – General Revision

Supersedes 01/06 Issue – Page shift due to general revisions.

3/c – 1/0 Aluminum Triplex Secondary Cable
Messenger 1/0 7 Strand 6201 or ACSR

TABLE 3
INITIAL SAGS AND TENSIONS – 150 FT. RULING SPAN – FOR INITIAL INSTALLATION ONLY

TEMP. (°F)	TENSION (LBS.)	SAG IN INCHES				
		ACTUAL SPAN IN FEET				
		100	125	150	175	200
0	1495	4	7	10	13	17
30	1245	5	8	11	16	20
40	1165	5	9	12	17	22
50	1085	6	9	13	18	23
60	1010	6	10	14	19	25
70	940	7	11	15	21	27
80	875	7	11	16	22	29
90	805	8	12	18	24	31
100	745	8	13	19	26	34
120	640	10	15	22	30	39

MAXIMUM DESIGN SAGS AND TENSIONS – INITIAL

TEMP. (°F)	ICE (IN.)	WIND (PSF)	K (LF./FT.)	SAG (IN.)	TENSION (LBS.)
0	0.5	4.0	0.3	31	2000
32	0.5	0	0	29	1630
32	0	0	0	12	1225
120	0	0	0	22	640

TABLE 4
FINAL SAGS AND TENSIONS – 150 FT. RULING SPAN – FOR CLEARANCES PURPOSES ONLY

TEMP. (°F)	TENSION (LBS.)	SAG IN INCHES				
		ACTUAL SPAN IN FEET				
		100	125	150	175	200
0	1250	5	8	11	15	20
30	975	6	10	15	20	26
40	895	7	11	16	22	29
50	820	8	12	18	24	31
60	745	8	13	19	26	34
70	690	9	14	21	28	37
80	635	10	16	23	31	40
90	580	11	17	24	33	44
100	535	12	18	26	36	47
120	470	13	21	30	41	54

MAXIMUM DESIGN SAGS AND TENSIONS – FINAL

TEMP. (°F)	ICE (IN.)	WIND (PSF)	K (LF./FT.)	SAG (IN.)	TENSION (LBS.)
0	0.5	4.0	0.3	32	1925
32	0.5	0	0	31	1505
32	0	0	0	15	955
120	0	0	0	30	470

3/c – 1/0 Aluminum Triplex Secondary Cable
Messenger 1/0 7 Strand 6201 or ACSR

TABLE 5
INITIAL SAGS AND TENSIONS – 200 FT. RULING SPAN – FOR INITIAL INSTALLATION ONLY

TEMP. (°F)	TENSION (LBS.)	SAG IN INCHES				
		ACTUAL SPAN IN FEET				
		150	175	200	225	250
0	1155	12	17	22	28	34
30	955	15	20	26	34	41
40	895	16	22	28	36	44
50	840	17	23	30	38	47
60	790	18	24	32	40	50
70	745	19	26	34	43	53
80	700	20	28	36	46	56
90	660	21	29	38	48	60
100	630	23	31	40	51	63
120	570	25	34	42	56	70

MAXIMUM DESIGN SAGS AND TENSIONS – INITIAL

TEMP. (°F)	ICE (IN.)	WIND (PSF)	K (LF./FT.)	SAG (IN.)	TENSION (LBS.)
0	0.5	4.0	0.3	56	2000
32	0.5	0	0	52	1600
32	0	0	0	26	955
120	0	0	0	45	570

TABLE 6
FINAL SAGS AND TENSIONS – 200 FT. RULING SPAN – FOR CLEARANCES PURPOSES ONLY

TEMP. (°F)	TENSION (LBS.)	SAG IN INCHES				
		ACTUAL SPAN IN FEET				
		150	175	200	225	250
0	965	15	20	26	33	41
30	775	18	25	32	41	51
40	725	20	27	35	44	54
50	680	21	28	37	47	58
60	640	22	30	39	50	62
70	605	26	32	42	53	65
80	575	25	34	44	56	69
90	545	26	35	46	59	73
100	520	27	37	49	61	76
120	475	30	41	53	67	83

MAXIMUM DESIGN SAGS AND TENSIONS – FINAL

TEMP. (°F)	ICE (IN.)	WIND (PSF)	K (LF./FT.)	SAG (IN.)	TENSION (LBS.)
0	0.5	4.0	0.3	56	1975
32	0.5	0	0	54	1530
32	0	0	0	33	765
120	0	0	0	53	475

Supersedes 01/06 Issue – Page shift due to general revisions.

CU = PR1STS	Sec. Clamp 0°-60°
CU = PR1SSA2	DE Sec. 61°-90°

10.3 1/0 - 3C ALUMINUM MAINLINE CONDUCTOR SPLICING

10.3.10 Application

This Section covers splicing 3/C – 1/0 secondary mains in the street. Splicing should not take place within 5 feet of any pole, to allow for multiple secondary services and streetlight.

10.3.20 Procedure – Initial Steps, Neutral Splicing

A. Cut conductors to give sleeve locations shown in Figure I below. **Note:** Total splicing length is about 36 inches.

B. Make certain ends are somewhat square and free of burrs.

C. Use **full tension automatic** splice**,** Std. Item S19K, on the neutral. **Make sure the neutral carries all the tension and the live legs are relatively slack when all splicing is complete.**

D. Follow manufacturer's splicing recommendations on splice packaging including wire brushing.

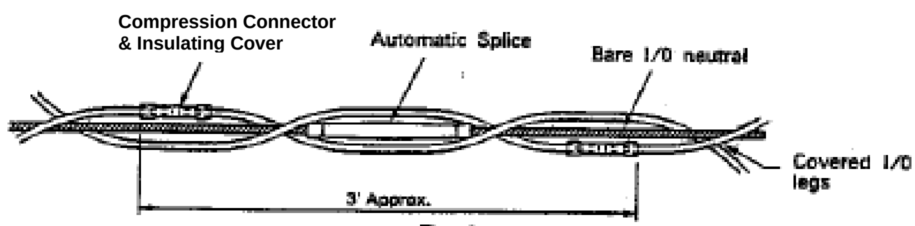
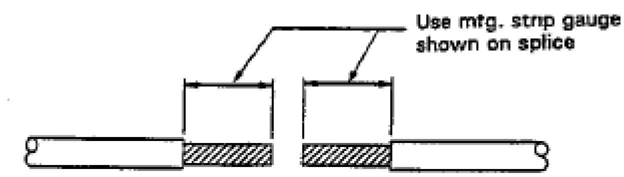


Fig. 1

10.3.30 Procedure – Leg Conductor Splicing



A) Use compression splice, Std. Item S26D on legs.

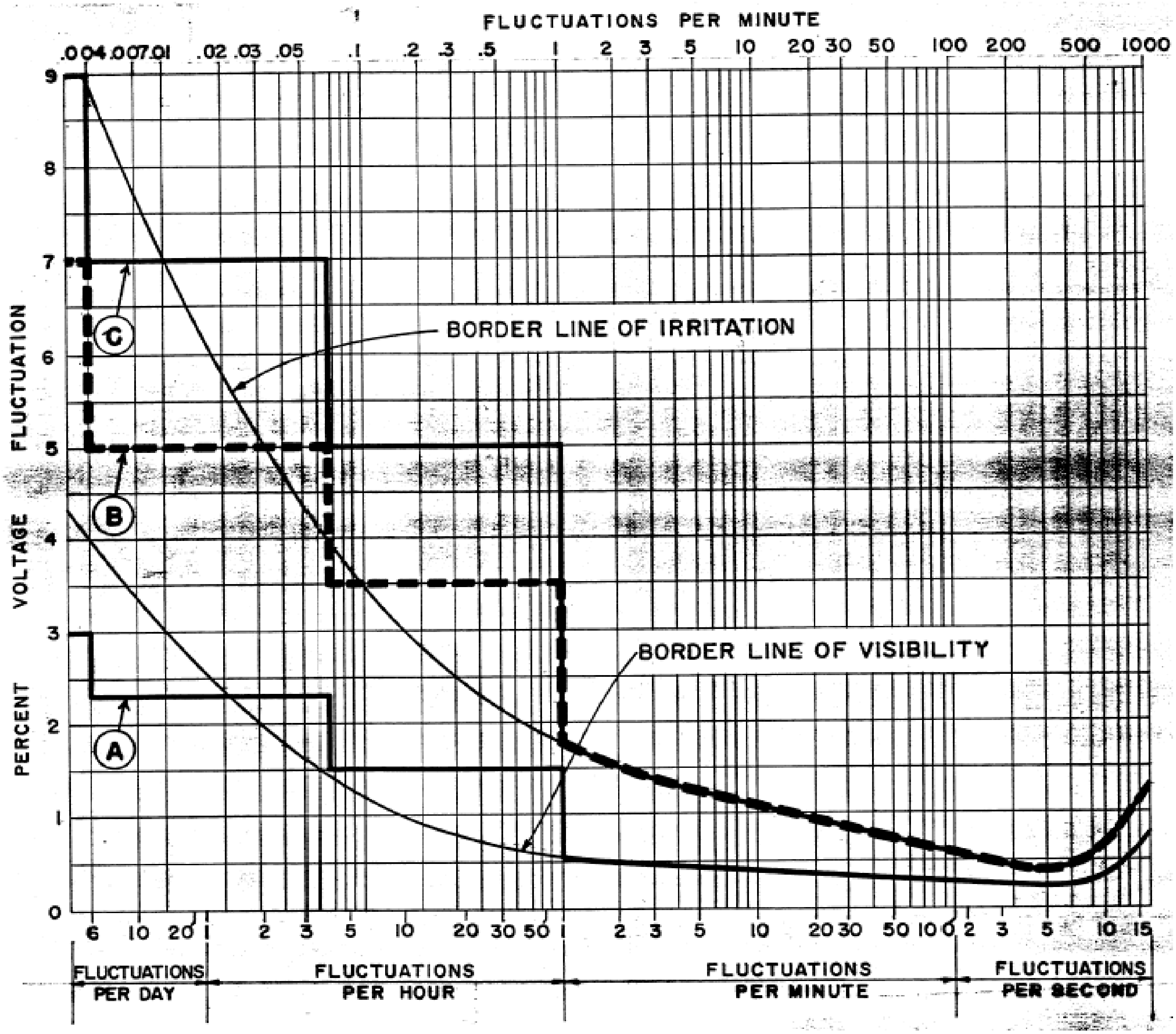
B) Strip covering from all leg conductors **using strip guide on Insulated splice.** Strip length is important to insure proper conductor insertion and to insure no exposed bare metal outside the splice housing.

C) Bring proper ends together, short conductor of left cable with long conductor of right cable, spiraling conductor around neutral to match lay of cable; and similarly with other two cable ends.

D) Insert skinned conductors into splice as far as barrier. No bare conductor should protrude from end of connector. Indent each splice in turn, making four crimps per side using the MD-6 or equivalent tool with W243 die, Item ID 6512709. Cover with poly cover or tape.

Supersedes 01/06 Issue – Page shift due to general revisions, added CUs.

 | Doc. # ST. 10.00.002



Supersedes 01/06 Issue – Page shift due to general revisions.

NOTES: For motor starting loads, the maximum percent voltage fluctuation allowable for each starting step shall be limited as follows:

a) On LVAC secondary network, at the service entrance equipment, or on the general system at the substation bus, *Curve A.*
b) On a primary feeder or secondary which can affect other customers, *Curve B.*
c) At service entrance on the radial service of the motor user, no limitations, but recommend voltage fluctuation not exceed, *Curve C.*

If the calculated fluctuation due to motor starting exceeds the above limitations the problem should be referred to the Engineering department. For other type of fluctuating loads, refer problem to the Engineering department.

Supersedes 01/06 Issue – Page shift due to general revisions.

INDIVIDUAL TRANSFORMER RATING IN KVA	SINGLE PHASE LOAD IN kVA TO GIVE 1% REGULATION AT VARIOUS POWER FACTORS							THREE PHASE TRANSFORMER BANK RATING IN kVA	THREE PHASE LOAD IN kVA TO GIVE 1% REGULATION AT VARIOUS POWER FACTORS						
	100	95	90	85	80	60	35		100	95	90	85	80	60	35
NEW TRANSFORMERS (AFTER 1975)															
10	6.1	5.7	5.7	5.8	5.9	6.7	8.5	30.0	18.4	17.2	17.1	17.4	17.8	20.1	25.4
15	10.0	8.1	7.7	7.5	7.4	7.5	8.3	45.0	30.0	24.2	23.1	22.5	22.2	22.5	24.8
25	17.9	14.5	13.8	13.5	13.4	13.5	14.9	75.0	53.6	43.6	41.4	40.5	40.1	40.5	44.6
37.5	30.5	23.3	21.8	20.6	20.5	20.0	21.2	112.5	91.5	69.9	65.4	61.8	61.5	59.8	63.6
50	41.7	31.3	29.1	27.9	27.2	26.3	27.8	150.0	125	93.8	87.2	83.8	81.5	79.0	83.3
75	67.0	44.8	43.6	41.2	39.9	37.8	38.9	225.0	201	134	131	124	120	113	117
100	100	74	67	64	62	59	61	300.0	300	221	201	192	185	177	182
167	167	113	103	97	94	88	90	501.0	501	339	309	291	281	265	271
TRANSFORMERS (1960 THRU 1975)															
5	2.4	2.1	2.0	2.0	2.0	2.2	2.5	15	7.2	6.2	6.1	6.1	6.0	6.5	7.5
10	7.2	6.3	6.2	6.2	6.3	6.8	8.1	30	21.5	18.9	18.5	18.5	18.8	20.4	24.3
15	10.1	10.0	9.7	9.7	9.4	10.1	12.8	45	30.2	30	29.2	29.2	28.2	30.2	38.4
25	19.2	16.0	15.2	14.8	14.8	14.8	16.2	75	57.6	47.8	45.5	44.4	44.1	44.1	48.6
37.5	34.1	26.2	24.8	24.0	23.4	23.4	25.7	112.5	102	78.7	74.5	72.9	70.2	70.2	77.1
50	45.5	34.5	32.1	30.9	29.4	29.4	31.0	150	137	103	96.2	92.6	88.2	88.2	93
75	75.0	53.2	49.0	46.9	46.9	44.1	46.0	225	225	160	147	141	141	132	138
100	100	75	70	67	67	63	66	300	300	226	210	200	200	188	199
167	167	113	101	95	93	85	85	501	501	339	304	286	278	254	255
TRANSFORMERS (PRIOR TO 1960)															
5	2.3				1.7	1.7	1.9	15	6.8				5.0	5.0	5.5
10	4.8				3.5	3.5	3.7	30	14.3				10.4	10.4	11.1
15	7.1				4.8	4.8	5.0	45	21.4				14.5	14.5	15.0
25	14.3				8.3	8.1	8.3	75	42.9				25.0	24.2	25.0
37.5	23.4				12.5	11.4	11.4	112.5	70.2				37.5	34.2	34.2
50	34.5				17.2	15.6	15.6	150	103				51.6	46.8	46.8
75	53.6				22.7	20.3	19.7	225	161				68.1	60.9	59.1
100	74				31	27	26	300	222				94	81	79

The values for 60% and 35% P.F. are intended principally for use in motor starting problems. The 60% power factor is applicable to low starting current, high starting torque motors while the 35% power factor is applicable to high starting current, normal starting torque motors.

10.6 RESIDENTIAL TRANSFORMER LOADING

The following loading schedules should be used as a guide for determining when to change a transformer and what size new transformer to install for residential load only. Peak month kWh data from GIS serves as a measurement of existing load. The table shown on Page 10-11 serves for estimating new customer's expected peak month kWh load.

The need for change outs due to new loads on existing transformers can be determined by kWh data and expected kWh loads. If the total of the two exceeds changeout loading criterion, a transformer change is warranted. If it exceeds the maximum install loading but not the changeout loading, change of the transformer should be avoided unless significant load growth or voltage problems are anticipated.

If the existing peak month kWh loads from GIS exceed transformer peak month change out loading, change transformer and size as shown below.

New transformer installations should be sized in accordance with the install loading table, with consideration for adjacent building lots if development is anticipated within 3 years. Refer to Electrical Service Information and Requirements Handbook and local city/town ordinances for information on and mandates to locate certain residential electric facilities underground.

Engineers and planners must exercise good judgment in selecting transformers, taking probable load growth, economy, and performance into consideration.

	SUMMER CRITICAL		WINTER CRITICAL	
Transformer Nameplate	**Change out Loading (Peak Month kWh)**	**Install Loading (Peak Month Kwh)**	**Change out Loading (Peak Month kWh)**	**Install Loading (Peak Month kWh)**
5 *	1,800	001 to 1,300	2,500	001 to 1,500
10	4,100	1,300 to 3,200	5,500	1,500 to 4,000
15 *	7,300	3,200 to 5,000	9,500	4,000 to 5,000
25	13,700	5,000 to 10,500	17,000	5,000 to 12,000
37 ½ *	20,500	10,500 to 17,000	27,000	12,000 to 18,000
50	27,500	17,000 to 26,500	38,000	18,000 to 30,000
75	41,000	26,500 to 35,000	60,000	30,000 to 39,000
100	55,000	35,000 to 53,000	82,000	39,000 to 70,000
167	92,000	53,000 to 83,000	140,000	70,000 to 110,000

* No longer Liberty Utilities standard transformer kVA sizes

The schedule for summer critical loading of pole mounted transformers is based on an expected 5% annual load growth and approximately 160% peak one-half hour demand at changeout.

The schedule for winter critical pole mounted transformer loading is based on an expected 5% annual load growth and approximately 200% peak one-half hour demand at changeout.

If a transformer is suspected of supplying appreciable air conditioning load, the 160% summer loading design criteria does not apply and field testing should be utilized.

Supersedes 7/09 issue – New page. Added residential transformer loading information and table.

Supersedes 7/09 issue – New page. Added residential transformer loading information and table.

When new residential customers are to be serviced and no kWh data is available the following figures may be used as expected peak month kWh consumption to add to other known kWh load for determining required transformer capacity.

Connected Load	**Expected Load (Peak Month kWh)**		
	Single Family	**Multifamily Family Dwelling Units**	**Mobile Homes Permanent Residence**
Less than 800 square feet, no heat		600 *	
More than 800 square feet, no heat		800 *	
No heat	900 *		800 *
Up to 5 kW heat	2800	1600	2500
Up to 10 kW heat	4300	2500	3500
Up to 15 kW heat	5800	3500	4500
Up to 20 kW heat	6300	4200	
Up to 25 kW heat	6800	4800	
Up to 30 kW heat	7300		
Up to 35 kW heat	7800		

Where connected load includes range, water heater and/or dryer, add applicable kWh shown below to the living unit expected load (Peak Month kWh).

Where connected load includes air conditioning, add applicable kWh to only those living units that do not have heat (e.g. living units designated *).

add:
100 kWh for Range
100 kWh for Dryer
400 kWh for Water Heater
<u>* Air conditioning</u>
600 kWh for 1-ton Window Unit
2000 kWh for 5-ton Central

To determine transformer size for overhead pole mounted transformers having connected load of both electric heat and air conditioning, the summer and winter peaks must be evaluated separately. The transformer Peak Month Kwh for each condition must be applied to respective load schedule (Summer Critical & Winter Critical) to determine which loading schedule is applicable.

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CU = PR1STS	Sec. Clamp
CU = PR1SSA	Sec. Clamp Angle
CU = PR1SSA2	Sec. DE Angle 61°-90°

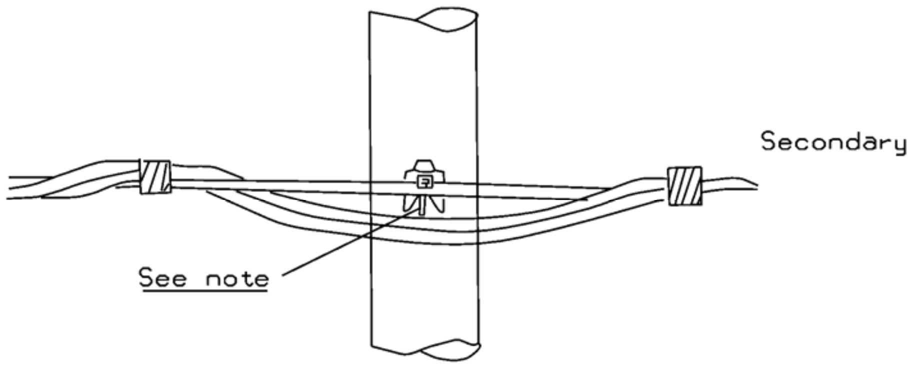


Fig. 1-Straight Line Pole

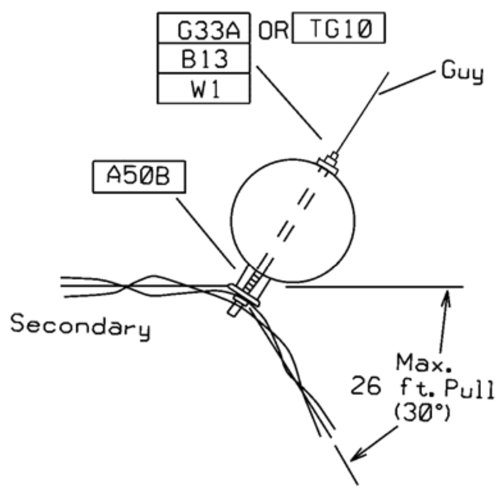


Fig. 2-Angle Pole

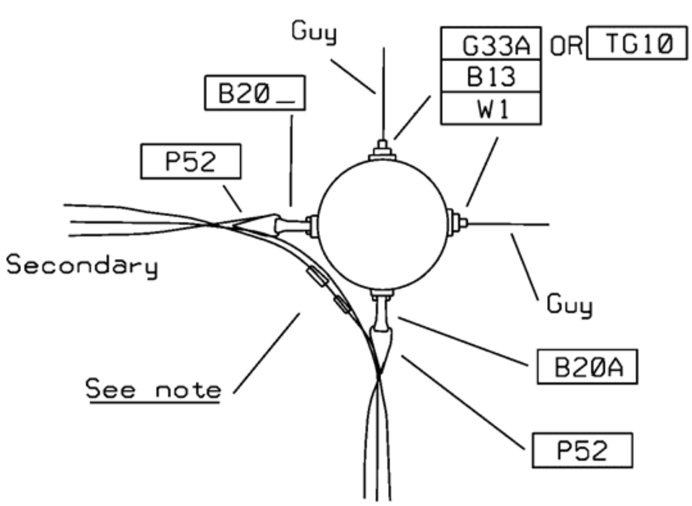


Fig. 3-corner pole

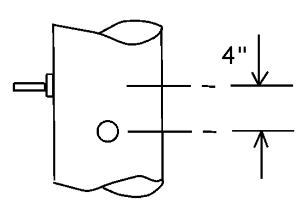


Fig. 3a-Elevation
Showing bolt seperation

NOTE: Train cables neatly and keep approximately 2” away from pole.

Supersedes 7/09 Issue – Updated Std Item #s.

CU = PR1STAP	Deadend Sec. Tap
CU = PR1SSADE	Deadend Sec.

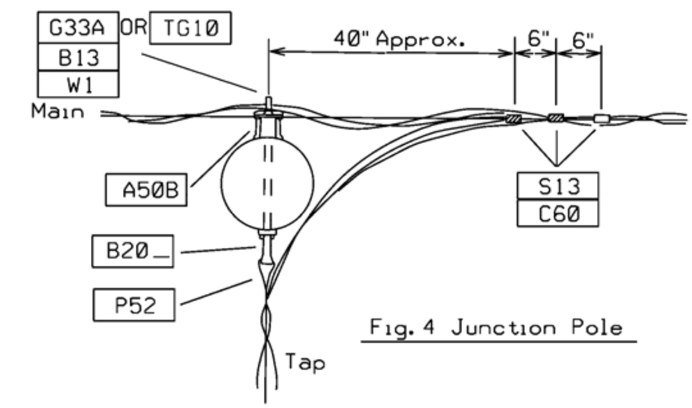


Fig. 4 Junction Pole

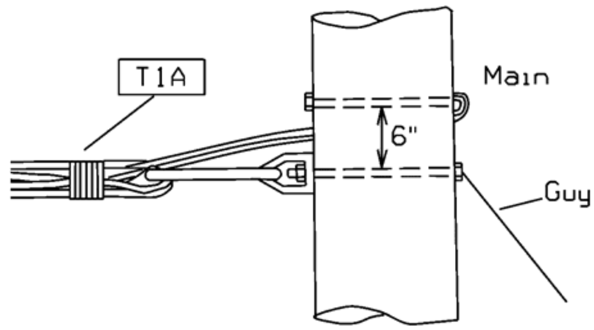


Fig. 4 - Side View

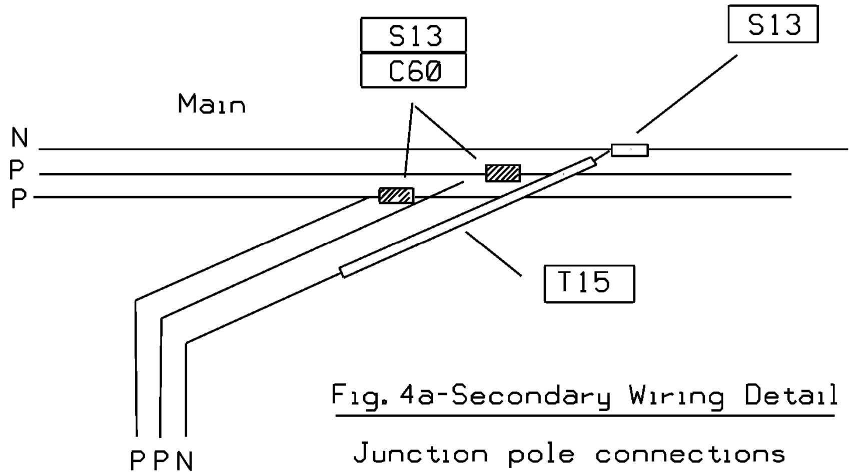


Fig. 4a-Secondary Wiring Detail

Junction pole connections

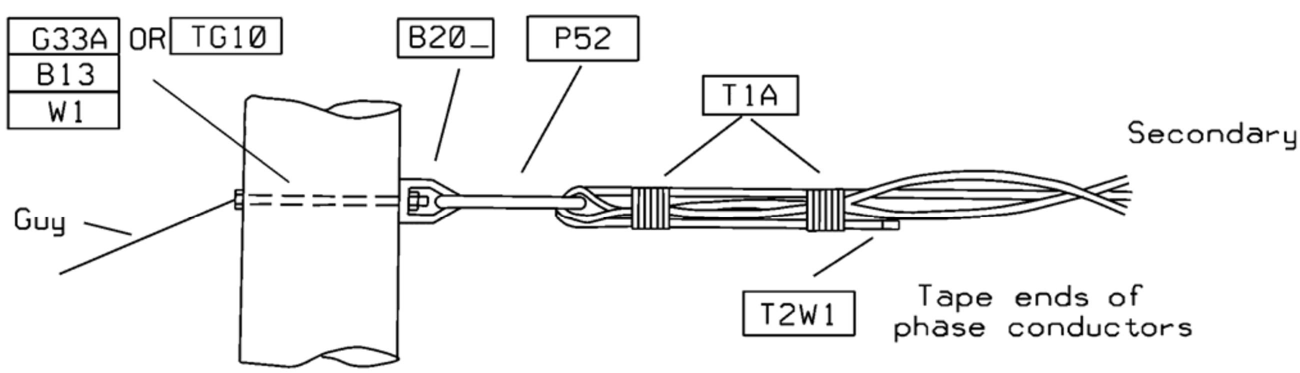


Fig. 5 - Dead End Pole

Supersedes 7/09 Issue – Updated Std Item #s, added side view of Figure 4 to show bolt separation.

CU = CNCUT	Sec. Crib Cut/Splice	PR1STS	Sec. Clamp 0° - 60°
CU = PR3SS	3-Spool Sec. Rack	PR1STRAP	Sec. Tap Triplex Bolteye
CU = CCTPS	Reconnect Sec. Taps		

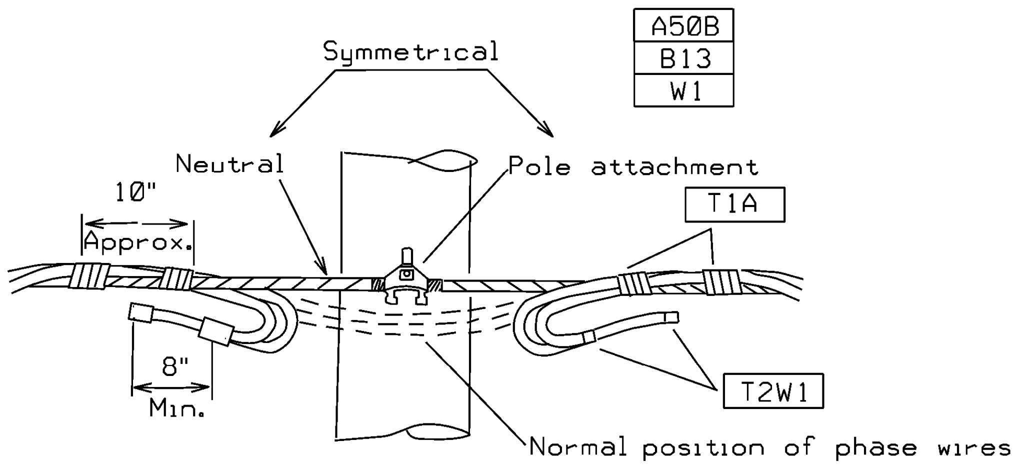


Figure 6 - Tie Point
Proceed as follows:

a) Tape triplex cable in place at two points each side of pole before cutting phase cable.
b) Cut phase cables at each side of pole. Cuts to be made not less than 8" apart.
c) Tape ends and bend back approximately to position shown.

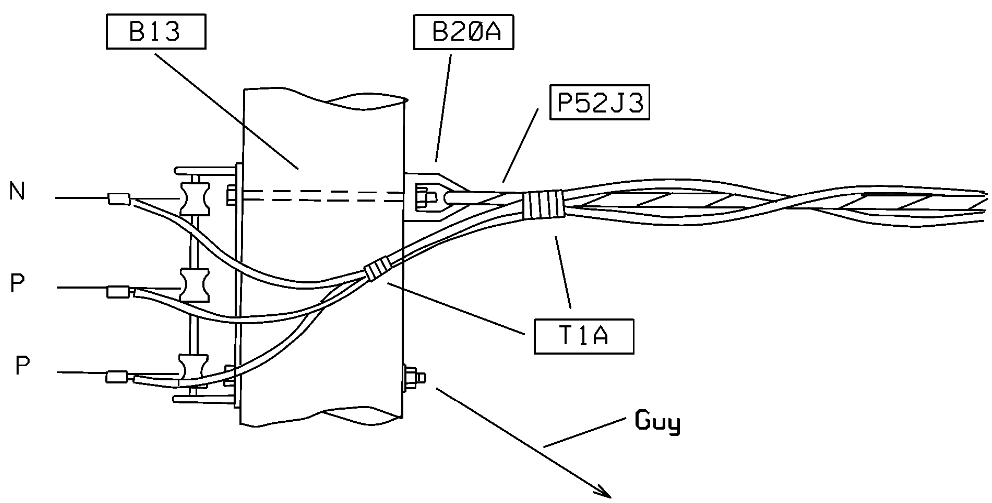


Fig. 7-Connection to Open Wire
Vertical rack illustrated

Supersedes 1/06 Issue – General revision, added CUs.

 Doc. # ST. 10.00.003

CU = CSTQS	Sec. Multiplex Spacer

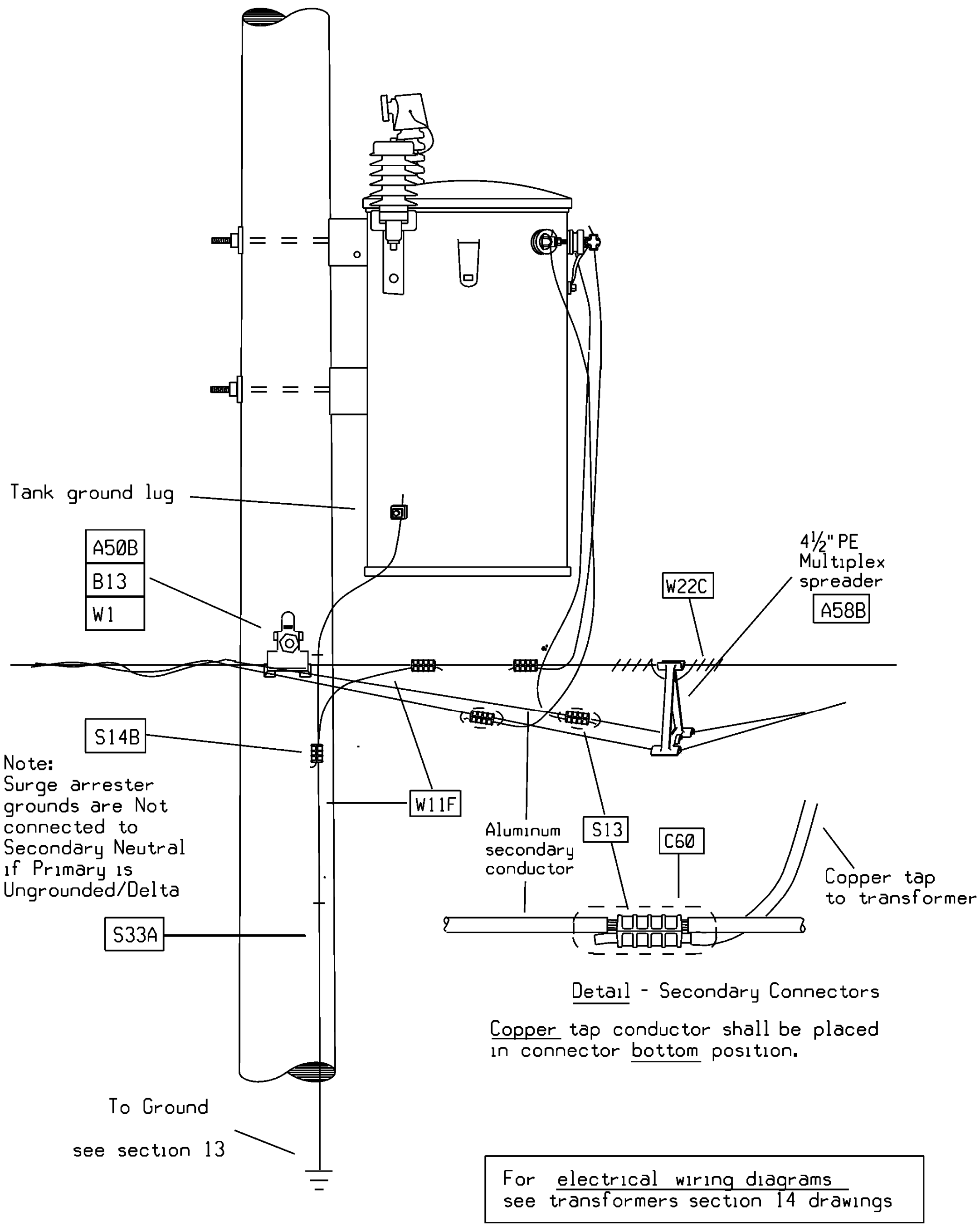


Figure 8 – Transformer Pole Connection

Supersedes 1/06 Issue – General revision, added CUs.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
3	7/12	• Added paragraph 10.0.70 – Secondary Cable Dimensions	Frederick Kippen	Susan Fleck, VP of Standards, Policies, & Codes
2	7/10	• Updated Std Item #s on Drawings 10-100 and 10-101. • Added side view of Figure 4 on Drawing 10-101 to show elevation difference between two bolts. • Added Section 10.6	Katie Croteau Frederick Kippen	Allen Chieco, Director of Distribution Standards and Work Methods
1	07/09	• General revision of entire section. • Added CUs to drawings/figures.	Frederick Kippen	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/06 Issue – New sentence added to Section 11.1.10. Changed 336.4 TRIPLEX to QUADRUPLEX and Item ID corrected.

11.0 GENERAL

These standards cover overhead services of less than 600 V and only that portion of each service that is to be installed by Liberty Utilities. See Section 10, Secondaries, for sizing conductors and transformers. Normally, overhead secondary services shall be offered in the following voltages:

120/240 V Single Phase - 3 wire (for load not exceeding 100 kVA)
208Y/120 Three Phase - 4 wire (for non-residential only)
480Y/277 Three Phase - 4 wire (available by special arrangement and approval only)
240 V and 480 V delta services are not available for new installations

The Service Drop or Lateral is the overhead conductor between the last pole or other aerial support on the primary line and the first point of attachment to a building. The Service Entrance is the conductor between the service drop/lateral and the service entrance switch.

The Company will attach the service drop/lateral to the Customer's structure at the service bracket (supplied by and installed by the customer). See the **"Specifications for Electrical Installations"** ESB No. 750 in New Hampshire.

CAUTION: 18 inches of clearance should be maintained between any gas regulator vent and the socket of an electric meter.

11.1 CONDUCTORS

11.1.10 Selection of Conductors

Aluminum multiplex conductors shall be installed for all new and replacement overhead services unless otherwise noted. For new construction, conductor size selected from Table 1 below will be determined by the Customer service entrance rating. Use triplex conductors for single-phase services and quadruplex for 3-phase, 4-wire services. Aluminum service cable #2 and 1/0 triplex and 1/0 and 336.4 kcmil quadruplex shall be used in accordance with information below and the standards that follow in this section. In general, #2 triplex cable shall be used for dwellings up to and including three family where the service load could be supplied by a 15 kVA transformer. This will include all but a very few large "all electric" homes. 1/0 Triplex service cable shall be used for large residential services where #2 cable is inadequate. Cable loads should be within limits shown on Table 2 on Page 11-2. If the length of service is such that the voltage drop may exceed 1%, a larger conductor should be used.
When a customer upgraded a service, the existing service cable can stay in service unless voltage drop or flicker will affect the customer.

TABLE 1

SERVICE ENTRANCE		RECOMMENDED CONDUCTOR		
TYPE	**MAX. AMPACITY**	**SIZE AND TYPE**	**STD. ITEM**	**ITEM ID**
SINGLE PHASE	100 A. **1**	#2 TRIPLEX	W15B	4003306
	150 or 2 100 A.	#2 TRIPLEX	W15B	4003306
	200 A. **4**	1/0 TRIPLEX	W15C	4003310
	400 A.	336.4 QUADRUPLEX **2**	W16E	4004436
THREE PHASE	150 A.	1/0 QUADRUPLEX	W16C	4004410
	400 A.	336.4 QUADRUPLEX	W16E	4004436
	800 A. **3**	(2) 336.4 QUADRUPLEX **2**	W16E	4004436
	800 A.	(8) #4/0 CU. **2**	W33C	4020111

Notes:

1. New single-phase service entrances shall have a capacity of not less than 100 A for a single meter or not less than 150 A for more than one meter.

2. #4/0 CU (W33C) may be substituted for 336.4 kcmil multiplex for short runs directly from transformer to service entrance.
3. See Page 11-141 for 400 A and 800 A services.
4. If loads are likely to exceed 25 kW, use 336.4 kcmil quadruplex.
5. Quadruplex cable shall be used for 240 V and 480 V delta services.

TABLE 2

SIZE AND TYPE CONDUCTOR		CAPACITY IN AMPERES		
LIVE LEG	MESSENGER	SINGLE CONDUCTOR	TRIPLEX	QUADRUPLEX
#4 Solid AAC*	#4 - 7 Strand AAAC	150	130	115
#2 – 7 Strand AAC	#2 – 7 Strand AAAC or ACSR	200	175	150
1/0 – 7 Strand AAC	1/0 – Strand AAAC or ACSR	270	245	210
4/0 – 7 Strand AAC*	4/0 – 7 Strand AAAC	415	380	-
336.4 – 19 Strand AAC	4/0 – 7 Strand AAAC or ACSR	550	515	445
795 – 37 Strand AAC*	336.4 – 19 Strand AAC	935	900	825
350 – 37 Strand CU		705	-	-
500 – 37 Strand CU		890	-	-

*Nonstandard – Values are given for comparison and special installations
The above is based on 100^0F/37.7^0C ambient and 194^0F/90^0C continuous operation with 3 feet per second wind velocity – also standard cable with cross-linked polyethylene insulation. The values should be reduced 20% for polyethylene insulation.

11.1.20 **Sag**

Sag service wire to the values shown on Page 11-61. It is often necessary to make some variations in sags to balance loads on service wires. Good judgment shall be used when making such variations.

11.2 CONNECTIONS TO SECONDARIES

Taps from multiplex secondaries should be located approximately 3 feet from the pole as shown on Page 11-115 (to minimize pole congestion). Taps may also be made elsewhere in the span if there are right-of-way or clearance problems. Balance the service wire tension at each tap when practicable. If loading cannot be balanced, or if services are very long, they should be deadended at the pole.

See Section 5, Connectors, for service/secondary connectors and splices.

See Section 48 (Underground – Risers)) for connection to underground service laterals. Use compression type connectors for service connections whenever possible. Cover or tape connections on covered conductors.

11.3 CONNECTIONS AT BUILDINGS

See 11-121 for multiplex service attachments at the building.

11.4 CLEARANCE FROM GROUND, SWIMMING POOLS, AND STRUCTURES

Adequate clearances shall be maintained. See Section 7 and also the **"Specifications for Electrical Installations**" ESB No. 750 in New Hampshire. Where it is necessary, an intermediate pole or a riser on the building shall be installed. Reference should be made to the above handbooks for a division of cost for such supports, or for long service drops/laterals on private property. Adjacent buildings not on property being served shall not be used to support service wire.

Supersedes 1/06 Issue – Section 11.1.10, Note 5, Deleted the word "NOT".

Services should not be installed over swimming pools or surrounding areas extending 25 feet horizontally from the pool edge. If crossing cannot be avoided, see Section 7 for clearance.

11.5 SURGE ARRESTERS

Surge arresters shall not be installed on services. Where customers desire protection against induced lightning surges, they may install an arrester in the service entrance box on the load side of the meter.

11.6 GUYING

It is recommended that guys be installed on poles with heavy unbalanced services, particularly when all services are taken off from the same side of a line of poles.

11.7 GROUNDING AND BONDING

The messenger of multiplex cables shall be connected to the grounded secondary neutral at the pole. It shall also be connected to the Customer's neutral for 120/240 V, 120/208 V, or other grounded neutral service. The messenger shall be bonded to the metal mast or riser at the building.

One of the three insulated conductors of a 240 V delta service may be grounded at the pole and at the service entrance box.

11.8 TYPICAL 100 AMPERE OVERHEAD TEMPORARY SERVICE STRUCTURE WHERE SERVICE DROP DOES NOT CROSS OVER A HIGHWAY

11.8.10 Application

The following are details for a 100 A, 120/240 V, single phase overhead temporary service. Temporary service is considered a service that will generally be in use for less that one year. Use of this installation as a permanent service basis shall not be permitted. Additional clearances per latest National Electrical Safety Code (NESC) must be incorporated with this design should a communication company attach to this structure.

11.8.20 Division of Responsibility (See Page 11-151)

Location of temporary service shall be specified by the Company.
The CUSTOMER and CONTRACTOR shall:

A. Furnish, install, maintain, and remove:
   1. Wood structure, braces, and stakes as shown.
   2. Weatherproof meter socket and disconnect including waterproof entrance fittings.
   3. GFCI protected polarized receptacles.
   4. SE cable, staples and weatherhead
   5. Ground rods, ground conductor, ground molding, staples and ground rod connector.
   6. Obtain inspection and approval from local wire inspector.

The Company shall:

A. Furnish, install, maintain and remove:
   1. Overhead service drop from pole to temporary service structure.
   2. Overhead service drop connectors and attaching hardware.
   3. Secondary meter.

11.8.30 Notes

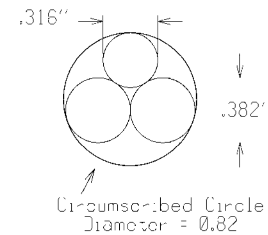
A. Where it is necessary to cross a roadway or highway with the overhead service drop conductors, distribution line construction as specified by the Company shall be used.
B. Service drop conductors shall meet all overhead clearance requirements of the latest issue of the NESC.
C. Service drop conductors shall be installed in accordance with sag/tension tables within these construction standards.
D. All post, brace, and stake wood members shall be "nominal", and those routinely available from lumber yard stock. Pressure treated lumber is recommended.
E. The customer, or the customer's contractor, shall meet all clearances and construction requirements set forth in the latest edition of the National Electrical Code (NEC) and as required by local authorities and the local Wire Inspector.

		INITIAL SAG (INCHES)			
	SPAN (FEET)	#2 AAC TRIPLEX (W15B)	1/0 AAC TRIPLEX (W15C)	1/0 AAC QUADRUPLEX (W16C)	336.4 AAC QUADRUPLEX (W16E)
TEMP. OF 32^{0}F	50	3	8	9	14
	60	6	12	14	20
	70	10	18	19	27
	80	15	24	26	34
	90	21	31	34	43
	100	27	39	42	53
	110	34	47	52	64
	120	43	57	62	76
TEMP. OF 60^{0}F	50	5	10	11	16
	60	8	15	16	22
	70	13	20	22	28
	80	18	26	28	36
	90	24	33	36	45
	100	30	41	44	55
	110	37	50	54	66
	120	45	59	64	78
TEMP. OF 90^{0}F	50	7	12	13	17
	60	11	17	18	23
	70	16	22	24	30
	80	21	28	30	38
	90	27	35	38	47
	100	33	43	46	57
	110	40	52	60	68
	120	49	62	66	80

		FINAL SAG (INCHES) @MAXIMUM DESIGN TENSION			
	SPAN (FEET)	#2 AAC TRIPLEX (W15B) 650 LBS	1/0 AAC TRIPLEX (W15C) 650 LBS	1/0 AAC QUADRUPLEX (W16C) 680 LBS	336.4 AAC QUADRUPLEX (W16E) 1,000 LBS
TEMP. OF 90^{0}F	50	10	14	14	18
	60	14	19	19	24
	70	19	24	25	31
	80	24	30	32	39
	90	30	37	40	48
	100	36	45	48	58
	110	43	54	58	69
	120	52	64	68	81

#2 AWG Triplex Service Cable – "SHRIMP/XLP" (W15B)

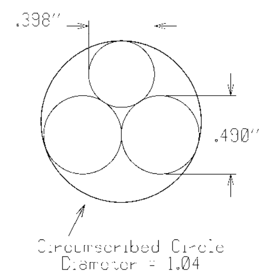
One - #2 AWG, 6201-T81, 7 strand AAAC Messenger Diameter = .316 inches
Two - #2 AWG, 1350-H19, 7 strand AAC Phase Conductor Diameter with 45 mils of XLP = .382 inches



LOADING	
DEADEND	650 LBS
TRANSVERSE	.590 LBS./FT.
VERTICAL	1.04 LBS./FT.
TOTAL	1.496 LBS./FT.
SWING ANGLE	57.0^0

1/0 AWG Triplex Service Cable – "GAMMARUS/XLP" (W15C)

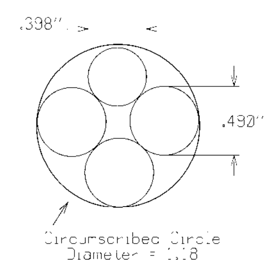
One - 1/0 AWG, 6201-T81, 7 strand AAAC Messenger Diameter = .398 inches
Two - 1/0 AWG, 1350-H19, 7 strand AAC Phase Conductor Diameter with 60 mils of XLP = .490 inches



LOADING	
DEADEND	650 LBS
TRANSVERSE	.666 LBS./FT.
VERTICAL	1.318 LBS./FT.
TOTAL	1.774 LBS./FT.
SWING ANGLE	51.0^0

1/0 AWG, Quadruplex Service Cable – "SHETLAND/XLP" (W16C)

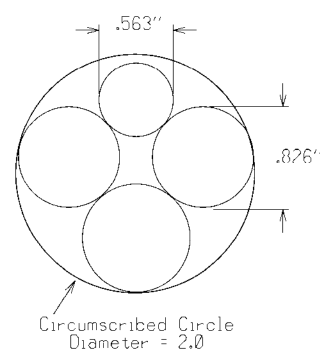
One - 1/0 AWG, 6201-T81, AAAC Messenger Diameter = .398 inches
Three - 1/0 AWG, 1350-H19, AAC Phase Conductor Diameter with 60 mils of XLP = .490 inches



LOADING	
DEADEND	680 LBS
TRANSVERSE	.707 LBS./FT.
VERTICAL	1.568 LBS./FT.
TOTAL	2.020 LBS./FT.
SWING ANGLE	45.0^0

336.4 KCMIL Quadruplex Service Cable – "EXMOOR/XLP" (W16E)

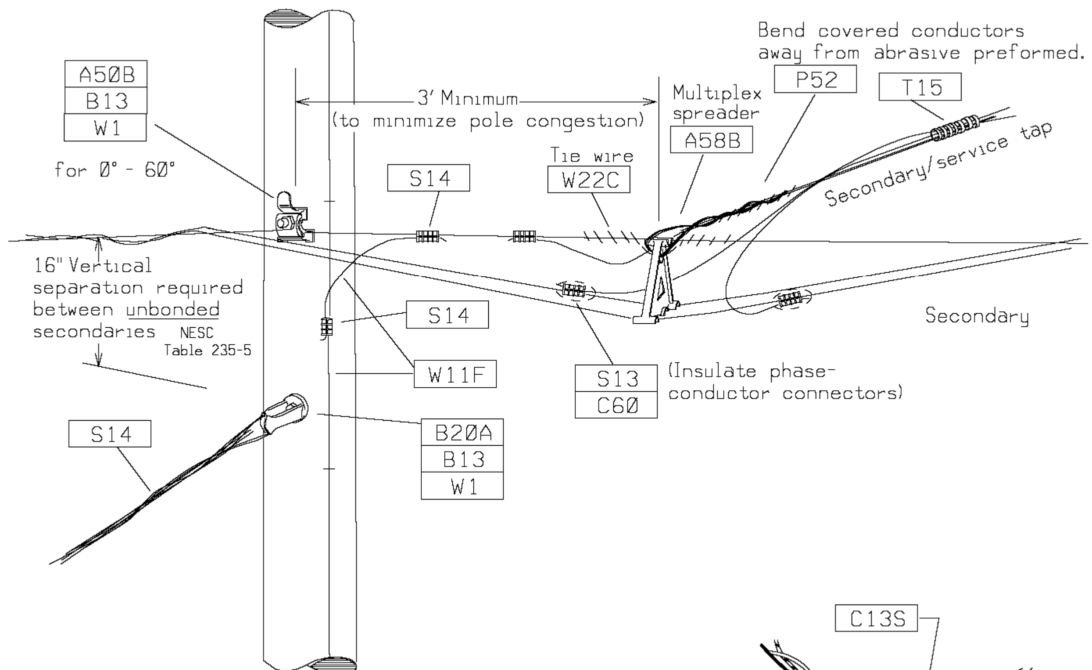
One - 4/0 AWG, 6201-T81, 7 strand AAAC Messenger Diameter = .563 inches
Three – 336.4 KCMIL, 1350-H19, 19 strand AAC Phase Conductor Diameter with 80 mils of XLP = .826 inches

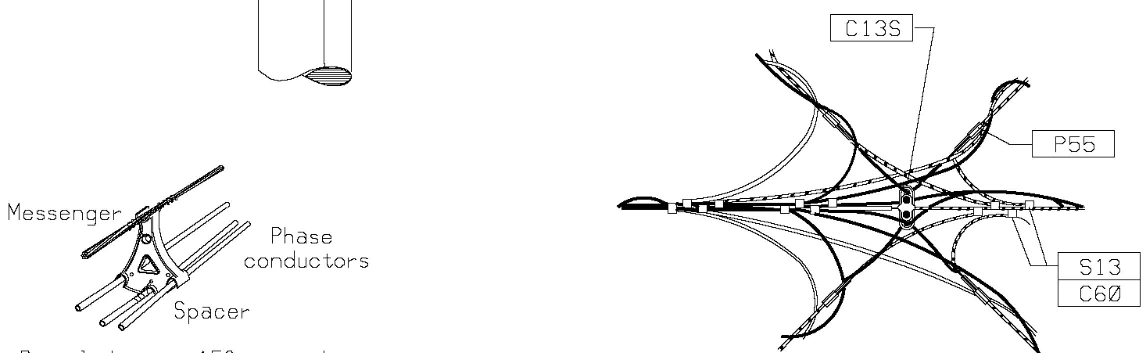


LOADING	
DEADEND	1,000 LBS
TRANSVERSE	.973 LBS./FT.
VERTICAL	3.00 LBS./FT.
TOTAL	3.452 LBS./FT.
SWING ANGLE	32.5^0

Supersedes 01/06 Issue – Revised circumscribed circle dimensions.

Typical Multiplex Midspan Tap



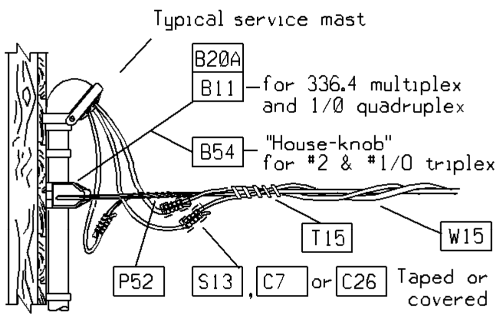


Detail showing A58 spreader on quadruplex cable

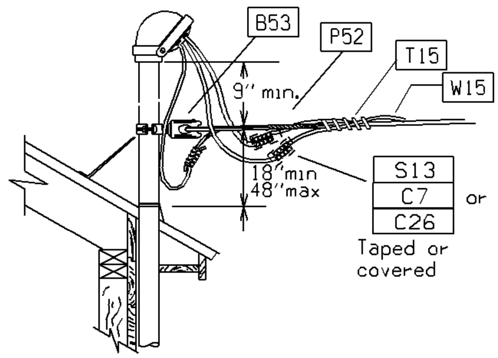
For a single or multiply midspan service tap from parallel-lay secondary or from a pole to pole guy.

Notes:

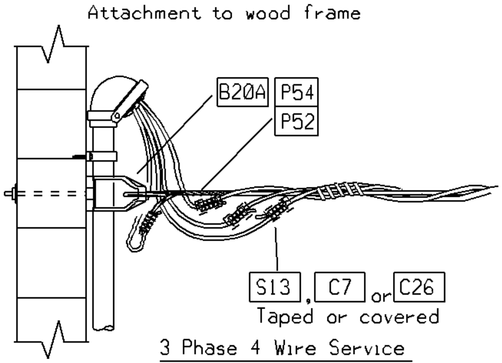
- Multiplex spreader is held into place by tie-wire, attached through top spacer hole and wired to the messenger.
- See Page 11-1 for conductor size selection.
- See Section 5 for connector details.
- Insulate all covered conductor connections.
- Always position copper conductors below aluminum in connectors.
- Refer to Page 11.2 for notes on location and balancing of taps.
- See guying statement on Page 11-3.
- To avoid excessive secondary cable offset due to an unbalanced midspan service, install a pole to pole guy, attach the midspan clamp (C13S) to the guy and bond the secondary neutral to the pole to pole guy.



1 Phase 3 Wire Service
Attachment to wood frame



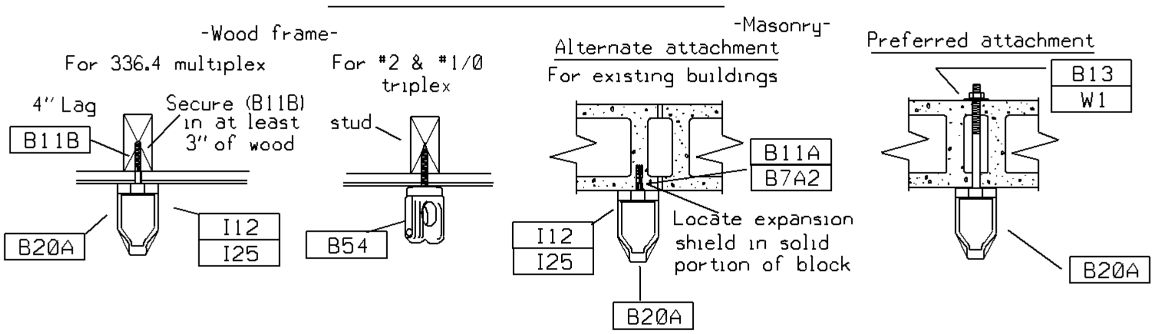
1 Phase 3 Wire Service
Attachment to service mast

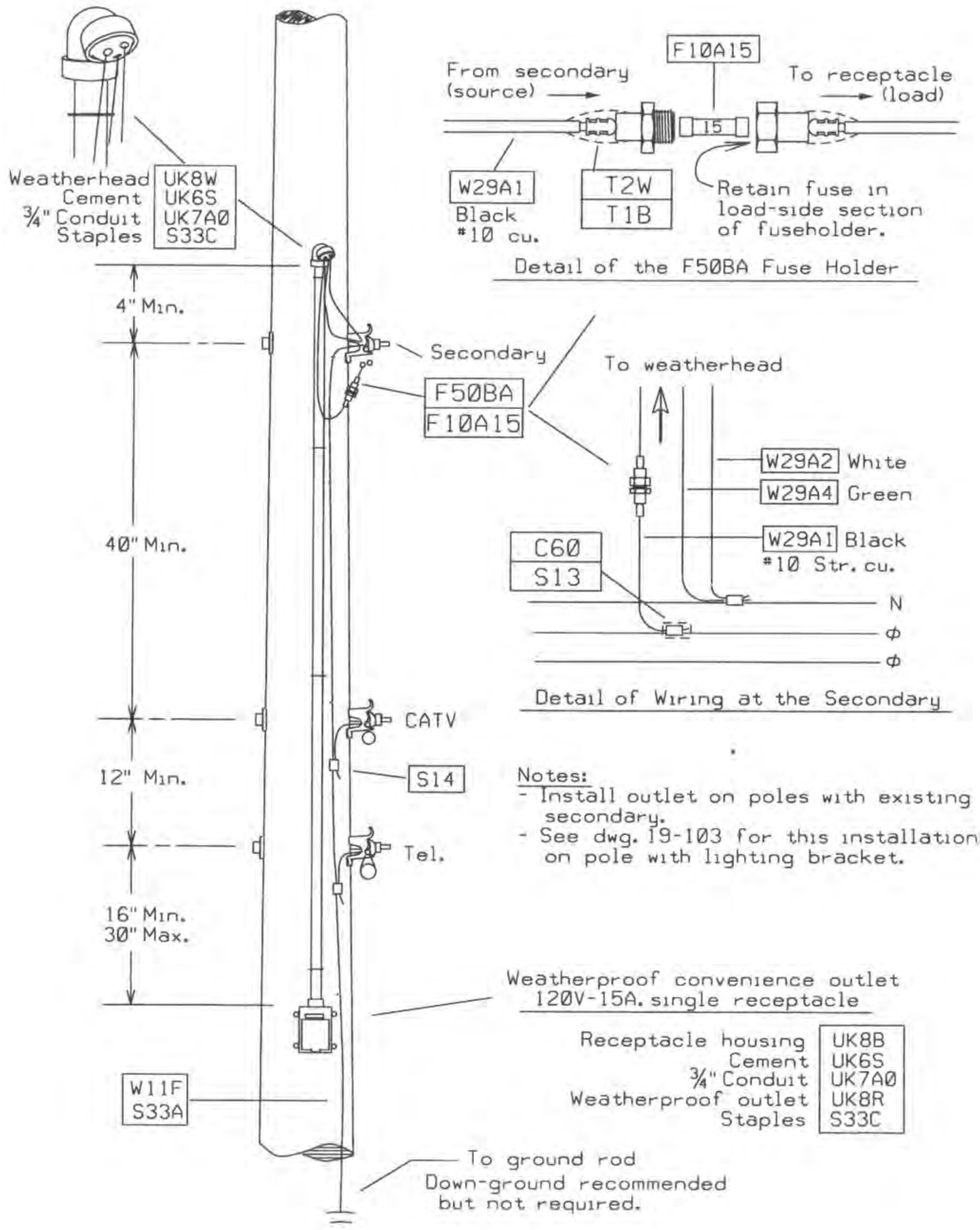


3 Phase 4 Wire Service
attachment to masonry bldg.

The structure or riser shall be capable of withstanding the following tensions:		
Service ampere rating	Service cable Size	Max. tension
150	#2 Triplex	650 lbs.
200(1Φ)	#1/0 Triplex	650 lbs.
200(3Φ)	#1/0 Quadruplex	680 lbs.
400	#336.4 Triplex	1000 lbs.
800	or quadruplex	2000 lbs.

Service Bracket Attachment Details



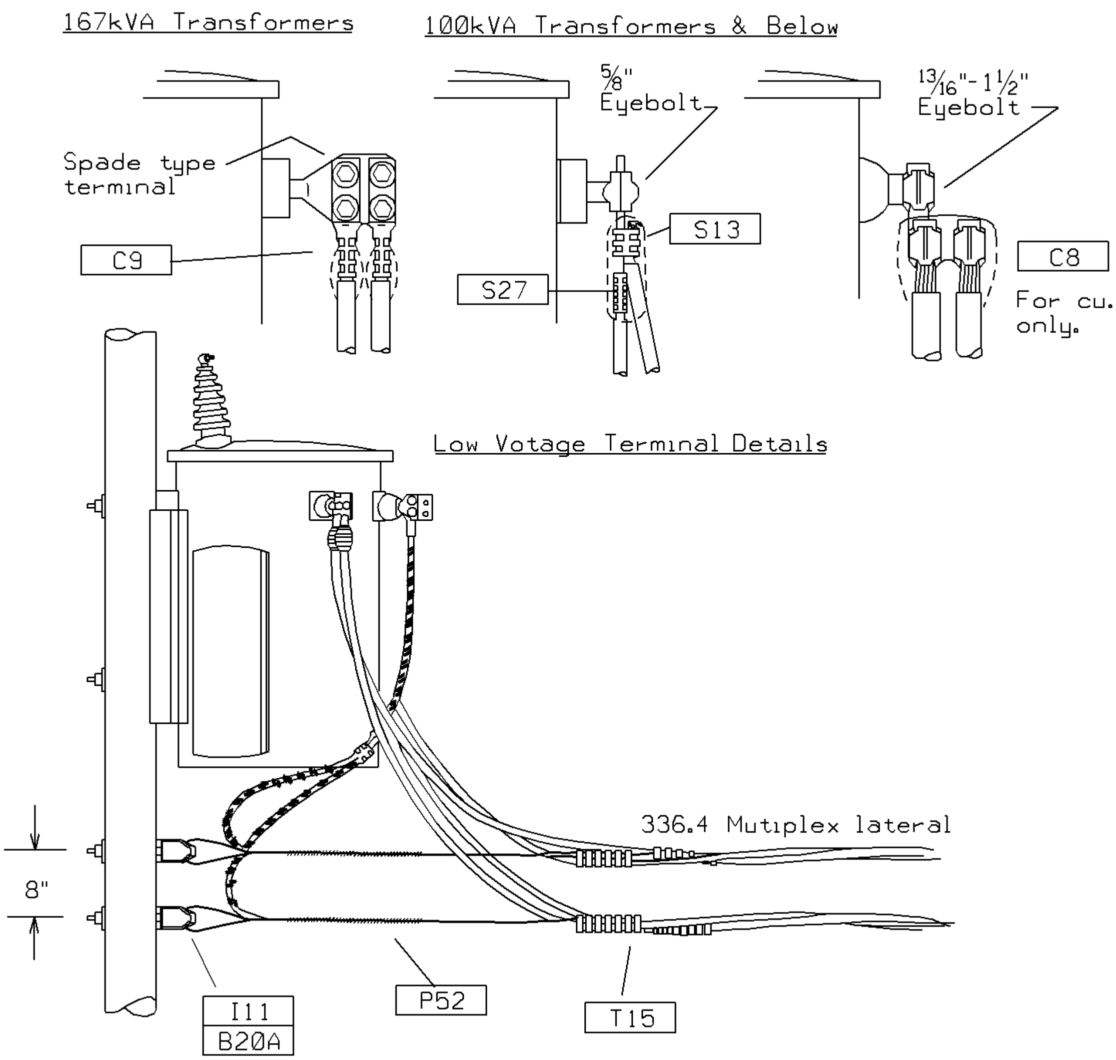


Notes:
- Install outlet on poles with existing secondary.
- See dwg. 19-103 for this installation on pole with lighting bracket.

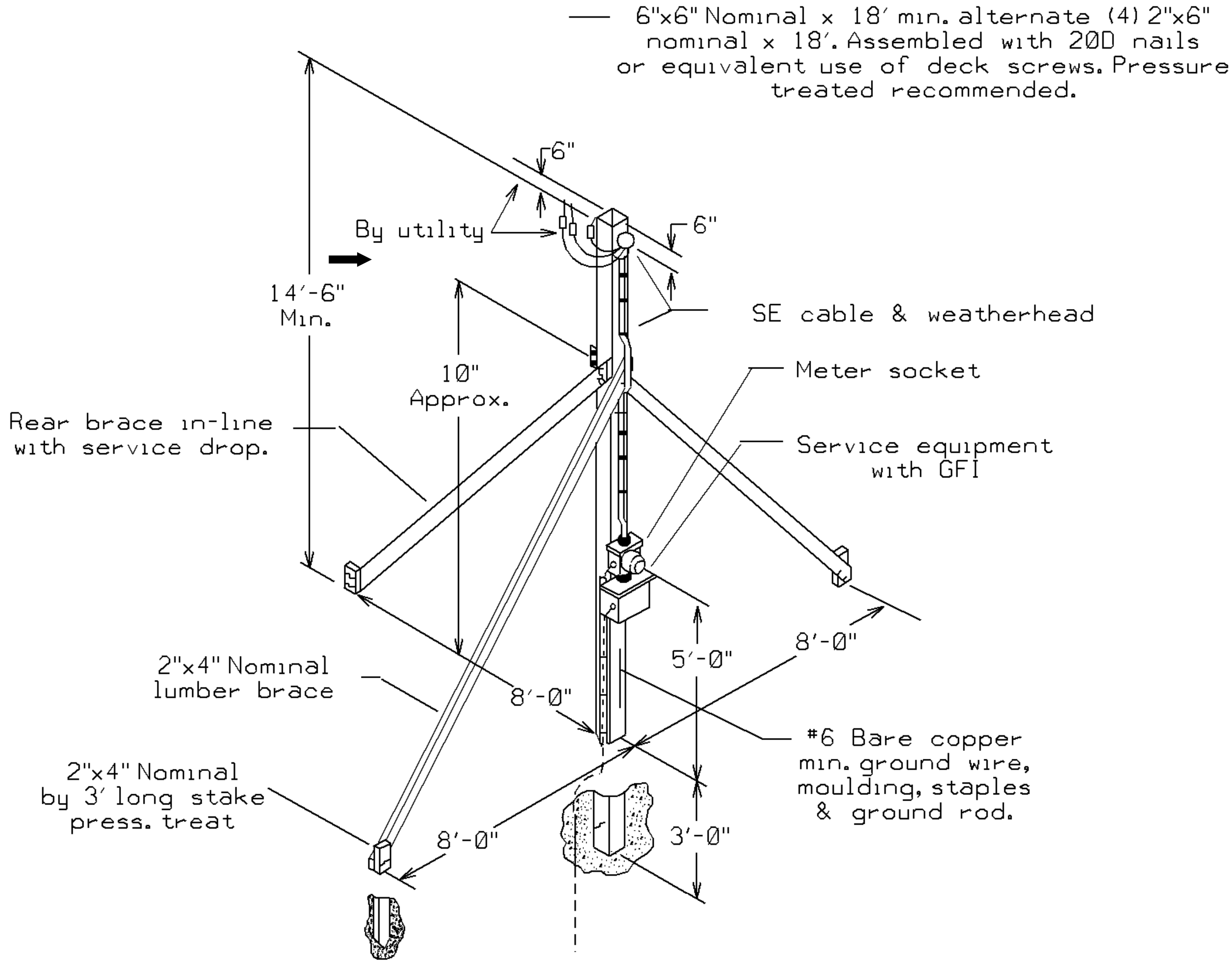
INSTALLATION OF CONVENIENCE OUTLET ON DISTRIBUTION POLE WITH SECONDARY

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		11-122	1/06

 Doc. # ST. 11.00.001



400 A AND 800 A MULTIPLES SERVICE POLE AND TRANSFORMER CONNECTION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
1/07	11-141		



TYPICAL 100 A OVERHEAD TEMPORARY SERVICE STRUCTURE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		11-151	1/07

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2	7/12	• Revised circumscribed circle dimensions on page 11-62.	Fred Kippen	Susan Fleck, VP of Standards, Policies, & Codes

Supersedes 6/12 Issue – Added pages 12-332, 12-9, 12-10 and renumbered.

12.0 GENERAL

Short circuits, the uncontrolled flow of electricity from energized conductors or equipment to a neutral or ground, occur in power systems when insulation fails or is bypassed due to; system overvoltages caused by lightning, switching surges, insulation contamination, mechanical failures, conductive materials crossing conductors, or other natural causes. These are also referred to as "faults" and the current flow is referred to as "fault current". The number of short circuits and the magnitude of the current flow can be minimized with proper design, operation, and maintenance of overhead distribution systems.

12.1 FUSE RATING

Type K expulsion fuse links (F1K), per ANSI C37.42, are the standard fuse links for use in enclosed and open type fuse cutouts on the Company system. K link fuses provide improved coordination with station equipment and a greater range of coordination between fuses. Type T expulsion fuse links (F1T), per ANSI C37.42, are for use in enclosed and open type fuse cutouts on the CalPeco distribution system only. All of these tin element links will carry continuous current up to 1½ times their nominal rating; above 1½ times, or 150% the "Minimum Melt" threshold, melting of the fuse link will start to occur with eventual blowing of the fuse, or weakening of the fuse link causing unpredictable operation in the future. Fuse links rated up to and including 100K or 100T shall only be used in cutouts rated 100 A. Fuse links rated above 100K or 100T up to 200K or 200T shall only be used in cutouts rated 200 A.

12.1.10 Fuse Sizes For Transformers

In general, transformer installations are fused for short circuit rather than overload protection. Three-phase fusing is based on motor loads with incidental lighting, with no motor having a horsepower rating greater than 50% of the total transformer bank capacity in kVA. Special cases, such as exceptionally large motors, may require the next size primary fuse to withstand excessive current drawn during start up.

Recommended fuse sizes are shown on Page 12-9. In addition, CSP transformers shall be considered as conventional transformers and fused per Page 12-9 which may aid in increased sectionalization opportunities.

12.1.20 Fuse Sizes For Capacitors

In selecting fuse sizes for capacitors, links with adequate continuous overcurrent ratings were chosen to provide roughly, a minimum capacity of 135% of the group total and to carry excessive currents caused by overvoltage, harmonics, and inrush. Recommended fuse sizes for capacitors are given on Page 12-11.

12.1.30 Fuse Sizes For Line Coordination

Where two adjacent fuses operate in series, the "protected fuse" is on the supply side and the "protecting fuse" is on the load side. If a fault develops beyond the protecting fuse, it should clear before the protected fuse has reached 75% of its melting time. This condition can be realized only for most values of short circuit current. Large fuses with high coordinating values are used near the supply end of distribution feeders and must coordinate properly with station protective devices. Transformer fuses always are protecting fuses, Table 1 below shows coordination that can be expected between standard K link fuse sizes.

Table 1

Protecting	Protected Fuse Size					
Fuse Size	**15**	**25**	**40**	**65**	**100**	**140**
	Maximum Fault Current for Coordination					
10	430	840	1350	2200	3900	5800
15		500	1350	2200	3900	5800
20			1200	200	3900	5800
25			700	2200	3900	5800
30				1800	3900	5800
40				1300	3900	5800
50					3500	5800
65					2400	5800
80						4500
100						2000

Special fuses and fuseholders should generally be avoided. However, it may be necessary to specify them for certain applications. For example, at locations where fault current is in excess of 16,000 amperes asymmetrical, the use of standard item C47A will need to be used. If there are a number of applications, the power fuses and holders will be kept in Stores.

12.2 CONTINUOUS RATING

All devices have a continuous rating for current carrying capacity in the closed position. This rating is not to be interpreted as the disconnecting rating.

Devices used for line fuses, disconnects, and primary services shall be selected so that the anticipated load will not exceed the continuous current rating of the device. It is recommended in those areas exhibiting a past pattern of growth that the device be selected so that its initial loading will not exceed two-thirds of the continuous rating, thereby permitting a margin for growth.

12.3 DISCONNECTING RATING

The ability to disconnect load is dependent upon operating voltage, separation of contacts, power factor, atmospheric conditions, the exact instant of break point in respect to the 60 cycle wave, and other factors beyond the control of the operator.

There is no official recognition that cutouts, fused or solid blade, have the ability to disconnect load (ANSI C37.40). All cutouts and disconnects include loadbuster hooks for the use of the loadbuster tool. When the loadbuster tool is used, loads up to the continuous rating of the device, but not to exceed 600 A, may be interrupted.

Cutouts shall be selected so that they will not be required to open loads in excess of the values shown in Table 2 on Page 12-3, except cutouts for capacitor applications.

12.4 INTERRUPTING RATING

12.4.10 Cutout

The maximum fault current that a cutout can successfully perform circuit interruption is known as the interrupting rating of the cutout. It is expressed in root mean square (rms) asymmetric amperes.

Proper application of fused cutouts require selection of an interrupting rating greater than the available fault current at the given location. Interrupting ratings of cutouts are shown in Table 2 below.

The available fault current, which a fused device is required to interrupt, is dependent upon many factors including:

1. Impedance at the fault.
2. Available fault current at the substation bus.
3. Size, type, and configuration of conductor supplying the fault.
4. Distance from the substation bus.
5. Point on voltage wave at the instant of the fault,
6. Fault duration.

Short circuit analysis is used for determining available fault current values.

Table 2

CUTOUT & DISCONNECT SELECTION & RATING TABLE						
			RATINGS			
			CONTINUOUS CURRENT AMPS	INTERRUPTING RMS AMPS		DISCON. AMPS
PRIMARY CIRCUIT VOLTAGE	**STANDARD ITEM #**	**DESCRIPTION**		**SYM**	**ASSYM**	**EXPERIENCE BASED**
5kV CIRCUITS ONLY	C41B1	H.D. enclosed cutout – fused	50	4000	5000	15
	C41D1	EHD enclosed cutout – fused	100	8000	10000	20
	C41D2	Enclosed cutout w/ solid blade	200	------	------	20
	D1C	Enclosed disconnect switch	600	------	------	35
0-15kV CIRCUITS	C43S10	Open type cutout w/ 100A fuse tube	100	7500	10000	------
	C43S20	Open type cutout w/ 200A fuse tube	200	8600	12000	------
	C43S30	Open type cutout w/ 300A solid blade	300	------	12000M	------
	C47A	EHD open type cutout	200	12500*	20000	------
	D5D	Open disconnect switch	600	------	------	------
25&35kV CIRCUITS	C43S41	Open type cutout w/ 100A fuse tube	100	5100	8000	------

*** - Based on X/R ratio of 20** **M – Momentary Rating**

Supersedes 1/06 Issue – Table 2 C43S30 Description Change

12.4.20 <u>Partial Range Current Limiting Fuses (CLFs)</u>

In areas of high fault currents, an energy limiting device may be required to limit let-through short circuit current to a level that will minimize disruptive failures to transformers and other distribution equipment. High fault currents can exceed the interrupting capabilities of standard overhead protective devices (cutout fuse link or CSP internal fuse).

The add-on partial limiting CLFs (F7A), when properly matched and used in series with overhead protective devices (cutout fuse links or CSP internal fuses), will operate only at the higher fault currents ensuring a successful interruption (up to 50,000 A symmetrical).

CLFs will activate within the first 1/2 cycle during high current faults, and they will limit the overcurrent let-through to allow fuse links or internal fuses to operate concurrently.

The cutout fuse link will operate normally upon low current faults and current-limited faults. The size of the fuse link cannot be larger than the rating of the CLF, which requires proper coordination.

The CLF may become weakened by the lower magnitude faults that normally cause operation of standard fuse links. Replacing the current limiting device in conjunction with the transformer protective link may prevent a later outage that would be caused when a weakened CLF completes its internal meltdown under normal load.

CLFs shall be installed on 15, 25, and 35 kV circuits where the calculated symmetrical fault current warrants such installations.

12.4.30 Reclosers

Reclosers shall be selected so that the calculated symmetrical fault current will not exceed the nameplate interrupting rating of the recloser. Vacuum reclosers with increase fault current capabilities can be purchased for particular installations.

12.5 SELECTION GUIDE

Cutouts, CLFs, and disconnecting devices shall be selected as follows:

12.5.10 Line and Riser Cutouts

A. On all Feeders

Open-type cutouts (C43S) with loadbuster hooks shall be used as line and riser fuses where the calculated symmetrical fault current is less than 7500 A, and where it is anticipated to remain less than 7500 A for at least 5 years. For high fault current line installations, see Section 12.5.10.B.

B. In High Fault Current Areas (Above 7500 A)

Heavy-duty power-fuse cutouts (C47) shall be used on all circuits where the calculated symmetrical fault current is 7500 to 12,500 A, and where fusing above 40 A (e.g. line fuses) may be needed. On circuits where calculated symmetrical fault current exceeds 7500 A, but fusing requirements will not exceed 40 A (e.g. transformers), a standard open-type cutout (C43S) shall be used in series with a coordinated CLF (F7A).

At junction pole locations where sectionalizing is necessary, line fuses can be installed on the first pole in or at the junction pole depending upon existing clearances and construction involved.

12.5.20 Overhead Transformer Cutouts

A. Conventional Transformers

Cutouts for overhead transformers should be selected in accordance with Table 2 on Page 12-3. Transformer cutouts can be located at the tap pole for fuse coordination or bucket accessibility purposes provided they feed a single transformer.

B. Conventional Transformers in High Fault Current Areas (Above 7500 A)

New installations and conversions involving transformers thru 167 kVA on feeders where calculated symmetrical fault current exceeds 7500 A shall be equipped with a cutout (C43S) mounted in series with a coordinated CLF (F7A). Reclosers or special fuses may be required for very large banks.

C. CSP Transformers in High Fault Current Areas (Above 3500 A)
All existing installations or conversions involving CSP transformers on 15 kV feeders where calculated symmetrical fault current exceeds 3500 A shall be equipped with CLFs.

Supersedes 1/06 Issue – Removed Voltage Designations Under 12.5.10, 12.5.20. Added Cutouts At Tap Pole For Single Transformers 12.5.20A

Supersedes 7/07 Issue – added new wordage to 12-5.50

12.5.30 Overhead Capacitor Cutouts

A. Capacitors

Cutouts for overhead capacitors should be selected in accordance with Table 2 on Page 12-3.

B. 100 kVAR Units and Above in High Fault Current Areas (Above 5000 A)

New installations on feeders where calculated symmetrical fault current exceeds 5000 A shall be equipped with a cutout (C43S) mounted in series with a coordinated CLF (F7A).

C. 50 kVAR Units and Below in High Fault Current Areas (Above 4000 A)

New installations on feeders where calculated symmetrical fault current exceeds 4000 A shall be equipped with a cutout (C43S) mounted in series with a coordinated CLF (F7A).

12.5.40 Line Switches - Single Blade

Open-type cutouts with a solid blade (C43S) are recommended for 5 kV circuits. Open-type cutouts or disconnect switches (C43S or D5D) depending upon load characteristics with loadbuster hooks shall be used on 15 kV circuits or 5 kV circuits that will be converted in the near future. In-line disconnect switches as shown on Page 12-138, are recommended where clearances will not allow switch installation on crossarms.

In order to provide superior customer service, avoid the single-phasing of loads, and minimize the possibility of ferroresonance when energizing unloaded transformer banks, individually operated, single phase line switches should not be used on three phase lines.

12.5.50 Loadbreak Switches - Group Operated

In order to provide superior customer service, eliminate the effects of ferroresonance, improve upon interruption duration indexes and simplify operating requirements on critical feeder sections, the use of group operated loadbreak switch devices is recommended on three phase lines.

Generally, the appropriate use of three phase reclosers at major feeder bifurcation points and beyond critical loads should adequately segment the feeder load into reasonable load groups, 2.5MVA or less. Group operated loadbreak switch devices should be used in the following circumstances:

A. Normally open tie points between feeders fed from two sources.
B. Long three phase underground and/or delta circuits.
C. Critical load (e.g. hospitals, prisons, shopping centers, ect.) that can be fed from two alternative sources with normally open ties.
D. Key tie points that are frequently utilized (two or more times a year).
E. First switch away from substation riser pole.
F. On the delta side of a floating wye-delta step-down bank that is a dedicated supply to an aerial cable or underground cable. This will eliminate the possibility for ferroresonent conditions developing.

Operating mechanism shall be locked in the open or closed position.

12.5.60 Regulator By-pass Switch

A non-loadbreak, sequenced, make-before-break switch, designed to by-pass and safely disconnect a regulator from the line once the regulator is in the neutral position. See Section 15 for construction details.

12.5.70 Line Breakers

A. Reclosers

Line reclosers enhance safety, improve customer reliability, and offer load side fault protection. Their general function is to sense and interrupt fault current, re-energize the line if the fault is of a temporary nature, and sectionalize non self-clearing faulted sections of distribution circuits. They may also be installed in loop sectionalizing applications or be supervisory controlled to improve distribution system reliability.

The SEL-651R control is specified for use with the G&W Viper-S recloser head. There is one SEL-651R control that can be applied to: radial installations; sectionalizing and tie reclosers in loop scheme configurations; and automatic source transfer applications. Separate controls are no longer needed for different system applications. Recloser control cabinets shall include proper identification including documentation on the inside door and appropriate labeling on the outside door.

1. Radial Recloser Applications

Radial reclosers operate as overcurrent protective devices. Radial applications require a 120 V supply from the source side for control and closing functions. In addition, the control can also accommodate a 120 V supply from the load side for AC transfer capability. The load side supply shall be connected when practical or as required (e.g. back-feeds, reliability). The 120 V supplies shall be connected to the X1 leg to assure correct 3 phase power analog values.

General 15kV and 35kV class recloser packages are furnished by the manufacturer as pre-wired, site ready units. These recloser packages require Company supplied transformation to meet the recloser and control power requirements. If Company owned secondary exists on a structure where a radial recloser is to be installed, the existing secondary may be used to meet the power requirements. If a possibility of backfeed exists, control requires both source and load side single phase secondary supplies. Therefore, the secondary crib must be split at the recloser structure. Both source and load side secondary supplies can be fed from any phase; however, phasing must be noted and accounted for in the control settings. It is not necessary for these 120 V secondary supplies to be in phase due to the break-before-make nature of the AC transfer switch.

Voltage specific recloser packages are available for 12.47 kV, 13.2 kV and 13.8 kV applications. These packages are furnished by the manufacturer as pre-wired, site ready units and include two frame mounted potential transformers to meet the recloser and control power requirements. As such, voltage specific recloser packages do not require additional Company supplied transformation.

Figure 1 shows a typical application for radial recloser controls.

Supersedes 1/09 Issue – Removed 'Radial Recloser Control' Section, Added 'Radial Recloser Applications' Section for 800A G&W Reclosers

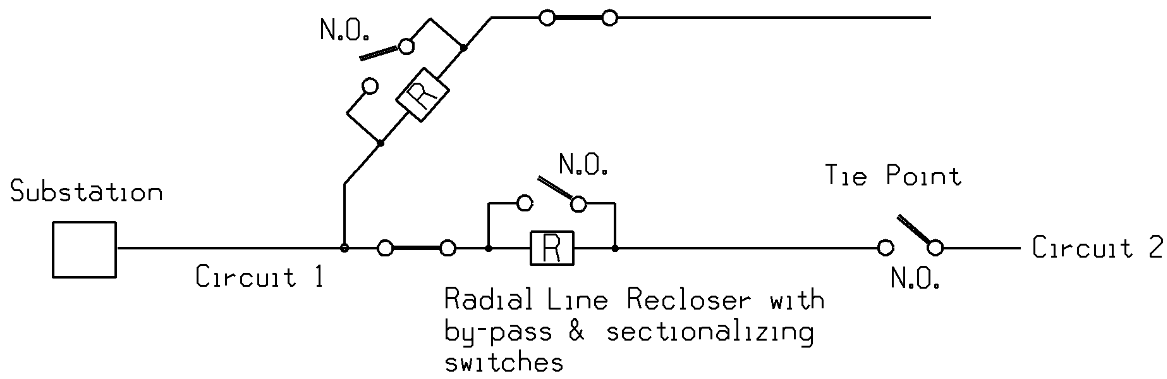


Figure 1 – Radial Application

2. Loop Scheme Recloser Applications

Loop scheme reclosers protect against overcurrent and automatically isolate the faulted section of a feeder, minimizing the outage duration for customers not directly affected. Reconfiguration is done based on loss of voltage detection, and it does not require any type of remote communications to function. These applications automatically isolate a faulted section of a feeder and restore power to the unaffected sections of the feeder, normally within one minute. Since most faults are transient in nature, loop sectionalizing applications must be programmed to only function when the substation breakers or line reclosers trip to lockout indicating a permanent fault has occurred.

The SEL-651R control requires a 3 phase 120 V supply for the control and closing functions on both sides of the tie recloser and on the source side of the sectionalizing recloser. In addition, the sectionalizing recloser requires 120 V supply on the load side.

General 15kV and 35kV class recloser packages are furnished by the manufacturer as pre-wired, site ready units. Loop scheme sectionalizing recloser applications require dedicated Company supplied three phase, source side transformation for both voltage sensing and control power. In addition, the sectionalizing recloser requires a single phase 120 V supply on the load side. This load side secondary supply can be fed from any phase; however, phasing must be noted and accounted for in the control settings. Loop scheme tie recloser applications require dedicated Company supplied three phase transformation on both the Source 1 ("line") and Source 2 ("load") sides of the recloser.

Voltage specific recloser packages are available for 12.47 kV, 13.2 kV and 13.8 kV applications. These packages are furnished by the manufacturer as pre-wired, site ready units and include two frame mounted potential transformers to meet the recloser and control power requirements, as well as three phase integrated voltage sensing on the Source 1 ("line"), horizontal bushings. As such, these voltage specific recloser packages do not require additional Company supplied transformation for loop scheme sectionalizing applications. However, a tie recloser application requires additional Company supplied three phase transformation on the Source 2 ("load") side to accommodate voltage sensing capability on both sides of the device.

Figure 2 shows a typical application for loop recloser controls.

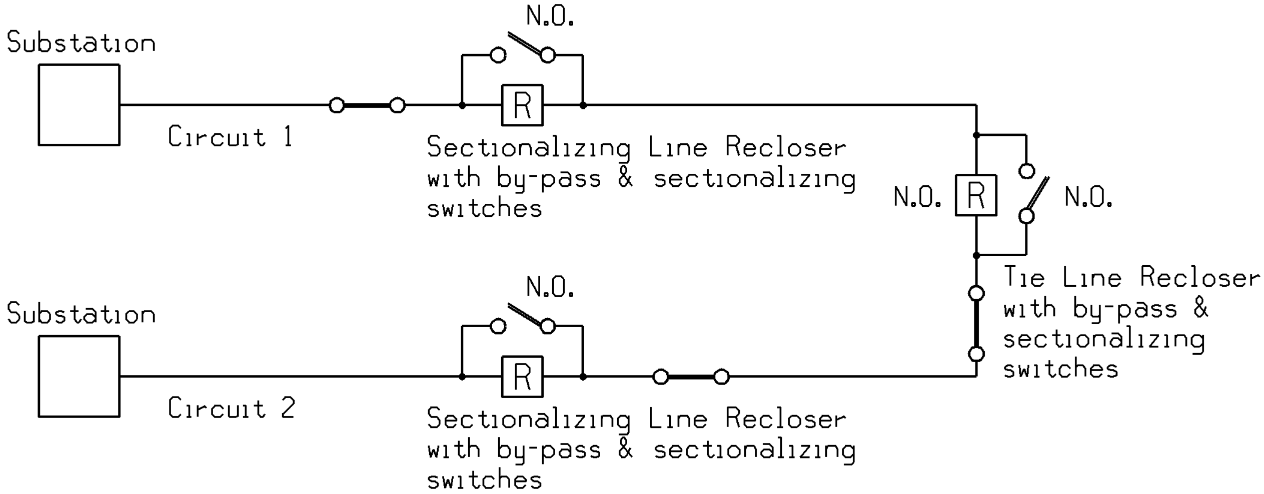


Figure 2 – Loop Application

Note: Alternate controls in-service may differ from current standard. Some include Cooper DC Nova, Cooper 3A, Cooper 4C, Cooper F5, Cooper F6, Joslyn Faultmaster, and Schweitzer 351R. The operation of all these alternatives achieves the same result.

3. Recloser Junction Box

The junction box is supplied pre-wired and includes Source 1 and Source 2 120 V input cables as well as a 19-position AC supply cable and 14-position control cable for bringing the signals to the control cabinet and recloser head. All power and control cables are provided and shall be connected as shown in the drawings. The junction box wiring diagrams indicate connections for radial, sectionalizing, and tie recloser applications, which require 120 V supply for control and closing. Radial applications that utilize single phase 120 V for control and closing, shall have 2-conductor Source 1 and Source 2 secondary supply cables where the black (120 V) and the white (neutral) wires shall be connected to the 120 V supply or supplies. General loop scheme applications shall have 4-conductor Source 1 and Source 2 secondary supply cables and may not require that all four conductors be connected on the Source 2 side (e.g., sectionalizing applications). Therefore, the red conductor should be connected and the unused black and orange conductors taped back at the supply cable breakout coming from the junction box.

4. Single Phase Reclosers

Provide overcurrent protection for single phase operation on a mainline feeder for single pole mount applications. The G&W Viper-SP solid dielectric recloser is designed for automatic or manual operation. For automatic operation the Viper-SP is compatible with the Schweitzer SEL-351 RS Kestrel control.

For a polemount cluster (3 single phase units) bracket application, 3 G&W Viper-ST solid dielectric reclosers are required to be used with Schweitzer SEL-651R control for electronic operation. Refer to Distribution Planning or Standards Engineering for installation and programing requirements.

Supersedes 6/10 Issue –Added 4. Note on Single Phase Reclosers.

B. Sectionalizers

Use of sectionalizers on the Company distribution system is not recommended.

C. Cutout-Mounted Recloser

The cutout mounted recloser is a self-powered, electronically controlled, single phase, vacuum fault interrupter mounted in a 100 amp fuse cutout.
The sole approved manufacturer requires the unit to be mounted in an MacLean Power Systems Type XS fuse cutout mounting (Poly type - factory shipped with the unit)

Application:

- 15kV circuits (Single phase or Three Phase fuse taps)
- Basic Insulation Level (BIL) of 110.
- The maximum continuous current carrying capability is 100 amperes.
- Symmetrical Interrupting rating is 6300 amperes.
- Must be installed on double crossarms for stability.
- Tag Holder to be installed on pole.

Operating Sequence:

- The unit is factory programmed to support up to 3 reclosing operations before it drops open.
- A wide variety of Time-Current Characteristic (TCC) curves are available.
- The opening interval between operations is 5 seconds. The interrupter resets 2 seconds after dropping open. The operator can then reclose the unit back into the mounting.
- The device must be opened manually with a Loadbuster tool.

- **Location, Application and Setup of this device must be done under direction of Electric Operations Engineering.**

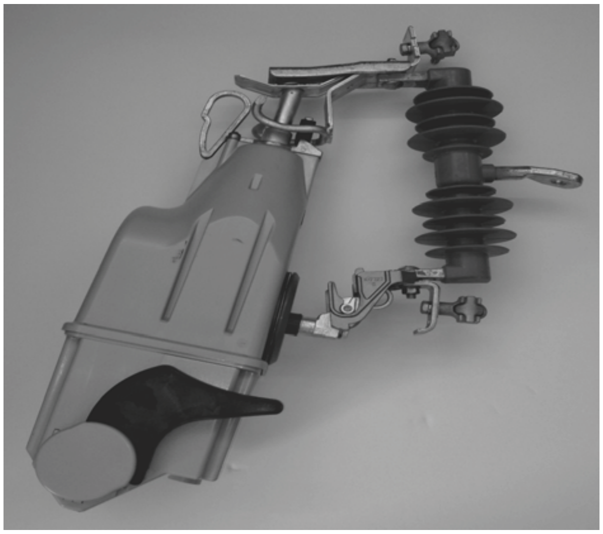
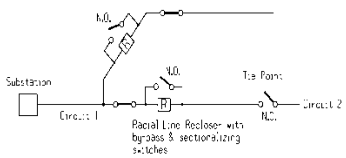
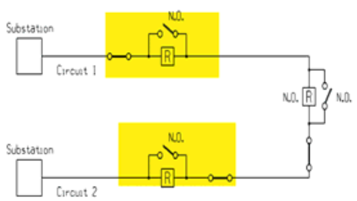


Figure 3 – Cutout Mounted Recloser

G&W Viper Recloser Application Table

Application	Type	Requirements	Std Item
Radial 	General Recloser Package	120V 1P supply from the **line** side for control and closing functions. Optional: **load** side 120V 1P supply for back-feeds and reliability.	R50AA R50FF R50FS
	Voltage Specific Package	12.47/13.2/13.8kV have 2 frame mtd PT's- requires no Company supplied transformation.	R50A1, R50A2, R50A3
Loop Scheme Sectionalizing 	General Recloser Package	Requires dedicated Company supplied 3 phase **line** side transformation for voltage sensing and control power. Requires Company supplied 120 volt 1P supply on the **load** side.	R50EE R50GG R50GS
	Voltage Specific Package	12.47/13.2/13.8kV have 2 frame mtd PT's and 3 phase Integrated Voltage sensing on the on the **Line** side. No Company supplied transformation required.	R50E1, R50E2, R50E3
Loop Scheme Tie	General Recloser Package	Requires dedicated Company supplied 3 phase **line** side and **load** side transformation for voltage sensing and control power.	R50EE R50GG R50GS
	Voltage Specific Package	12.47/13.2/13.8kV have 2 frame mtd PT's and 3 phase Integrated Voltage sensing on the on the **line** side. Company supplied 3P transformation on the **load** side is required. Requires an additional 15' - 4 conductor cable (R52D or R52C).	R50E1, R50E2, R50E3
Sub T Sectionalizer	35kV Recloser Package	35kV with 3 phase Integrated Voltage sensing on the on the line and load side. Requires Company supplied 120 volt 1P supply on the line and load side for the control.	R50HA

12.6 FAULT CIRCUIT INDICATORS (FCI's)

Automatic reset type Fault Circuit Indicators (FCI) are available and are used in an attempt to reduce operating call out time by helping to pinpoint circuit faults. If a fault occurs, a target on the indicator appears or changes color. There are various types of FCIs installed onto the Company's overhead distribution system, which operate as follows:

Automatic Reset - If there is a fault, the red indicating target gives the device a strikingly different appearance. When the line is re-energized with the fault removed, the red indicating target will reset instantaneously.

Time Delay Reset - If there is a fault, the red and yellow indicating targets give the device a strikingly different appearance. When the line is re-energized, with the fault removed, the red indicating target will reset while the yellow indicating target resets within a prescribed time delay. The time delay is identified on the unit and is not adjustable.

Manual Reset - If there is a fault, the red indicating target gives the device a strikingly different appearance. When the line is re-energized, with the fault removed, the red indicating target will remain until it is manually reset with the magnetic reset tool (F2T) by the line worker.

12.6.10 Application

FCI's should be used at selected locations such as:

A. Unfused 3 phase lines.
B. Unfused single phase lines.
C. Load side of 3 phase switches.
D. Load side of 3 phase sectionalizers.
E. Locations not easily accessible by line worker personnel (e.g. rights-of-way, campgrounds, etc.)

Note: When the time delay reset type FCIs are first installed, and there is more current then the minimum trip setting, the FCI needs to adjust and then will begin to flash. The red LEDs will turn off within 1 minute if there is no fault current, and the yellow LEDs will turn off in 4, 8 or 24 hours (depending on time reset).

12.7 INSTALLATION - CUTOUTS & DISCONNECTING DEVICES

Typical installations are shown on Pages 12-127 through 12-333. Cutouts should be turned toward the pole for easier opening. Disconnect switches should be installed so that normally the blade opens away from the circuit source. In addition, the location of all disconnecting devices shall be chosen to minimize the possibility of an arc flaring up, or being blown into other circuits.

All mainline switching devices shall be properly numbered and located per construction drawing requirements.

Conductors inserted into the terminals of cutouts and disconnects shall be copper or electrically equivalent aluminum. Hyseal plugs (S27H or S27J) are available for terminating aluminum conductors in cutouts.

CONVENTIONAL TRANSFORMER FUSING – SINGLE PHASE INSTALLATIONS															
PRIMARY CIRCUIT VOLTAGE	**EACH TRANSFORMER TANK KVA SIZE**														
	10	**15**	**25**	**37**	**50**	**75**	**100**	**150**	**167**	**200**	**250**	**333**	**500**	**667**	**833**
	ANSI TYPE_K FUSE LINK AMPERE RATING (F1K)														
2400 delta **2400/4160 Grd. Y**	10	15	25	40	40	65	65	100	100		140				
4160 Ungrd. Y	6	10	15	25	25	40	40	65	65		100	140			
4800 delta **4800/8320 Grd. Y**	6	10	15	25	25	40	40	65	65		100	140			
7200 delta **7200/12470 Grd. Y** **7620/13200 Grd. Y** **7970/13800 Grd. Y**	3	6	10	10	15	25	25	40	40		65	65	100	140	200
12000 delta **13200 Ungrd. Y** **13800 Ungrd. Y** **13200/22860 Grd. Y** **13800/23900 Grd. Y** **14400/24900 Grd. Y**	3	3	3	6	10	15	15	25	25		40	40	65	100	
23000 delta **19920/34500 Grd. Y**	3	3	3	6	6	10	10	15	15		25	25	40	65	65

CONVENTIONAL TRANSFORMER FUSING – THREE PHASE INSTALLATIONS															
PRIMARY CIRCUIT VOLTAGE	**EACH TRANSFORMER TANK KVA SIZE**														
	10	**15**	**25**	**37**	**50**	**75**	**100**	**150**	**167**	**200**	**250**	**333**	**500**	**667**	**833**
	ANSI TYPE_K FUSE LINK AMPERE RATING (F1K)														
2400 delta	15	25	40	65	65	100	100	140	140	200	200				
2400/4160 Grd. Y **4160 Ungrd. Y**	10	15	25	40	40	65	65	100	100	140	140	200			
4800 delta	10	15	25	40	40	65	65	100	100	100	140	140			
4800/8320 Grd. Y	6	10	15	25	25	40	40	65	65	65	100	140			
7200 delta **7200/12470 Grd. Y** **7620/13200 Grd. Y** **7970/13800 Grd. Y** **12000 delta** **13200 Ungrd. Y** **13800 Ungrd. Y**	3	6	10	10	15	25	25	40	40	40	65	65	100	140	200
13200/22860 Grd. Y **13800/23900 Grd. Y** **14400/24900 Grd. Y** **23000 delta**	3	3	3	6	10	15	15	25	25		40	40	65	100	
19920/34500 Grd. Y	3	3	3	6	6	10	10	15	15		25	25	40	65	65

1. For open delta or Scott connections, fuse individual transformers the same as for single phase.
2. All fuses in standard three phase (3Φ) banks (same kVA ratings) shall be of the same rating maintaining consistent operating characteristics. Three phase (3Φ) transformers (T-T winding) are fused the same as an equivalent transformer bank of three single-phase transformers.
3. For non-standard banks (unlike kVA ratings) ONLY, fuse as follows:
   a. For wye or open delta, fuse individual transformers the same as for single phase.
   b. For closed delta banks, the two fuses feeding the larger transformer shall be fused for the size and voltage rating of the larger transformer. The fuse common to the smaller transformers shall be fused for the size and voltage rating of the smaller transformer.

(shaded box) Non-standard Company application. If necessary, consult Standards Engineering

Supersedes 1/06 Issue - Page shift due to other changes in the section.

CONVENTIONAL TRANSFORMER FUSING – SINGLE PHASE INSTALLATIONS

PRIMARY CIRCUIT VOLTAGE	EACH TRANSFORMER TANK KVA SIZE														
	10	**15**	**25**	**37**	**50**	**75**	**100**	**150**	**167**	**200**	**250**	**333**	**500**	**667**	**833**
	ANSI TYPE_T FUSE LINK AMPERE RATING (F1T)														
2400 delta 2400/4160 Grd. Y	6	10	15	25	40	40	65	100	100						
7200 delta 7200/12470 Grd. Y 7620/13200 Grd. Y 7970/13800 Grd. Y	3	3	6	10	10	10	15	25	25		40	65	100		

CONVENTIONAL TRANSFORMER FUSING – THREE PHASE INSTALLATIONS

PRIMARY CIRCUIT VOLTAGE	EACH TRANSFORMER TANK KVA SIZE														
	10	**15**	**25**	**37**	**50**	**75**	**100**	**150**	**167**	**200**	**250**	**333**	**500**	**667**	**833**
	ANSI TYPE_T FUSE LINK AMPERE RATING (F1T)														
2400/4160 Grd. Y	6	10	15	25	40	40	65	100	100						
7200 delta 7200/12470 Grd. Y 7620/13200 Grd. Y 7970/13800 Grd. Y	3	3	6	10	10	10	15	25	25		40	65	100		

1. For open delta or Scott connections, fuse individual transformers the same as for single phase.
2. All fuses in standard three phase (3Φ) banks (same kVA ratings) shall be of the same rating maintaining consistent operating characteristics.
3. Three phase (3Φ) transformers (T-T winding) are fused the same as an equivalent transformer bank of three single-phase transformers.
4. For non-standard banks (unlike kVA ratings) ONLY, fuse as follows:
   c. For wye or open delta, fuse individual transformers the same as for single phase
   d. For closed delta banks, the two fuses feeding the larger transformer shall be fused for the size and voltage rating of the larger transformer. The fuse common to the smaller transformers shall be fused for the size and voltage rating of the smaller transformer.

(shaded) Non-standard Company application. If necessary, consult Standards Engineering

Supersedes 1/06 Issue - Page shift due to other changes in the section.

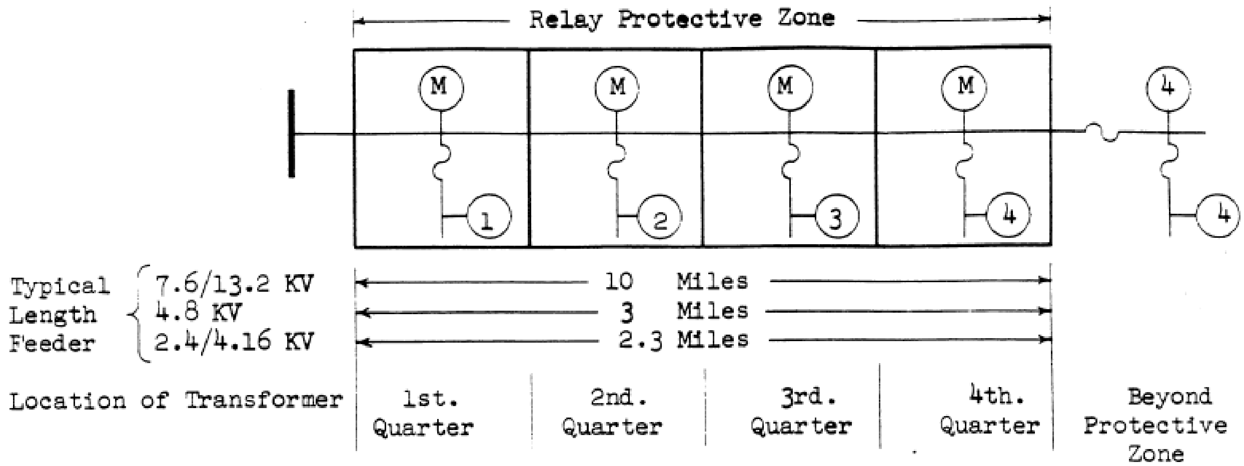
CAPACITOR FUSING – 3Φ AND 1Φ PHASE INSTALLATIONS									
PRIMARY CIRCUIT VOLTAGE	**CAP (KV)**	**KVAR PER 3Φ/1Φ**							
		150/50	**300/100**	**450/150**	**600/200**	**900/300**	**1200/400**	**1800/600**	**2700/900**
		CAPACITOR VOLTAGE (KV)							
		ANSI TYPE_K FUSE LINK AMPERE RATING (F1K)							
2400 delta	**2.4**	40	80						
2400/4160 Grd. Y **4160 Ungrd. Y**	**2.4** **4.16**	20	40	65					
4800 delta	**4.8**	20	40	50	65				
4800/8320 Grd. Y	**4.8**	10	25	40	40	65			
6900 Ungrd. Y **7200 delta** **7200/12470 Grd. Y** **7620/13200 Grd. Y** **7970/13800 Grd. Y**	**6.64** **7.2** **7.6** **7.9**	10	15	20	30	40	65		
13200 Ungrd. Y **13800 Ungrd. Y** **13200/22860 Grd. Y**	**13.2** **13.8**				15	25	40	50	65
13800/23900 Grd. Y **14400/24900 Grd. Y**	**14.4**				15	25	40	40	65
19920/34500 Grd. Y	**19.9**					15	25	40	50

1. This Table is applicable for three phase (3Φ) & single phase (1Φ) installations.
2. See C40 for standard capacitors & C36 for standard capacitor racks
3. Three phase (3Φ) capacitor units are fused the same as individual units utilizing the kVAR per three phase (3Φ) values above.

Non-standard Company application. If necessary, consult distribution engineering

Supersedes 1/06 Issue - New page - information shifted due to other changes in the section.

Supersedes 1/06 Issue - New page - information shifted due to other changes in the section.

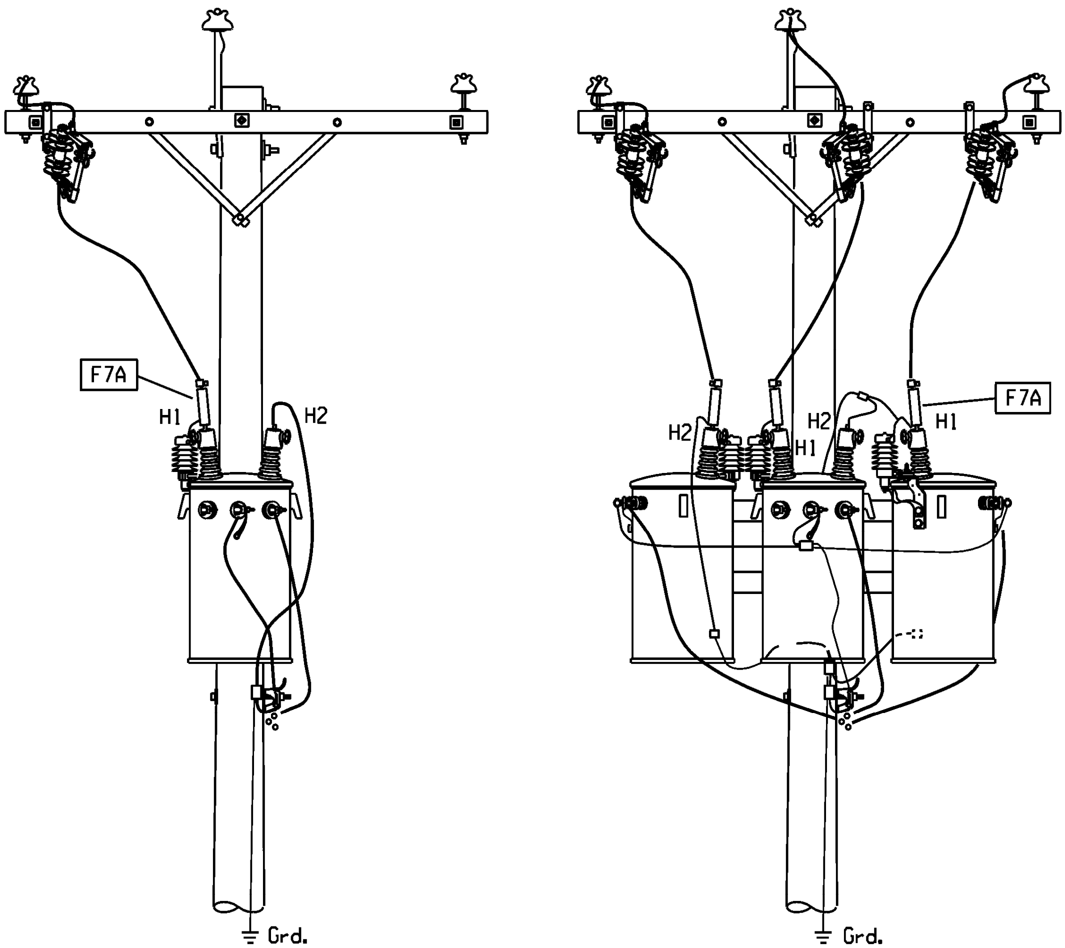


ANSI TYPE_K FUSE LINK AMPERE RATING (F1K)							
SIZE CSP TRANS.	**LOCATION**	**2.4/4.16 KV**		**4.8 KV**		**7.6/13.2 KV**	
		REC.	**MIN.**	**REC.**	**MIN.**	**REC.**	**MIN.**
5	1	100		100		100	
5	2	65		50		50	
5	3	50		40		40	
5	4	50	40	40	25	40	25
10	1	100		100		100	
10	2	65		50		50	
10	3	65		40		40	
10	4	65	40	40	25	40	25
15	1	100		100		100	
15	2	65		65		50	
15	3	65		50		40	
15	4	65	65	50	40	40	25
25	1	140		100		100	
25	2	100		65		65	
25	3	100		50		50	
25	4	100	100	50	40	40	40
37.5	1	200		140		100	
37.5	2	200		100		65	
37.5	3	200		100		65	
37.5	4	200	140	100	100	65	65
50	1-4	200	200	140	140	140	100
75	1-4	200	200	200	200	140	100
5-75	M	----------STATION BREAKER---------					

If CSP transformers are installed behind minimum size line fuses, there is a calculated risk that a fault in one of the transformers will cause the line fuse to blow.

CU = TFC5	25 A Current Limiting Fuse
CU = TFC7	40 A Current Limiting Fuse

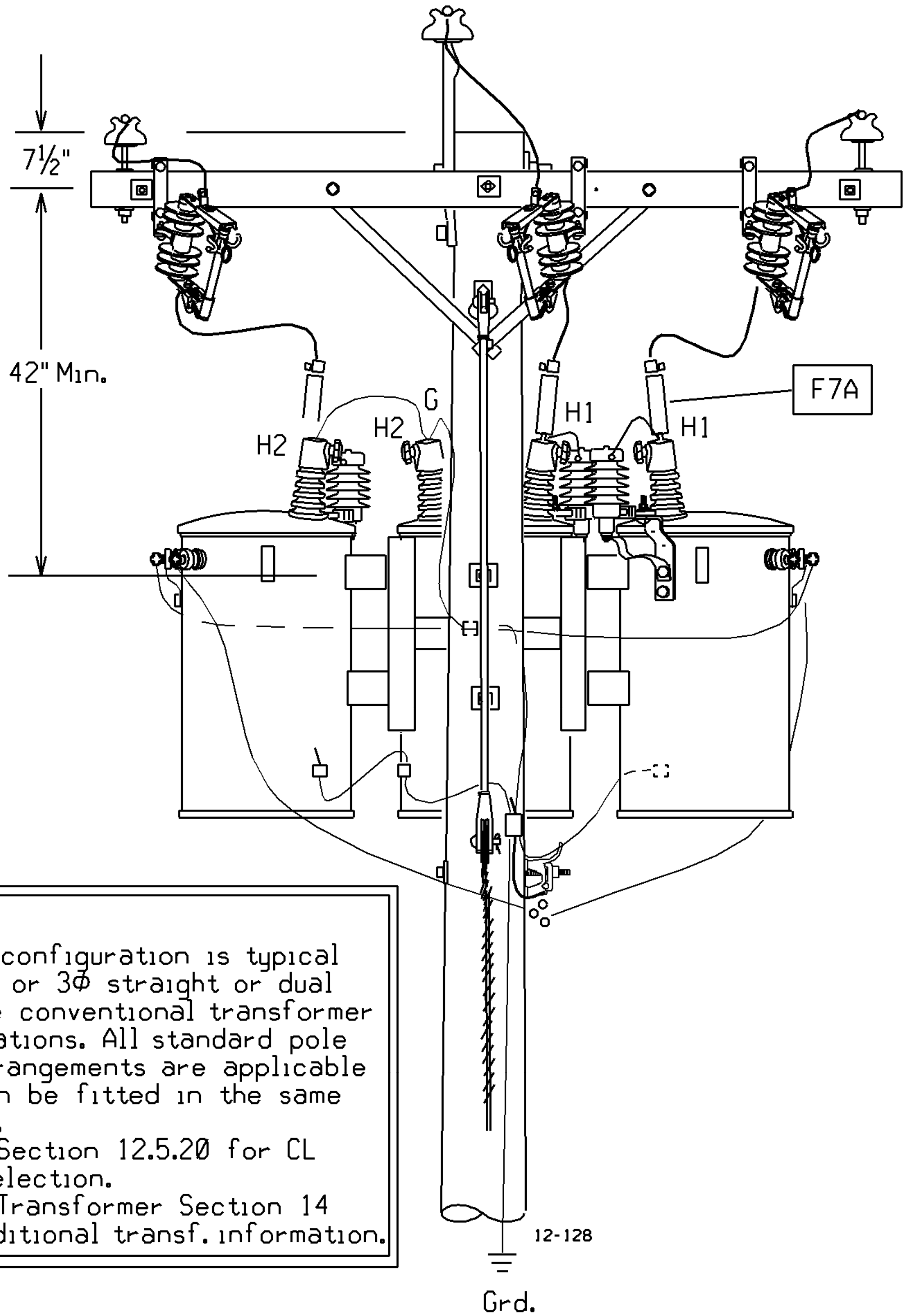
Supersedes 1/08 Issue – Added in Cutouts to pole top.



NOTES:

1. This configuration is typical for 1Φ or 3Φ straight or dual voltage CSP transformer installations. All standard pole top arrangements are applicable and can be fitted in the same manner.
2. See Secton 12.5.20 for CL Fuse selection.
3. See Transformer Secton 14 for additional transformer information.

CU = TFC5	25 A Current Limiting Fuse
CU = TFC7	40 A Current Limiting Fuse



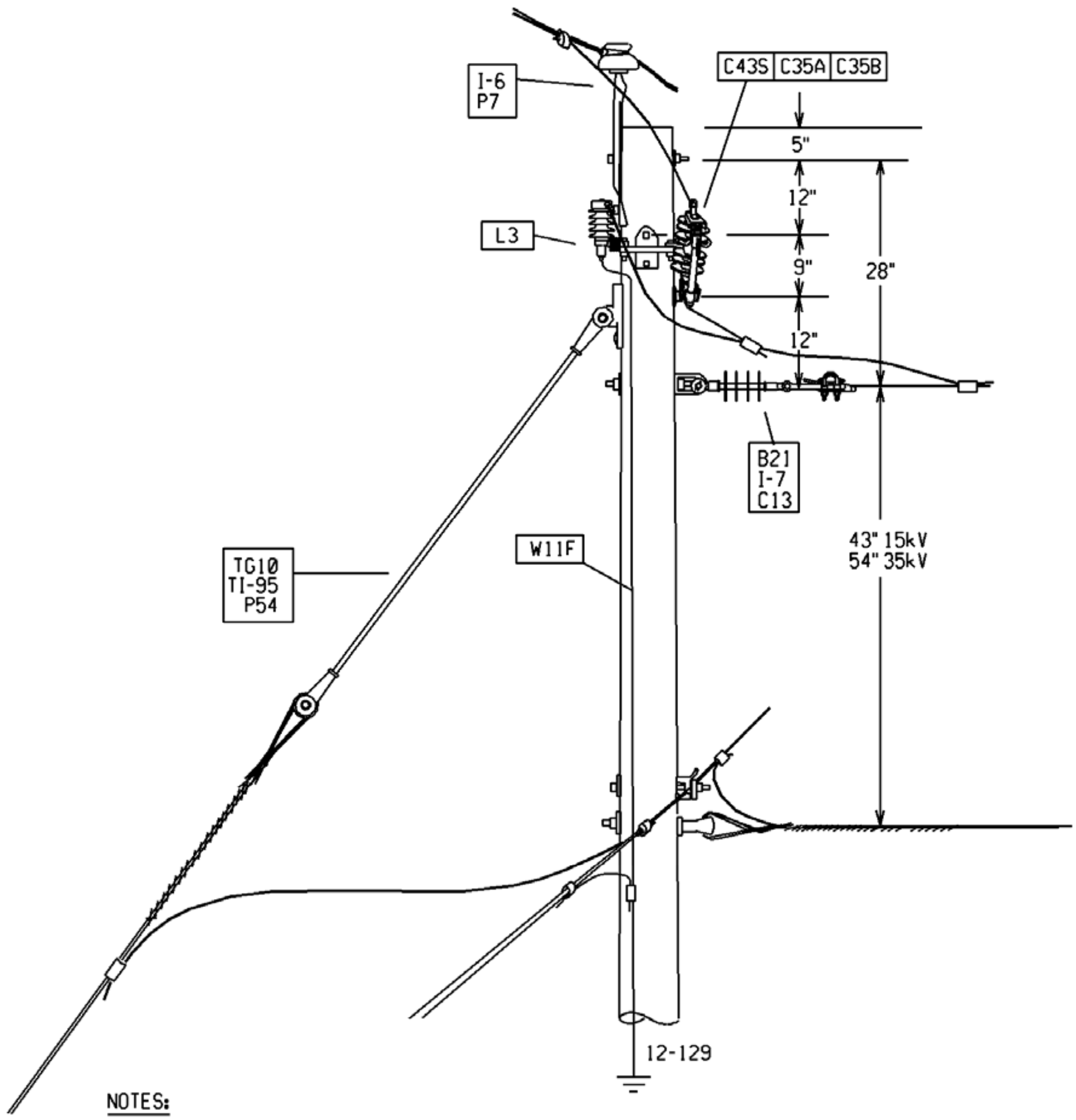
Notes:
1. This configuration is typical for 1Φ or 3Φ straight or dual voltage conventional transformer installations. All standard pole top arrangements are applicable and can be fitted in the same manner.
2. See Section 12.5.20 for CL Fuse selection.
3. See Transformer Section 14 for additional transf. information.

Supersedes 1/07 Issue – Revised Drawing To Include Standard Item F7A

CURRENT LIMITING FUSE INSTALLATION ON CONVENTIONAL TRANSFORMER 15-35 KV			
ISSUE: 7/07	PAGE NUMBER: 12-128	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

CU = CC15K(I)	15 kV Cutout & Fuse Holder, (I) = S1-100 A, S2-200 A, S3S-300 A	CU = CFLK(P)	15 kV Fuse, (P) = Fuse Rating
CU = CC27KS1	27 kV Cutout & Fuse Holder (NE)	CU= CFLK35(P)	35 kV Fuse, (P) = Fuse Rating
CU = CAL(X)K	Arrester, Lightning, (X) = Duty Cycle Rating kV	CU = PBCA	Cutout Bracket, Crossarm
CU = PABCA	Bracket for Cutout/Arrester 1 Position		
CU = PABCA3	Bracket for Cutout/Arrester 3 Position		
CU = CSVGLA	Single Vertical Ground for Lightning Arrester		

Supersedes 7/09 Issue – Revised note 1 to reference 13.6.30, Replaced CU table.

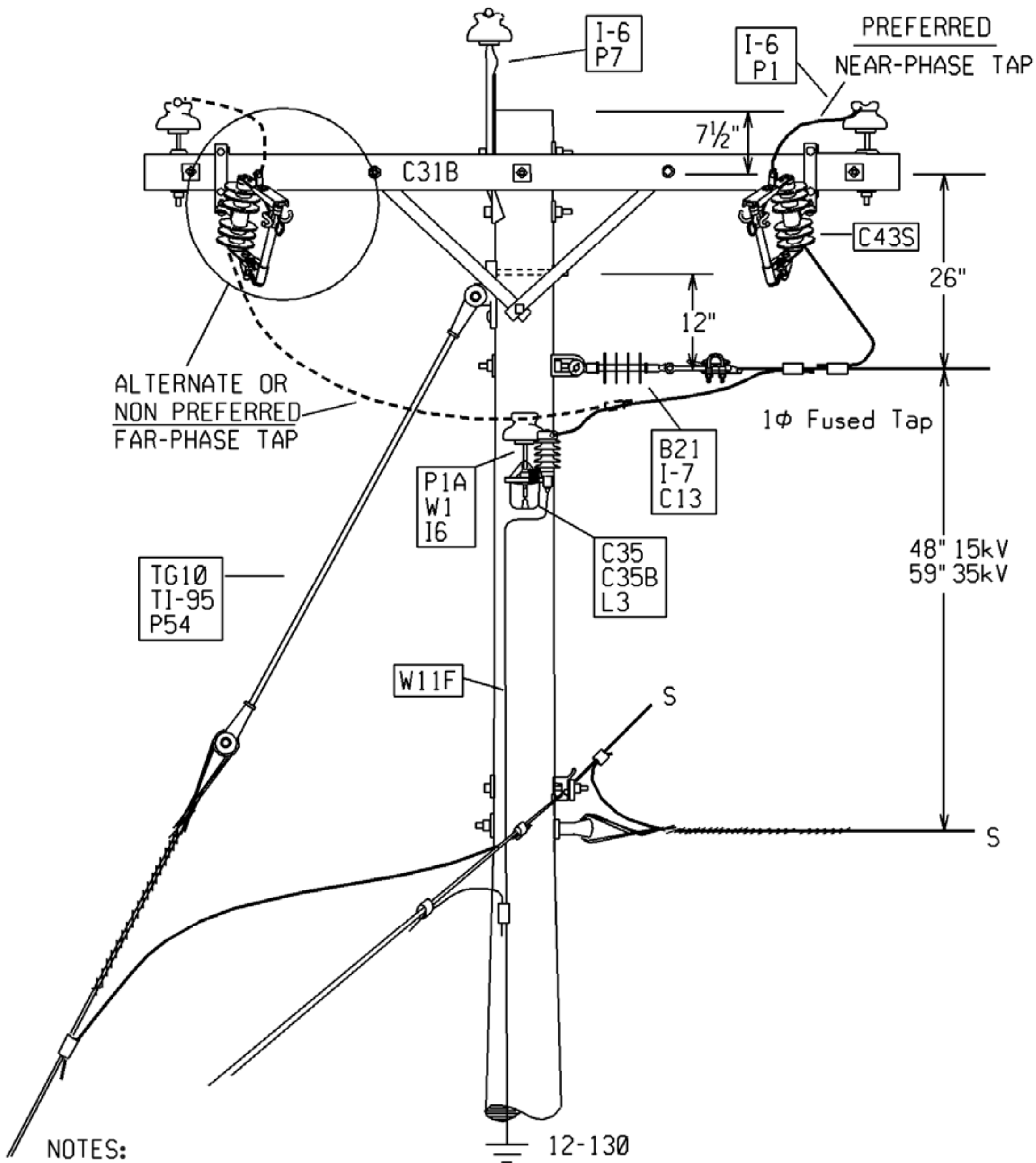


NOTES:

1. See standards section 13.6.30 for proper surge arrester location.

 Doc. # ST. 12.00.002

CU = CC15K(I)	15 kV Cutout & Fuse Holder, (I) = S1-100 A, S2-200 A, S3S-300 A	CU = CFLK(P)	15 kV Fuse, (P) = Fuse Rating
CU = CC27KS1	27 kV Cutout & Fuse Holder (NE)	CU = CFLK35(P)	35 kV Fuse, (P) = Fuse Rating
CU = CAL(X)K	Arrester, Lightning, (X) = Duty Cycle Rating kV	CU = PBCA	Cutout Bracket, Crossarm
CU = PABCA	Bracket for Cutout/Arrester 1 Position		
CU = PABCA3	Bracket for Cutout/Arrester 3 Position		
CU = CSVGLA	Single Vertical Ground for Lightning Arrester		



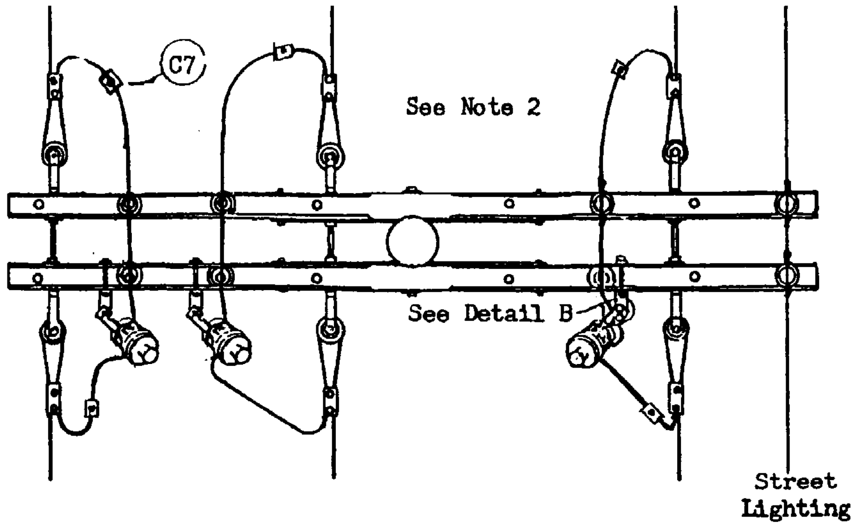
Supersedes 7/09 Issue – Revised Notes to reference 13.6.30

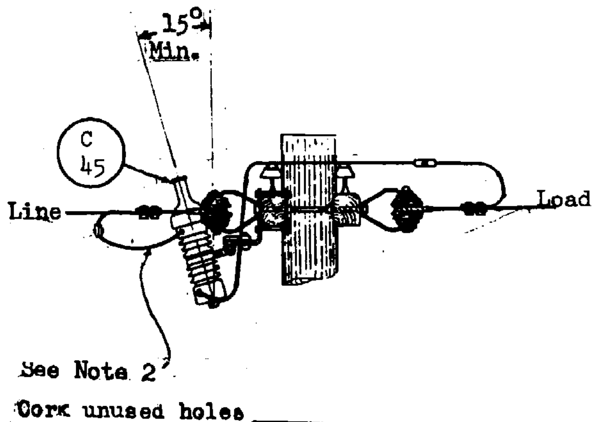
NOTES:

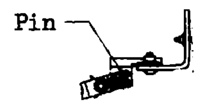
1. See standards section 13.6.30 for proper surge arrester location.
2. Can use three position bracket (C35A) instead of cutout on arm.

3Φ PRIMARY WITH 1Φ FUSED TAP 15-35 KV			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
6/10	12-130		

CU = CC5K(L)	5 kV Cutout, (L) = Cutout Box Size
CU = CFLK(P)	Fuse Size, (P) = Fuse Rating



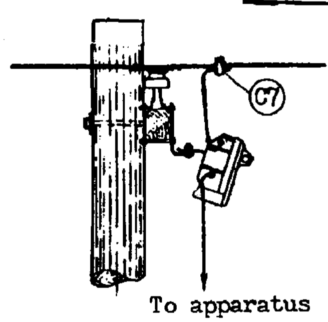


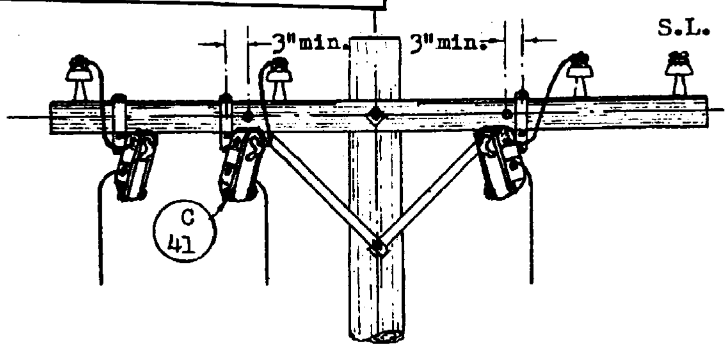


DETAIL B

View showing swivel bracket with pin in desired position to obtain 15° angle for Hot Stick Operation

— INFORMATION ONLY —
USE OPEN-TYPE CUTOUTS





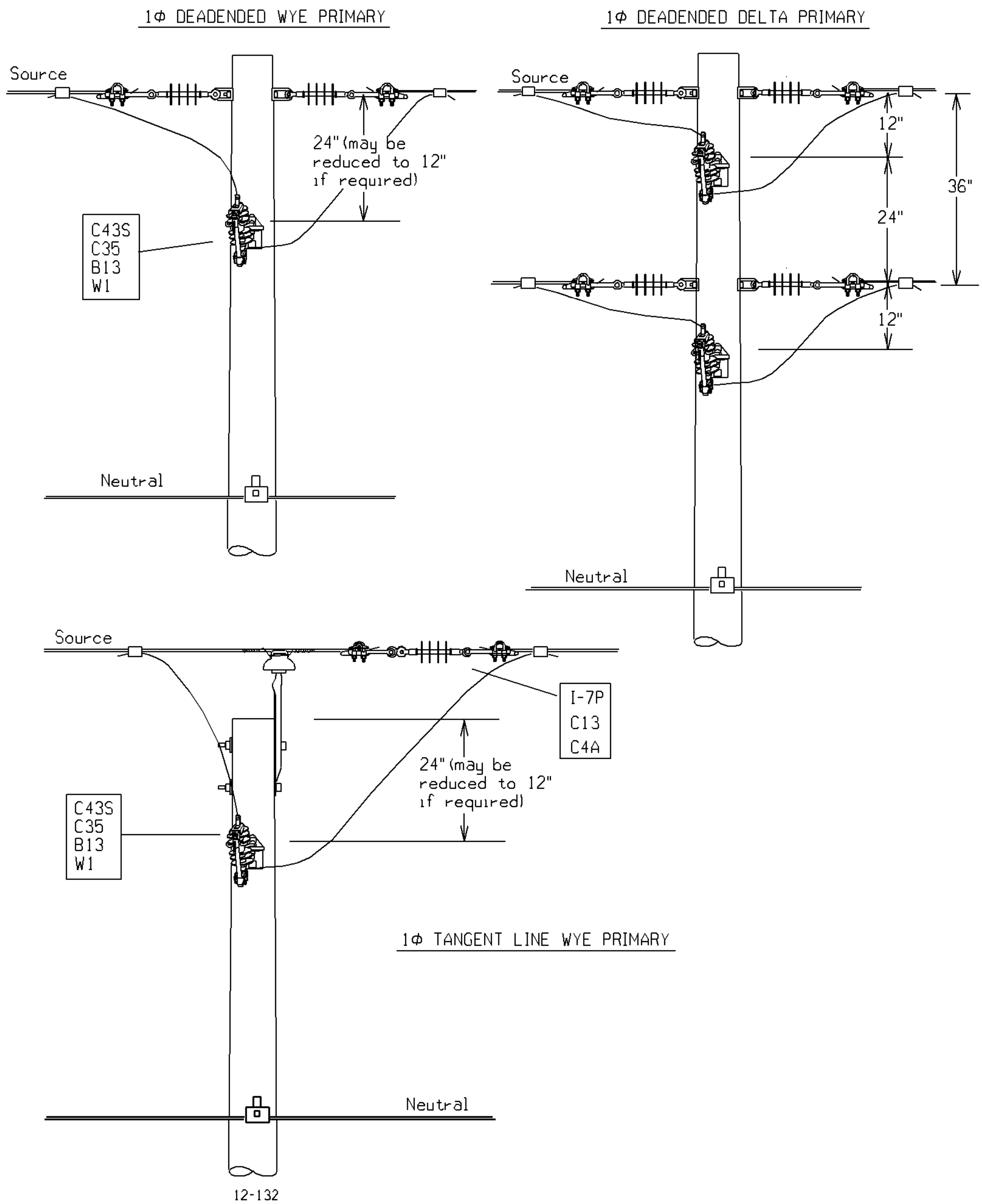
NOTES:-

1. The location of all disconnecting devices MUST BE CHOSEN TO MINIMIZE POSSIBILITY OF AN ARC FLARING UP INTO, OR BEING BLOWN INTO OTHER CIRCUITS.

2. Conductors inserted into the terminals of cutouts and disconnects shall be copper.

 Doc. # ST. 12.00.002

CU = CC15K(I)	15 kV Cutout & Fuse Holder, (I) = S1-100 A, S2-200 A, S3S-300 A	CU = CFLK(P)	15 kV Fuse, (P) = Fuse Rating
CU = CC27KS1	27 kV Cutout & Fuse Holder (NE)	CU = CFLK35(P)	35 kV Fuse, (P) = Fuse Rating
CU = CAL(X)K	Arrester, Lightning, (X) = Duty Cycle Rating kV	CU = PBCA	Cutout Bracket, Crossarm
CU = PABCA	Bracket for Cutout/Arrester 1 Position		
CU = PABCA3	Bracket for Cutout/Arrester 3 Position		
CU = CSVGLA	Single Vertical Ground for Lightning Arrester		



Supersedes 7/07 Issue – Replaced CU table

1Φ PRIMARY SECTIONALIZING 15-35 KV

ISSUE	PAGE NUMBER		
6/10	12-132	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @C3COTL(I)K	15 kV 3 Phase Tangent Line, (I) = CO Body Size: S1-100, S2-200 K Link
MU = @C3COTL35K(I)K	27 kV 3 Phase Tangent Line, (I) = CO Body Size 35 kV: S41-100 (NE)
MU = @C3CODE(I)K	15 kV 3 Phase Deadend, (I) = CO Body Size: S1-100, S2-200 K Link
MU = @C3CODE35K(I)K	27 kV 3 Phase Deadend, (I) = CO Body Size 35 kV: S41-100 (NE)

FIGURE I - Tangent Line and Angles 0° to 20°

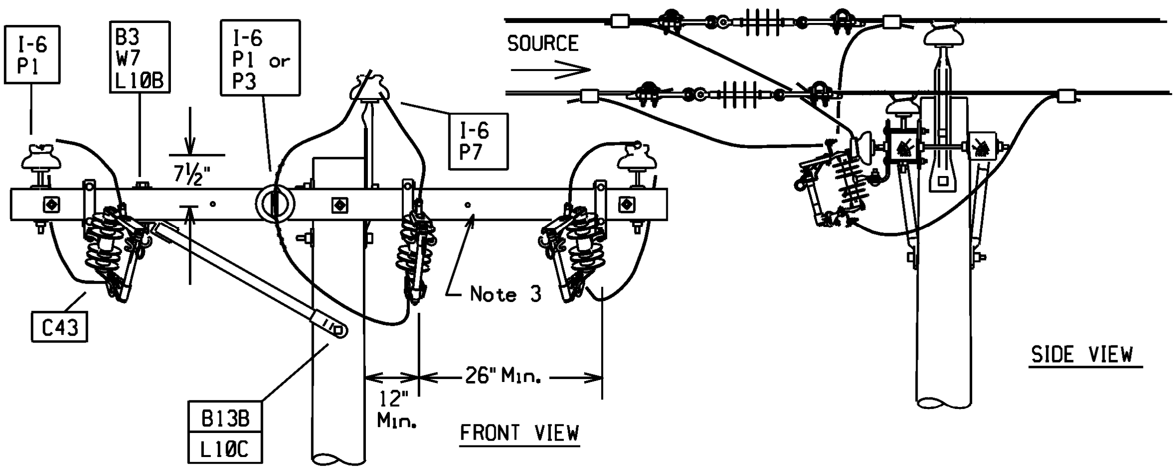
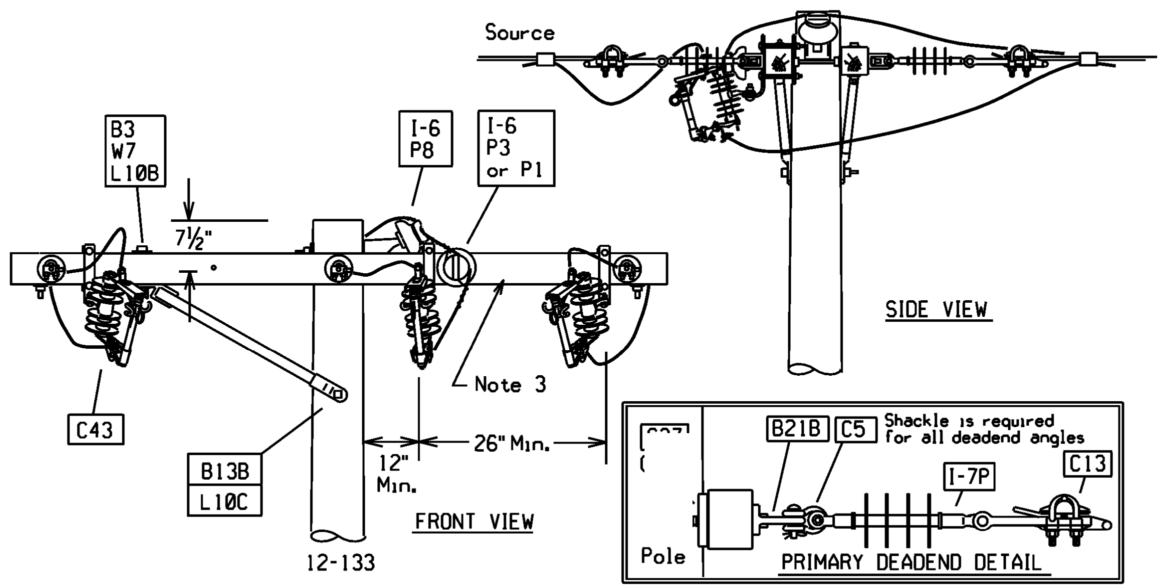


FIGURE II - Deadends and Angles 21° to 60°

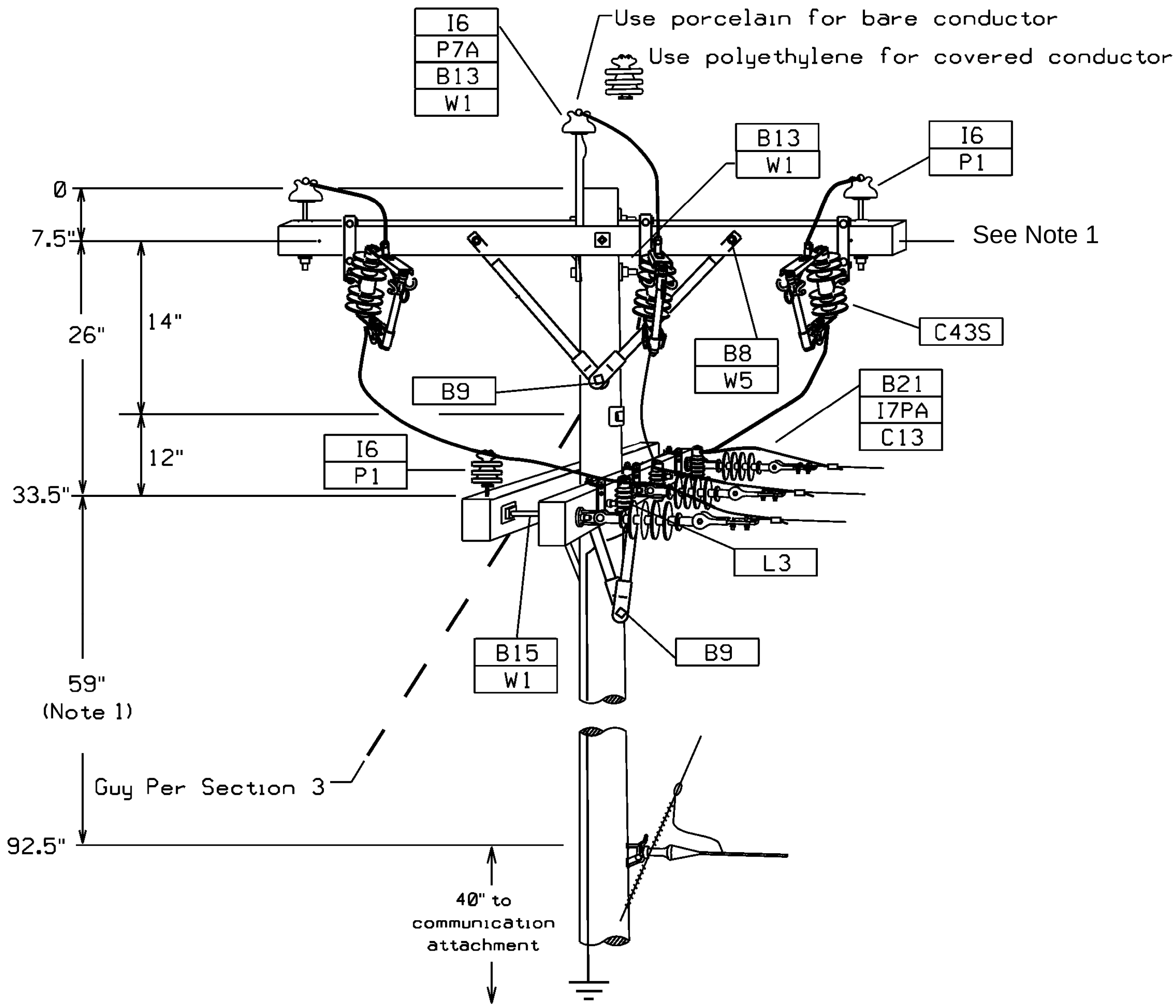


Supersedes 7/07 Issue – Added Note 3.

NOTES:

1. Covered-wire taps may require stripping to provide 6" of bare wire for operational grounding near the cutout terminals.
2. Use double pins and insulators on arm for angles 11 to 20 deg. and put conductor in side groove.
3. Use Item C31B - 8ft crossarm with B37B brace for 15kv construction and Item TC10 - 10ft crossarm with TB60 brace for 35kv construction.

CU = CC15K(I)	15 kV Cutout & Fuse Holder, (I) = S1-100 A, S2-200 A, S3S-300 A
CU = CC27KS1	27 kV Cutout & Fuse Holder (NE)
CU = CFLK(P)	15 kV Fuse, (P) = Fuse Rating
CU = CFLK35(P)	35 kV Fuse, (P) = Fuse Rating



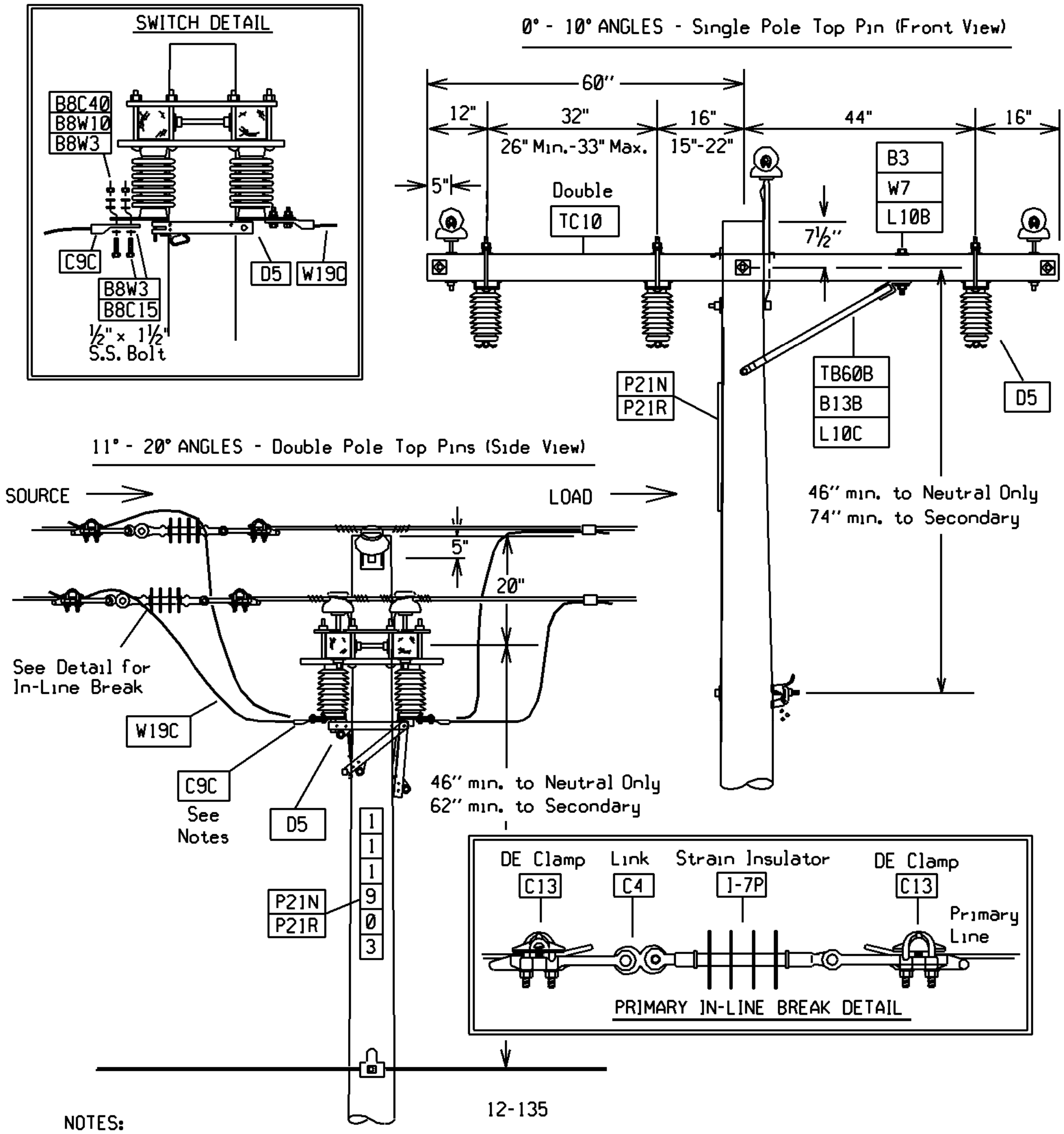
Supersedes 6/10 Issue – Relocated cutouts to upper arms & arrestors to match OH STD 9-435

Notes:

1. Use Item C31B - 8 ft crossarm with B37B brace for 15kv construction & Item TC10 -10 ft crossarm with TB60 brace for 35kv construction.

MU = @12-13510D15K	15 kV 3 phase Disconnect 0°-10°
MU = @12-13510D35K	35 kV 3 phase Disconnect 0°-10° (NE)
MU = @12-1351120D15K	15 kV 3 phase Disconnect 11°-20°
MU = @12-1351120D35K	35 kV 3 phase Disconnect 11°-20° (NE)

Supersedes 1/06 Issue – Re-Scaled Drawing And Added Appropriate Notes

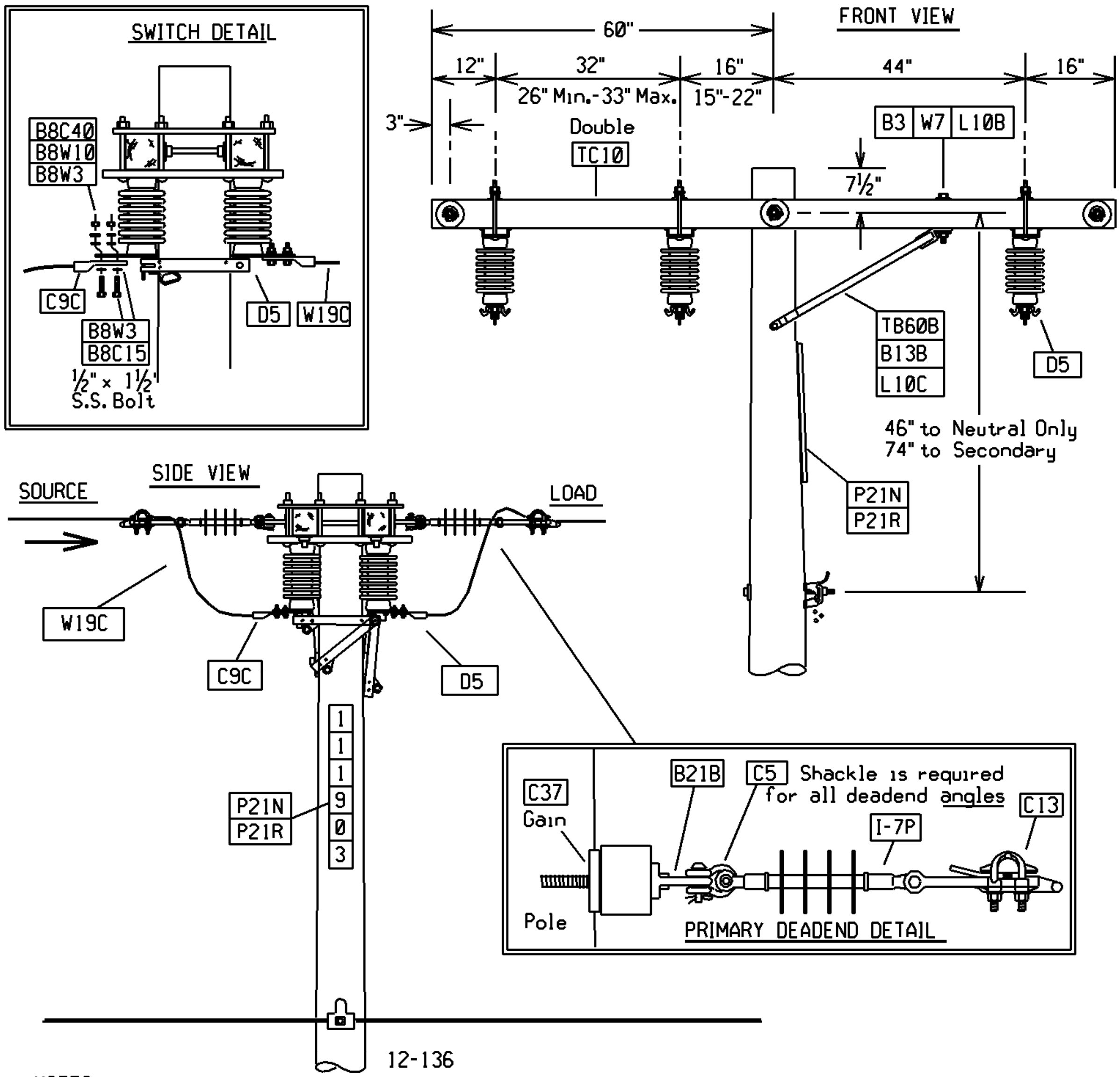


NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. See Table 2 for disconnect ratings. Standard practice is to install switch so that the blade opens away from the source and is deenergized when open.
3. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
4. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
5. See Drawings 12-139 and 12-140 for switch installations on seperate switcharms.
6. Use double pins and insulators for angles 11° - 20° and insert conductor into side grooves. See dwg. 12-136 for all deadends and angles 21° to 60°.
7. Switch identification mounted vertically on road side providing maximum visibility.

UNDERSLUNG DISCONNECT SWITCH TANGENT LINE ANGLES 0°-20° 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 12-135	ISSUE 7/07

MU = @12-1362160D15K	15 kV 3 Phase Disconnect
MU = @12-1362160D35K	35 kV 3 Phase Disconnect (NE)



Supersedes 1/06 Issue – Re-Scaled Drawing And Added Appropriate Notes

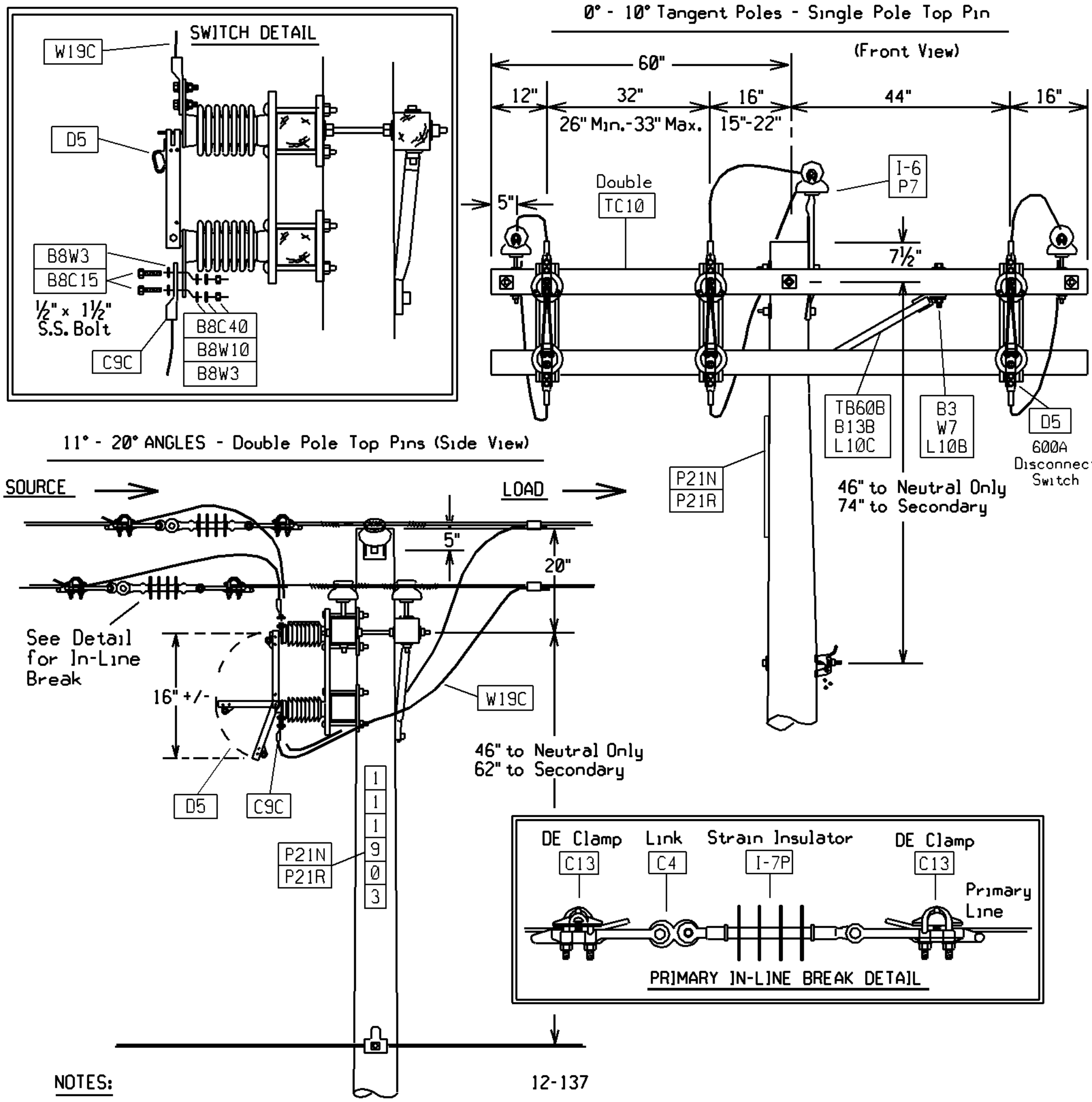
NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300′.
2. See Table 2 for disconnect ratings. Standard practice is to install switch so that the blade opens away from the source and is deenergized when open.
3. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
4. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
5. See Drawings 12-139 and 12-140 for switch installations on seperate switcharms.
6. See dwg. 12-135 for conductors on pins and angles 0° to 20°.
7. Switch identification mounted vertically on road side providing maximum visibility.

 Doc. # ST. 12.00.002

MU = @12-13710D15K	15 kV 3 Phase Disconnect Vertical 0°-10°
MU = @12-13710D35K	35 kV 3 Phase Disconnect Vertical 0°-10° (NE)
MU = @12-1371120D15K	15 kV 3 Phase Disconnect Vertical 11°-20°
MU = @12-1371120D35K	35 kV 3 Phase Disconnect Vertical 11°-20° (NE)

Supersedes 1/06 Issue – Re-Scaled Drawing, Added Crossarm For D5, And Added Appropriate Notes

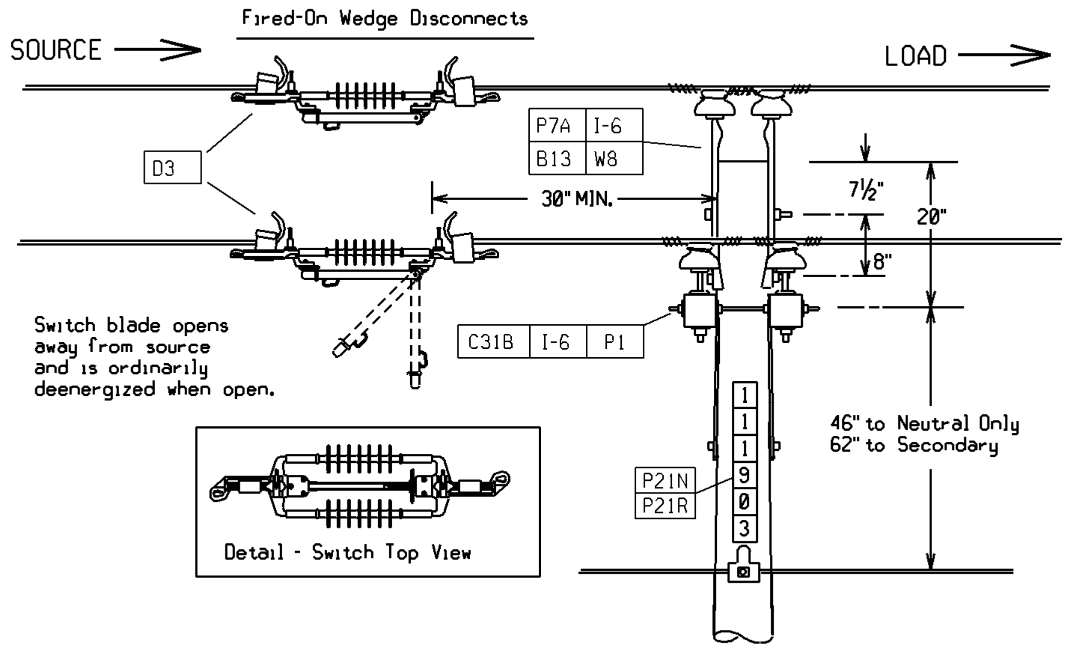


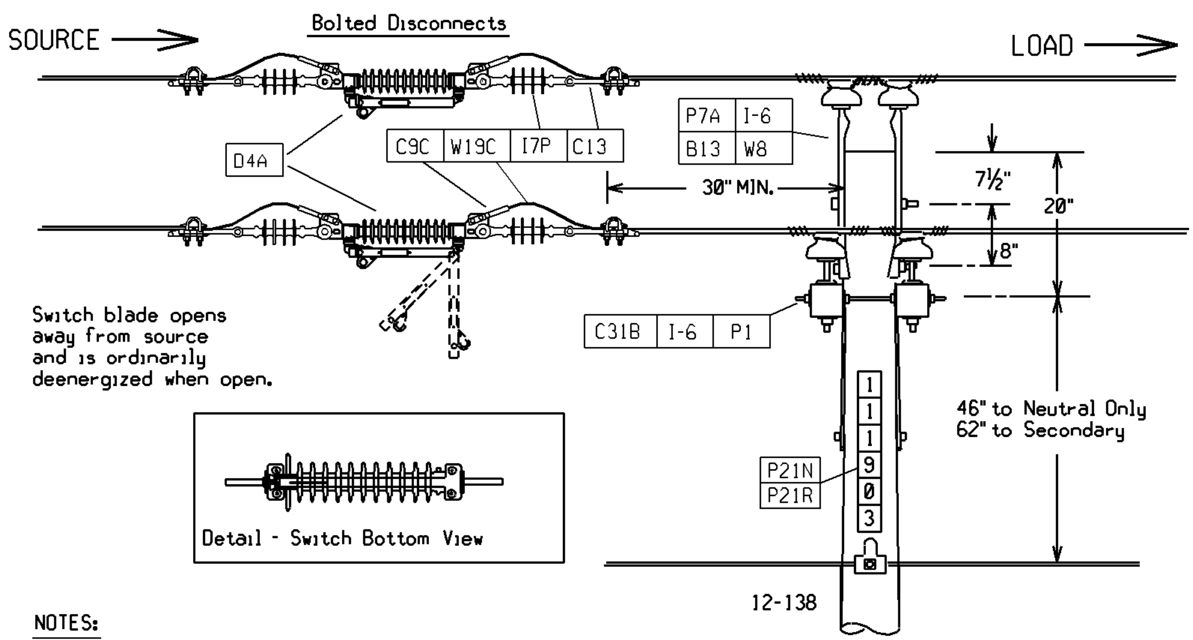
NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300′.
2. See Table 2 for disconnect ratings. Standard practice is to install switch so that the blade opens away from the source and is deenergized when open.
3. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9) to switch pads.
4. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
5. See Drawings 12-139 and 12-140 for switch installations on seperate switcharms.
6. Use double pins and insulators for angles 11° - 20° and insert conductor into side grooves. For angles 21° to 60°, see Dwg. 12-136.
7. Switch identification mounted vertically on road side providing maximum visibility.

 Doc. # ST. 12.00.002

CU = CDS(X)K(Y)AIL	Fired-On Wedge In-Line Switch, (X) = Nominal Voltage, (Y) = Wire Size
CU = CDS(X)K(Y)IL	Bolted In-Line Switch, (X) = Nominal Voltage, (Y) = Wire Size





NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. Use In-Line Switch arrangement only when clearances will not allow switch installation on crossarms (see Dwgs. 12-135, 136, 137, 139 and 140). Locate switches for ease of hot stick operation.
3. This arrangement may be applied to other types of open wire pole-tops, including recloser installations.
4. For this pole top configuration, double insulator tie points are required to reduce tie strain under switch operation.
5. Switch identification mounted vertically on road side providing maximum visibility.
6. Do not install in-line switches on a pole where the construction angle is greater than 20°.

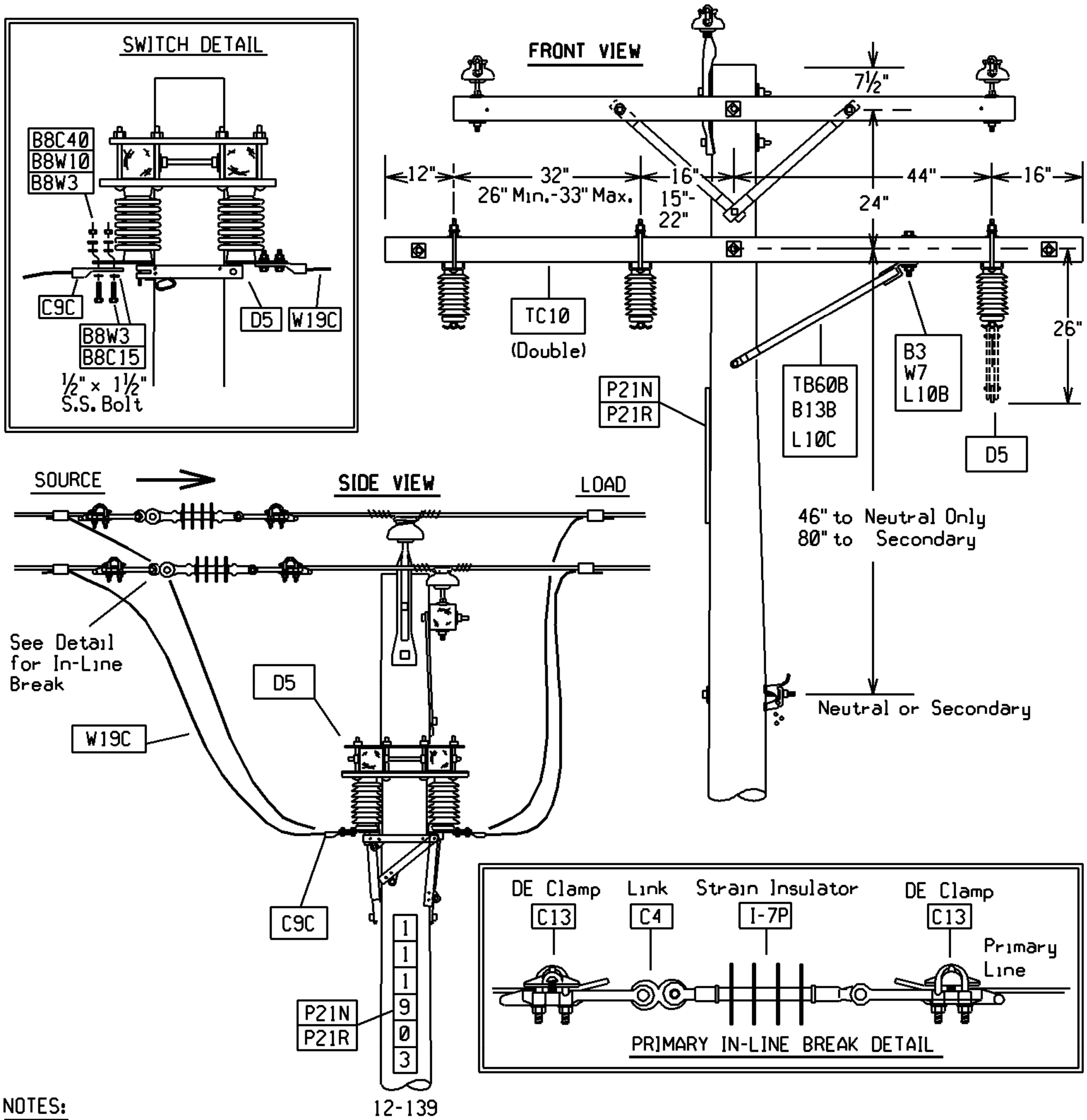
Supersedes 1/06 Issue – Re-Scaled Drawing, Added Bolted Disconnects, And Added Appropriate Notes

INSTALLATION OF IN-LINE SWITCHES 15-35 KV

ISSUE	PAGE NUMBER		
7/07	12-138	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @12-13910D15K	15 kV 3 Phase Disconnect Underslung
MU = @12-13910D35K	35 kV 3 Phase Disconnect Underslung (NE)

Supersedes 1/06 Issue – Re-Scaled Drawing And Added Appropriate Notes

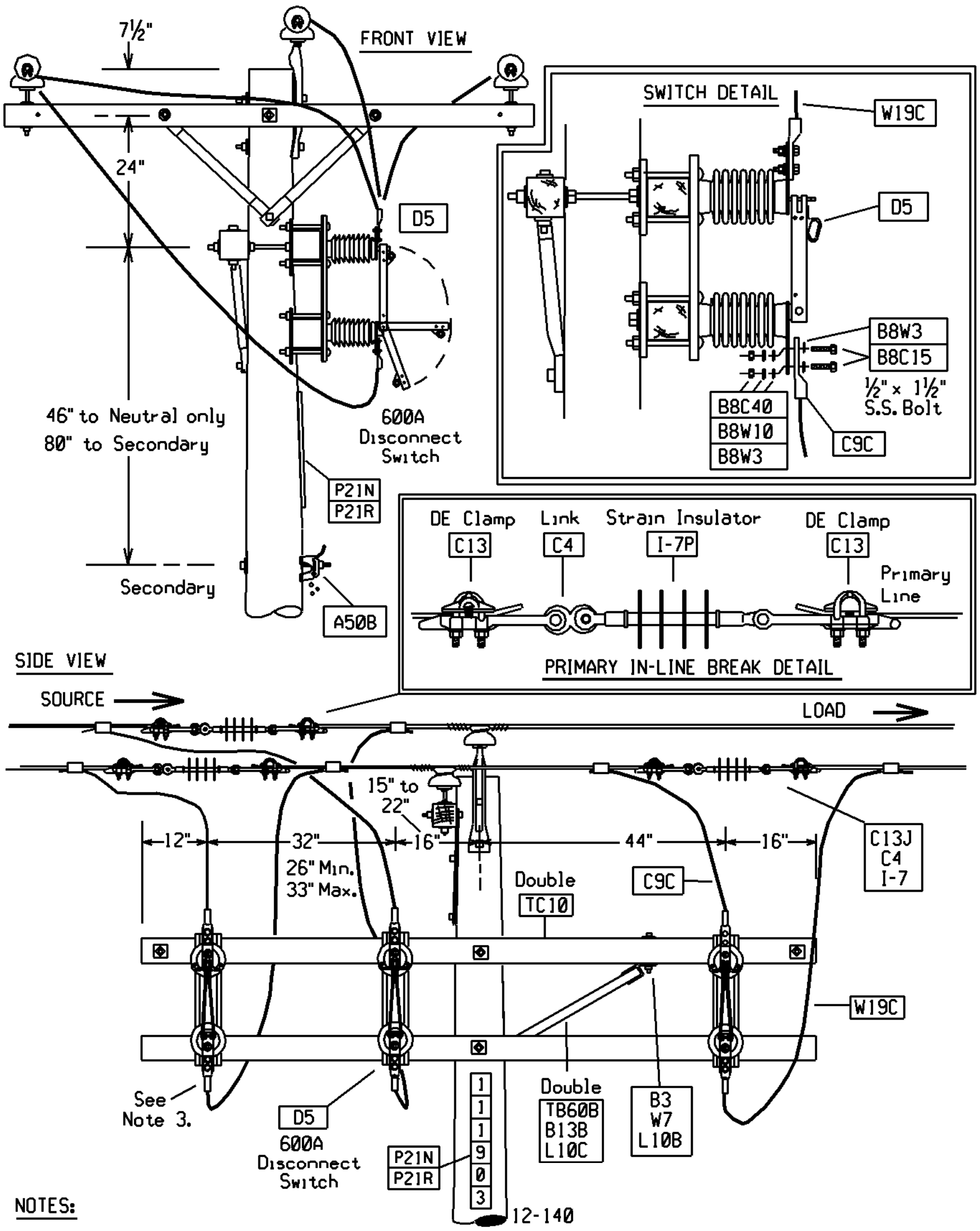


NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. See Table 2 for disconnect ratings. Standard practice is to install switch so that the blade opens away from the source and is deenergized when open.
3. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
4. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
5. This arrangement is an alternate to Dwg. 12-135, 0°-10° angle drawing shown. See Dwg. 12-140 for vertical disconnects on switcharms. (Disconnects installed directly to the double 10' primary crossarms).
6. Switch identification mounted vertically on road side providing maximum visibility.

 Doc. # ST. 12.00.002

MU = @12-14010D15K	15 kV 3 Phase Disconnect Vertical
MU = @12-14010D35K	35 kV 3 Phase Disconnect Vertical (NE)



NOTES:

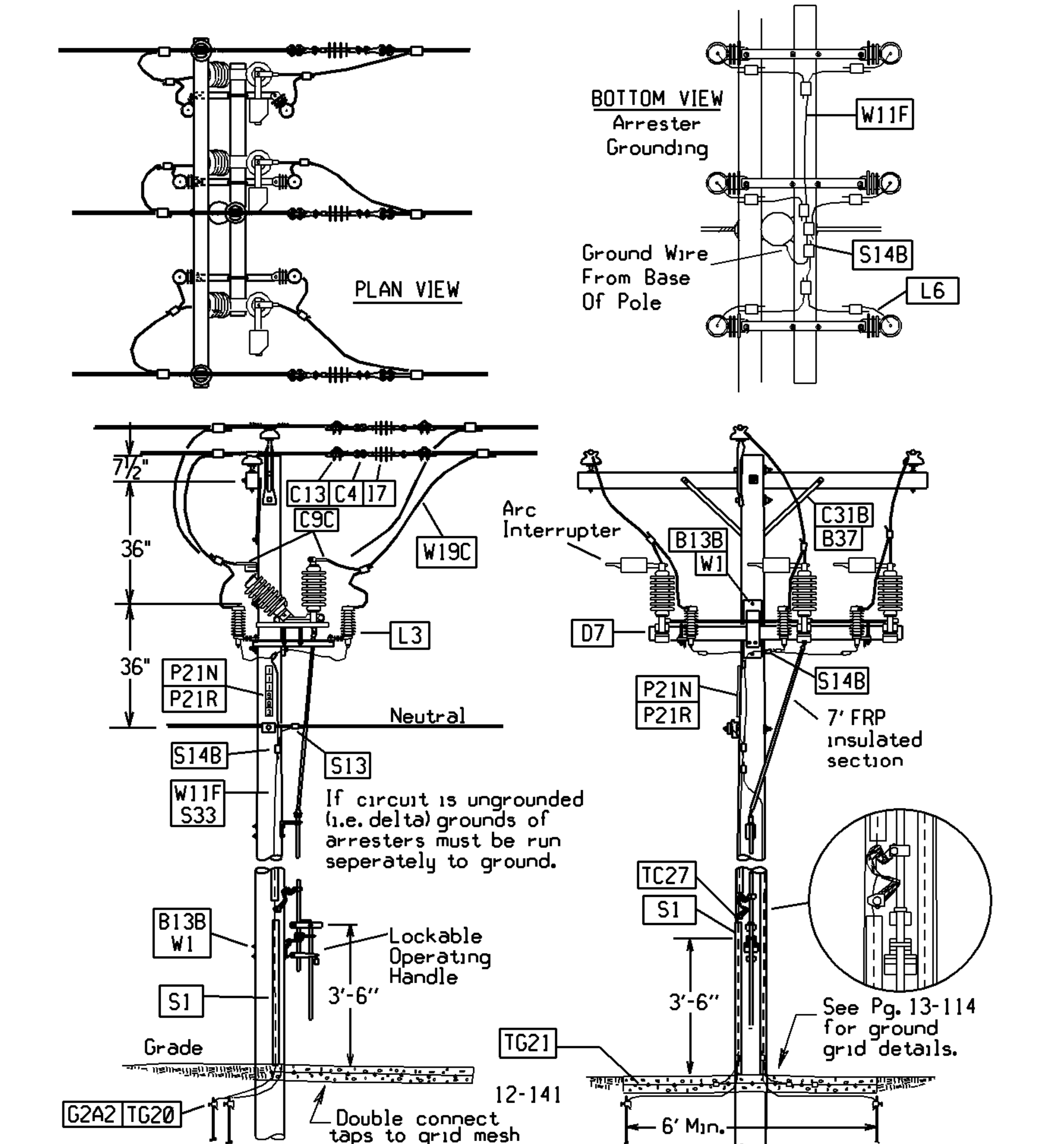
1. Surge arrestoers shall be installed onto adjacent source and load side poles within 300'.
2. See Table 2 for disconnect ratings. Standard practice is to install switch so that the blade opens away from the source and is deenergized when open.
3. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
4. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
5. This arrangement is an alternate to Dwg. 12-137, 0°-10° angle drawing shown. See Dwg. 12-139 for horizontal underhung disconnects on switcharms. Switcharms are oriented parallel to pole line for operator accessability. (Disconnects installed directly to the double 10' primary crossarms).
6. Switch identification mounted vertically on road side providing maximum visibility.

Supersedes 1/06 Issue – Re-Scaled Drawing, Added Crossarm For D5, And Added Appropriate Notes

VERTICAL DISCONNECT SWITCHES – ON SWITCHARMS 15-35 KV

MU = @12-141LBSW15KVWXA	15 kV 3 Phase Loadbreak Switch)
MU = @12-141LBSW35KVWXA	35 kV 3 Phase Loadbreak Switch (NE)

Supersedes 1/06 Issue – Re-Scaled Drawing And Added Appropriate Notes

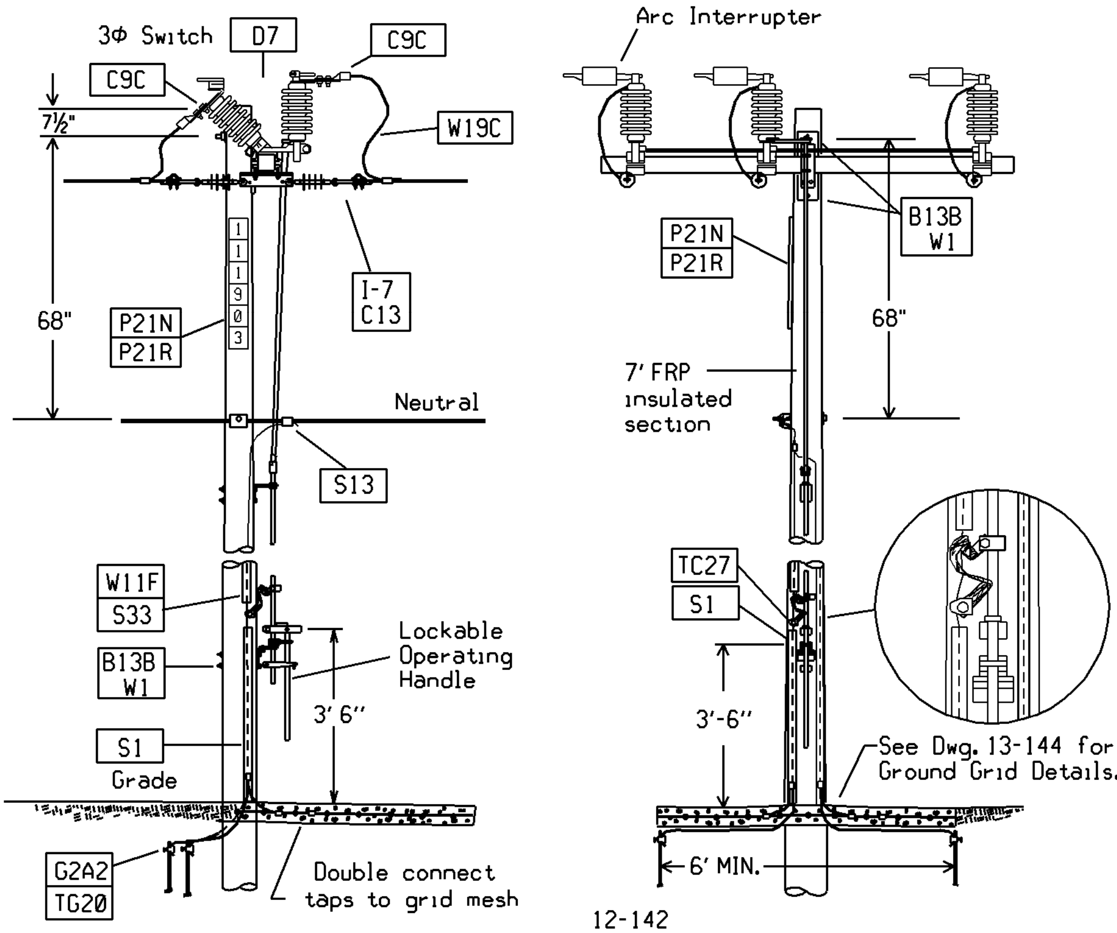


NOTES:

1. Surge arresters shall be installed onto the loadbreak arrester provisions provided or onto adjacent source and load side poles within 300'.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees. 0° to 10° angle drawing shown.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechansim shall be locked in the open or closed position.
8. Switch identification mounted vertically on road side providing maximum visibility.

 Doc. # ST. 12.00.002

MU = @12-142LBSW15KV	15 kV 3 Ph LB Sw	MU = @12-142LBSW1120D35KV	35 kV 3 Ph LB Sw 11-20 Deg. (NE)
MU = @12-142LBSW35KV	35 kV 3 Ph LB Sw (NE)	MU = @12-142LBSWUNK15KV	35 kV 3 Ph LB Sw Unk Deg.
MU = @12-142LBSW1120D15KV	15 kV 3 Ph LB Sw 11-20 Deg.	MU = @12-142LBSWUNK35KV	35 kV 3 Ph LB Sw Unk Deg. (NE)



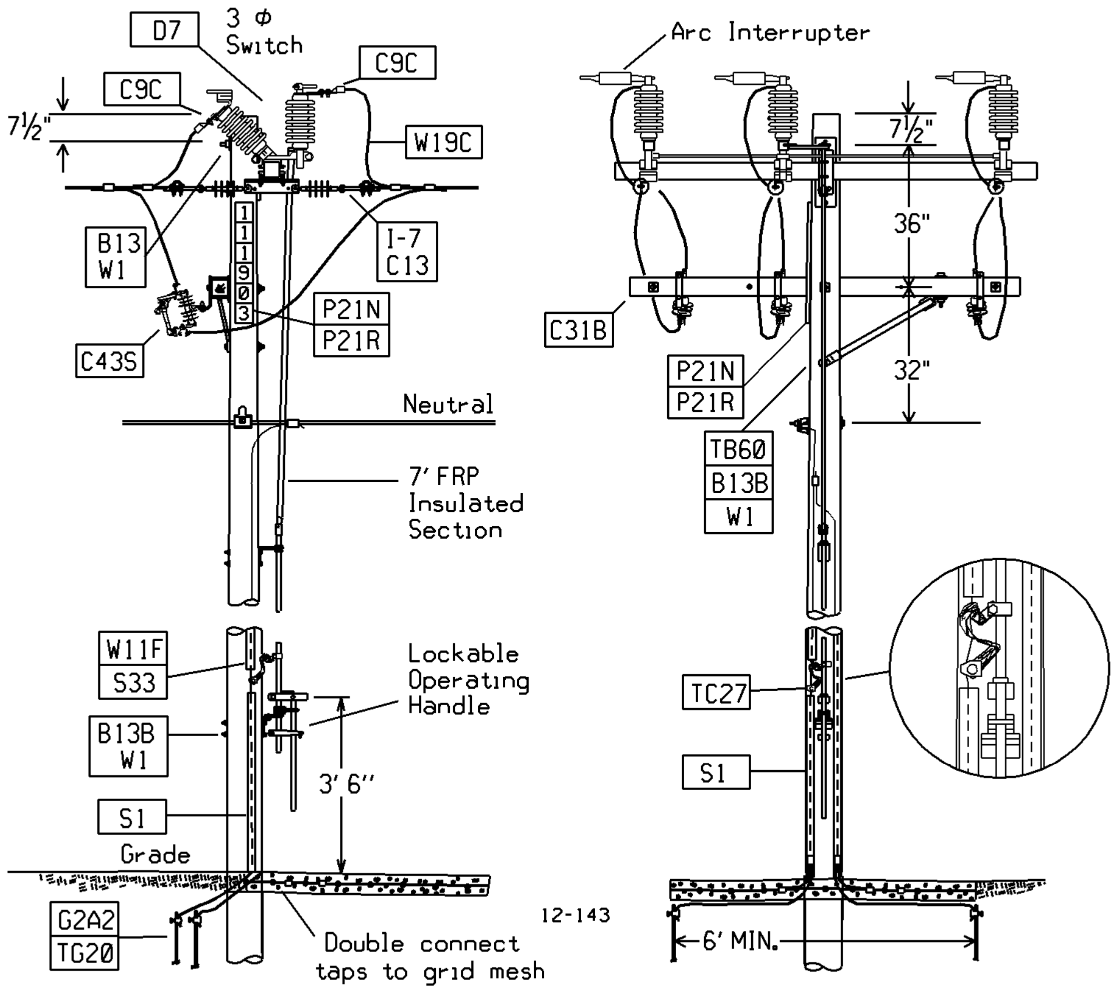
12-142

Supersedes 1/06 Issue – Re-Scaled Drawing And Added Appropriate Notes

NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use ⅝" thru bolts to mount operating rod guides.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechanism shall be locked in the open or closed position.
8. Switch identification mounted vertically on road side providing maximum visibility.

MU = @12-143LBSW15KVWCO	15 kV 3 Phase Loadbreak Switch (NE), Plus Cutout MUs
MU = @12-143LBSW35KVWCO	35 kV 3 Phase Loadbreak Switch (NE), Plus Cutout MUs



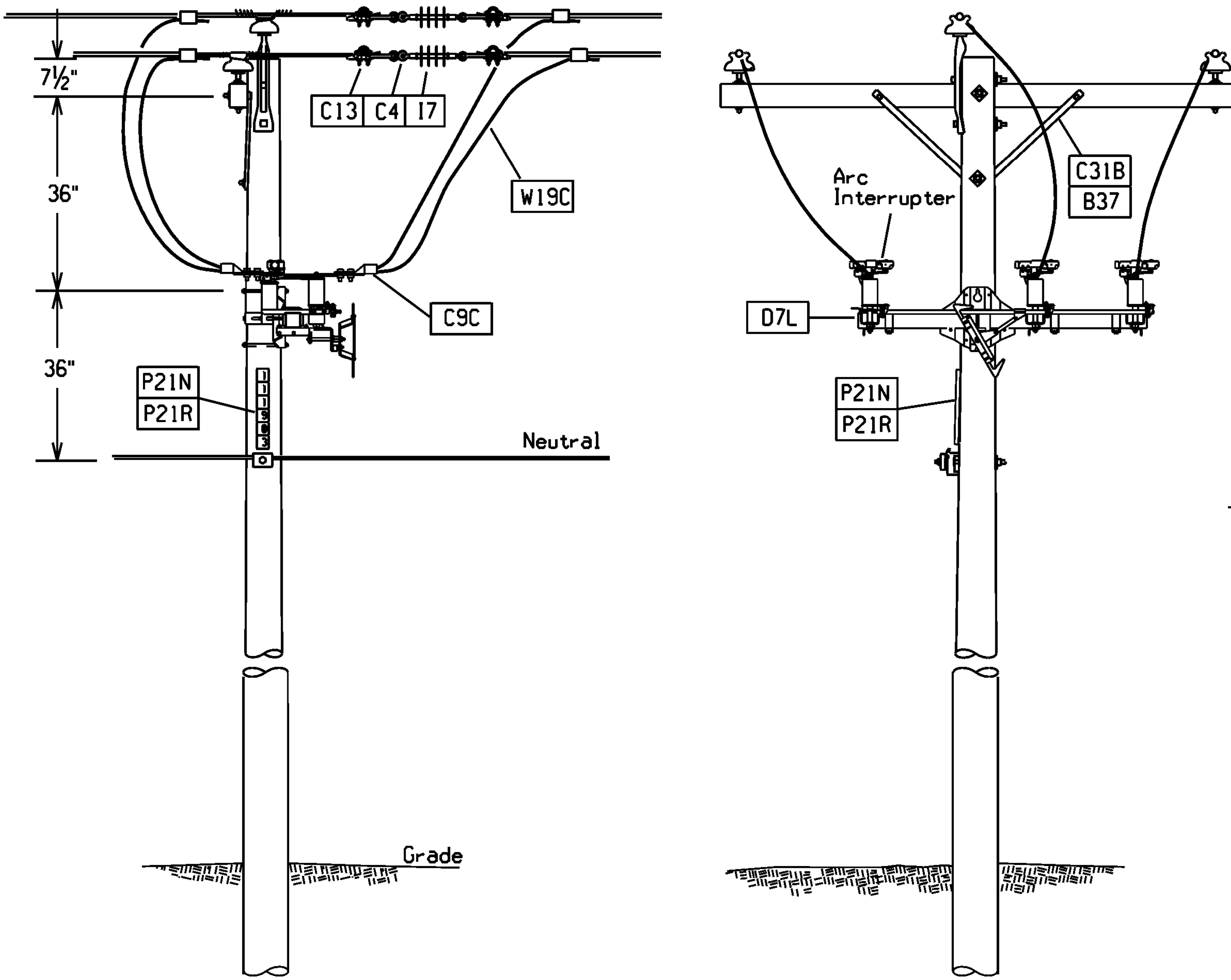
NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. Shunt fuse cutouts shall be installed below the loadbreak switch onto an 8' crossarm.
3. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
4. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use ⅝" thru bolts to mount operating rod guides.
5. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
6. DO NOT install switch on a pole where the construction angle is greater than 20 degrees.
7. Lifting straps shall be removed after installation is complete.
8. Operating mechanism shall be locked in the open or closed position.
9. Switch identification mounted vertically on road side providing maximum visibility.

Supersedes 1/06 Issue – Re-Scaled Drawing And Added Appropriate Notes

3Φ PRIMARY SECTIONALIZING - LOADBREAK SWITCH WITH SHUNT CUTOUTS INSTALLATION 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 12-143	ISSUE: 7/07

MU=@12- 144LBHKSTSW15KWXA	15 kV 3 Phase Loadbreak



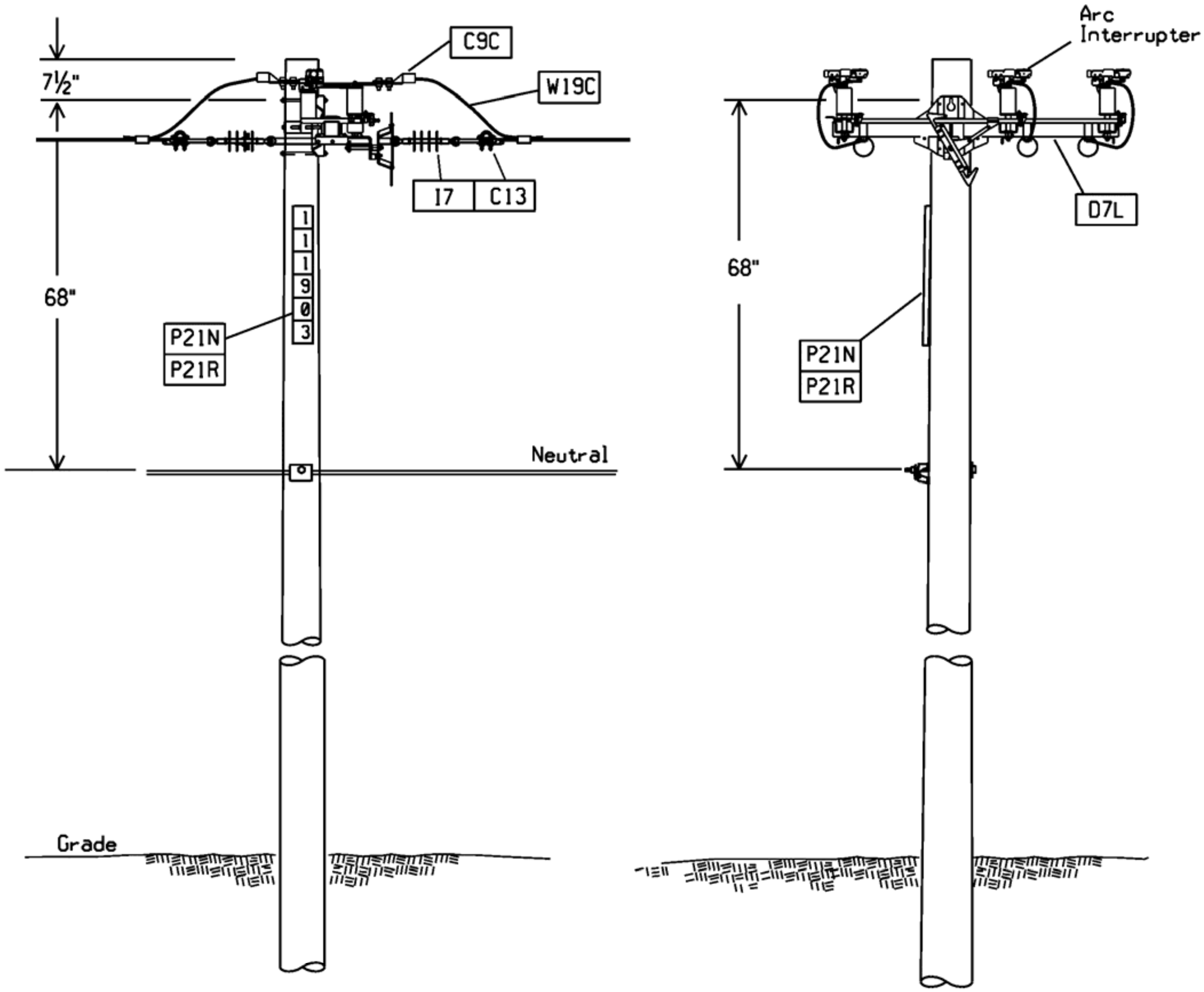
Supersedes All Previous Issues – New Standard

NOTES:

1. Surge arresters shall be installed on adjacent source and load side poles within 300'. Down ground and/or surge arresters SHALL NOT be installed at the same pole as the switch installation.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees. 0° to 10° angle shown.
6. Lifting straps shall be removed after installation is complete.
7. Switch identification number shall be mounted vertically on road side providing maximum visibility.

MU=@12-145LBHSW15KWXA	15 kV 3 Phase

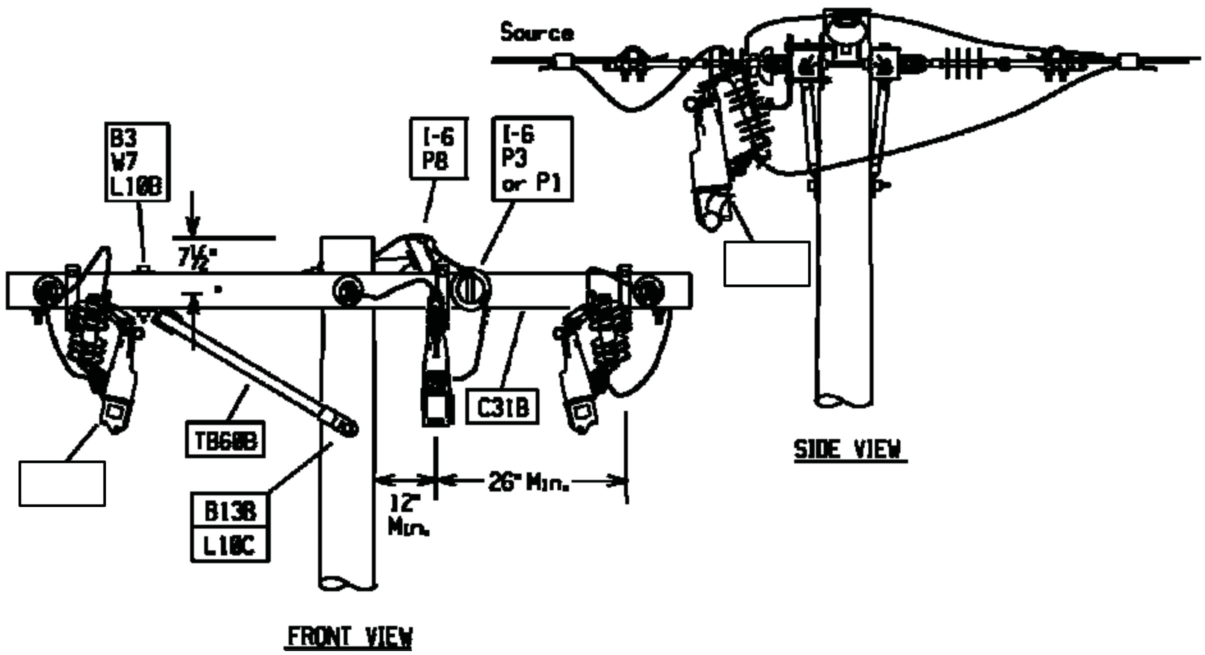
Supersedes All Previous Issues – New Standard



NOTES:

1. Surge arresters shall be installed on adjacent source and load side poles within 300'. Down ground and/or surge arresters SHALL NOT be installed at the same pole as the switch installation.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees. o° to 10° angle shown.
6. Lifting straps shall be removed after installation is complete.
7. Switch identification number shall be mounted vertically on road side providing maximum visibility.

 | Doc. # ST. 12.00.002



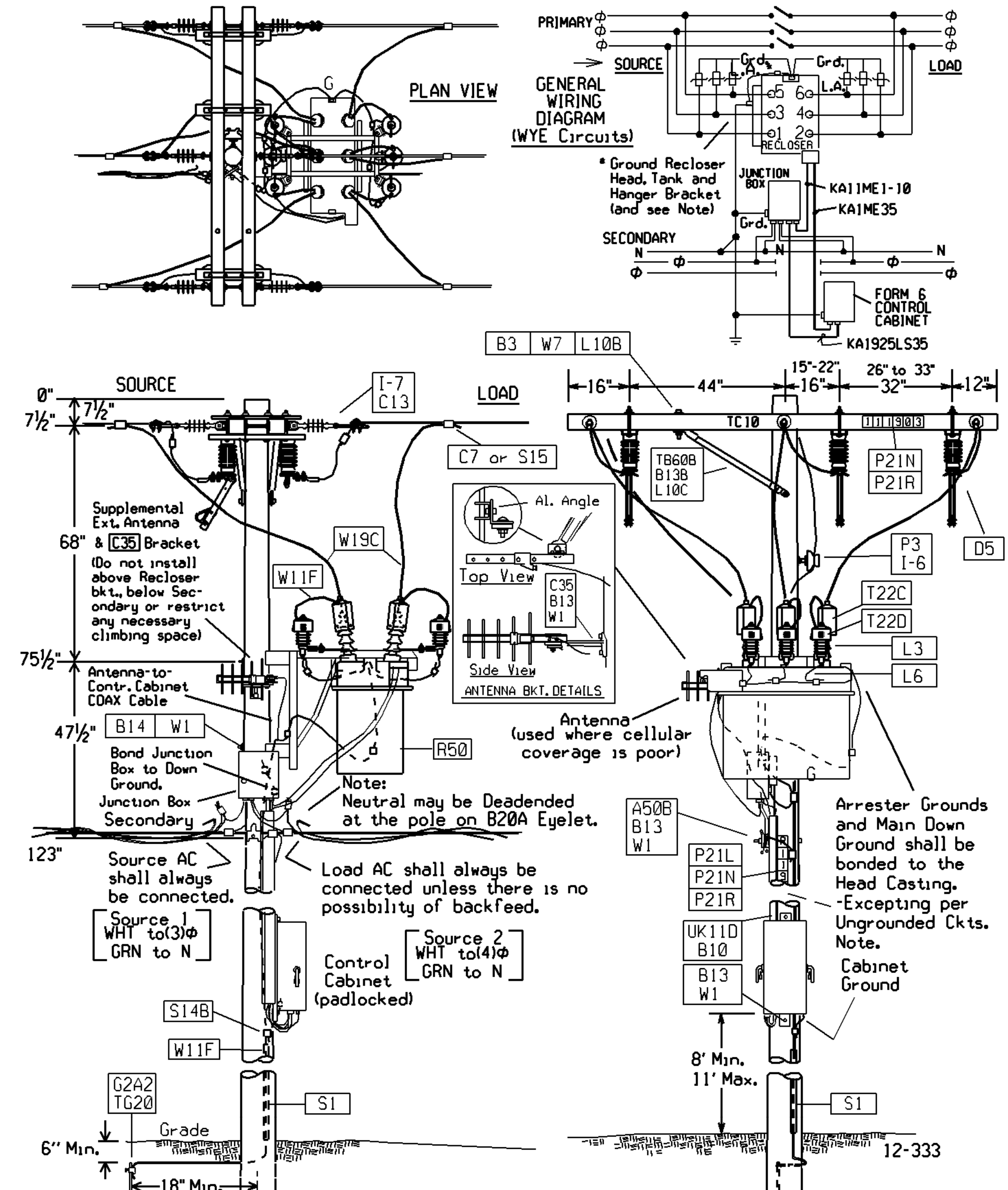
Notes:

1. Reclosers must be installed in a 100amp MacLean Power Systems Type XS fuse cutout mounting. (included with unit)
2. Units must be installed on double crossarms for stability.
3. Install tag holder on pole - 8' up from ground level.
4. Provide sufficient clearance for operation, installation and removal of unit.
5. Install arrestors on **load side** of Recloser on same pole or adjacent poles within 300'.
6. Location, application and setup of this device must be done under the direction of Electric Distribution Engineering.

 Doc. # ST. 12.00.002

MU = @REC-3PH,EL,(X)KV,(Y),(Z)	Three Phase Electronic Recloser, 560A, (X)=Nominal Voltage, (Y)=LP or RD, (Z)=GRD or UNGRD
CU = REC-MT,3PH,(X)KV,12-333	Recloser Mount, Three Phase, (X) = Nominal KV Voltage, 12-133
MU = @DSWBYPNE	Bypass Switch - NE
MU = @DSWBYP35KNE	Bypass Switch 35KV - NE
MU = @DSWBYP	Bypass Switch - NY

Supersedes 1/07 Issue – Re-Scaled Drawing , Added T22D Arrester Covers, & And Added Appropriate Notes

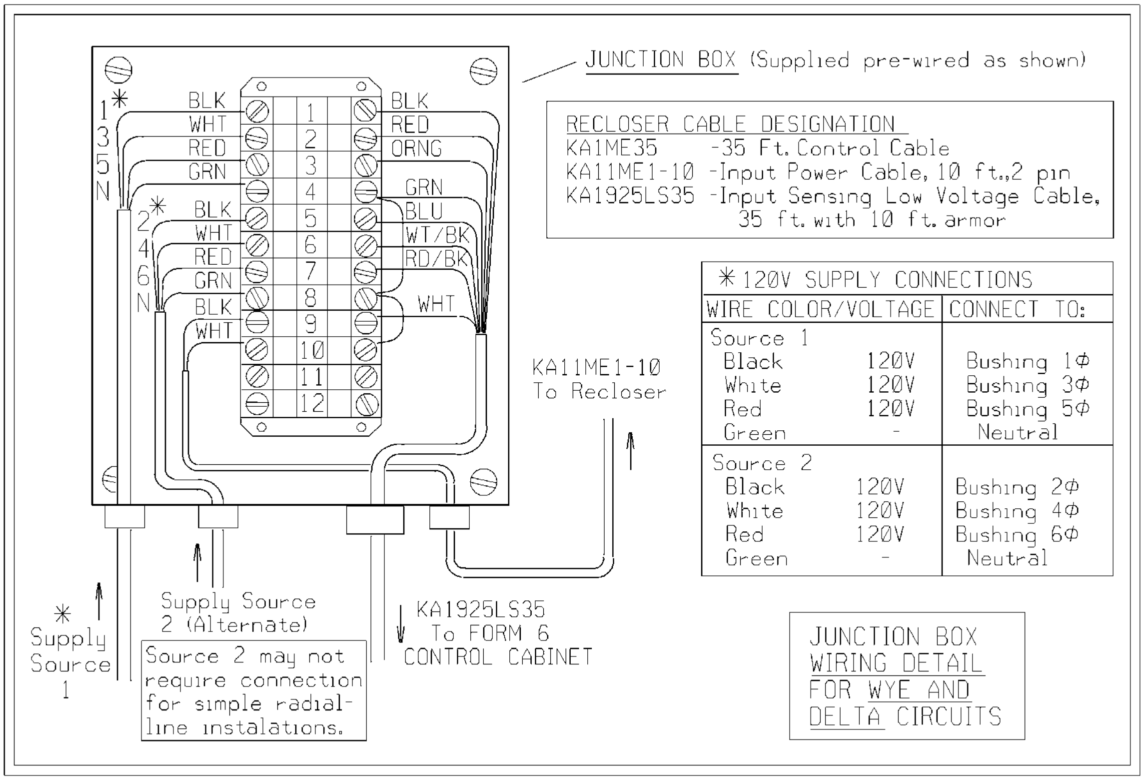


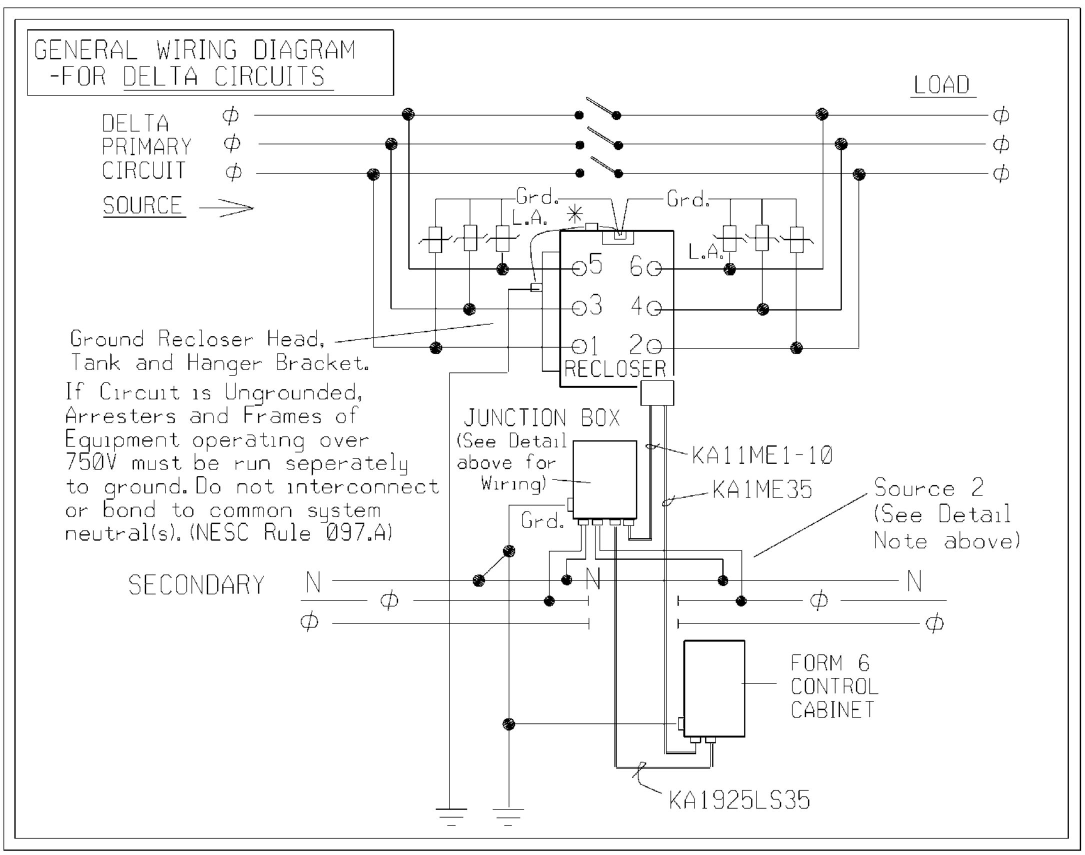
NOTES:

1. If Circuit is ungrounded, grounds of Arresters and the Frames of Equipment operating above 750V must be run seperately to ground. (NESC Rule 097.A.)
2. Sectionalizing switches shall be installed onto the adjacent source or load side pole or installed adjacently in-line.
3. The control cabinet may be mounted lower than 8 feet provided such control cabinets do not overhang roadways or obstruct pedestrian traffic, and after full consideration of worker and public safety, possible vandalism, and aesthetics. A ground grid (13-114) shall be installed.
4. Do not install recloser on a pole where the construction angle is greater than 20°.
5. Control switch identification mounted vertically above control and bypass switch identification mounted horizontally onto crossarm.
6. Stinger cover (T23) can be used for recloser leads/taps for enhanced wildlife protection.

3Φ ELECTRONIC RECLOSER EFFECTIVELY GROUNDED INSTALLATION 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 12-333	ISSUE: 7/07

 Doc. # ST. 12.00.002

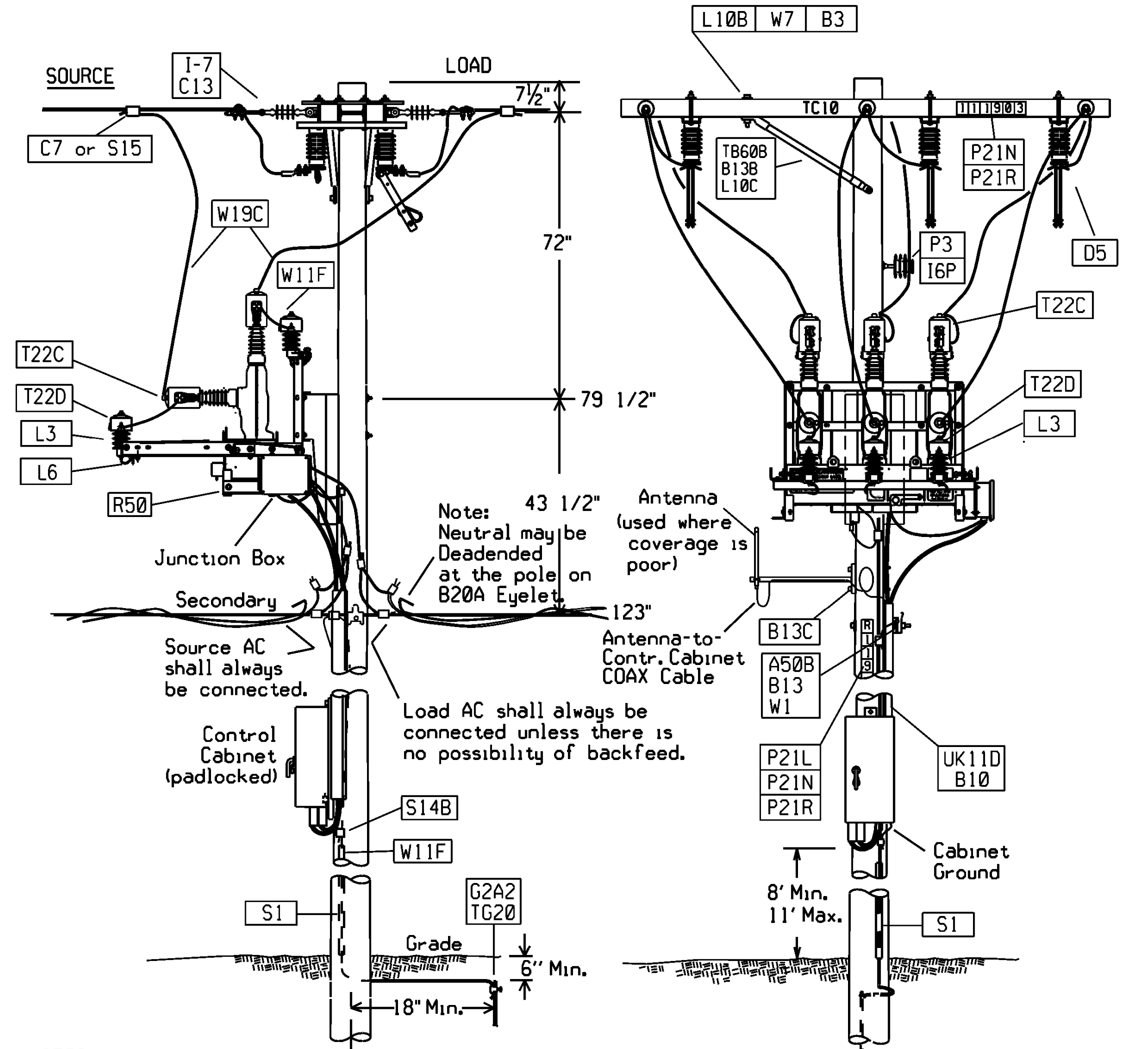




 Doc. # ST. 12.00.002

MU = @REC-3P,800A,EL,(X)KV(Y)GRD	Recloser, Three Phase, 800A, Electronic, (X)=Nominal KV Voltage (Y)=LP or RD Grounded
MU = @REC-3P,800AEL(X)KV(Y)UNGRD	Recloser, Three Phase, 800A Electronic (X)=Nominal KV Voltage (Y)=LP or RD Ungrounded
CU = REC-MT,3PH,(X)KV,12-133	Recloser, Mount, Three Phase, (X)=Nominal KV Voltage, 12-133
MU = @DSWBYPNE	Bypass Switch - NE
MU = @DSWBYP35KNE	Bypass Switch 35KV - NE
MU = @DSWBYP	Bypass Switch - NY

New 800A Recloser Drawing

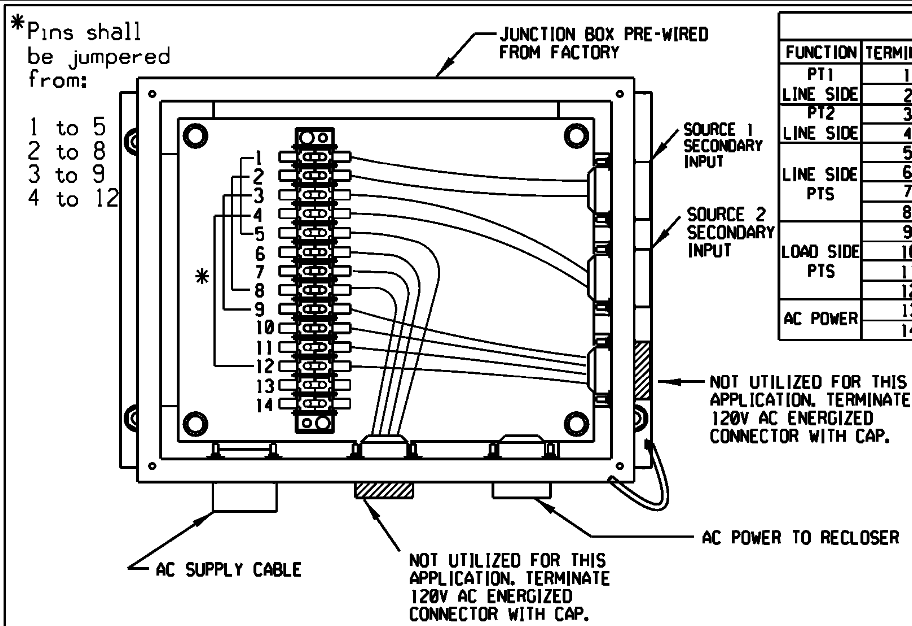


NOTES:

1. For delta circuits secondary sources shall be used solely to power recloser. No service connections shall be made on either source or load side secondary crib.
2. Sectionalizing switches shall be installed onto the adjacent source or load side pole or installed adjacently in-line.
3. The control cabinet may be mounted lower than 8 feet provided such control cabinets do not overhang roadways or obstruct pedestrian traffic, and after full consideration of worker and public safety, possible vandalism, and aesthetics. A ground grid (13-114) shall be installed.
4. Do not install recloser on a pole where the construction angle is greater than 20°.
5. Control switch identification mounted vertically above control and bypass switch identification mounted horizontally onto crossarm.
6. Stinger cover (T23) can be used for recloser leads/taps for enhanced wildlife protection.

 | Doc. # ST. 12.00.002

WYE AND DELTA CIRCUIT WIRING DIAGRAMS FOR RADIAL RECLOSER WITHOUT PT'S



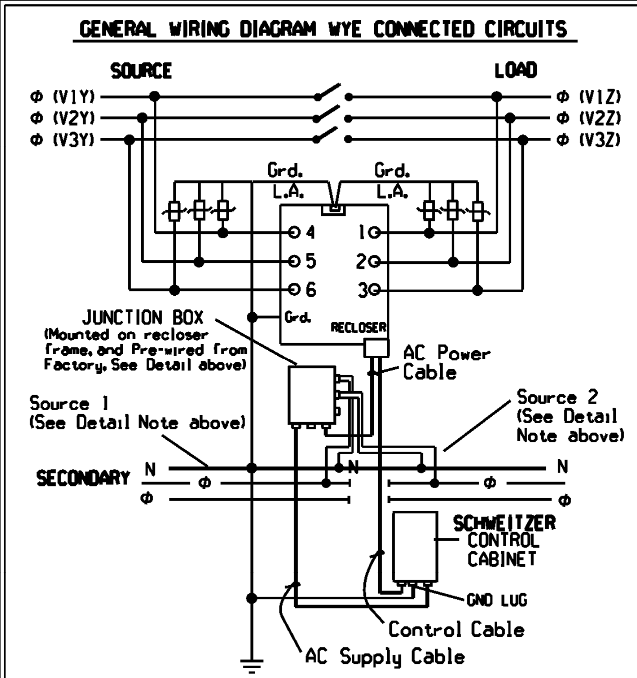
JUNCTION BOX COLOR CODE

FUNCTION	TERMINAL *	INPUTS	19 POSTION CONNECTOR
PT1 LINE SIDE	1	BLACK, S1 SECONDARY INPUT	ORANGE
	2	WHITE, S1 SECONDARY INPUT	WHITE
PT2 LINE SIDE	3	BLACK, S2 SECONDARY INPUT	BROWN
	4	WHITE, S2 SECONDARY INPUT	WHITE W/VIOLET
LINE SIDE PTS	5	BLACK, S1 SECONDARY INPUT	YELLOW
	6	RED, S1 SECONDARY INPUT	RED W/BLACK
	7	ORANGE, S1 SECONDARY INPUT	BLUE
	8	WHITE, S1 SECONDARY INPUT	WHITE W/BLACK
LOAD SIDE PTS	9	BLACK, S2 SECONDARY INPUT	BLACK
	10	RED, S2 SECONDARY INPUT	VIOLET
	11	ORANGE, S2 SECONDRY INPUT	RED
	12	WHITE, S2 SECONDARY INPUT	WHITE W/ORANGE
AC POWER	13	RED	BLUE W/BLACK
	14	WHITE	WHITE W/BLUE

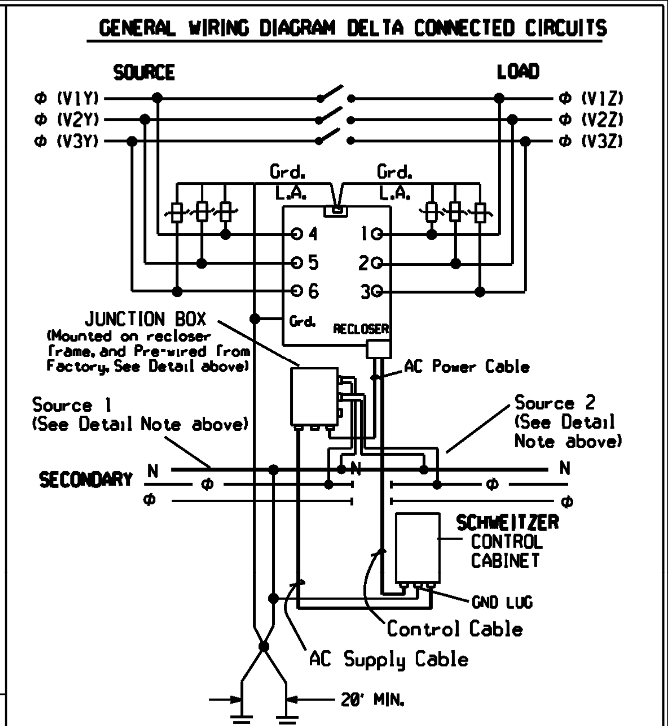
120V SUPPLY CONNECTIONS

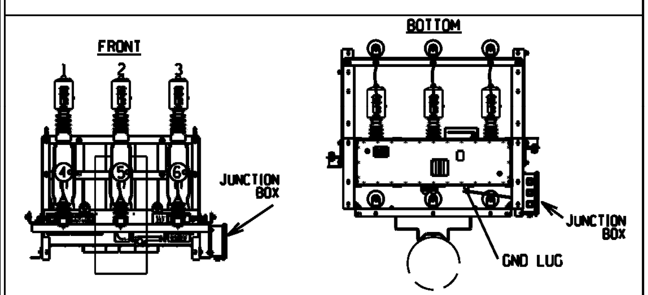
WIRE COLOR/VOLTAGE	CONNECT TO
SOURCE 1 BLACK 120V	X1 LEG OF SOURCE SIDE SECONDARY SUPPLY
WHITE -	NEUTRAL
SOURCE 2 BLACK 120V	X1 LEG OF LOAD SIDE SECONDARY SUPPLY
WHITE -	NEUTRAL

GENERAL WIRING DIAGRAM WYE CONNECTED CIRCUITS



GENERAL WIRING DIAGRAM DELTA CONNECTED CIRCUITS

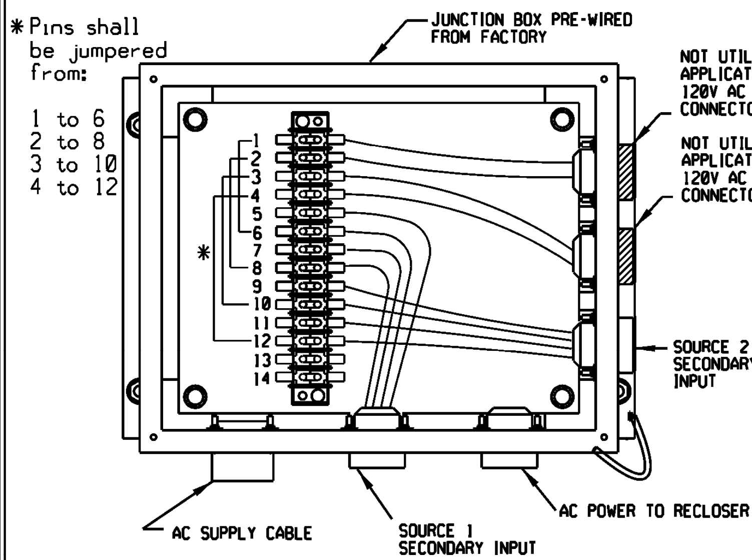




NOTE: Secondary sources shall be used solely to power recloser. No service connections shall be made on either source or load side secondary crib.

New Radial Junction Box Detail Drawing

WYE AND DELTA CIRCUIT WIRING DIAGRAMS FOR LOOP RECLOSER WITHOUT PT'S

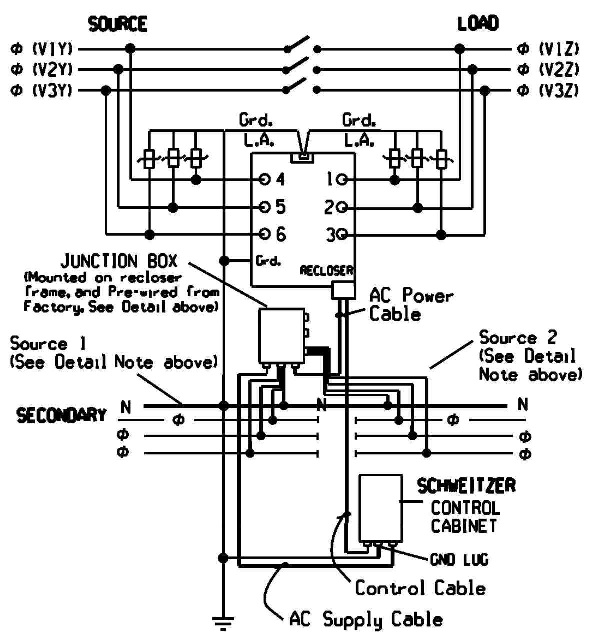


120V SUPPLY CONNECTIONS	
WIRE COLOR/VOLTAGE	CONNECT TO
SOURCE 1	
BLACK 120V	BUSHING 4
RED 120V	BUSHING 5
ORANGE 120V	BUSHING 6
WHITE -	NEUTRAL
SOURCE 2	
BLACK 120V	BUSHING 1
RED 120V	BUSHING 2
ORANGE 120V	BUSHING 3
WHITE -	NEUTRAL

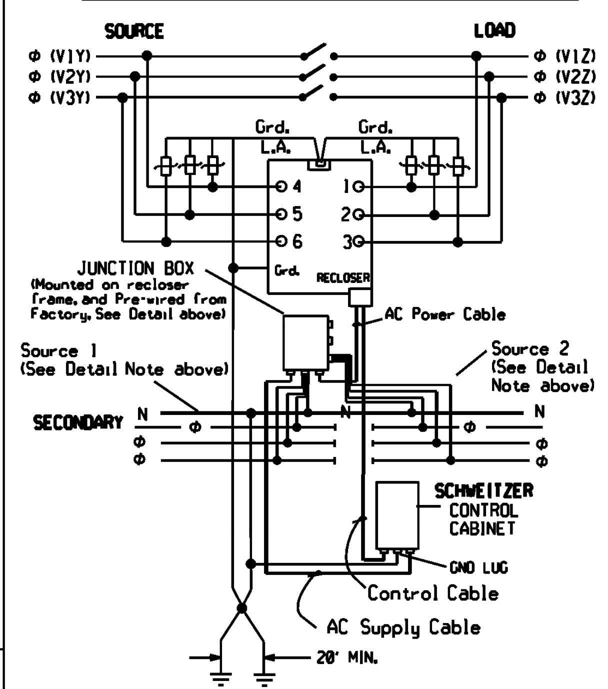
JUNCTION BOX COLOR CODE			
FUNCTION	TERMINAL *	INPUTS	19 POSTION CONNECTOR
PT1 LINE SIDE	1	BLACK, S1 SECONDARY INPUT	ORANGE
	2	WHITE, S1 SECONDARY INPUT	WHITE
PT2 LINE SIDE	3	BLACK, S2 SECONDARY INPUT	BROWN
	4	WHITE, S2 SECONDARY INPUT	WHITE W/VIOLET
LINE SIDE PTS	5	BLACK, S1 SECONDARY INPUT	YELLOW
	6	RED, S1 SECONDARY INPUT	RED W/BLACK
	7	ORANGE, S1 SECONDARY INPUT	BLUE
	8	WHITE, S1 SECONDARY INPUT	WHITE W/BLACK
LOAD SIDE PTS	9	BLACK, S2 SECONDARY INPUT	BLACK
	10	RED, S2 SECONDARY INPUT	VIOLET
	11	ORANGE, S2 SECONDORY INPUT	RED
	12	WHITE, S2 SECONDARY INPUT	WHITE W/ORANGE
AC POWER	13	RED	BLUE W/BLACK
	14	WHITE	WHITE W/BLUE

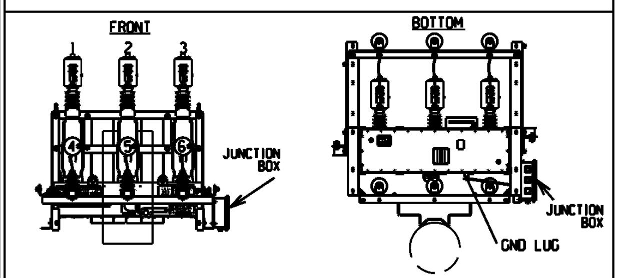
New LS Junction Box Detail

GENERAL WIRING DIAGRAM WYE CONNECTED CIRCUITS



GENERAL WIRING DIAGRAM DELTA CONNECTED CIRCUITS

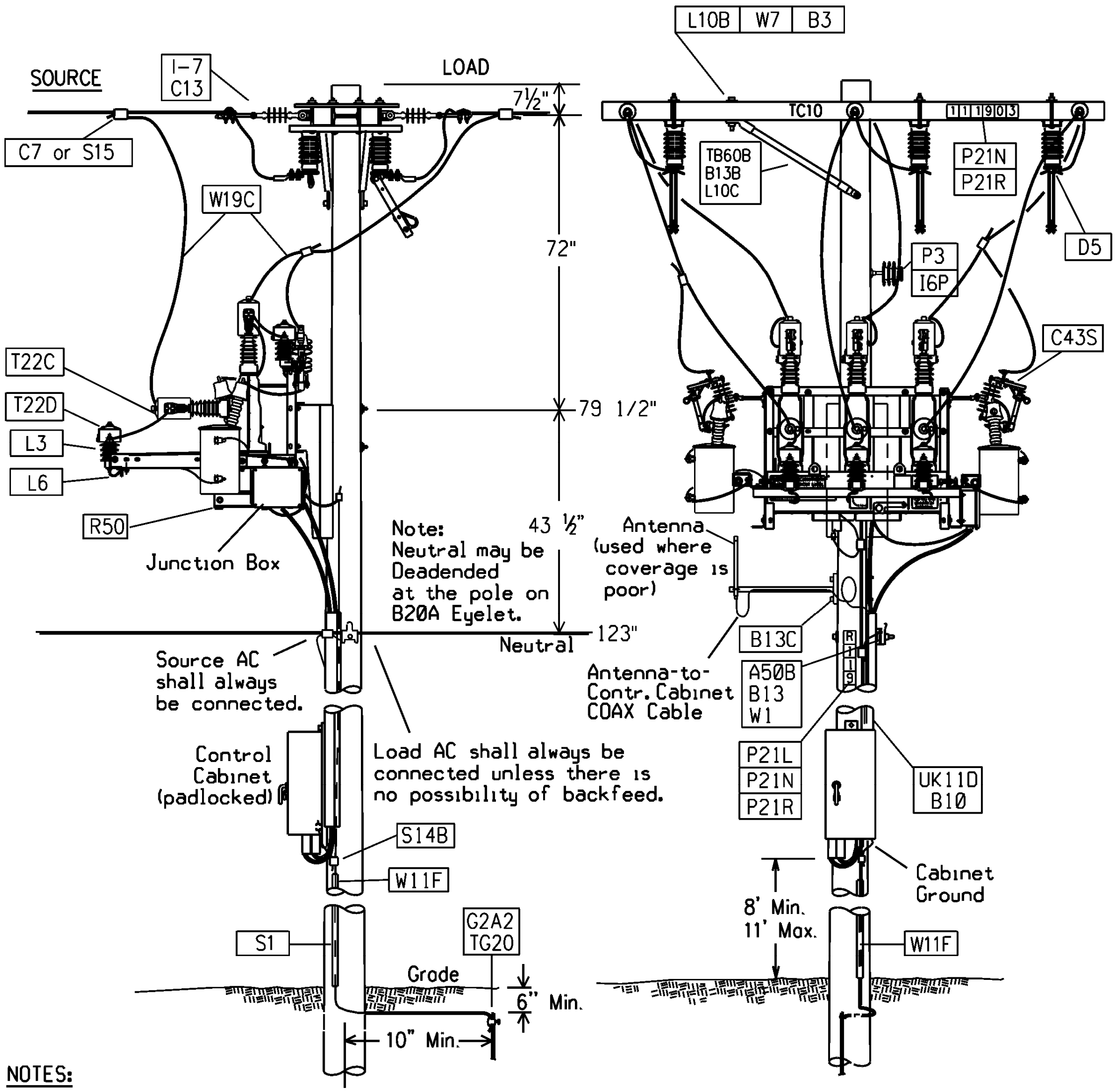




NOTE: Secondary sources shall be used solely to power recloser. No service connections shall be made on either source or load side secondary crib.

3Φ ELECTRONIC RECLOSER INSTALLATION WIRING DETAIL 15-35 KV LOOP SCHEME APPLICATIONS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 12-337	ISSUE 6/10

MU = @REC-3P,800A,(X)KV,(Y)WPT	Recloser, Three Phase Electronic, 800A, (X)=KV Voltage, (Y)=LP or RD With PTS
CU = REC-MT,3PH,(X)KV,12-133	Recloser, Mount, Three Phase, (X)=Nominal KV Voltage, 12-133
MU = @DSWBYPNE	Bypass Switch - NE
MU = @DSWBYP	Bypass Switch - NY
CU = REC-3P,CABLEFORTIER52A	Voltage Sensing Cable For Loop Scheme Tie Application



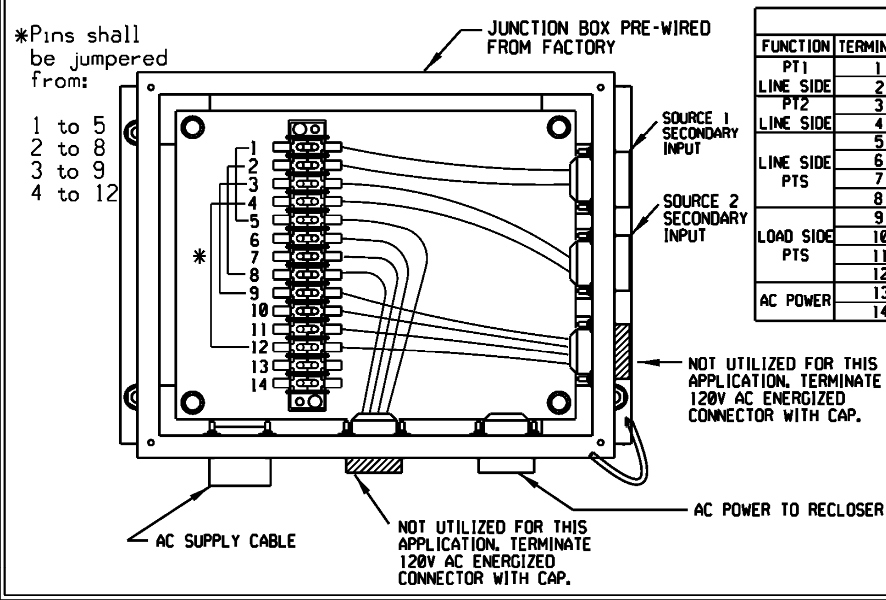
New 800A Recloser Drawing

NOTES:

1. Sectionalizing switches shall be installed onto the adjacent source or load side pole or installed adjacently in-line.
2. The control cabinet may be mounted lower than 8 feet provided such control cabinets do not overhang roadways or obstruct pedestrian traffic, and after full consideration of worker and public safety, possible vandalism, and aesthetics. A ground grid (13-114) shall be installed.
3. Do not install recloser on a pole where the construction angle is greater than 20°.
4. Control switch identification mounted vertically above control and bypass switch identification mounted horizontally onto crossarm.
5. Stinger cover (T23) can be used for recloser leads/taps for enhanced wildlife protection.
6. Loop Scheme Tie applications require an additional 4-conductor supply cable (Std. Item R52A) to accommodate voltage sensing on the Source 2 ("load side") three phase input.

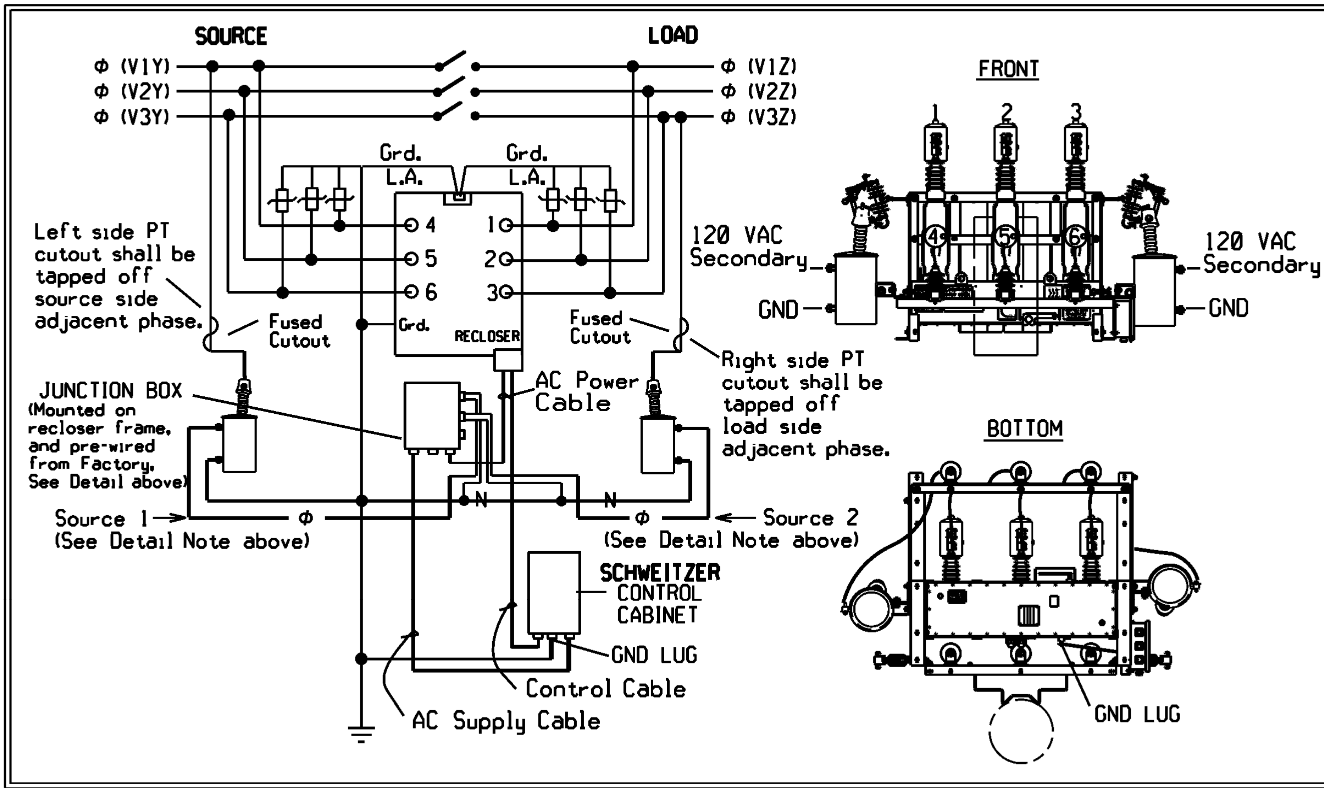
New Radial Junction Box Detail

GENERAL WIRING DIAGRAM 15kV RADIAL WITH PT



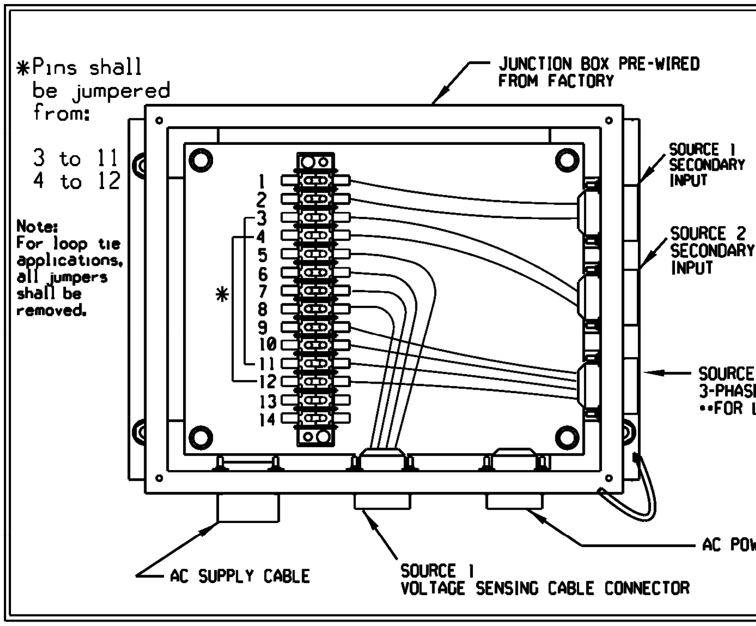
JUNCTION BOX COLOR CODE

FUNCTION	TERMINAL *	INPUTS	19 POSTION CONNECTOR
PT1 LINE SIDE	1	BLACK, S1 SECONDARY INPUT	ORANGE
	2	WHITE, S1 SECONDARY INPUT	WHITE
PT2 LINE SIDE	3	BLACK, S2 SECONDARY INPUT	BROWN
	4	WHITE, S2 SECONDARY INPUT	WHITE W/VIOLET
LINE SIDE PTS	5	BLACK, S1 SECONDARY INPUT	YELLOW
	6	RED, S1 SECONDARY INPUT	RED W/BLACK
	7	ORANGE, S1 SECONDARY INPUT	BLUE
	8	WHITE, S1 SECONDARY INPUT	WHITE W/BLACK
LOAD SIDE PTS	9	BLACK, S2 SECONDARY INPUT	BLACK
	10	RED, S2 SECONDARY INPUT	VIOLET
	11	ORANGE, S2 SECONDRY INPUT	RED
	12	WHITE, S2 SECONDARY INPUT	WHITE W/ORANGE
AC POWER	13	RED	BLUE W/BLACK
	14	WHITE	WHITE W/BLUE



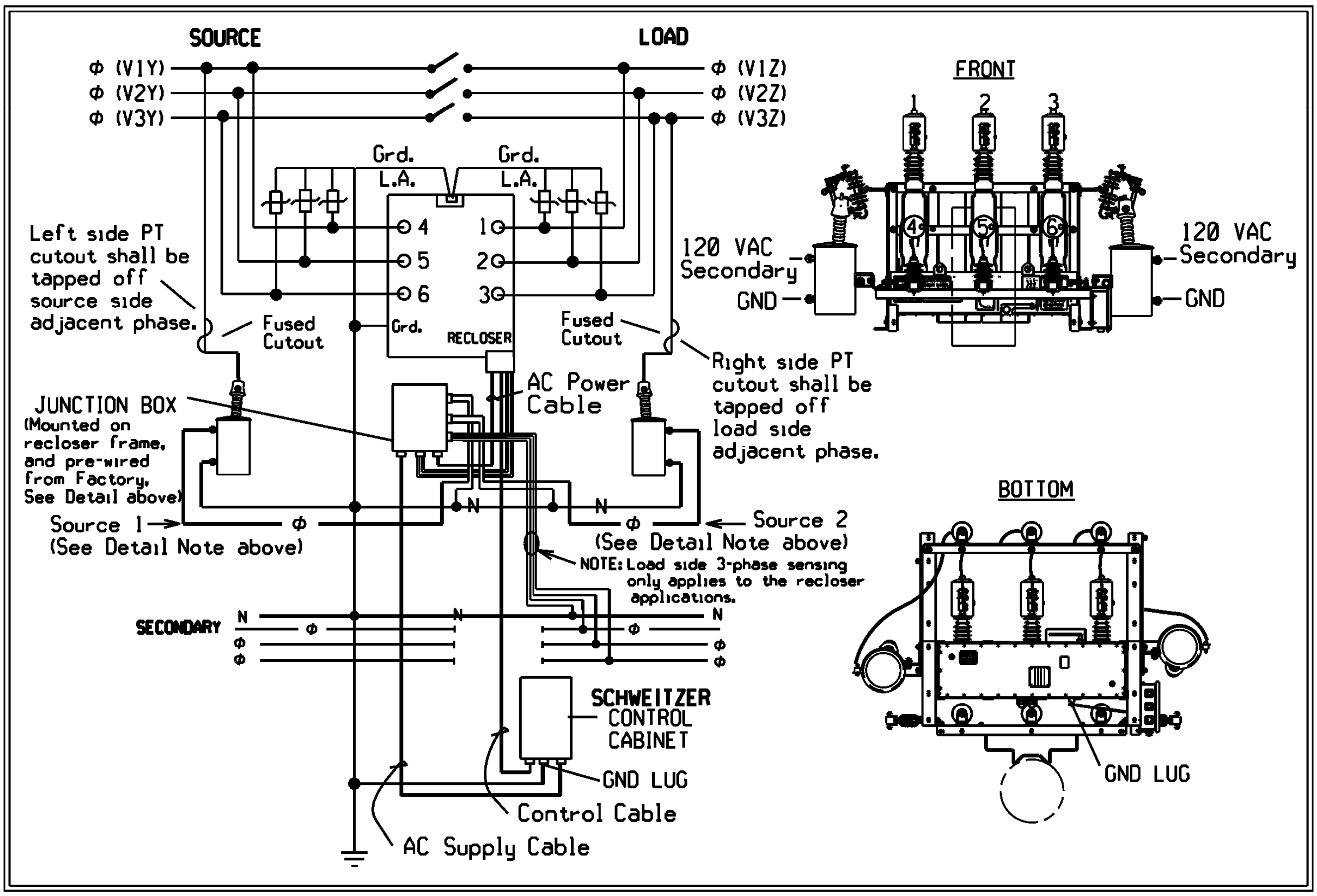
Doc. # ST. 12.00.002

GENERAL WIRING DIAGRAM 15kV LOOP WITH PT



JUNCTION BOX COLOR CODE			
FUNCTION	TERMINAL *	INPUTS	19 POSTION CONNECTOR
PT1	1	BLACK, S1 SECONDARY INPUT	ORANGE
LINE SIDE	2	WHITE, S1 SECONDARY INPUT	WHITE
PT2	3	BLACK, S2 SECONDARY INPUT	BROWN
LINE SIDE	4	WHITE, S2 SECONDARY INPUT	WHITE W/VIOLET
LINE SIDE PTS	5	BLACK, S1 SECONDARY INPUT	YELLOW
	6	RED, S1 SECONDARY INPUT	RED W/BLACK
	7	ORANGE, S1 SECONDARY INPUT	BLUE
	8	WHITE, S1 SECONDARY INPUT	WHITE W/BLACK
LOAD SIDE PTS	9	BLACK, S2 SECONDARY INPUT	BLACK
	10	RED, S2 SECONDARY INPUT	VIOLET
	11	ORANGE, S2 SECONDRY INPUT	RED
	12	WHITE, S2 SECONDARY INPUT	WHITE W/ORANGE
AC POWER	13	RED	BLUE W/BLACK
	14	WHITE	WHITE W/BLUE

120V SUPPLY CONNECTIONS	
WIRE COLOR/VOLTAGE	CONNECT TO
SOURCE 2 •(LS TIE APPLICATION ONLY)•	
BLACK 120V	BUSHING 1
RED 120V	BUSHING 2
ORANGE 120V	BUSHING 3
WHITE -	NEUTRAL



New LS Junction Box Detail Drawing

3Φ ELECTRONIC RECLOSER INSTALLATION WIRING DETAIL 12.47 KV, 13.2 KV, 13.8 KV LS APPLICATIONS WITH FRAME MOUNTED PT'S			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
6/10	12-340		

Version	Date	Modifications	Author(s)	Approval by (Name/Title)
4	7/13	• 12-332 New Standard – 1 Phase Vacuum operated cutout mounted recloser. • 12-134 Updated to match 9-435 • Added G&W Recloser application Table • Appended Note 1 on 12-141 • Added Section 12.5.70.A.4 Single Phase Reclosers	Robert Johnson	Robert Johnson Program Manager CQ&EM Standards, Policies, and Codes
3	7/12	• 12-134 – Updated to match 9-435.- Cutouts on top crossarm. Added note to use 10' crossarms for 35kV • 12-133- Added note to use 10' crossarms for 35kV	Dave Allen	Susan Fleck, VP of Standards, Policies, and Codes
2	7/11	• 12-144 - New Standard - 3Φ PRIMARY SECTIONALIZING – HOOK STICK LOADBREAK SWITCH BELOW CROSSARM INSTALLATION 15 KV • 12-145 - New Standard - 3Φ PRIMARY SECTIONALIZING – HOOK STICK LOADBREAK CONDUCTOR DEADEND ON SWITCH INSTALLATION 15 KV	Mike Brigandi	Susan Fleck, VP of Standards, Policies, and Codes
1	6/10	• Under 12.5.70, Edited section to reflect 800A radial and LS recloser configurations, Removed 'Radial Recloser Control' section. • Revised notes on 12-129, 12-130, 12-134 • Added new Standards drawings 12-335, 12-336, 12-337, 12-338, 12-339, 12-340	Mike Brigandi, John-Paul Knauss	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/06 Issue – Title for page 13-114 corrected and page numbers updated.

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13.0 GENERAL

13.0.10 Grounding

Grounding is an essential component of the overhead electric distribution system. Grounding certain types of circuits serve to protect workers and the public from being exposed to dangerous voltage levels. Grounding aids fuses and relays in system protective schemes to clear faulted circuits, and it also helps drain high voltage lightning surges from overhead distribution lines.

Grounding is usually accomplished by establishing an adequate connection to a driven ground rod, or rods, and then connecting to a continuous common neutral system if accessible.

Multiple grounds may be required to assure a low resistance connection to Earth. Driven grounds with connections to a continuous neutral are designed into an effectively grounded system. Driven grounds are also required on not effectively grounded (e.g. 4.8 kV) circuits through the secondary neutral, which effectively ties together all customer-owned grounds. Neutral secondary systems of not effectively grounded primary circuits shall not be electrically interconnected to effectively grounded circuit neutrals. An open section using a deadend insulator shall be provided between these two systems. This is to prevent transfer of neutral-to-Earth voltage onto the not effectively grounded secondary system from the effectively grounded system neutral. (The general bonding to communication company messengers may circumvent efforts to isolate some systems.)

When cutting over a not effectively grounded circuit to an effectively grounded circuit, a grounded neutral system shall be established.

While all low voltage circuits shown in these standards are grounded, some existing 480 V or 600 V not effectively grounded circuits are not solidly grounded. Certain circuits used in the oil industry, in tunnels, and other special applications are also ungrounded. Work on such circuits shall be done under the direction of persons who are familiar with the safety and lightning protection problems involved.

13.0.20 Bonding

Bonds are installed to limit the potential between two or more grounded systems. Bonds also improve lightning protection and general effectiveness of each system through multiple ground connections. Bonds are required between the Company's system neutral and grounded communication messengers on the same poles in grounded wye systems and between the Company's secondary neutral and grounded communication messengers on the same poles in delta and uni-grounded systems. There are some cases where a utility may desire an independent secondary grounding system, to limit stray voltage (in delta and uni-grounded systems)but, the grounded communication messengers must be bonded to the grounded system neutral where one exists.

13.0.30 Lightning Protection – General

Surge arresters provide a low resistance path across equipment when exposed to lightning or switching surges. This reduces the probability of insulation flash-over, or otherwise damaging equipment or lines. Arresters serve to drain the excess charge from lines, thereby reducing the probability of conductor burn down due to overvoltages that result. A metal oxide varistor (MOV) has very low resistance to the current of a high voltage surge and very high resistance to normal 60 Hz voltages. Once the voltage level returns to normal (below the maximum continuous operating voltage [MCOV]), negligible leakage current flows through the arrester.

Supersedes 1/07 Issue – Clarified communication messenger bonding requirement.

Riser type, intermediate type, and station type arresters have lower discharge characteristics and therefore provide better equipment overvoltage protection. However, distribution type arresters do limit voltages from lightning strikes below the basic impulse level (BIL) of the equipment used on distribution circuits.
On effectively grounded systems, the arrester down-ground lead to a driven ground rod is always bonded to the system neutral and any available communication messengers, as shown on Page 13-115. On not effectively grounded primary systems, some special problems can be avoided by not interconnecting the arrester down-ground to the messengers of the other utilities.

13.1 WHAT TO GROUND

13.1.10 The following equipment and circuits shall be grounded:

A. Neutrals & Secondaries of Distribution Transformers
1. The neutral wire of each 120 V single phase, 2 wire circuit
2. The neutral wire of each 120/240 V single phase, 3 wire circuit
3. The neutral wire of each 208Y/120 V single phase, 3 wire circuit
4. The neutral wire of each 208Y/120 V or 480Y/277 V 3 phase, 4 wire circuit
5. One phase wire of each 240 V three phase circuit (has been general practice)

Each of the above secondary systems shall be grounded to a driven ground rod at both the transformer pole and at the customer's service point.

B. Secondaries of Metering

C. Neutrals of Effectively Grounded Primary Circuits

D. Ground Terminals of Surge Arresters

E. Metallic Cable Sheaths or Concentric Neutral Conductor on Riser Poles and Metal Conduits Containing Non-Metallic Sheathed Cables

F. Spacer Cable and Lashed Cable Sheaths and Messenger Strands

G. The Cases or Frames of:
1. Apparatus such as capacitors, reclosers, regulators, transformers, etc.
2. Any piece of equipment that is within 8 feet of the Earth. (See Section 13.2.20C)
3. Metering transformers and housing equipment.
4. Metal operating handles of switches that can be manually operated.

13.2 HOW TO GROUND

13.2.10 General

The circuits and equipment specified in Section 13.1 shall be grounded to a driven rod or rods or to another suitable connection to Earth as discussed below. Driven ground rods shall be installed in undisturbed Earth and extend at least 8 feet below grade.

On effectively grounded primary neutral systems that have at least four ground connections per rolling mile of neutral, all ground connections and bonds may be made to a single #4 or larger copper wire that is connected to a driven ground rod. Copper compression connectors shall be used for ground conductor bonds and taps. All surge arresters shall be connected to the grounding conductor through a flexible grounding lead (L6) as shown on Page 13-115.

On not effectively grounded primary systems, the surge arrester grounding conductor and the secondary neutral grounding conductor shall be run separately to two ground rods. The two

Supersedes 1/06 Issue – Clarified ground resistance requirements, sections 13.2.20 & 13.2.30.

rods shall be separated by a minimum distance of 20 feet as per NESC Rule 97. To accomplish this, the secondary neutral grounding conductor can be extended to the next available pole, assuming no other grounding conductor is located on that pole, and connected to a down ground installed at that location.

A #4 soft drawn copper conductor with 45 mils HDPE cover (W11F) shall be used for most ground connections on distribution poles.

A ½ inch flexible molding shall be installed over all distribution down ground installations from finished grade up to 8 feet, for mechanical protection.

13.2.20 <u>Effectively Grounded Systems</u>

A. Grounding the Common Neutral

Effectively grounded common neutral systems utilize the large number of parallel connected grounds to ensure an effective low resistance to ground the common neutral. Therefore, the installation of one 8 foot rod at each required location shall be sufficient. No resistance test is required.

B. Grounding Equipment Accessible to the Public (within 8 feet of grade)

When any metal part, frame or case of the equipment listed below is installed within 8 feet of grade, such equipment shall be connected to a ground rod at the pole and the ground wire shall be connected to the common neutral. Items 1, 2, and 3 below shall also have a ground grid (see Page 13-113) when any portion is within 8 feet of grade.

1. Primary instrument transformer cabinets and primary meter housings,
2. Manually operated switch handles,
3. Control cabinets*,
4. Metal riser pipes,
5. Transformers, and
6. Regulators.

* - Control cabinets should be mounted with the lowest component (e.g. drip loop, control cable or ladder bracket) between 8 feet and 11 feet above grade. Worker access to control cabinets, including identifying locations where ladders or bucket trucks may be set up to allow worker access, shall be considered when selecting poles for the installation of equipment requiring control cabinets. After consideration of public and worker safety, potential vandalism and aesthetics, control cabinets may be mounted within 8 feet of grade with a ground rod at the pole and a ground grid (see Page 13-113). Control cabinets mounted at any height shall neither overhang roadways nor obstruct pedestrian traffic.

13.2.30 <u>Not Effectively Grounded Systems (Delta, Ungrounded Wye or Uni-grounded Wye)</u>

A. Grounding Secondary Neutrals or Equipment Not Accessible to the Public (8 feet or more above grade)

Not effectively grounded primary systems are dependent on individual grounds to ensure effective low resistance grounding. Where practical, individual ground resistance to earth shall not exceed 25 ohms. If the earth resistance of a single ground rod exceeds 25 ohms or is not tested, a second ground rod shall be installed, connected in parallel and at least 6 feet away from the first ground rod.

B. Grounding Equipment Accessible to the Public (within 8 feet of grade)

When the installation of any metal part, frame or equipment within 8 feet of grade is planned in a not effectively grounded system, installation and testing of ground rods prior to the installation of the equipment is recommended. This allows installation of the equipment 8 or more feet above grade to be considered before the installation of the equipment or ground grid, when required.

When any metal part, frame or case of the equipment listed below is installed within 8 feet of grade, such equipment shall be connected to a ground at the pole tested to 25 ohms or below. Items 1, 2, and 3 below shall also have a ground grid (see Page 13-113) when any portion is within 8 feet of grade. If after the installation of one ground rod and the ground grid, where required, the ground resistance is 25 ohms or below, no additional work is required. If the ground resistance is above 25 ohms, (i) install additional ground rods (each at least 6 feet away from each of the other ground rods) until the tested ground resistance is 25 ohms or below or (ii) move the equipment 8 or more feet above grade.

1. Primary instrument transformer cabinets and primary meter housings,
2. Manually operated switch handles,
3. Control cabinets*,
4. Metal riser pipes**,
5. Transformers, and
6. Regulators.

* - Control cabinets should be mounted with the lowest component (e.g. drip loop, control cable or ladder bracket) between 8 feet and 11 feet above grade. Worker access to control cabinets, including identifying locations where ladders or bucket trucks may be set up to allow worker access, shall be considered when selecting poles for the installation of equipment requiring control cabinets. After consideration of public and worker safety, potential vandalism and aesthetics, control cabinets may be mounted within 8 feet of grade with a ground at the pole tested to 25 ohms or below and a ground grid (see Page 13-113). Control cabinets mounted at any height shall neither overhang roadways nor obstruct pedestrian traffic.

** - Because metal riser pipes cannot be moved 8 or more feet above grade, they must have a tested ground resistance of 25 ohms or below. If, after installing 4 ground rods (each at least 6 feet away from each of the other ground rods), the tested ground resistance is above 25 ohms, contact Standards Engineering for additional options.

Supersedes 7/09 Issue – Page numbering updated.

13.3 BONDING

13.3.10 Bonding Between Different Parts of the Distribution System

Except as noted in Section 13.0.10 for not effectively grounded system secondaries, all grounded parts of the distribution system should be bonded together through connections to the system neutral; the effectively grounded secondary neutrals, spacer cable or lashed cable messengers; or through other grounded conductors. Guy wires on effectively grounded systems shall also be bonded to the system neutral or the effectively grounded secondary neutrals. In addition, spacer cable messengers shall be bonded to the system neutral at every pole. All messenger and phase conductor supports and fuse cutout brackets of spacer cable installations shall be bonded to the pole equipment grounding conductor.

The bonds shall be established at intervals along the line, at each location of driven ground rods which are installed not less than 4 per each rolling mile of line and at; transformers, arresters, capacitors, regulators or any other pole with a vertical grounding conductor installed.

13.3.20 Bonding Between Different Systems of the Company

Supersedes 7/09 Issue – Page numbering updated.

The system neutral and the messengers of spacer cable or lashed cables on the distribution system shall normally be bonded or connected to station grounds at all stations feeding the distribution lines. They shall also be connected to the vertical ground of transmission lines where they occupy the same pole.

13.3.30 Bonding Between the Company and Other Grounding Systems

The Company system neutral shall be bonded to the grounding system of other utilities that occupy the same pole. Such bonds shall be made only after consultation with other utilities. Where isolation of primary and secondary neutrals is done to minimize the effects of neutral-to-Earth voltages on customer facilities, separate neutrals must be established for these two systems. The communication messengers must be bonded only to the primary neutral at these locations.

13.3.40 Bonding Between Communication Company and the Company Grounding Systems

Bonds shall be installed between power company vertical grounding conductors connected to the system neutral in a multi-grounded wye system and to the secondary neutral in other types of systems and grounded communication company messengers. Page 13-115 shows typical installations. Communication messengers shall not be bonded to electric equipment or arrester ground wires that are not connected to an electric system neutral (separate equipment and arrester grounds are common in delta or uni-grounded systems). Caution should be used when line workers of either company removes their facilities and the associated bonds. Communication lines and Communication Company messengers include (by NESC definition) all lines used for public or private signal or communication service. Included are telephone, telegraph, railroad signal, fire and police alarms, cable television, and various other non-electrical supply lines.

Responsibility for bonding communication cable support messengers is as follows:

- Communication Company Attaching to Pole With an Existing Downground:
  The communication company bonds its support messenger to an existing downground on a pole (with an existing downground that is connected to: a system neutral on a multi-grounded wye system or a secondary neutral in other types of systems). This installation of the bond is done by the communication company at the communication company's expense. This includes bonding when existing communication company messengers and cables are transferred to replacement poles.

- Liberty Utilities Installs a Downground on Existing Pole With Communication Attachment(s):
  When a down ground (connected to a system neutral on a multi-grounded wye system or a secondary neutral in other types of systems) is installed by Liberty Utilities on an existing pole, Liberty Utilities bonds the existing communication messenger(s) to the new downground wire. This downground installation and bonding of communication company support messenger(s) is done by Liberty Utilities at Liberty Utilities's expense.

- Communication Company Requires a Bond at Pole Without an Existing Downground:
  When newly installed communication support messengers are attached to an existing pole, must be bonded to the electric neutral at that pole, and the pole does not have an existing downground, the communication company attaches a bond wire to its newly installed support messenger and leaves it coiled up in the communication space. Liberty Utilities will bring the coiled tail (bond wire) up to the supply space and bond it to the electric neutral. As shown above, the communication support messengers must be bonded to the system neutral on a multi-grounded wye system or to the secondary neutral (and not to arrester, equipment or transformer downgrounds) in other types of systems.

This bond to the electric neutral in the supply space is done by Liberty Utilities at the communication company's expense. Invoicing the communication company for this bonding is done by the engineering department as part of the work order design.

13.4 EFFECTIVELY GROUNDED PRIMARY NEUTRAL

The neutral conductor of all new distribution circuits shall be effectively grounded. Where this neutral grounding has not already been accomplished, the change from not effectively grounded to effectively grounded shall be made in connection with all new construction and large maintenance jobs.

The effectively grounded system neutral shall always follow the same route as the primary conductors and be physically located on the same pole line. The system neutral must not be opened.

On any effectively grounded section of a feeder, there shall be a minimum of four grounds per rolling mile.

The effectively grounded neutral shall be installed at the secondary level on the pole. An existing phase conductor of a single phase line on crossarms may, however, be left on 5 kV insulators and converted to an effectively grounded neutral. Where secondaries exist, the secondary neutral should be grounded at the transformer pole and bonded to the effectively grounded neutral at each end of the secondary net/crib.

Similarly, an existing conductor on a vertical or "armless" type pole top may be left on 5 kV insulators and converted to an effectively grounded neutral if there are no transformers or secondaries on the pole. If a transformer is installed on a vertical or armless pole, or if a secondary is installed on any pole, the effectively grounded neutral shall be relocated to the secondary position.

13.5 COMMON NEUTRAL

Common neutral exists wherever the same conductor serves as the neutral for both the primary and secondary circuits. Only one vertical ground wire should be installed on a pole with a common neutral.

The Common neutral shall meet the size requirement in Section 9.1.3. A common neutral shall not be used as the grounded phase conductor of a not effectively grounded secondary. It shall, however be bonded to this conductor. The secondary grounded neutral of a not effectively grounded primary circuit shall be isolated from any effectively grounded system neutral as stated above in Section 13.0.10.

Every effort should be made to preserve the continuity of the system neutral and to establish the best possible connections between the neutral and Earth. It shall meet the grounding requirements in Section 13.4 above and shall be bonded to grounded equipment whenever practicable.

13.6 LIGHTNING PROTECTION

13.6.10 General

Surge arrester protection shall be provided for capacitors, reclosers, regulators, transformers, and other equipment as prescribed in section 13.6.30 below. Surge arresters are also used to improve system reliability as prescribed in section 13.6.40 below.

When any silicon carbide (SiC) porcelain arrester is replaced with an MOV polymer arrester in a cluster mount or riser pole configuration, all SiC porcelain arresters are to be removed and replaced with MOV polymer arresters.

To obtain the proper equipment protection and arrester operation, the following practices are recommended:

A. Surge arresters shall be installed on the same pole with the equipment to be protected.
B. Surge arresters shall be connected to a driven ground at the same pole as the arrester.

Supersedes 7/08 Issue – Page numbering updated.

C. Both the line side and the ground side arrester leads shall be kept as short and as straight as possible. Long leads will significantly reduce the margin of protection provided by the arrester. For the combined line and ground lead length, normal practice is to add 1.6 kV per foot to the specified arrester discharge voltage at the discharge current level selected for coordination.

D. When installing MOV arresters, the ground lead shall be connected first. Since MOV arresters continuously conduct a small amount of current, a slight arc may be drawn when connecting the line side of the arrester.

E. When disconnecting MOV arresters, always disconnect the ground lead last. An MOV arrester should have the line end touched to the pole ground to discharge it immediately after removal since it can retain a small electrical charge for a few minutes. After removing a MOV arrester with an intact disconnector from service a restraining device should be installed to comply with U.S. Department of Transportation regulations.

F. **WARNING:** A failed arrester with a blown disconnector shall be treated as energized at full line potential at both ends of the arrester.

G. One should avoid dropping an MOV arrester. The internal charge in the disconnector could be discharged.

13.6.20 Selection Criteria

It is necessary to select the proper arrester and install it in the correct location. An improperly selected or applied arrester will not provide the desired protection to the distribution system and can lead to arrester failure and poor reliability performance. For proper selection, it is necessary to determine the following:

A. Operating voltage of the circuit
Note: No part of the circuit with connected surge arresters should normally experience voltages greater than 1.05 per unit of the nominal circuit operating voltage.

B. Basic impulse level of the equipment to be protected

C. Connection of equipment to the circuit
WARNING: Some equipment may be utilized on circuits of the same voltage class but with those voltage classes having different degrees of grounding. Be sure that the arresters specified or supplied with the equipment are of the correct rating for the specified circuit.

D. Circuit grounding type
Determine whether the circuit is effectively grounded or not effectively grounded. Engineering shall confirm circuit grounding if necessary. Effectively grounded circuits have an X0/X1 ratio of 3 or less while not effectively grounded circuits have an X0/X1 ratio of greater than 3. If, via permanent field switching, equipment has the potential to lose its effective grounding and remain energized from a not effectively grounded circuit, equipment BIL requirements and arrester application should be reviewed.

After determining the above criteria, select the proper arrester from Table 1 in Section 13.7.

13.6.30 Protecting Equipment With Surge Arresters

To protect equipment MOV surge arresters shall be installed in accordance with the following, utilizing properly rated arresters from Table 1, in Section 13.7. Actual physical arrester locations on circuits and equipment are shown in specific standard sections for the construction involved.

A. Primary Wire Transitions

Arresters are required at all junctions from bare conductors to anything other than bare conductor. This includes transitions from bare conductor to covered wire, tree wire or spacer cable. For purposes of this requirement, fabric-covered conductors (sometimes called "weatherproof" conductors) shall be considered bare conductors. These arresters protect the insulation on the covered conductor, tree wire or spacer cable from damage.

These arresters shall be placed at the pole with the wire transition and should be as close to the wire transition as possible.

Surge arresters are not required because of transitions between conductors of different materials (aluminum to copper). Surge arresters are not required because of transitions between different types or thicknesses of covering on conductors.

B. Primary Risers

Riser type surge arresters shall be installed at the transition from underground cable to open wire (bare or tree wire) or spacer cable circuits. Arresters shall be installed on the termination side of the closed disconnects immediately adjacent to the riser termination. The grounding conductor from the arrester shall be bonded to the concentric neutral or metallic sheath of the underground cable as close to the termination as possible, and to a driven ground at that pole. On grounded wye circuits, it shall also be connected to the system neutral of the overhead circuit.

C. Lashed Aerial Cables

Riser type surge arresters shall be installed at the transition from lashed aerial cable to open wire (bare or tree wire) or spacer cable circuits. Arresters shall be installed on the termination side of the closed disconnects immediately adjacent to the riser termination. The grounding conductor from the arrester shall be bonded to the concentric neutral or metallic sheath of the underground cable as close to the termination as possible, and to a driven ground at that pole. On grounded wye circuits, it shall also be connected to the system neutral of the overhead circuit.

D. Transformers

All overhead transformers shall be protected by surge arresters. Surge arrester location, and grounding and bonding methods, for overhead transformers installed on standard effectively grounded and not effectively grounded circuits are shown on Page 13-112. The arrester shall be connected to the transformer side of the primary fused cutout for conventional transformers.

> **EXCEPTION** – Floating wye - delta connected transformer banks shall not use tank mounted arresters. Surge arresters shall be crossarm mounted on the same pole as the transformer bank and connected to the source side of the fused cutouts. This connection avoids exposure of the arresters to possible overvoltages when a fuse cutout is open.

In grounded wye systems, the transformer tank and arrester ground leads shall be connected to the common neutral. In other systems, including delta systems, the transformer tank and arrester ground leads shall be isolated from the secondary neutral.

Step-down and step-up transformers, shall have surge arresters installed on all phase conductors on both the high voltage and low voltage sides of the unit. When the arresters are mounted separately (not installed on the transformers), they shall be connected between the fused cutouts or disconnect switches and the transformer bushings, as close to the transformer bushing as practical.

> **EXCEPTION** – Floating wye - delta connected transformer banks shall not use tank mounted arresters. Surge arresters shall be crossarm mounted on the same pole as the transformer bank and connected to the source side of the fused cutouts. This connection avoids exposure of the arresters to possible overvoltages when a fuse cutout is open.

Supersedes 7/08 Issue – Revised section 13.6.30 to clarify arrester application requirements.

E. Regulators

Regulators shall have tank mounted surge arresters installed on the source and load bushings. The manufacturer may also provide a bypass arrester between the source and load bushings depending upon design.

F. Primary Metering Equipment

Primary metering equipment shall be protected with surge arresters.

G. Capacitors

Capacitors shall have surge arresters. Arresters shall be connected between the fused cutouts or other switch and the capacitor bushings. Arrester connections should be made as short and as straight, and as close to the bushings, as possible. New capacitor banks are supplied with arresters already mounted on the capacitor frame.

13.6.40 **Improving Reliability With Surge Arresters**

Arresters are generally required at open points in the system and at switching points that may become open point under some operating conditions. Open points in lines become reflection points for lightning surges, producing a voltage doubling of the surge at that location. This will frequently cause insulation flashovers and result in poor reliability.

A. Fused Taps

For new construction, arresters are required on all fused taps and shall be installed on the load side of the fused cutout. Where the fused tap is being installed on a new pole, these arresters shall be installed on the tap pole. Where the fused tap is being made on an existing pole, this arrester requirement may be met in the following ways listed in order of preference:

- Existing arresters on the load side of the fused tap on any pole within 300’ of the cutout will fulfill the requirement,
- New arresters may be installed on the tap pole, and
- New arresters may be installed on an adjacent pole on the load side of the fused tap within 300’ of the cutout.

B. Airbreak and Loadbreak Switches

Surge arresters are required on all phase conductors on both sides of the switches.

For new installations, phases should be deadended above the switch frame with the arresters mounted on the switch frame. Where phases are deadended on the switch frame, arresters shall be installed on the next pole on the source and load side of the switch. If there are already surge arresters installed on all phase conductors within 300 feet of the switch, additional surge arresters on that side of the switch are not required.

When installing arresters at an adjacent pole, crossarm mounting is preferred. Where crossarm mounting of the arresters is not possible, mount arresters on a three phase fiberglass equipment mount.

It is important to install surge arresters on all three phases so that all phases experience the same level of protection. Otherwise, flashover of the lightly protected phases might occur.

Note: For existing normally closed airbreak or loadbreak switches without arresters, install arresters on both sides of the switch when the switch is to become normally open. If arrester installation is not convenient at the switch pole location, arresters should be installed on all phase conductors on the adjacent poles.

C. Disconnect Switches

Surge arresters are required on all phase conductors on both sides of the disconnect switches.

Arresters shall be installed on the next pole on the source and load side of the disconnect switches. If there are already surge arresters installed on all phase conductors within 300 feet of the disconnect switches, additional surge arresters on that side of the disconnect switches are not required.

When installing arresters at an adjacent pole, crossarm mounting is preferred. Where crossarm mounting of the arresters is not possible, mount arresters on a three phase fiberglass equipment mount.

It is important to install surge arresters on all three phases so that all phases experience the same level of protection. Otherwise, flashover of the lightly protected phases might occur.

Note: For existing normally closed disconnect switches without arresters, install arresters on both sides of the disconnect switches when the disconnect switches are to become normally open. If arrester installation is not convenient at the disconnect switch pole location, arresters should be installed on all phase conductors on the adjacent poles.

D. Line Reclosers and Sectionalizers

Line reclosers and sectionalizers shall have arresters installed on both the source and load side using the mounting provisions provided. New line reclosers are supplied with arresters already installed on the recloser. Surge arrester connections should be made as short, straight and close to the bushings as possible.

E. End of Line

Arresters shall be installed on each phase at end of line deadends. Where there is equipment with surge arresters on that pole, additional surge arrester(s) are not required for any phase that already has a surge arrester at that pole.

13.6.50 Miscellaneous

A. Customer Equipment

Surge arrester protection for customer owned equipment served at the distribution voltage is the customer's responsibility. The customer shall be advised of the degree of surge protection that may be incidentally provided by the Company, but shall be responsible for arranging and installing any additional protection requirements.

B. Generators

Any generators connected to the distribution system may impact arrester application. This connection must undergo a Company engineering review.

Supersedes 7/08 Issue – Added new sections 13.6.40 & 13.6.50 to clarify arrester application requirements.

13.7 SURGE ARRESTER APPLICATION TABLE

Surge arresters shall be selected based upon the application criteria below.

Table 1

PRIMARY CIRCUIT VOLTAGE	ARRESTER DUTY CYCLE RATING (kV)	MAX. CONTINUOUS OPERATING VOLTAGE	STANDARD ITEM NUMBER (HEAVY DUTY TYPE)	STANDARD ITEM NUMBER (RISER TYPE)
2400 Delta 4160 Grd Y/2400	3	2.55 kV	L3A	L3DR
4160 Delta 4800 Delta 8320 Grd Y/4800 7200 Delta	10	8.40 kV	L3D	
12470 Grd Y/7200 13200 Grd Y/7620 13800 Grd Y/7960 11000 Delta	12	10.2 kV	L3E	L3ER
11500 Delta 12000 Delta 13200 Delta 13800 Delta	15	12.7 kV	L3F	L3FR
22900 Grd Y/13200 23900 Grd Y/13800 24940 Grd Y/14400	21	17.0 kV	L3G	L3GR
34500 Grd Y/19900 22900 Delta 23000 Delta 23900 Delta 34500 Delta	27	22.0 kV	L3J	L3JR

Supersedes 7/09 Issue – Page numbering updated.

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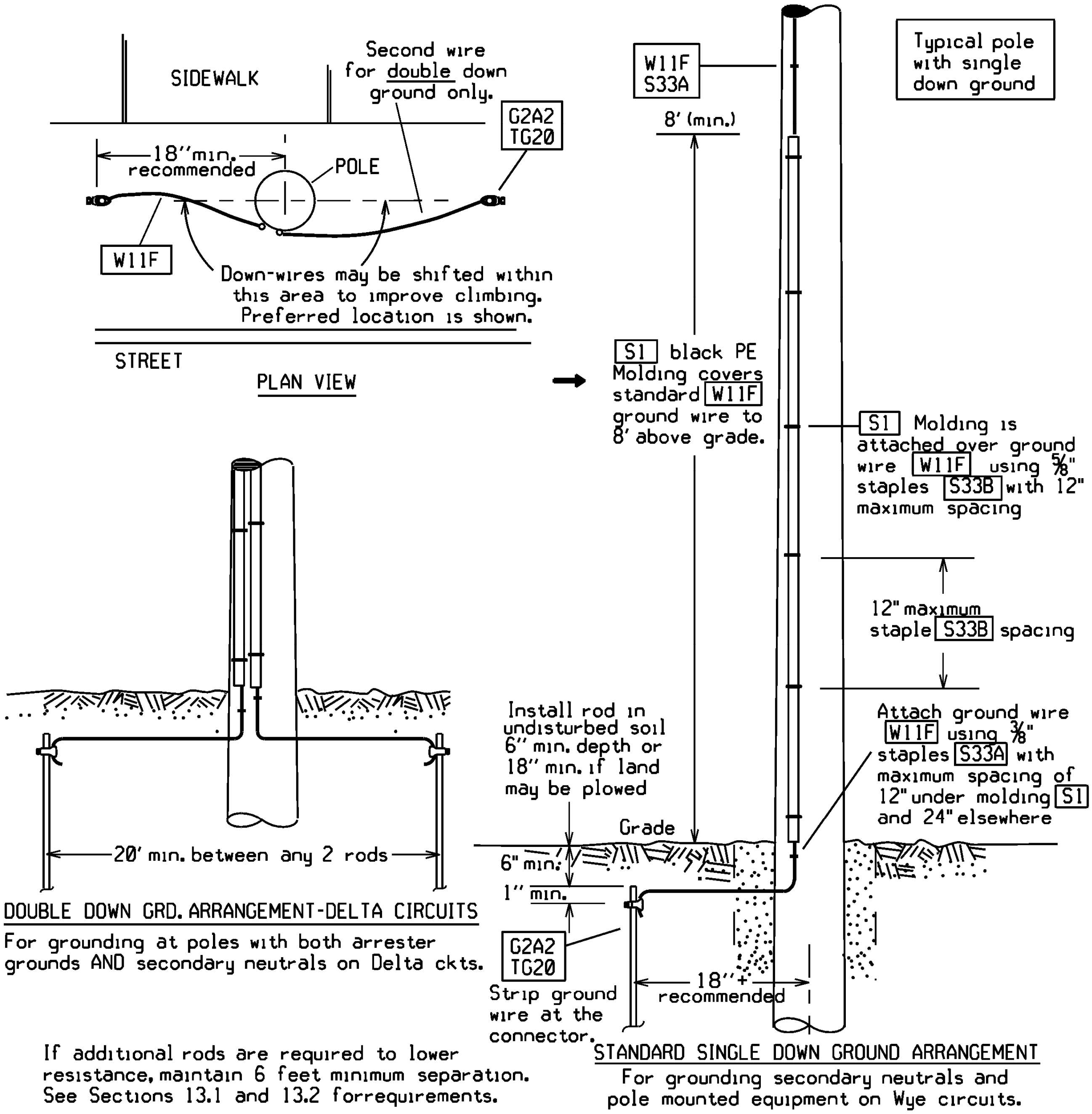
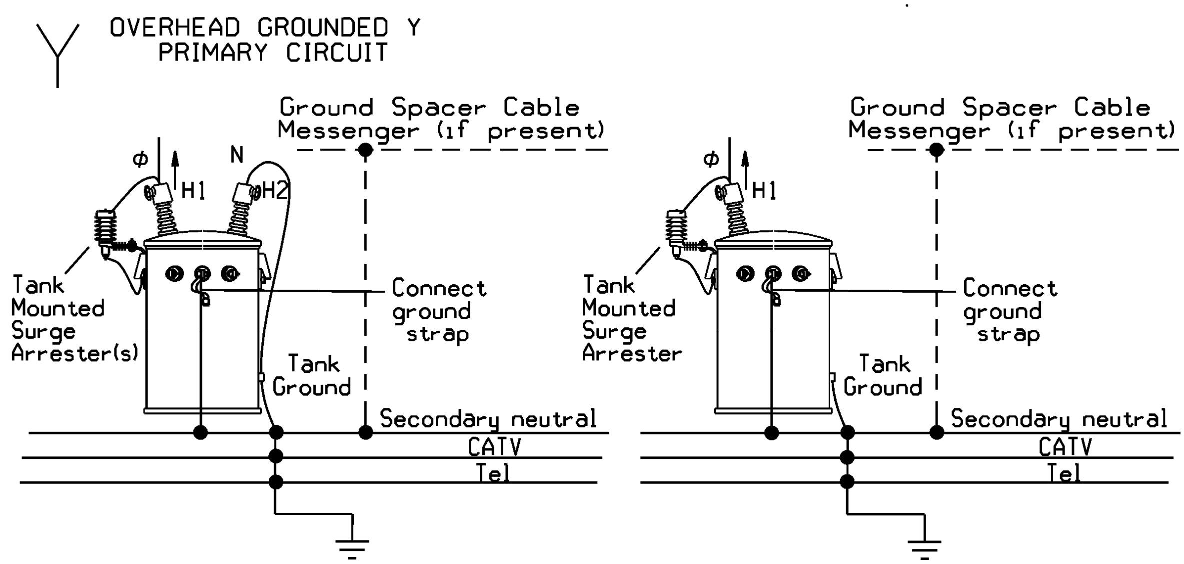
Supersedes 7/098 Issue – Revised staple requirements for bottom 8 feet.



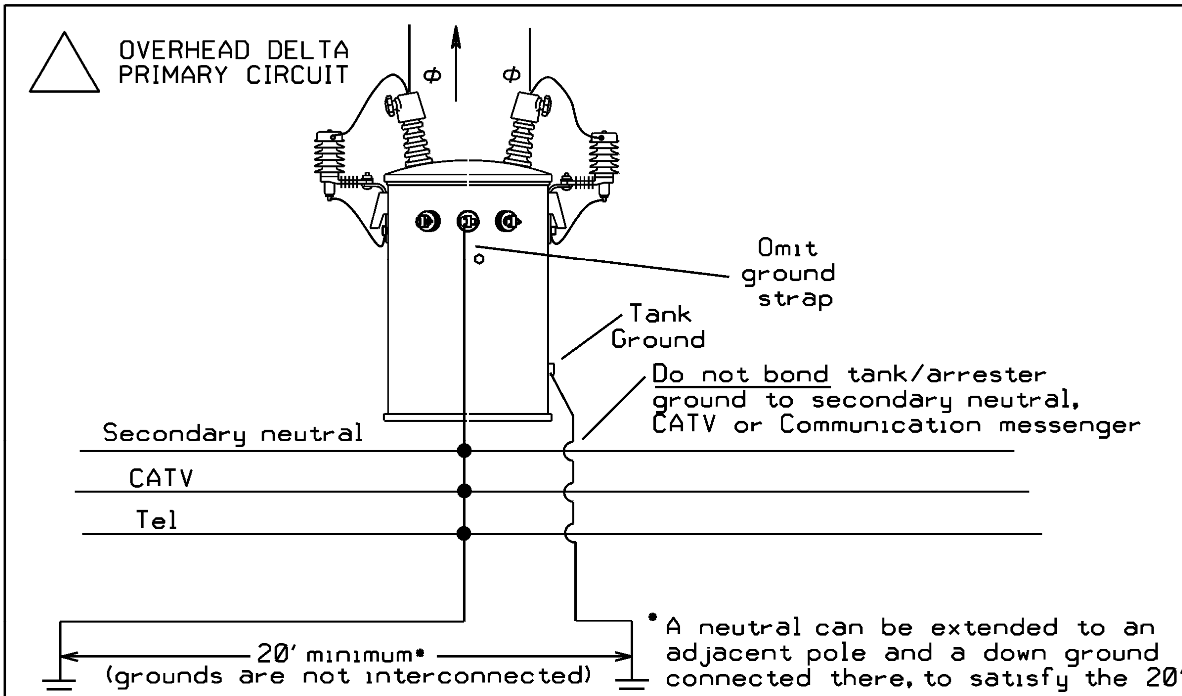
If additional rods are required to lower resistance, maintain 6 feet minimum separation. See Sections 13.1 and 13.2 forrequirements.

NOTES:
1. Cover down ground with (S1) PE Molding for the first 8' above grade.
2. Use ground rod driving head when installing ground rods.
3. Install rods into undisturbed soil and maintain 6' min. spacing between any 2 rods.
4. Only one 8' driven ground rod is required if the ground wire is interconnected to a multigrounded neutral and the pole has no equipment within 8' of grade (see 13.2.10).
5. For typical overhead transformer grounding, see Drawing 13-112.



per ANSI C57.105 Sect. 2.5.1 and C57.12.20 Para. 6.1.3.1 convention is to consider the H2 bushing as the grounded bushing (or winding terminus).

GROUNDING OF OVERHEAD TRANSFORMERS ON GROUNDED WYE CIRCUITS
(Except 3Φ Delta Secondary Services - i.e. Fig. 4, Dwg. 14-304)



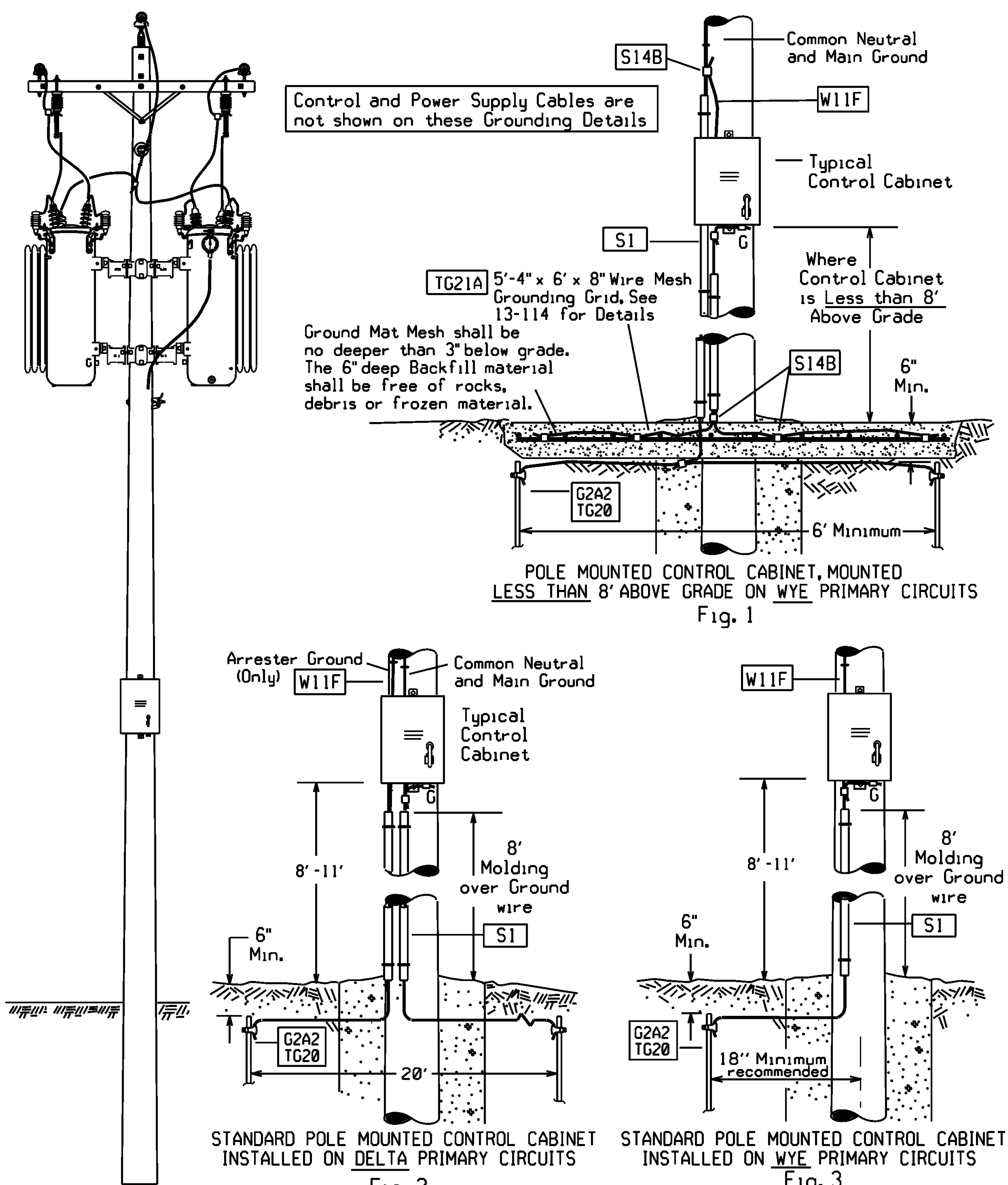
• A neutral can be extended to an adjacent pole and a down ground connected there, to satisfy the 20' requirement.

GROUNDING OF OVERHEAD TRANSFORMERS ON UNGROUNDED WYE AND DELTA CIRCUITS

Supersedes 7/08 Issue – Modified arrester and tank grounds for grounded-wye transformers.

GROUNDING FOR OVERHEAD TRANSFORMERS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/08	13-112		

CU = CSVG	Single Vertical Ground
CU = CDVG	Double Vertical Ground
CU = CDVGG	Grounding Grid



POLE MOUNTED CONTROL CABINET, MOUNTED LESS THAN 8' ABOVE GRADE ON WYE PRIMARY CIRCUITS
Fig. 1

STANDARD POLE MOUNTED CONTROL CABINET INSTALLED ON DELTA PRIMARY CIRCUITS
Fig. 2

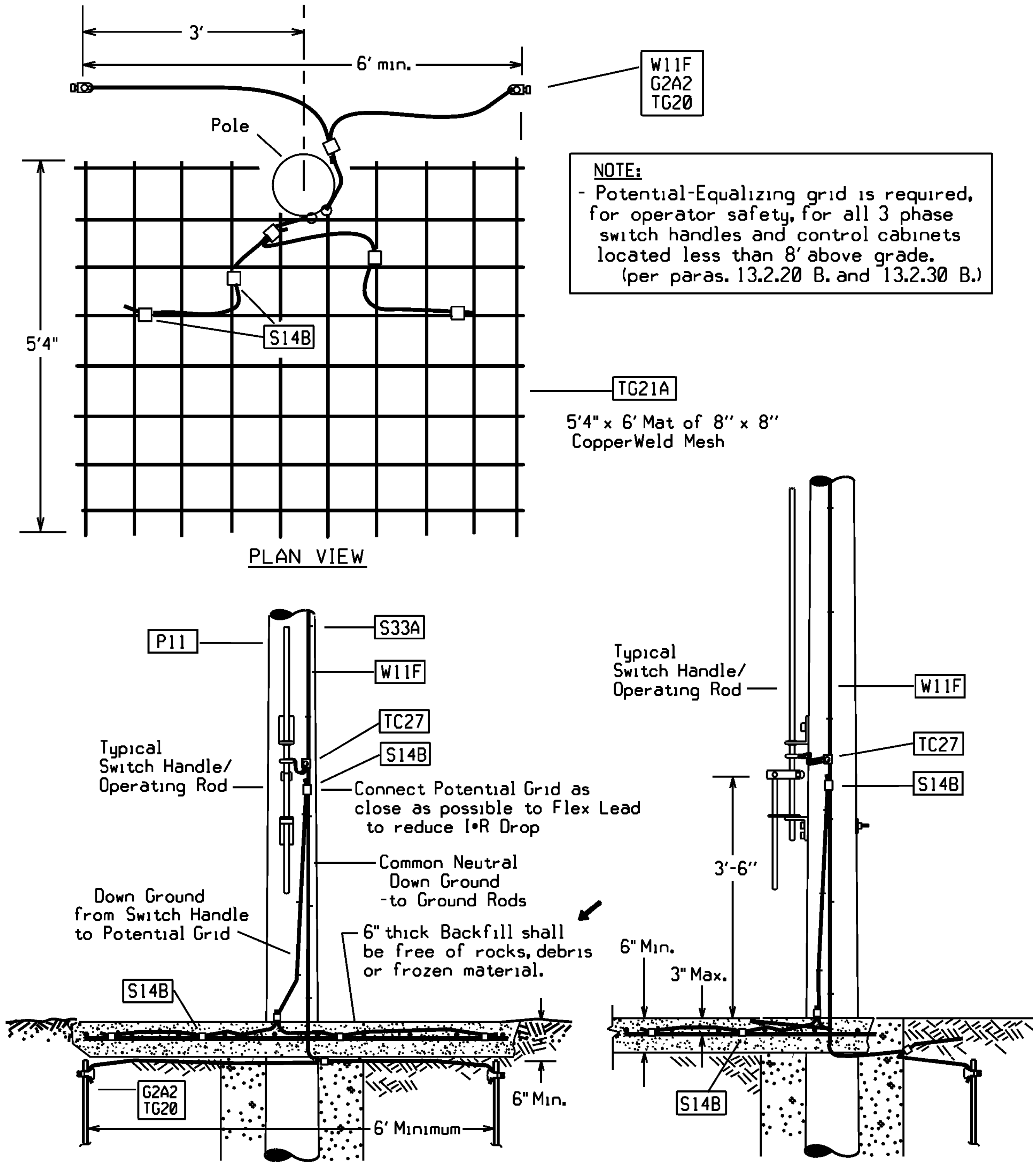
STANDARD POLE MOUNTED CONTROL CABINET INSTALLED ON WYE PRIMARY CIRCUITS
Fig. 3

Supersedes 7/08 – Revised ground mat size.

GROUNDING FOR OVERHEAD EQUIPMENT CONTROL CABINETS

 Doc. # ST. 13.00.002

CU = CSVG	Single Vertical Ground
CU = CDVG	Double Vertical Ground
CU = GRD-GRID,MESH,13-114	Grounding Grid, Mesh 8"X8", 6'X5' Area, TG21



NOTE:
- Potential-Equalizing grid is required, for operator safety, for all 3 phase switch handles and control cabinets located less than 8' above grade.
(per paras. 13.2.20 B. and 13.2.30 B.)

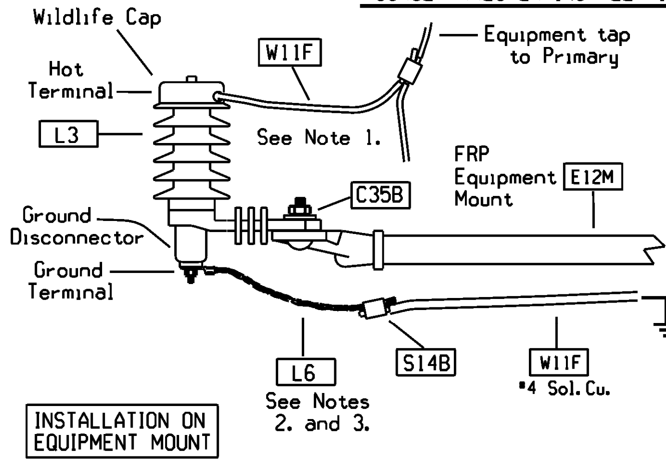
Supersedes 7/08 Issue – Revised ground mat size.

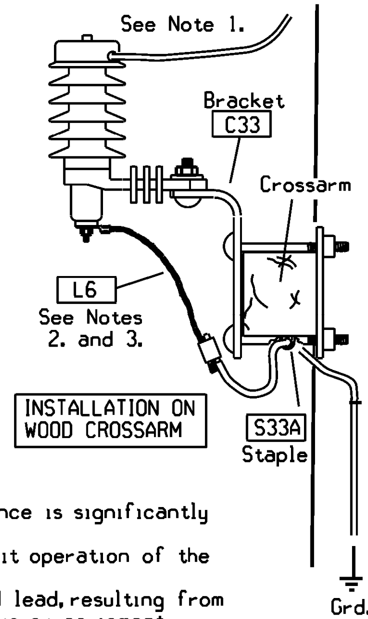
GROUNDING FOR MANUALLY OPERATED SWITCH HANDLE

ISSUE	PAGE NUMBER		
7/12	13-114	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Supersedes 7/08 Issue – Added Note 4 in Surge Installation Notes.

SURGE ARRESTER INSTALLATION DETAILS



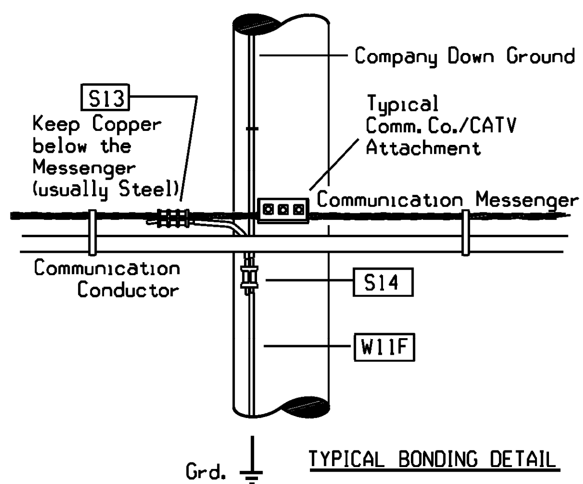


SURGE ARRESTER INSTALLATION NOTES:

1. Keep arrester lead(s) length to a minimum. Arrester performance is significantly reduced by long conductors. See Text Section 13.0.30.
2. Flexible braid grounding lead (Item L6) must be used to permit operation of the disconnector. Do not staple, restrain or shorten flex lead.
3. Grounding arrangement shall be installed so that a detached lead, resulting from a faulted arrester, can not make contact with live conductors or equipment.
4. Installing arresters on wood or fiberglass crossarms:
   a. All three phases are protected by arresters:
      Arrester ground leads should be attached to the bottom of the crossarm to restrain blown disconnectors. A ground wire should be attached under the crossarm between arrester ground leads to connect all of the arresters to the down ground.
   b. Two phases are protected by arresters:
      Arrester ground leads should be attached to the bottom of the crossarm to restrain blown disconnectors. Maintain 20" of wood insulation between the arrester ground leads attached to the crossarm and metal hardware supporting insulators of the phase not protected by an arrester. This may require floating all or part of the lead to the down ground.
   c. One phase is protected by an arrester:
      The arrester ground lead should be attached to the bottom of the crossarm to restrain a blown disconnector. Maintain 20" of wood insulation between the arrester ground lead attached to the crossarm and metal hardware supporting insulators of either of the other two phases. This may require floating all or part of the lead to the down ground.
   d. Attach arrester ground leads to wood crossarms using staples (S33A).
   e. Attach arrester ground leads to fiberglass crossarms using grounding kit (S34).

GENERAL BONDING NOTES:

1. The NESC currently requires the bonding of communications messengers and effectively grounded system neutrals.
2. Communication mesenger strand shall not be bonded to vertical ground conductor unless that conductor is connected to the electric neutral or messenger.
3. Bond spacer cable messenger to common neutral at each support pole and to a driven ground at frequent points, not more than 800' apart.
4. Bond the messenger of primary lashed aerial cable to secondary or common neutral at each transformer, at ends of each secondary and elsewhere to provide a bond at every fourth pole.
5. Bolted connectors should not be used to splice or bond ground wires.



TYPICAL BONDING DETAIL

 | Doc. # ST. 13.00.002

Version	Date	Modification	Author(s)	Approval by (Name/Title)
5	7/12	• Revised ground mat size on pages 13-113 and 13-114.	G. Paul Anundson	Susan Fleck, VP of Standards, Policies and Codes
4	7/11	• Added Note 4 to top drawing on page 13-115, clarifying requirements for restraining arrester ground leads.	G. Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods
3	7/10	• Revised 13.2.20 and 13.2.30 to clarify testing requirements for grounds in delta systems. • Replaced 13.6.30 with new sections 13.6.30 through 13.6.50 to clarify arrester application requirements.	Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods
2	7/09	• Under 13.0.20, clarified communication messenger bonding requirement. • Under 13.3.40, communication messenger bonding information modified. • Required additional staples for theft prevention on bottom 8 feet of downground on page 13-111. • Modified arrester and tank grounds for grounded-wye transformers on page 13-112.	Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods
1	07/08	• Under 13.3.40, communication messenger bonding information modified. • Under 13.6.30.A.3, clarified application of surge arresters on existing fused taps. • Under 13.6.30.B.5, location of arresters at capacitors corrected. • Added ground lead from arrester to transformer tank on page 13-112. • Corrected page title on page 3-114. • Modified communication bonding requirements on page 3-115.	Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/06 Issue - Updated page numbers.

 Doc. # ST. 14.00.001

Supersedes 1/06 Issue - Corrected Ppge reference in 3rd paragraph on Section 14.0

14.0 GENERAL

This section covers the details of installing and connecting transformers. It also provides guidance on selection of dual voltage rated versus single voltage rated transformers. While conventional transformers are the standard transformer, completely self protected (CSP) transformers will be covered for maintenance purposes. The selection of transformer size and loading is covered in Section 10-Secondaries. Details of fusing, grounding, and lightning protection are covered in Section 12-Fuses and Section 13-Grounding.

In general, conventional ANSI Standard Distribution Transformers will be purchased and considered as the "Standard" transformers for the overhead system. However, existing transformers in good condition shall be used or reused whenever practical.

Normal transformer design life is derived from projected material heat aging of its internal components. The nameplate kVA rating of the transformer is the load at which the unit can be continuously operated in severe (high temperature) conditions without loss of service life. Generally, transformers may, for limited periods, be loaded above nameplate. See Page 10-10.

14.1 LOCATION

The location of transformers is discussed in Section 10-Secondaries. In general, transformers shall be placed as near to the center of the load served as possible.

Transformers shall be installed only on sound poles with a life expectancy of at least 10 years. Placement on corners, junctions, or other congested poles should be avoided. Banks should be located to minimize exposure to traffic when practicable.

When transformers are placed on poles carrying joint construction or street lighting fixtures, special care must be taken to provide required clearances. Where extra pole height can be avoided by turning the transformer to permit the secondary to pass by the case at higher level, such method should be used as shown on Page 14-121.

14.2 SIZING AND LOADING

Transformer size and loading is discussed in Section 10-Secondaries.

14.3 INSTALLATION

Details for installing overhead transformers in 3 phase applications are shown starting at Page 14-301. The recommended maximum sizes shown on these drawings are based on modern transformers mounted on standard poles. When the poles are already heavily stressed by wire loading, heavy down guys, or by unbalanced angle or service pulls, pole strength should be checked. Transformers heavier than recommended maximum may be used with approval of Standards Engineering. (See Page 14-80 for approximate weights of transformers).

Clearances and crossarm pole top designs for the various standard size and types of transformers and voltages are shown on Pages 14-200 thru 14-300. Consult Section 14-Transformer Index for specific applications. **Note: See Section 16-Aerial/Spacer Cable for additional designs of transformer installations on spacer cable.**

14.4 CONNECTIONS

14.4.10 Secondary Connections

Secondary connections for overhead transformers are shown in Section 10. Transformers shall not normally be banked (multiple banks on the same secondary net) on the secondary side. Polyethylene or other covered copper conductors are recommended transformer leads with sizes as shown in Table 1 and 2. Equivalent aluminum conductors with compression type aluminum to copper transition terminals may be substituted.

Use the following copper conductors for secondary in air.

Table 1

FOR 3 PHASE BANKS		
Transformer kVA Size (Each Tank)	**L.V. Copper Conductor Size**	
	208Y/120 V Secondary	**480Y/277 V Secondary**
10 & 15	#2 (W13E)	#2 (W13E)
25	#4/0 (W19C)	#2 (W13E)
37½ & 50	#4/0 (W19C)	#4/0 (W19C)
75	500 kcmil (UC9G)	#4/0 (W19C)
100	Double 4/0	#4/0 (W19C)
167	Double 500 kcmil	500 kcmil (UC5G)

Table 2

FOR 1 PHASE TRANSFORMERS	
Transformer kVA Size	**L.V. Copper Conductor Size 120/240 V**
5 – 25	#2 (W13E)
37½ – 75	#4/0 (W19C)

Note: Double #4/0 may be substituted for single 500 kcmil above.

14.4.20 Primary Connections

Primary connections and grounding details are shown on the installation drawings starting on Page 14-204. No connection diagrams are shown for unigrounded neutral circuits. When transformers are installed, such circuits shall be converted to the multigrounded systems as discussed in Section 13-Grounding.

Connection diagrams are not shown for Open Wye or Open Delta banks or for Scott connections. Also, omitted are connections for 4,160 V Delta, 6,900 V, 11,000 V, and other special circuits. If such installations are essential, details shall be furnished by Engineering Design.

The use of distribution transformers as voltage boosters is not recommended.

Use the copper conductors shown on Table 3 for connections of the transformer high-voltage bushing to the primary circuit. Due to breakage concerns, #2 Cu AWG is the minimum recommended conductor size.

Table 3

PRIMARY WIRING FOR OVERHEAD TRANSFORMERS					
Description	**Size & Bushing**		**Conductor**	**Std. Item**	**Item ID**
Standard Secondary Transformers	10 – 167 kVA	H.V.	#2 Str. Cu.	W13E	4001042
Primary Dual Voltage/Step-Down Transformers	50 – 167 kVA	H.V. & L.V.	#2 Str. Cu.		
	250 – 500 kVA	H.V.	#2 Str. Cu.		
		L.V.	#4/0 Str. Cu.	W33C	4020111

Supersedes 7/08 Issue – Revised Table 1 Standard Item #

14.5 SELECTION OF TRANSFORMERS

Conventional transformers are to be used for all new installations. Where CSP transformers are used, conventional transformers with external fusing shall be used to replace CSP transformers where space allows. If a CSP transformer in a 3 phase bank needs to be replaced, all three transformers in the bank shall be replaced with conventional transformers. Where space is limited, consider a pole top extension or replace the existing pole with a taller pole. Replacing existing CSP transformers with another CSP transformer will delay the ability to better coordinate feeder/tap fusing to improve reliability. Anytime a CSP transformer is taken out of service for routine maintenance or emergency repairs, it shall have an open style fused cutout (s) installed. The CSP transformers shall be fused as a conventional transformer. **WARNING: Never** use CSP transformers for 3 phase banks on Delta secondary systems (an open CSP secondary breaker would result in undesirable voltage imbalances and reduces load capability).

Normally, a new 3 phase service will not be made available for a residential service. Non-residential loads greater than 100 kVA shall be supplied by 3 a phase service. New 3 phase services requiring larger than 3-100 kVA, 208Y/120 (3-167 kVA if 480Y/277) transformers shall be supplied by non-pole mounted equipment.

Single bushing transformers shall not be used for Wye-Delta connections. See Page 14-78 for recommended transformers for most common distribution circuits. Refer to Section 22-Material Catalog for a listing of standard transformers.

14.5.10 Protection

For cutout fuse selection for conventional transformers, and current limiting fuse selection for conventional and CSP transformers, see Section 12-Protection.

14.6 GROUNDING OF TRANSFORMERS

See Section 13-Grounding for details on grounding transformers

14.7 STEP-DOWN/STEP-UP TRANSFORMERS

Certain branch lines may be supplied through step-down/step-up transformers for the following reasons:

A. Where immediate conversion is not economically justified.
B. To relieve load from a lower voltage distribution feeder.

Conversely, certain branch feeders requiring immediate conversion to a higher voltage, where conversion of the entire area is not justified, may be supplied through step-up transformers.

14.7.10 Step-down/step-up Transformer Connections

Table 1 shows what transformers to use for step-down/ step-up transformers. Engineering Design will issue the phasor connection diagram(s) when the branch line that is supplied from a step-down/step-up transformers, may be phased to either another feeder or branch of the same feeder of equal voltage rating.

Supersedes 7/08 Issue – Removed "ratio" from 14.7.10 title.

Table 1

Primary Feeder – 3 Phase	Secondary Feeder – 3 Phase			
	For 3 Phase, 3 Wire Feeders of 2400 or 4800 Volts Delta		3 Phase, 4 Wire of 4160, 8320, 12470, 13200 or 13800 Volts Wye	
	Transformer Primary Voltage Rating	Transformer Connection	Transformer Primary Voltage Rating	Transformer Connection
12470 Volts Wye 4 Wire	7200/12470Y	Wye-Delta	7200/12470Y	Wye-Wye
13200 Volts 3 Wire	13800/23900Y (At 95% Taps)	Delta-Delta	13800/23900Y (At 95% Taps)	Delta-Wye
13200 Volts Wye 4 Wire	7620/13200Y(1) 13800/23900Y(2) (At 95% Taps)	Wye-Delta Delta-Delta	7620/13200Y(1) 13800/23900Y(2) (At 95% Taps)	Wye-Wye Delta-Wye
13800 Volts 3 Wire	13800/23900Y (At 100% Taps)	Delta-Delta	13800/23900Y (At 100% Taps)	Delta-Wye
13800 Volts Wye 4 Wire	7970/13800Y 13800/23900Y(2) (At 100% Taps)	Wye-Delta Delta-Delta	7970/13800Y 13800/23900Y(2) (At 100% Taps)	Wye-Wye Delta-Wye
23000 Volts 3 Wire	22900	Delta-Delta	22900	Delta-Wye
23000 Volts Wye 4 Wire	13800/23900Y (At 100% Taps)	Wye-Delta	13800/23900Y (At 100% Taps)	Wye-Wye
34500Volts Wye 4 Wire	-	-	19920/34500Y	Wye-Wye

14.7.20 Neutral Connection

Wye-Delta connections shall have the high side neutral not connected.

Wye-Wye connection shall have both the high and low side neutrals connected together and to the system and connected to a driven ground.

Delta-Wye connection shall have the low side neutral connected to the low side feeder neutral and to a driven ground.

14.7.30 Floating Wye/Delta Step-down/Step-up Transformer Installation/Operation Recommendations

A. Installation

1. Consistency in installations and conformance with the construction standards needs to be followed.

2. Proper secondary load balancing can improve the voltage supply quality during normal and abnormal events significantly reducing overvoltages from occurring. The maximum allowable current unbalance should not be greater than 25%, which has been determined through experience and independent research. The current unbalance is determined by measuring the current of each of the three legs and then calculating the percent current unbalance using the following formula

Supersedes 1/06 Issue – Revised wording in paragraph 14.7.30.

$$\text{Percent Current Unbalance} = \frac{\text{Maximum current difference in any leg from average current}}{\text{Average current}} \times 100$$

3. Single-phase line-to-neutral load shall not be installed between the high side single-phase fuse cutout/disconnect and the step-down/step-up bank.

4. For new construction, a solid blade cutout shall be installed between the neutral and ground to temporarily ground the floating Wye neutral for switching the high side fuses/disconnects. The cutout shall be closed prior to any switching being preformed to energize or de-energize the transformers. **The cutout shall be open for normal operations with the blade removed and secured to the pole.**

5. For existing installations where a solid blade grounding cutout has not been installed, a grounding jumper shall be installed on the step-down bank between the neutral and ground to temporarily ground the floating Wye neutral for switching the high side fuses/disconnects. The grounding jumper shall be installed for energizing and de-energizing the step-down bank and then removed for normal operation. **The cutout shall be open for normal operations with the blade removed and secured to the pole.**

6. High side arresters shall be installed on the source side of fused cutouts/disconnects. Low side arresters can remain on the transformers.

7. Fault locators can be installed on the low side of the step-down/step-up transformer to help identify failures quickly.

8. Fuse only the high side of step-down transformers.

9. There may be specific instances where a high side 3 phase circuit interrupter may be required. Each feeder will need to be evaluated to determine if such a device is necessary due to inadequate protection from fuses on the high side of the bank.

10. A low side gang operated loadbreak switch may be required if the bank is a dedicated supply to an aerial cable or underground cable. This will eliminate the possibility for ferroresonent conditions developing.

Supersedes 7/10 Issue – Revised wording to paragraph #4, #5 and #10.

14.7.40 Protection

The step-down/step-up transformers shall be protected by one of the following methods:

A. Conventional fusing
B. Conventional fusing with current limiting fuses
C. Recloser

The choice would depend on the relative importance, load, short circuit current available, and exposure of the branch.

Surge arresters shall be installed on the primary and secondary sides and connected to a driven ground on same pole.

Surge arresters on the Wye side of a floating Wye-Delta installation shall be connected on the source side of the fuses. When a high side fuse blows, there is a neutral shift that causes the voltage on load side of the fuse device to rise above the maximum withstand voltage of the lightning arrester. The arrester will experience thermal runaway, overheat, and then fail.

14.8 PHASING TRANSFORMERS

In New Hampshire, there are several phase rotations utilized throughout the system. Each installation is unique and must be addressed with Distribution Engineering Design.

Any Lines or Equipment serving three-phase customers that have any work performed on them that could result in the established phasing and or rotation of equipment being installed or changed and the physical configuration (radial feed) of the circuit does not allow for phase testing to be performed shall have rotation verified. Refer to EOP G018 Phasing and Rotation Procedures for Overhead & Underground Personnel on Circuits above 600 Volts.

Supersedes 7/08 Issue – Removed "ratio" from text.

14.8.10 Step-down/Step-up Transformers

When step-down/step-up transformers are installed, they establish new voltages and phase rotations (Systems). It is desirable to identify phases on these systems and to understand the phase rotation and position so they may be paralleled with others of the same voltage.

If two such systems are to be paralleled, the voltage, rotation, and phase position must be the same.

Do not load larger (over 100 kVA) step-down/step-up transformers over 100% of nameplate rating. Overloading will significantly reduce the service life of the transformers.

Feeder protection at primary step-down/ratio bank installations, as shown on standard installation drawings in this Section, shall be provided by fused disconnects (cutouts) on the source side of the bank. Solid blade disconnecting devices may additionally be used on the load side of the bank so bank isolation can be accomplished.

14.8.20 Three Phase Distribution Banks

The drawings for normal distribution transformer banks are arranged for the most convenient wiring of the secondary. They should be followed exactly wherever this is practical. If two overhead transformer banks are to be paralleled, the wiring on each should be identical. If a standard transformer bank is to be paralleled with a 3 phase transformer (padmount or power/station unit type), it may have to be rewired so that phasing is correct.

14.9 SPECIAL CONNECTIONS

14.9.10 Open-Wye and Open-Delta Connected Banks for 3 Phase Services Only

A. Limit application to the use of 25 kVA transformers or smaller on 2400 Delta, 4160 Wye, 4800 Delta and 8320 Wye volt feeders. 50 kVA transformers or smaller may be used on 12,470 Wye; 13,200 Delta or Wye; 13,800 Delta or Wye; 23,000 Delta or Wye; and 34,500 Wye volt feeders.

B. Open-Wye and Open-Delta connected transformer banks can be used for the emergency operation of either Delta-Delta or Wye-Delta connected banks when one of the units becomes inoperative. These banks can also be used to supply 3 phase, 4 wire delta loads composed of a large single phase load in conjunction with a small 3 phase load.

C. When these connections are used to operate purely Delta connected loads under emergency conditions or when one unit out of a Wye-Delta or Delta-Delta bank becomes inoperative, loading of the bank is reduced. If the bank in question is to be connected Open-Wye, the Wye must be grounded. The reduced loading on these banks is equal to 57.7% of the original three unit bank or 86% of the combined kVA of the two units connected.

D. This transformer connection can be used to supply 3 phase, 4 wire Delta connected loads, composed of large single phase loads in conjunction with small 3 phase Delta loads. This application usually involves the use of different sized (kVA) transformers, with the larger single phase load taken off of the larger of the two transformers.

The selection of correct transformer size (kVA) is dependent on both the connected 3 phase and single phase load. The calculation of the load expected on each transformer is as follows:

kVA_L = load on larger transformer (both 3 phase and single phase)
kVA_T = load on small transformer (small 3 phase delta)
T = kVA load 3 phase
S = kVA load single phase

Where

$$kVA_L = (S^2 + T^2/3 + ST)^{1/2}$$

$$kVA_T = \frac{\sqrt{3}}{3}T$$

The aforementioned equations assume unity power factor for both single and 3 phase loads.

For example, assume in the course of converting a 5 kV feeder to 15 kV, a customer is encountered with both a 60 A, 240 V Delta service and a 200 A, 120/240 V single phase service. Presently, the customer is being supplied from both a 15 kVA 3 phase Delta pole type transformer and a 25 kVA single phase pole type transformer. Furthermore, the customer is not willing to upgrade his service to 208Y/120 V. Average demand on the customer's 3 phase service is found to be less than 15 kVA and that of the single phase load is found to be 30 kVA. With this information, an Open-Wye bank can be sized to fit the customer's service requirements.

T = kVA load 3 phase = 15 kVA

S = kVA load single phase = 30 kVA

$kVA_L = (30^2 + 15^2/3 + (30)(15))^{1/2}$

$kVA_L = (1425)^{1/2} = 38kVA$

$kVA_T = \frac{\sqrt{3}}{3}(30) = 17kVA$

In this case, the customer's present three-phase and single-phase service requirements could be handled by an Open-Wye connected bank composed of both a 50 kVA and 15 kVA transformer. The single phase load must be taken from the 50 kVA transformer.

14.10 HANDLING RETURNED TRANSFORMERS

14.10.10 Procedures

The following guideline outlines procedures for handling returned distribution transformers, including overhead, pad-mounted, subsurface, and subway types.

14.10.20 When To Junk Transformers

Transformers shall be junked under the following conditions:

A. Transformers 7.5 kVA and 15 kVA.
B. Non-usable ratings – declare surplus before junking.
C. Cast iron cases.
D. Nonstandard mounting.
E. Repair parts not available.
F. Primary Codes 013, 022, 035, 040, 085, 095, and 529
G. Tap Codes 77, 78, 83 and 89.
H. PCB transformers (500 ppm and above). **WARNING:** Transformers containing PCB fluid require special handling.
I. Transformers manufactured during or before 1970 unless the unit is required for assurance/back-up.
J. Pole type single phase transformers manufactured by Cooper Power Systems at Nacogdoches, Texas during or before January, 2012.

Supersedes 7/08 Issue – Modifications to Process 14.10.20.

14.10.30 When To Return Transformers To Stock For Reissue

Return transformers to stock for reissue, without electrical testing, if all of the following apply:

A. Transformer has non-PCB label.
B. Transformer was removed on routine change-out or due to new construction.
C. Transformer bushings, terminals, protective coatings, and other accessory equipment are in good condition.
D. Single phase transformer with secondary voltage rating of 120/240 or 240/480 (E/2E) with internal secondary connections set up for three wire operation. This applies to transformers with three low voltage terminals 100 kVA and below.

In addition:

A. Assign new physical data code to transformer if not already assigned.
B. Inspect condition of transformer markings and replace if necessary.
C. Remove bottom portion of “Transformer On Stock Status” tag.
D. Transfer transformer to stock.

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DESCRIPTION – Code numbers specify five basic items regarding transformers as follows:

00	000	00	00	00
Type Code (Table 1)	Primary Code (Table 2)	Secondary Code (Table 3)	Tap Code (Table 4)	Fuse & Switch Code (Table 5)

TABLE 1 – TYPE CODE

KEY	
OA – Mineral Oil-Filled, Air Cooled	**LF – Less Flammable-Filled, Air Cooled**
10	Overhead – OA
11	Overhead – OA w/Stainless Steel Tank
13	Overhead – LF
17	Overhead – CSP – OA – with Built In Overload Tripout
18	Pole type Pad Mounted Deadfront
20	Auto-Transformer – OA
30	Pad-mounted – Loop Feed – Dead Front – OA
31	Pad-mounted – Loop Feed – Dead Front – OA w/Stainless Steel Tank
32	Pad-mounted – Loop Feed – Live Front – OA
34	Pad-mounted – Loop Feed – Dead Front – LF
40	Subway – OA
41	Subway – OA – Low Profile
50	Pad-mounted – Radial Feed – Dead Front – OA
52	Pad-mounted – Radial Feed – Live Front – OA
54	Pad-mounted – Radial Feed – Dead Front – LF
56	Pad-mounted – Radial Feed – Dead Front – Dry
60	Network – OA
62	Network – LF
65	Network – Pad-mounted – LF
70	Subsurface – Radial Feed – OA
72	Subsurface – Loop Feed – OA
80	Self-Regulated – OA
90	Station Type
99	Other – Not Listed
Note:	Transformer types listed above may or may not have surge arresters.

Supersedes 1/06 Issue - Added Type Code 11 and 31 and revised Type Code 18 description

Supersedes 1/06 Issue – Corrected Type Code 108 voltage and added Code 116

TABLE 2 - PRIMARY CODE

KEY:

(-) Voltage Nomenclature
E_1 = √3 E
E_2 = Any Value of E Other Than E, E_1, or 2E

* - One Primary Bushing - Single Phase Overhead Transformers
** - Two Primary Bushings - Single Phase Overhead
*** - Junk Codes

SINGLE PHASE TRANSFORMERS (001 – 500)

001 – 025	**E ****
005	480
007	600
010	11500
011	12000
012	13800
013	22000 ***
014	13200
015	22900
017	34400
018	34500
022	11000 ***
023	14400

026 – 050	**E/2E ****
035	2300/4600 ***
040	11000/22000 ***
042	11550/23100

076 – 088	**E X 2E ****
080	1200 X 2400
082	2400 X 4800
085	11000 X 22000***
086	11500 X 23000

089 – 100	**E X E_2 ****
095	22000 X 33000 ***

101 – 150	**E/E_1 Y ****
108	2160/3740Y
109	2400/4160Y
112	4160/7200Y
114	4800/8320Y
116	6930/12000Y
118	7200/12470Y
119	7620/13200Y
120	7970/13800Y
125	11500/19900Y
126	12000/20780Y
127	12470/21600Y
129	13200/22860Y
131	13800/23900Y
133	14400/24940Y
140	19920/34500Y

151 - 200	**E_1 Grounded Y/E ***
155	3740 Grounded Y/2160
157	4160 Grounded Y/2400
159	8320 Grounded Y/4800
165	12470 Grounded Y/7200
167	13200 Grounded Y/7620
169	13800 Grounded Y/7970
175	22860 Grounded Y/13200
177	24940 Grounded Y/14400
178	34400 Grounded Y/19860
180	34500 Grounded Y/19920

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TABLE 2 – PRIMARY CODE (Continued)

SINGLE PHASE TRANSFORMERS (001 – 500) (Continued)

201 – 250	**E/E Grounded Y ****
217	13200/22860 Grounded Y
220	14400/24940 Grounded Y

251 – 300	**E/E$_1$Y x E/E$_1$Y ****
255	2160/3740Y x 7620/13200Y
257	2400/4160Y x 4800/8320Y
258	2400/4160Y x 7200/12470Y
259	2400/4160Y x 7620/13200Y
260	2400/4160Y x 7970/13800Y
263	2400/4160Y x 13800/23900Y
264	4160/7200Y x 7620/13200Y
265	4160/7200Y x 7970/13800Y
267	4160/7200Y x 12470/21600Y
269	4160/7200Y x 13800/23900Y
271	4160/7200Y x 14400/24900Y
272	4800/8320Y x 7200/12470Y
273	4800/8320Y x 7620/13200Y
275	4800/8320Y x 7970/13800Y
277	4800/8320Y x 14400/24940Y
280	7200/12470Y x 19920/34500Y
281	7620/13200Y x 19920/34500Y
282	7970/13800Y x 19920/34500Y

301 – 350	**E1 Grd Y/E x E1 Grd Y/E ***
310	3740 GrdY/2160 x 13200 GrdY/7620
315	4160 GrdY/2400 x 12470 GrdY/7200
316	4160 GrdY/2400 x 13200 GrdY/7620
317	4160 GrdY/2400 x 13800 GrdY/7970
325	8320 GrdY/4800 x 12470 GrdY/7200
326	8320 GrdY/4800 x 13200 GrdY/7620
327	8320 GrdY/4800 x 13800 GrdY/7970
330	12470 GrdY/7200 x 34500 GrdY/19920
331	13200 GrdY/7620 x 34500 GrdY/19920
332	13800 GrdY/7970 x 34500 GrdY/19920
333	13800 GrdY/7970 x 23900 GrdY/13800

401 – 425	**(E/E$_1$ Y x E/E$_1$ Y x E/E$_1$ Y ****
405	2400/4160Y x 7200/12470Y x 7620/13200Y
408	2400/4160Y x 7620/13200Y x 7970/13800Y
415	2400/4160Y x 7200/12470Y x 14400/24940Y
419	4800/8320Y x 7620/13200Y x 7970/13800Y
420	2400/4160Y x 7200/12470Y x 7970/13800Y

426 – 450	**E$_1$ Grd. Y/E x E$_1$ Grd. Y/E x E$_1$ Grd. Y/E ***
432	4160 GrdY/2400 x 13200 GrdY/7620 x 13800 GrdY/7970

451 – 460	**E$_1$ Grd. Y/E x E$_1$ Grd. Y/E x E$_1$ Grd. Y/E x E$_1$ Grd. Y/E ****
453	2400/4160Y x 7200/12470Y x 7620/13200Y x 7970/13800Y

461 - 475	**E$_1$ Grd Y/E x E$_1$ Grd Y/E x E$_1$ Grd Y/E x E$_1$ Grd Y/E ***

500	**Other**

Supersedes 1/07 Issue – Deleted PDC 453 because this connection cannot be built

Supersedes 1/07 Issue – Added Type Code 684 and removed *** from Type Code 529

TABLE 2 – PRIMARY CODE (Continued)

THREE PHASE TRANSFORMERS (501 – 999) (Continued)

501 – 550	E	501 – 550	E
505	480	532	12470
507	600	533	13200
515	2400	534	13500
520	4160	535	13800
523	4800	537	14400
525	8320	540	22900
529	11000	542	23900
530	11500	545	34500

551 – 575	E_1Y

576 – 600	E x 2E
580	2400 x 4800
592	11500 x 23000

601 – 635	E x E_2
605	2400 x 4160
610	2400 x 13200
612	2400 x 13800
614	3740 x 13200
616	4160 x 12470
617	4160 x 13200
619	4160 x 13800
621	4800 x 8320
622	4800 x 13200
623	4800 x 13800
624	8320 x 12470
630	13800 x 22860

636 – 650	E/E_1 Y
640	2400/4160Y

651 – 675	E_1 Y/E
652	4160Y/2400

676 – 725	E_1 Grd Y/E
682	4160 GrdY/2400
684	4330 GrdY/2500
690	12470 GrdY/7200
691	13200 GrdY/7620
693	13800 GrdY/7970
700	24900 GrdY/14400
705	34500 GrdY/19920

726 – 740	E/E_1 Y/E
730	2400/4160Y/2400

750 - 755	E_2 x E_1 Grd Y/E
750	4800 x 13200 GrdY/7620

826 – 875	E_1 Grd Y/E x E_1 Grd Y/E
828	3740 GrdY/2160 x 13200 GrdY/7620
832	4160 GrdY/2400 x 12470 GrdY/7200
833	4160 GrdY/2400 x 13200 GrdY/7620
835	4160 GrdY/2400 x 13800 GrdY/7970
840	8320 GrdY/4800 x 12470 GrdY/7200
841	8320 GrdY/4800 x 13200GrdY/7620
843	8320 GrdY/4800 x 13800 GrdY/7970
860	12470 GrdY/7200 x 34500 GrdY/19920
861	13200 GrdY/7620 x 34500 GrdY/19920
862	13800 GrdY/7970 x 34500 GrdY/19920

876 – 900	E/E_1 Grd Y/E

901 – 925	E/E_1 Y x E x E_1 Y/E
905	2400/4160Y x 2400 x 13800Y/7970

926 – 950	E x E_2 x E_2
935	4160 x 4800 x 13200

951 – 970	T
951	4160T
955	12470T
957	13200T
959	13800T

971 – 990	T x T
971	4160T x 12470T
973	4160T x 13200T
975	4160T x 13800T
980	4800T x 13200T

990 – 999	Others
997	23000 x 34500
999	Other

TABLE 3 – SECONDARY CODE

KEY:

(-) Voltage Nomenclature
E_1 = √3 E
E_2 = Any Value of E Other Than E, E_1, or 2E

SINGLE PHASE TRANSFORMERS (01 – 50)

01 – 09	E
01	120
02	240
05	480
07	600
08	14400

21 – 24	E x 2E
21	120 x 240
22	240 x 480
23	292 x 584
24	300 x 600

31 – 40	E/E_1 Y
31	120/208Y
32	265/460Y
33	277/480Y
34	4160/7200Y
35	2400/4160Y
36	4800/8320Y
37	7200/12470Y
38	7620/13200Y
39	7970/13800Y
40	12000/20780

44 – 46	E/E_1 Y x E/E_1 Y
44	2400/4160Y x 4800/8320Y
45	2400/4160Y x 7200/12470Y
46	2400/4160Y x 7620/13200Y

10 – 15	E/2E
10	120/240
11	115/230
12	240/480
14	292/584

25 – 30	E x E_2
26	277 x 600
27	300 x 650
28	480 x 600
30	600 x 2400

41 – 43	E_1 Grd Y/E
41	13200 GrdY/7620
42	4160 GrdY/2400

47 – 50	Others
47	120/240/208
48	2400/4160Y x 4160/7200Y
49	120/240/480/600
50	Other

16 – 20	2E/E
16	240/120
17	480/240

THREE PHASE TRANSFORMERS (51 – 99)

51 – 57	E
51	240
52	480
53	600
54	2400
55	4800

69 – 71	E/E_1 Y
70	7200/12470Y
71	4360Y/2520

79 – 82	E_1 Grd Y/E
79	4160 GrdY/2400
80	12470 GrdY/7200
81	13200 GrdY/7620
82	13800 GrdY/7970

90 – 94	T
90	240T
91	208T/120
92	480T/277
93	480T x 240T
94	600T

61 – 65	E x 2E
61	240 x 480
63	2400 x 4800

72 – 78	E_1 Y/E
72	216Y/125
73	208Y/120
74	480Y/277
75	4160Y/2400
76	13200Y/7620
77	13800Y/7970
78	600Y/346

83 – 85	E/E_1 Y/E
83	2400/4160Y/2400

95 – 99	OTHERS
95	120 x 240/208Y
96	480Y/277 x 208Y/120
97	600 x 2400 x 4800
98	480Y/277 x 600Y/346
99	600 x 2400

Supersedes 7/08 Issue – Revised two tables

TABLE 4 – TAP CODE

KEY:

A = Taps Above Primary Nameplate Rating
B = Taps Below Primary Nameplate Rating

*- Not Exact Tap Code. Reference for finding GIS / Storms ONLY
** - Junk Codes

00	**None**
01	1 - 2½ A
02	2 - 2½ A
04	4 - 2½ A

11	1 - 2½ B
12	2 - 2½ B
13	3 - 2½ B
14	4 - 2½ B
15	5 - 2½ B

21	1 - 2½ A + 3 - 2½ B
22	2 - 2½ A + 2 - 2½ B
23	3 - 2½ A + 1 - 2½ B
27	2 - 2½ A + 4 - 2½ B
29	4 - 2½ A + 2 - 2½ B

31	1 - 5 A
32	2 - 5 A
34	4 - 5 A

41	1 - 5 B
42	2 - 5 B
43	3 - 5 B
44	4 - 5 B

51	1 - 5 A + 2 - 2½ B
53	1 - 5 A + 1 - 5 B

61	1 - 10 A
65	1 - 10 B

72	4160 Volt

75	2520/2460/2400/2340/2280 Volt (Code 22)
76	4360/4260/4160/4055/3590 Volt (Code 22) *
77	5040/4920/4680/4560 Volt **
78	8720/8520/8100/7900 Volt **
79	11275/11000/10725/10450/10175 Volt (Code 21)
80	11800/11500/11200/10900/10600 Volt (Code 21) *
82	13090/12780/12470/12160/11850 Volt (Code 22) *
83	13200/12480/11500 Volt **
84	14400/13800/13200/12870/12540 Volt (Code 21) *
85	13860/13530/13200/12870/12540 Volt (Code 22)
86	14400/14100/13800/13500/13200 Volt (Code 14) *
87	14400/14100/13800/13500/13200 Volt (Code 22) *
88	15600/15000/14400/13800/13200 Volt (Code 22) *
89	17200/16770/15910/15480 Volt **
90	14100/13800/13500/13200/12900 Volt (Code 21) *
92	24100/23500/22900/22300/21700 Volt (Code 22) *
94	36200/35300/34400/33500/32600 Volt (Code 22) *
96	36225/35363/34500/33638/32775 Volt (Code 22) *
98	14400/14040/13680/13320/12960 Volt (Code 14)
99	Others

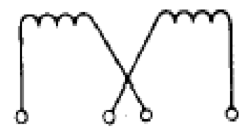
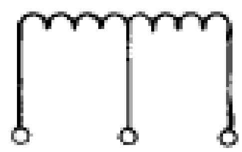
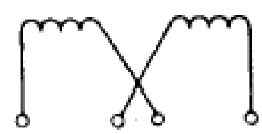
TABLE 5 – FUSE & SWITCH CODE (00 – 99)

00	None
01	Bayonet Fuse Holder (Loadbreak) With Expulsion Link Without Isolation Link Or Current Limiting Fuse
02	Bayonet Fuse Holder (Loadbreak) With Expulsion Link And With Isolation Link
04	Bayonet Fuse Holder (Loadbreak) With Current Limiting Fuse
05	Bayonet Fuse Holder (Loadbreak) With Expulsion Link And With Current Limiting Fuse Under Oil
07	Bayonet Fuse Holder (Loadbreak) With Expulsion Link Without Isolation Link Or Current Limiting Fuse And With Four Position Loadbreak Switch Under Oil
08	Bayonet Fuse Holder (Loadbreak) With Expulsion Link With Isolation Link And With Four Position Loadbreak Switch Under Oil
11	Drywell Cannister (Loadbreak) With Current Limiting Fuse
12	Drywell Cannister (Non-Loadbreak) With Current Limiting Fuse
21	Externally Mounted Hinge Type, Current Limiting Fuse
32	Current Limiting Fuse With Arc-Strangler Loadbreaking Device
33	Single Current Limiting Fuse (Clip Mounted) And Arc-Strangler Switchblade (Tandem-Unit Mounting)
34	Parallel Current Limiting Fuses (Clip Mounted) And Arc-Strangler Switchblade (Tandem-Unit Mounting)
35	Single Current Limiting Fuse (Hinge Mounted)
36	Parallel Current Limiting Fuse (Unitized-Hinge Mounted)
37	Single Current Limiting Fuse (Clip Mounted)
38	Parallel Current Limiting Fuse (Unitized-Clip Mounted)
51	Internal Weak Link Fuse Under Oil
53	Internal Weak Link Fuse Under Oil With Secondary Breaker
55	Secondary Breaker With No Internal Weak Link Fuse Under Oil
60	Two Position Loadbreak Switch Under Oil Without Fuse
61	Four Position Loadbreak Switch Under Oil Without Fuse
62	Four Position Loadbreak Switch Under Oil With Current Limiting Fuse
75	Three Position Deadbreak Switch With Two Electrical Interlocks Scheme
76	Three Position Mag Break Switch With Locked Energized Interlock Scheme
80	Network Protector
99	Other

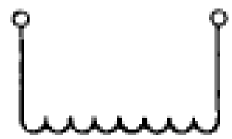
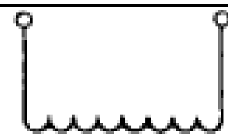
EXPLANATION OF VOLTAGE RATINGS

KEY:

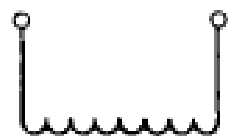
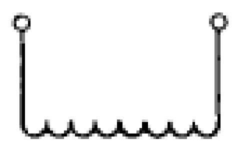
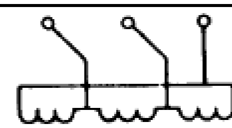
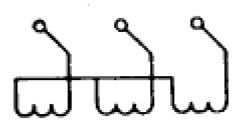
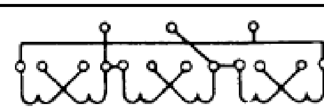
$E_1 = \sqrt{3}\,E$
E_2 = Any Value Of E Other Than E, E_1 or 2E

SINGLE PHASE TRANSFORMERS					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
001-025	01 - 09	E	34500		Indicates a winding for connection on an E volt system.
026-050	10 - 15	E/2E	120/240		Indicates a winding for multiple, series or three-wire service.
051-075	16 - 20	2E/E	240/120		Indicates a winding for 2E volts, two-wire full kVA, or for 2E/E volts three-wire service with one-half kVA available from mid-point to each outside terminal.
076-088	21 - 24	E x 2E	1200 x 2400		Indicates a winding for multiple or series operation only. (Not for three-wire service).
089-100	25 - 30	E x E_2	22000 x 33000		
101-150	31 - 40	E/E_1 Y	2400/4160 Y		Indicates a winding for connection on an E volt system or Y connection on an E_1 volt system.

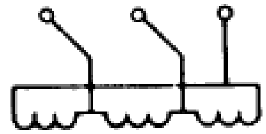
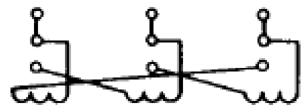
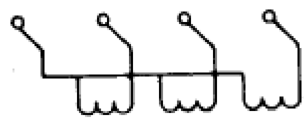
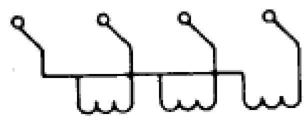
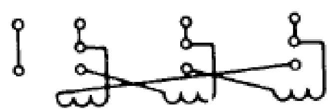
EXPLANATION OF VOLTAGE RATINGS (Continued)

SINGLE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
151-200	41 - 43	E_1 GrdY/E	124700 GrdY/7200		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on an E_1 volt system with the neutral end of the winding effectively grounded.
201-250	--	E/E_1Grd Y	7620/13200 Grd Y		Indicates a winding with reduced insulation for Y connection on an E_1 volt system with the transformer neutral effectively grounded or for connection on an E volt system.
251-300	44 - 45	E/E_1 Y x E/E_1 Y	2400/4160 Y x 7200/12470 Y		Indicates a winding for connection on an E volt system of Y connection on an E_1 volt system.
301-350	--	E_1 Grd Y/E x E_1 Grd Y/E	4160 Grd Y/2400 x 12470 Grd Y/7200		Indicates a winding with reduced insulation of the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on an E_1 volt system with the neutral end of the winding effectively grounded.
401-425	--	E/E_1 Y x E/E_1 Y x E/E_1 Y	2400/4160 Y x 7200/12470 Y x 7620/13200 Y		Indicates a winding for connection on an E volt system or Y connection on an E_1 volt connection.

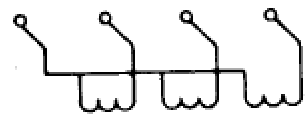
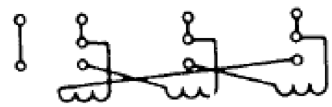
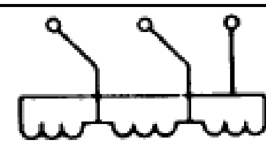
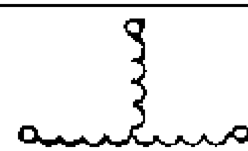
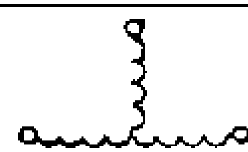
EXPLANATION OF VOLTAGE RATINGS (Continued)

SINGLE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
426-450	--	E_1 Grd Y/E x E_1 Grd Y/E x E_1 Grd Y/E	4160 Grd Y/2400 x 12470 Grd Y/7200 x 13800 Grd Y/7970		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on and E_1 volt system with the neutral end of the winding effectively grounded.
451-460	--	E/E_1 Y x E/E_1 Y x E/E_1 Y x E/E_1 Y	2400/4160 Y x 7200/12470 Y x 7620/13200 Y x 7970/13800 Y		Indicates a winding for connection on an E volt system or Y connection on an E_1 volt system.
461-475	--	E_1 Grd Y/E x E_1 Grd Y/E x E_1 Grd Y/E x E_1 Grd Y/E	3740 Grd Y/2160 x 4160 Grd Y/2400 x 13200 Grd Y/7620 x 13800 Grd Y/7970		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tnak for connection single phase or in Y on an E_1 volt system with the neutral end of the winding effectively grounded.
THREE PHASE TRANSFORMERS					
501-550	51 - 57	E	11500		Indicates a winding permanently connected.
551-575	58 - 60	E_1 Y	4160 Y		Indicates a winding permanently Y connected with the neutral isolated.
576-600	61 - 65	E x 2E	2400 x 4800		Indicates a permanently connected winding for multiple or series operation.

EXPLANATION OF VOLTAGE RATINGS (Continued)

THREE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
601-635	66 - 68	E x E_2	2400 x 13200		Indicates a winding permanently connected.
636-650	69 - 71	E/E_1 Y	2400/4160 Y		Indicates a winding for connection E volts or E_1Y volts with the neutral isolated.
651-675	72 - 77	E_1 Y/E	4160 Y/2400		Indicates a winding permanently Y connected with fully insulated neutral available.
676-725	78 - 82	E_1 Grd Y/E	13800 Grd Y/7970		Indicates a winding having reduced insulation and permanently Y connected with the transformer neutral grounded.
726-740	83 - 85	E/E_1 Y/E	2400/4160 Y/2400		Indicates a winding for connection E volts or E_1Y volts with a fully insulated neutral available.
750	73 - 74	E_2 x E_1 Grd Y/E	4800 x 13200 GrdY/7620		Indicates a winding for connection E_2 volts or E_1Y volts having a reduced insulation and permanently connected with the transformer neutral grounded.

EXPLANATION OF VOLTAGE RATINGS (Continued)

THREE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
826-875	--	E_1 Grd Y/E x E_1 Grd Y/E	4160 Grd Y/2400 x 13800 Grd Y/7970		Indicates a winding having reduced insulation and permanently Y connected with the transformer neutral grounded.
876-900	--	E/E_1 Grd Y/E	7970/13800 Grd Y/7970		Indicates a winding having reduced insulation for Y connection on an E_1 volt system with the transformer neutral grounded, or for connection on an E volt system.
901-925	--	E/E_1 Y/E x E_1 Y/E	2400/4160 Y/2400 x 13800 Y/7970		
926-950	--	E x E_2 x E_2	4160 x 4800 x 13200		Indicates a winding permanently connected.
951-970	90 - 94	T	13800 T		Indicates a primary winding consisting of two windings - the main and a teaser.
971-990	--	T x T	4160 T x 13800 T		Indicates a primary winding consisting of two windings - the main and a teaser.
991-999	95 - 99	Others -	Those Three Phase Transformers That Do Not Fall Into One Of The Classifications Above		

 | Doc. # ST. 14.00.003

1. **NOTE VOLTAGE** marked on transformer nameplate and transformer tag. All changes to internal connections should be made in the shop.

2. **POLARITY DESIGNATION** - Additive has X1 on the right and H1 on the left as viewed from the secondary side. Subtractive has X1 and H1 on the left as viewed from the secondary side. Single phase transformers, 200 kVA and under having high voltage winding rated 8660 volts and below, have additive polarity. All other single phase transformers have subtractive polarity.

3. **SECONDARY CONNECTIONS**

   A. 120/240 (E/2E) and 240/480 (E/2E) can be connected for series, parallel or three wire operation. Transformers 100 kVA and below have three low voltage terminals and transformers 167 - 500 kVA have four low voltage terminals. See Figures 1 through 14.
   B. 240/120 (2E/E) can be connected for three wire or two wire operation, but not for parallel operation. Note - only one-half of the kVA rating available between center tap terminal and either extreme terminal. Three low voltage terminals are provided on all kVA sizes. See Figures 15 through 18.
   C. 292 x 584 (E x 2E) can be connected for series or parallel operation. Transformers will have four low voltage terminals on all kVA sizes. See figures 8, 9, 11 and 12. This rating must be used with primary taps.
   D. 277/480 Y (E/E_1Y) and 600 (E) transformers have two low voltage terminals on all sizes. See Figures 19 through 21.

New single ratio overhead transformers for existing 600 V customers should be ordered 292 x 584 with primary taps so that 600 V can be obtained from the 584 volt connection. These transformers can also be used at 277 volts. Specify the 600 V rating for dual ratio transformers.

4. **100 kVA AND BELOW WITH E/2E VOLT SECONDARIES – PRIMARY 8660 VOLTS AND BELOW**

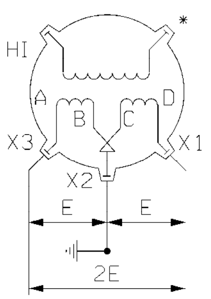


FIG. 1
(Three Wire)
Additive

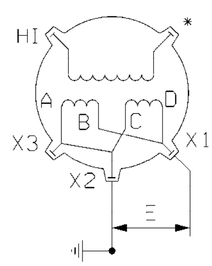


FIG. 2
(Parallel)
Additive

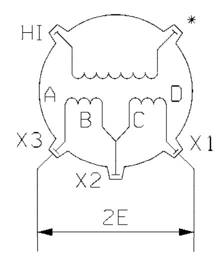


FIG. 3
(Series)
Additive

* Transformers with one primary bushing have other end of coil connected to the tank.

5. 100 kVA AND BELOW WITH E/2E VOLT SECONDARIES – PRIMARY ABOVE 8660 VOLTS

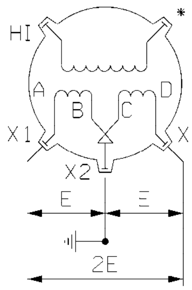


FIG. 4
(Three Wire)
Subtractive

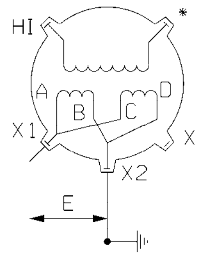


FIG. 5
(Parallel)
Subtractive

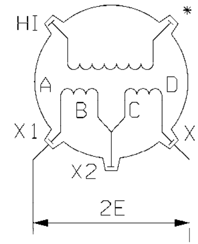


FIG. 6
(Series)
Subtractive

6. 167 kVA WITH E/2E AND 167 kVA AND BELOW WITH E X 2E VOLT SECONDARIES – PRIMARY 8660 VOLTS AND BELOW

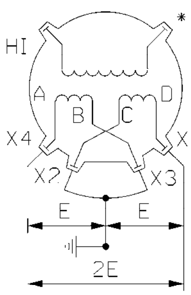


FIG. 7
(Three Wire)
Additive

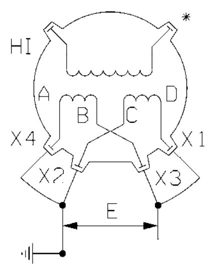


FIG. 8
(Parallel)
Additive

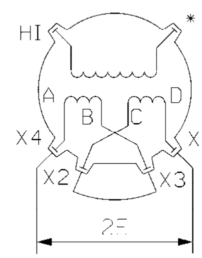


FIG. 9
(Series)
Additive

* Transformers with one primary bushing have other end of coil connected to the tank.

7. 167 kVA WITH E/2E AND 167 kVA AND BELOW WITH E X 2E VOLT SECONDARIES – PRIMARY ABOVE 8660 VOLTS

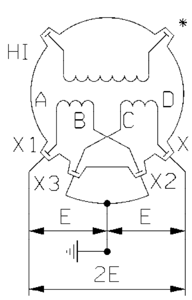


FIG. 10
(Three Wire)
Subtractive

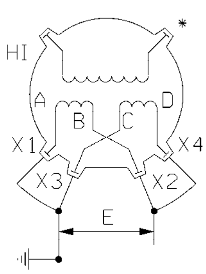


FIG. 11
(Parallel)
Subtractive

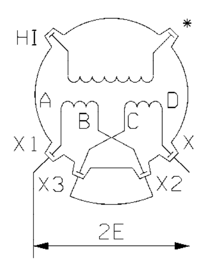


FIG. 12
(Series)
Subtractive

8. 250 – 500 kVA WITH E/2E AND E X 2E VOLT SECONDARIES – PRIMARY ABOVE AND BELOW 8660 VOLTS

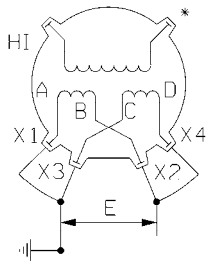


FIG. 13
(Parallel)
Subtractive

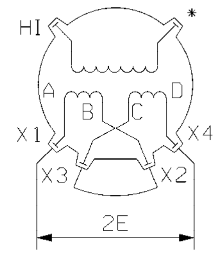


FIG. 14
(Series)
Subtractive

* Transformers with one primary bushing have other end of coil connected to the tank.

9. 167 kVA AND BELOW WITH 2E/E VOLT SECONDARIES

PRIMARY 8660 VOLTS AND BELOW

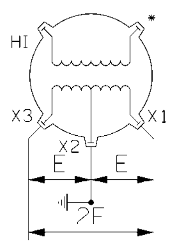


FIG. 15
(Three Wire)
Additive

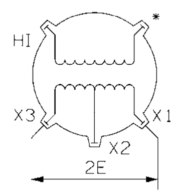


FIG. 16
(Two Wire)
Additive

PRIMARY ABOVE 8660 VOLTS

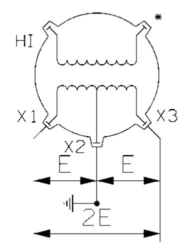


FIG. 17
(Three Wire)
Subtractive

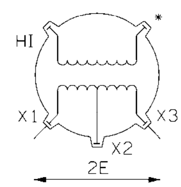


FIG. 18
(Two Wire)
Subtractive

10. 25 – 500 kVA WITH E OR E_1/Y VOLT SECONDARIES

**25 – 167 kVA
PRIMARY 8660 VOLTS
AND BELOW**

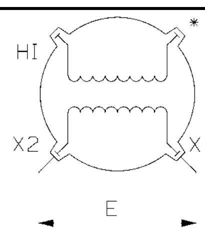


FIG. 19
Additive

**250 – 500 kVA
PRIMARY 8660 VOLTS
AND BELOW**

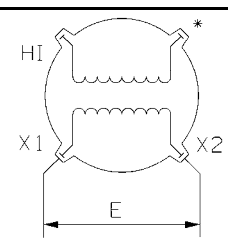


FIG. 20
Subtractive

**25 – 500 kVA
PRIMARY ABOVE
8660 VOLTS**

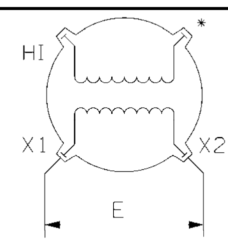


FIG. 21
Subtractive

 Doc. # ST. 14.00.003

Supersedes 1/07 Issue - Updated Primary Codes.

CIRCUIT VOLTAGE			PRI. CODE	SEC. CODE	TAP CODE	STD. ITEM	TRANSFORMER NAMEPLATE VOLTAGES		STD. KVA SIZES	3Ø DIAGRAM #
PRIMARY	SECONDARY	PHASE					PRIMARY	SECONDARY		
2400 V DELTA 3 WIRE	120/240	1Ø ΔY	258	10	00	T91AD	2400/4160Y x 7200/12470Y	120/240	10-100	-
			259	10	00	T91AF	2400/4160Y x 7620/13200Y			
			260	10	00	T91AC	2400/4160Y x 7960/13800Y			
	208Y/120	3Ø ΔY	258	10	00	T91AD	2400/4160Y x 7200/12470Y	120/240	10-100	2
			259	10	00	T91AF	2400/4160Y x 7620/13200Y			
			260	10	00	T91AC	2400/4160Y x 7960/13800Y			
	480Y/277	3Ø ΔY	258	33	00		2400/4160Y x 7200/12470Y	277/480Y	25-167	2
			259	33	00	T91AE	2400/4160Y x 7620/13200Y			
			260	33	00		2400/4160Y x 7960/13800Y			
	240 (1) (2)	3Ø ΔΔ	258	10	00	T91AD	2400/4160Y x 7200/12470Y	120/240	10-100	8
			259	10	00	T91AF	2400/4160Y x 7620/13200Y			
			260	10	00	T91AC	2400/4160Y x 7960/13800Y			
	480 (1) (2)	3Ø ΔY (5)	258	33	00		2400/4160Y x 7200/12470Y	277/480Y	25-167	2 or 4
			259	33	00		2400/4160Y x 7620/13200Y			
			260	33	00		2400/4160Y x 7960/13800Y			
	600 (1) (2)	3Ø ΔΔ	258	23	00		2400/4160Y x 7200/12470Y	292 X 584	25-167	8
			259	23	00		2400/4160Y x 7620/13200Y			
			260	23	00		2400/4160Y x 7960/13800Y			
4160 V WYE 4 WIRE	120/240	1Ø YY	258	10	00	T91AD	2400/4160Y x 7200/12470Y	120/240	10-100	-
			259	10	00	T91AF	2400/4160Y x 7620/13200Y			
			260	10	00	T91AC	2400/4160Y x 7960/13800Y			
	208Y/120	3Ø YY	258	10	00	T91AD	2400/4160Y x 7200/12470Y	120/240	10-100	1
			259	10	00	T91AF	2400/4160Y x 7620/13200Y			
			260	10	00	T91AC	2400/4160Y x 7960/13800Y			
	480Y/277	3Ø YY	258	33	00		2400/4160Y x 7200/12470Y	277/480Y	25-167	1 or 3
			259	33	00		2400/4160Y x 7620/13200Y			
			260	33	00		2400/4160Y x 7960/13800Y			
	240 (1) (3)	3Ø YΔ (4)	258	10	00	T91AD	2400/4160Y x 7200/12470Y	120/240	10-100	7
			259	10	00	T91AF	2400/4160Y x 7620/13200Y			
			260	10	00	T91AC	2400/4160Y x 7960/13800Y			
	480 (1) (3)	3Ø YY (5)	258	33	00		2400/4160Y x 7200/12470Y	277/480Y	25-167	1 or 3
			259	33	00		2400/4160Y x 7620/13200Y			
			260	33	00		2400/4160Y x 7960/13800Y			
	600 (1) (3)	3Ø YΔ (4)	258	23	00		2400/4160Y x 7200/12470Y	292 X 584	10-100	7
			259	23	00		2400/4160Y x 7620/13200Y			
			260	23	00		2400/4160Y x 7960/13800Y			
4800 V DELTA 3 WIRE	120/240	1Ø ΔY	272	10	00		4800/8320Y x 7200/12470Y	120/240	10-100	
			273	10	00	T91BA	4800/8320Y x 7620/13200Y			
			275	10	00	T91BC	4800/8320Y x 7960/13800Y			
	208Y/120	3Ø ΔY	273	10	00		4800/8320Y x 7620/13200Y	120/240	10-100	2
			275	10	00		4800/8320Y x 7960/13800Y			
	480Y/277	3Ø ΔY	273	33	00		4800/8320Y x 7620/13200Y	277/480Y	25-167	2 or 4
			275	33	00		4800/8320Y x 7960/13800Y			
	240 (1) (2)	3Ø ΔΔ	273	10	00		4800/8320Y x 7620/13200Y	120/240	10-100	8
			275	10	00		4800/8320Y x 7960/13800Y			
	480 (1) (2)	3Ø ΔY (5)	273	33	00		4800/8320Y x 7620/13200Y	277/480Y	10-100	2
			275	33	00		4800/8320Y x 7960/13800Y			
	600 (1) (2)	3Ø ΔΔ	273	23	00		4800/8320Y x 7620/13200Y	292 X 584	25-167	8
			275	23	00		4800/8320Y x 7960/13800Y			
8320 V WYE 4 WIRE	120/240	1Ø YY	272	10	00		4800/8320Y x 7200/12470Y	120/240	10-100	-
			273	10	00	T91BA	4800/8320Y x 7620/13200Y			
			275	10	00	T91BC	4800/8320Y x 7960/13800Y			
	208Y/120	3Ø YY	272	10	00		4800/8320Y x 7200/12470Y	120/240	10-100	1
			273	10	00	T91BA	4800/8320Y x 7620/13200Y			
			275	10	00	T91BC	4800/8320Y x 7960/13800Y			
	480Y/277	3Ø YY	273	33	00		4800/8320Y x 7620/13200Y	277/480Y	25-167	1 or 3
			275	33	00		4800/8320Y x 7960/13800Y			
	240 (1) (3)	3Ø YΔ (4)	272	10	00		4800/8320Y x 7200/12470Y	120/240	10-100	7
			273	10	00	T91BA	4800/8320Y x 7620/13200Y			
			275	10	00	T91BC	4800/8320Y x 7960/13800Y			
	480 (1) (3)	3Ø YY (5)	273	33	00		4800/8320Y x 7620/13200Y	277/480Y	25-167	1 or 3
			275	33	00		4800/8320Y x 7960/13800Y			
	600 (1) (3)	3Ø YΔ (4)	273	23	00		4800/8320Y x 7620/13200Y	292 X 584	10-100	7
			275	23	00		4800/8320Y x 7960/13800Y			

CIRCUIT VOLTAGE			PRI. CODE	SEC. CODE	TAP CODE	STD. ITEM	TRANSFORMER NAMEPLATE VOLTAGES		STD. KVA SIZES	3Ø DIAGRAM #
PRIMARY	SECONDARY	PHASE					PRIMARY	SECONDARY		
12470 V WYE 4 WIRE	120/240	1Ø YY	165	10	00	T91DA	12470GRDY/7200	120/240	10-100	-
	208Y/120	3Ø YY	165	10	00	T91DA	12470GRDY/7200	120/240	10-100	1
	480Y/277	3Ø YY	165	33	00	T91DC	12470GRDY/7200	277/480Y	25-167	1 or 3
	240 (1) (2)	3Ø YΔ (4)	118	10	00	T91DA	7200/12470Y	120/240	10-100	7
	480 (1) (2)	3Ø YY (5)	165	33	00	T91DC	12470GRDY/7200	277/480Y	25-167	1 or 3
	600 (1) (2)	3Ø YΔ (4)	118	23	00		7200/12470Y	292 X 584	25-167	7
13200 V WYE 4 WIRE	120/240	1Ø YY	167	10	00	T91DE	13200GRDY/7620	120/240	10-100	-
	208Y/120	3Ø YY	167	10	00	T91DE	13200GRDY/7620	120/240	10-100	1
	480Y/277	3Ø YY	167	33	00	T91DEA	13200GRDY/7620	277/480Y	25-167	1 or 3
	240 (1) (3)	3Ø YΔ (4)	119	10	00	T91DE	7620/13200Y	120/240	10-100	7
	480 (1) (3)	3Ø YY (5)	167	33	00	T91DEA	13200GRDY/7620	277/480Y	25-167	1 or 3
	600 (1) (3)	3Ø YΔ (4)	119	23	00		7620/13200Y	292 X 584	10-100	7
13200 V DELTA 3 WIRE	120/240	1Ø ΔY	133	10			14400/24940Y (at 13200 V tap)	120/240	10-100	
	208Y/120	3Ø ΔY	133	10			14400/24940Y (at 13200 V tap)	120/240	10-100	2
	480Y/277	3Ø ΔY	133	33			14400/24940Y (at 13200 V tap)	277/480Y	25-167	2 or 4
	240 (1) (2)	3Ø ΔΔ	133	10			14400/24940Y (at 13200 V tap)	120/240	10-100	8
	480 (1) (2)	3Ø ΔY (5)	133	33			14400/24940Y (at 13200 V tap)	277/480Y	10-100	2
	600 (1) (2)	3Ø ΔΔ	133	23			14400/24940Y (at 13200 V tap)	292 X 584	25-167	8
13800 V WYE 4 WIRE	120/240	1Ø YY	169	10	00	T91EB	13800GRDY/7960	120/240	10-100	-
	208Y/120	3Ø YY	169	10	00	T91EB	13800GRDY/7960	120/240	10-100	1
	480Y/277	3Ø YY	169	33	00	T91EBA	13800GRDY/7960	277/480Y	25-167	1 or 3
	240 (1) (3)	3Ø YΔ (4)	120	10	00	T91EA	7960/13800Y	120/240	10-100	7
	480 (1) (3)	3Ø YY (5)	169	33	00	T91EBA	13800GRDY/7960	277/480Y	25-167	1 or 3
	600 (1) (3)	3Ø YΔ (4)	120	23	00		7960/13800Y	292 X 584	10-100	7
13800 V DELTA 3 WIRE	120/240	1Ø ΔY	133	10			14400/24940Y (at 13800 V tap)	120/240	10-100	-
	208Y/120	3Ø ΔY	133	10			14400/24940Y (at 13800 V tap)	120/240	10-100	2
	480Y/277	3Ø ΔY	133	33			14400/24940Y (at 13800 V tap)	277/480Y	25-167	2 or 4
	240 (1) (2)	3Ø ΔΔ	133	10			14400/24940Y (at 13800 V tap)	120/240	10-100	8
	480 (1) (2)	3Ø ΔY (5)	133	33			14400/24940Y (at 13800 V tap)	277/480Y	25-167	2
	600 (1) (2)	3Ø ΔΔ	133	23			14400/24940Y (at 13800 V tap)	292 X 584	10-100	8
23000 V WYE 4 WIRE	120/240	1Ø YY	177	10			24900GRDY/14400 (at 13800 V tap)	120/240	10-100	-
	208Y/120	3Ø YY	177	10			24900GRDY/14400 (at 13800 V tap)	120/240	10-100	1
	480Y/277	3Ø YY	177	33			24900GRDY/14400 (at 13800 V tap)	277/480Y	25-167	1 or 3
	240 (1) (3)	3Ø YΔ (4)	144	10			14400/24940Y (at 13800 tap)	120/240	10-100	7
	480 (1) (3)	3Ø YY (5)	144	33			14400/24940Y (at 13800 tap)	277/480Y	25-167	1 or 3
	600 (1) (3)	3Ø YΔ (4)	144	23			14400/24940Y (at 13800 tap)	292 X 584	10-100	7
23000 V DELTA 3 WIRE	120/240	1Ø ΔY	015	10	00		22900	120/240	10-100	-
	208Y/120	3Ø ΔY	015	10	00		22900	120/240	10-100	2
	480Y/277	3Ø ΔY	015	33	00		22900	277/480Y	25-167	2 or 4
	240 (1) (2)	3Ø ΔΔ	015	10	00		22900	120/240	10-100	8
	480 (1) (2)	3Ø ΔY (5)	015	33	00		22900	277/480Y	25-167	2
	600 (1) (2)	3Ø ΔΔ	015	23	00		22900	292 X 584	10-100	8

CIRCUIT VOLTAGE			PRI. CODE	SEC. CODE	TAP CODE	STD. ITEM	TRANSFORMER NAMEPLATE VOLTAGES		STD. KVA SIZES	STD. DRAWING	3Ø DIAGRAM #
PRIMARY	SECONDARY	PHASE					PRIMARY	SECONDARY			
34500 V WYE 4 WIRE	120/240	1Ø YY	180	10	00	T91HC	34500GRDY/19920	120/240	10-100		-
	208Y/120	3Ø YY	180	10	00	T91HC	34500GRDY/19920	120/240	10-100		1
	480Y/277	3Ø YY	180	33	00	T91HD	34500GRDY/19920	277/480Y	25-167		1
	240 (1) (3)	3Ø YΔ (4)	180	10	00	T91HC	19920/34500Y	120/240	10-100		7
	480 (1) (3)	3Ø YY (5)	180	33	00	T91HD	19920/34500Y	277/480Y	25-167		7
	600 (1) (3)	3Ø YΔ (4)	180	23	00		19920/34500Y	292 X 584	10-100		7

Notes:

1. Non-standard voltage – for maintenance only.
2. For Open-Delta connection, see Diagram #10.
3. For Open-Wye connection, see Diagram #9.
4. Do not ground the primary neutral.
5. Company will only supply a 480Y service. Customer must provide protection from ground faults on a 480 V Delta service.

INSTALLATION NOTES:

- Use conventional mineral filled transformers for new installations. Physical Data Code for Type is 10.
- For less flammable filled conventional transformers for special installations, Physical Data Code for Type is 13.
- Use CSP transformers for maintenance only in New York. Physical Data Code for Type is 17.
- Use transformers without taps unless otherwise directed. Physical Data Code for Taps is 00.
- Unless otherwise directed, internal fused or switches are not needed. Physical Data Code for Fuses and Switches is 00
- For other transformer voltages and configurations, refer to the Physical Data Code on Page 14-101.
- **Do not use CSP transformers on Delta Secondary Systems.** A tripped breaker will result in customer voltage imbalance.
- 167 kVA, 120/120V transformers have 4 low voltage bushings. 277 V transformers have 2 low voltage bushings. All others have 3 low voltage bushings.
- 277 V secondary transformers with primary ± taps can supply existing 265 V customers. Primary taps must be +5% (max. setting) to provide 263 volts secondary.
- Non-directly connected CSP surge arresters (pre-1990 units only) shall be gapped as follows: 2,400 V – ¼”; 4,800 V – ⅜”; 7,620 V – ½”.
- Single bushing transformers shall not be used for Wye-Delta connections.
- For 3Ø Delta connected transformers (ΔΔ, YΔ), use transformers with identical turns ratios (preferable from same manufacturer) on all three phases to guard against capacity loss. A mismatch in turns or mixing low loss type transformers (e.g. “Amorphous Core”) with standard types will result in a high circulating current which increases losses and decreases capacity to serve the electric system.

Supersedes 1/06 Issue – Deleted “Recommended Transformer” note at top of table. Correct primary code for 2400V Delta 3 wire

Note: These weights are approximate and are given as comparative information. Actual Unit weights may be found on the Transformer Nameplate. Refer to Transformer Specifications MS 2523, MS 2526 and MS 2541 (Step-downs) for additional information.

Approximate Weights for 1Φ Overhead Transformers (2004)			**Overall Height and Weight LIMITS for Standard 1Φ Overhead Transformers per NGRID Specifications MS 2523 and MS 2541**		
kVA	**Averaged Lbs. Wt.**		**Size**	**Max. Weight**	**Max. Height**
10	230-280		10 thru 25 kVA	500 (lbs.)	44" (Inches)
25	320-390		37 & 50 kVA	750	48"
50	550-640		75 & 100 kVA	2000	50"
75	850-970		167 &250 kVA	2000	--
100	1250		333 & 500 kVA	3000	--

APPROXIMATE WEIGHT IN POUNDS (OIL INCLUDED) – TRANSFORMERS THROUGH 1992

kVA	**1992 – 1989**				**1988 – 1980**				**1979 - 1969**			
	Dual		**15 kV**		**Dual**		**15 kV**		**Dual**		**15 kV**	
	Conv.	**CSP**	**Conv.**	**CSP**	**Conv.**	**CSP**	**Conv.**	**CSP**	**Conv.**	**CSP**	**Conv.**	**CSP**
10	270	277	193	203	280	278	225	254	266	338	224	235
15	303	347	224	293	347	343	305	335	381	397	297	330
25	400	416	400	384	413	408	378	413	474	456	360	410
37 ½	510	511	540	550	550	560	343	340	541	544	505	555
50	663	720	740	720	686	719	698	675	651	655	650	705
75	895	903	858	895	903	880	870	975	986	1120	1005	1054
100	1054		1129		990	1350	1013	1060	1280	1330	1140	1160
167	1457		1568		1457		1482		1475		1425	
250			1887				1866				1900	
333			2250				2250				2308	
500			2710				2749				3365	

kVA	**1968 - 1962**				**1961 - 1957**		**1957 – 1946**		**1946 - 1937**
	Dual		**15 kV**		**5 kV**		**5 kV**		**5 kV**
	Conv.	**CSP**	**Conv.**	**CSP**	**Conv.**	**CSP**	**Conv.**	**CSP**	**Conv.**
5			165	200	205	205	200	220	240
10	255	280	230	250	260	265	260	290	360
15	305	340	270	290	330	340	340	370	420
25	420	450	395	400	455	455	480	520	570
37 ½	570	620	575	620	675	690	720		890
50	670	710	660	720	750	760	850		1160
75	920	1020	910	940	975	995	1130		1350
100	1060	1180	1050	1080	1165	1125	1350		1450
167	1380		1330		1400	1430			
250			1640						
333			2100						
500			3230						

Supersedes 1/06 Issue – Added reference to MS 2526 and changed voltage labels from 7.6kV to 15kV

Some of the following drawings contain default **Macro Units (MU)** and **Compatible Units (CU)** in the header for quick reference. These default MU's and CU's are shown with some of the characters in parentheses. These parenthetical characters are variables that help define the exact MU or CU required in STORMS. The definitions of these variables and the method of constructing the required MU and/or CU are shown below.

MACRO UNIT VARIABLES

(U) = 3 Phase Transformer Bank kVA
(W) = 1 Phase Transformer kVA
(X) = Primary Physical Data Code (xxx)
(Y) = Secondary Physical Data Code (xx)
(Z) = Tap Physical Data Code (xx)

Example 1:

MU = @WKXPYSZT
(W) for a 100kVA transformer = **100**
(X) for a 13200GRDY/7620 Primary = **167**
(Y) for a 120/240 V Secondary = **10**
(Z) for a transformer with no taps = **00**

Complete MU = @100K167P10S00T

COMPATABLE UNIT VARIABLES

(E) = Transformer Description (each tank)
15B = 15kVA and Below
25 = 25kVA
37 = 37½ thru 50kVA
75A = 75kVA thru 100kVA
A100 = Above 100kVA
(F) = Secondary Code (3Ø)
2 = 240V and below
4 = above 240V
(U) = 3 Phase Transformer Bank kVA
(X) = Primary Physical Data Code (xxx)
(Y) = Secondary Physical Data Code (xxx)
(Z) = Tap Physical Data Code (xx)

Example 1:

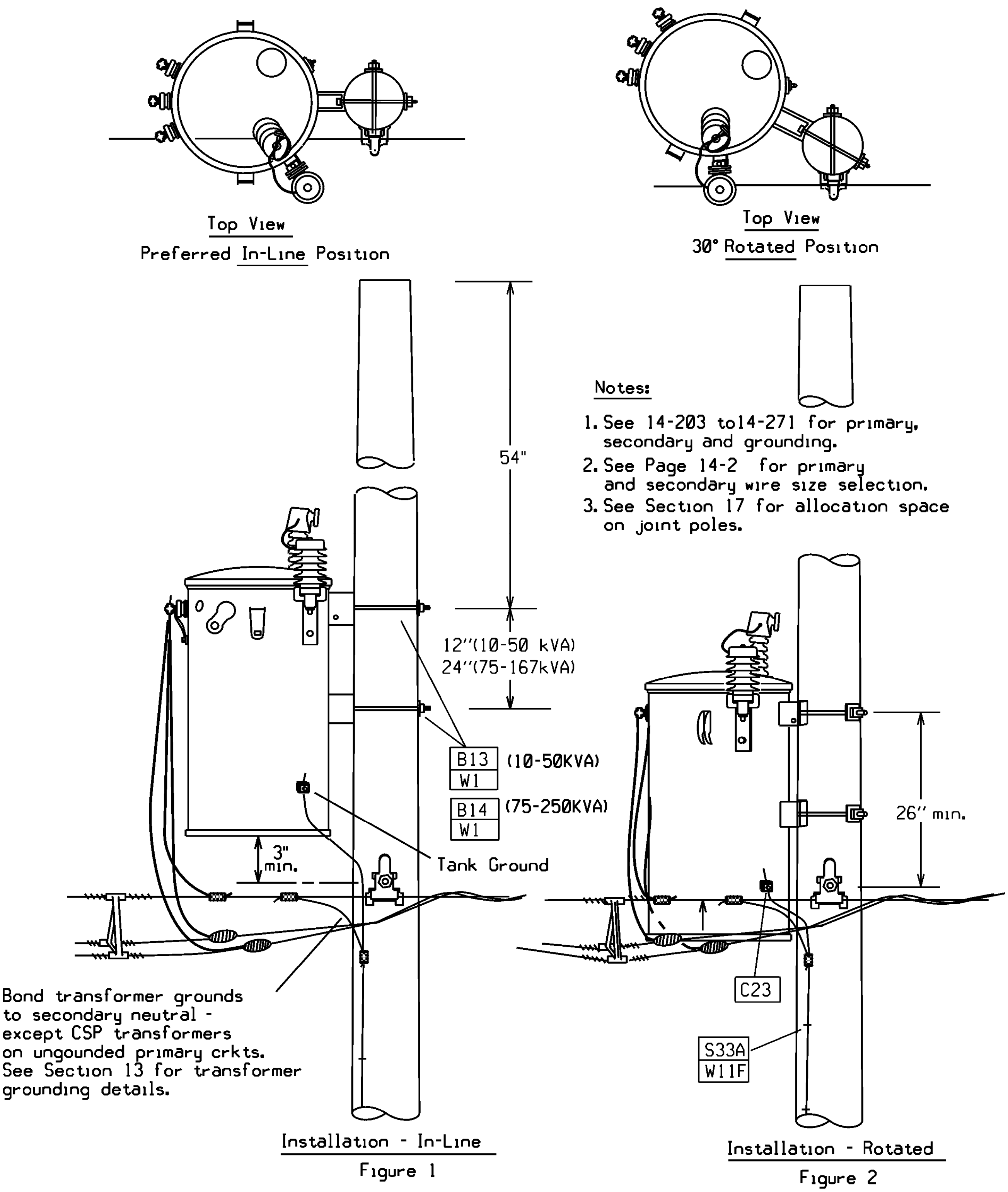
CU for a Transformer = TVWKXPYSZT
(W) for a 100kVA transformer = **100**
(X) for a 13200GRDY/7620 Primary = **167**
(Y) for a 120/240 V Secondary = **10**
(Z) for a transformer with no taps = **00**

Complete CU = TV167P10S00T

Example 2:

CU for a Cluster Mount = TMEFVS
(E) for a 25kVA Transformer = **25**
(F) for a 240V Secondary Voltage = 2

Complete CU = TV252VS



Notes:

1. See 14-203 to14-271 for primary, secondary and grounding.
2. See Page 14-2 for primary and secondary wire size selection.
3. See Section 17 for allocation space on joint poles.

Installation - In-Line
Figure 1

Installation - Rotated
Figure 2

Supersedes 1/06 Issue – Revised Notes and mounting bolt dimensions

MOUNTING DETAIL 1Φ TRANSFORMER INSTALLATION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/08	14-121		

BRACKET SELECTION FOR TRANSFORMERS					
SIZE KVA (each transfomer)	MAX. WEIGHT LBS. (each transfomer)	SUPPORT LUGS *		CLUSTER BRACKET *	ADAPTER PLATE *
		TYPE	SPACING		
10 - 50	500	A	12" (11¼)	T9C	None
75 - 167	2000	B	24" (23¼)	T9D	None
250 - 333	3000	C	24"	T9E	T10
500	2250 - 3000	PLATFORM (36") (SEE 14 - 377)		T6	None

* - Refer to Page 14 - 132 for support lugs and bracket descriptions.

Notes:

1. See Page 14 - 121 for mounting single transformers.

2. For soft soil conditions or transformers weighting more than 1,000 lbs. each, backfill hole as shown in Figure I. Also use 8' pole setting depth for transformers of 167 KVA or larger. (over 4500 total lbs.)

** - The pole butt diameter of a CLass 3 pole is approximately 12" and a minimum of 4" clearance around pole butt is recommended for proper backfilling

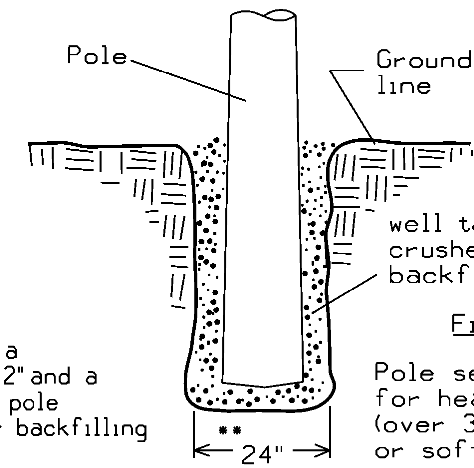


Figure I

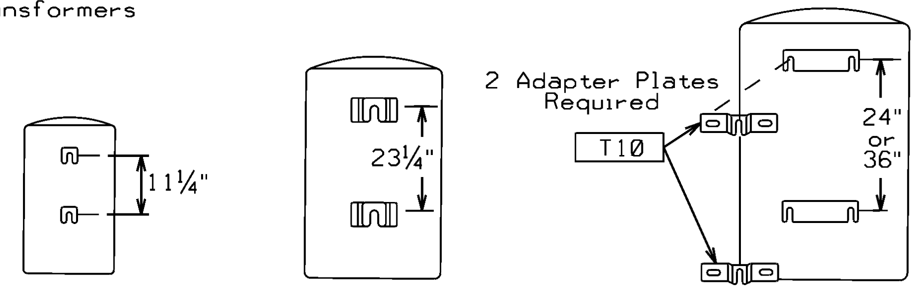
Pole setting detail for heavy equipment (over 3000 total lbs.) or soft soils

3. Banks of transfomers weighting over 2000 lbs. each shall be mounted on platform (Item TMP2) as shown on Page 14 - 377 and the installation should be located outside traffic areas or barricaded. Use minimum pole height necessary for ground clearance and avoid down guys.

4. See Page 14 - 80 for typical transformer weights.

Supersedes 7/08 Issue – Revised table title

Standard Support Lugs on Overhead Distribution Transformers



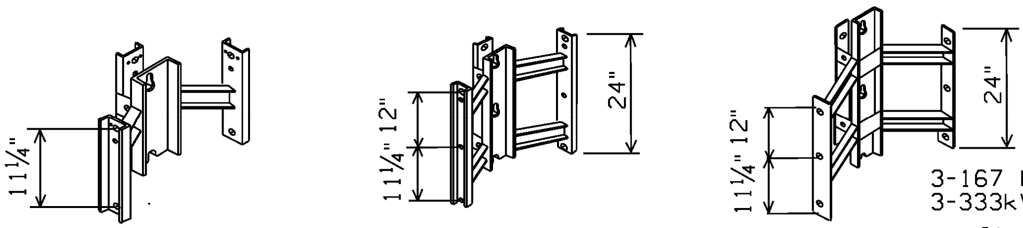
Type A Lugs
10-50kVA Transformers -use⅝" mtng. bolts

Type B Lugs
75-167kVA Transformers -use¾" mtng. bolts

Type C Lugs
250-500kVA Transformers
Adapter plates to lugs use (4)⅝" bolts
Adapter plates to pole use (2)¾" bolts

Transformer Cluster Brackets

Small Cluster | Medium Cluster | Large Cluster



Up to 3-25kVA
Use two⅝" thru bolts ✱ and two 2¼" square washers

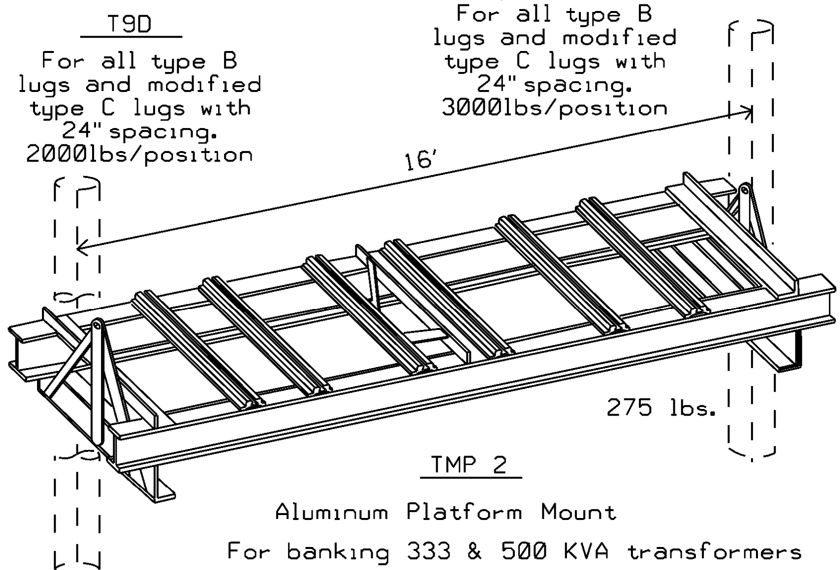
T9C
For all type A lugs 11¼" spacing. 500 lbs./position

3-37½kVA to 3-100kVA
Use three¾" thru bolts ✱✱ and 3" curved washers

T9D
For all type B lugs and modified type C lugs with 24" spacing. 2000lbs/position

3-167 kVA to 3-333kVA
Use three¾" thru bolts ✱✱ and 3" curved washers

T9E
For all type B lugs and modified type C lugs with 24" spacing. 3000lbs/position



TMP 2
Aluminum Platform Mount
For banking 333 & 500 KVA transformers (weighting between 2000# to 4500# each)

✱ Pole drilling - two11/16" holes space 12"

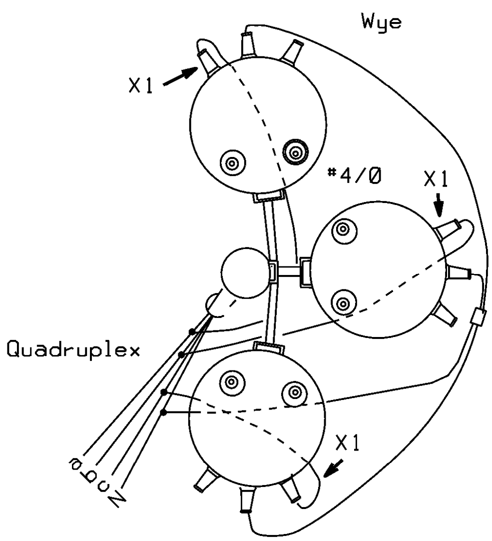
✱✱ Pole drilling - three13/16" holes space 12"

Supersedes 1/07 Issue – Added support lug dimensions and deleted reference to Regulators

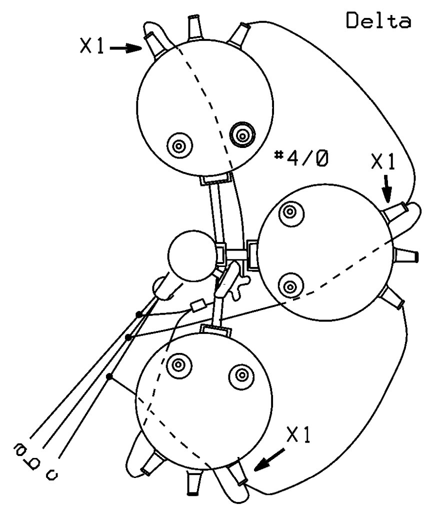
CLUSTER MOUNTS FOR BANKING
3 - 1Φ TRANSFORMERS

ISSUE	PAGE NUMBER		
7/08	14-132	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Supersedes 7/08 Issue – Revised table – changed 50kVA transformer wire size for 208Y/120.



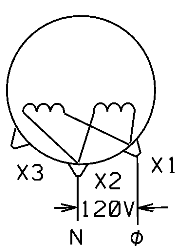
3-25 through 75 KVA
Transformers
4W 208Y/120V Wye Service



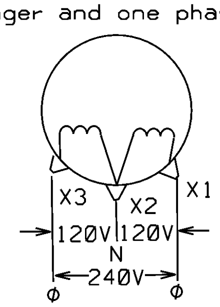
3-25 through 75 KVA
transformers
3W 240 Delta Service

Note:
Secondary voltage test readings (taken with a high-impedence voltmeter) will be inaccurate if low voltage breaker is open on CSP transformers.

Notes:
No modification of internal taps required for delta sevice
Use quadruplex service conductors, as shown in Section 11, bounding the grounded messenger and one phase conductor together.



Internal secondary taps require paralleling.
X3 bushing is unused



Standard series connection winding

Secondary Conductors				
Individual transformer KVA Size	208Y/120 or ✱240 V Service		480Y/277 or ✱480 V Service	
	L.V. CU. Tank wiring	Multiplex service conductor	L.V. CU. tank wire	Multiplex Service Conductor
25	4/0 (W19C)	336.4 (W16E)	#2 (W13E)	#1/0 (W15C)
50	4/0 (W19C)	336.4 (W16E)	4/0 (W19C)	#336.4 (W16E)
75	500 (UC5G)	double 336.4 (16E)	4/0 (W19C)	#336.4 (W16E)

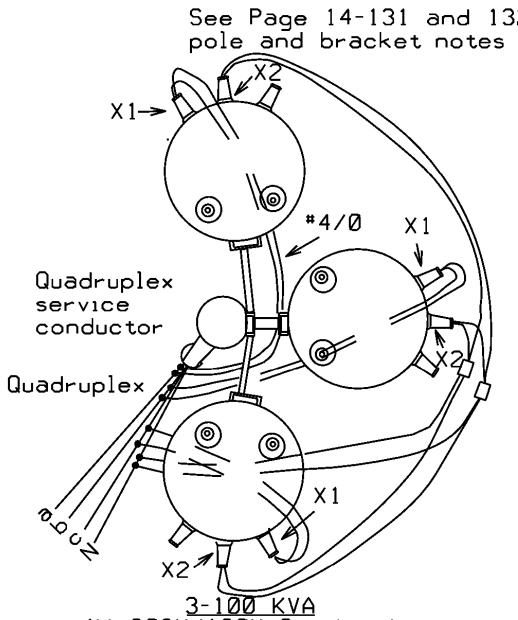
Note: Double (W19C) #4/0 CU may be substituted for single 500 kcmil above.

✱ Shown for information only. This is not a standard service.

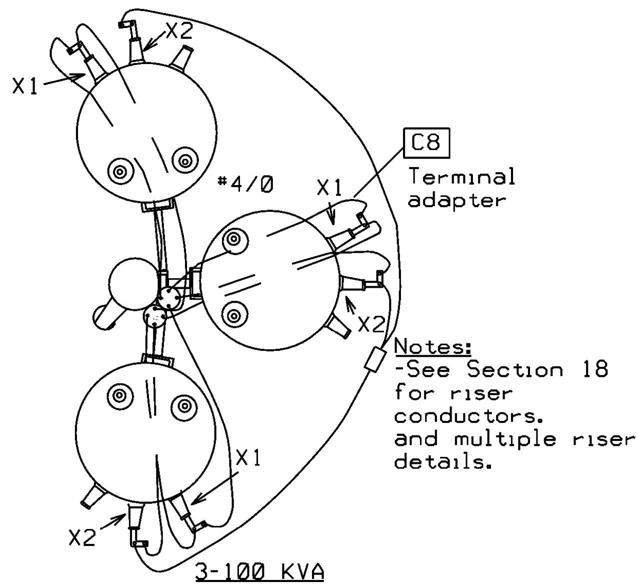
See: Section 11 for service connections to buildings.
Page 14-131& 14-132 for cluster mount selection and details.
Section 13 for grounding details.
Page 14-301-326 for 3 primary wiring.

3Φ SECONDARY CONNECTIONS
10 – 75 kVA – TOP VIEW

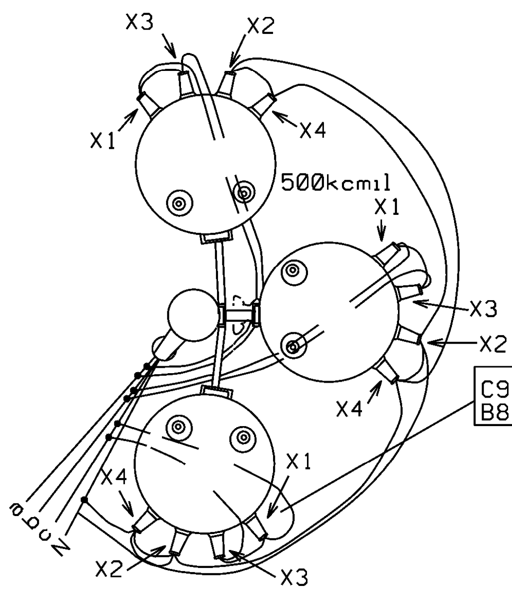
Doc. # ST. 14.00.004



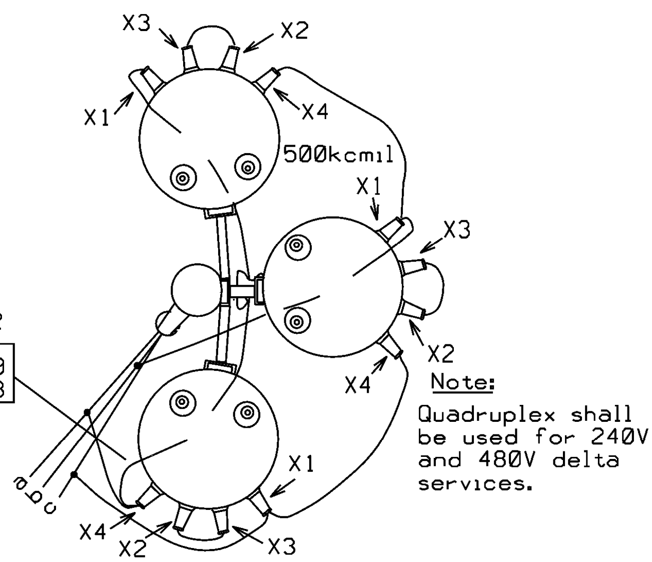
3-100 KVA
4W 208Y/120V Overhead service
4W 480Y/277V Overhead service



3-100 KVA
4W 208Y/120 V underground service
4W 480Y/277 V underground service



3-167 KVA
4W 208Y/120V Overhead service
4W 480Y/277V Overhead service



3-167 KVA (Delta)
3 W 480 V Overhead service
3 W 240 V Overhead service

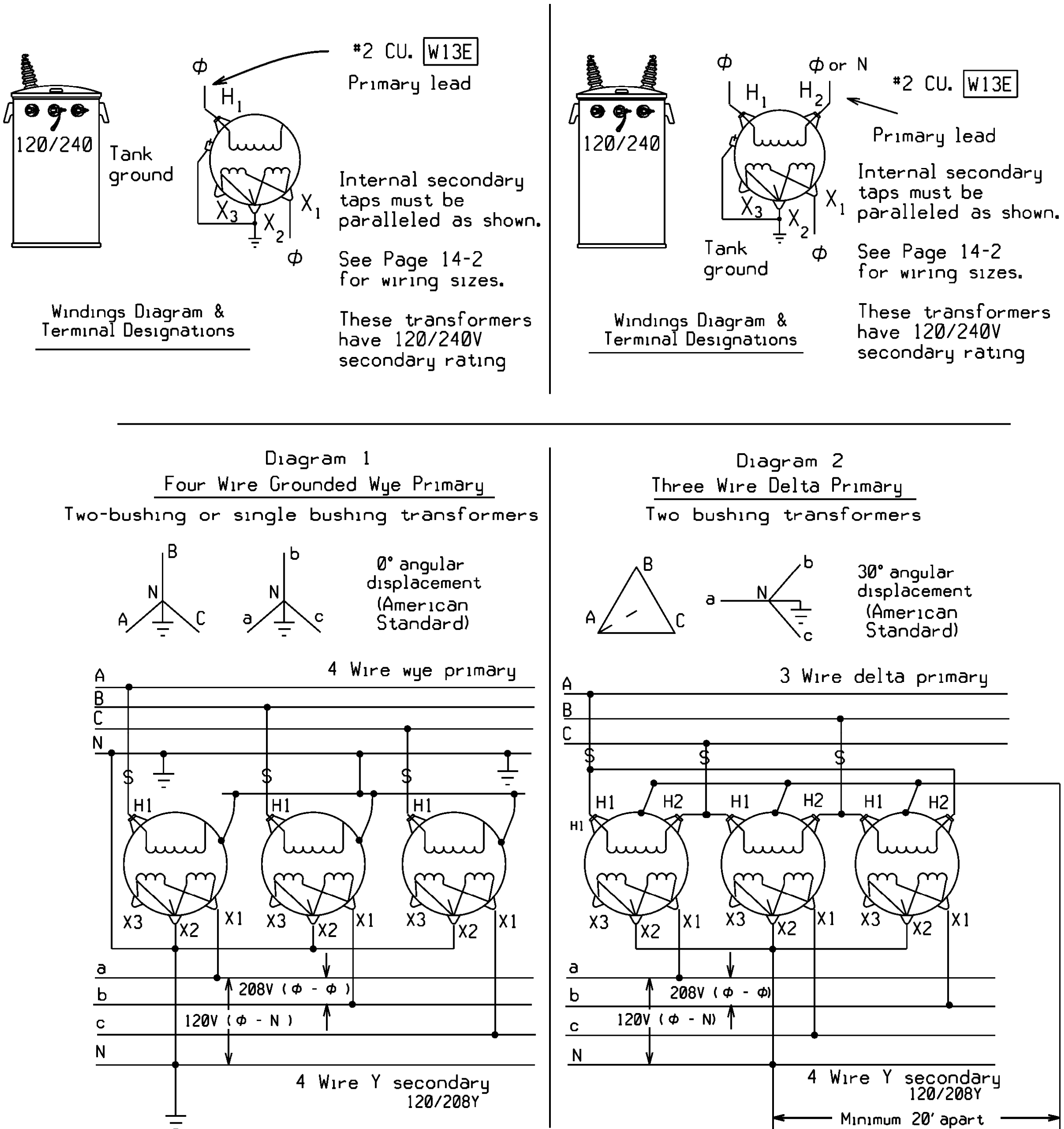
Secondary Conductors		
Individual transformer KVA	L.V. Copper cable size 208Y/120 or 240V	L.V. Copper Cable size 480Y/277 or 480V
3-100 3-167	2-4/0 (W19C) 2-500 (UC5G)	1-4/0 (W19C) 1-500 (UC5G)

Supersedes 7/08 Issue – Added 4W 480Y/277 Overhead Service to 3-167KVA drawing

3Φ SECONDARY CONNECTIONS
100 – 167 kVA – TOP VIEW

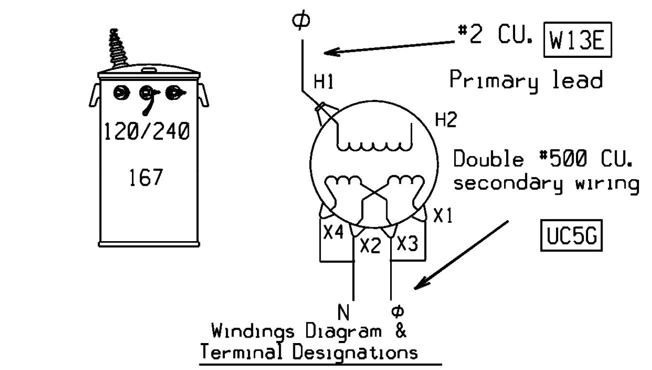
ISSUE	PAGE NUMBER		
7/10	14-172	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

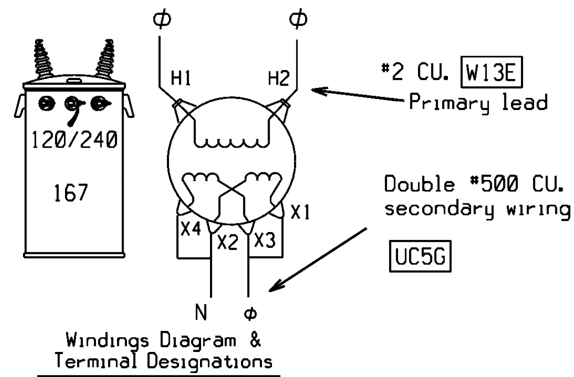
Supersedes 7/08 Issue – Added tank ground and removed tap to phase A in Diagram 2.



NOTES:

- This information is additional to other information shown in these standards. See 3Φ transformer installation Pages 14-301 through 14-373 for pole top wiring.
- Refer to Pages 13-111 & 112 for transformer grounding details.
- On CSP transformers secondary voltage test readings (taken with a high-impedence voltmeter) will be inaccurate if low-voltage breaker is open on CSP transformers





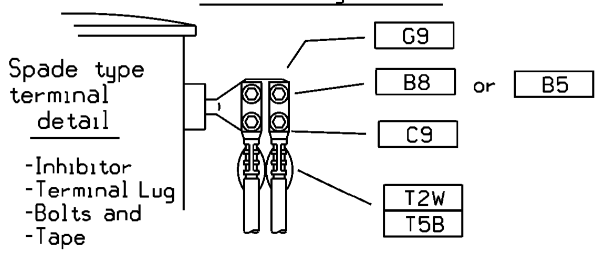
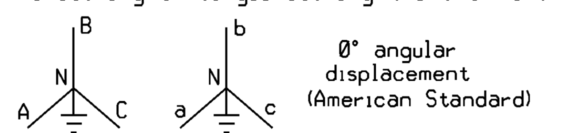


Diagram 3

Four Wire Grounded Wye Primary

Two-bushing or single-bushing transformers



Caution: The primary neutral should be tied firmly to the system neutral; otherwise, excessive voltages may develop on the secondary side.

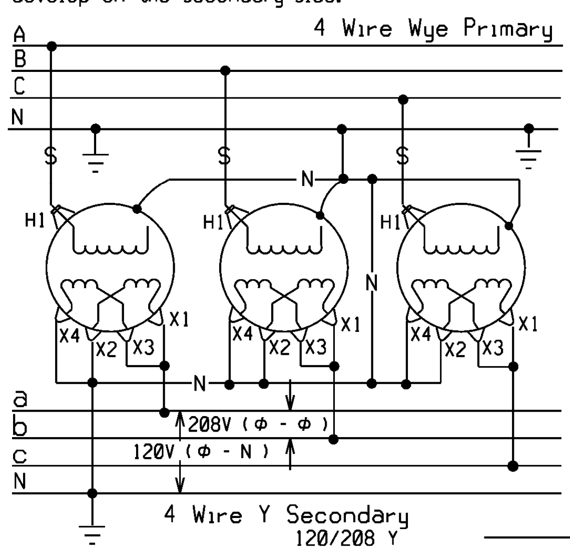
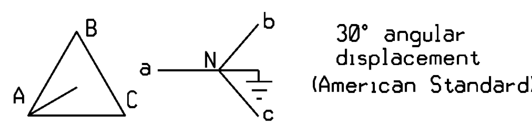
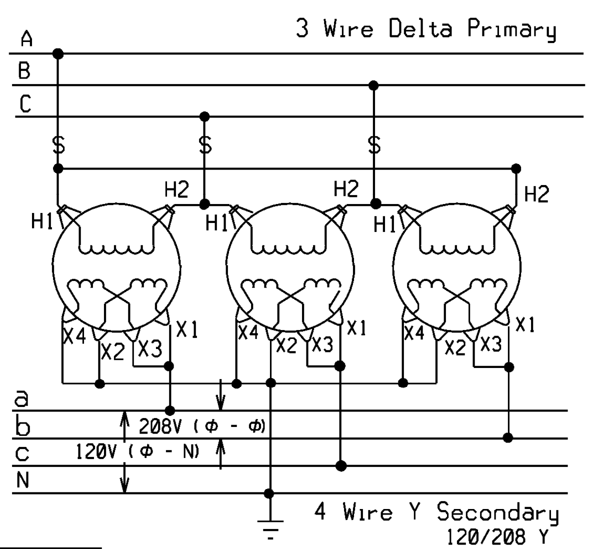


Diagram 4

Three Wire Delta Primary

Two-bushing transformers





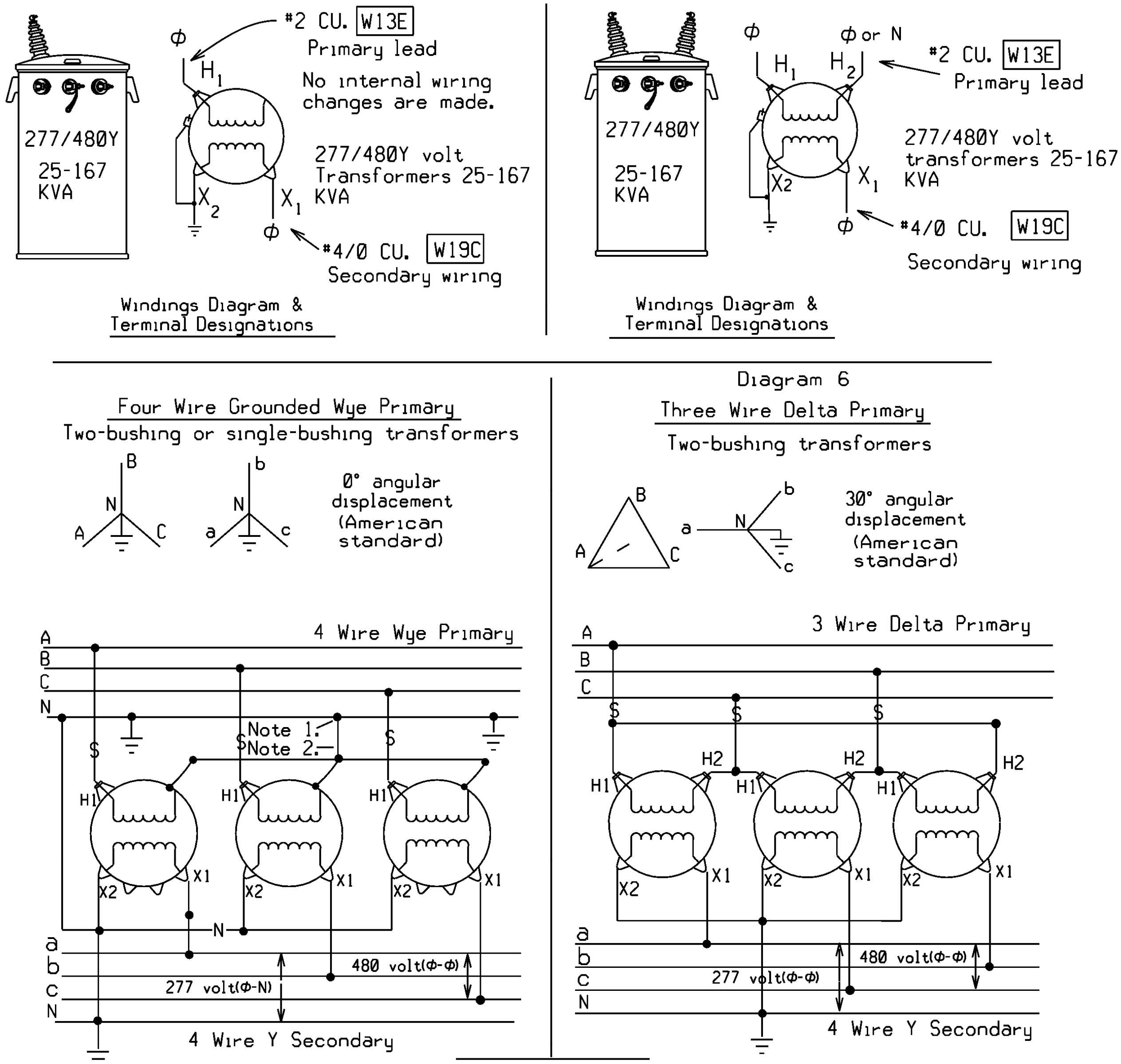
Notes:

- 3 wire 240V or 480V delta services are not available for new installations.
- This information is additional to other information shown in these standards. See Page 14-172 for more information on secondary wiring.

Supersedes 1/06 Issue – Added primary conductor size and correct Diagram 4 wiring

3Φ SECONDARY CONNECTIONS
167 kVA 1Φ TRANSFORMERS - 3Φ 4 WIRE 208Y/120 V SERVICE

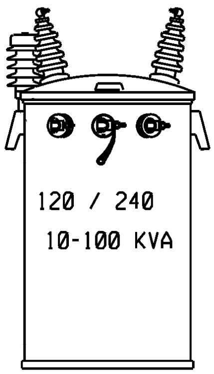
ISSUE	PAGE NUMBER		
7/08	14-174	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

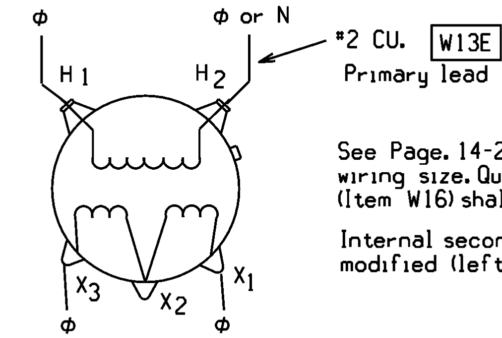


Notes:

1. The primary neutral should be tied firmly to the system neutral; otherwise, excessive voltages may develop on the secondary side.
2. See Page 14-304 for 480V delta 3 wire service installations from wye primary.

Supersedes 1/06 Issue – Added primary conductor size





Windings Diagram & Terminal Designations

See Page. 14-2 for secondary wiring size. Quadruplex conductor (Item W16) shall be used.

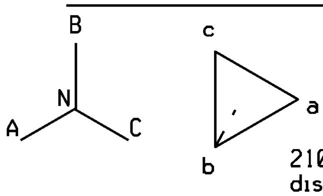
Internal secondary taps are not modified (left in series).

Notes:

- This information is supportive of related information shown in these standards.
- See installation Pages 14-304 through 14-373 for pole top wiring.
- Do not use CSP transformers for 3Φ delta secondaries. 240 V & 480 V Delta services are not available for new installations.
- See Section 13 for transformer grounding details.

Diagram 7

Four Wire Grounded Wye Primary



Two bushing transformer Remove and relocate tank mounted arresters to crossarm or equipment mount.

210° angular displacement

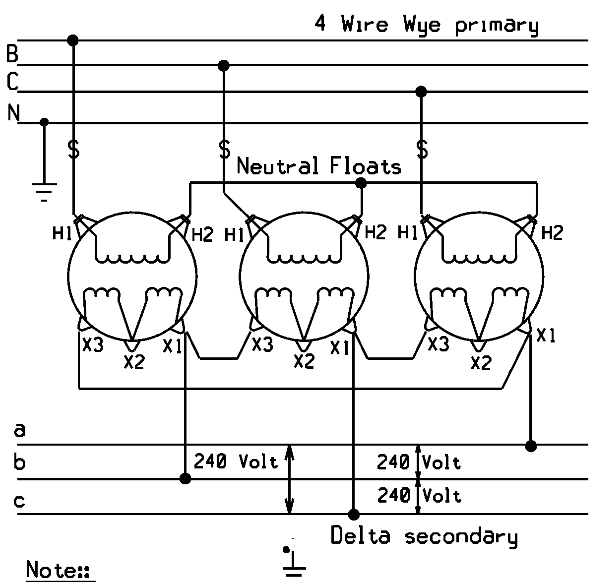
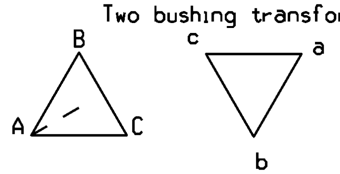


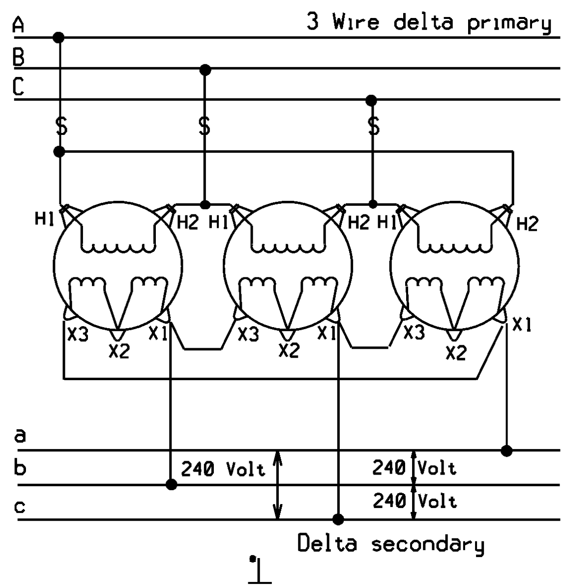
Diagram 8

Three Wire Delta Primary

Two bushing transformer



180° angular displacement

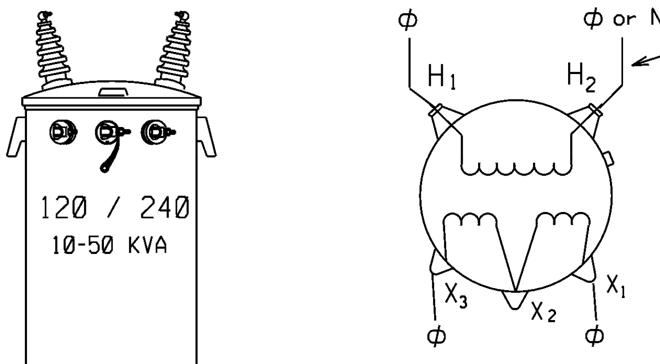


Note::

- The grounding of one phase of the delta secondary has been general practice and is shown on the wiring diagrams for these installations - i.e. figure 4, Page 352. This is not required for performance or safety but may be continued in practice.

Supersedes 7/08 Issue – Moved note regarding arrester location from top of page to Diagram 7

Supersedes 7/08 Issue – Removed note regarding installing arresters on source side of cutouts



#2 CU. W13E
Primary lead

See Page 14-2 for secondary wiring size. Quadruplex conductor (Item W16) shall be used.

Internal secondary taps are not modified (left in series).

Windings Diagram &
Terminal Designations

Notes:
- See information regarding these connections on Page 14-7.

Diagram 9
Four Wire Grounded Wye Primary

Two bushing on single bushing transformers

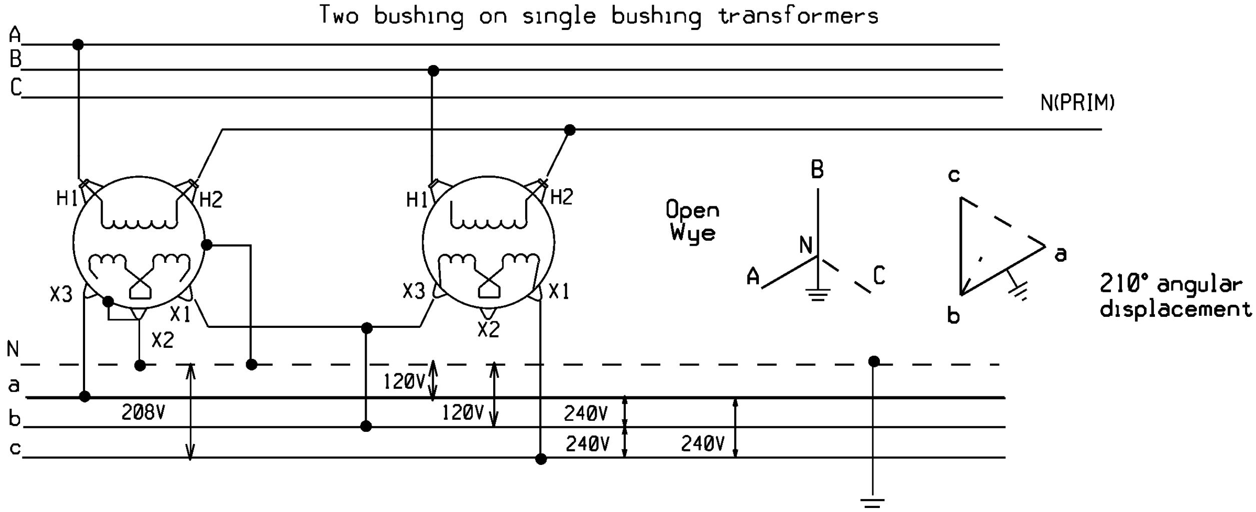
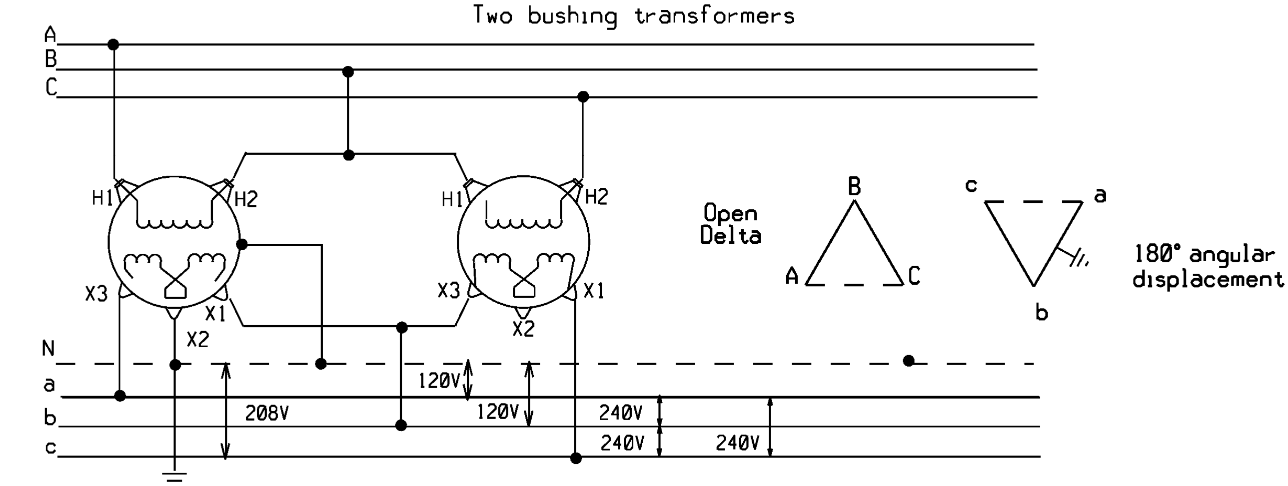
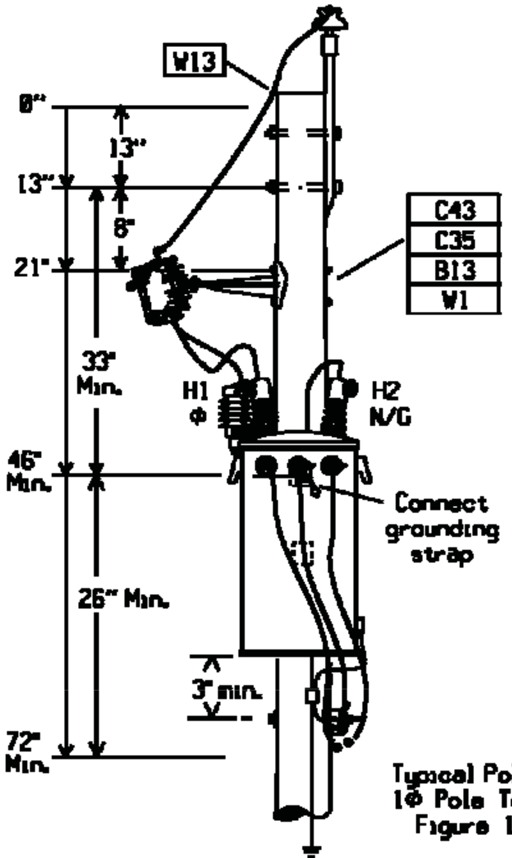


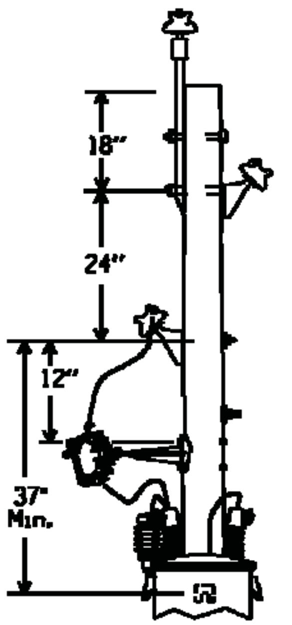
Diagram 10
Three Wire Delta Primary

Two bushing transformers

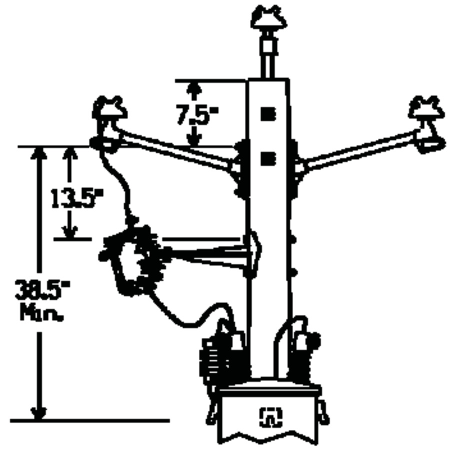




Typical Pole
1Φ Pole Top
Figure 1



3Φ Vertical Pole Top
Figure 2



3Φ Armless Pole Top
Figure 3

Notes
- See Page 14-121 for details & materials for mounting transformer & making secondary connections.
- See Section 13 for grounding diagrams.
- See Section 13 for conversion to 7620V (D.V. Unit).

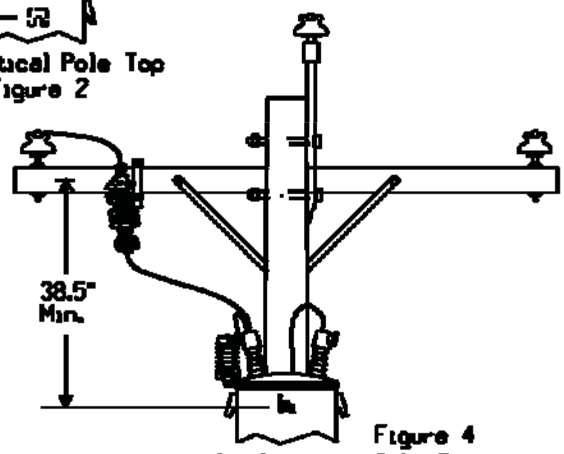
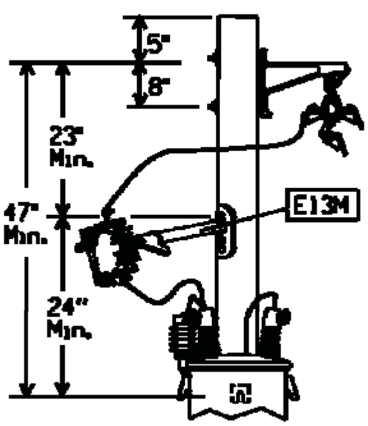
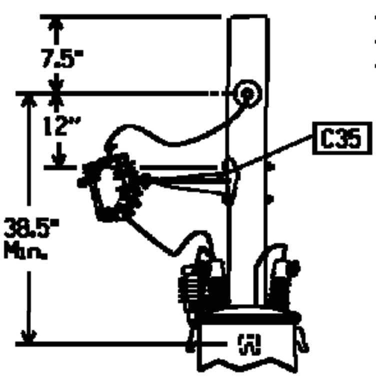


Figure 4
1Φ or 3Φ Crossarm Pole Top

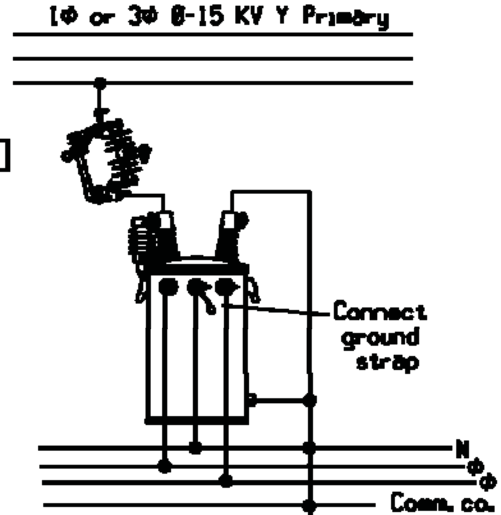


3Φ Spacer Cable Pole Top
Figure 5



1Φ Dead End
Figure 6

1Φ or 3Φ 0-15 KV Y Primary



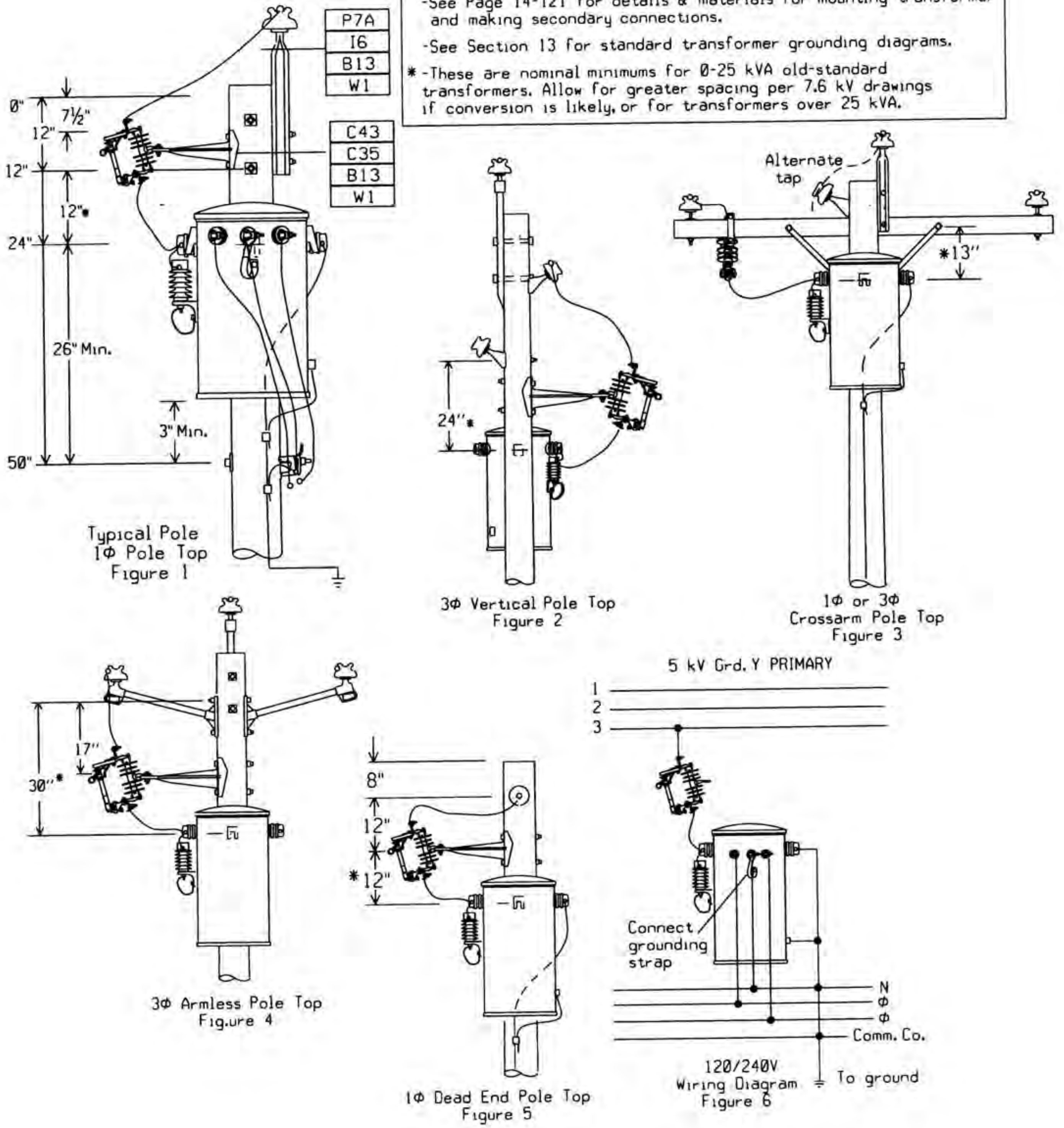
Wiring Diagram
Figure 7

Supersedes 1/08 Issue – Revised minimum spacing dimensions in Figures 1, 2, 3, 4, and 6.

MU = @(W)K(X)P(Y)S(Z)TY	Assembly
CU = TV(W)K(X)P(Y)S(Z)TC	Transformer
***See Page 14-81 For ( ) Variables	

Notes
- See Page 14-121 for details & materials for mounting transformer and making secondary connections.
- See Section 13 for standard transformer grounding diagrams.

* - These are nominal minimums for 0-25 kVA old-standard transformers. Allow for greater spacing per 7.6 kV drawings if conversion is likely, or for transformers over 25 kVA.



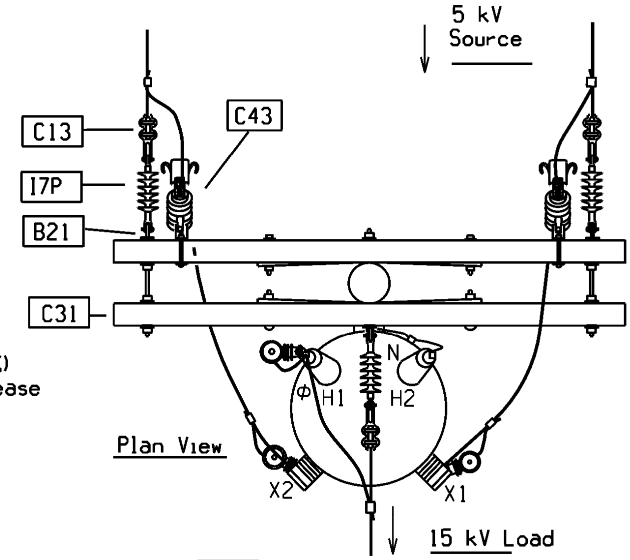
1Φ CONVENTIONAL TRANSFORMER INSTALLATION
ALL 5 kV WYE CIRCUITS

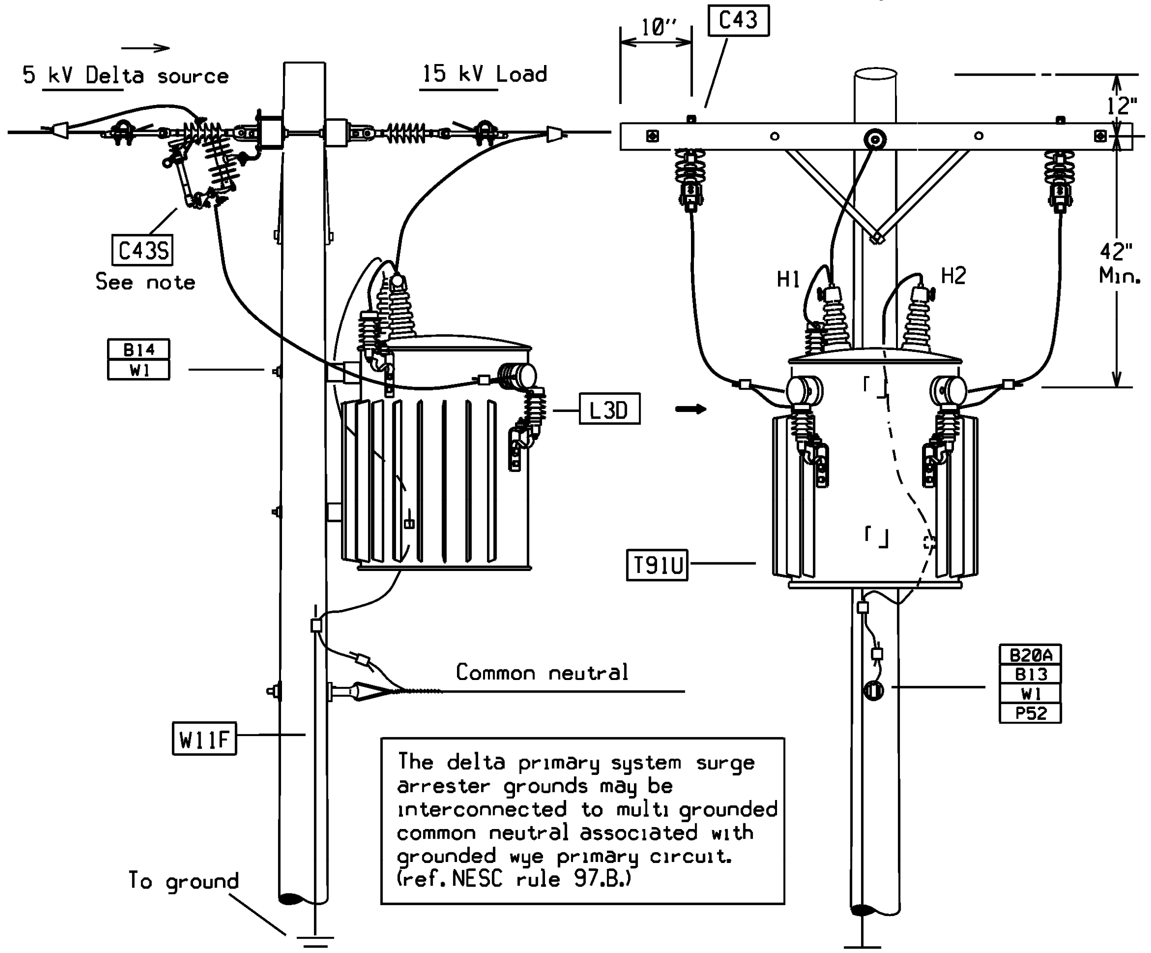
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		14-212	1/06

MU = @(W)K(X)P(Y)S(Z)TD1PRSU	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	

Notes:

- Transformer is located to facilitate cutout operation.
- Place cutouts on source side. Cutouts may be located on adjacent source-side pole for added safety.
- Too-high-impedence transformers (over 3.75%) impair good coordination and tend to increase use of line regulating equipment.
- See Section 9 for deadend details.

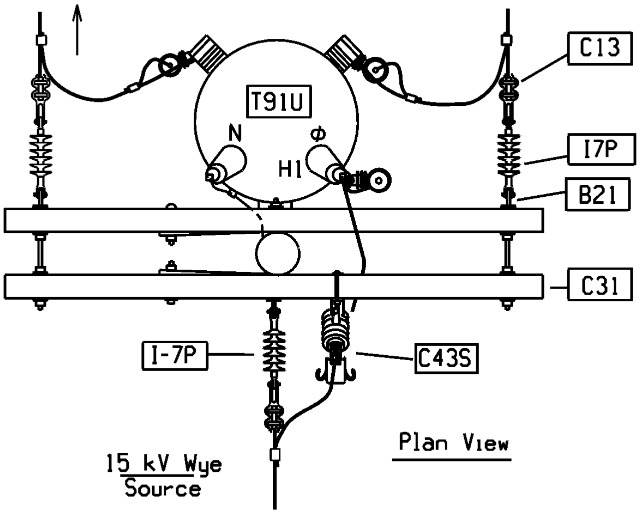




Supersedes 1/06 Issue – Removed note limiting max. transformer size to 167kVA

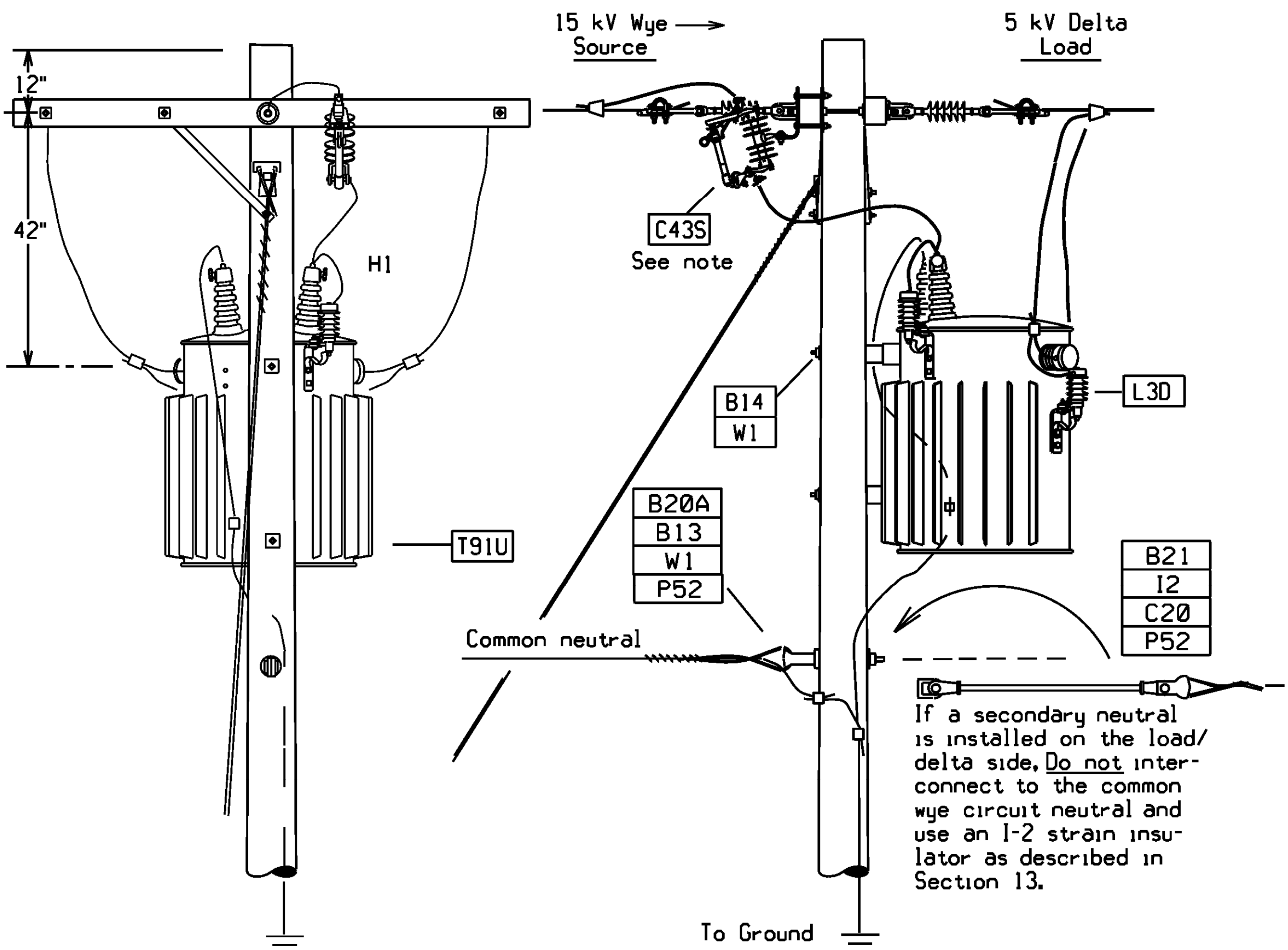
1Φ TRANSFORMER INSTALLATION 5 kV DELTA TO 15 kV GROUNDED WYE STEP-UP INSTALLATION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	14-247		

MU = @(W)K(X)P(Y)S(Z)TY1PR	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	



Notes:

- For added safety, cutout (Item C43) may be located on adjacent source side pole.
- See Section 9 for deadends.
- See Section 5 for connectors

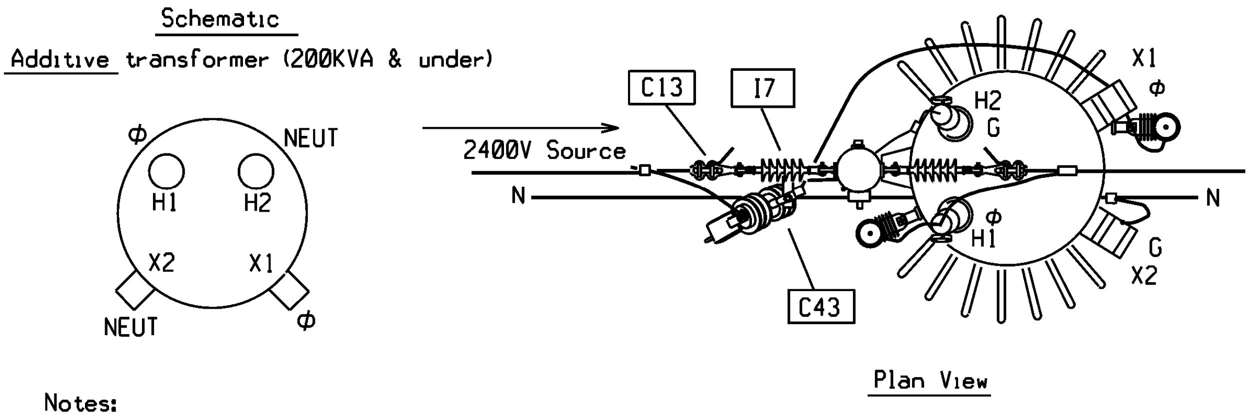


If a secondary neutral is installed on the load/ delta side, Do not interconnect to the common wye circuit neutral and use an I-2 strain insulator as described in Section 13.

Supersedes 7/09 Issue – Removed note limiting max. transformer size to 167kVA

1Φ TRANSFORMER INSTALLATION 15 kV GROUNDED WYE TO 5 kV DELTA STEP-DOWN INSTALLATION			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 14-248	ISSUE 7/10

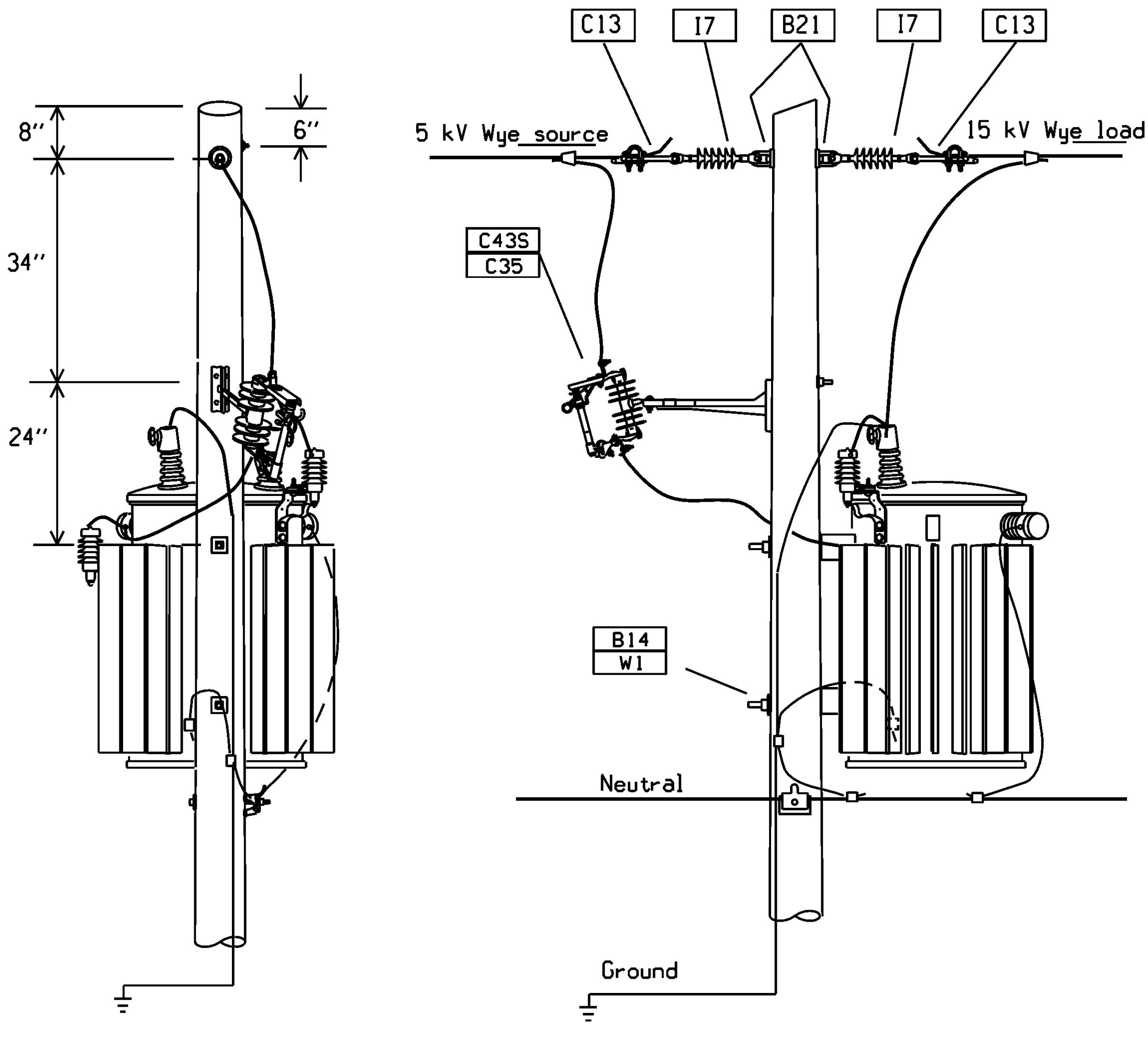
MU = @(W)K(X)P(Y)S(Z)TY1PRSU	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	



Notes:

See Section 9 for deadends.

See Section 5 for connectors.



Supersedes 7/09 Issue – Removed note limiting max. transformer size to 167kVA.

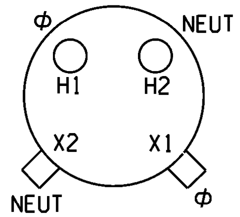
1Φ TRANSFORMER INSTALLATION 5 kV GROUNDED WYE TO 15 kV GROUNDED WYE STEP-UP INSTALLATION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	14-249		

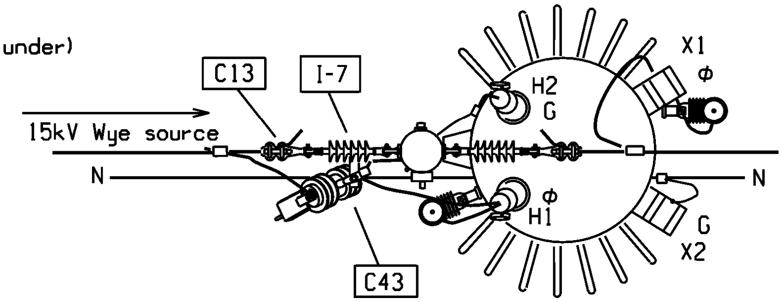
MU = @(W)K(X)P(Y)S(Z)TY1PR	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	

Supersedes 7/08 Issue – Removed note limiting max. transformer size to 167kVA

Schematic

Additive transformer (200KVA & under)

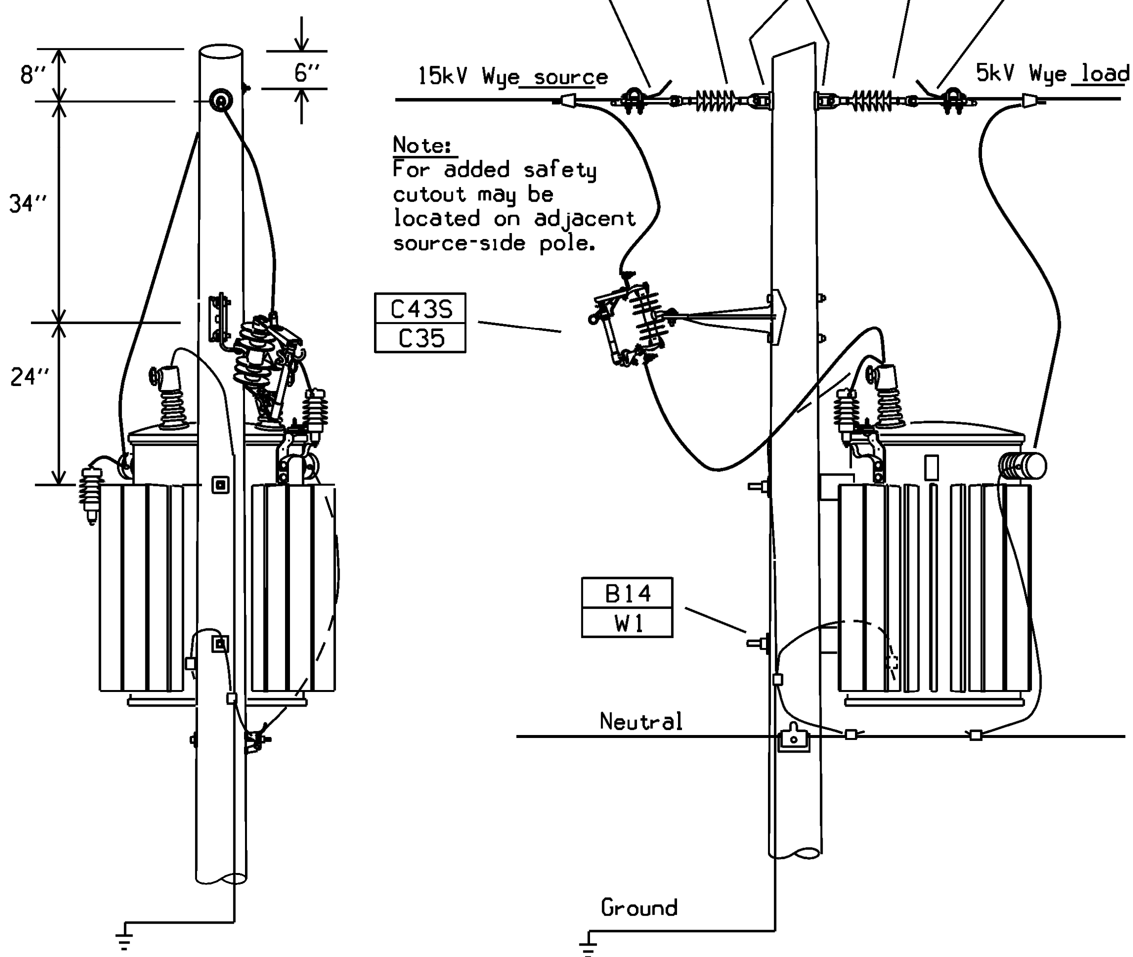




Plan View

Notes:

See Section 9 for deadends.
See Section 5 for connectors.

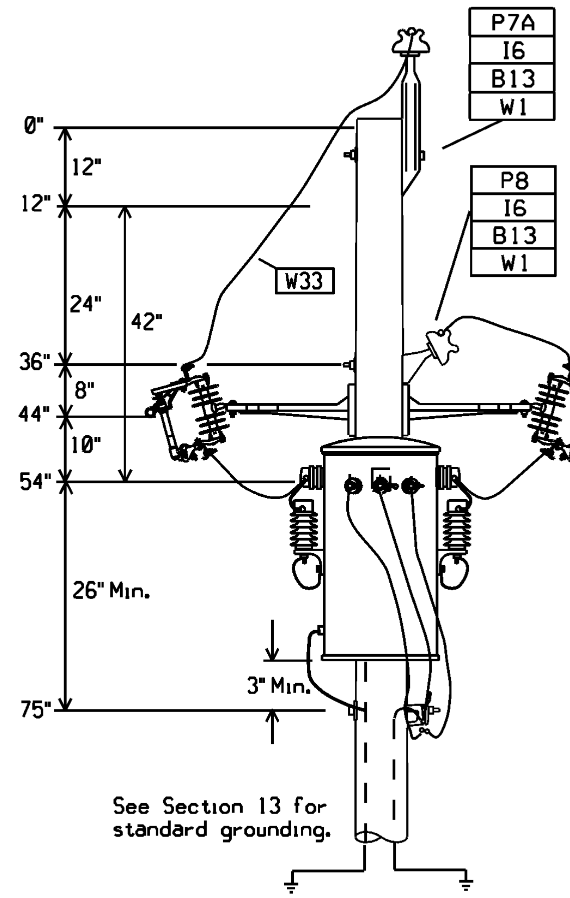


1Φ TRANSFORMER INSTALLATION
15 kV GROUNDED WYE TO 5 kV GROUNDED WYE STEP-DOWN INSTALLATION

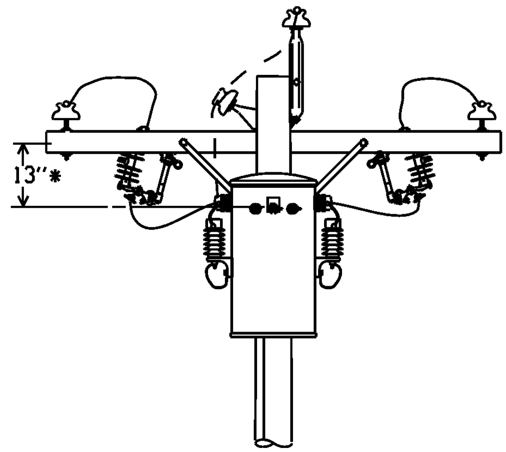
 Doc. # ST. 14.00.004

MU = @(W)K(X)P(Y)S(Z)TY1PRSU	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	

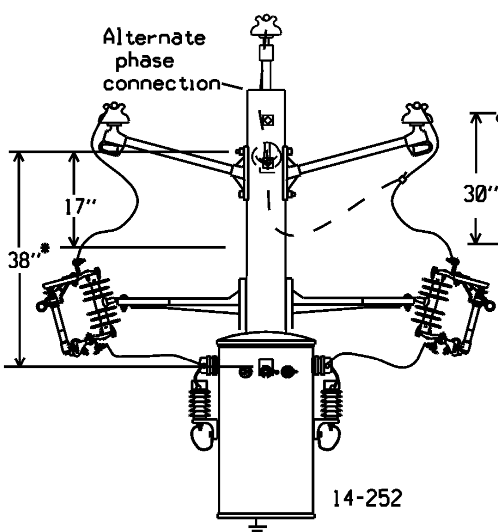
Notes
- -See Page 14-121 for details & materials for mounting transformer & making secondary connections.
- -See Section 13 for standard overhead transformer grounding diagrams.
- -Surge arresters are grounded through the transformer tank ground and isolated from the secondary neutral ground by removeing the grounding strap between the secondary neutral bushing and the tank.
- * -These are nominal minimums for 0-25 kVA old-standard transformers. Allow for greater spacing per 7.6 kV drawings if conversion is likely, or for transformers over 25 kVA.



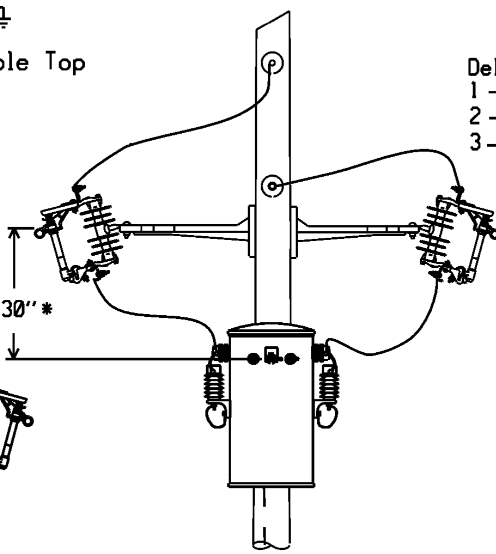
Typical Pole - 1Φ Pole Top
Figure 1



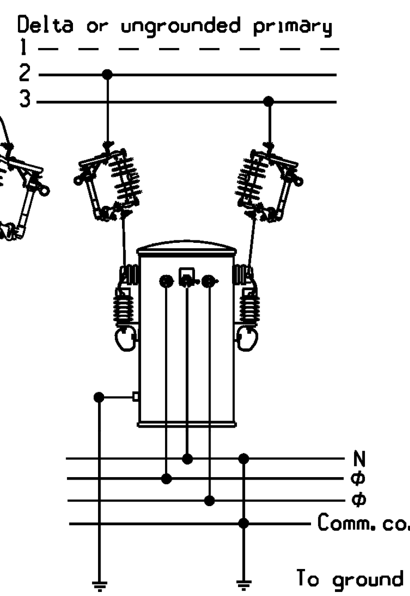
1Φ or 3Φ Crossarm Pole Top
Figure 2



3Φ Armless Pole Top
Figure 3



1Φ Dead End
Figure 4

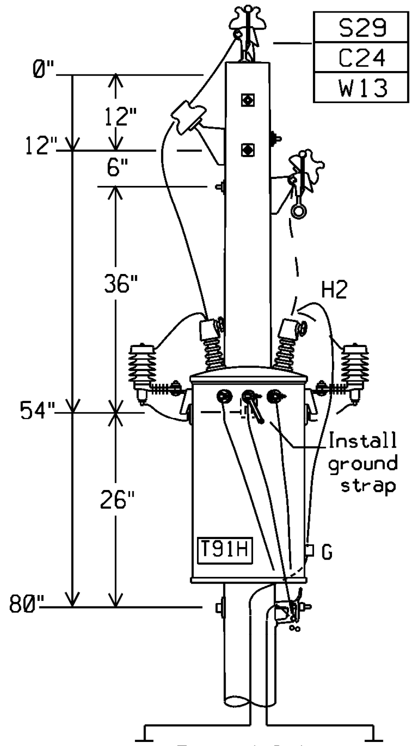


120/240V Wiring Diagram
Figure 5

Supersedes 7/09 Issue – Revised ntoes, showing arresters on transformers, added tank ground on Fig 1 revised grounding on Fig 5.

1Φ CONVENTIONAL TRANSFORMER INSTALLATION
5 kV DELTA OR UNGROUNDED WYE

ISSUE	PAGE NUMBER		
7/10	14-252	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

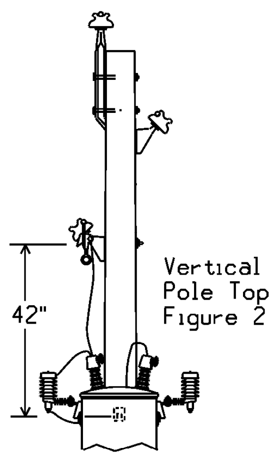


Typical Pole
1Φ Pole Top
Figure 1

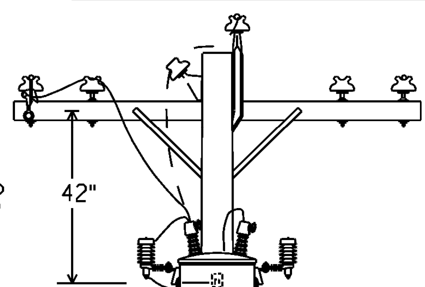
Conversion Procedure

1. Establish the multigrounded common neutral system (Per Section 13). Check grounds at the ends of branches and improve if necessary. 25 ohms maximum is desired before, and 5 ohms maximum after, interconnecting last ground.
2. The 4800 volt circuit may be de-energized at any time. It may be re-energized to 13,200Y/7620 volts at any time after step 4. This guide will not attempt to outline safety rules or general work procedures for the conversion of the primary line.
3. Open the secondary breaker.
4. Remove the primary hot line clamps.
5. Leave disconnected H2 lightning arrester in place. (as a spare)
6. Remove the tank ground discharge gap (if present).
7. Using a continuous #4 Cu. ground wire (W11F) connect the H2 H.V. transformer terminal to the tank grounding stud and to the (new) secondary/common neutral.
   If connectors must be used, compression connectors are recommended. Avoid bolted-type connectors for grounding wire.
8. Bond the grounding conductor to the grounded communication company messenger. If there are two existing grounding conductors, they shall both be bonded to the neutral and one bond made to the communication co. messenger as shown.
   Note: Communication Company should be advised that conversion is underway before this step (8.) is taken.
9. Install a grounding strap/conductor from the transformer secondary neutral bushing to the tank.
10. Turn the dual-voltage ratio switch to the 7620 Volt position.
    Note: If transformer is located in an area where the available fault current is expected to exceed 3500 amperes after conversion, a current-limiting fuse shall be installed as illustrated in Section 12. The CLF installation should precede Step #11.
11. Connect the hot-line tap to the specified primay phase conductor.
12. Close the secondary breaker.
13. Check secondary voltage after conversion.

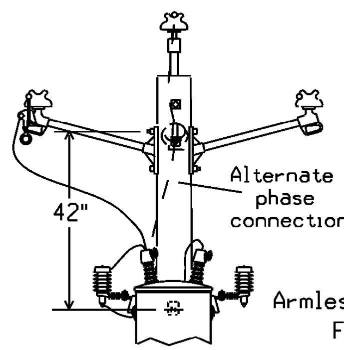
Supersedes 1/06 issue – Fixed text to correctly fit in box.



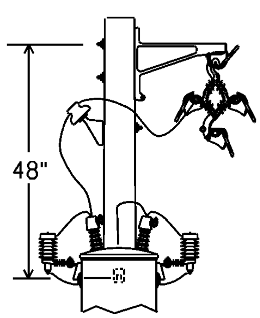
Vertical
Pole Top
Figure 2



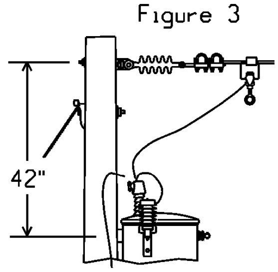
1Φ or 3Φ
Crossarm Pole Top
Figure 3



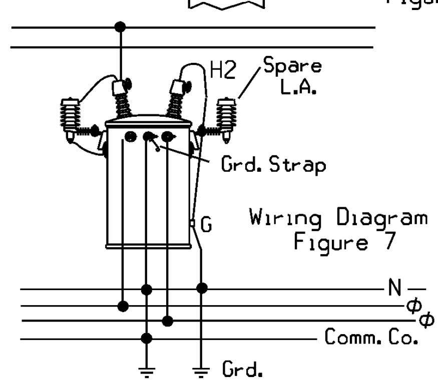
Armless Pole Top
Figure 4



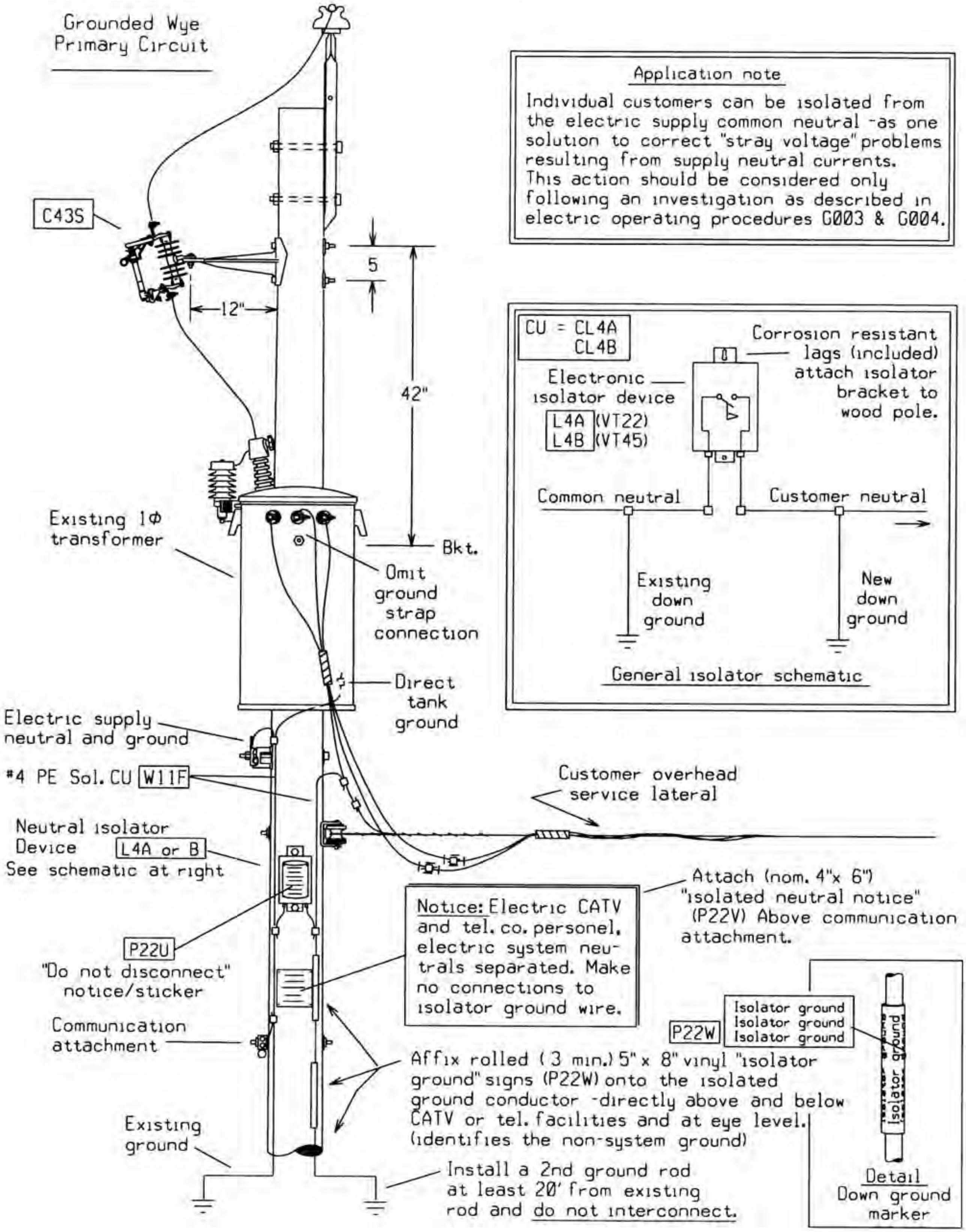
Spaced Cable Pole Top
Figure 5



1Φ Dead End Pole Top
Figure 6



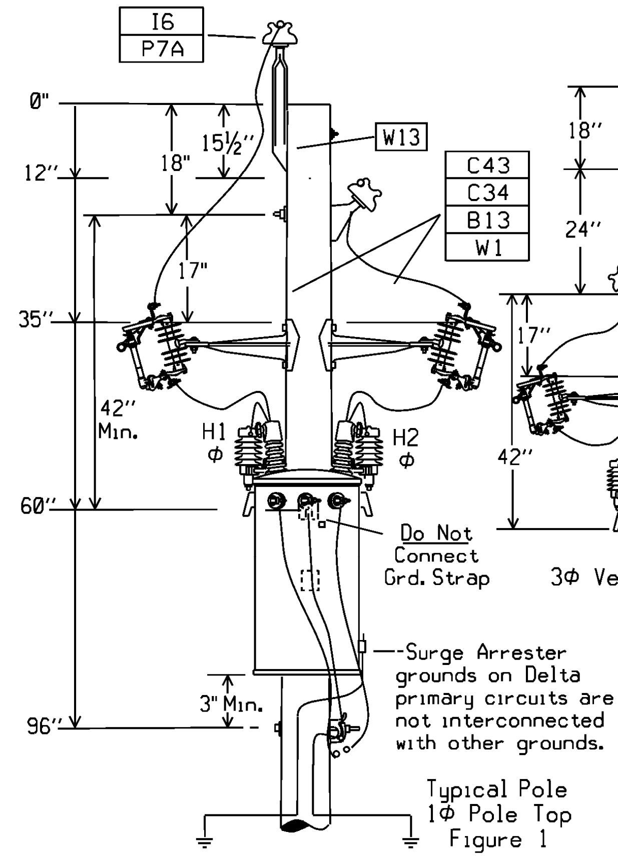
Wiring Diagram
Figure 7



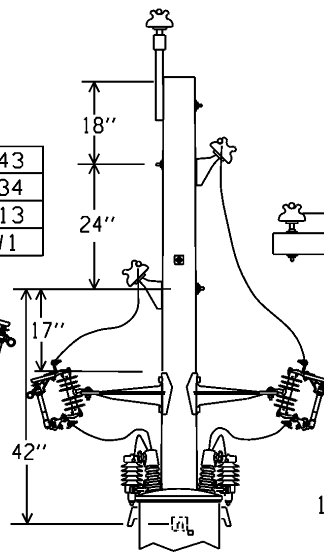
<table>
<tr><td colspan="4">ISOLATED NEUTRAL TRANSFORMER CONNECTION FOR CUSTOMERS AFFECTED BY NEUTRAL TO EARTH POTENTIAL – WYE CIRCUITS</td></tr>
<tr><td>ISSUE
1/06</td><td>PAGE NUMBER
14-264</td><td>OVERHEAD
CONSTRUCTION STANDARD</td><td>Liberty Utilities</td></tr>
</table>

MU = @(W)K(X)P(Y)S(Z)TD	Assembly
CU = TV(W)K(X)P(Y)S(Z)TC	Transformer
***See Page 14-81 For ( ) Variables	

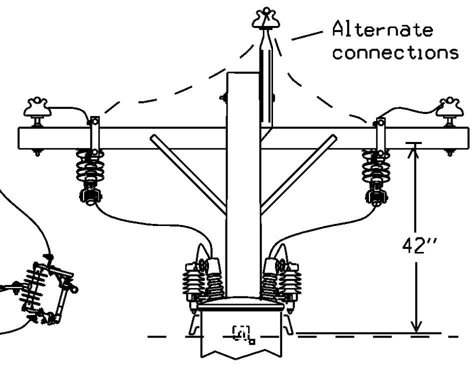
Supersedes 1/06 Issue – Revised cutout bracket on figure 5 from metal to fiberglass



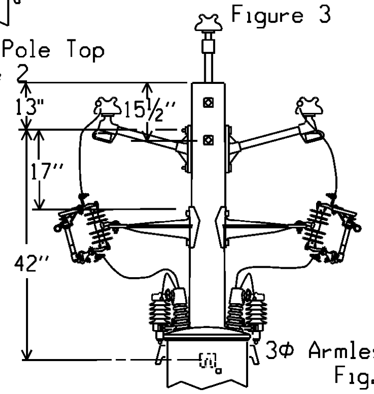
Typical Pole
1Φ Pole Top
Figure 1



3Φ Vertical Pole Top
Figure 2

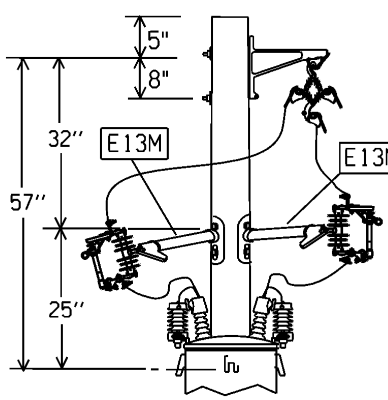


1Φ or 3Φ Crossarm Pole Top
Figure 3

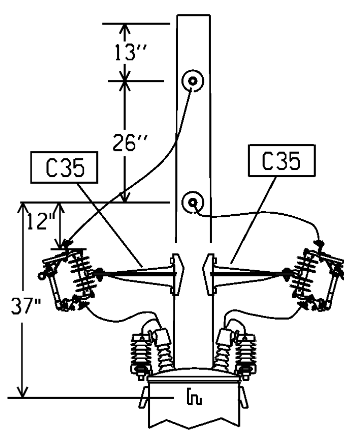


3Φ Armless Pole Top
Fig.ure 4

Notes
- See Page 13-112 for standard transformer grounding.
- See 14-121 for details & materials for mounting transformer & making secondary connections.
- See Section 13 for conversion to 7620V.

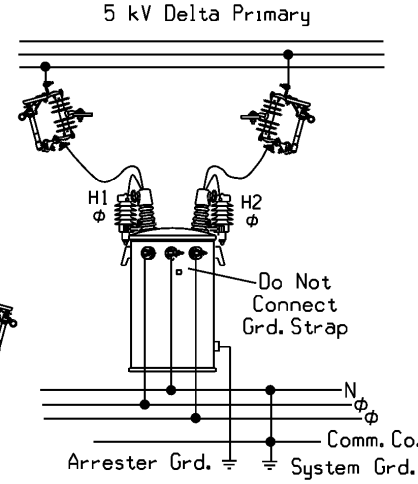


3Φ Spacer Cable Pole Top
Figure 5



1Φ Dead End
Fig.ure 6

5 kV Delta Primary



Wiring Diagram
Figure 7

1Φ CONVERSION OF DUAL-VOLTAGE TRANSFORMERS ALL 5 kV DELTA CIRCUITS

The Drawings on the following pages show Pole Top Details for the Most Common installation of Transformers in three phase banks. Cluster mounts are recommended as the standard installation for individual transformers weighing up to 2,000 pounds each

The following Notes apply to the Three-Phase Drawings on Page 14-304 through 14-378:

1. For details of Secondary Wiring on three banks, see Page 14-2 and Pages 14-171 & 14-172.

2. Transformers exceeding 2000 pounds each should be mounted on a Platform arrangement as shown on 14-377. Typical Weights are given on Page 14-80. Unit weight of any specific transformer can be found on the nameplate.

3. One vertical Grounding Conductor shall be installed at each bank (as at every equipment installation). This shall be solidly connected from the driven ground to the Secondary or Common neutral. It shall also be bonded or interconnected to any Communication Messenger present on the pole. It shall be (except as described in Note 4.) connected to the Surge Arrester grounds and to the transformer tanks as indicated on the Drawings.

4. A second vertical Grounding Conductor is required for Arrester Grounds on Delta Primary Circuits. This grounding conductor connects the arresters to a second driven ground without any interconnections. The two ground rods shall be separated by 20' or more (6' minimum required) and not bonded together.

5. Banks of 300 kVA or more shall be located outside of heavy traffic area. Transformers may be rotated 90° as required.

6. Banks should not exceed three 100 kVA transformers for 208Y/120V Services or three 167 kVA transformers for 480Y/277V Services. Services larger than this shall be served by non-pole-mounted installations. Services exceeding 800A are not recommended.

7. Additional information pertaining to transformer installations is shown in other Sections of these standards. For Selection of Service Conductors see Section 11. Fusing Selection for Overhead Conventional Transformers is found on Section 12. Standard Grounding arrangements for Overhead Transformers are shown in Section 13 and other Grounding and Bonding notes are found throughout section 13.

8. See Section 5 for information on Connectors and Section 10 for Transformer Connections to Multiplex Secondaries.

9. Wye-Delta connected transformer installations that require a floating Primary Neutral shall require Double Bushing Transformers. These Floating Wye-Delta connected transformers SHALL NOT have direct-connected tank-mounted arresters.

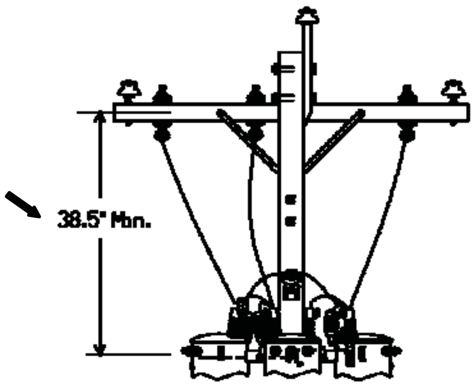
   The tank mounted arresters shall be Removed and separately mounted (i.e. Crossarm-mounted) on the same pole and connected at the source-side of the Fused Cutout. Arresters, otherwise, could become subjected to damaging induced overvoltages during operation of the cutout (if located on the load side of cutout).

10. For Existing CSP transformer banks, when it is necessary to replace a CSP unit with a conventional unit, Cutouts with appropriate fuse link shall be installed on all units.

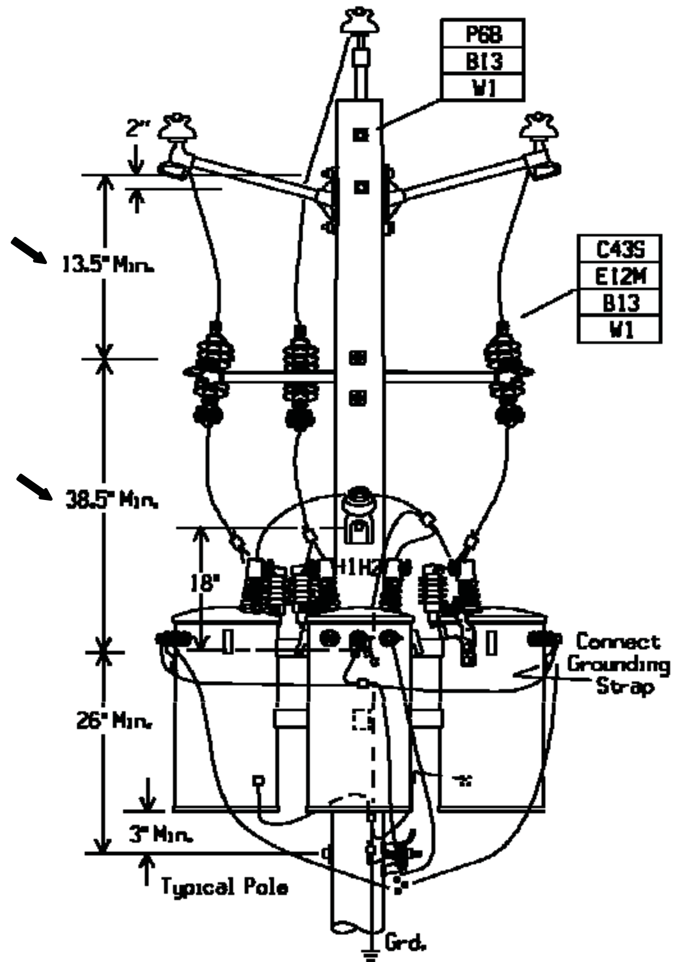
Supersedes 1/08 Issue – Corrected page title

MU = @(U)K(X)P(Y)S(Z)TY	Assembly
CU = TV9W)K(X)P(Y)S(Z)TC	Transformer
CU = TMC(E)(F)VSNE	Cluster Mount
***See Page 14-81 For ( ) Variables	

Supersedes 7/11 Issue – Revised spacing dimensions.



3Φ Crossarm Pole Top
Figure 1



3Φ Armless Pole Top
Figure 2

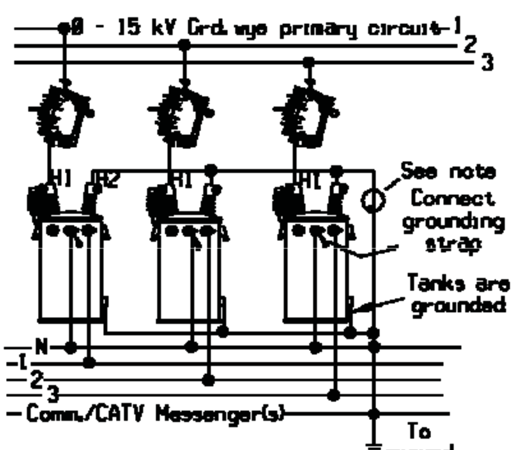
Notes

- See Page 14-121 for details & materials for mounting transformer and making secondary connections.

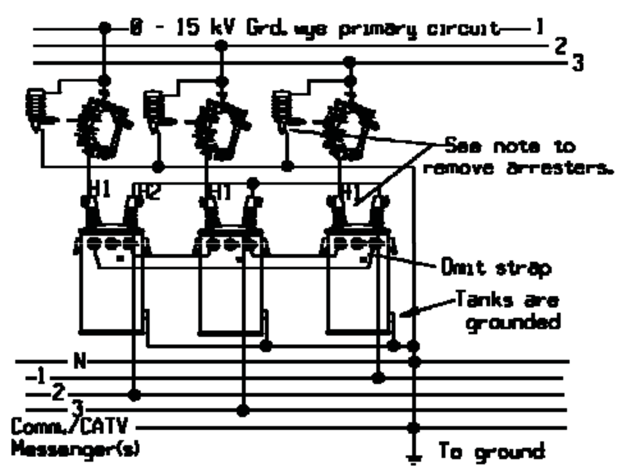
Surge arrester grounds are not interconnected with any other multi-grounds on delta primary circuits.

- Floating wye delta installations (Figure 4) must have arresters removed from the tank and relocated ahead of the cutout onto a bracket or crossarm for protection of the arrester from damaging over voltages induced during switch operations (opening/enclosing of its associated cutout).

*

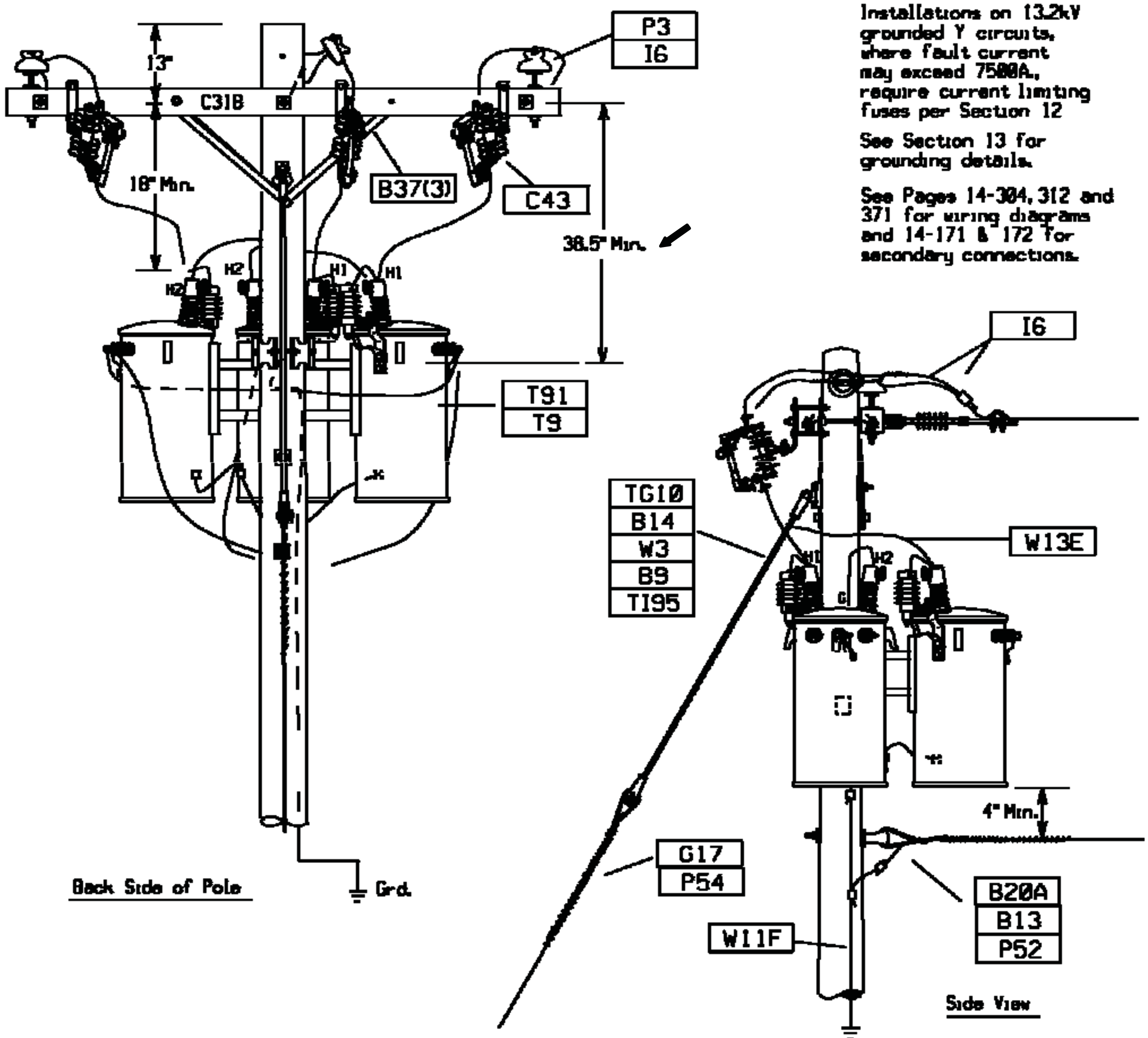


480Y/277V or 208Y/120V
Wiring Diagram
Figure 3



240V Wiring Diagram
Figure 4

3Φ CONVENTIONAL TRANSFORMER INSTALLATION ALL 15 kV WYE CIRCUITS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 14-304	ISSUE 7/13



Notes:

Installations on 13.2kV grounded Y circuits, where fault current may exceed 7500A., require current limiting fuses per Section 12

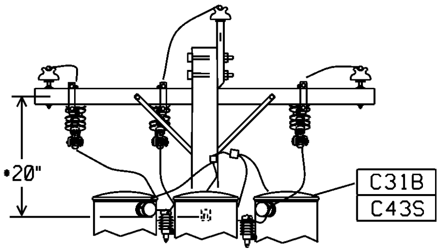
See Section 13 for grounding details.

See Pages 14-304, 312 and 371 for wiring diagrams and 14-171 & 172 for secondary connections.

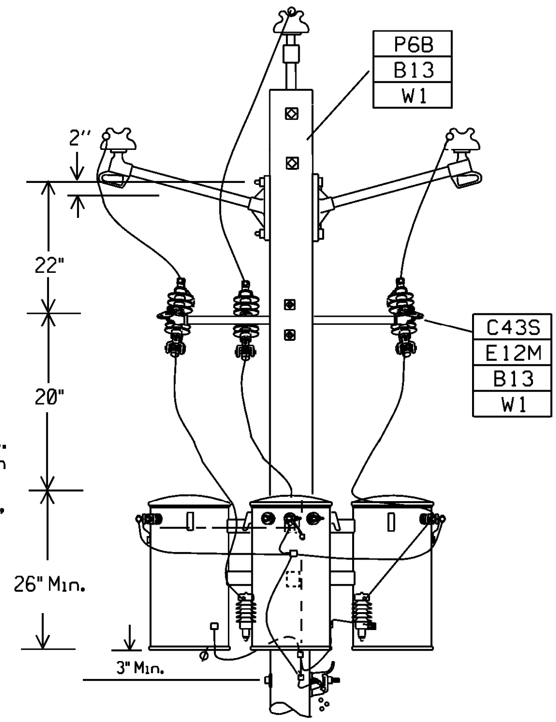
Supersedes 1/06 Issue – Revised spacing dimensions.

MU = @(U)K(X)P(Y)S(Z)TY	Assembly
CU = TV9W)K(X)P(Y)S(Z)TC	Transformer
CU = TMC(E)(F)VSNE	Cluster Mount
***See Page 14-81 For ( ) Variables	

Supersedes 7/08 – Revised Figure 1 and Notes, revised CU, MU.



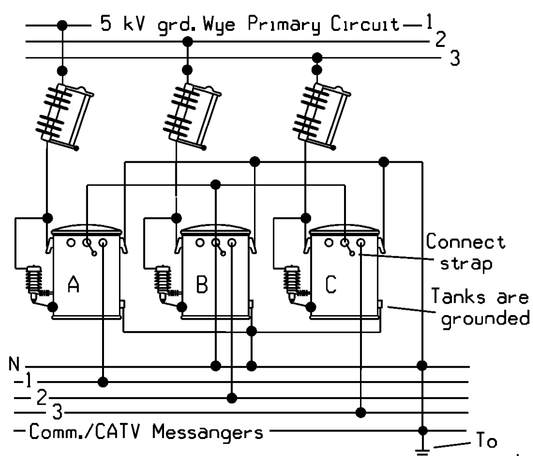
3Φ Crossarm Pole Top - Figure 1



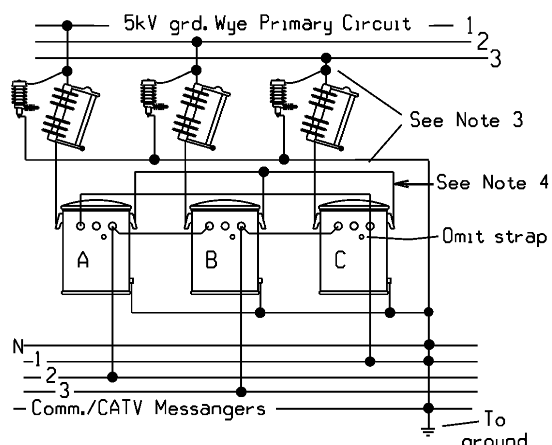
Typical Pole
3 Armless Pole Top
Figure 2

Notes:

1. - These are nominal minimums for 0-25 KVA transformers. Allow greater spacing per 7.6 kV drawings if conversion is likely or for transformers over 25 KVA.
2. - For 480V delta service, provide a 480Y/277V, 4 wire service per Figure 3.
3. - Remove the tank-mounted arresters and relocate them to a bracket or crossarm and connect to the source side of the cutouts.
4. - Neutral floats on transformers supplying delta service from Wye primary.



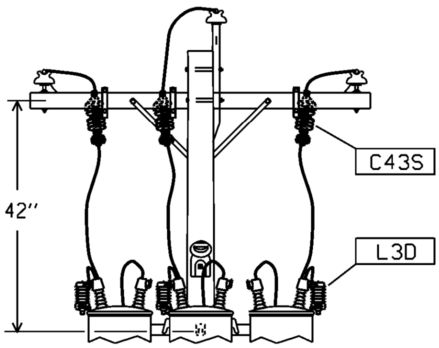
480Y/277 or 208Y/120V
Wiring Diagram Figure 3



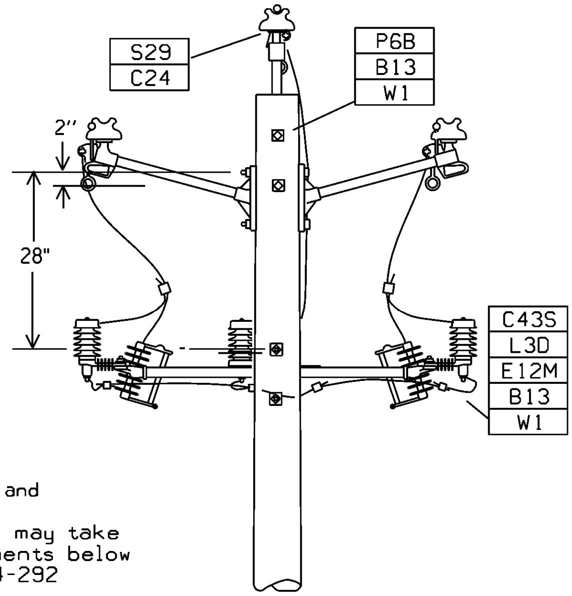
240V
Wiring Diagram Figure 4

 Doc. # ST. 14.00.004

MU = @(U)K(X)P(Y)S(Z)TY	Assembly
CU = TV(W)K(X)P(Y)S(Z)TC	Transformer
CU = TMC(E)(F)VSNE	Cluster Mount
***See Page 14-81 For ( ) Variables	



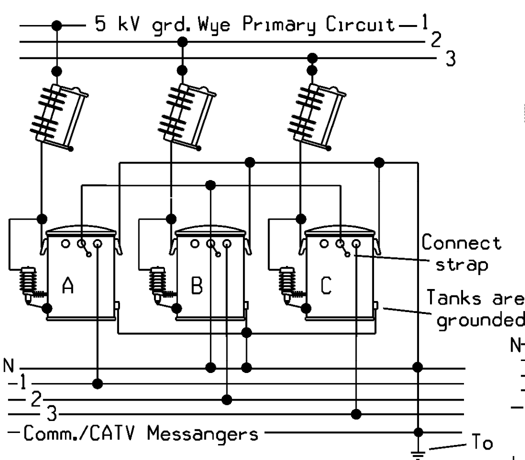
3Φ Crossarm Pole Top - Figure 1



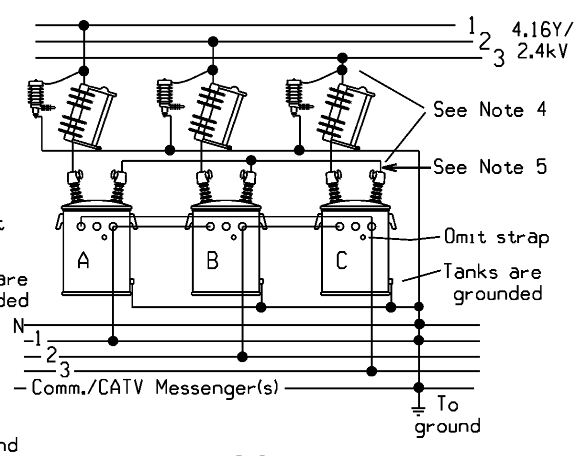
Typical Pole
3Φ Armless Pole Top
Figure 2

Notes:

1. See Page 14-131 & 132 for mounting transformers and pages 14-173 & 176 for wiring diagrams.
2. See section 9 for primary pole tops which may take less pole space or use alternate arrangements below for reusing existing 35' poles. See page 14-292 Figures for clearances before converting.
3. For 480V delta service, provide a 480Y/277V, 4 wire service per Figure 3.
4. Remove the tank-mounted arresters and relocate them to a bracket or crossarm and connect to the source side of the cutotus.
5. Neutral floats on transformers supplying delta service from Wye primary.



480Y/277 or 208Y/120V
Wiring Diagram Figure 3



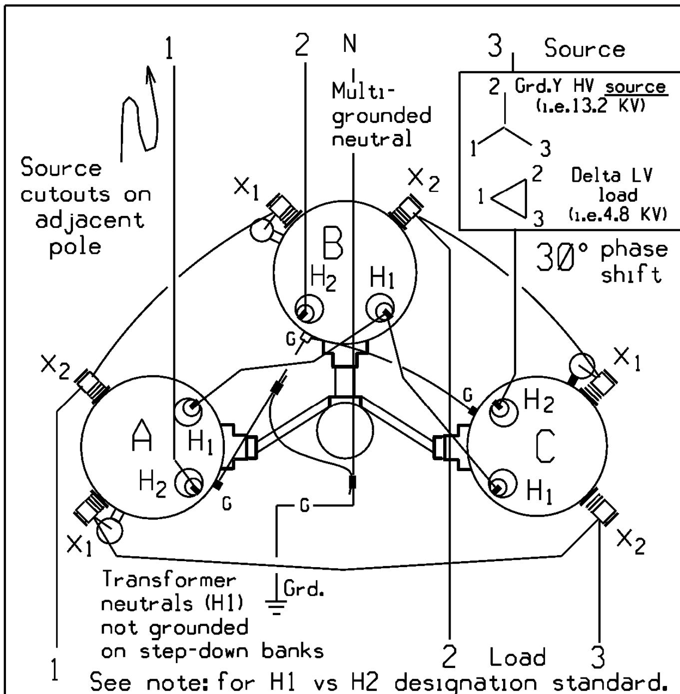
240V
Wiring Diagram Figure 4

Supersedes 7/08 Issue – Revised Notes, revised CU, MU.

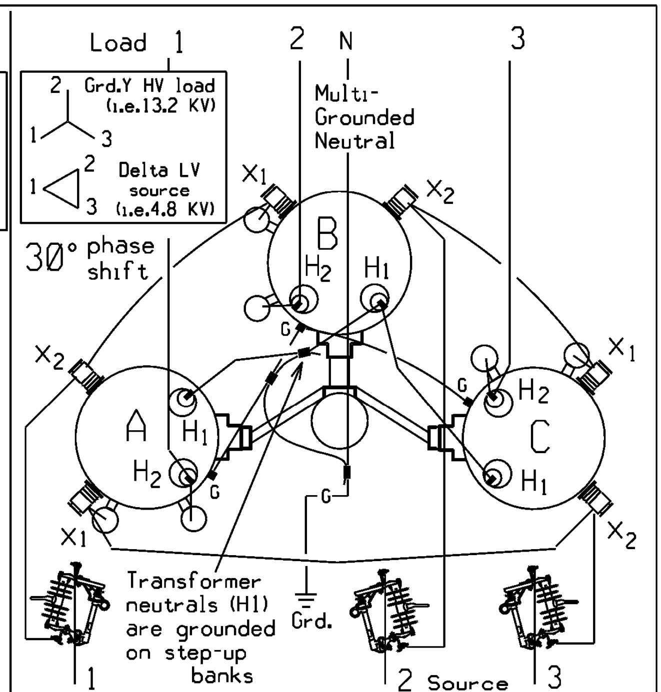
3Φ CONVENTIONAL DUAL VOLTAGE TRANSFORMER INSTALLATION 5 kV WYE CIRCUITS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	14-326		

 Doc. # ST. 14.00.004

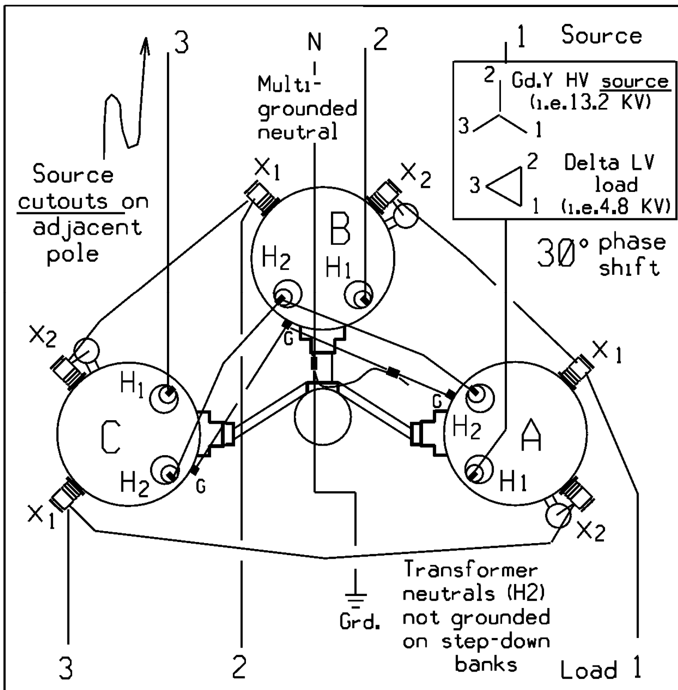
Supersedes 1/06 Issue – Removed arrestors on Figure 1 & 3.



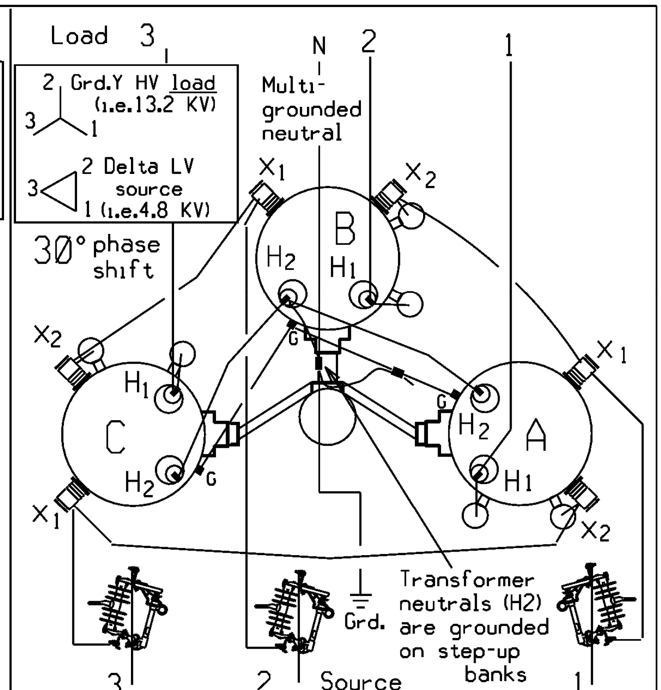
1-2-3 Phase Rotation Step Down Y- ▲ Figure 1



1-2-3 Phase Rotation Step Up ▲ -Y Figure 2



3-2-1 Phase Rotation Step Down Y- ▲ Figure 3

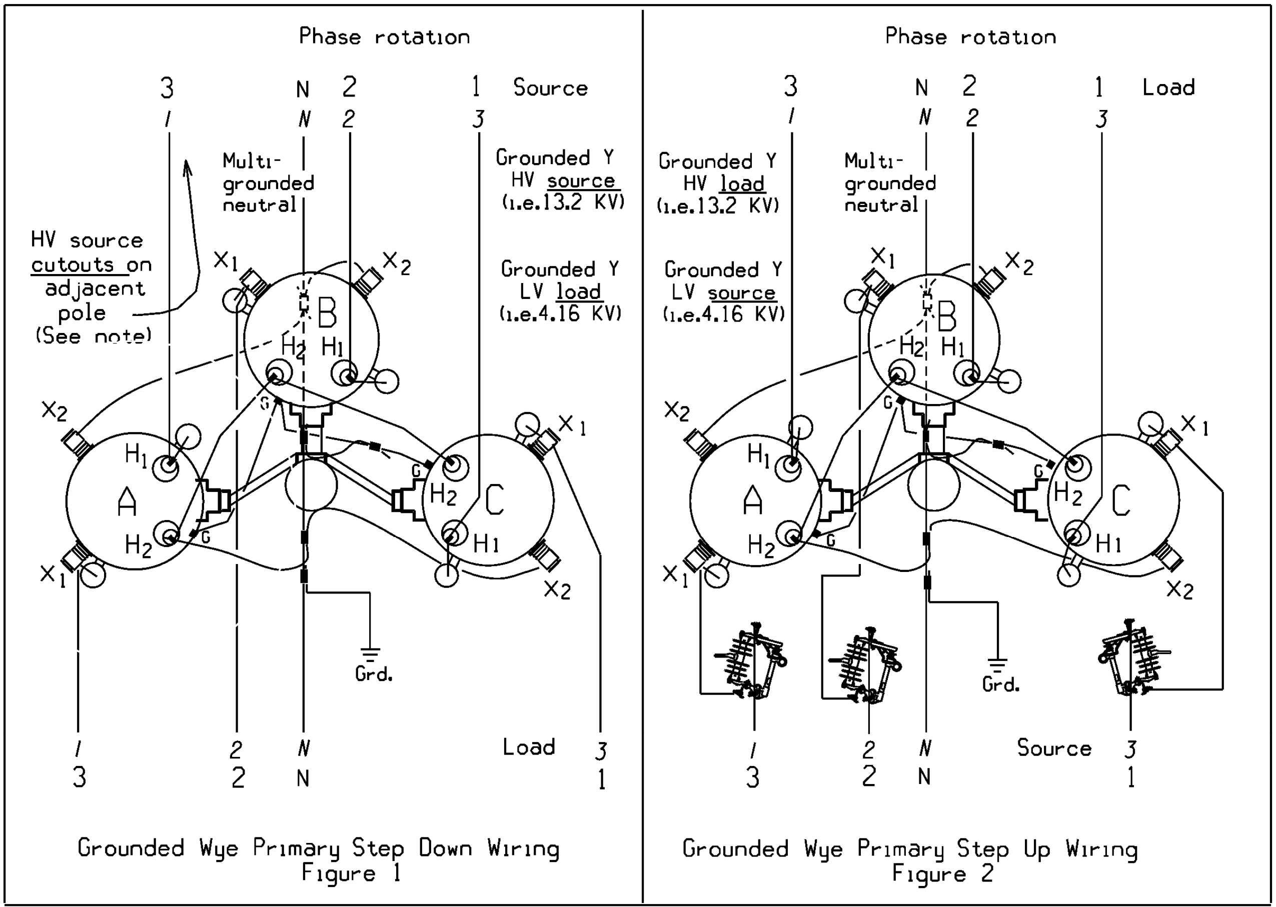


3-2-1 Phase Rotation Step Up ▲ -Y Figure 4

Note: -"American standard practice (ANSI C57.105) is to connect the H1 & X1 bushing to phase and to ground the H2 & X2 designated bushing. The H2 & X2 bushings are connected to phase in some of these wiring diagrams, however, where doing so will simplify (shorten) the secondary wiring.
Tank mounted surge arresters may require repositioning where phase bushings are switched.
Relative feeder phase positions are maintained through the bank installation.

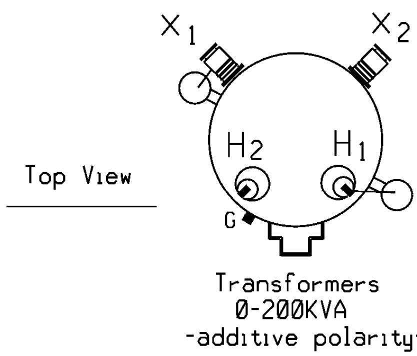
3Φ STEP-UP/STEP-DOWN WIRING DIAGRAM
DELTA (LV): WYE (HV) – ADDITIVE TRANSFORMERS (200 kVA AND UNDER)

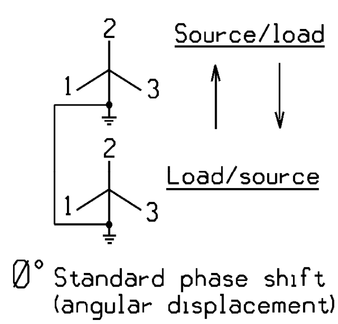
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		14-343	7/08



Notes:

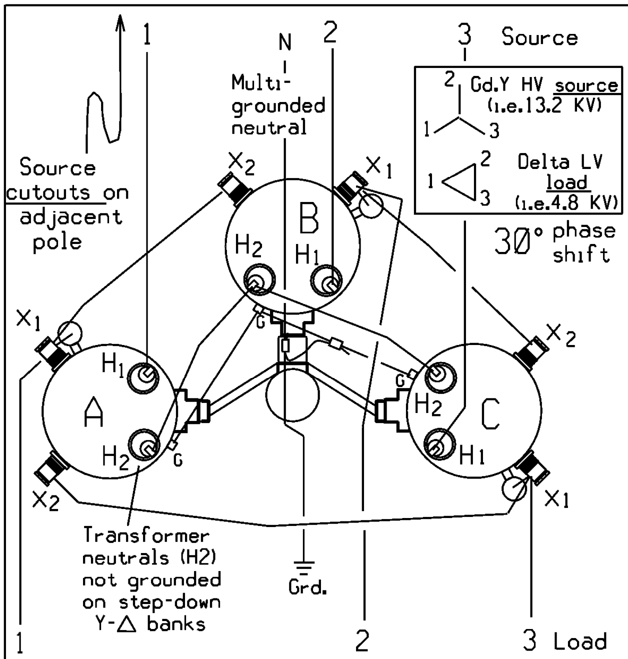
Figures 1 and 2 are the same except for placement of the cutouts, which are always located on the source side.
Location of the transformers on the high voltage side of the pole limits available space for the source cutouts on the same pole. These shall be located on an adjacent source-side pole.
See Page 14-375 for wiring diagrams for subtractive polarity transformers (250-500KVA).



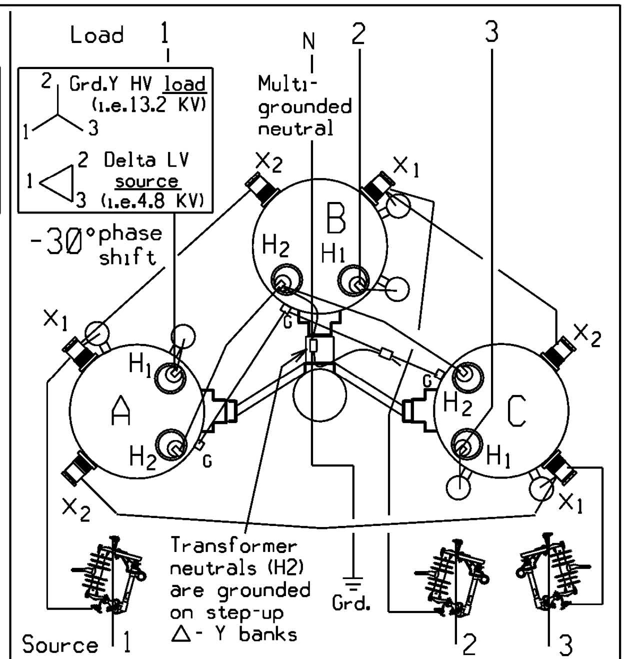


Supersedes 1/06 Issue – Corrected spelling of additive on Top View Diagram

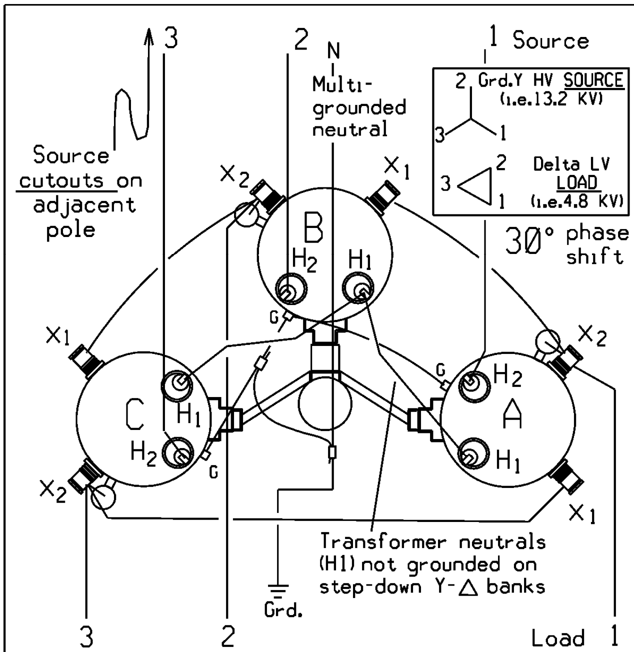
Supersedes 7/08 Issue – Revised Figures 1, 3 & 4 – Incorrect phase



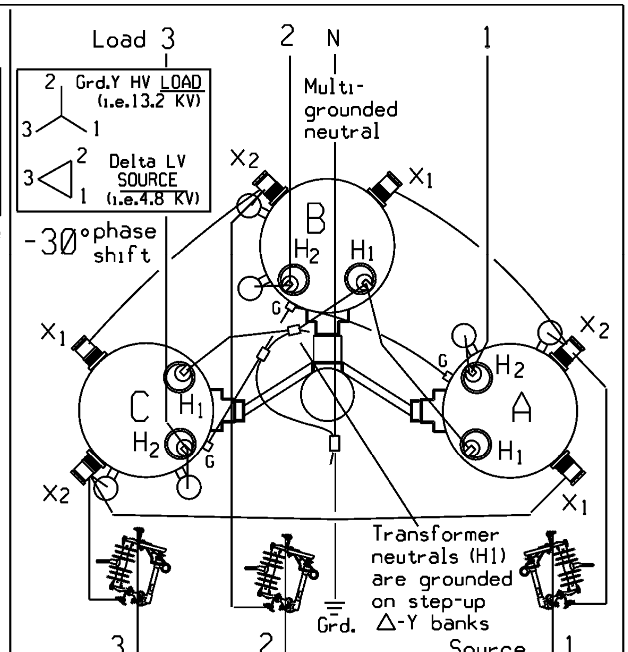
1-2-3 Phase Rotation Step Down Y- △ Figure 1



1-2-3 Phase Rotation Step Up △ -Y Figure 2



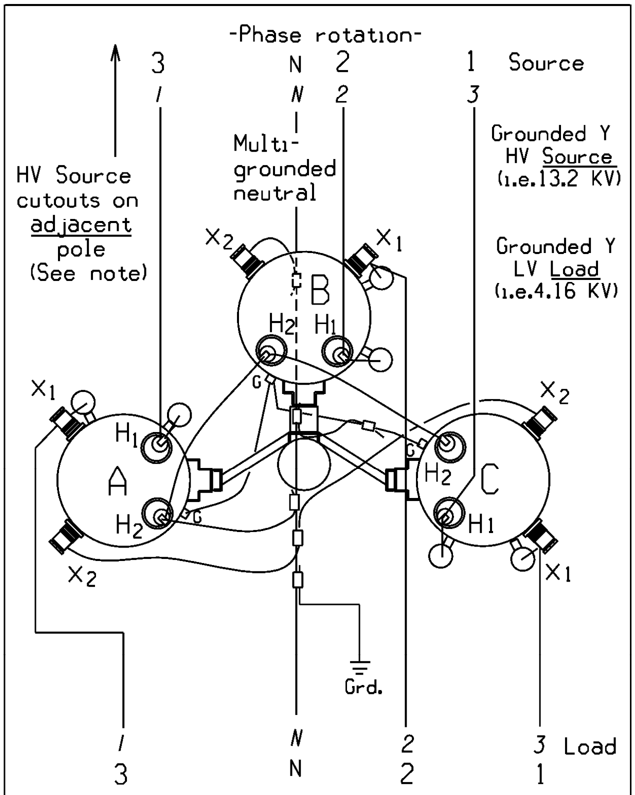
3-2-1 Phase Rotation Step Down Y- △ Figure 3



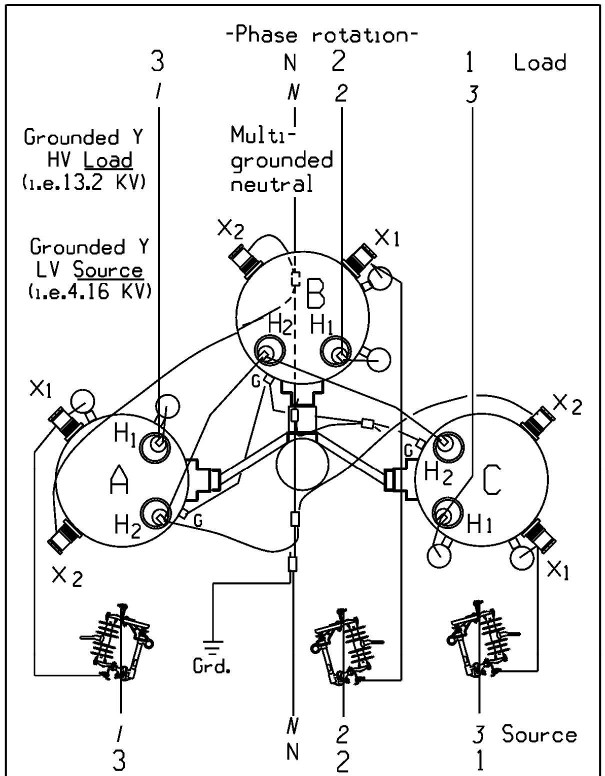
3-2-1 Phase Rotation Step Up △ -Y Figure 4

NOTE: - Standard practice (ANSI C57.105) is to connect the H.V. H1 bushing to phase and to ground the H2 designated bushing. The H2 bushing is connected to phase in some of these wiring diagrams where doing so will simplify (shorten) the secondary wiring.
- Relative feeder phase positions are maintained through the bank installation.

3Φ STEP-UP/STEP-DOWN WIRING DIAGRAM DELTA (LV): WYE (HV) – SUBTRACTIVE TRANSFORMERS (250 kVA)			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER **14-345**	ISSUE **7/10**



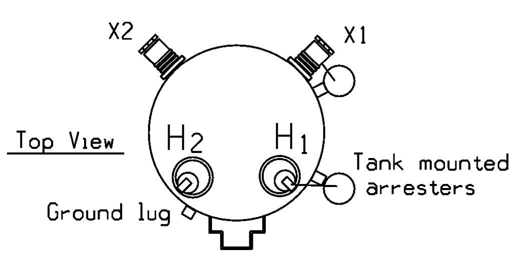
Grounded Wye Circuits Step Down Wiring
Figure 1



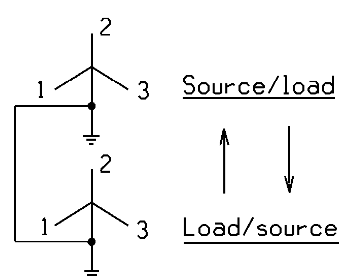
Grounded Wye Circuits Step Up Wiring
Fig. 2

Notes:
Figures I and II are the same except for placement of the source-side cutouts.
Location of the transformers on the high voltage side of the pole limits available space for the source cutouts on the same pole. These shall be located on an adjacent source-side pole.

See Pages 14-345, 14-346 and 14-375 for subtractive polarity transformers (250-500KVA) wiring diagrams.



250KVA Transformers
-subtractive polarity-



0° Standard phase shift
(Angular displacement)

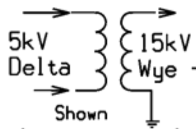
Supersedes 1/06 Issue – Changed arrester position from X2 to X1 on Top View

3Φ STEP-UP/STEP-DOWN WIRING DIAGRAM
WYE (LV): WYE (HV) – SUBTRACTIVE TRANSFORMERS (250 kVA)

ISSUE	PAGE NUMBER		
7/08	14-346	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

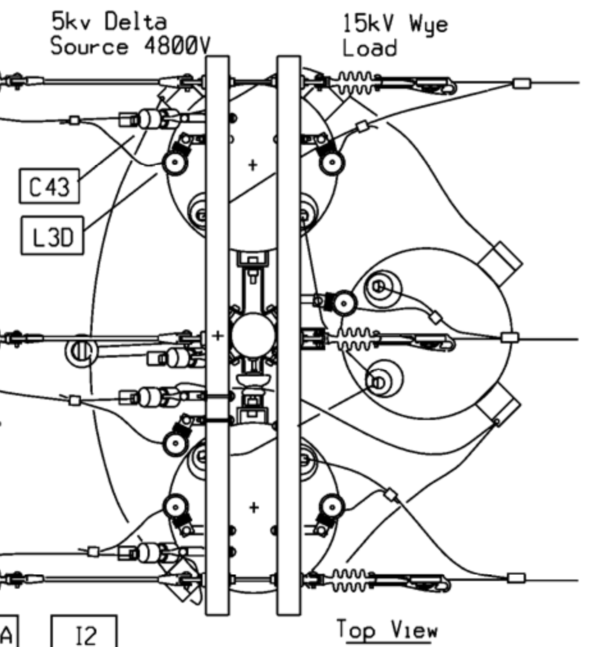
 Doc. # ST. 14.00.004

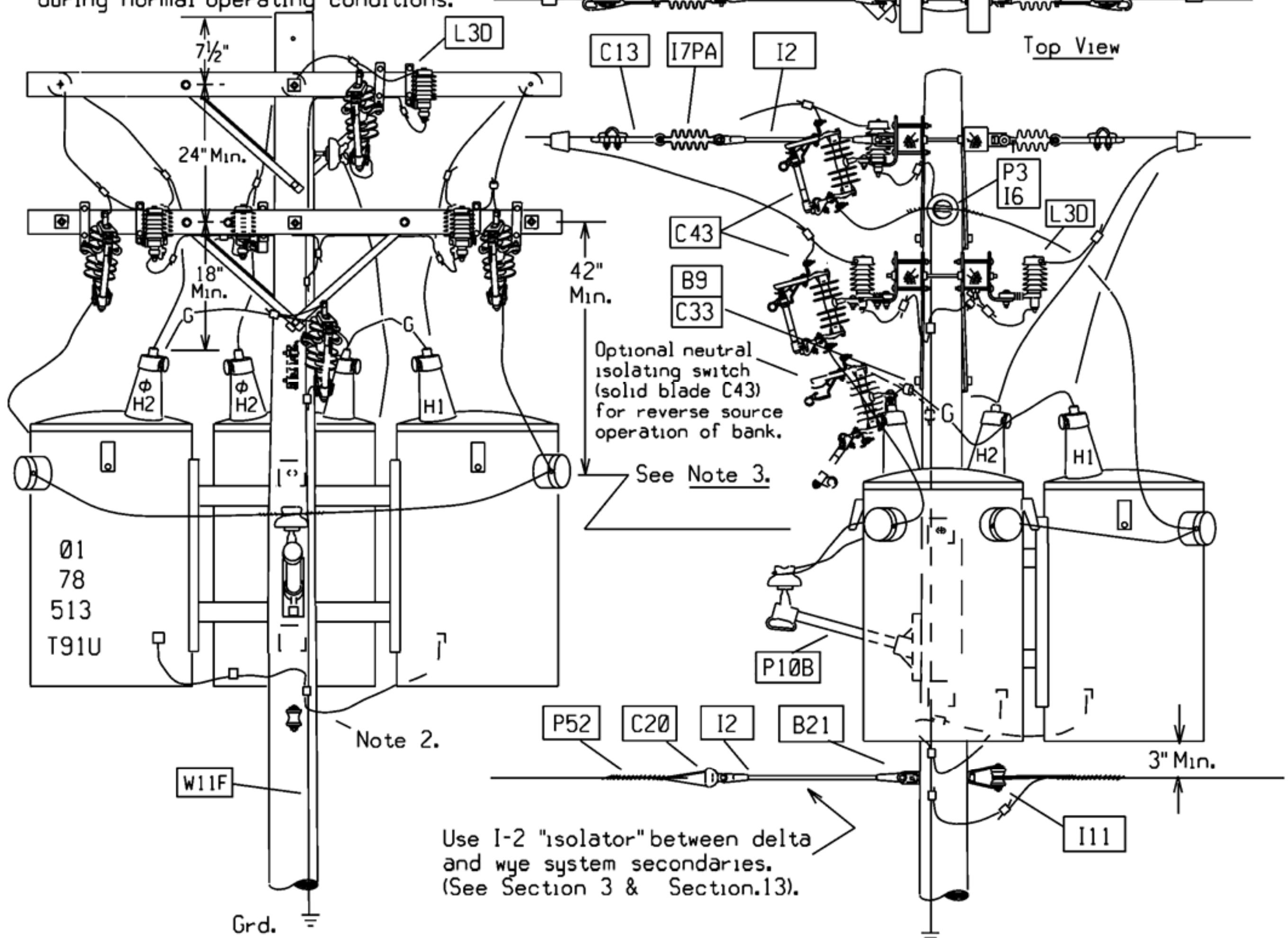
MU = @(U)K(X)P(Y)S(Z)TYR	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	



Notes:

1. This installation is based on wiring diagram Figure 2, Page 14-343 - delta-wye step-up using additive (200kva & below) transformers. See specific wiring diagrams (Pages. 14-343-346) for this and other schemes.
2. All grounds may be tied together at primary ratio banks. Primary/HV winding neutrals are tied together and grounded except on wye to delta step-down banks where the primary transformer neutral "floats" and is not grounded (as in Figure 1 Page.14-343).
3. On wye-delta banks that may be reverse-sourced a neutral-isolating disconnect shall be installed -located at the primary level for crew safety. The solid blade should be removed from the switch and hung (stapled) on the pole, below the switch during normal operating conditions.



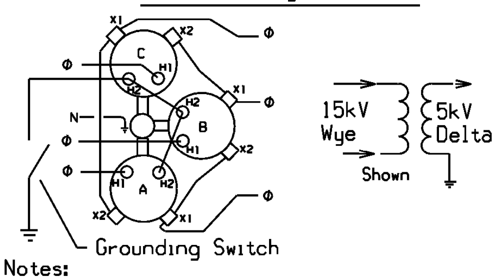


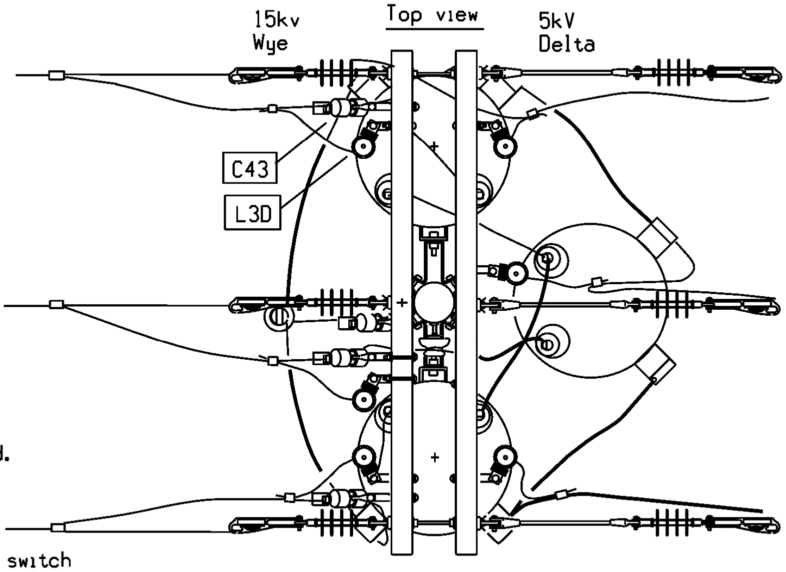
Supersedes 7/08 Issue – Revised Std Item labels.

 Doc. # ST. 14.00.004

MU = @(U)K(X)P(Y)S(Z)TYR	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
***See Page 14-81 For ( ) Variables	

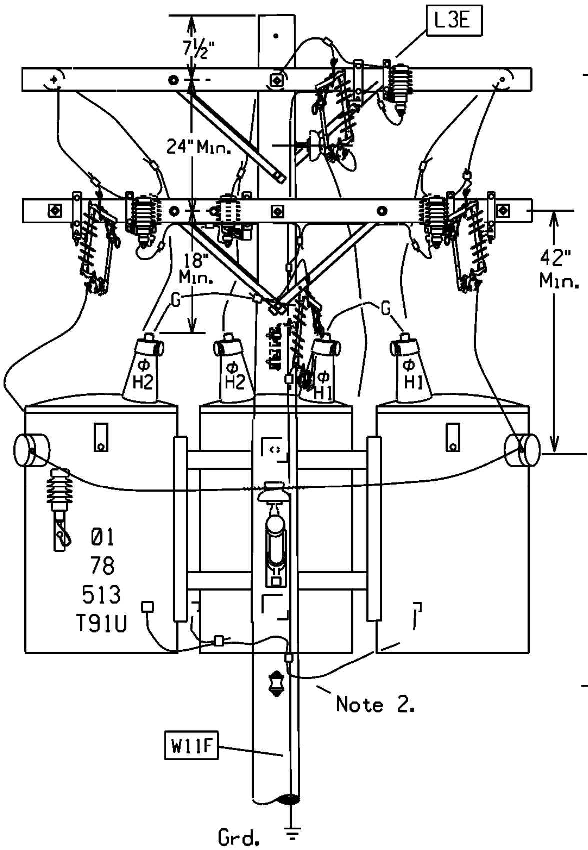
General Wiring Schematic

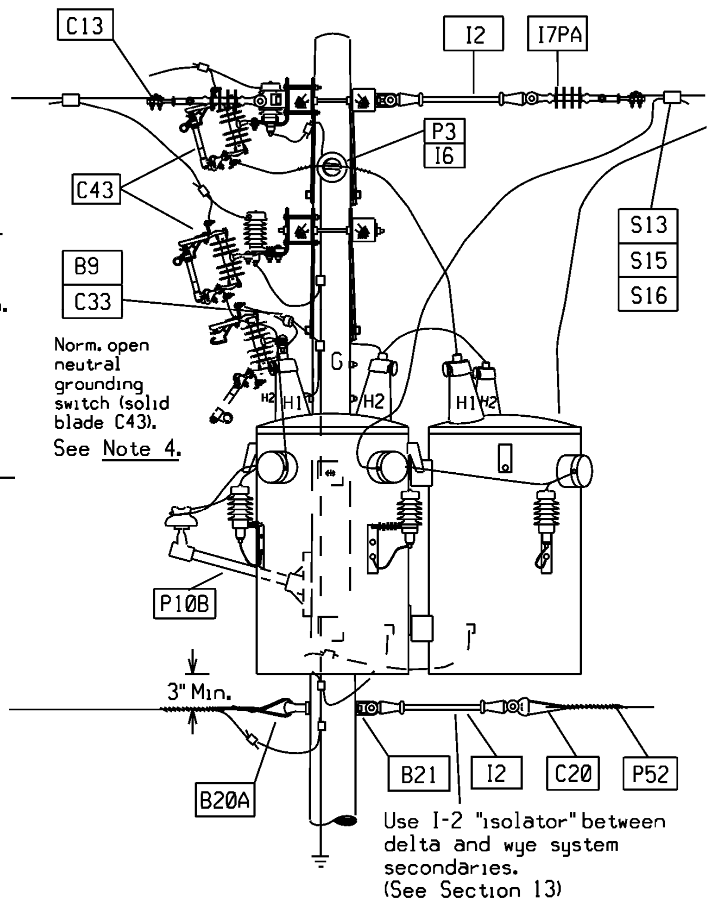




Notes:

1. This installation is based on wiring diagram Figure 3 Page 14-343. "If the connection is wye-elta, then the phase of X1 lags that of H1 by 30°" (ANSI)
2. All grounds may be tied together at primary ratio banks. Primary/HV winding neutrals are tied together and not grounded.
3. Source side open cutouts may be located on adjacent pole to minimize congestion.
4. The solid blade should be removed from the switch and hung (stapled) on the pole, below the switch during normal operating conditions.

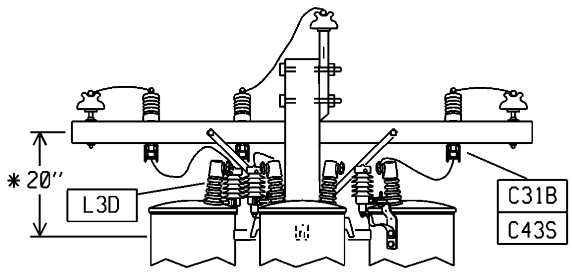




Supersedes 7/08 Issue - Revised Notes.

3Φ TRANSFORMER BANK 15 kV TO 5 kV STEP-DOWN INSTALLATION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/08	14-348		

MU = @(U)K(X)P(Y)S(Z)TD	Assembly
CU = TV(W)K(X)P(Y)S(X)TC	Transformer
CU = TMC(E)(F)VSNE	Cluster Mount
***See Page 14-81 For ( ) Variables	



3Φ Crossarm Pole Top
Figure 1

Notes:

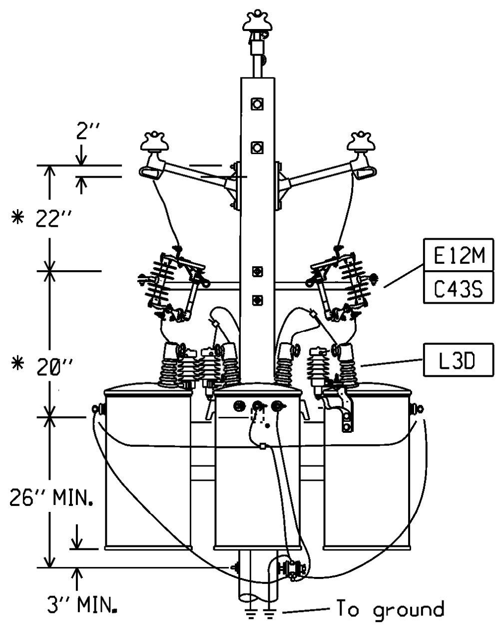
See Pages 14-131 & 132 for details and materials for mounting transformers.

See Section 5 for connectors.

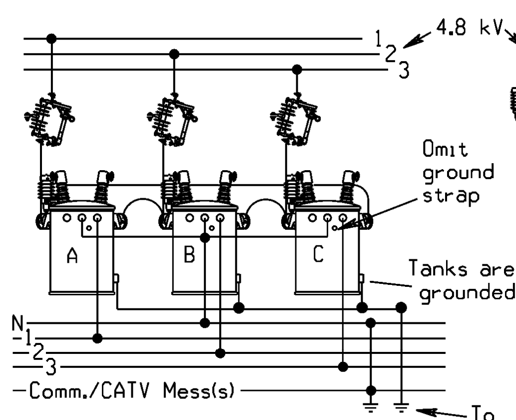
See Section 9 for primary pole tops which may take less pole top space if rearranged. Alternate arrangements with slight modifications exist reusing 35′ poles.

∗ These are nominal minimums for 0-25 kva transformers. Allow greater spacing per 15kV drawings. if conversion is likely or for transformers over 25 kva.

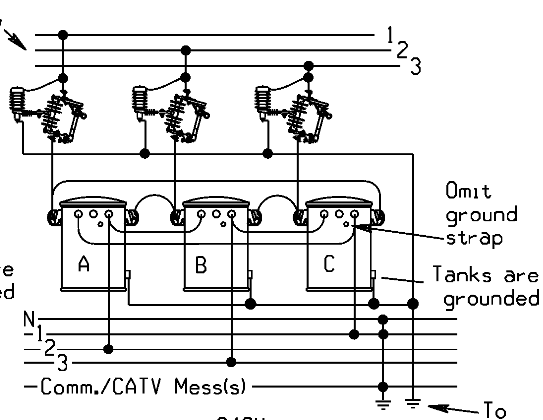
For 480 V delta services, provide a 480Y/277, 4 wire service per Figure 3.



Typical Pole
3Φ Armless Pole Top
Figure 2



480Y/277 or 208Y/120V
Wiring Diagram Figure 3

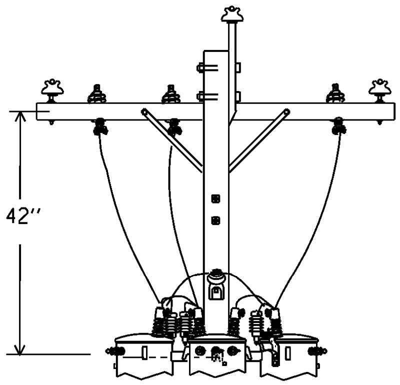


240V
Wiring Diagram Figure 4

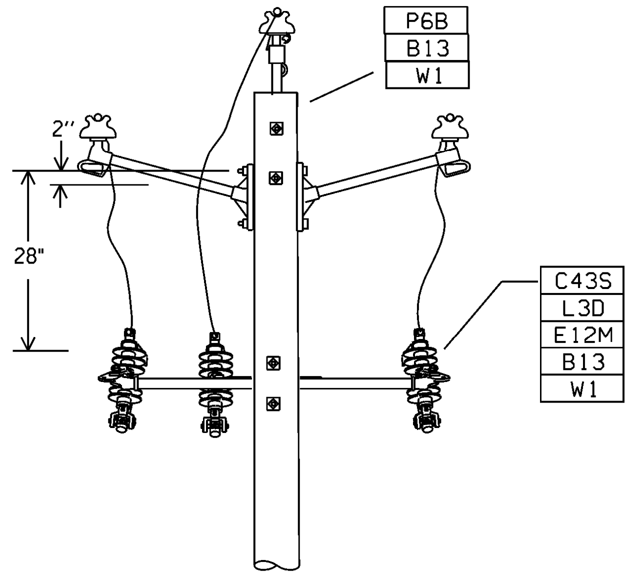
Supersedes 7/09 Issue – Removed secondary ground straps in Figure 3 & 4 .

3Φ CONVENTIONAL TRANSFORMER INSTALLATION 5 kV DELTA			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER **14-352**	ISSUE **7/10**

MU = @(U)K(X)P(Y)S(Z)TD	Assembly
CU = TV(W)K(X)P(Y)S(Z)TC	Transformer
CU = TMC(E)(F)VNE	Cluster Mount
***See Page 14-81 For ( ) Variables	



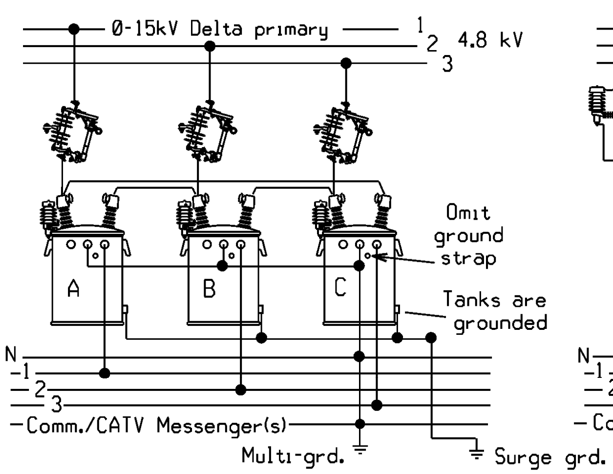
3Φ Crossarm Pole Top - Figure 1



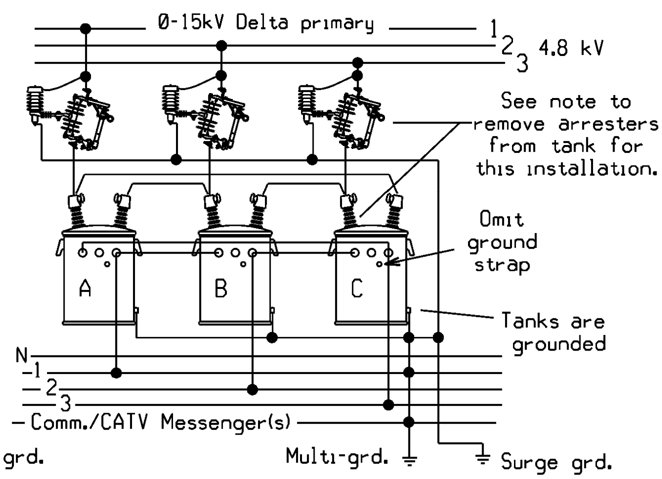
3Φ Armless Pole Top - Figure 2

Notes:

- See Pages 14-173 & 176 for wiring diagrams.
- Surge arrester gournds are not interconnected with any other multi-grounds on delta primary circuits.
- Floating wye-delta installations (Figure 4) must have arresters removed from the tank and relocated ahead of the cutout onto a bracket or crossarm for protection of the arrester from damaging overvoltages induced during switching operations (opening/reclosing of its associated cutout).



480Y/277 or 208Y/120V
Wiring Diagram Figure 3

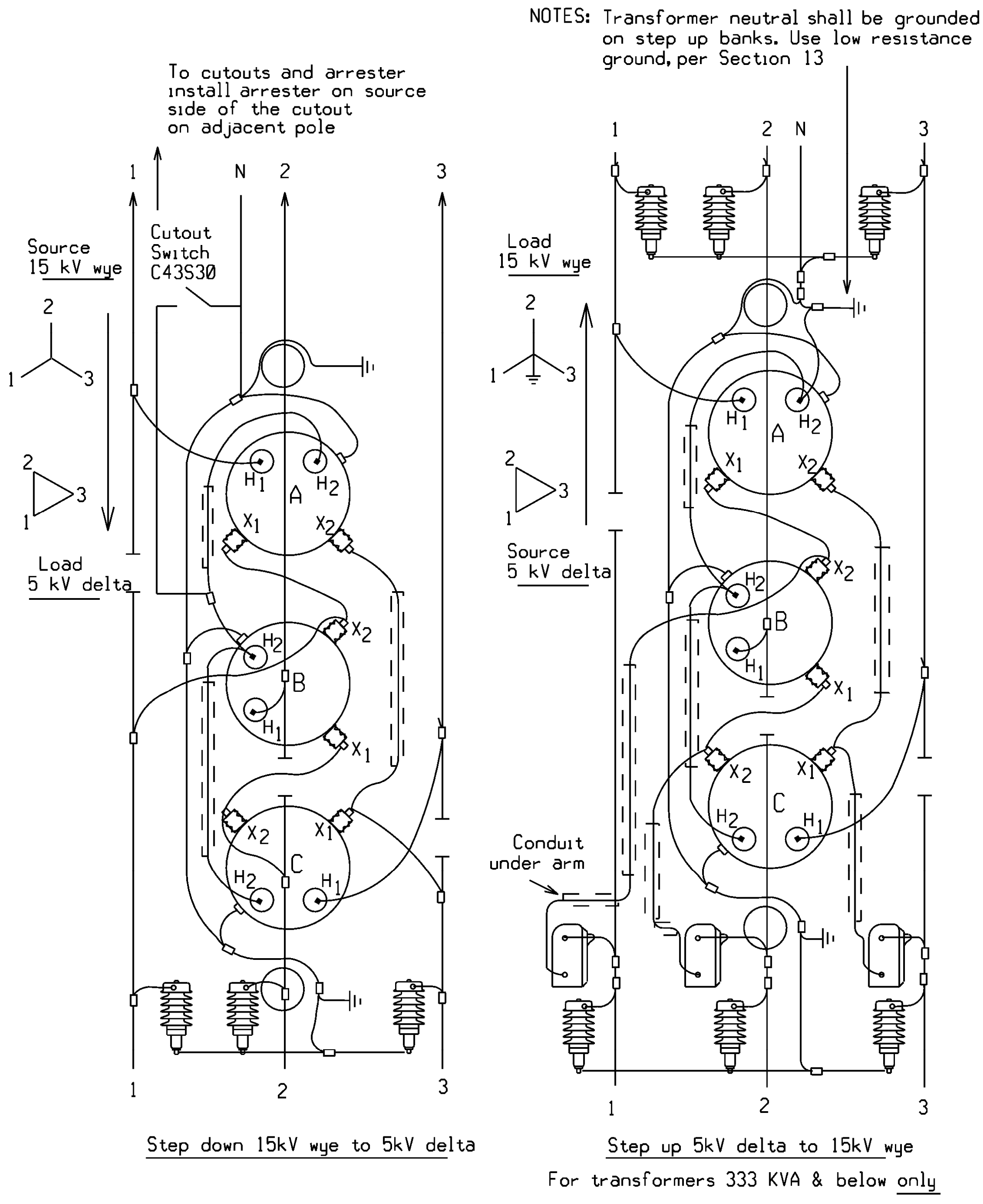


240V
Wiring Diagram Figure 4

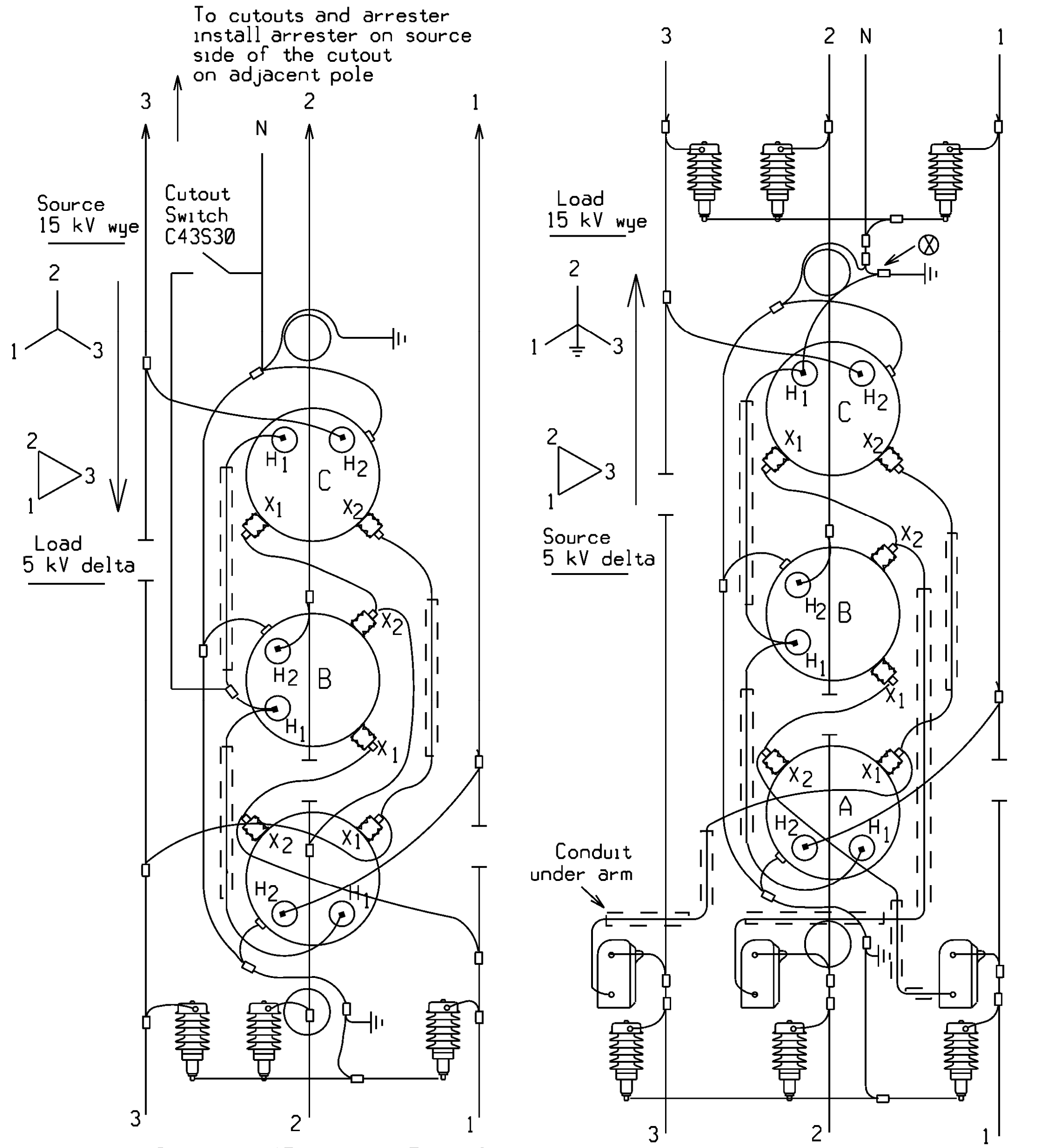
Supersedes 7/09 Issue – Removed secondary ground straps in Figure 3 & 4.

 Doc. # ST. 14.00.004

Supersedes 7/09 Issue – Revised wiring of neutral cutout switch



3Φ STEP-UP/STEP-DOWN BANK (PLATFORM MOUNT) 5 – 15 kV – 333 AND 500 kVA TRANSFORMERS (SUBTRACTIVE) - 123 ROTATION			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER **14-373**	ISSUE **7/11**



Step down 15kV wye to 5kV delta

Step up 4.8 to 13.2Y/7.6 KV

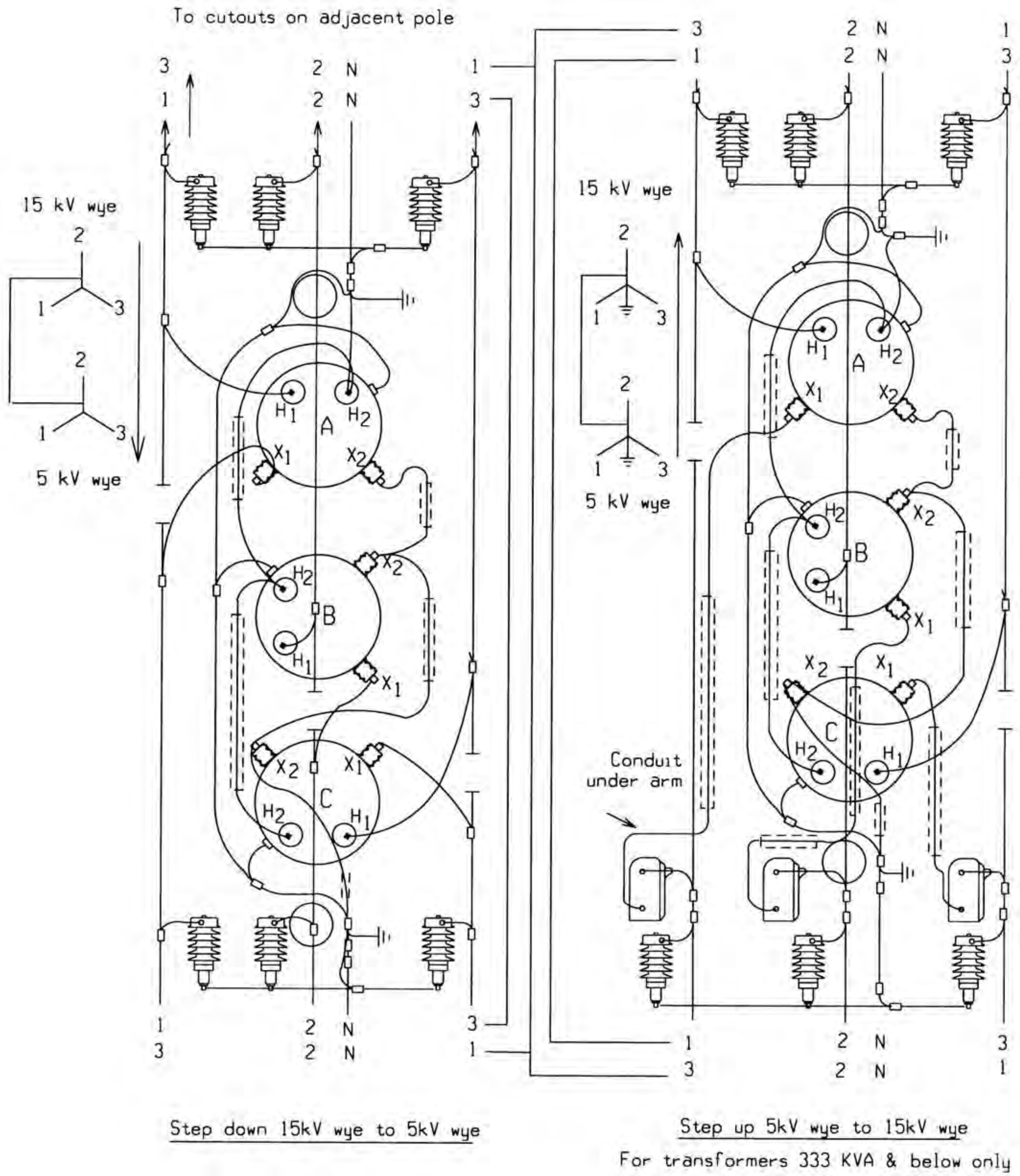
For transformers 333 KVA & below only

Notes:

- ⊗ Transformer neutral shall be grounded on step up banks. If this ground connection is made disconnectable on installations which may be operated bi-directionally, that cutout shall be located at the primary level. A single-phase interruption or transformer failure during a step-down condition could result in primary voltage at point of opened ground.
- Use low resistance ground see Section 13.. Illustrated Neutral is multi-grounded.
- Standard practice (ANSI C57.105) is to connect the H.V. H1 bushing to Phase and to ground the H2 designated bushing. Practical bussing considerations of the Delta L.V. conductors, however, may make other schemes preferable. Relative feeder phase positions are maintained across/through the bank installation.

Supersedes 7/09 Issue – Revised wiring of the neutral cutout switch

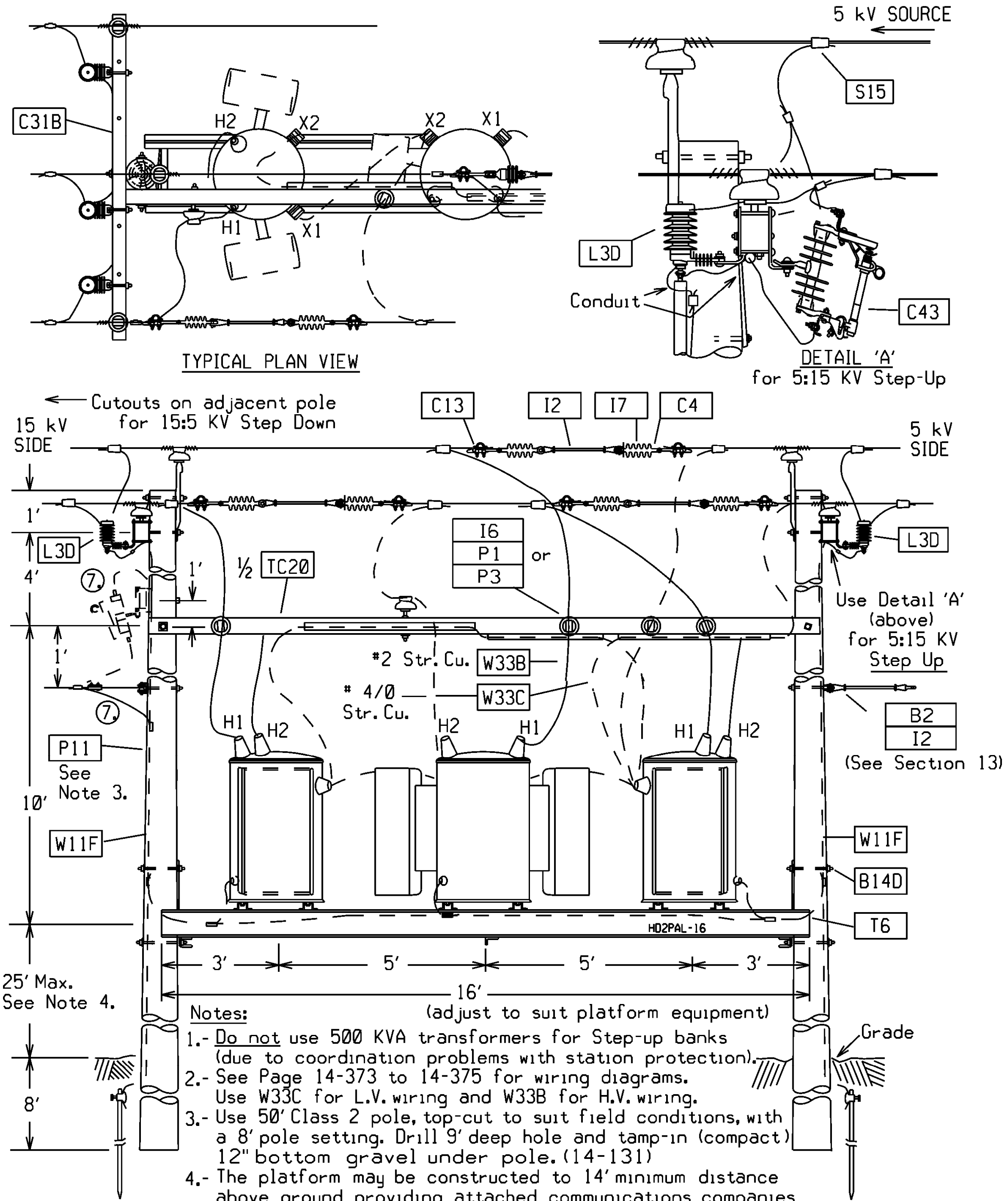
3Φ STEP-UP/STEP-DOWN BANK (PLATFORM MOUNT) 5 – 15 kV – 333 AND 500 kVA TRANSFORMERS (SUBTRACTIVE) – 321 ROTATION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/11	14-374		



5 kV WYE TO 15 kV WYE WIRING DIAGRAM – 333 AND 500 kVA TRANSFORMERS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		14-375	1/06

 Doc. # ST. 14.00.004

MU = @(U)K(X)P(Y)S(Z)TYR	Assembly
CU = TV(W)K(X)P(Y)S(Z)TR	Transformer
CU = TMP2	Cluster Mount
***See Page 14-81 For ( ) Variables	



Notes:

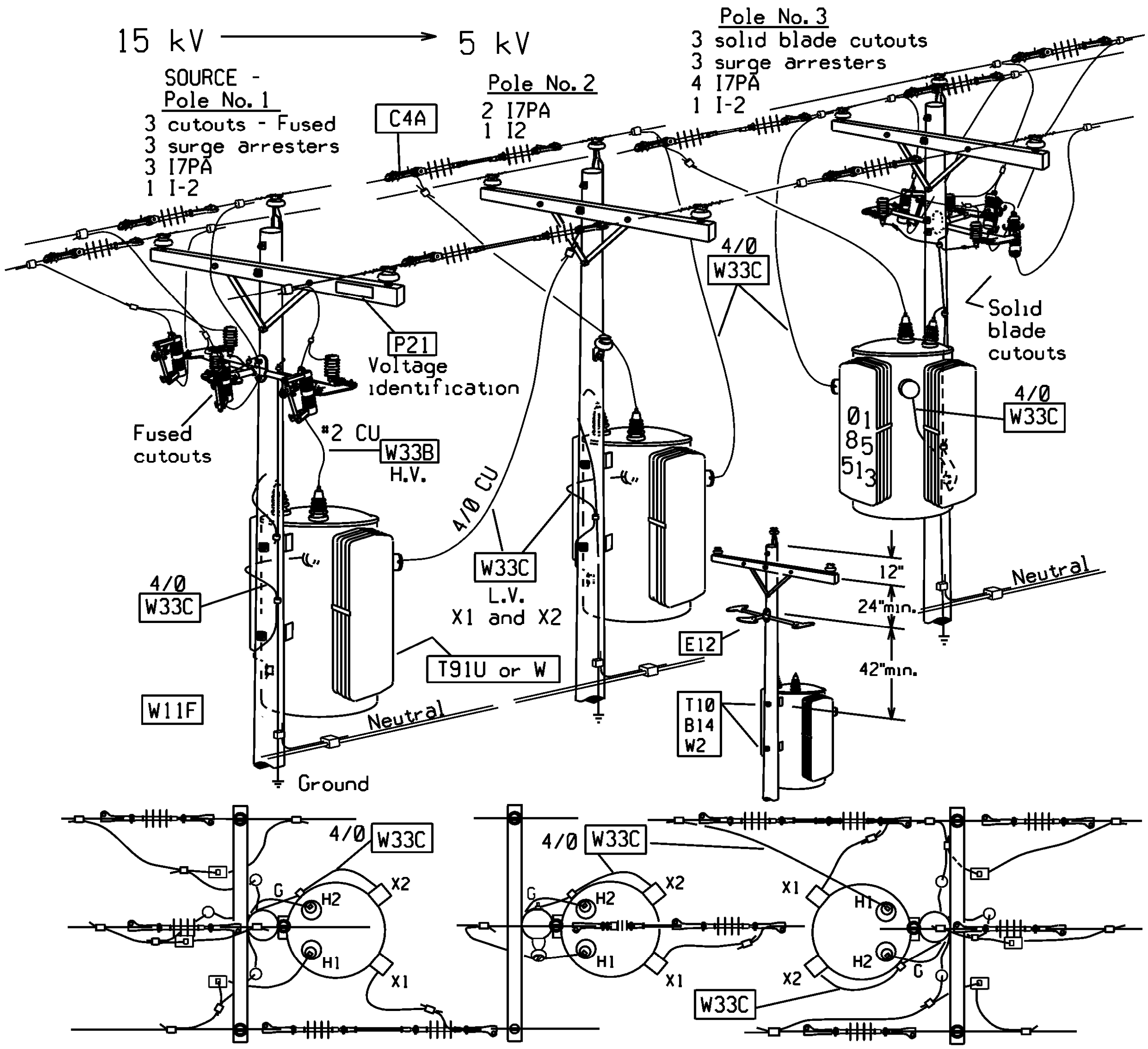
1.- Do not use 500 KVA transformers for Step-up banks (due to coordination problems with station protection).
2.- See Page 14-373 to 14-375 for wiring diagrams. Use W33C for L.V. wiring and W33B for H.V. wiring.
3.- Use 50' Class 2 pole, top-cut to suit field conditions, with a 8' pole setting. Drill 9' deep hole and tamp-in (compact) 12" bottom gravel under pole. (14-131)
4.- The platform may be constructed to 14' minimum distance above ground providing attached communications companies have been notified of the propose construction and are in agreement with their attachment levels.
5.- Transformers are not normally bolted to platform.
6.- See Page 14-378 for 3-Pole installation alternate.
7. Optional ground isolating switch (Cutout) for bi-directionally sourced installations. See Page 14-374 for special grounding note X pertaining to bi-directional installations.

Supersedes 7/10 Issue – Corrected primary tap wiring on right transformer

3Φ STEP-UP/STEP-DOWN TRANFORMER BANK INSTALLATION 333 AND 500 kVA PLATFORM MOUNTED – 15:5 kV AND 5:15 kV			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/11	14-377		

 Doc. # ST. 14.00.004

Supersedes 1/06 Issue - Added neutral and conductor Std number identification



Notes: 14-378

- Cost and appearance considerations may preclude use of standard (14-377) platform arrangement.
- This drawing shows 1500 KVA YY, zero phase-shift, transformation. Do not use 500 KVA transformers for step-up banks (due to coordination problems with station protection).
- Standard new or sound existing poles shall be used and poles shall not be used for other (i.e. secondary transformer) equipment. Poles shall be consecutive and in-line and preferably in-view of each other. Do not install midspan poles and avoid heavy down guys.
- Pole/Crossarm shall be clearly marked as required for safety to indicate primary voltages.

3Φ STEP-UP/STEP-DOWN BANK TRANSFORMER INSTALLATION 333 AND 500 kVA POLE MOUNTED TRANSFORMERS 15:5 kV AND 5:15 kV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 14-378	ISSUE 7/08

Version	Date	Modification	Author(s)	Approval by (Name/Title)
6	07/13	• Minor text edits for 14-5, 14-8, 14-51 and 14-53	Robert Johnson	
5	07/12	• Corrected date on page 14-204 • Revised minimum spacing for transformer installations on pages 14-204, 14-304 and 14-305	Robert Johnson	
4	07/11	• Corrected page reference on Page 14-1 • Wording revisions on Pages 14-4 and 14-5 • Corrected Std Item # on Page 14-171 • Added washer on page 14-211 • Added washer and changed crossarm mounting dimension on pages 15-212, 15-331, 15-332, 15-333, 15-334. • Corrected incorrect neutral switch wiring on Pages 14-373 and 14-374.	Joe Tumidajski	Allen Chieco, Director of Distribution Standards and Work Methods
3	07/10	• Revised 500kcmil Std Item # • Revised PDC Tables on page 14-54. • Moved arrester note from top of page to Diagram 7 on page 14-176. • Removed note on arrester locations on page 14-177. • Added 4W 480Y/277 to 3-167KVA drawing • Removed ground strap on page 14-252 • Removed note limiting transformer size to 167kVA on pages 14-247, 248, 249 and 250 • Revised page title on apke 14-301 • Revised tank lettering on figure 1 and phaser diagrams on figures 3 & 4 on page 14-345 • Corrected error in Notes on Page 14-347. • Removed secondary ground straps on Page 14-352 and 14-371. • Corrected Std Item # on Page 14-377. • Removed “ratio” from sections of the text (correct term is “step-up/setp-down”).	Joe Tumidajski	Allen Chieco, Director of Distribution Standards and Work Methods
2	07/09	• Corrected spelling in title on page 14-131 • Revised conductor size in table on page 14-171 • Revised grounding on Figure 1 & 5 • Replaced Figure 1 with correct drawing and revised notes on page 14-312 • Revised notes on page 14-326 • Revised Figure 1, 2 & 3 on drawing 14-352. Relocated arresters to transformers revised last note. • Revised Figure 3 on drawing 14-371. Placed arresters on transformers and deleted note “Do not connect grd. strap” in Figure 3 • Removed source side arresters, added cutout/arrester note and added neutral switch to drawing on page 14-373	Joe Tumidajski	Allen Chieco, Director of Distribution Standards and Work Methods

		• Removed source arresters, added cutout/arrester note to drawing on page 14-374 • Removed source side arresters, added cutout/arrester note to drawing on page 14-377 • Updated CUs and MUs on pages 14-248, 14-249, 14-304, 14-312, 14-326, 14-352, 14-371		

Supersedes 7/11 Issue – Updated Drawings 15-335 and 15-336 and relocated 15-211

15.0 GENERAL

This Section covers the details of installing and connecting distribution voltage regulators, capacitors and primary metering. Step voltage regulators and fixed or switched capacitors are installed on primary distribution feeders to maintain and improve power factor and/or voltage regulation.

15.0.10 New Purchases – Re-use

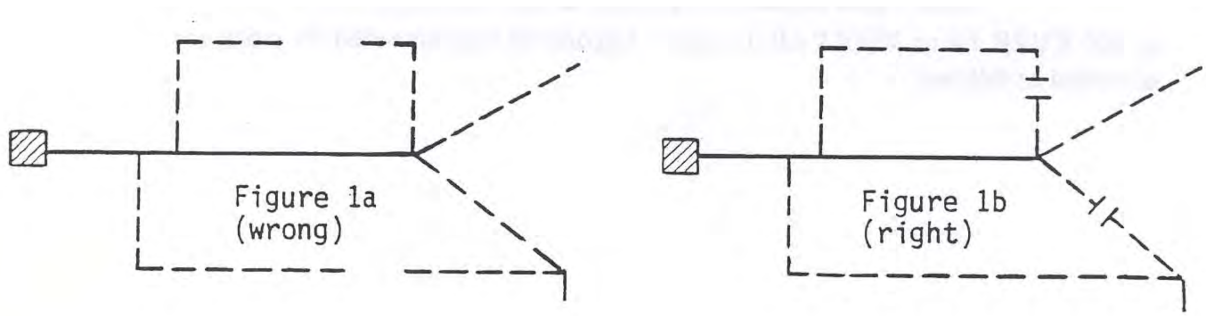
Distribution regulators and capacitors will be purchased in accordance with Company material specifications MS2821, MS2851, MS2852, and MS2853.

15.1 VOLTAGE CONTROL

Voltage control on distribution feeders shall be maintained through a combination of feeder design, application of capacitors, and the use of regulators.

15.1.10 Feeder Design

Feeder design should consider anticipated loads and future substation sites. Judicial selection of multiple feeder routes can reduce feeder losses as illustrated in Figure 1a and 1b below.



Note: Assuming uniformly distributed loads and constant conductor size.

15.2 VOLTAGE CORRECTION

Normal acceptable voltage at the customer service point is outlined in Section 9-Primary.

If voltage correction is necessary, proper feeder balancing shall first occur which will improve the voltage profile and in many cases resolve voltage complaints. In some cases, feeder balancing may eliminate the need for existing line regulators and/or capacitors. If the feeder is relatively balanced, station settings may need to be re-adjusted and/or additional line regulators and/or capacitors may need to be installed.

15.3 CAPACITORS

15.3.10 Distribution Capacitor Application

Capacitors are required on the distribution system to correct voltage drop, improve power factor, reduce losses, and increase system capacity. The capacitor needs of distribution feeders should be evaluated, along with conductor requirements, fusing, etc., whenever a feeder study is made by the Engineering or Planning Department.

A power engineering analysis simulation program should be used to determine the total requirements and location of capacitors. Capacitors should be installed in appropriate locations and sizes to minimize overall losses and investment cost. Proper attention must be given to both peak and light load voltage for excursions outside the allowable voltage limits. Switched banks of capacitors shall not cause a step-voltage rise of more than 3%.

Supersedes 1/07 Issue - Revised section numbers.

A power engineering analysis simulation program should be used to determine the available short circuit current with consideration being given to ties to adjacent feeders that may increase the available short circuit current.

The actual locating and sizing of capacitor banks on feeders is detailed in the Feeder Management Guidelines. Control settings are discussed in the application guide section of the Feeder Management Guidelines. Refer to Distribution Asset Management document DAM-007, “Reactive Compensation for Distribution Systems”. Refer to Table 1 for standard assembled capacitor banks.

15.3.20 Capacitor Installation Details

The mechanical details of installing capacitors in single or three-phase applications are shown on pages 15-211 thru 15-409.

Fuse cutouts, Std. Items C41 and C43, shall be installed on all non-switched capacitor installations. See Section 12-Protection for selection of recommended fuse size for capacitor groupings.

Lightning protection shall be provided on capacitor installations by using surge arresters suitable for the respective capacitor voltage class. See Section 13-Grounding for surge arrester selection guide, as well as MS 2852 Table II.

Supersedes 7/11 Issue - Updated table 1

Table 1

Individual Capacitor Units							
System Voltage	**Bank kVAR**	**Fixed**	**Switched**	**Quantity**	**Size**	**No. of Bushings**	**Rack Size**
2400 Volt Delta	150 300	X X	X X	3 3	50 100	2 2	3 Unit 3 Unit
2400/4160 Volt Grd Y	150 300 450	X X X	X X X	3 3 3	50 100 150	2 2 2	3 Unit 3 Unit 3 Unit
4800 Volt Delta	150 300 450	X X X	X X ‘X	3 3 3	50 100 150	2 2 2	3 unit 3 Unit 3 Unit
4800/8320 Volt Grd Y	150 300 450 600	X - X x	- X X X	3 3 3 3	50 100 150 200	2 2 2 2	3 Unit 3 Unit 3 Unit 3 Unit
6640/11500 Y	1200	-	x	6	200	2	6 Unit
7200/12470 Volt Grd Y thru 14400/24940 Volt Grd Y	300 600 900 1200	- X X -	X X X X	3 3 3 6	100 200 300 200	2 2 2 2	3 unit 6 Unit 6 Unit 6 Unit
13200/22860 Y thru 14400/24940	1200 2700	- -	X X	6 9	200 300	2 2	9 Unit 9 Unit
23000 Volt Delta	2700	-	X	9	300	2	9 Unit
19920/34500 Grd Y	1200 1800 1800	- - -	X X X	6 9 6	200 200 300	1 1 1	9 Unit 9 Unit 9 Unit

REGULATORS

15.3.30 Regulator Application

Where primary voltage levels cannot be controlled within acceptable limits by capacitors and station regulation, pole mounted feeder regulation is required. The data sources available to perform a review include RAP reports, feeder V/O monthly readings, feeder modeling studies and portable recording voltmeters.

Step type voltage regulators raise or lower the incoming primary voltage by 10% and the regulator tap changers divide the 10% raise or lower voltage into 16 individual steps. Each step on a regulator adds ⅝% of the maximum raise or lower voltage to the primary circuit.

The range of regulation can also be limited and the regulator's normal current rating will increase as follows.

Table 2

REGULATION RANGE % RAISE AND LOWER	NORMAL RATING % NAMEPLATE AMPERES
10	100
8-¾	110
7-½	120
6-¼	135
5	160

15.3.40 Regulator Construction Details

Single and 3 phase regulator construction details are shown on Pages 15-111 thru 15-131.

The primary connections and grounding details are shown on the installation drawings. No connection diagrams are shown for unigrounded neutral circuits.

The preferred 3 phase regulator method of installation on effectively grounded circuits is to install each regulator onto a separate pole eliminating unnecessary congestion and allowing for a quicker replacement and re-energization during a contingency condition (e.g. motor vehicle accident).

Single phase regulator installations, depending upon operating preference on effectively grounded circuits, shall be in accordance with Pages 15-112 and 15-113.

The preferred 3 phase regulator method of installation on not effectively grounded circuits (e.g. delta), is to use either three regulators or two regulators. If using two regulators resulting in an open delta connection, the location shall be relatively balanced and the high and low inductive voltage phases shall be determined through a preliminary load/voltage monitoring check and be the phases regulated.

Should there be more than one point of regulation on a single radial 3-phase line, the phases being regulated should be alternated. For example, if the first point of regulation is connected between phases 1-2 and 2-3, then the second point should be connected between phases 2-3 and 3-1, and the third point should be connected between phases 3-1 and 1-3.

Supersedes 1/07 Issue - Revised section numbers.

15.4 PRIMARY METERING

This section specifies pole-top primary metering installations using outdoor-type instrument transformers mounted on a pre-fabricated aluminum bracket. For pad-mounted primary metering devices to be used with UG cables, please refer to Section 38 in the UG Construction Standards book.

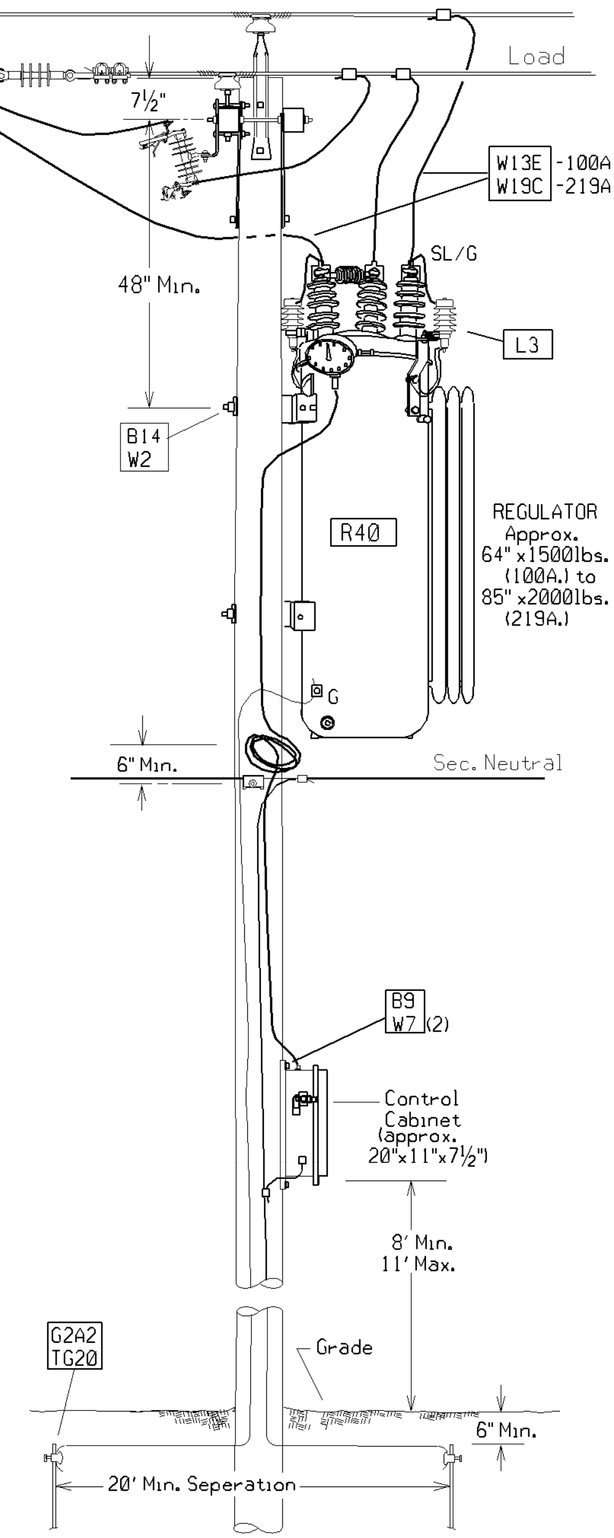
All Customer-furnished devices shall be approved by the Company and be placed on a Company-approved pole or structure. The Customer shall submit their plans and specifications to the Company before equipment is ordered or before construction has started to insure that the proposed design for the electric service installation conforms to the Company's requirements.

15.4.10 Primary Metering Accompanied by a Riser

A primary metering device and a riser may be placed on the same pole if the loadbreak device is on an adjacent pole when a loadbreak switch is used as a disconnect point. See the drawings on Pages 15-501 or Page 15-502 for details regarding primary metering and a riser on the same pole.

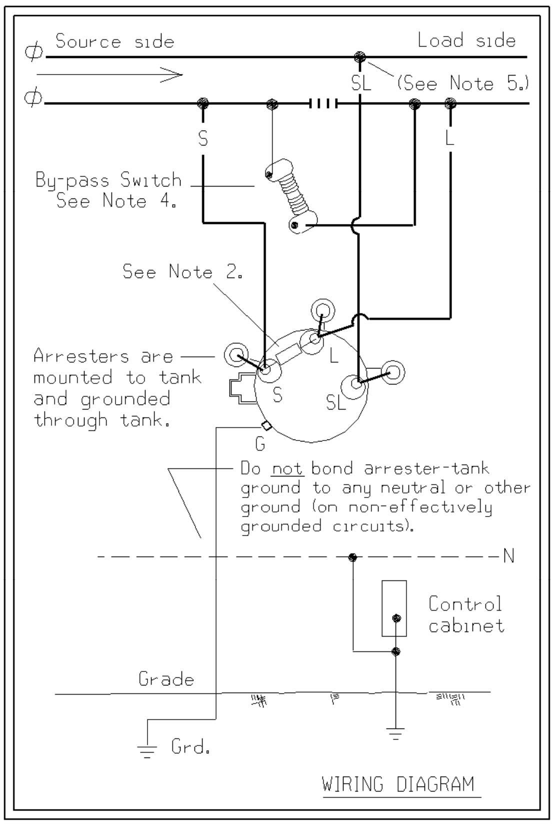
New page - new section added.

MU = @(C)KR590D	Single Regulator, (C) =(76)=76.2kVA or (167)=167kVA @4.16kV
MU = @(C)KR590D48	Single Regulator, (C) =(76)=76.2kVA or (167)=167kVA @4.8kV



NOTES:

1. Locate installation away from vehicular traffic.
2. External series or by-pass arrester(s), if present, should not be disconnected.
3. Refer to page 13-111 for grounding details.
4. Do not close by-pass switch with load current flowing through the regulator unless regulator is in the neutral position.
5. Regulator SL (common) terminal must be connected to the primary when connecting or disconnecting S (source) or L (load) taps to the primary (for the safety of personnel and equipment).



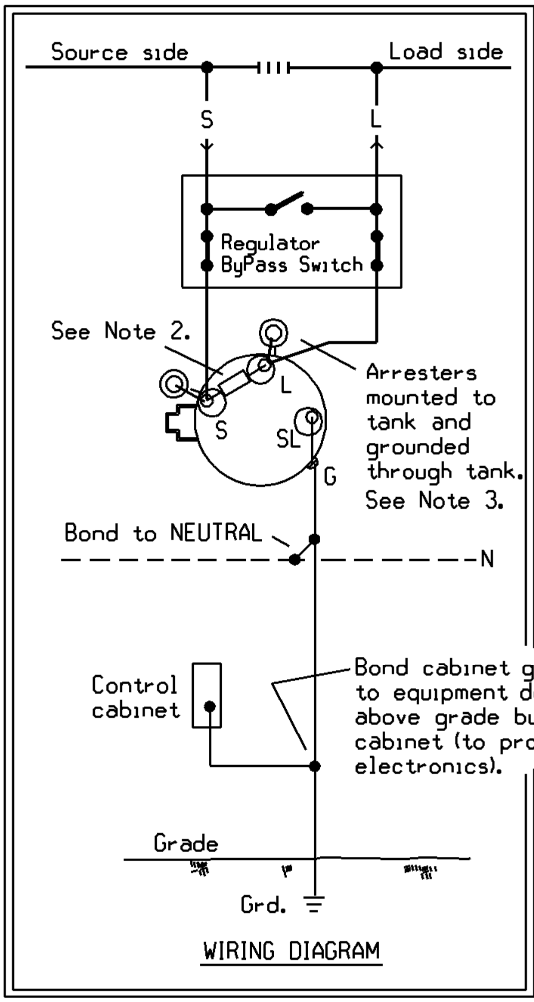
Supersedes 7/09 Issue - Revised/Added MU

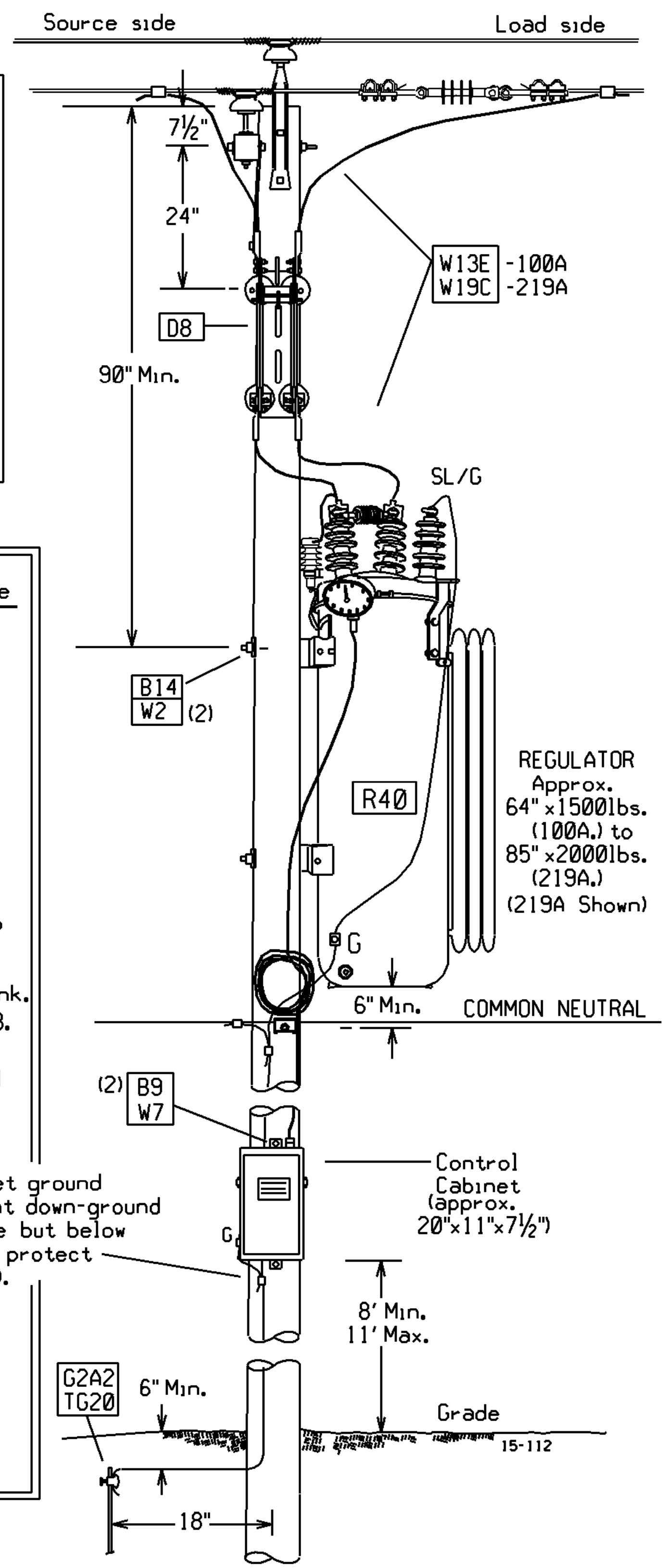
1Ø REGULATOR INSTALLATION - NOT EFFECTIVELY GROUNDED, 15kV

MU = @333KR590W(V)	333kVA; (V) =(76)=7.62kV or (796)=7.97kV

NOTES:

1. Locate installation away from vehicular traffic.
2. External series or by-pass arrester(s), if present, should not be disconnected.
3. Refer to Page 13-111 for detailed grounding connections.
4. Do not close by-pass switch with load current flowing through the regulator unless regulator is in the neutral position.





Supersedes 1/07 Issue - Page shift.

1Ø REGULATOR INSTALLATION - EFFECTIVELY GROUNDED, 15kV

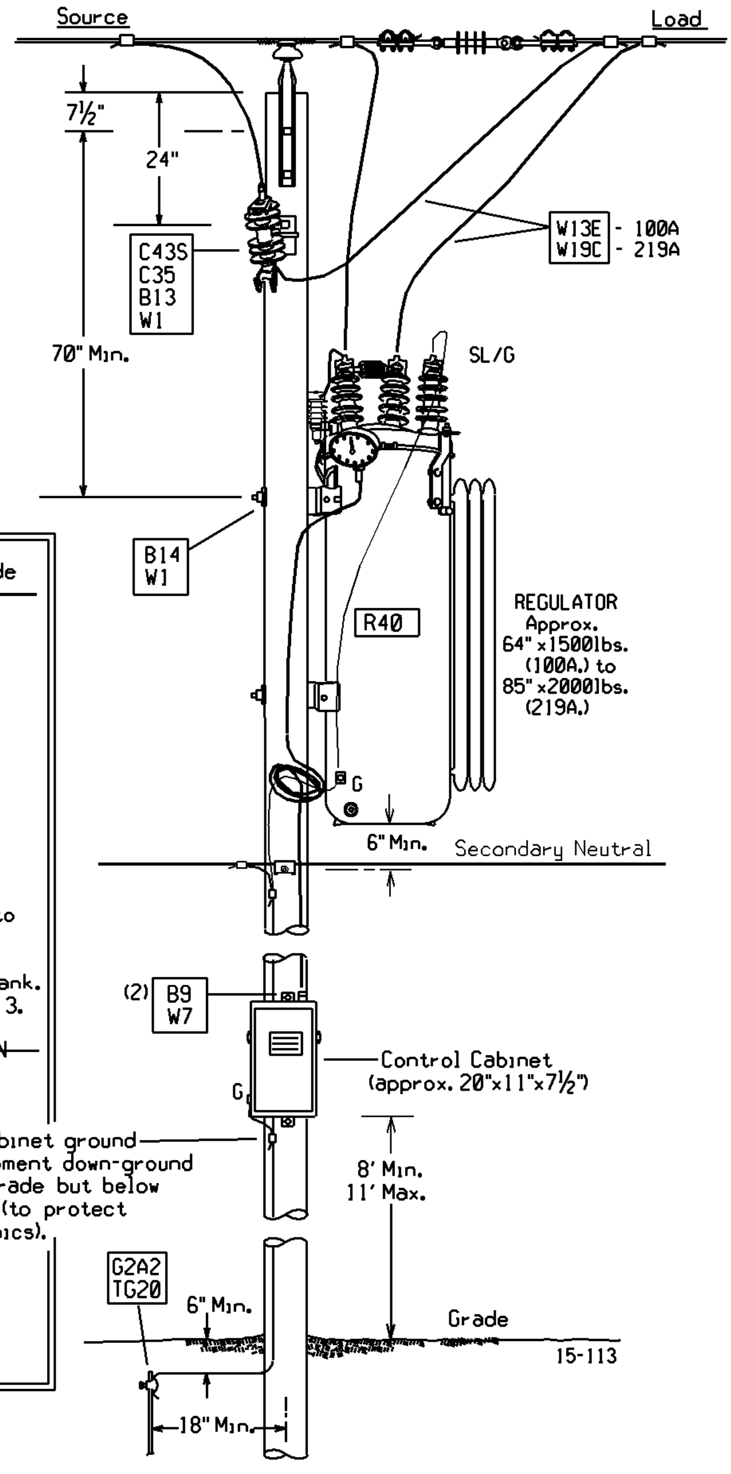
ISSUE	PAGE NUMBER		
7/09	15-112	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

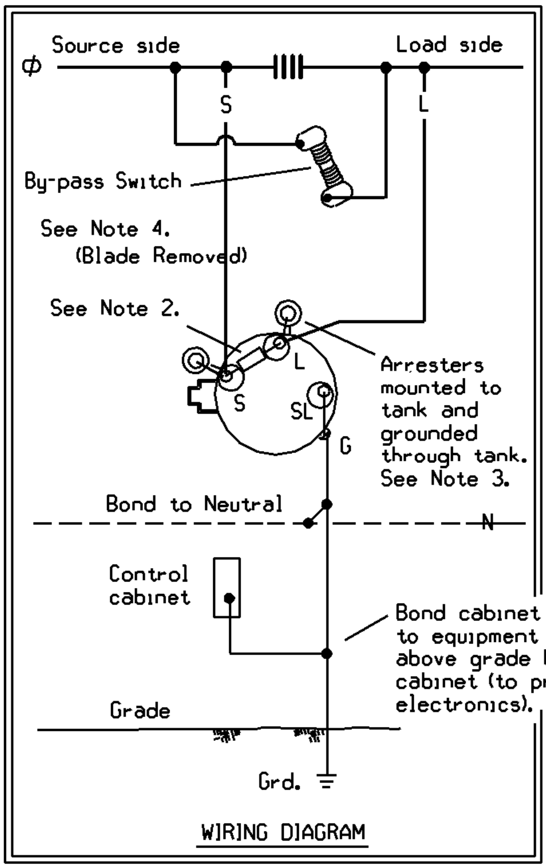
 Doc. # ST. 15.00.002

MU = @(C)KR590W(V)	Single Regulator, (C)=(76)=76.2kVA or (167)=167kVA (V)=(2)=2.4kV or (7)=7.62kV or (72)=7.2kV or (796)= 7.97kV

NOTES:

1. Locate installation away from vehicular traffic.
2. External series or by-pass arrester(s), if present, should not be disconnected.
3. Refer to page 13-111 for grounding details.
4. Do not close by-pass switch with load current flowing through the regulator, unless regulator is in the neutral position.





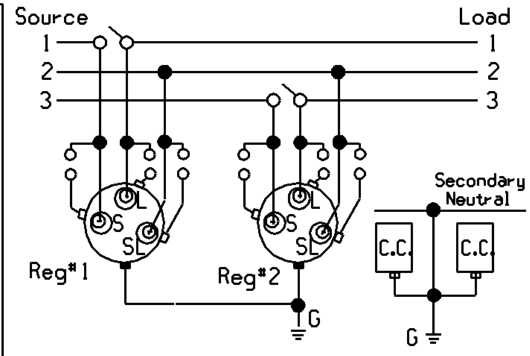
Supersedes 1/07 Issue - Page shift.

1Ø REGULATOR INSTALLATION EFFECTIVELY GROUNDED 15 kV

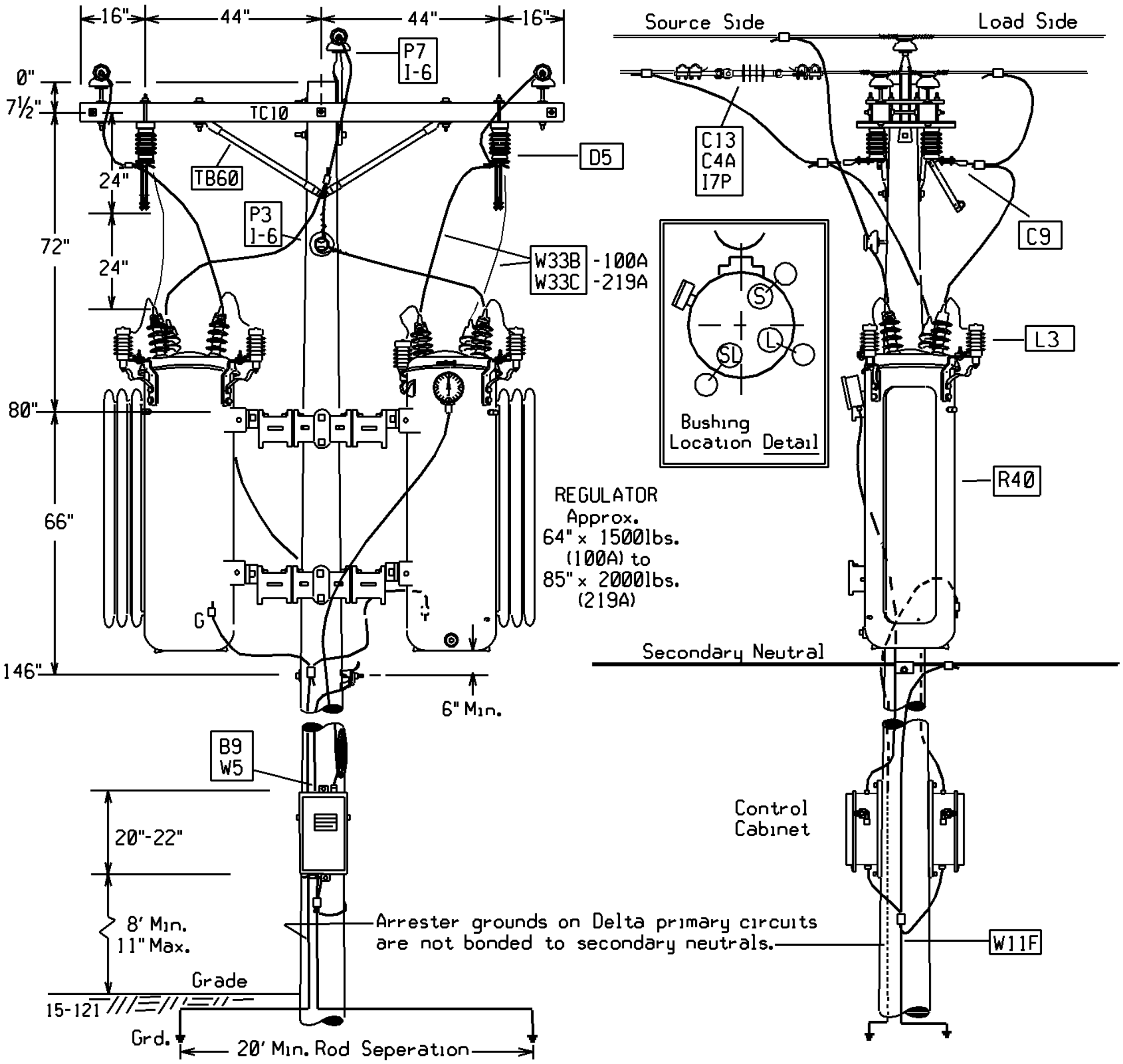
		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	15-113	7/09

MU = @(C)K3R590D	Two Regulators, (C) = (152)=76.2kVA or (334)=167kVA @ 4.16kV
MU = @(C)K3R590D48	Two Regulators, (C) = (152)=76.2kVA or (334)=167kVA @ 4.8kV

NOTES:
1. Locate installation away from vehicular traffic.
2. External series or by-pass arrester(s), if present, should not be disconnected.
3. Do not close by-pass switches (D5) with load current flowing through the regulator unless regulator is in the neutral position. When connecting Regulators, place in neutral position, then connect SL (common) terminal, then connect S terminal followed, lastly, by the L (Load) terminal.
4. Regulator SL (common) terminal must be connected to the primary when connecting or disconnecting S (source) or L (load) taps to the primary for the safety of personnel and equipment.
5. Regulators may be size mixed, provided each is adequate for maximum expected load current.
6. Phases regulated may be other than shown.



Delta Primary Wiring Diagram



Supersedes 1/07 Issue - Page shift.

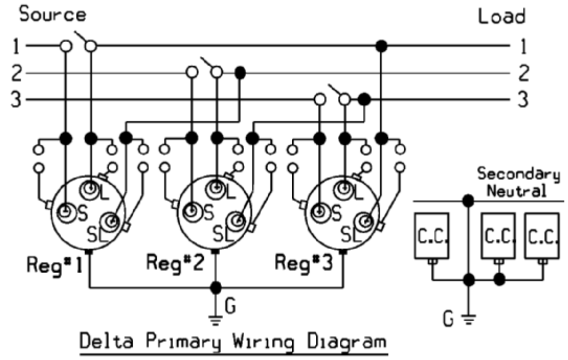
3Ø TWO-REGULATOR INSTALLATION NOT EFFECTIVELY GROUNDED 15 kV

MU = @(C)K3R590D	Three Regulators, (C)=(228)= 76.2kVA or (501)=167kVA @4.16kV
MU = @(C)K3R590D48	Three Regulators, (C)=(228)= 76.2kVA or (501)=167kVA @4.8kV

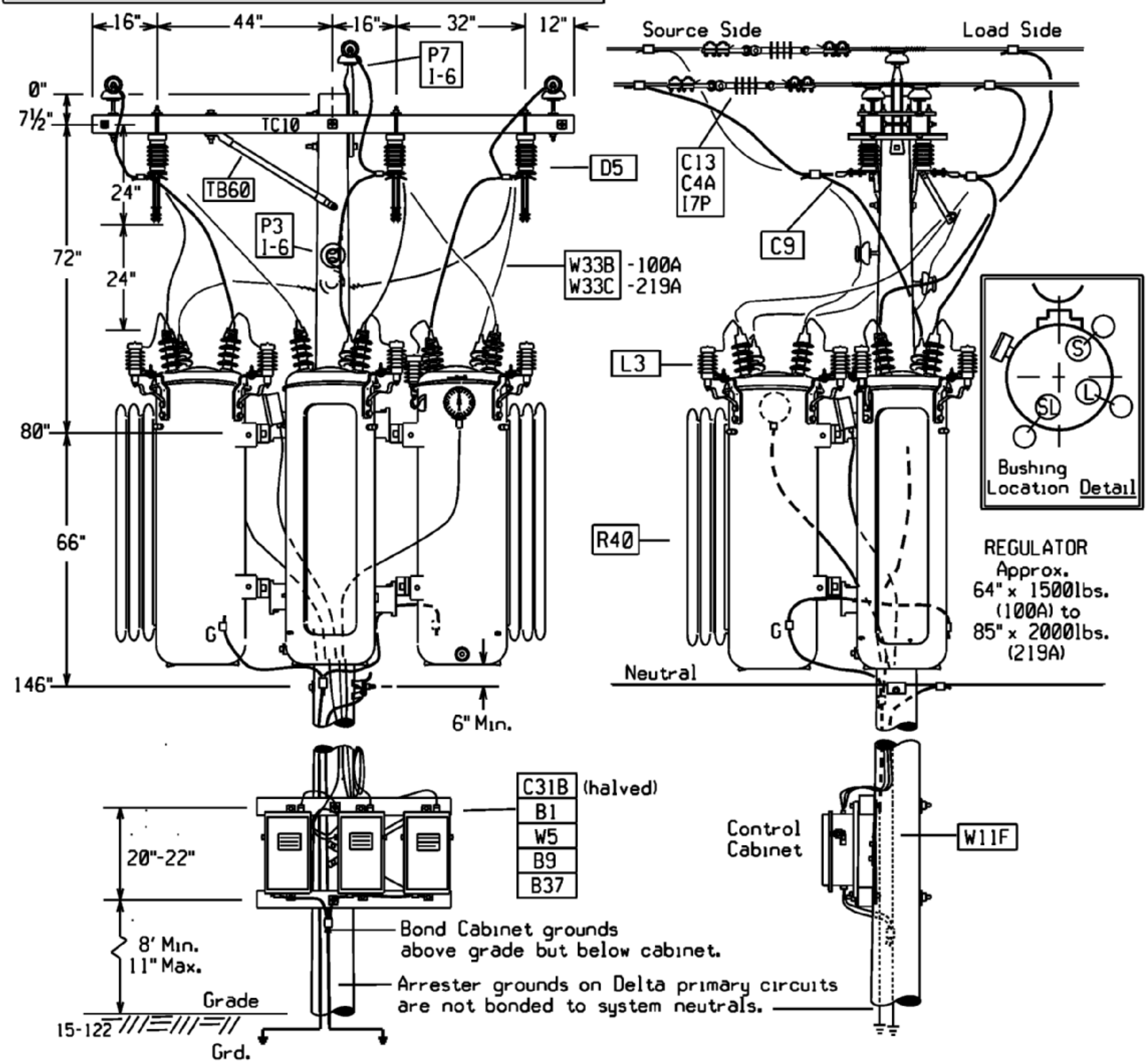
Supersedes 7/11 Issue - Revised Wiring Diagram for Reverse Power Operation

NOTES:

1. Locate installation away from vehicular traffic.
2. External series or by-pass arrester(s)*, if present, should not be disconnected.
3. Do not close by-pass switches (D5) with load current flowing through the regulator unless regulator is in the neutral position. When connecting Regulators, place in neutral position, then connect SL (common) terminal, then connect S terminal followed, lastly, by the L (Load) term.
4. Regulator SL (common) terminal must be connected to the primary when connecting or disconnecting S (source) or L (load) taps to the primary for the safety of personnel and equipment.
5. Regulators may be size mixed, provided each is adequate for maximum expected load current.



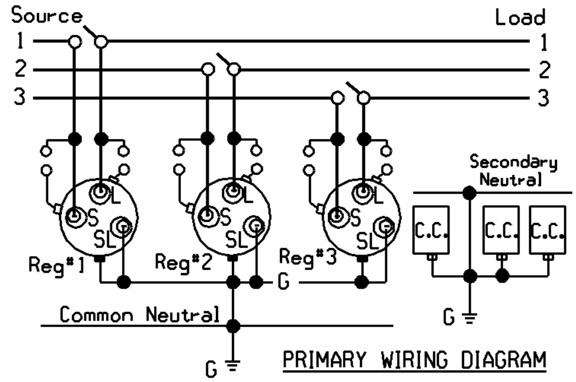
Delta Primary Wiring Diagram

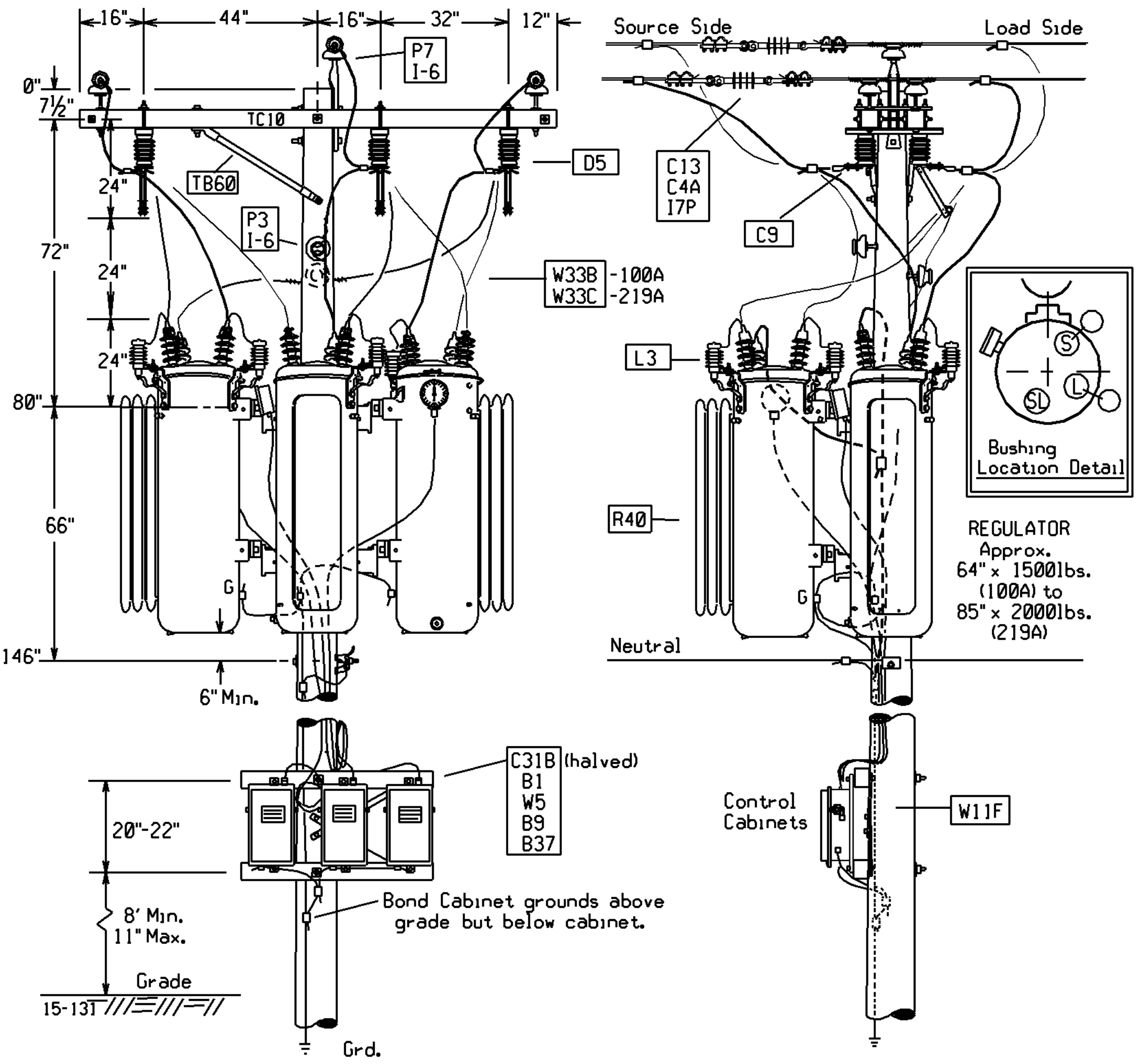


MU = @(C)K3R590W(V)	ThreeRegulators,(C)=(228)=76.2kVA or (501)=167kva (V)=(416/24)=2.4kV or (124/72)=12.4/7.2kV or (132/76)=7.62kv or (138/7.9)= 13.8/7.9kV

NOTES:

1. Locate installation away from vehicular traffic.
2. External series or by-pass arrester(s), if present, should not be disconnected.
3. Do not close by-pass switches (D5) with load current flowing through the regulator unless regulator is in the neutral position. When connecting Regulators, place in neutral position, then connect SL (common) terminal, then connect S terminal followed, lastly, by the L (Load) term.
4. Regulator SL (common) term. must be solidly grounded when connecting or disconnecting the S (source) or L (load) taps to the primary for the safety of personnel and equipment.
5. Regulators may be size mixed, provided each is adequate for maximum expected load current.





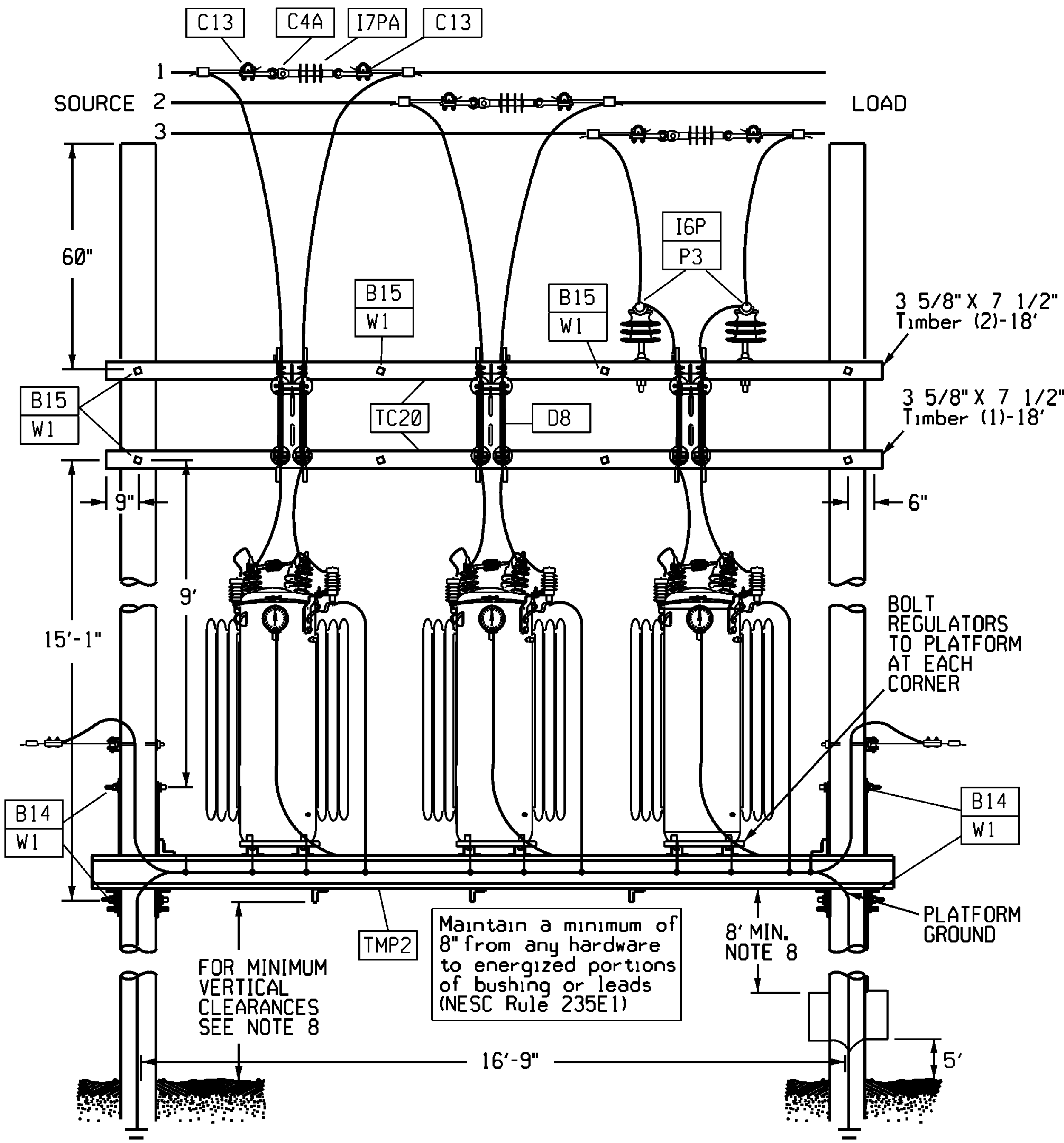
Supersedes 7/09 Issue - Revised MU

3Ø REGULATOR INSTALLATION EFFECTIVELY GROUNDED 15kV

 Doc. # ST. 15.00.002

MU=@(C)K3R590DPF	Three Regulators, (C)=(501)=167kVA or (999)=333kVA@4.16kV
MU=@(C)K3R590D48PF	Three Regulators, (C)=(501)=167kVA or (999)=333kVA@4.8kV

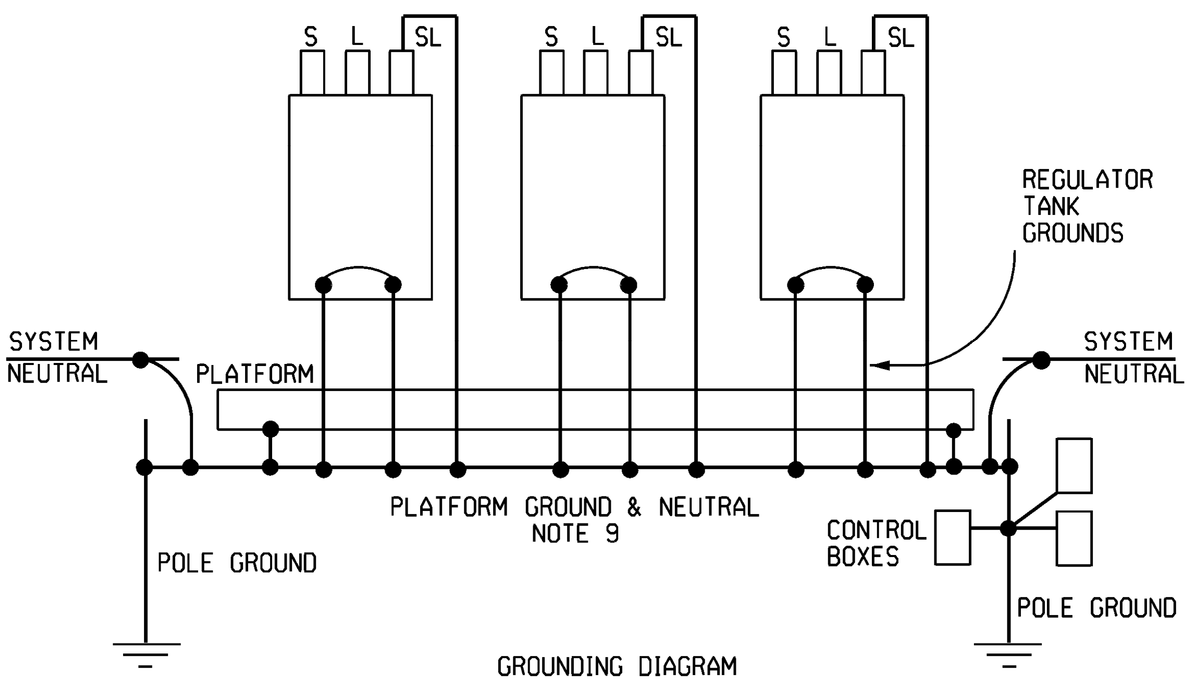
Supersedes 7/10 Issue – Changed tap porcelain insulators to poly insulators



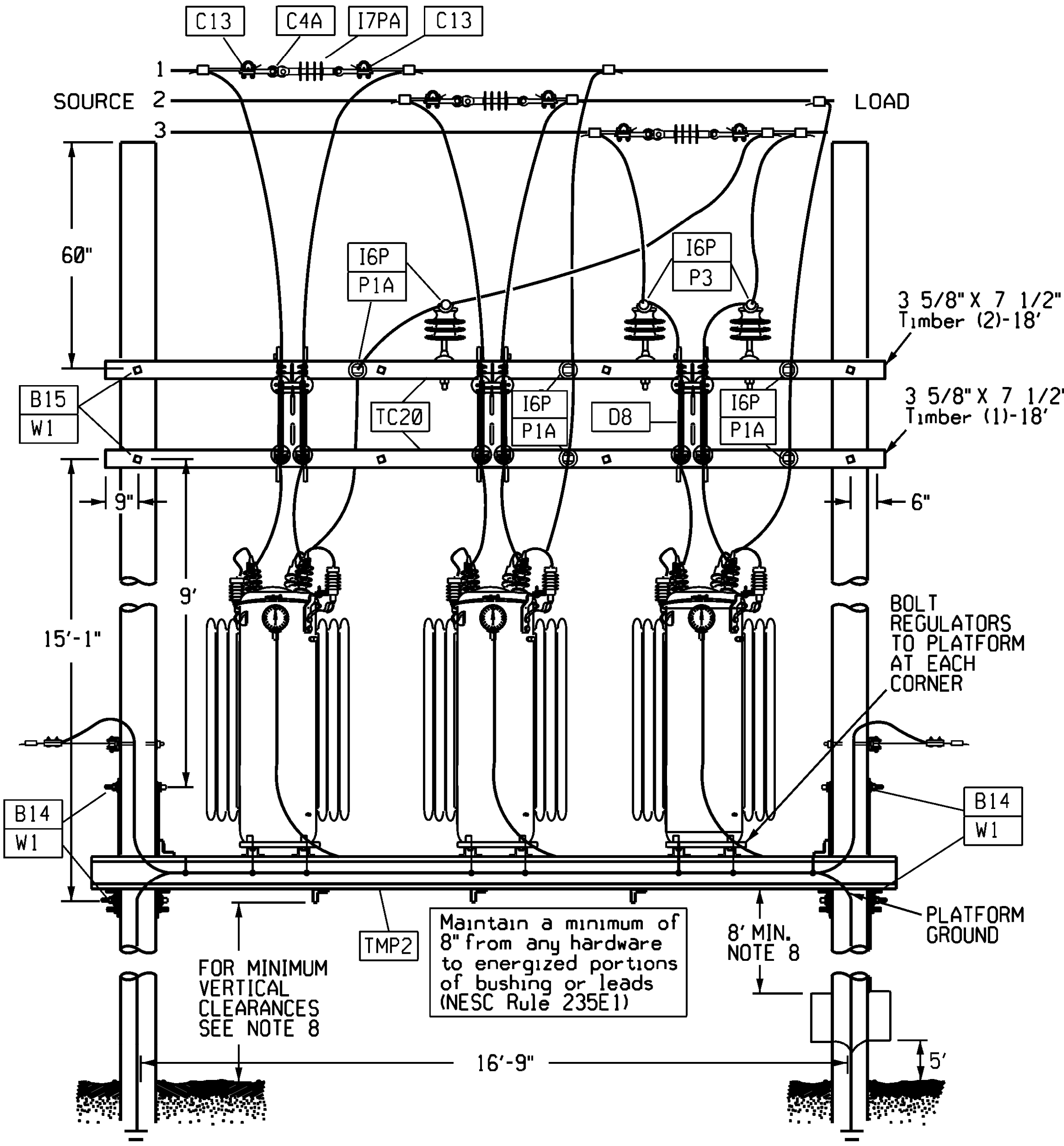
Notes

1. Dimensions may vary based on switch design.
2. Arresters must be installed on both load and source side bushings
3. Minimum pole class for plies up through 50 feet is Class 3. Poles taller that 55 feet require a Class 2 pole
4. Mount the platform to the poles with ¾ inch bolts.
5. Install animal guards on all regulator and arrester bushings.
6. **Caution:** Regulators must always have their tap changers in the neutral position before the regulator bypass switch is operated or they are put on or taken off an energized line otherwise, a violent regulator failure could occur. Refer to EOP D003 for more details.
7. Platform ground and neutral conductor shall be the same size as or larger that the system neutral.
8. For minimal vertical clearance, for spaces and ways subject to pedestrians or restricted traffic only, the minimum vertical clearance may be reduced to 11'-0", per NESC Rule 232B3.
9. **Caution:** Minimum distance from the top of the control box to the lowest point of the platform or on a separate structure.
10. Care should be taken to install platform structures in locations where their visibility to the public is minimized.

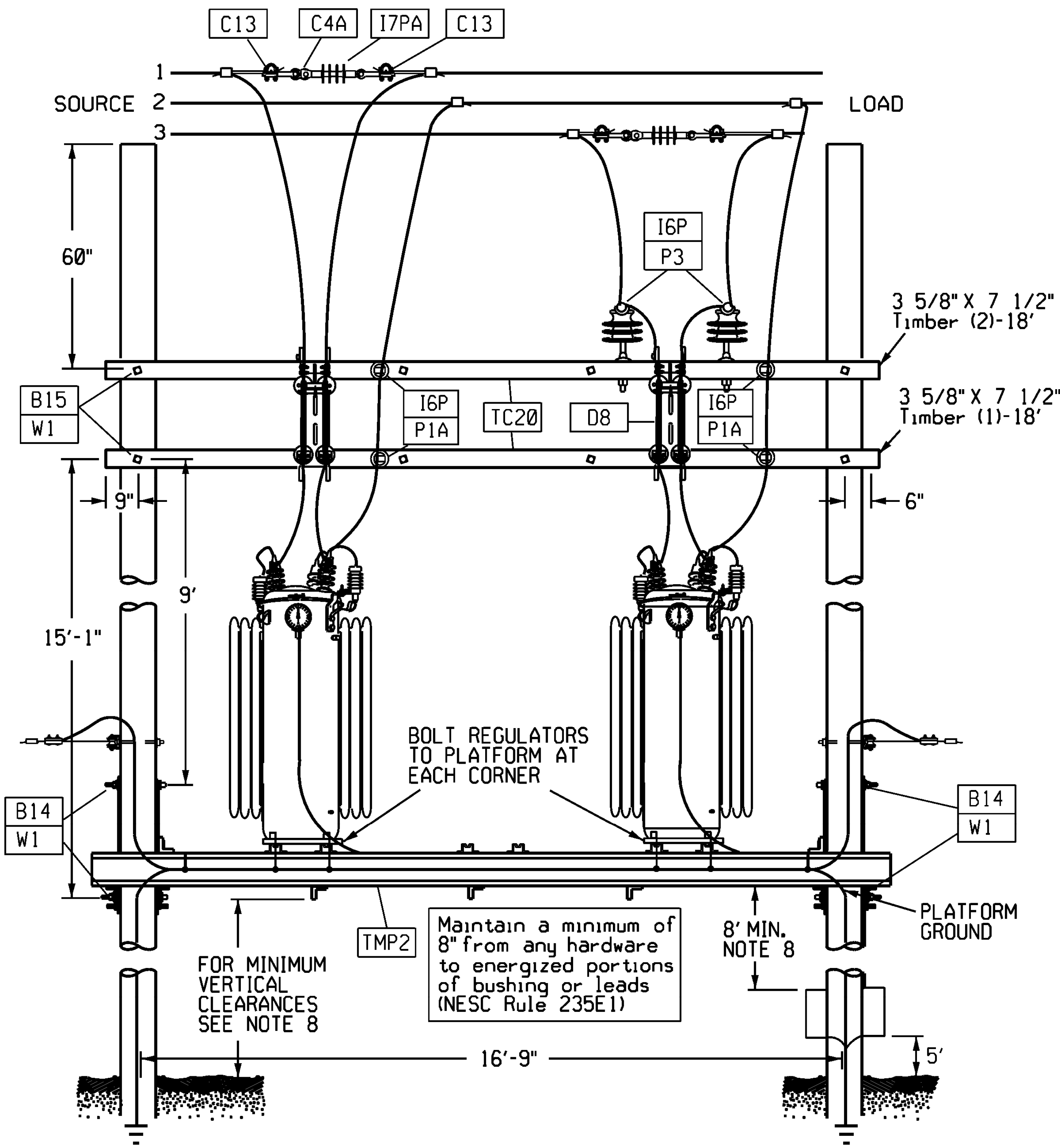
Supersedes 7/10 Issue - Corrected EOP reference



Supersedes 7/10 Issue – Changed tap porcelain insulators to poly insulators



REGULATOR PLATFORM DELTA INSTALLATION 2 OR 3 REGULATORS (SIDE VIEW)			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 15-155	ISSUE 7/11

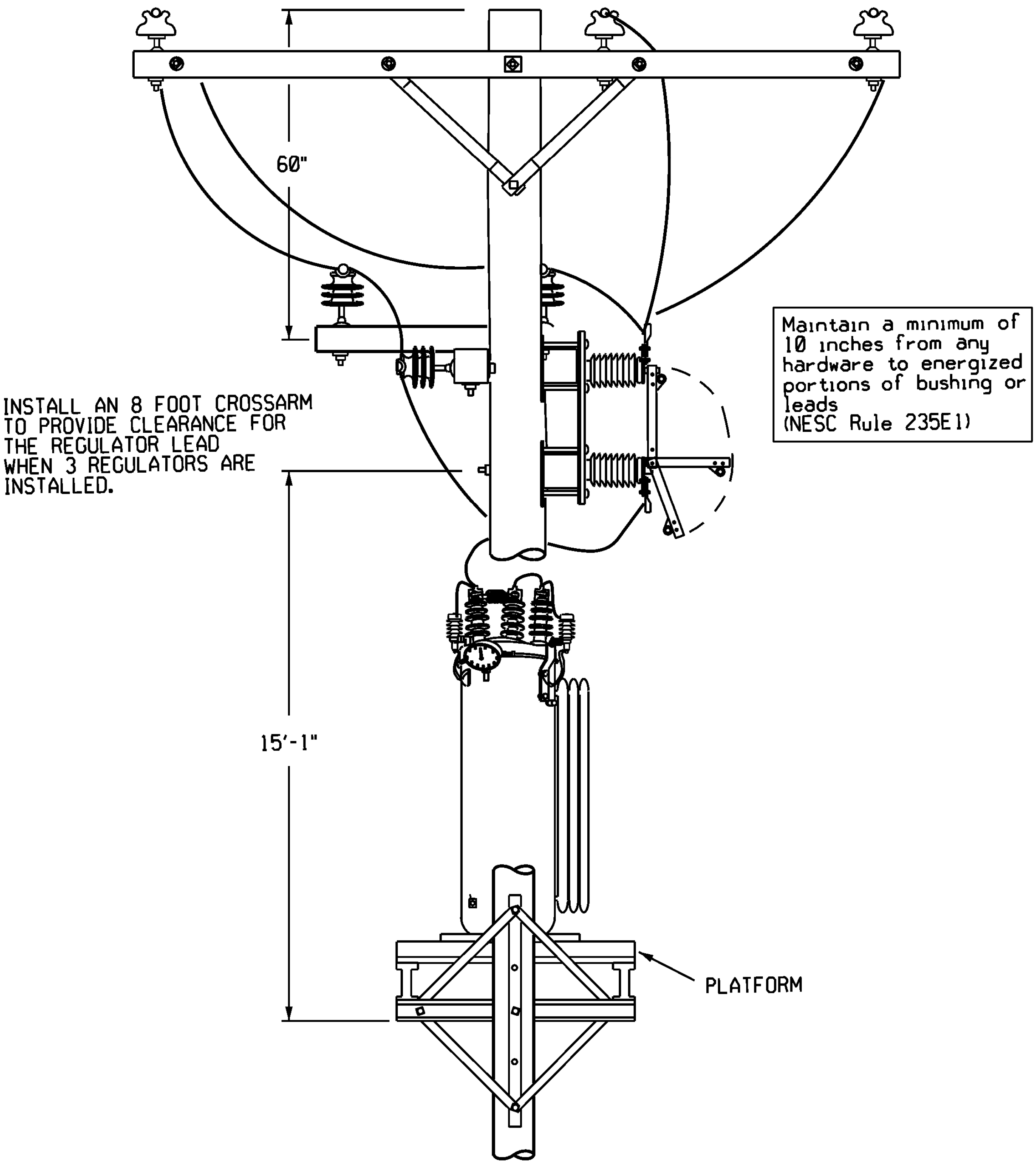


Supersedes 7/11 Issue – Replaced tap porcelain insulators with poly insulators

2 REGULATOR PLATFORM INSTALLATION DELTA SYSTEM

ISSUE	PAGE NUMBER		
7/12	15-156	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Supersedes 7/10 Issue – Changed tap porcelain insulators to poly insulators

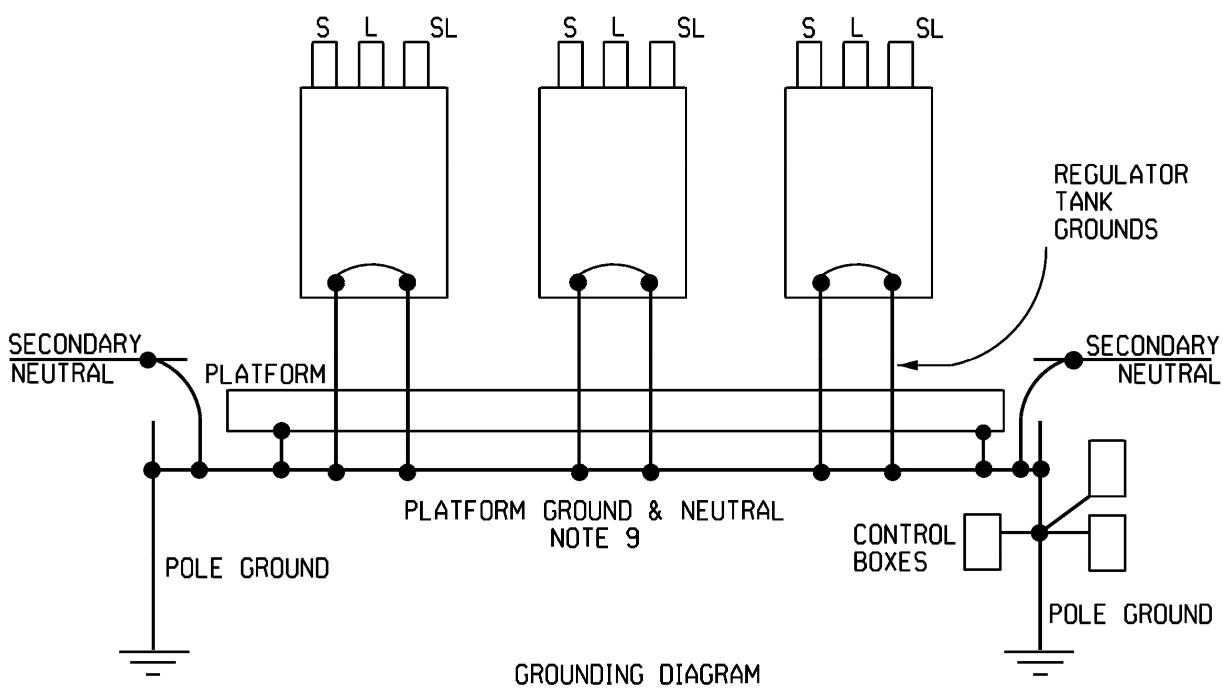


REGULATOR PLATFORM DELTA INSTALLATION 2 OR 3 REGULATORS (SIDE VIEW)			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 15-155	ISSUE 7/11

Notes

1. Dimensions may vary based on switch design.
2. Arresters must be installed on both load and source side bushings
3. Minimum pole class for plies up through 50 feet is Class 3. Poles taller that 55 feet require a Class 2 pole
4. Mount the platform to the poles with ¾ inch bolts.
5. Install animal guards on all regulator and arrester bushings.
6. **Caution:** Regulators must always have their tap changers in the neutral position before the regulator bypass switch is operated or they are put on or taken off an energized line otherwise, a violent regulator failure could occur. Refer to EOP D003 for more details.
7. Platform ground shall be #2 copper.
8. For minimal vertical clearance, for spaces and ways subject to pedestrians or restricted traffic only, the minimum vertical clearance may be reduced to 11'-0", per NESC Rule 232B3.
9. **Caution:** Minimum distance from the top of the control box to the lowest point of the platform or on a separate structure.
10. Care should be taken to install platform structures in locations where their visibility to the public is minimized.

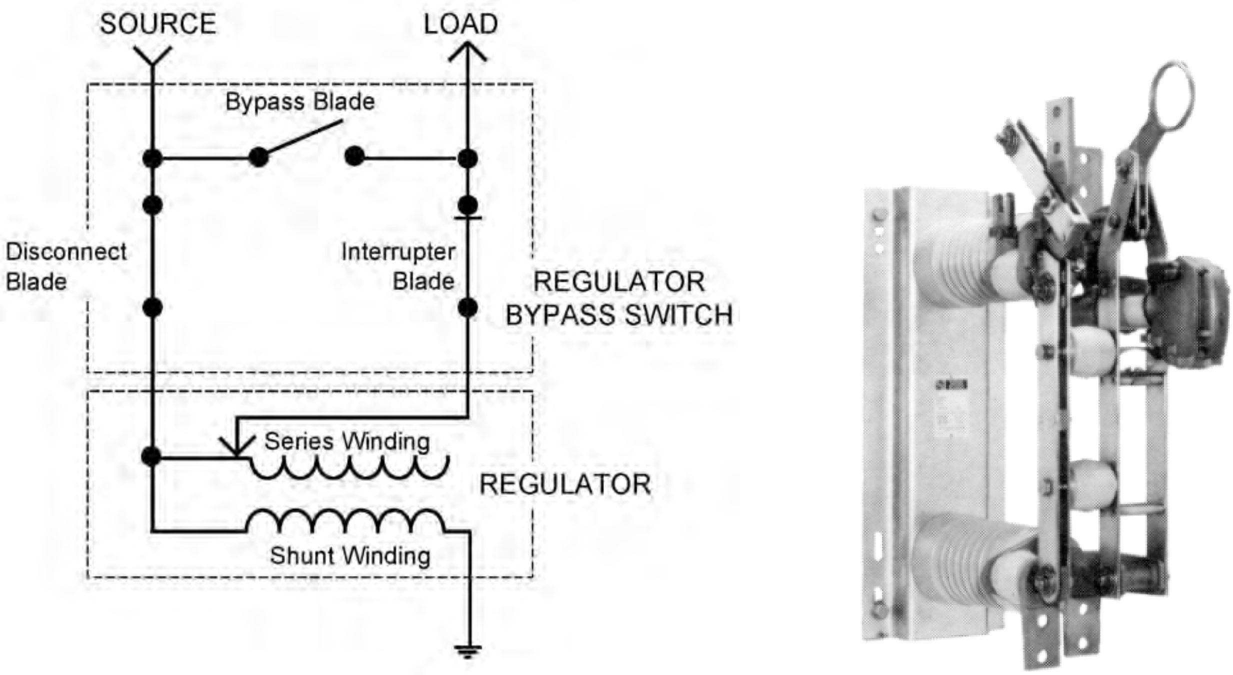
Supersedes 7/11 Issue – Updated EOP reference in note 6.



GROUNDING DIAGRAM

CU = CDBPS15KNE	Bypass Switch D8

Regulator bypass switches must not be operated until the automatic control circuits of the associated regulator tap changers have been opened and the tap changers have been moved to the neutral position.



New page.

Figure 1 - Switch closed; voltage regulator is energized. Bypass blade is open; disconnect blade and interrupter blade are closed.

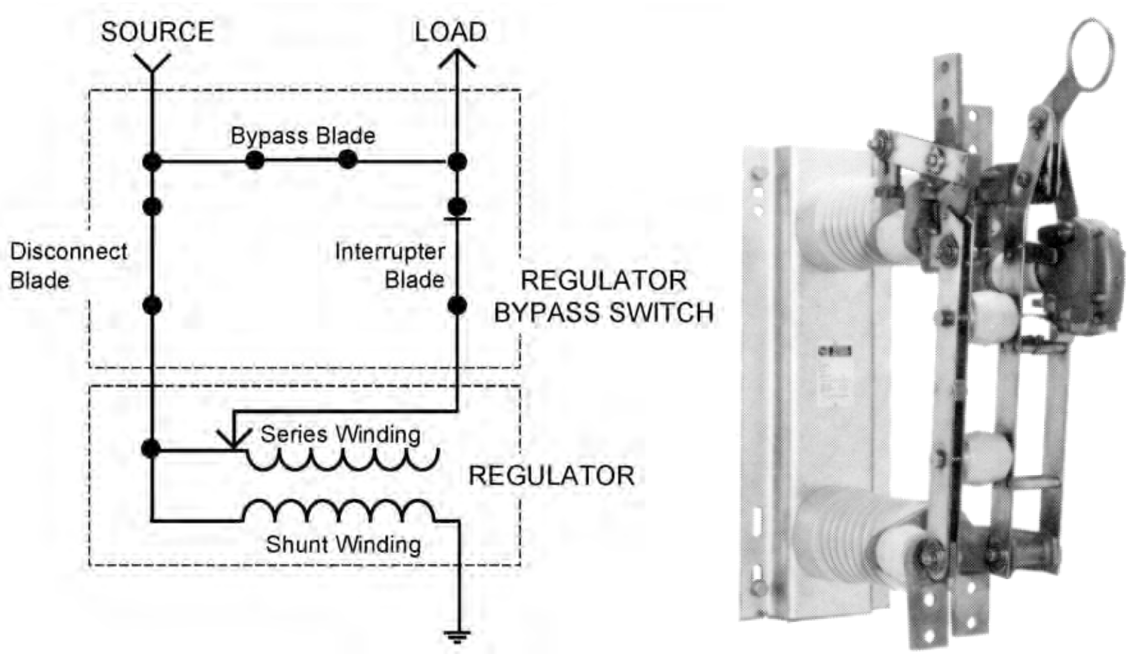


Figure 2 - Switch in early stage of opening stroke. Bypass blade has closed, making a direct connection between the source and load. Disconnect blade and interrupter blade are still closed.

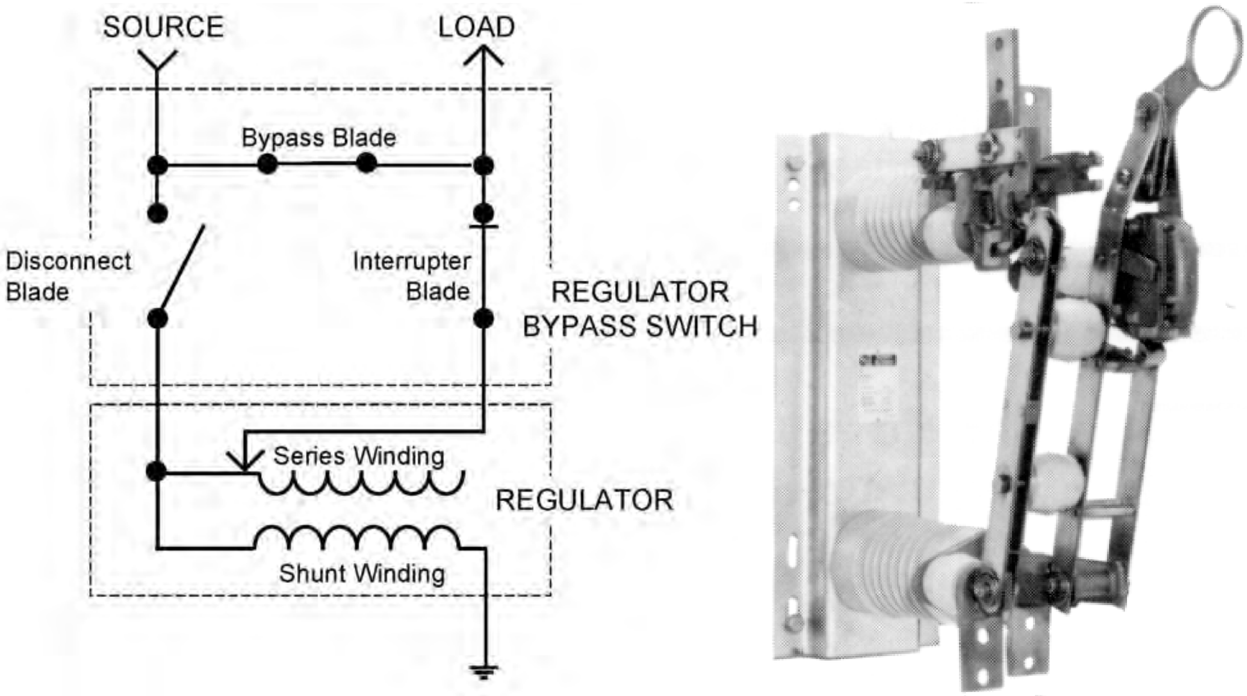
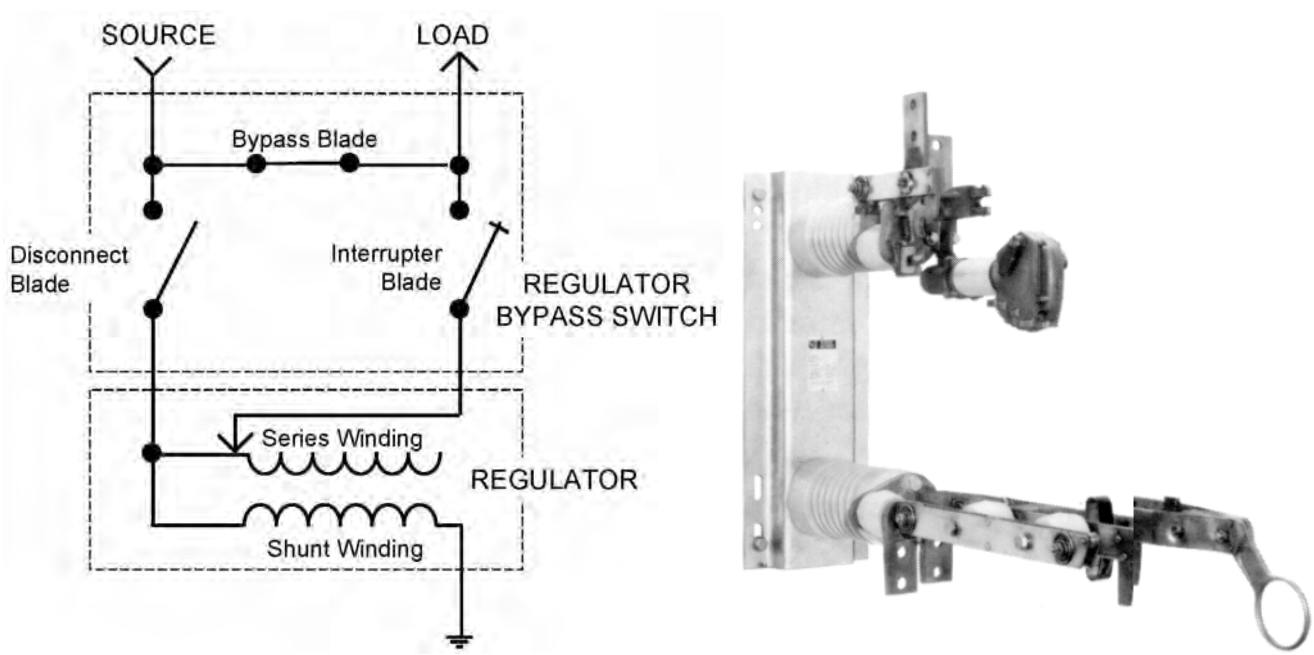


Figure 3 - Switch in later stage of opening stroke. Disconnect blade has opened, but voltage-regulator shunt winding is still energized through the interrupter blade.



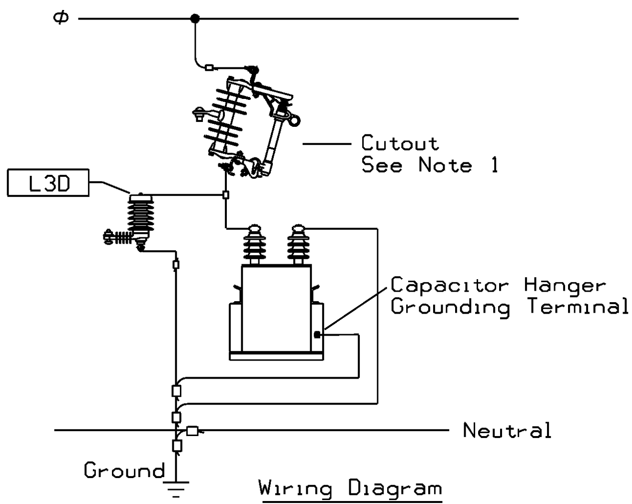
New page.

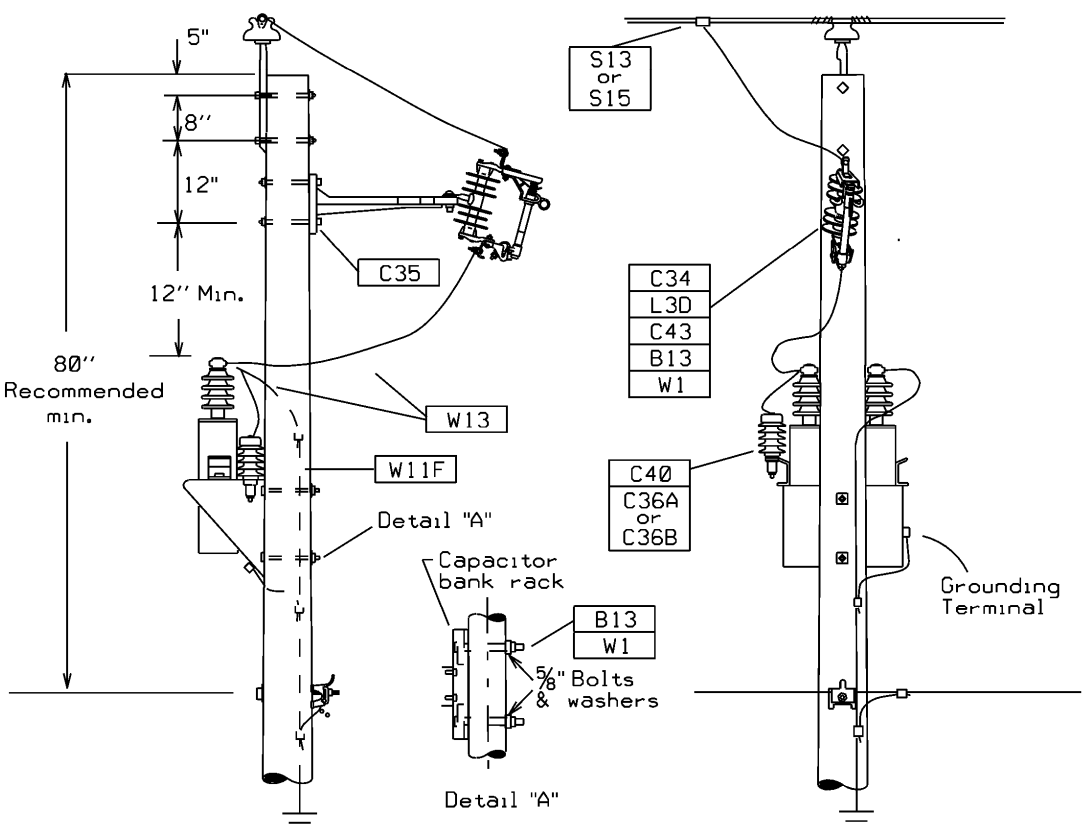
Figure 4 - Switch fully open. Voltage-regulator magnetizing-current interruption has taken place within the interrupter with no external arc or flame. Voltage regulator is de-energized and bypassed.

MU = @TCS(E)C(V)NE	(E) = kVAR Size, (V) = Voltage

Notes:

1. Use cutout and fuse size as shown in Section 12.
2. See Section 5 for Connectors.





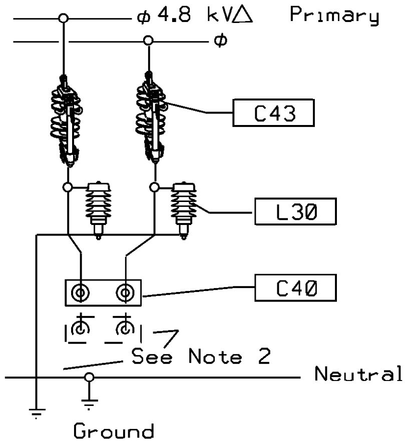
Supersedes 7/09 Issue - Added missing bolt/washer on lower right drawing

1Ø CAPACITOR INSTALLATION EFFECTIVELY GROUNDED 15 kV

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		15-211	7/11

 Doc. # ST. 15.00.002

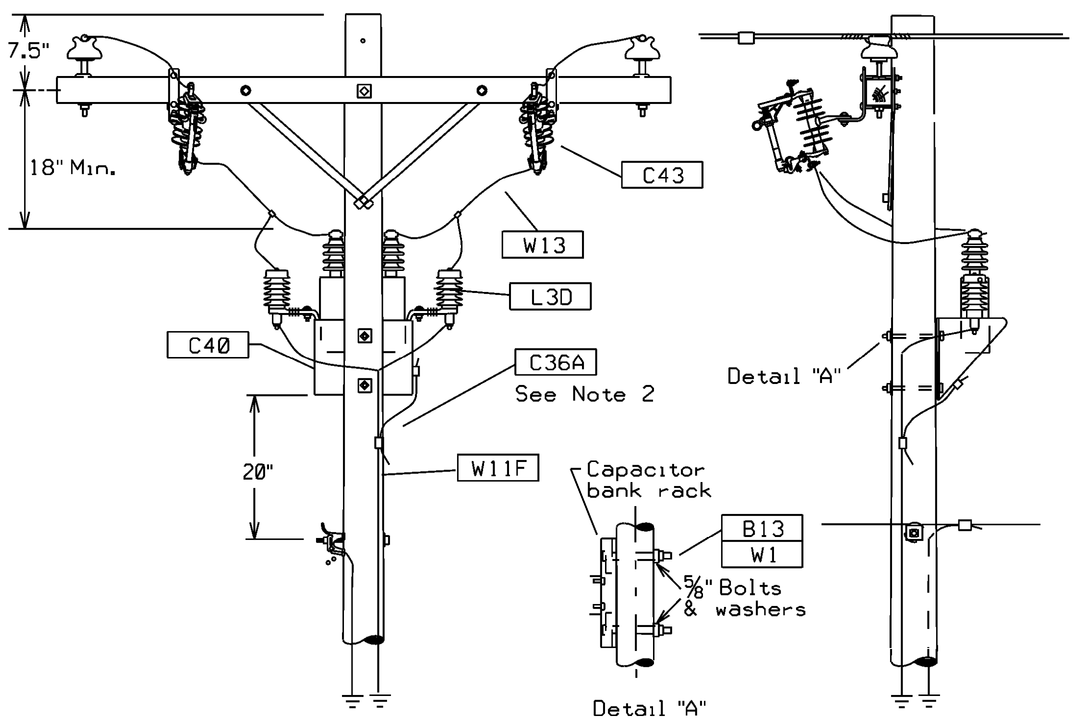
MU=@TCS(E)C(V)NE MU=@TCS(E)C416UNGRDYNE MU=@TCS(E)C24DNE	(E) = kVAR Size, (V) = Voltage



Wiring Diagram

Notes:

1. For use with 25 , 50 and 100 kvar, 1ϕ units. 25 kvar units not recommended for new purchases.
2. On delta primary systems the surge arrester grounding conductor and the secondary neutral grounding conductor shall be run separately to two ground rods. See Section 13 for grounding details.
3. Use cutout and fuse size as shown in Section 12.



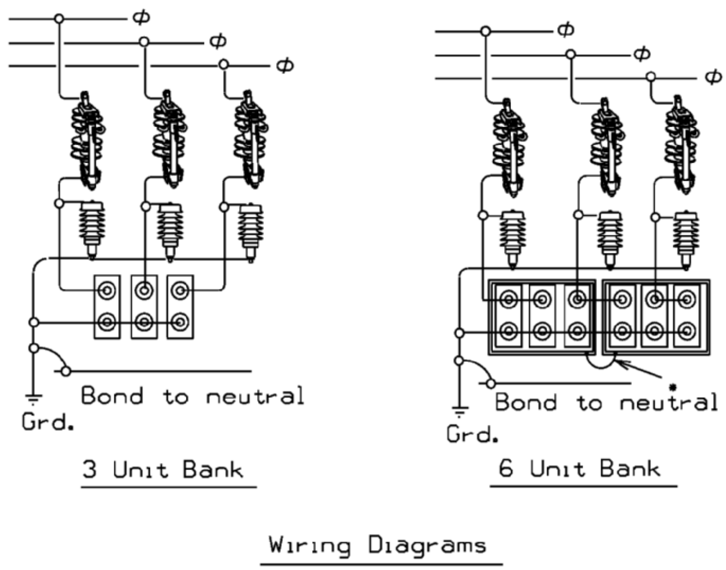
Supersedes 7/09 - Changed crossarm attachment from 12" to 7.5"

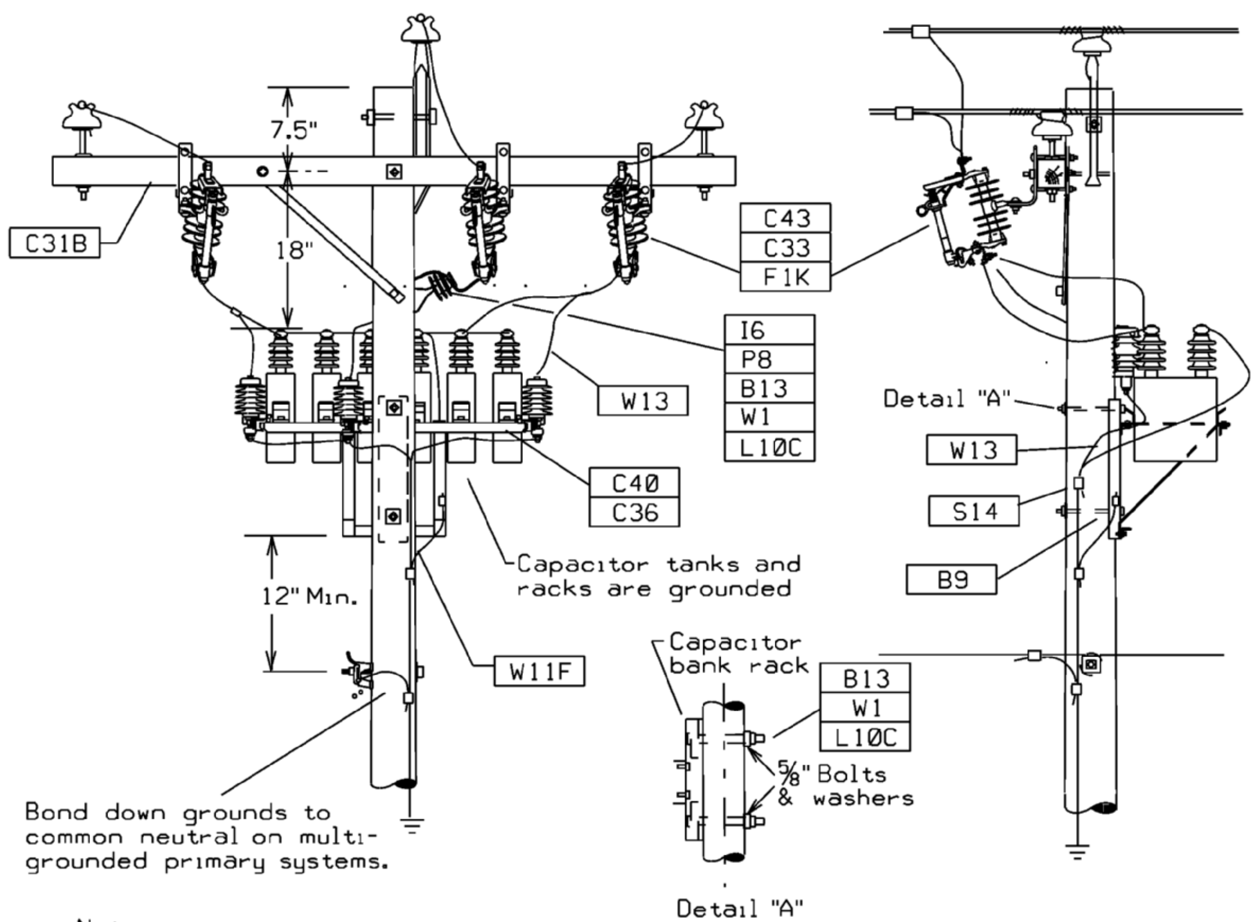
1Ø CAPACITOR INSTALLATION NOT EFFECTIVELY GROUNDED 15 kV

ISSUE	PAGE NUMBER		
7/11	15-212	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @(E)KB(V)YFNE	(E) = kVAR Size, (V) = Voltage

Supersedes 7/11 Issue - Added Std Items for several items and adjusted minimum clearance from neutral.



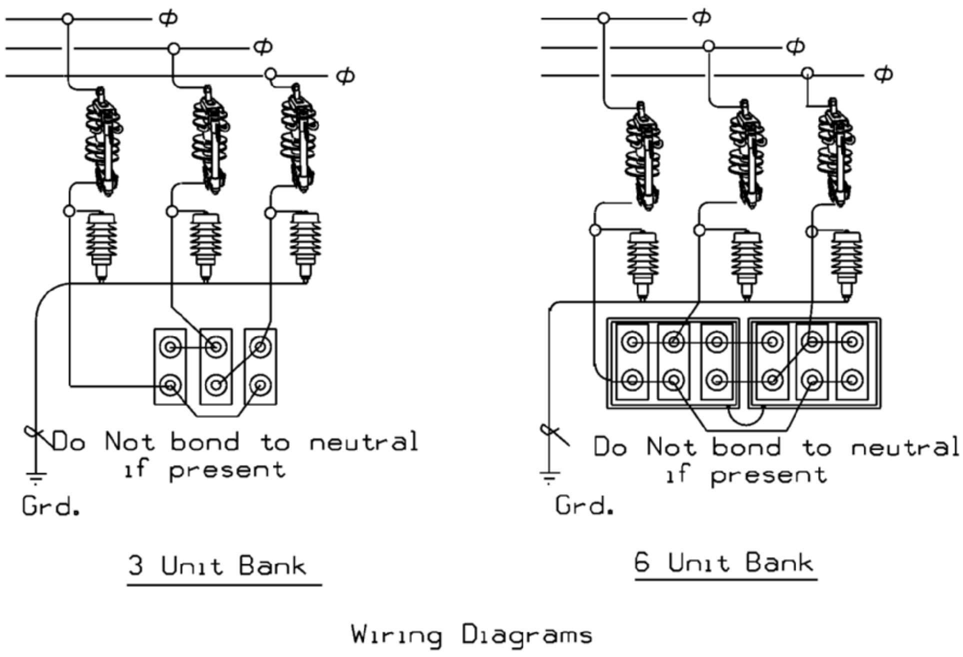


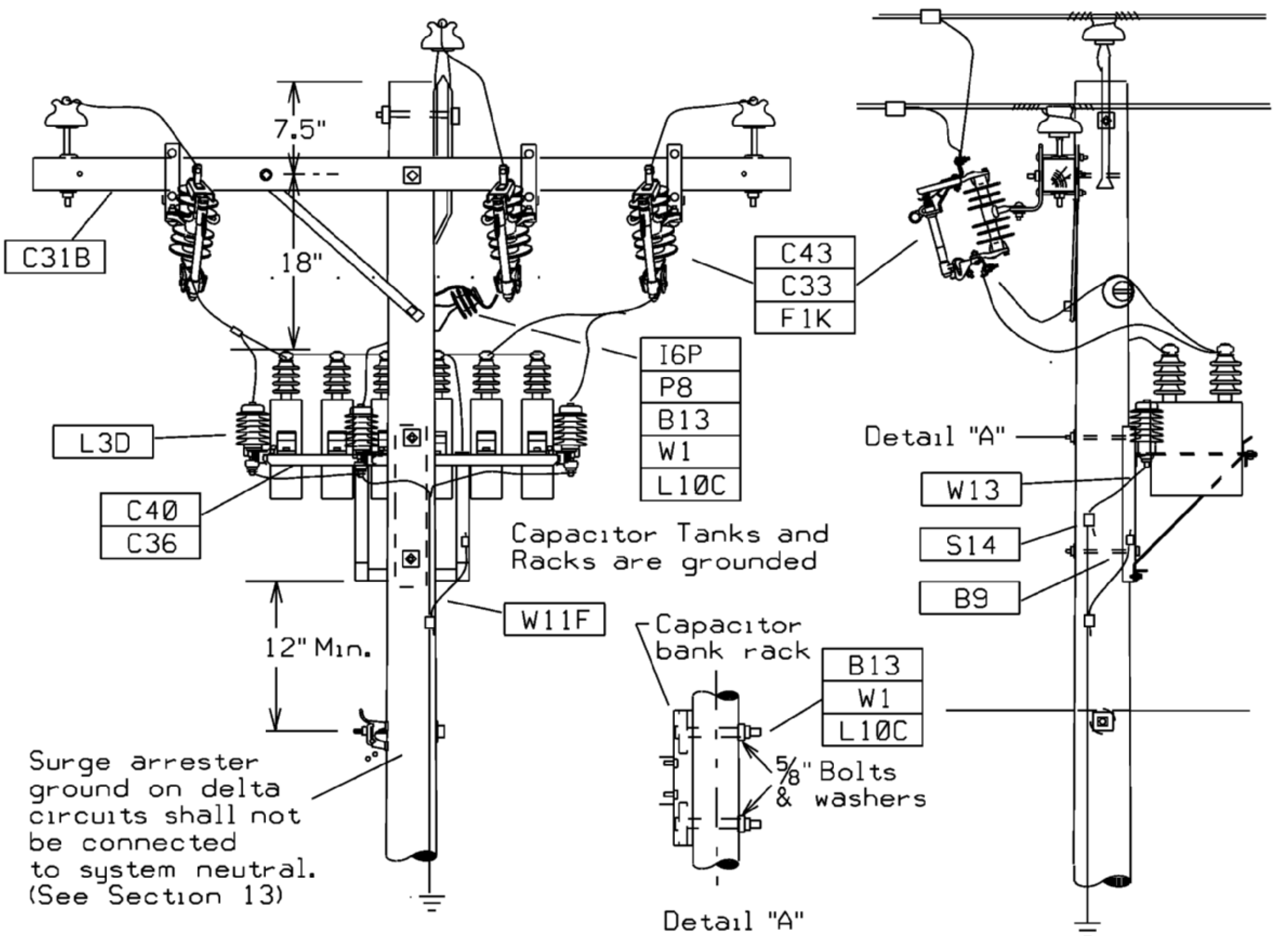
Notes:
- Bond separate capacitor racks together.

3Ø FIXED CAPACITOR INSTALLATION EFFECTIVELY GROUNDED 15 kV

 Doc. # ST. 15.00.002

MU = @(E)KB(V)DFNE	(E) = kVAR Size, (V) = Voltage





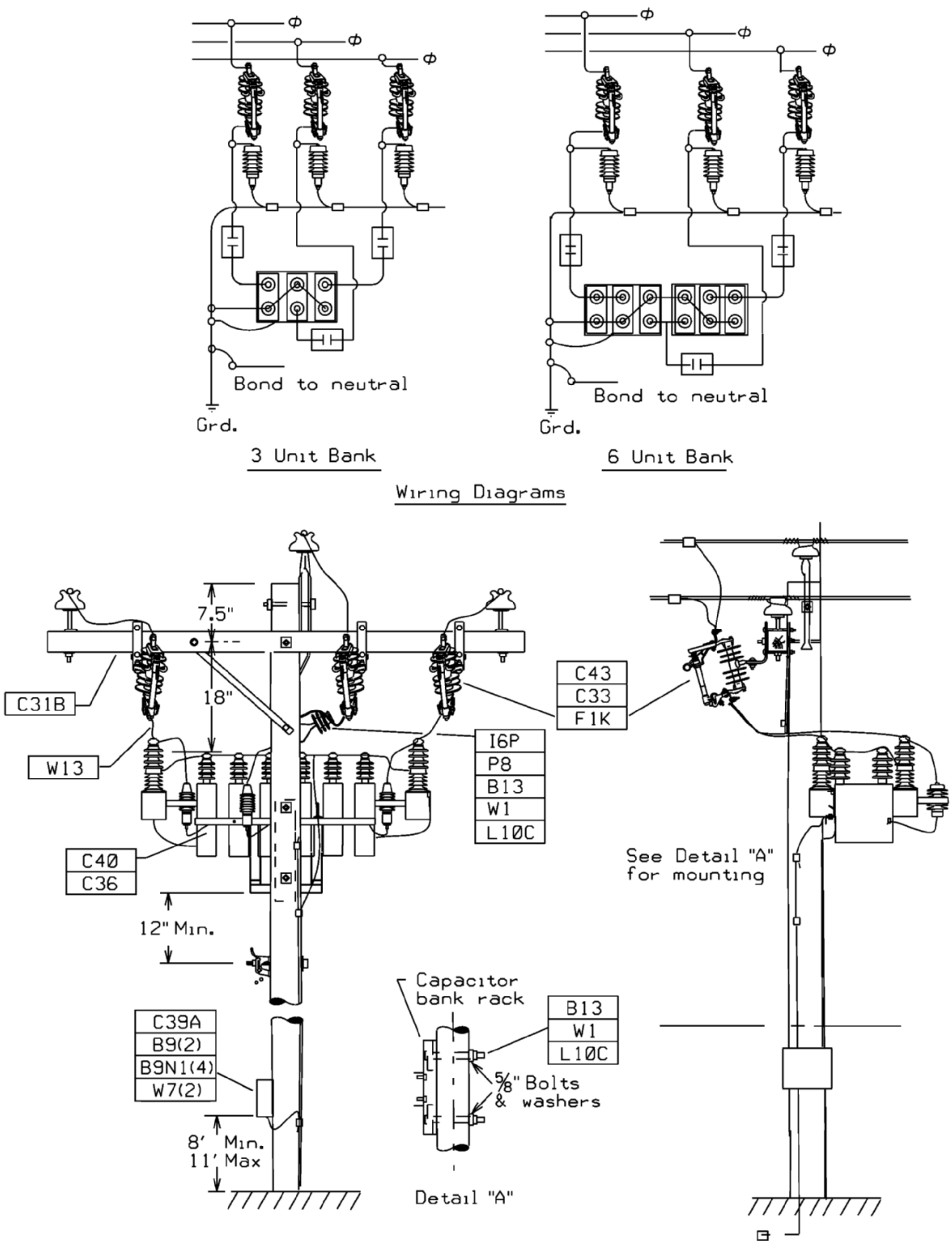
Supersedes 7/11 Issue - Added Std Items for several items and adjusted minimum clearance from neutral.

3Ø FIXED CAPACITOR INSTALLATION NOT EFFECTIVELY GROUNDED 15 kV

ISSUE	PAGE NUMBER		
7/12	15-332	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

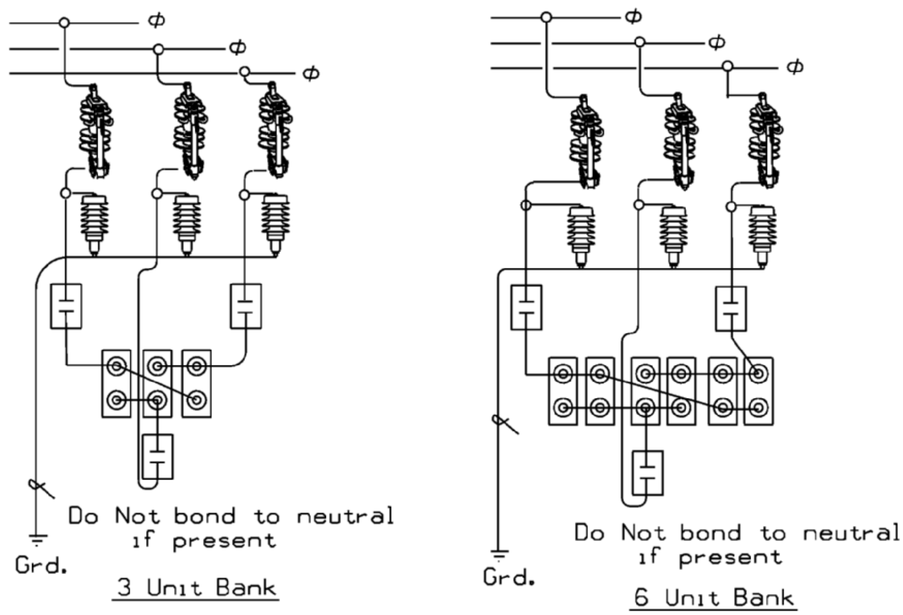
MU = @(E)KB(V)YSW or YSWNE	(E) = kVAR Size, (V) = Voltage
MU = @(E)K3C(V)YSWNE	

Supersedes 7/11 Issue - Added insulator to side of pole, added several STD Items and adjusted minimum clearance from neutral.

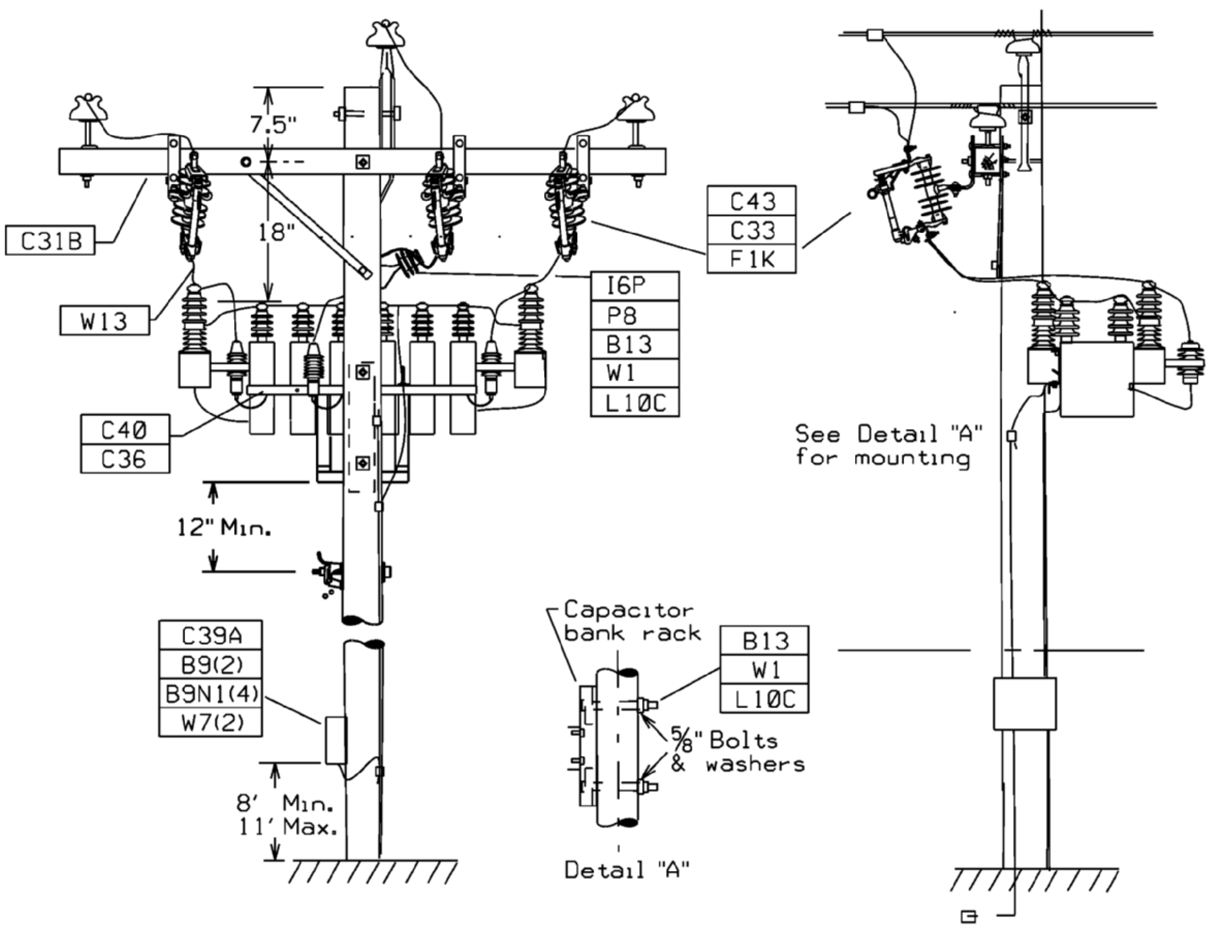


3Ø SWITCHED CAPACITOR INSTALLATION EFFECTIVELY GROUNDED 15 kV

MU = @(E)KBC3(V)DSWNE or DW	(E) = kVAR Size, (V)= Voltage



Wiring Diagrams

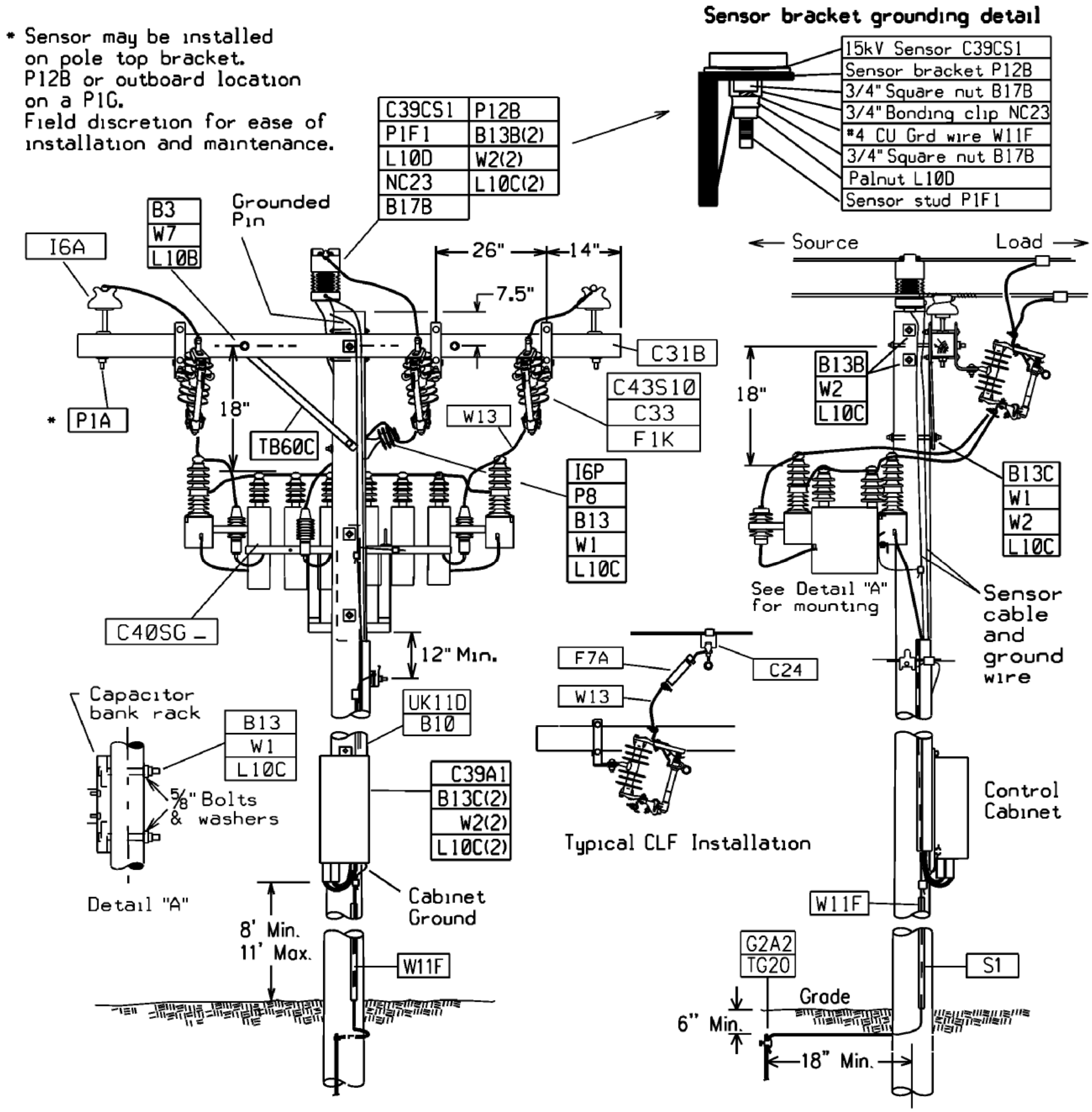


Supersedes 7/11 Issue - Added insulator to side of pole, added several STD items, updated and adjusted minimum clearance from neutral.

3Φ SWITCHED CAPACITOR INSTALLATION NOT EFFECTIVELY GROUNDED 15 KV			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/12	15-334		

MU = @300K3C2441YSWADVANCED	[redacted]
MU = @600KB7613YSWADVANCED	MU = @900KB7613YSWADVANCED

Supersedes 7/11 Issue - Entire drawing updated and moved notes to next page.



See page 15-335A for construction notes

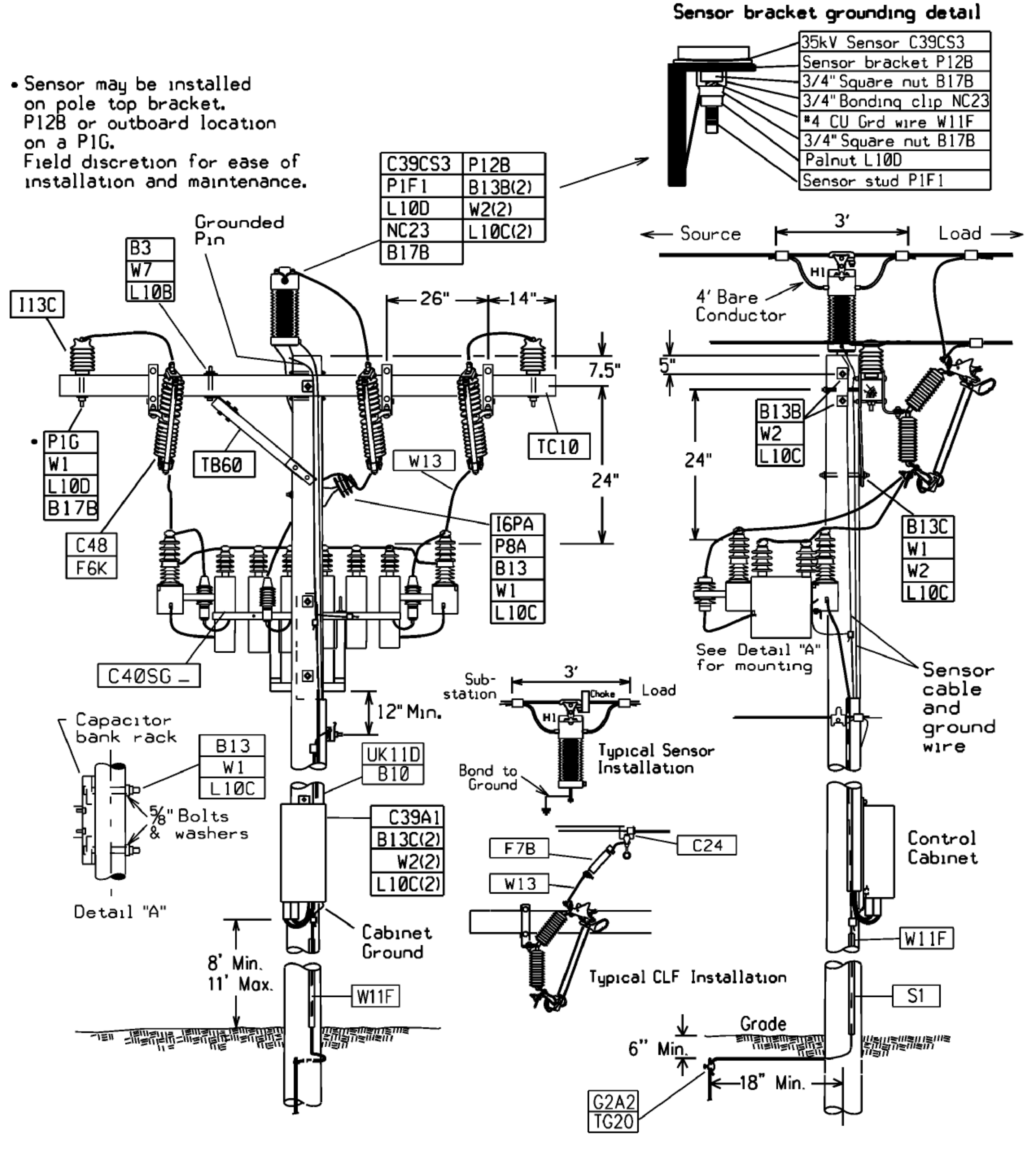
Notes for 15kV class capacitor bank with current/voltage sensor:

1. For available fault current over 5,000 sym, requires a current limiting fuse (Std Item F7A__). If units are 50kVAR and smaller available fault current is reduced to 4,000 sym.
2. Capacitors must be connected to primary on the load side of the current/voltage sensor with the H1 marking on the insulator/sensor facing source.
3. Sensor pin P1F1 or P1G must be grounded prior to any energized phase being placed on the insulator sensor. Ground shall be attached along the underside of the crossarm and down the pole to attach to the ground system. Secure with staples.
4. Covered primary conductor must be striped 18" on each side of sensor.
5. Locate control away from vehicular traffic (field side of pole).
6. See Section 13 for grounding and ground rod installation details.
7. Typical primary pole top construction shown, alternate pole top construction may be needed based on wire size and span.
8. Both ends of U duct STD Item UK11D shall be sealed with expanding foam Std Item UF10.

New Standard Page - Moved notes to separate page for clarity.

MU = @1200K3C1934YSWADVANCED
MU = @1800KB1934YSWADVANCED

Supersedes 7/11 Issue - Entire drawing updated and moved notes to next page.



See page 15-336A for construction notes

3Ø SWITCHED CAPACITOR INSTALLATION EFFECTIVELY GROUNDED 35kV CLASS AND BELOW WITH CURRENT/VOLTAGE SENSOR			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	**PAGE NUMBER** 15-336	**ISSUE** 7/12

Notes for 35kV class capacitor bank with current/voltage sensor:

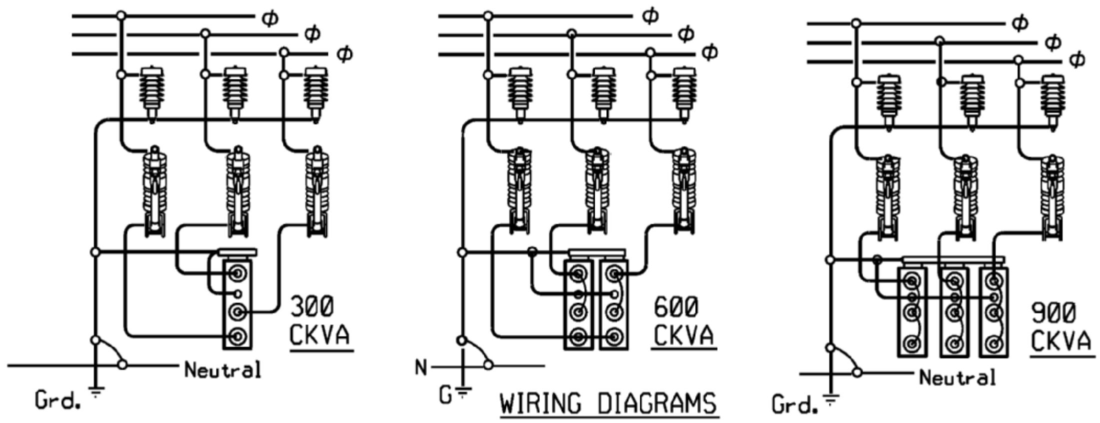
1. For available fault current over 5,000 sym, requires a current limiting fuse (Std Item F7B__).
2. Capacitors must be connected to primary on the load side of the current/voltage sensor with the H1 marking on the insulator/sensor facing source.
3. Sensor pin P1F1 or P1G must be grounded prior to any energized phase being placed on the insulator sensor. Ground shall be attached along the underside of the crossarm and down the pole to attach to the ground system. Secure with staples..
4. Covered primary conductor must be striped 18” on each side of sensor.
5. Locate control away from vehicular traffic (field side of pole).
6. See Section 13 for grounding and ground rod installation details.
7. Typical primary pole top construction shown, alternate pole top construction may be needed based on wire size and span.
8. Trunions used: Aluminum wire must be galvanized trunion, Copper wire must be ductile iron trunion. Trunions are packaged with the sensor.
9. The 4' bare conductor CVMI jumper must be sized for full ampacity of the main line and connected to the main line with Ampacts
10. Choke can not be closed until CVMI jumper is installed.
11. Both ends of U duct STD Item UK11D shall be sealed with expanding foam STD Item UF10.

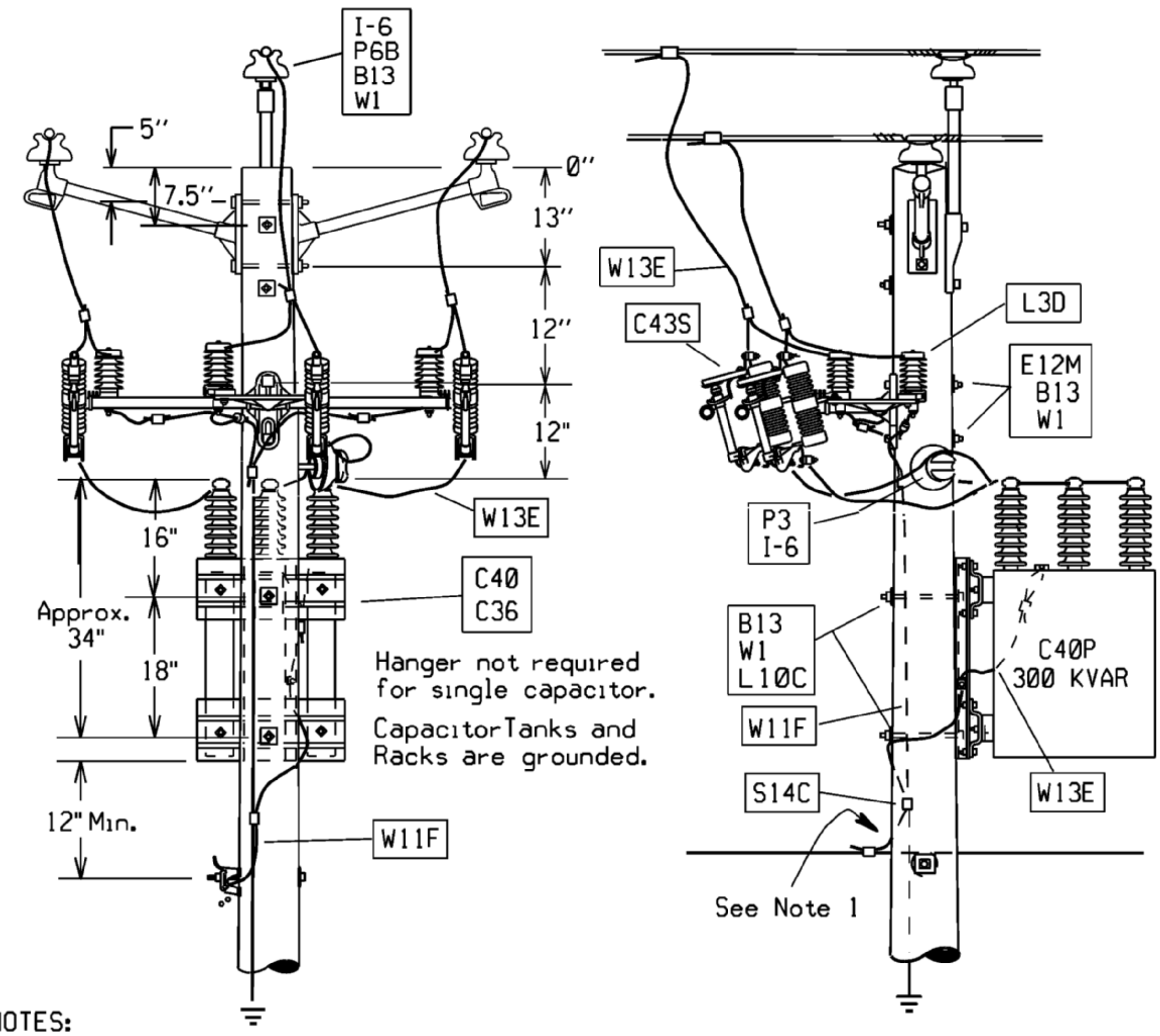
New Standard Page Moved notes to separate page for clarity.

 | Doc. # ST. 15.00.002

MU = @(E)K3C570
E= 300 or 600 or 900 kVAR

Supersedes 1/06 Issue – Updated Title Block Description, updated mounting bracket STD Items and adjusted minimum clearance from neutral.





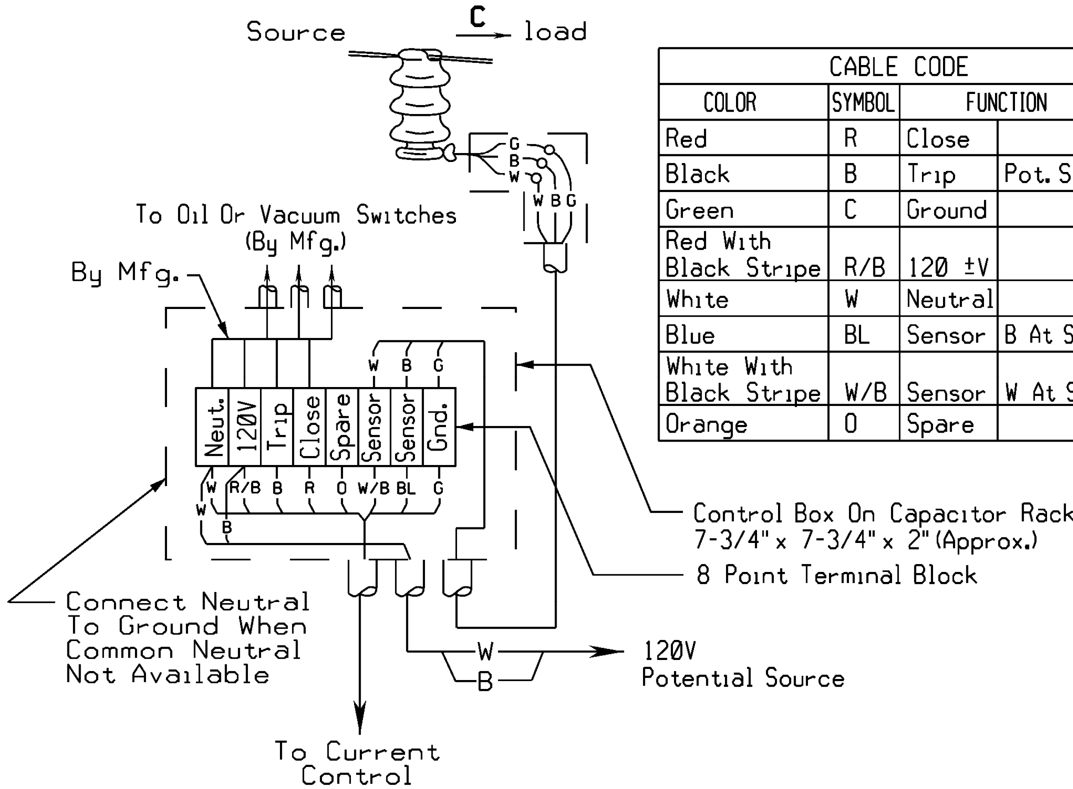
NOTES:

1 - Bond down grounds to common Neutral on Multi-grounded Primary Systems.

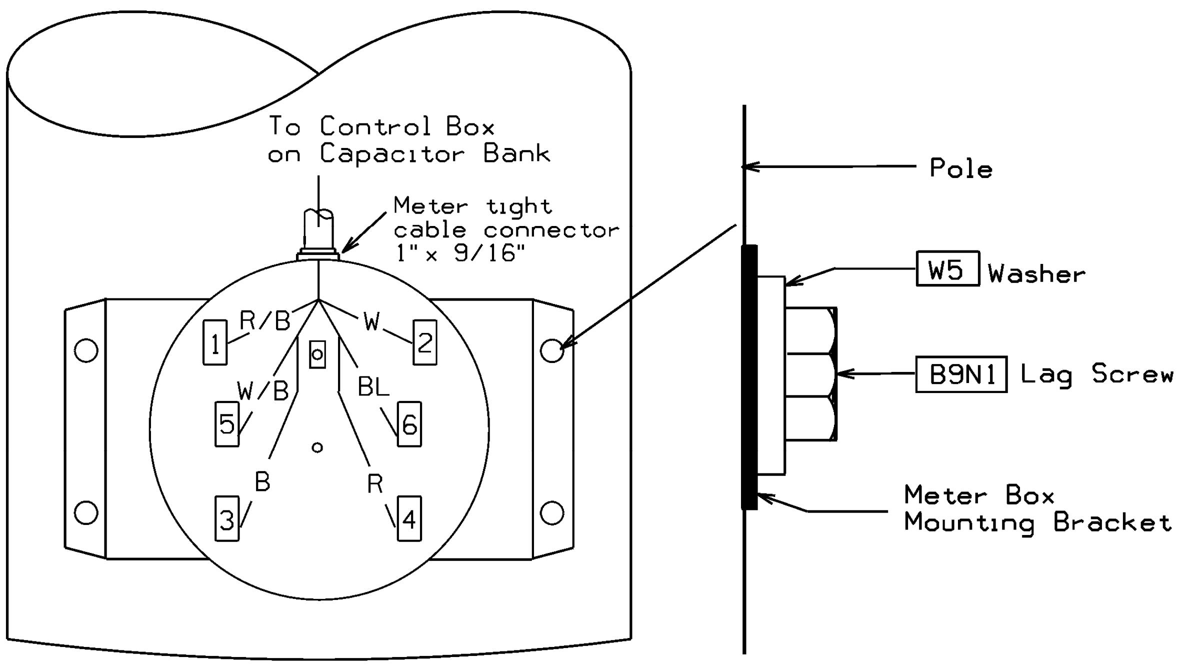
2 - See Drawings 15-331 and 15-332 3 Phase installation using 1 Phase Capacitors.

3Ø FIXED CAPACITOR INSTALLATION 15kV – WITH 3Ø PHASE UNIT			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 15-363	ISSUE 7/12

Current Control Wiring Diagram



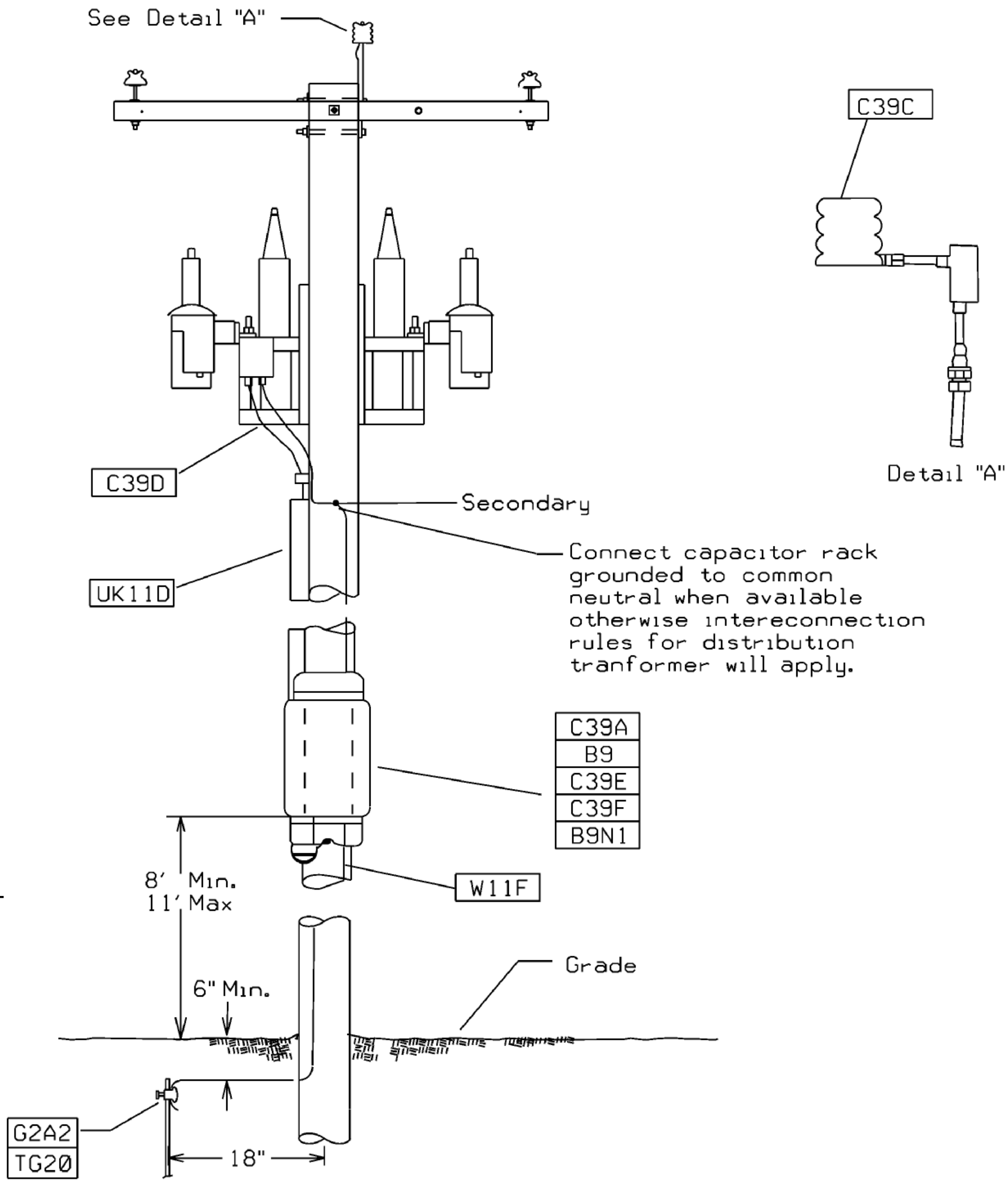
CABLE CODE			
COLOR	SYMBOL	FUNCTION	
Red	R	Close	
Black	B	Trip	Pot. Source
Green	C	Ground	
Red With Black Stripe	R/B	120 ±V	
White	W	Neutral	
Blue	BL	Sensor	B At Sensor
White With Black Stripe	W/B	Sensor	W At Sensor
Orange	O	Spare	



Supersedes 7/09 – Revised meter socket wire labels.

SWITCHED CAPACITOR CURRENT CONTROL WIRING DIAGRAM
6 PIN METER SOCKET

ISSUE	PAGE NUMBER		
7/10	15-399	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

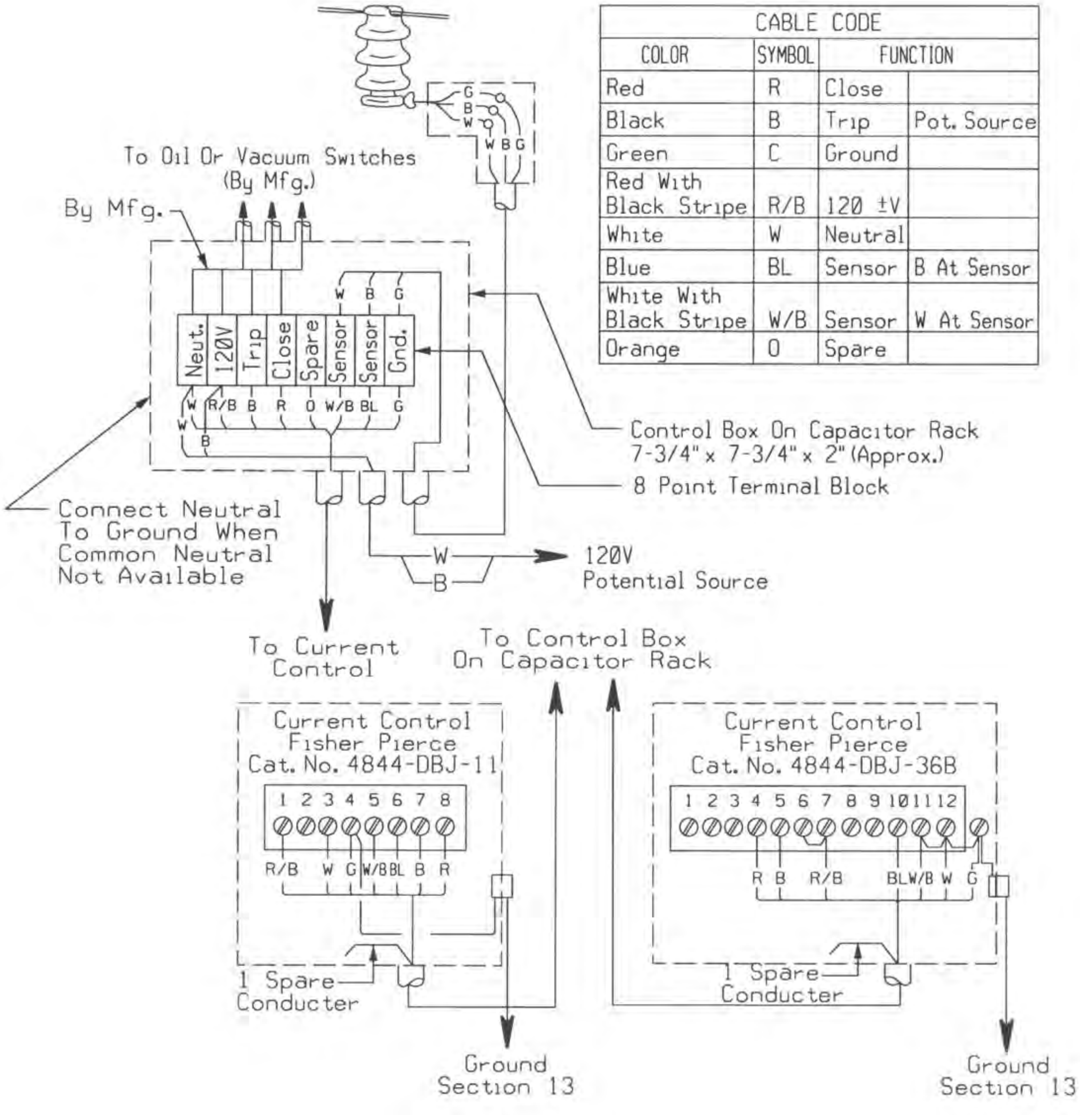


Supersedes 7/10 Issue – Added note

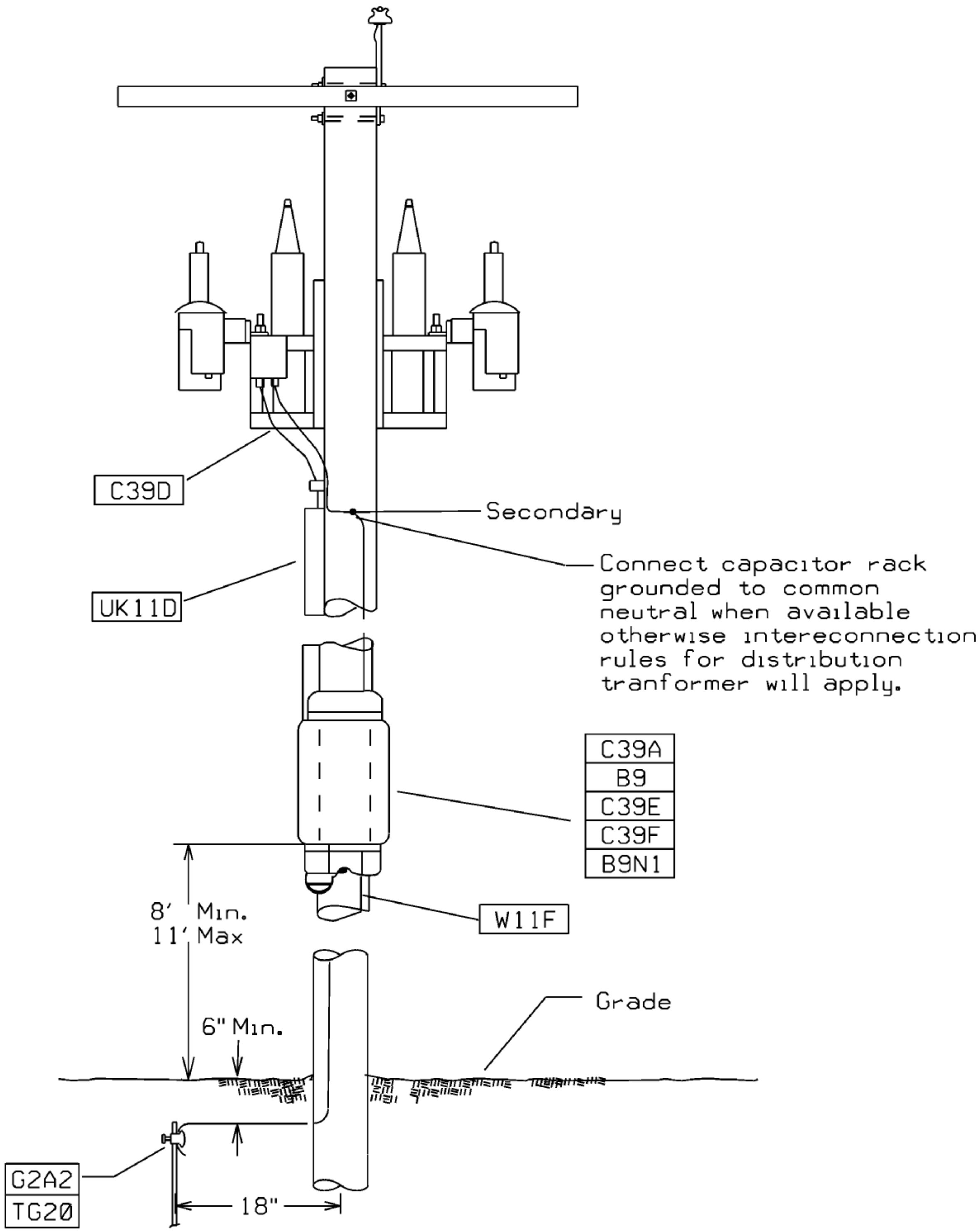
Notes:
1. Locate installation away from vehicular traffic.
2. Capacitors to be connected to Primary on station side of current sensor.
3. Current sensor should always be located on ridge pin or on phase conductor nearest the pole.
4. Phase conductor must be in center groove of the sensor.
5. See section 13 for grounding and ground rod installation details
6. Both ends of U duct Std Item UK11D shall be sealed with expanding foam STD Item UF10.

Current Control Wiring Diagram

CABLE CODE			
COLOR	SYMBOL	FUNCTION	
Red	R	Close	
Black	B	Trip	Pot. Source
Green	C	Ground	
Red With Black Stripe	R/B	120 ±V	
White	W	Neutral	
Blue	BL	Sensor	B At Sensor
White With Black Stripe	W/B	Sensor	W At Sensor
Orange	O	Spare	



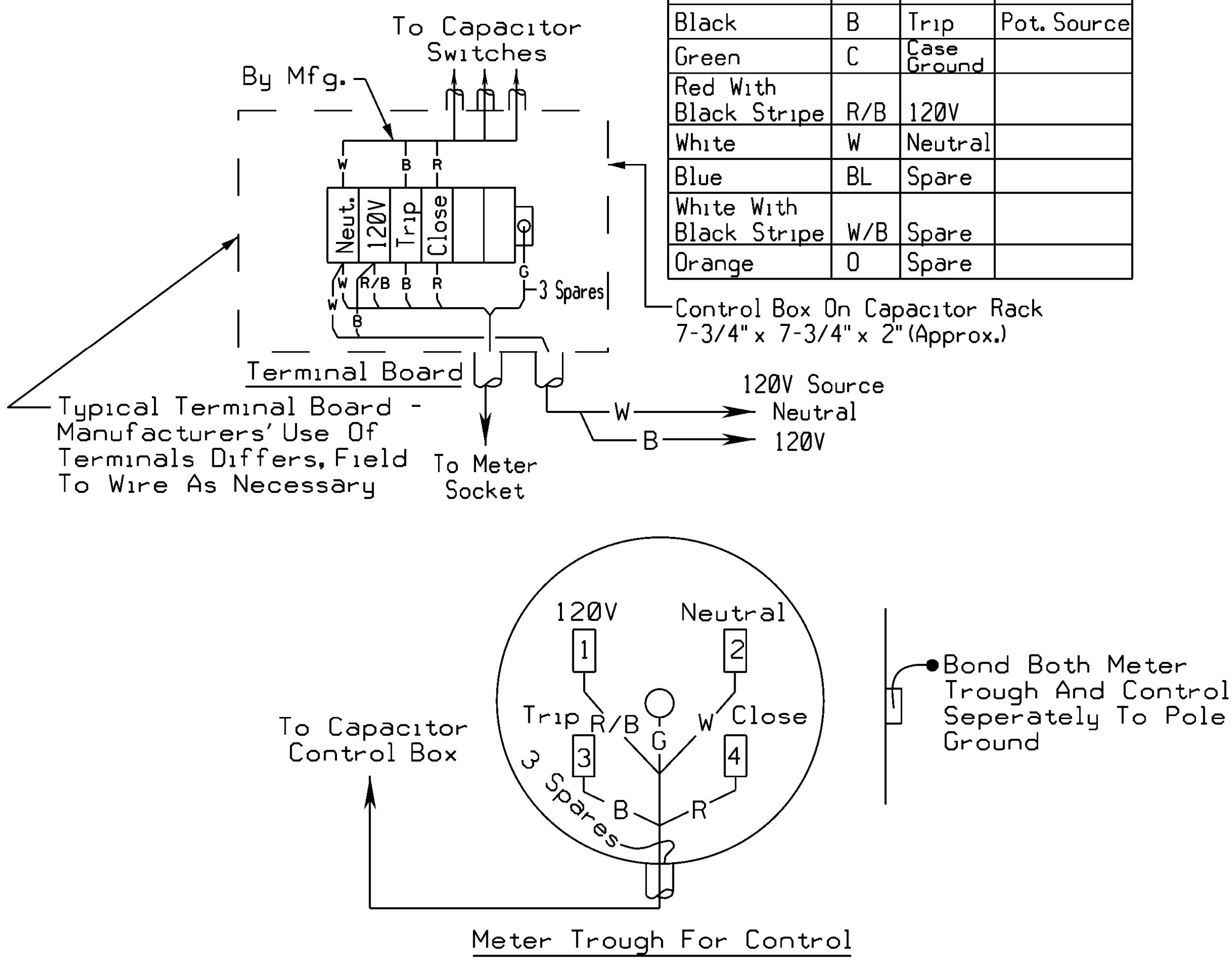
Supersedes 7/10 Issue – Added note 2.



Notes:
1. See Section 13 for grounding and ground rod installation details.
2. Both ends of U duct STD Item UK11D shall be sealed with expanding foam STD Item UF10.

3Ø SWITCHED CAPACITOR TIME CLOCK/VOLTAGE/TEMPERATURE INSTALLATION 15kV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 15-402	ISSUE 7/12

Control Cable Code			
Color	Symbol	Function	
Red	R	Close	
Black	B	Trip	Pot. Source
Green	C	Case Ground	
Red With Black Stripe	R/B	120V	
White	W	Neutral	
Blue	BL	Spare	
White With Black Stripe	W/B	Spare	
Orange	O	Spare	

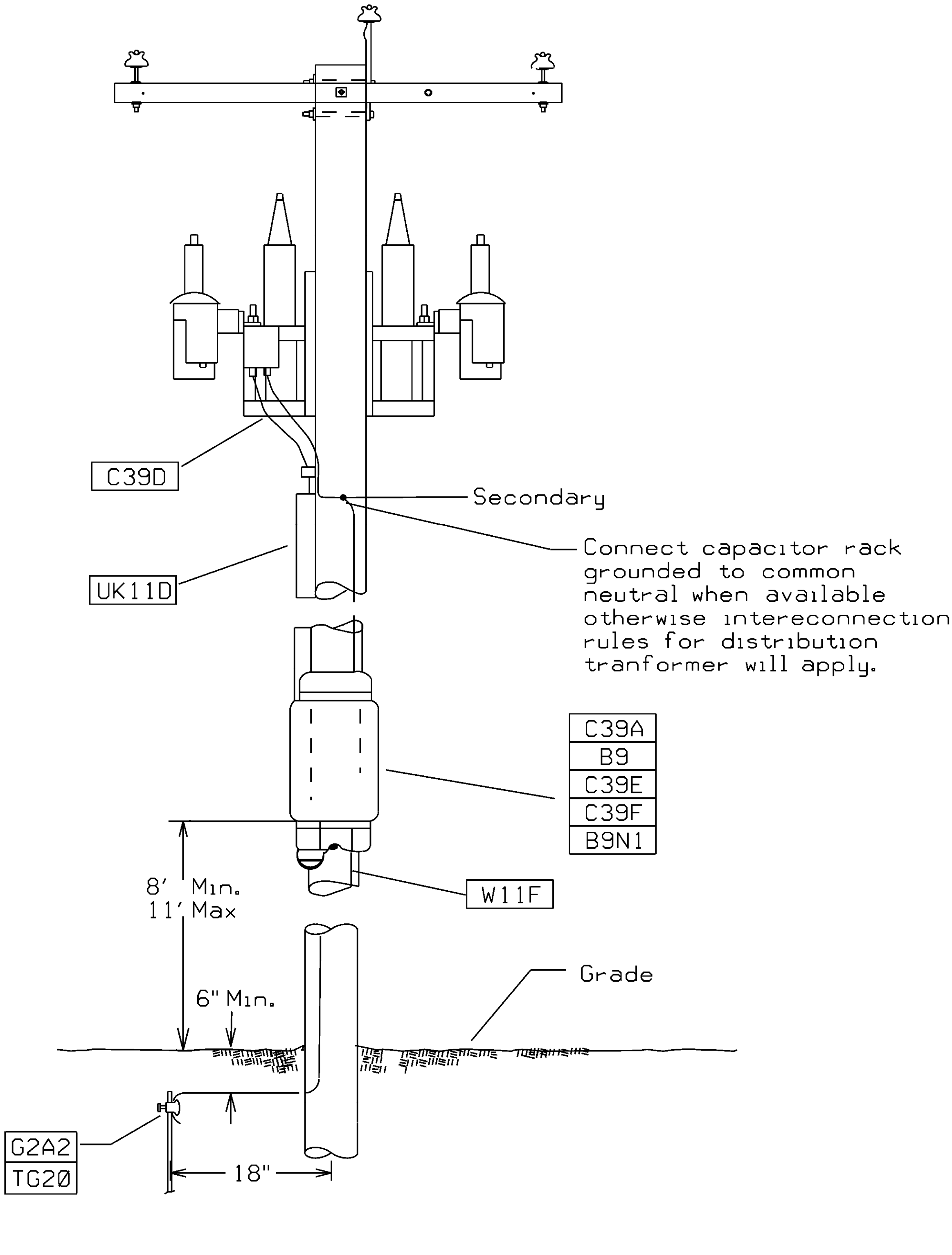


Supersedes 1/06 - Spelling error correction

TIME CLOCK/VOLTAGE/TEMPERATURE CONTROL WIRING DIAGRAM

 Doc. # ST. 15.00.002

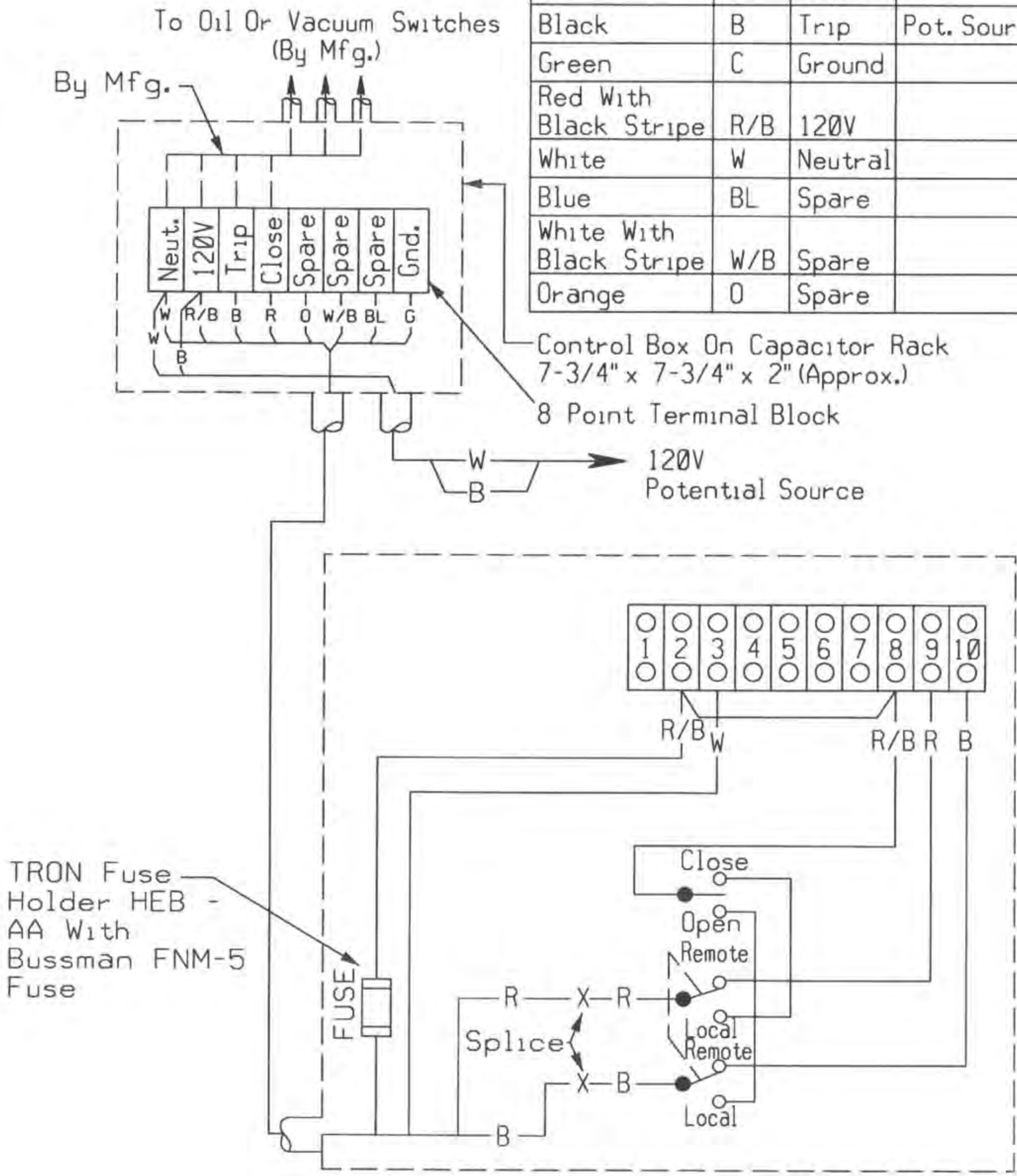
Supersedes 7/10 Issue – Added Note.



Note: Both ends of U duct STD Item UK11D shall be sealed with expanding foam STD Item UF10.

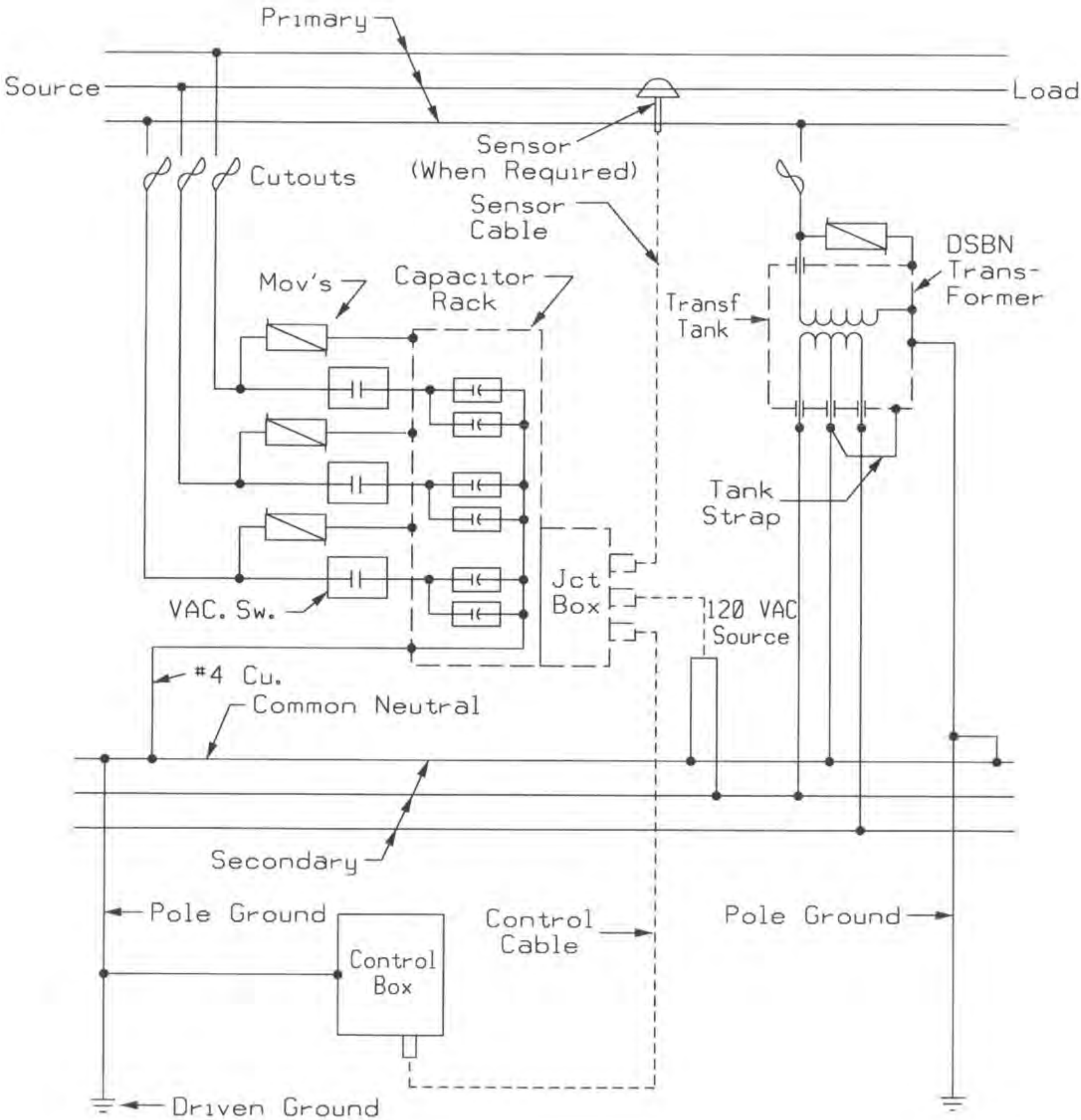
3Ø SWITCHED CAPACITOR RADIO CONTROL INSTALLATION 15kV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 15-404	ISSUE 7/12

CABLE CODE			
COLOR	SYMBOL	FUNCTION	
Red	R	Close	
Black	B	Trip	Pot. Source
Green	C	Ground	
Red With Black Stripe	R/B	120V	
White	W	Neutral	
Blue	BL	Spare	
White With Black Stripe	W/B	Spare	
Orange	O	Spare	



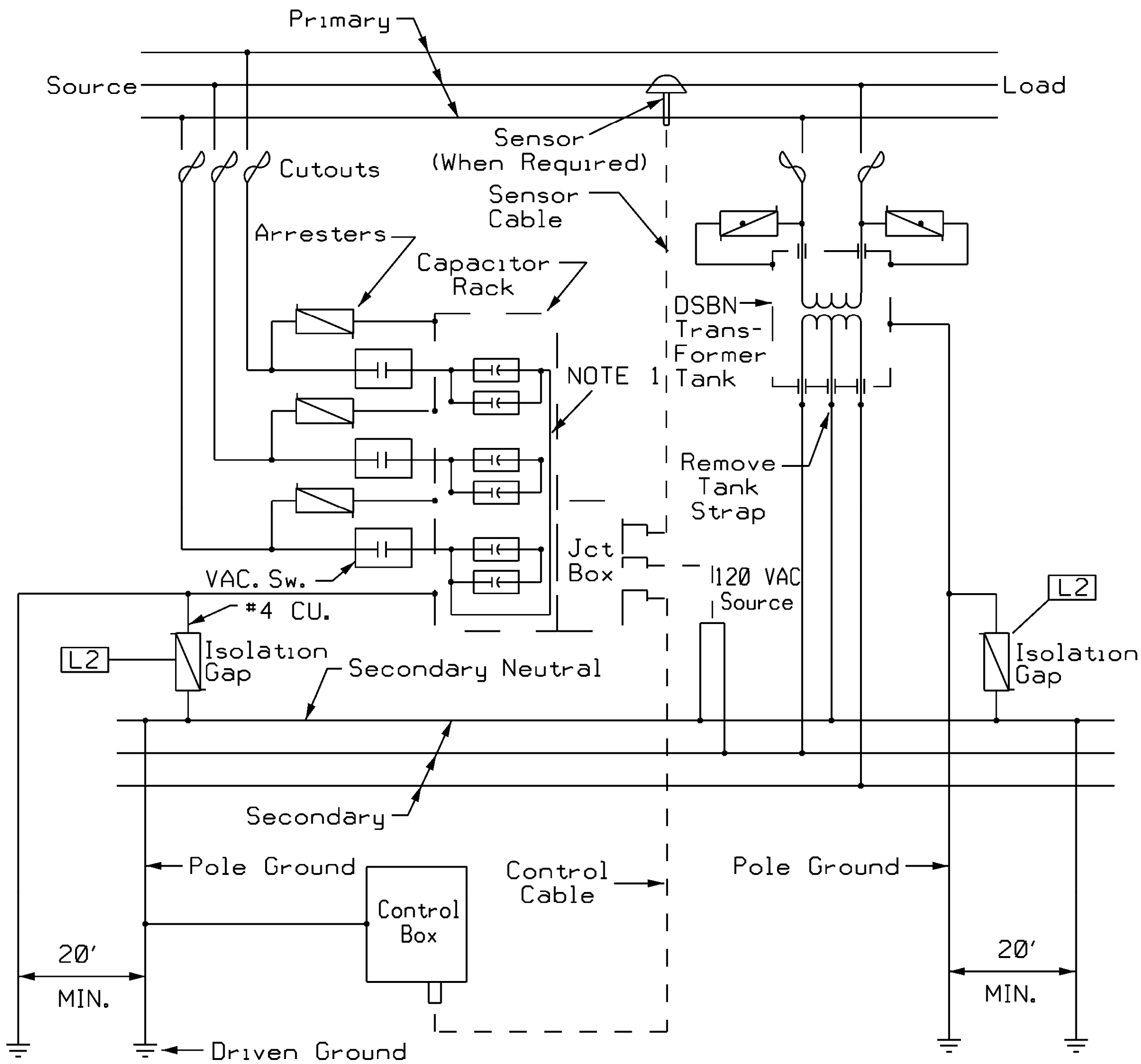
RADIO CONTROL WIRING DIAGRAM

ISSUE	PAGE NUMBER		
1/06	15-405	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities



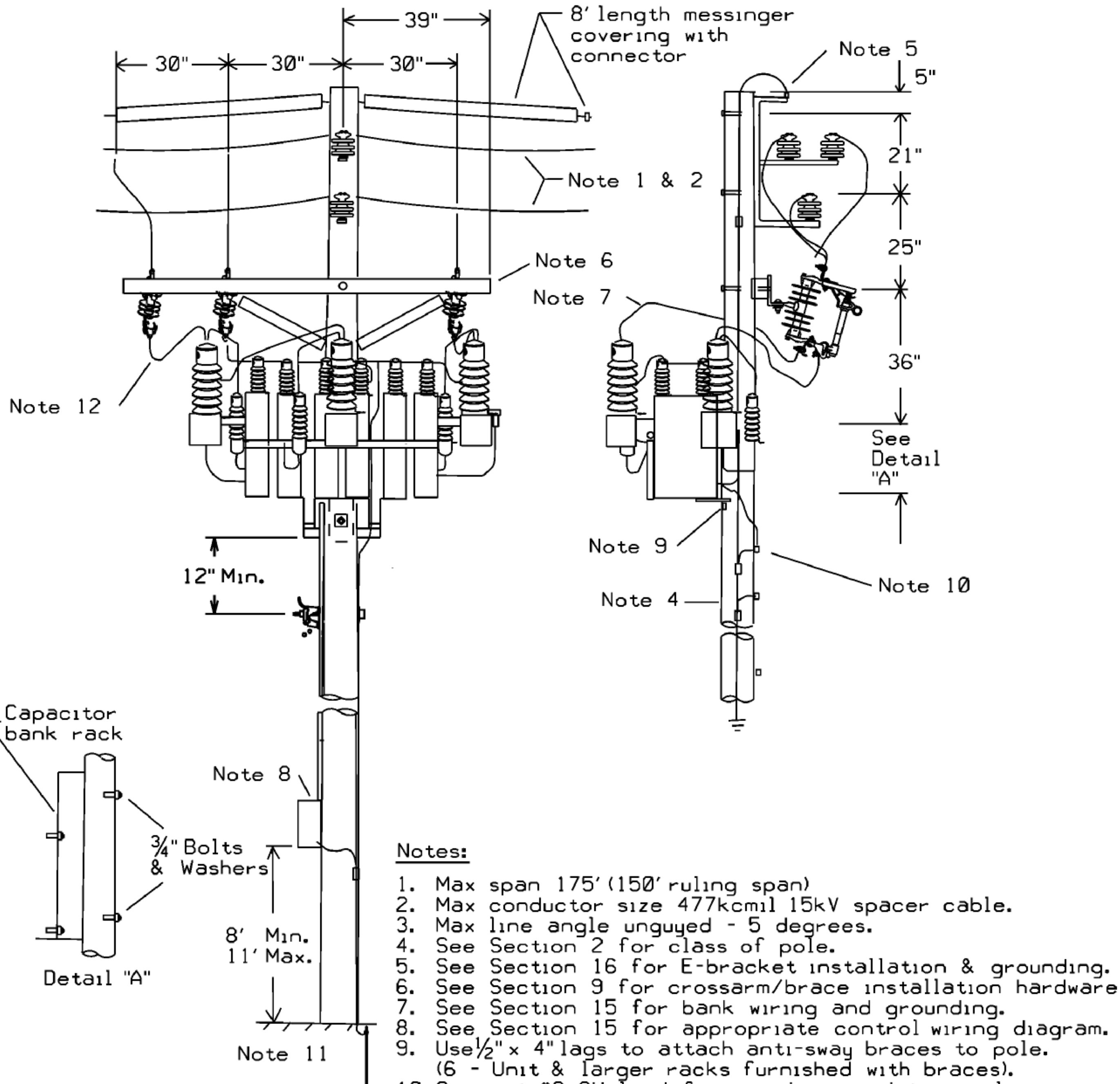
COMMON NEUTRAL WIRING SWITCHED CAPACITOR INSTALLATION DIAGRAM

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	15-406	1/06



Supersedes 7/09 Issue -Added note 2.

Note: 1. Delta connection shown. This Standard also covers ungrounded wye with appropriate bank connection. See Section 14-Transformers for transformer installation details.
2. Std Item L2 isolation gap is rated for up to 11 kV, do not install on electric systems greater then 11kV.

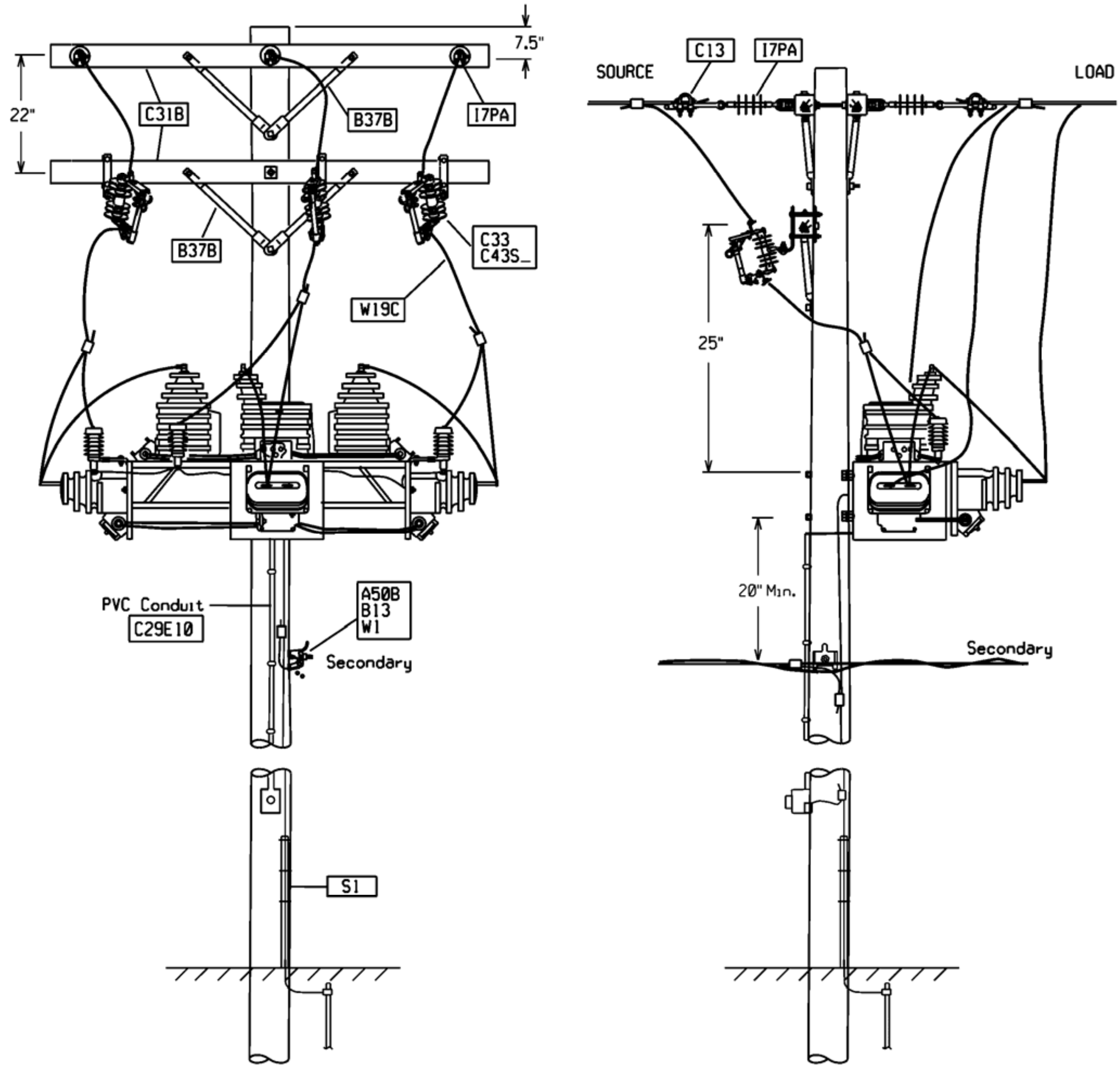


Notes:

1. Max span 175' (150' ruling span)
2. Max conductor size 477kcmil 15kV spacer cable.
3. Max line angle unguyed - 5 degrees.
4. See Section 2 for class of pole.
5. See Section 16 for E-bracket installation & grounding.
6. See Section 9 for crossarm/brace installation hardware
7. See Section 15 for bank wiring and grounding.
8. See Section 15 for appropriate control wiring diagram.
9. Use 1/2" x 4" lags to attach anti-sway braces to pole. (6 - Unit & larger racks furnished with braces).
10. Connect #3 CU lead from rack ground terminal connector to common neutral and connect common neutral to pole ground and ground rod.
11. See Section 13 Grounding and ground rod installation details.
12. Capacitor bank wiring should have heat shrink wild life protection.

Supersedes 1/06 Issue – Updated capacitor mounting bracket and adjusted minimum clearance from neutral.

3Ø SWITCHED CAPACITOR INSTALLATION EFFECTIVELY GROUNDED SPACER CABLE 15 kV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		15-409	7/12

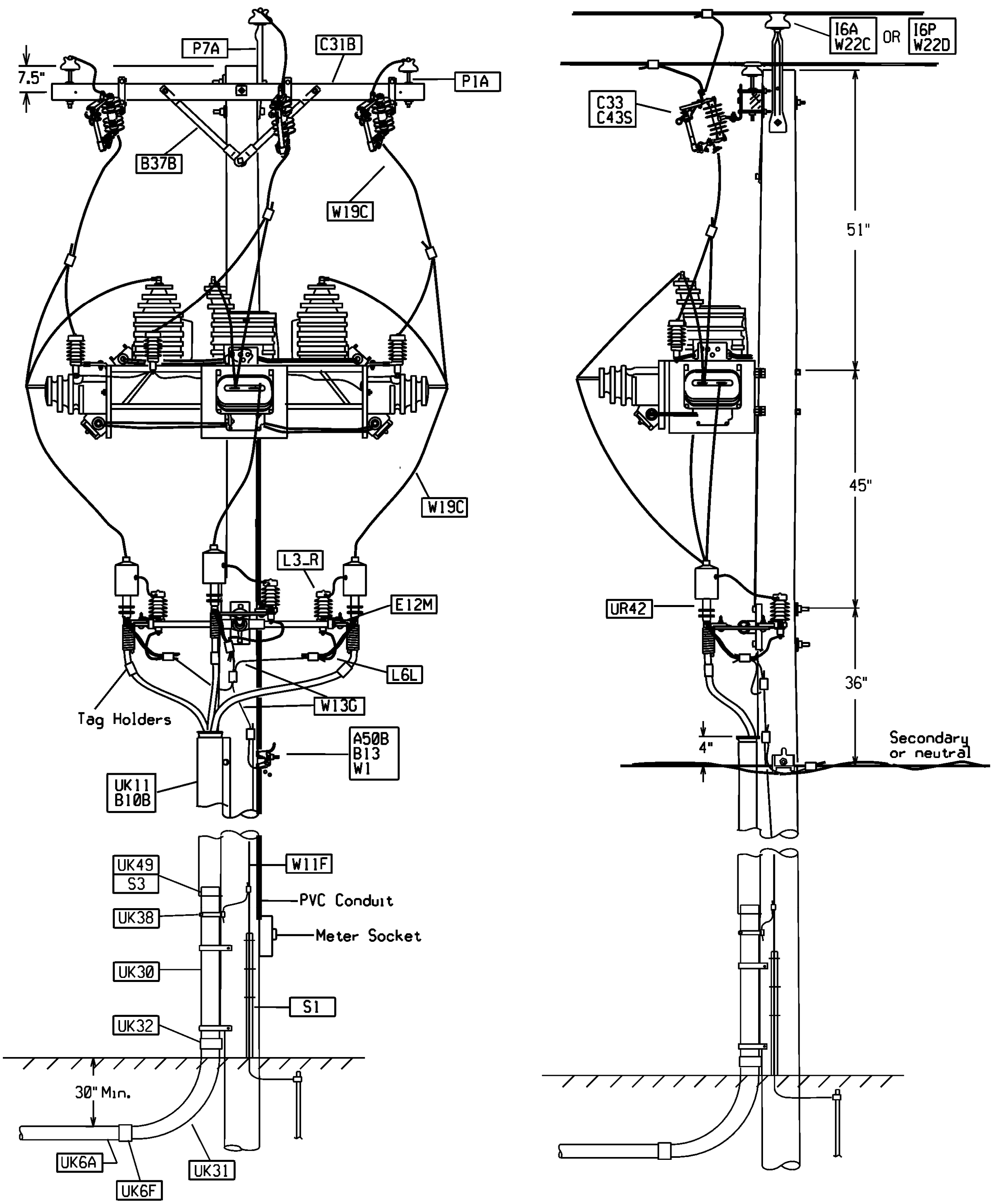


Supersedes 1/06 Issue - Updated drawing.

NOTES:

1. Metering equipment shall be specified by Meter Standards Engineering.
2. Meter socket height is to be no less than 3 feet and no more than 6 feet from ground to center of meter unless otherwise specified by Meter Standards Engineering.

Supersedes 1/06 Issue - Updated drawing.

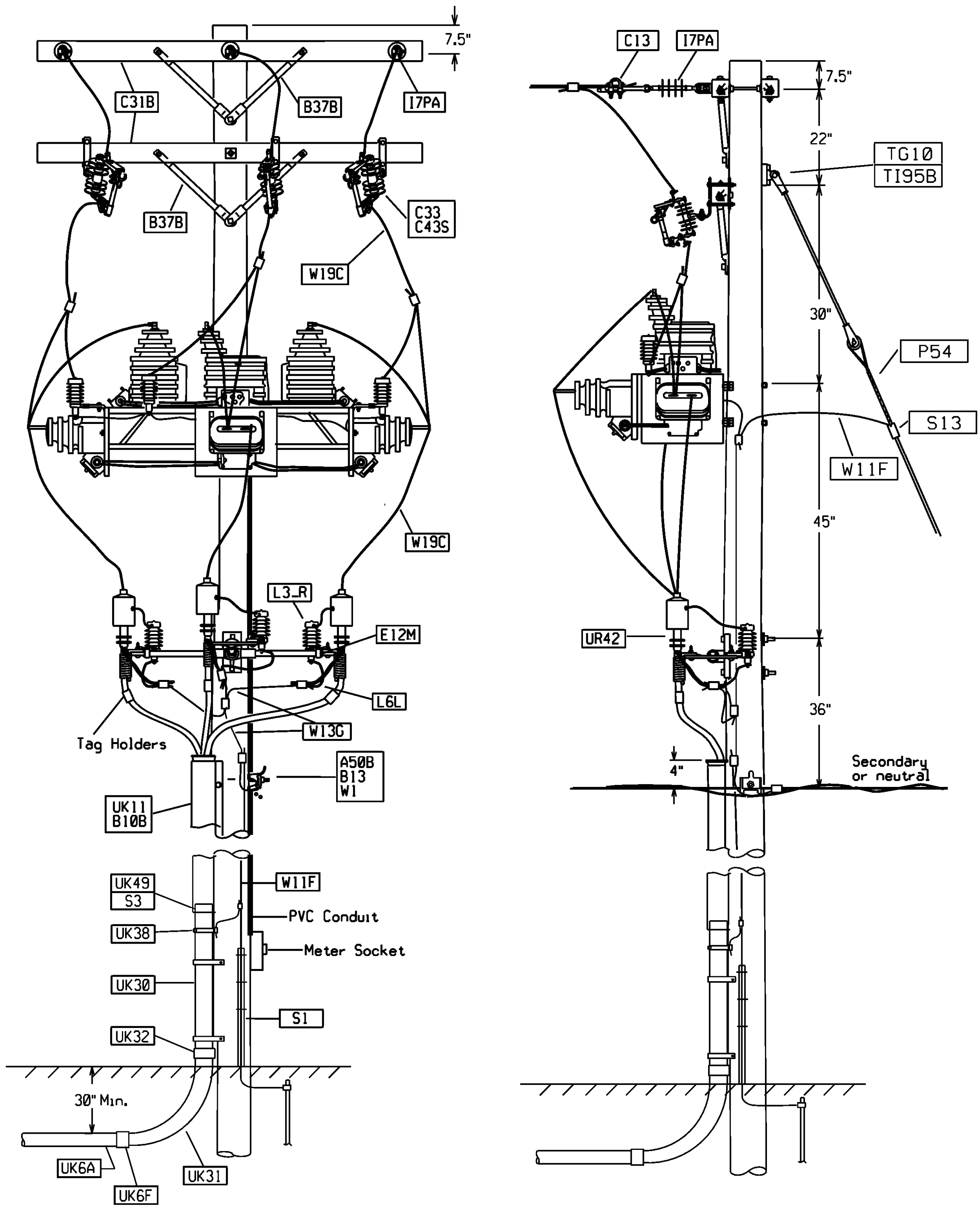


NOTES:

1. Metering equipment shall be specified by Meter Standards Engineering.
2. Meter socket height is to be no less than 3 feet and no more than 6 feet from ground to center of meter unless otherwise specified by Meter Standards Engineering.
3. For UG cables larger than #2, W17G shall be used instead of W13G for concentric connections.

3Ø PRIMARY METERING - FUSED RISER POLE, TANGENT			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 15-501	ISSUE 7/10

 Doc. # ST. 15.00.002



Supersedes 1/06 Issue - Updated drawing.

NOTES:
1. Metering equipment shall be specified by Meter Standards Engineering.
2. Meter socket height is to be no less than 3 feet and no more than 6 feet from ground to center of meter unless otherwise specified by Meter Standards Engineering
3. For UG cables larger than #2, W17G shall be used instead of W13G for concentric connections.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2.5	7/13	• Corrected Drawing 15-500	Robert Johnson	Robert Johnson Program Manager
2.4	7/12	• Updated table 1 • Updated 15-152 and 15-156 item 6 EOP referral • Drawing updates to 15-122, 331, 332, 333, 334, 335, 336, 400, 402, 404, 407 and 409	John Vartanian Tim Hayden	Susan Fleck, VP of Standards, Policies, & Code
2.0	7/11	• Revised 15-122 – revised wiring diagram to show Reg#1L lead connected to Line 3 instead of tap to Reg# 3. • Revised 15-151 thru 15-154 – changed tap insulators to poly instead on porcelain. • Revised 15-211 – added washer • Revised 15-212, 15-331, 15-322, 15-333, & 15-334 – added washer and changed pole top clearance to 7 ½" • Added new standards 15-335 and 15-336	Joe Tumidajski	Allen Chieco, Director of Distribution Standards and Work Methods
1.1	7/10	• Revised MU's on 15-111, 15-122 & 15-131 • Added Regulator Platform drawings 15-151 thru 15-156 • Added By-Pass Switch Operation Guide 15-157 • Revised meter socket wire labeling 15-399 • Corrected Std Item # on 15-400, 15-402 and 15-404. • Revised Drawings 15-500, 15-501, and 15-502. Added more details on each drawing.	Joe Tumidajski Katie Croteau	Allen Chieco, Director of Distribution Standards and Work Methods
1.0	7/09	• Renumbered sections of the document. • Added Section 15.5 (Primary Metering). • Updated drawing 15-333 • Updated drawing 15-334 • Added Drawing 15-399 • Revised Drawing 15-407	Katie Croteau Joe Tumidajski	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/06 Issue – Revised Index To Reflect Page Number Changes

 Doc. # ST. 16.00.001

Supersedes 7/07 Issue – Revised Title of Section 16-153.

Supersedes 1/06 Issue – Revised Index To Reflect Page Number Changes And Added Page 16-321

Supersedes 7/07 Issue – Revised Title of Section 16-153.

Supersedes 1/06 Issue – Revised WARNING To Reflect The Addition Of A Semiconducting Layer For All New Spacer Cable / Tree Wire

16.0 SCOPE

This Standard includes the basic philosophy, design, and recommended practices for all new spacer cable distribution line construction at voltages of 35 kV and below as well as for all new aerial cable construction at voltages of 15 kV and below.

16.1 APPLICATION

16.1.10 Safety Cautions

A. **WARNING:** Although spacer cable coverings offer some electrical protection, **SPACER CABLE CONDUCTORS ARE NOT INSULATED. THEY MUST BE TREATED AS BARE CONDUCTORS DURING INSTALLATION AND MAINTENANCE.**

B. **WARNING:** All new spacer cable coverings contain a layer of semiconducting material right at the aluminum conductor surface. **WHEN SKINNING ALL SPACER CABLE COVERINGS, DO NOT ALLOW THE REMOVED COVERING TO COME IN CONTACT WITH GROUND OR ANOTHER PHASE. A FLASH MAY RESULT.**

16.1.20 Recommended Applications

Spacer cable systems are recommended for the following applications:

A. Heavily treed areas where tree removal is not possible.

B. Areas where proper horizontal line clearances cannot be maintained using other construction alternatives.

C. Areas where multiple primary feeders on the same pole line are required.

D. Areas where right-of-way space is limited.

16.2 GENERAL

16.2.10 Spacer Cable System

An overhead primary distribution system consisting of covered conductors held in a close triangular configuration by spacers that are supported by a messenger and attached to brackets on a pole.

16.2.20 Basic Impulse Level (BIL) in a Spacer Cable System

BIL in a spacer cable system is dependent upon the coordinated insulation capabilities of the individual parts making-up the spacer cable; insulation covered conductor, spacers, conductor ties, and grounded messenger.

The messenger is required to be grounded approximately every 800 feet, every other pole is recommended, to aid in preventing lightning flashover resulting in conductor burn down. Thus, the basic pole top is shielded and grounded.

Basic impulse level is determined primarily by two factors: (1) inches of insulating material between conductors and (2) conductor cover thickness. Estimated minimum impulse withstand for a 15 kV class spacer cable system without conductor insulation removed, or surge arresters installed, is 280 kV.

Note: When spacer cable covering is removed and the conductors remain in their normal close configuration, the BIL is lowered. Arresters shall be applied per Section 16.3.40-Surge Protection, to reduce the possibility of flashover to the messenger or to an adjacent phase conductor. Furthermore, all phase conductor taps shall be taped or covered to help minimize the potential for flashover.

16.2.30 Design Basis for Individual Poles

A. NESC (National Electrical Safety Code - ANSI C-2)

1. Loading – Heavy loading in accordance with latest edition of the NESC.

2. Vertical Clearances – Sag Related Clearances.

   Messenger at worst final sag producing condition (of four conditions listed below)

   - Ambient temperature of 0˚F/-18˚C with 4 lbs. wind and with ½ inch ice, or
   - Ambient temperature of 32˚F/0˚C with no wind but with ½ inch ice, or
   - Ambient temperature of 60˚F/15˚C with 6 lbs. wind but with no ice.
   - Maximum conductor operating temperature under unloaded conditions.

   Any conductors below the spacer cable configuration, at same operating ambient, final, unloaded (no ice) sag.

   Midspan clearances must be 75% of those required at the pole.

3. Grades of Construction – NESC specifies three grades of overhead power line construction based on required strengths for safety.

   The relative order of grades for conductors and structures is B, C, and N, with grade B being the highest.

   The Company Distribution Construction Standards are designed predominantly for grade C, except where grade B construction is required (mainly where supply conductors cross either a railroad or a limited access highway). Grade N construction is not used by the Company for distribution construction.

B. Ownership/Attachments – Poles are jointly owned with the telephone company. Company designed space is based on two additional communication cables being installed in the communication space, such as fire alarm and cable TV. Both pole owners, by agreement, relinquish 12 inches (i.e., 6 inches per attachment) of vertical ownership area in order to maintain the 40 inch required communication worker safety space at the pole. Additional third party attachments each require that both parties relinquish an additional 6 inches.

C. Primary Conductors – Maximum phase conductor size of 795 kcmil installed using a 1/0-2/5 AWAC messenger.

D. Definition of “S-S” – Indicates that the neutral of the secondary supply cable is located on the pole in this position.

   To allow room for connections to the cable, the lowest secondary supply conductor is located 6 inches below S-S.

Supersedes 1/06 Issue – Revised Vertical Clearance Requirements, Max. Conductor Size & Added Ownership Clarification

E. Secondary Conductor/Neutral – Use of 3/C-1/0 aluminum secondary cable per Section 10-Secondaries, with its messenger attachment located at Line S-S.

Installation of a single 1/0 6201 neutral in place of secondary cable requires sags of the single 1/0 neutral to match those of secondary cable.

Clearances in this Standard do not allow for the vertical space required by any existing secondary racks. If racked secondary exists, it shall be replaced with standard secondary cable.

F. Use of Messenger as the Sole Neutral – In special instances the messenger may be used as the circuit's only solidly grounded neutral conductor.

Grounding shall be as specified in Section 13-Grounding.

Transformer or other equipment neutral taps to the messenger shall be made using covered conductor having equal ampacity to that of the equipment phase lead.

G. Top Communication Cable Sags – No sag assumed.

H. Supply Space Communication Conductors – Shown in construction drawings for reference purposes only. Poles in this standard are not specifically designed to accommodate these conductors. See the Company "Policy For Installing Communication Cables In The Supply Space."

16.2.40 Thermal Ratings

A. Normal & Emergency – Refer to Section 6-Primary Conductors.

B. Sags for Clearance Purposes – Using the NESC conditions in Section 16.2.30-Part A. above, refer to Sag & Tension Tables in 16.5-Messenger and Phase Conductor Installation for specific values.

16.3 PRACTICES

16.3.10 Guying

A. Shall be in accordance with that specified in the individual drawings in this Section and per requirements of Section 3-Guying.

B. A messenger designed storm loaded tension of 6,800 pounds, in accordance with Section 16.4-Deadending, Splicing, and Splice Recovering, shall be used for purposes of guying.

C. Maximum allowable angles in a line may be limited by the ability to properly guy the pole.

D. All spacer cable deadends and angle poles in excess of 30 degree line angles require a minimum of a double 12.5M guy strand and compatible hardware.

E. Obtain the maximum guy lead possible. A ratio of Height /Lead ≤ 1 is preferred. Short leads (5-10 feet) can result in pole splitting, excessive column loading, and anchor creepage.

F. Fiberglass guy strain insulators shall be used in accordance with individual drawings in this Section and will generally be located on every primary down guy.

16.3.20 Installation

A. Poles – Shall be as shown on individual construction drawings in this Section. Pole height is dictated by what equipment is installed on the pole, whether joint use is required, span lengths, and size and type of conductors installed.

Pole class shall be determined by Distribution Design in accordance with Section 2-Poles/Hardware. Specific design criteria listed in Section 16.2.30-Design Basis for Individual Poles above, have been applied to the individual pole construction drawings in this Section.

B. Brackets

1. Tangent Brackets – Are designed for messenger support on straight line poles up to a maximum line angle of 6 degrees.

   Tangent brackets provide three messenger offset distances from the pole: 14, 24, and 44 inches.

   Note: The 24 inch bracket must be used on 35 kV straight line poles in order to provide required clearance from the pole surface.

2. Anti-Sway Brackets – Are designed for spacer support on transformer tap poles and areas that are subject to high wind (e.g., coastal construction). All 15 kV transformer tap poles should utilize the anti-sway bracket to help minimize potential damage to tap connections at these locations. Additionally, these brackets are available for use in high wind areas (Std. Item A54B).

3. E-Brackets – Are designed for angle construction at 15 kV up to a maximum line angle of 60 degrees.

   For guying purposes, the line angles for E-Brackets are broken down into “light angle” (6-30 degrees); and “heavy angle” (31-60 degrees).

   The E-Bracket shall not be used at 25 kV or 35 kV, as it does not provide required clearances.

4. C-Brackets – Are designed for use at 15 kV for line angles from 61-90 degrees. Adapter plates, double pins, and pin insulators must be used at these line angles to split the conductor angle to control stress cracking of the conductor covering.

5. C-Brackets, Braced – Are designed for use at 25 kV & 35 kV. They provide required clearances for these voltages classes.

   Since E-Brackets cannot be employed at 35 kV, the braced C-Bracket is designed for use with line angles between 6 and 90 degrees.

   6. 60-inch Metal Pole Top Extension – Is designed to provide approximately 48 approximately 48 inches of added height, where needed, to an existing pole that otherwise doesn’t warrant replacement.

   Individual construction drawings in this Section detail maximum span lengths when these brackets are used with existing pole heights.

   The 60 inch pole top extension shall only be employed on straight line poles and at line angles not exceeding 30 degrees, as shown in this Section.

Supersedes 7/07 Issue – Text shift

Pole top extensions should not be used repeatedly for more than four or five spans in order to limit the extent of pole top damage that might occur during pole or span impact.

C. Messenger – Properly guyed structures are critical to maintaining installed spacer cable system's designed sags and tensions, which meet NESC clearance requirements.

Install messenger in accordance with Section 16.5-Messenger and Phase Conductor Installation instructions, sags and tensions. Use approved running blocks and safety methods. Poles shall be prepared prior to pulling the messenger to insure that electrical contact will not occur during pulling. Do not pull messenger over crossarms, brackets or other means of support, as messenger damage may occur.

Do not over tension messenger during initial installation. Doing so will result in storm loaded tensions that are excessive of those designed for the installed system. Anchor pulling, pole splitting, and hardware breakage may result.

D. Phase Conductors – Install in accordance with recommendations in 16.5-Messenger and Phase Conductor Installation.

PHASE CONDUCTORS SHALL BE TREATED AS IF THEY WERE BARE CONDUCTORS AT ALL TIMES DURING INSTALLATION AND MAINTENANCE.

Particular attention must be given to obtain recommended phase conductor sags between spacers during installation to avoid over-tensioning. During cold weather, over-tensioned phase conductors will cause angle bracket insulator pin bending, overstressing of phase conductor covering, splice failure, and phase conductor contact with grounded brackets, all of which can lead to failure of the system.

E. Conductor Ties

At spacers – For maintenance on poles utilizing the older spacer design, use molded EPDM rubber ring ties furnished with spacers. New spacer designs do not require rubber ring ties as this design utilizes a built-in latch for securing conductors.

At pin type polyethylene insulators – Preferred – Thermoplastic Rubber (TRP) covered, solid, soft drawn (SD) #4 aluminum tie wire (Std. Item W22D).

On C-Brackets or on crossarms, where double pins and insulators are called for, an alternate method utilizing molded plastic ties or "jar rubbers" may be used for ease of installation. Manufacturer's recommendations must be followed to insure proper installation.

Do not remove factory insulation covering at spacers or at polymer pin insulators for any of the above tying methods.

F. Spacers

1. Placement – Shall be as shown on individual drawings in this Section.

   Tangent Brackets – Install two spacers, one on each side of the bracket, about six inches from the bracket.

   C or E-Brackets – Install first spacer approximately 30 feet either side of the bracket.

   At Crossarm Deadends – Install double spacers approximately 50 feet out from the crossarms.

Supersedes 7/07 Issue - Text shift

<u>Span Between Poles</u> – Install spacers as close as practical to 30 foot spacing.

2. <u>Maintenance</u> – When replacing broken or damaged spacers, the new spacers shall be placed a few inches away from the old location to utilize a “fresh” portion of conductor covering.

G. <u>Insulators</u>

1. <u>Pin Type – 15 kV and below</u> – A one piece, molded 15 kV pin-type polyethylene insulator shall be used.

2. <u>Pin Type – 25 kV and 35 kV</u> – A one piece, molded 35 kV pin-type polyethylene insulator shall be used.

3. <u>Deadends</u> – Polymer one-piece insulators shall be used at both voltage levels above in accordance with individual drawings in this Section.

   Note: There are some construction designs that require an added insulator for increased electrical isolation.

4. <u>Maintenance</u> – When performing maintenance or in the process of converting to higher voltage levels, older porcelain pin insulators shall be replaced with polyethylene units, provided conductor covering is not damaged.

   If conductor damage is present, Standards Engineering shall be notified. New conductor may have to be spliced in and splices recovered per 16.4-Deadending, Splicing, and Splice Recovering.

H. <u>Deadends</u>

1. <u>Messenger</u> – Deadends shall be made with approved formed wire grips as shown and listed in Section 16.4-Deadending, Splicing, and Splice Recovering.

2. <u>Phase Conductors</u> – The preferred method for deadending is by use of approved straight, bolted strain clamps as shown in 16.4-Deadending, Splicing, and Splice Re-Covering.

   The alternate method of deadending is with the use of formed wire grips installed directly over the conductor covering. This method is shown in 16.4-Deadending, Splicing, and Splice Re-Covering.

   In no instance should formed wire grips be used to deadend covered conductors installed using crossarm construction. Formed wire grips require support by a messenger.

I. <u>Tapping Conductors</u>

1. <u>Location</u> – Locate taps a minimum of 30 inches away from any grounded bracket as shown in individual standards.

   Multiple taps, as in the case of two-and three-phase applications, shall be staggered a minimum of 30 inches from each other.

Supersedes 7/07 Issue – Text shift

Supersedes 7/07 Issue – Amended explanation of how to properly cover tap leads on spacer cable (16.20.I.6)

2. Skinning Cautions – **WARNING**: Since some coverings contain a layer of semiconducting material at the metal conductor surface, it is important when skinning all spacer cable conductors, not to let the removed covering get so long that it could come in contact with another phase or ground. An electrical flash may result.

3. Tools – Coverings shall be removed using approved strippers listed in Table 5 on Page 16-13. **Conductor damage may result from not selecting the right stripping tool for the conductor involved.**

4. Skinning Lengths – Shall allow for approximately 3 inches either side of the connector.

5. Lead Training – Tap leads shall be trained around the spacer cable bundle as shown in individual construction drawings. **Tap leads shall not be routed between phases in the spacer bundle.**

6. Connectors – Use appropriate connector for desired application as specified in Section 5-Connectors.

   Connectors of covered tap leads without proper lightening protection at immediate pole location shall be covered by gel wrap (STD C67, C68). See section 13.6.30 for proper lightening arrester installation.

7. Messenger Covering – Shall be installed in lengths specified by individual Standards. Messenger covering shall be secured using the appropriate connector for the specified conductor as outlined in Section 5-Connectors. Messenger covering is installed to prevent wildlife and tree contact from occurring.
   WARNING: MESSENGER COVERING IS NOT RATED FOR ELECTRICAL PROTECTION AND THEREFORE SHALL NOT BE USED FOR WORKER PROTECTION.

J. Splicing & Recovering

1. Messenger – Full tension automatic splices shall be used in accordance with Section 16.4-Deadending, Splicing, and Splice Recovering.

2. Phase Conductors – Full tension compression splices shall be used in accordance with Section 16.5-Deadending, Splicing, and Splice Recovering. **WARNING:** DO NOT USE AUTOMATIC SPLICES. AUTOMATIC SPLICES REQUIRE THAT THE CONDUCTOR BE HELD UNDER TENSION AND THIS IS NOT THE CASE FOR PHASE CONDUCTORS OF A SPACER CABLE CIRCUIT.

   Splices should be located away from the pole as shown in Section 16.4-Deadending, Splicing, and Splice Recovering, Figure 4 on Page 16-13. This will allow room for future taps to be made at the splice pole.

   Splices shall be staggered a minimum of 30 inches as shown in Section 16.4-Deadending, Splicing, and Splice Recovering.

   New construction shall utilize either the "cold shrink", "hand applied tape" or the "gel wrap" method for recovering as shown in Section 16.4-Deadending, Splicing, and Splice Recovering, Figure 4 on Page 16-12.
   Do not install splices at or near polyethylene pin insulators or spacers.

16.3.30 Grounding

A. Messenger – Ground messenger in accordance with drawings in this Section and practices in Section 13-Grounding.

Messenger to be electrically direct connected to the system neutral at every pole.

WARNING: MESSENGER GROUNDING BY GROUNDING ITS' SUPPORTING BRACKET SHALL NOT BE PERMITTED. This creates a high resistance connection. Messengers are to be electrically connected to driven ground rods at intervals not to exceed 800 feet, preferably at every other pole; a driven ground rod at a transformer or other equipment counts toward satisfying this requirement.

B. Brackets – All messenger and phase conductor supporting brackets shall be bonded to the pole equipment grounding conductor as shown in individual drawings in this Standard.

All other brackets, such as capacitor racks, recloser racks, transformer cluster mounts, and metering racks shall be grounded in accordance with specific Standards in this book (Refer to Section 13-Grounding).

Single phase fiberglass equipment mounts (Std. Item E13M) shall be used for mounting all fused cutout assemblies, fused cutout / arrester assemblies and terminator / arrester assemblies located on a spacer cable system. The practice of utilizing metal equipment mounts for such applications shall be discontinued for new spacer cable construction; however, existing installations shall remain in service unless the structure is being significantly rebuilt (e.g., reconductoring, structure replacement, etc.) in compliance with the latest Standard.

C. Guys – Guys shall be insulated and/or grounded. The Company calls for grounding guys below their guy strain insulators when down-guying.

Refer to Section 3–Guying for additional guying detail.

D. Television and Radio Interference – The higher the primary voltage, the greater the possibility of generating radio and television interference.

This interference can be controlled by taking reasonable care to properly install connectors per the manufacturer's recommendations and Company outlined practices located in Section 5-Connectors as well as by properly maintaining suitable clearances between un-bonded metal pole line hardware, and by ensuring that all hardware is properly tightened.

25 kV and 35 kV construction standards call for double coil lock washers to be used with all bolts and lag screws in the process of securing metal hardware to wood structures.

The minimum clearances from unbonded metal to other metal are:

FEEDER VOLTAGE (PHASE – TO – GROUND)	CLEARANCE IN INCHES
15 kV and Below	3
Above 15 kV – 20 kV	4½"

Supersedes 7/07 Issue – Text shift

E. Arresters – Ground rods are required at every surge arrester location.

All arresters require a direct electrical connection to a grounding conductor which is connected to a driven ground rod.

WARNING: IN NO INSTANCE SHALL ARRESTER GROUNDS BE TIED TO THE SYSTEM NEUTRAL CONDUCTOR ONLY, WITHOUT INSTALLING A DRIVEN GROUND ROD AND GROUNDING CONDUCTOR. Ground leads should be kept as short as possible.

The arrester ground lead shall be trained to allow for proper arrester disconnect operation. This means that the disconnect point be allowed to break free from the arrester housing. Standard construction for surge arrester application calls for a flexible line arrester grounding lead (Std. Item L6) which will accommodate the proper disconnect operation of the device.

F. Bonding of Cable Messengers Located in the Communication Space – Pole equipment grounding conductor shall be bonded to communication cable messengers in accordance with Pole Joint Owned Practices.

16.3.40 Surge Protection

A. Application – Arresters shall be:

1. Applied in accordance with Standards in Section 13-Grounding.
2. Located at all end-of-line spacer cable deadends.
3. Installed at all deadends and junctions with bare or covered line conductors.
4. Installed at switch locations. Arresters are to be installed on the both sides of the switch.
5. Installed at riser poles. **Note:** Riser type arresters must be used on riser poles.
6. Installed at all equipment taps if no arresters exist on the equipment.
7. Installed on the load side of fuse cutouts where practical.
8. Installed at abandoned spacer cable tap skinnings if recovering is not practical.

Messenger grounding and driven ground rods are required at poles either side of the switch pole per Section 12-Protection.

Every attempt shall be made to locate arresters at the tap, junction, or deadend pole itself. Prior practice of installing arresters a pole or two away from a spacer cable junction shall be discontinued.

B. Tree Trimming

Spacer cable systems are designed to be installed in highly treed areas, or where required physical separation from buildings cannot be met with crossarm construction. They are not intended to be installed to eliminate trimming.

Spacer cable phase conductors have the ability to withstand momentary contacts with tree limbs and branches, wildlife, and other airborne objects.

WARNING: Continuous tree contact should not be allowed at any voltage. Erosion of the cover will result and lead to its puncture and conductor damage, and may result in conductor burndown.

Cover erosion rates increase approximately with the 6th power of the voltage. Therefore, during continuous tree contact, 35 kV circuits can be expected to fail approximately 200 times faster than 15 kV circuits.

Trimming priorities should first address circuits of higher voltage.

16.4 DEADENDING, SPLICING & SPLICE RECOVERING

16.4.10 General

This Section covers recommended methods of deadending, splicing, and splice recovering of the various spacer cable messengers and phase conductors.

16.4.20 Messenger Deadending

Hardware – Refer to the following, Figure 1, for messenger deadend assembly hardware. Do not use D-eyes with formed wire grips.

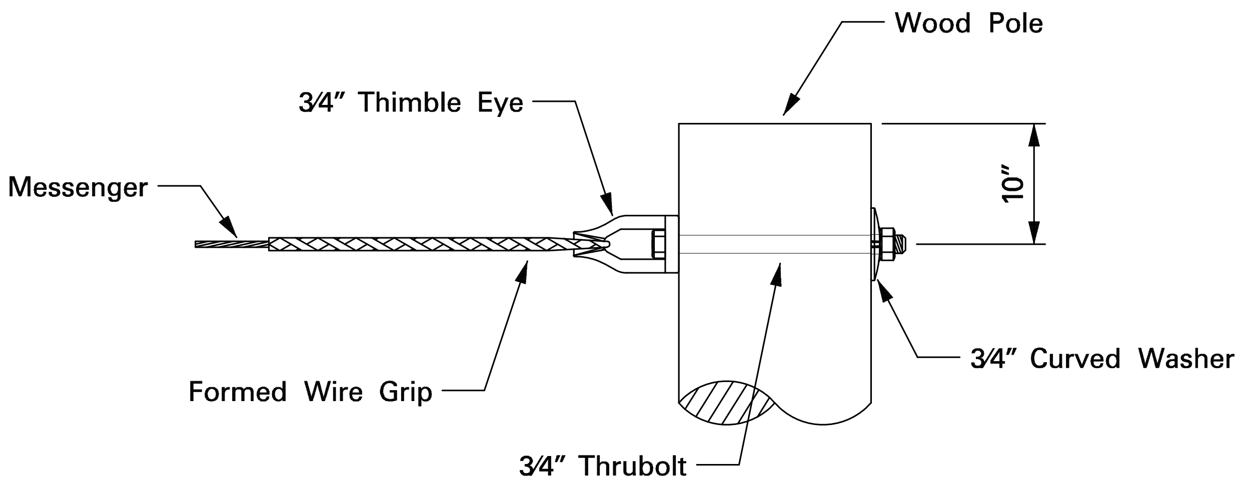


Figure 1

Deadends – Use formed wire messenger deadends as shown in Table 2.

Table 2
Formed Wire Messenger Deadends

MESSENGER		FORMED WIRE DEADEND ITEM ID
NEW CONSTRUCTION	MAINTENANCE	
1/0 – 3/4 AWAC		3503569
	1/0 – 4/3 AWAC	5989142[E]
	⅜", 7 - #8 CW	5989135[E]

16.4.30 Phase Conductor Deadending

There are two approved methods for deadending phase conductors: (1) use aluminum strain clamps, or (2) use formed wire deadends. Method (1) must be used at 35 kV.

Supersedes 1/06 Issue – Revised Section Numbering References Due to Reformatting.

Supersedes 1/06 Issue – Revised Figure 2 And Figure 3 To Reflect Polymer One-Piece Insulator Application

Aluminum Strain Clamps – Use aluminum strain clamps per Section 5-Connectors. Allow enough phase conductor tail out of the strain clamp to make arrester and other tap connections. Avoid tapping the span if possible. See Figure 2 below.

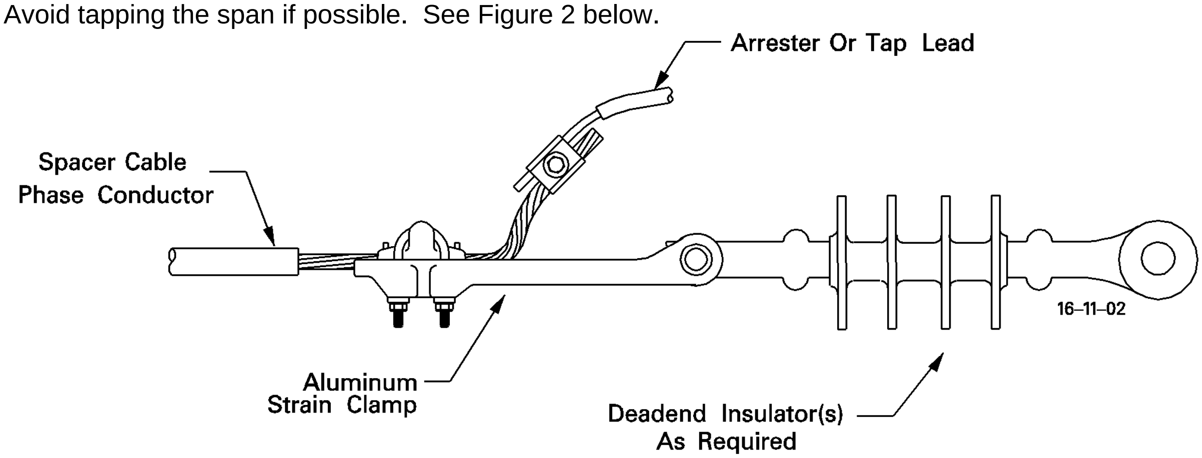


Figure 2

Formed Wire Deadends – Refer to Figure 3 below. Use phase conductor formed wire grips listed in Table 3.

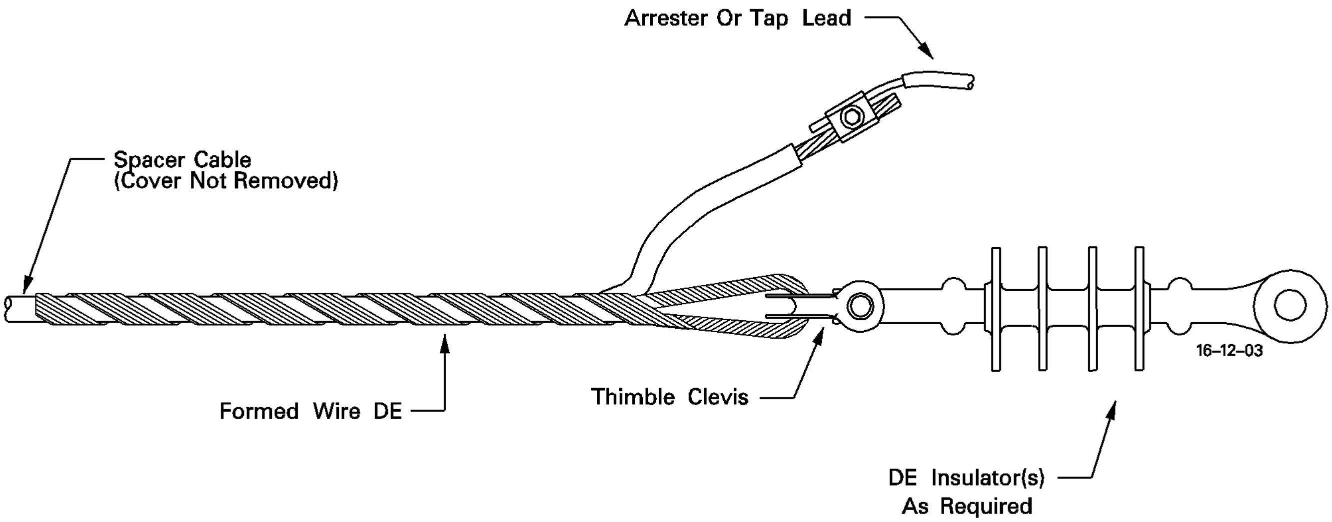


Figure 3

Table 3
Phase Conductor Formed Wire Deadends

CONDUCTOR		FORMED WIRE DEADEND ITEM ID
NEW CONSTRUCTION	MAINTENANCE	
1/0 – 7 Str 6201-15 kV		3506748
477 – 19 Str EC-Compact-15 kV		3506749
336.4 – 19 Str EC-Compact-15 kV		5106085
795 – 37 Str EC-Compact-15 kV		5989149[E]
1/0 – 7 Str 6201-35 kV		3506749
477 – 19 Str EC-Compact-35 kV		5989151[E]
795 – 37 Str EC-Compact-35 kV		N/A
	1/0 – 7 Str EC-Compact-15 kV	5989145[E]

16.4.40 Messenger Splicing

Use automatic splices or full-tension compression splices listed in Table 4 below. It is pertinent to an electrical connection that the conductor be properly cleaned; therefore, wire brush all conductors prior to splicing.

Table 4
Messenger Splices

MESSENGER TO BE SPLICED		SPLICE TYPE	ITEM ID	SPLICE CAT NO	TOOL	DIE	TOTAL CRIMPS
NEW CONSTRUCTION	MAINTENANCE						
1/0 – 3/4 AWAC		Automatic	5969624	Fargo GLA – 1165			
1/0 – 2/5 AWAC		Compression	5969625	Burndy YDS7M6TG2	Y - 35	U 679	4
	1/0 – 4/3 AWAC	Automatic	5969624^{E}	Fargo GLA – 1165			
	⅜", 7 – #8 CW	Automatic	5968510^{E}	Fargo GLA – 812			
	½", 7 STR 052 AW	Automatic	5106265^{E}	Reliable 5044			

16.4.50 Phase Conductor Splicing

Application: Full tension compression splices are used for all new construction.

WARNING: DO NOT USE AUTOMATIC SPLICES.

Splice Location: Figure 4 below shows the preferred location for splicing. Splices should be located a minimum of 60 inches from a pole to allow for future taps to be made at that pole.

Splices should be staggered along the spacer cable circuit keeping 30 inch minimum between recovered splice ends. This helps to maintain designed BIL's, and is particularly important because field applied recovering may not be electrically equivalent to factory applied covering.

Because the splice will be covered, it is not necessary to install messenger covering (line duct) on the messenger in the splice vicinity. Messenger covering does little to increase spacer cable BIL levels and is not required for wildlife protection.

Location of Phase Conductor Splices

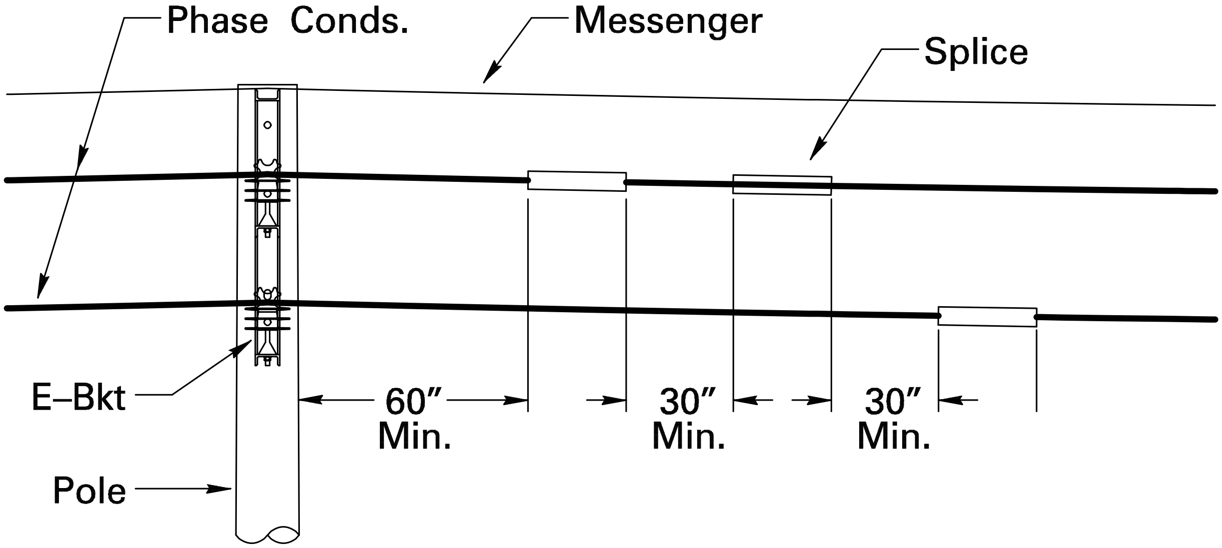


Figure 4

Supersedes 1/06 Issue – Page Content Shift / Change Due To Reformatting

Supersedes 1/06 Issue – Revised Spacer Cable Stripping Tool Table

Conductor End Preparation: Using a stripping tool from Table 5 below, remove the covering a distance equal to ½ the uncrimped splice length plus 1½ inches. Use care not to nick the conductor strands. Refer to Figure 5 below.

Table 5
Spacer Cable Stripping Tools

Spacer Cable	Conductor Code	Cond O.D.	Cov Thkns	Cond Shield	Cover O.D.	Mid-Span Stripper	Spare Blade	Spare Ring Knife
1/0 – 7 Str 6201 – 15 kV	5942105[E]	0.398”	150 M	15 M	0.728”	WSP1 – 166	CB – 1	N/A
1/0 – 7 Str.AAC – 15 kV*	N/A	0.338”	150 M	15 M	0.638”	WSP1 – 319	CB – 1	N/A
4/0 – 7 Str. EC Compact – 15 kV*	N/A	0.478”	150 M	--	0.778”	WSP1 – 193	CB – 1	N/A
336.4 – 19 Str. EC Compact – 15 kV	5106085	0.607”	150 M	15 M	0.937”	WSP2 – 238	CB – 1	N/A
477 – 19 Str. EC Compact – 15 kV	5942638[E]	0.722”	145 M	15 M	1.042”	WSP2 – 252	CB – 1	N/A
795 – 19 Str. EC Compact – 15 kV	5942646[E]	0.932”	160 M	20 M	1.292”	WSP10 – 003	CB – 1	N/A
336.4 – 19 Str. EC Compact – 25 kV*	N/A	0.607”	250 M	15 M	1.137”	WSRK2 – 75	CB8 – 2A	CB19
336.4 – 19 Str. EC Compact – 35 kV*	N/A	0.607”	300 M	15 M	1.237”	WSBK10-133	CB8 – 2B	CB162
795 – 37 Str. EC Compact – 25 kV*	N/A	0.932”	250 M	20 M	1.472”	WSRK10 – 71	CB8 – 2B	CB162
1/0 – 7 Str. 6201 – 35 kV	5942107[E]	0.398”	300 M	15 M	1.028”	WSK10 – 99	CB8 – 2A	CB19
1/0 – 7 Str. EC Compact – 35 kV*	N/A	0.338”	300 M	15 M	0.968”	WSRK2 – 246	CB8 – 2A	CB19
477 – 19 Str. EC Compact – 35 kV	5942639[E]	0.722”	300 M	20 M	1.362”	WSK10 – 102	CB8 – 2B	CB162
795 – 19 Str. EC Compact – 35 kV	5942647[E]	0.932”	300 M	20 M	1.572”	WSK10 – 103	CB8 – 2B	CB162

* Non-STD Conductor

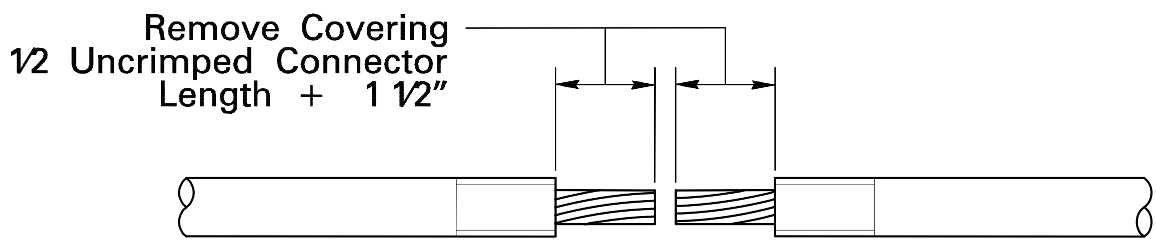


Figure 5

Clean and buff the conductor covering at both ends for a distance of 3½ inches. Use cable preparation kit, Std. Item UC80F, or kit supplied with the packaged cold shrink recovering. Refer to Figure 6 below.

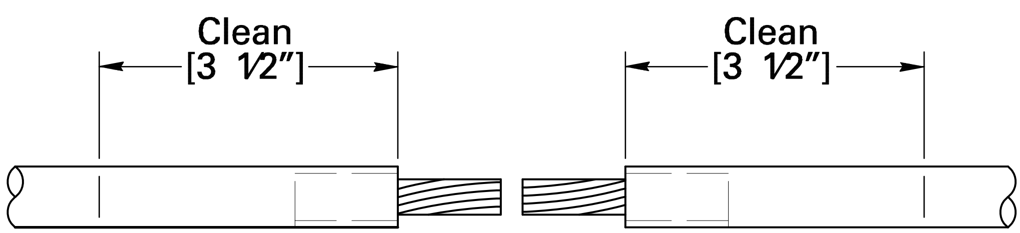


Figure 6

Note: If using "COLD SHRINK" method of splice recovering install tube at this time, before installing the splice. Park the tube on one side. Do not remove plastic liner.

Splice Installation: Select the proper splice for the conductor application from Table 6 below.

Table 6
Phase Conductor Splices
Full-Tension Compression Splices

CONDUCTORS TO BE SPLICED	CONDUCTOR "OD"	ITEM ID	SPLICE CAT. NO.	TOOL	DIE	TOTAL CRIMPS
1/0 6201 7-Str Std Round to 1/0 6201 7-Str Std Round	0.398"	2014332	Burndy YDS25RL Alcoa 7511 – 453	Y35 30A	U660 11AH	16
1/0 EC 7-Str Compact to 1/0 EC 7-Str Compact	0.338"	2014332	Burndy YDS25RL Alcoa 7511 – 453	Y35 30A	U660 11AH	16
1/0 EC 7-Str Compact to 1/0 6201 7-Str Standard Round	0.338 – 0.398"	2014332	Burndy YDS25RL Alcoa 7511 – 453	Y35 30A	U660 11AH	16
4/0 EC 7-Str Compact to 4/0 EC 7-Str Compact	0.478"	3506505	Burndy YDS28AT	Y35	U249	12
336.4 EC 19-Str Compact to 336.4 EC 19-Str Compact	0.607"	3506570	Burndy YDS301AT	Y35	U321	16
477 EC 19-Str Compact to 477 EC 19-Str Compact	0.722"	3506472	Burndy YDS331AT	Y35	U317	18
795 EC 37-Str Compact to 795 EC 37-Str Compact	0.932"	5968975[E]	Fargo C1511CD - 11	60T	11CD – 60	25% Overlap

Table 7
Phase Conductor Splices
Non-Tension Compression Reducing Splices

CONDUCTORS TO BE SPLICED	CONDUCTOR "OD"	ITEM ID	SPLICE CAT. NO.	TOOL	DIE	TOTAL CRIMPS
4/0 EC Compact to 477 EC Compact	0.478" – 0.722"	5968620[E]	Burndy YCR32RG3	Y35	U317	25% Overlap
336.4 EC Compact to 477 EC Compact	0.607" – 0.722"	5969470[E]	Burndy YCR32RG5	Y35	U317	25% Overlap

Install connector in accordance with manufacturer's instructions. Push conductor ends into splice body until fully inserted. Crimp using tools and dies shown in Tables 6 & 7. Remove excess oxide inhibitor and file off any sharp crimp flashings. Refer to Figure 7 below.

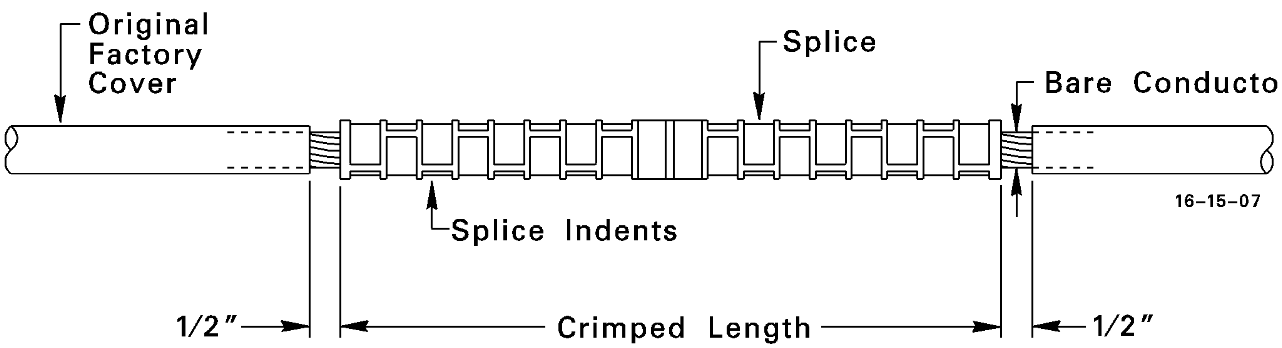


Figure 7

Supersedes 1/06 Issue – Revised Crimping Detail On Figure 7

16.4.60 **Phase Conductor Recovering**

Application: There are three methods included in this Section for recovering spacer cable splices:

(1) COLD SHRINK, (2) HAND APPLIED TAPE AND (3) GELWRAP

New Construction 35 kV & Below: The preferred method is to use COLD SHRINK (Std. Item S16 fits all sizes except 1/0 15 kV).

Supersedes 1/06 Issue – Revised Crimping Detail On Figure 8

New Construction 15 kV & Below - 1/0: The preferred method is to use hand applied tape; however, gelwrap (Std. Item's C62 & C63) may also be used and shall be installed in accordance with manufacturer specifications.

A. Cold Shrink Method

1. **Apply Marker Tape** – Measure cold shrink body length and place marker tapes (adhesive side out) 2 inches away from each end of the centered cold shrink body. Refer to Figure 8 below.

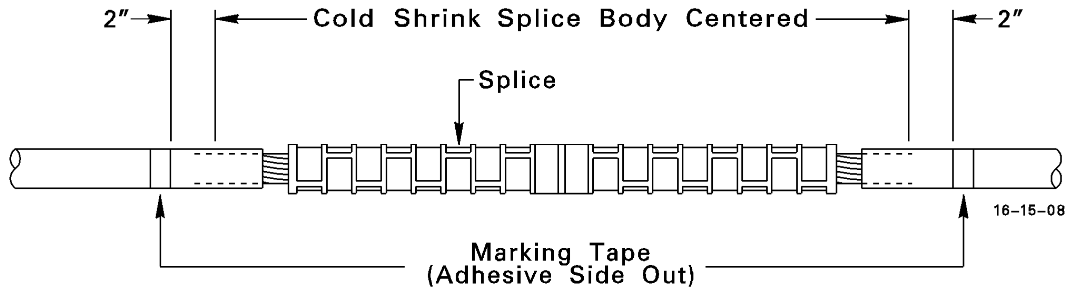


Figure 8

2. **Apply Silicone Grease** – Lubricate the entire surface of conductor covering from the marker tape(s) toward the crimped splice. Use the yellow tube of silicone grease supplied in the kit. Use foam pad under cap to spread grease. It is not necessary to apply grease over the connector.

3. **Slide Cold Shrink Body Into Position** – Remove the red factory tape securing the plastic cover. Unfold the plastic and slide the cold shrink body into the center of the splice area. The plastic liner will be left behind and can be removed at this point. Refer to Figure 9 below.

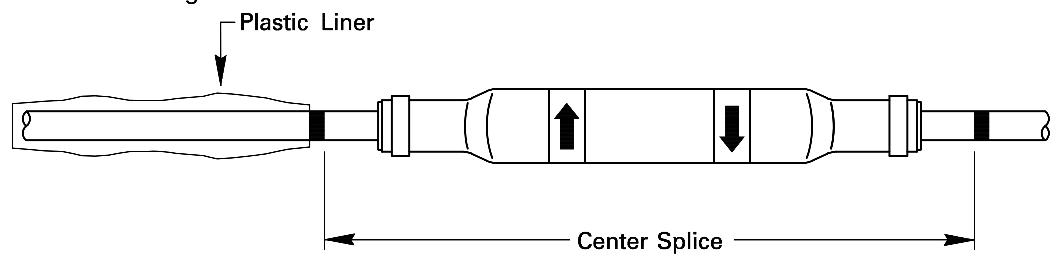


Figure 9

4. **Shrink the Body** – Steadily pull on the plastic cord, unwinding it around the conductor in the direction shown by the arrow on the cold shrink body. As the cord is pulled, it wraps around the conductor 1 or 2 times, and must be unwound before pulling again. Refer to the following, Figure 10.

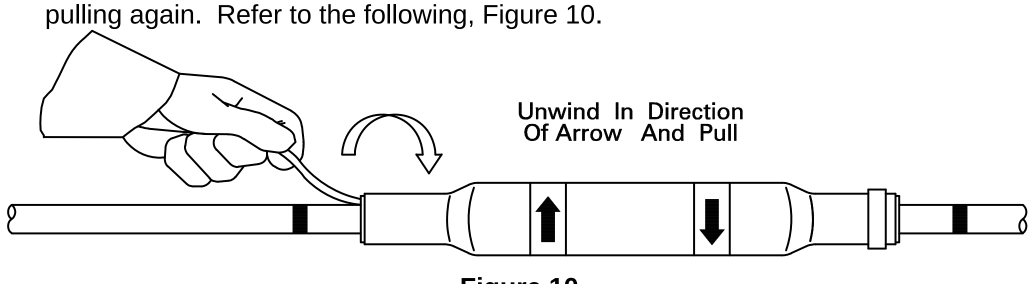


Figure 10

After shrinking the first 1-2 inches, the splice body should begin to grip the conductor. Re-center the body between marker tapes if necessary. Continue unwinding and pulling the cord until one side is completely shrunk. Refer to Figure 11 below.

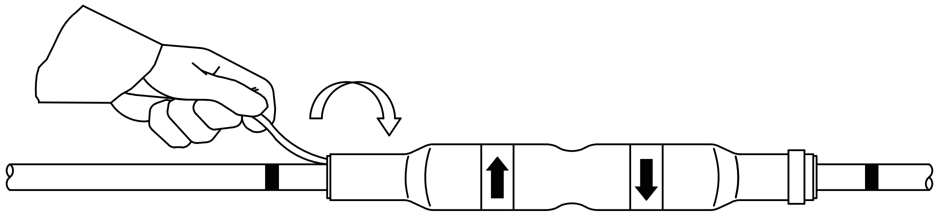


Figure 11

Repeat the shrinking process on the other side of the cold shrink splice body. Be sure to let the cord unwind in the direction indicated by the arrows. This completes the installation. Refer to Figure 12 below.

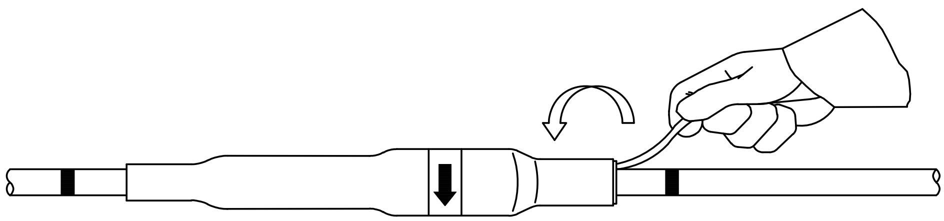


Figure 12

B. Hand Applied Tape Method

1. After filing off any sharp splice flashings, fill indents with filler compound, Std. Item T5E on the material list. Reference Figure 13 below.

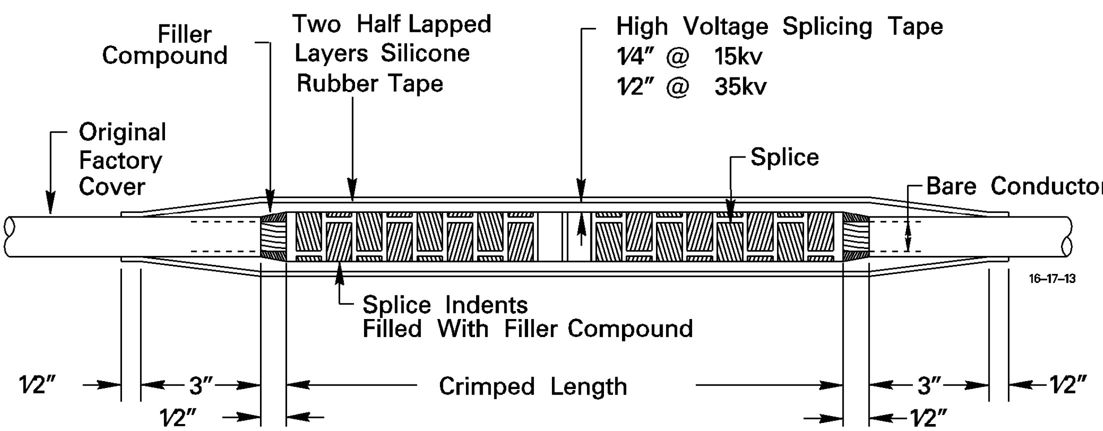


Figure 13

2. Apply ½ lap layer of high voltage splicing tape, Std. Item T5B, to the following thicknesses, over the connector and the outer conductor covering:
   15 kV - ¼ inch
   35 kV - ½ inch
   Taping to the above thickness is important in attempting to restore original factory insulation levels.

3. Cover the entire splice with two ½ lapped layers of silicone tape extending ½ inch beyond the high voltage splicing tape. Wrap tightly at both ends applying two additional turns of tape with only slight tension.

C. Gelwrap Method

Installation instructions provided by the manufacturer shall be followed.

Supersedes 1/06 Issue – Revised Crimping Detail On Figure 13

16.5 MESSENGER AND PHASE CONDUCTOR INSTALLATION

16.5.10 Preliminary

It is recommended that guying in accordance with individual Standards in this Section and Section 3-Guying be installed prior to pulling in the spacer cable messenger and phase conductors.
It is also recommended that tools, pulling blocks, hardware, procedures, and methods specified by Work Methods and Standards Engineering be employed to insure a properly installed system.

STEP 1: Pull messenger in place through stringing devices.

STEP 2: Refer to Messenger Initial Installation Sag & Tension Tables in this Standard for the appropriate messenger and phase conductors to be installed.

With one end of the messenger deadended, and using a dynamometer, tension the messenger in accordance with the following values for the ruling span involved and for the temperature at the time of installation. Sags are listed only for a visual check of the installation. (For ruling spans less than 150 feet, use installation tensions for 150 feet ruling span realizing that sags will be less.)

Once the appropriate tension has been reached, clamp messenger in place and remove messenger running blocks.

WARNING: Extreme care should be taken to see that the messenger has the correct initial installation tension. Low tension may result in excessive sags that do not comply with the NESC clearance requirements. Excessive initial tension may cause undue strain on the pole and on related hardware during storm loaded conditions (ice and wind).

STEP 3: After the messenger has been properly tensioned, pull all phase conductors in at the same time. Temporarily deadend both ends of the phase conductors.

STEP 4: Spacers should be installed at approximately 30 foot intervals between poles. They should be doubled at tangent brackets (one on each side of the bracket). First spans at locations where the phase conductors are spread out, such as at a crossarm deadend, should have double spacers placed approximately 50 feet out from the crossarm. Spacers should be placed out 30 feet from an E- or C-Bracket.

STEP 5: Spacer installation can begin by permanently deadending the phase conductors at one end and installing spacers, making sure that the phase conductor sag between spacers is as recommended in Table 8 on Page 16-19 and the corresponding illustration.

Alternately, spacer installation can begin in the middle of the run beginning at an E-Bracket where the phases can be tied to the insulators, and then spacers installed in both directions working toward the permanent deadend poles.

It will be necessary in most instances to pull slack ahead towards the ends of the conductors as the spacer installation and sagging process proceeds.

WARNING: Proper sagging between spacers is extremely important due to the different expansion rates of the messenger and the phase conductors. At below zero temperatures, the phase conductors can produce excessive forces on insulator pins causing bending. Also, phase conductors can cause spacer breakage. DO NOT OVER-TENSION PHASE CONDUCTORS DURING INSTALLATION.

Note: For spacer cable systems other than those depicted in these Standards, consult Standards Engineering (double circuit construction, larger messengers, larger phase conductors, longer spans, etc.).

Table 8
Phase Conductor Sags – 30 Foot Span Between Spacers

Temp. °F/°C	20/-7	40/4.5	60/15.5	80/26.7	100/37.8	120/48.9	167/75
Sag In Inches	3	4	5	6	7	8	9

Supersedes 1/06 Issue – Page Content Shift / Change Due To Reformatting

PHYSICAL PROPERTIES	
R.B.S.	*19500 lbs.
C.S.A.	*0.1785 sq. in.
R. (@ 25˚C)	0.0227 Ω / 1000’
R. (@ 75˚C)	0.0271 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.541”
CONDUCTOR DIAMETER	1.572”
SYSTEM WEIGHT	4466 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	3.0847 Lb/Ft
VERTICAL	9.055 Lb/Ft
TOTAL	9.866 Lb/Ft
SWING	18.81˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
669	NORMAL	952
828	EMERGENCY	1058

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2,325	1,722	1,380	1,052	1,150	863	688	526	574	481	437	398	423	390	371	352
ACTUAL SPAN (FEET)																
50	0.7	0.9	1.2	1.5	1.4	1.8	2.3	3.1	2.8	3.3	3.7	4.0	3.8	4.1	4.3	4.6
60	1.0	1.3	1.7	2.2	2.0	2.6	3.4	4.4	4.0	4.7	5.3	5.8	5.5	5.9	6.3	6.6
70	1.4	1.7	2.3	3.0	2.7	3.5	4.6	6.0	5.5	6.4	7.2	7.9	7.5	8.0	8.5	9.0
80	1.8	2.3	3.0	3.9	3.6	4.6	6.0	7.8	7.2	8.4	9.4	10.4	9.8	10.5	11.1	11.8
90	2.2	2.9	3.8	5.0	4.5	5.8	7.6	9.9	9.1	10.6	11.9	13.1	12.3	13.2	14.1	14.9
100	2.8	3.6	4.7	6.1	5.6	7.1	9.3	12.2	11.2	13.1	14.7	16.2	15.2	16.3	17.4	18.4
110	3.3	4.3	5.7	7.4	6.8	8.6	11.3	14.8	13.6	15.9	17.8	19.6	18.4	19.8	21.0	22.2
120	4.0	5.1	6.7	8.8	8.1	10.3	13.4	17.6	16.1	18.9	21.2	23.3	21.9	23.5	25.0	26.4
130	4.7	6.0	7.9	10.4	9.5	12.1	15.8	20.6	18.9	22.2	24.9	27.3	25.8	27.6	29.4	31.0
140	5.4	7.0	9.2	12.0	11.0	14.0	18.3	23.9	22.0	25.7	28.9	31.7	29.9	32.0	34.0	36.0
150	6.2	8.0	10.5	13.8	12.6	16.0	21.0	27.5	25.2	29.5	33.1	36.4	34.3	36.8	39.1	41.3
160	7.1	9.1	12.0	15.7	14.3	18.3	23.9	31.3	28.7	33.6	37.7	41.4	39.0	41.8	44.5	47.0
170	8.0	10.3	13.5	17.8	16.2	20.6	27.0	35.3	32.4	37.9	42.6	46.8	44.0	47.2	50.2	53.1
180	9.0	11.5	15.2	19.9	18.1	23.1	30.2	39.6	36.3	42.5	47.7	52.4	49.4	52.9	56.3	59.5
190	10.0	12.8	16.9	22.2	20.2	25.7	33.7	44.1	40.5	47.3	53.2	58.4	55.0	59.0	62.7	66.3
200	11.1	14.2	18.7	24.6	22.4	28.5	37.3	48.9	44.8	52.5	58.9	64.7	61.0	65.4	69.5	73.4
210	12.2	15.7	20.7	27.1	24.7	31.4	41.2	53.9	49.4	57.8	65.0	71.4	67.2	72.0	76.6	81.0
220	13.4	17.2	22.7	29.7	27.1	34.5	45.2	59.1	54.2	63.5	71.3	78.3	73.8	79.1	84.1	88.9
230	14.6	18.8	24.8	32.5	29.6	37.7	49.4	64.6	59.3	69.4	77.9	85.6	80.6	86.4	91.9	97.1
240	15.9	20.5	27.0	35.4	32.3	41.1	53.8	70.3	64.5	75.5	84.9	93.2	87.8	94.1	100.1	105.8
250	17.3	22.2	29.3	38.4	35.0	44.6	58.3	76.3	70.0	82.0	92.1	101.1	95.3	102.1	108.6	114.8
260	18.7	24.0	31.7	41.5	37.9	48.2	63.1	82.6	75.8	88.7	99.6	109.4	103.0	110.4	117.4	124.1
270	20.2	25.9	34.2	44.8	40.8	52.0	68.0	89.0	81.7	95.6	107.4	118.0	111.1	119.1	126.6	133.8
280	21.7	27.8	36.7	48.2	43.9	55.9	73.2	95.8	87.9	102.8	115.5	126.9	119.5	128.1	136.2	143.9
290	23.3	29.9	39.4	51.7	47.1	60.0	78.5	102.7	94.2	110.3	123.9	136.1	128.2	137.4	146.1	154.4
300	24.9	32.0	42.2	55.3	50.4	64.2	84.0	109.9	100.9	118.0	132.6	145.6	137.2	147.0	156.3	165.2

Supersedes 7/07 Issue – Revised Sag Tables

 | Doc. # ST. 16.00.002

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**167**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**75**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	2.8	3.1	3.6	4.2	5.0	6.6	7.0	7.8
75	7.0	7.9	9.0	10.3	11.9	14.4	14.9	16.0
100	14.3	16.0	17.9	19.8	21.8	25.1	25.7	26.9
125	25.6	28.0	30.4	32.6	35.0	38.6	39.4	40.7
150	40.9	43.6	46.2	48.8	51.4	55.2	55.9	57.4
175	59.8	62.6	65.4	68.2	70.8	74.8	75.6	77.0
200	82.1	85.0	87.8	90.6	93.2	97.4	98.3	99.8
225	107.6	110.5	113.4	116.2	118.9	123.2	124.0	125.6
250	136.3	139.3	142.2	145.1	147.8	152.2	153.0	154.6
275	168.4	171.4	174.2	177.1	179.9	184.3	185.0	186.7
300	203.8	206.6	209.5	212.4	215.3	219.6	220.4	222.1

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	6.0	5.8	4.1	*6,800
75	13.3	13.1	10.0	*6,800
100	23.8	23.4	19.2	*6,800
125	37.2	36.7	31.9	*6,800
150	53.6	53.2	47.9	*6,800
175	73.2	72.6	67.1	*6,800
200	95.8	95.2	89.5	*6,800
225	121.6	120.8	115.1	*6,800
250	150.4	149.8	143.9	*6,800
275	182.5	181.8	175.9	*6,800
300	217.9	217.2	211.2	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

 Doc. # ST. 16.00.002

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*13800 lbs.
C.S.A.	*0.1450 sq. in.
R. (@ 25˚C)	0.0227 Ω / 1000’
R. (@ 75˚C)	0.0271 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.487”
CONDUCTOR DIAMETER	1.572”
SYSTEM WEIGHT	4351 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	3.0691 Lb/Ft
VERTICAL	8.906 Lb/Ft
TOTAL	9.720 Lb/Ft
SWING	19.01˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
669	NORMAL	952
828	EMERGENCY	1058

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2,479	1,897	1,547	1,178	1,661	1,221	981	760	754	563	451	379	390	345	321	298
ACTUAL SPAN (FEET)																
50	0.5	0.6	0.8	1.0	0.7	0.9	1.2	1.5	1.6	2.0	2.6	3.1	3.0	3.4	3.7	4.0
60	0.7	0.9	1.1	1.4	1.0	1.3	1.7	2.2	2.2	2.9	3.8	4.5	4.3	4.8	5.3	5.7
70	0.9	1.2	1.5	2.0	1.4	1.8	2.4	3.0	3.1	3.9	5.1	6.1	5.9	6.6	7.2	7.7
80	1.2	1.5	2.0	2.6	1.8	2.4	3.1	4.0	4.0	5.1	6.7	7.9	7.7	8.6	9.4	10.1
90	1.6	1.9	2.5	3.2	2.3	3.0	3.9	5.0	5.0	6.5	8.4	10.1	9.8	10.9	11.9	12.8
100	1.9	2.4	3.1	4.0	2.8	3.7	4.8	6.2	6.2	8.0	10.4	12.4	12.1	13.5	14.7	15.8
110	2.3	2.9	3.7	4.8	3.4	4.5	5.8	7.5	7.5	9.7	12.6	15.0	14.6	16.3	17.8	19.1
120	2.8	3.4	4.4	5.8	4.1	5.3	6.9	8.9	9.0	11.5	15.0	17.9	17.4	19.4	21.1	22.8
130	3.2	4.0	5.2	6.7	4.8	6.3	8.1	10.5	10.5	13.5	17.6	21.0	20.4	22.7	24.8	26.7
140	3.8	4.7	6.0	7.8	5.5	7.2	9.4	12.1	12.2	15.7	20.4	24.3	23.6	26.4	28.8	31.0
150	4.3	5.4	6.9	9.0	6.4	8.3	10.8	13.9	14.0	18.0	23.5	27.9	27.1	30.3	33.0	35.6
160	4.9	6.1	7.9	10.2	7.2	9.5	12.3	15.8	15.9	20.5	26.7	31.8	30.9	34.5	37.6	40.5
170	5.5	6.9	8.9	11.5	8.2	10.7	13.9	17.9	18.0	23.1	30.1	35.9	34.9	38.9	42.4	45.7
180	6.2	7.8	10.0	12.9	9.2	12.0	15.6	20.0	20.2	25.9	33.8	40.2	39.1	43.6	47.5	51.2
190	6.9	8.6	11.1	14.4	10.2	13.4	17.3	22.3	22.5	28.9	37.6	44.8	43.5	48.6	53.0	57.1
200	7.7	9.6	12.3	16.0	11.3	14.8	19.2	24.7	24.9	32.0	41.7	49.7	48.2	53.8	58.7	63.2
210	8.5	10.6	13.5	17.6	12.5	16.3	21.2	27.3	27.5	35.3	46.0	54.8	53.2	59.4	64.7	69.7
220	9.3	11.6	14.9	19.3	13.7	17.9	23.2	29.9	30.2	38.7	50.4	60.1	58.4	65.1	71.0	76.5
230	10.2	12.7	16.3	21.1	15.0	19.6	25.4	32.7	33.0	42.3	55.1	65.7	63.8	71.2	77.6	83.6
240	11.1	13.8	17.7	23.0	16.3	21.3	27.6	35.6	35.9	46.1	60.0	71.5	69.5	77.5	84.5	91.1
250	12.0	15.0	19.2	25.0	17.7	23.1	30.0	38.7	38.9	50.0	65.1	77.6	75.4	84.1	91.7	98.8
260	13.0	16.2	20.8	27.0	19.1	25.0	32.4	41.8	42.1	54.0	70.5	84.0	81.5	91.0	99.2	106.9
270	14.0	17.4	22.4	29.1	20.6	27.0	35.0	45.1	45.4	58.3	76.0	90.6	87.9	98.1	106.9	115.3
280	15.1	18.8	24.1	31.3	22.2	29.0	37.6	48.5	48.8	62.7	81.7	97.4	94.6	105.5	115.0	124.0
290	16.1	20.1	25.8	33.6	23.8	31.1	40.4	52.0	52.4	67.2	87.7	104.5	101.4	113.2	123.4	133.0
300	17.3	21.5	27.6	35.9	25.4	33.3	43.2	55.7	56.1	72.0	93.8	111.8	108.5	121.1	132.0	142.3

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**167**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**75**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	3.6	4.1	4.7	5.5	6.5	8.3	8.6	9.4
75	8.4	9.5	10.7	12.0	13.6	16.0	16.4	17.4
100	15.5	17.2	19.0	20.8	22.7	25.8	26.3	27.5
125	25.3	27.4	29.6	31.9	34.1	37.6	38.3	39.6
150	37.7	40.2	42.7	45.2	47.8	51.6	52.3	53.8
175	55.8	58.6	61.3	64.1	66.7	70.8	71.5	73.1
200	77.5	80.4	83.3	86.0	88.8	93.0	93.8	95.4
225	102.5	105.5	108.4	111.2	114.0	118.3	119.2	120.7
250	130.8	133.8	136.7	139.6	142.4	146.8	147.6	149.3
275	162.2	165.2	168.2	171.1	174.0	178.4	179.3	180.8
300	197.0	200.0	203.0	205.9	208.8	213.2	214.1	215.8

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	7.4	7.2	5.3	5,373
75	15.5	15.0	11.8	5,807
100	25.8	25.1	20.4	6,194
125	38.3	37.3	31.4	6,524
150	52.9	51.7	44.8	*6,800
175	72.2	70.8	63.5	*6,800
200	94.4	93.0	85.4	*6,800
225	119.9	118.3	110.5	*6,800
250	148.3	146.8	138.8	*6,800
275	180.0	178.3	170.4	*6,800
300	214.8	213.2	205.2	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*19500 lbs.
C.S.A.	*0.1785 sq. in.
R. (@ 25˚C)	0.0227 Ω / 1000’
R. (@ 75˚C)	0.0271 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.541”
CONDUCTOR DIAMETER	1.292”
SYSTEM WEIGHT	3658 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	2.8078 Lb/Ft
VERTICAL	7.716 Lb/Ft
TOTAL	8.511 Lb/Ft
SWING	20.00˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
714	NORMAL	1005
881	EMERGENCY	1118

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	3,241	2,506	2,060	1,585	2,010	1,487	1,203	945	1,102	858	714	572	659	551	501	455
ACTUAL SPAN (FEET)																
50	0.5	0.6	0.8	1.0	0.8	1.0	1.3	1.7	1.5	1.8	2.3	2.8	2.4	2.9	3.2	3.5
60	0.7	0.9	1.1	1.5	1.2	1.5	1.9	2.4	2.1	2.6	3.2	4.0	3.5	4.1	4.6	5.1
70	1.0	1.2	1.5	2.0	1.6	2.0	2.6	3.3	2.9	3.5	4.4	5.5	4.8	5.6	6.3	6.9
80	1.3	1.6	2.0	2.6	2.0	2.6	3.4	4.3	3.7	4.6	5.8	7.2	6.2	7.3	8.2	9.0
90	1.6	2.0	2.6	3.3	2.6	3.3	4.3	5.5	4.7	5.8	7.3	9.1	7.9	9.3	10.4	11.4
100	2.0	2.5	3.1	4.1	3.2	4.1	5.3	6.8	5.8	7.2	9.0	11.2	9.8	11.4	12.8	14.1
110	2.4	3.0	3.8	4.9	3.9	5.0	6.5	8.2	7.1	8.7	10.9	13.6	11.8	13.8	15.5	17.1
120	2.9	3.6	4.5	5.9	4.6	5.9	7.7	9.8	8.4	10.4	13.0	16.2	14.0	16.5	18.5	20.3
130	3.4	4.2	5.3	6.9	5.4	7.0	9.0	11.4	9.9	12.2	15.2	19.0	16.5	19.3	21.7	23.9
140	3.9	4.8	6.2	8.0	6.3	8.1	10.5	13.3	11.4	14.1	17.7	22.0	19.1	22.4	25.2	27.7
150	4.5	5.6	7.1	9.2	7.2	9.3	12.0	15.2	13.1	16.2	20.3	25.3	21.9	25.7	28.9	31.8
160	5.1	6.3	8.1	10.4	8.2	10.6	13.7	17.3	14.9	18.4	23.1	28.8	25.0	29.2	32.9	36.2
170	5.8	7.1	9.1	11.8	9.2	11.9	15.4	19.6	16.9	20.8	26.0	32.5	28.2	33.0	37.1	40.8
180	6.5	8.0	10.2	13.2	10.4	13.4	17.3	21.9	18.9	23.3	29.2	36.4	31.6	37.0	41.6	45.8
190	7.2	8.9	11.4	14.7	11.6	14.9	19.3	24.5	21.1	26.0	32.5	40.6	35.2	41.2	46.4	51.0
200	8.0	9.9	12.6	16.3	12.8	16.5	21.3	27.1	23.4	28.8	36.0	45.0	39.0	45.7	51.4	56.5
210	8.8	10.9	13.9	18.0	14.1	18.2	23.5	29.9	25.7	31.8	39.7	49.6	43.0	50.4	56.6	62.3
220	9.7	12.0	15.2	19.7	15.5	20.0	25.8	32.8	28.3	34.9	43.6	54.4	47.2	55.3	62.1	68.4
230	10.6	13.1	16.7	21.5	16.9	21.8	28.2	35.8	30.9	38.1	47.7	59.5	51.6	60.4	67.9	74.7
240	11.5	14.2	18.1	23.4	18.4	23.8	30.7	39.0	33.6	41.5	51.9	64.8	56.2	65.8	74.0	81.4
250	12.5	15.4	19.7	25.4	20.0	25.8	33.3	42.3	36.5	45.0	56.3	70.3	60.9	71.4	80.3	88.3
260	13.5	16.7	21.3	27.5	21.6	27.9	36.1	45.8	39.5	48.7	60.9	76.0	65.9	77.2	86.8	95.5
270	14.6	18.0	23.0	29.7	23.3	30.1	38.9	49.4	42.6	52.5	65.7	82.0	71.1	83.3	93.6	103.0
280	15.7	19.4	24.7	31.9	25.1	32.4	41.8	53.1	45.8	56.5	70.7	88.2	76.4	89.6	100.7	110.8
290	16.8	20.8	26.5	34.2	26.9	34.7	44.9	57.0	49.1	60.6	75.8	94.6	82.0	96.1	108.0	118.8
300	18.0	22.2	28.3	36.6	28.8	37.1	48.0	61.0	52.5	64.8	81.1	101.2	87.8	102.8	115.6	127.2

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	2.2	2.5	2.9	3.4	4.1	5.6	6.0	6.7
75	5.4	6.2	7.2	8.4	9.8	12.4	13.0	14.0
100	11.0	12.5	14.3	16.2	18.2	21.7	22.3	23.6
125	19.8	22.1	24.5	27.0	29.6	33.5	34.3	35.8
150	32.3	35.2	38.0	40.9	43.7	48.0	48.8	50.4
175	48.2	51.4	54.5	57.6	60.5	65.0	65.9	67.6
200	67.3	70.7	73.8	77.0	80.0	84.7	85.7	87.4
225	89.4	92.8	96.0	99.2	102.4	107.2	108.1	109.9
250	114.4	117.7	121.0	124.2	127.4	132.4	133.2	135.0
275	142.1	145.4	148.8	152.0	155.3	160.2	161.2	163.0
300	172.7	176.0	179.4	182.6	185.9	190.9	191.8	193.7

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	5.2	4.9	3.4	*6,800
75	11.6	11.2	8.0	*6,800
100	20.8	20.0	15.6	*6,800
125	32.5	31.7	26.3	*6,800
150	46.9	45.8	39.8	*6,800
175	63.8	62.8	56.4	*6,800
200	83.5	82.3	75.8	*6,800
225	106.0	104.6	97.9	*6,800
250	131.0	129.7	122.9	*6,800
275	158.9	157.6	150.7	*6,800
300	189.6	188.3	181.3	*6,800
* Note: Design Specification Constraint				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*13800 lbs.	TRANSVERSE	2.7874 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	*0.1450 sq. in.	VERTICAL	7.568 Lb/Ft			
R. (@ 25˚C)	0.0227 Ω / 1000’	TOTAL	8.365 Lb/Ft	714	NORMAL	1005
R. (@ 75˚C)	0.0271 Ω / 1000’			881	EMERGENCY	1118
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	20.22˚			
MESSENGER DIAMETER	0.487”					
CONDUCTOR DIAMETER	1.292”					
SYSTEM WEIGHT	3543 lbs / 1000’					

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

Supersedes 7/07 Issue – Revised Sag Tables

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	3,220	2,564	2,154	1,695	2,592	2,002	1,646	1,269	1,551	1,150	936	743	806	638	523	438
ACTUAL SPAN (FEET)																
50	0.4	0.4	0.5	0.7	0.5	0.6	0.7	0.9	0.8	1.0	1.3	1.6	1.5	1.8	2.2	2.7
60	0.5	0.6	0.8	1.0	0.7	0.8	1.0	1.3	1.1	1.4	1.8	2.3	2.1	2.5	3.2	3.9
70	0.7	0.9	1.1	1.4	0.9	1.1	1.4	1.8	1.5	1.9	2.5	3.1	2.9	3.5	4.4	5.3
80	0.9	1.1	1.4	1.8	1.2	1.4	1.8	2.4	1.9	2.5	3.2	4.0	3.7	4.5	5.7	6.9
90	1.2	1.4	1.7	2.2	1.5	1.8	2.3	3.0	2.4	3.2	4.1	5.1	4.7	5.7	7.3	8.7
100	1.5	1.8	2.2	2.8	1.8	2.2	2.8	3.7	3.0	3.9	5.0	6.3	5.8	7.1	9.0	10.7
110	1.8	2.1	2.6	3.3	2.2	2.7	3.4	4.5	3.7	4.8	6.1	7.6	7.0	8.6	10.9	13.0
120	2.1	2.6	3.1	4.0	2.6	3.2	4.1	5.3	4.3	5.7	7.2	9.1	8.4	10.2	12.9	15.5
130	2.5	3.0	3.6	4.7	3.1	3.8	4.8	6.2	5.1	6.7	8.5	10.7	9.8	12.0	15.2	18.2
140	2.9	3.5	4.2	5.4	3.6	4.4	5.5	7.2	5.9	7.7	9.8	12.4	11.4	13.9	17.6	21.1
150	3.3	4.0	4.8	6.2	4.1	5.1	6.4	8.3	6.8	8.9	11.3	14.2	13.1	15.9	20.2	24.2
160	3.7	4.5	5.5	7.1	4.6	5.8	7.2	9.4	7.7	10.1	12.8	16.1	14.9	18.1	23.0	27.5
170	4.2	5.1	6.2	8.0	5.2	6.5	8.2	10.6	8.7	11.4	14.5	18.2	16.8	20.5	25.9	31.0
180	4.7	5.7	7.0	9.0	5.9	7.3	9.2	11.9	9.8	12.8	16.3	20.4	18.9	22.9	29.1	34.8
190	5.3	6.4	7.8	10.0	6.5	8.1	10.2	13.3	10.9	14.2	18.1	22.8	21.0	25.6	32.4	38.8
200	5.8	7.1	8.6	11.1	7.3	9.0	11.3	14.7	12.1	15.7	20.1	25.2	23.3	28.3	35.9	43.0
210	6.4	7.8	9.5	12.2	8.0	9.9	12.5	16.2	13.3	17.4	22.1	27.8	25.7	31.2	39.6	47.4
220	7.1	8.6	10.4	13.4	8.8	10.9	13.7	17.8	14.6	19.1	24.3	30.5	28.2	34.3	43.4	52.0
230	7.7	9.4	11.4	14.6	9.6	11.9	15.0	19.5	16.0	20.8	26.5	33.4	30.8	37.5	47.5	56.8
240	8.4	10.2	12.4	15.9	10.4	13.0	16.3	21.2	17.4	22.7	28.9	36.3	33.5	40.8	51.7	61.9
250	9.1	11.1	13.4	17.3	11.3	14.1	17.7	23.0	18.9	24.6	31.3	39.4	36.4	44.3	56.1	67.1
260	9.9	12.0	14.5	18.7	12.3	15.2	19.1	24.9	20.4	26.6	33.9	42.6	39.3	47.9	60.6	72.6
270	10.6	12.9	15.7	20.2	13.2	16.4	20.6	26.8	22.0	28.7	36.6	46.0	42.4	51.6	65.4	78.3
280	11.4	13.9	16.9	21.7	14.2	17.6	22.2	28.9	23.7	30.9	39.3	49.5	45.6	55.5	70.3	84.2
290	12.3	14.9	18.1	23.3	15.3	18.9	23.8	30.9	25.4	33.1	42.2	53.1	48.9	59.6	75.4	90.3
300	13.1	16.0	19.4	24.9	16.3	20.2	25.4	33.1	27.2	35.4	45.1	56.8	52.4	63.7	80.7	96.7

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**167**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**75**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	2.9	3.2	3.8	4.6	5.5	7.3	7.7	8.4
75	6.6	7.6	8.6	10.0	11.5	14.0	14.5	15.6
100	12.2	13.7	15.4	17.3	19.2	22.4	23.0	24.4
125	19.8	21.8	24.1	26.4	28.8	32.5	33.2	34.7
150	29.5	32.0	34.7	37.4	40.2	44.4	45.1	46.8
175	44.0	47.0	50.0	53.0	55.9	60.5	61.3	63.0
200	62.3	65.5	68.8	71.9	75.0	79.8	80.6	82.4
225	83.8	87.1	90.4	93.6	96.8	101.8	102.6	104.4
250	108.1	111.5	114.8	118.2	121.4	126.4	127.3	129.1
275	135.2	138.7	142.1	145.4	148.7	153.7	154.7	156.6
300	165.2	168.7	172.1	175.4	178.8	183.8	184.8	186.7

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	6.6	6.2	4.4	5,292
75	13.7	13.1	9.7	5,704
100	22.8	21.8	16.9	6,094
125	33.8	32.4	26.0	6,443
150	46.4	44.8	37.1	6,750
175	62.9	61.0	52.4	*6,800
200	82.2	80.2	71.3	*6,800
225	104.3	102.0	92.9	*6,800
250	129.0	126.6	117.4	*6,800
275	156.4	154.0	144.6	*6,800
300	186.6	184.1	174.6	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*19500 lbs.	TRANSVERSE	2.8749 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	*0.1785 sq. in.	VERTICAL	7.427 Lb/Ft			
R. (@ 25˚C)	0.0373 Ω / 1000'	TOTAL	8.264 Lb/Ft	489	NORMAL	692
R. (@ 75˚C)	0.0447 Ω / 1000'			603	EMERGENCY	768
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	21.16˚			
MESSENGER DIAMETER	0.541"					
CONDUCTOR DIAMETER	1.362"					
SYSTEM WEIGHT	3230 lbs / 1000'					

Note: Quantities identified with an " * " are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	3,407	2,653	2,193	1,696	2,196	1,633	1,321	1,028	1,236	953	815	631	755	605	539	484
ACTUAL SPAN (FEET)																
50	0.5	0.6	0.7	0.9	0.7	0.9	1.2	1.6	1.3	1.6	2.0	2.5	2.1	2.6	3.0	3.3
60	0.7	0.8	1.1	1.4	1.1	1.4	1.7	2.2	1.9	2.3	2.8	3.7	3.1	3.7	4.3	4.8
70	0.9	1.1	1.4	1.8	1.4	1.8	2.4	3.1	2.6	3.2	3.9	5.0	4.2	5.1	5.9	6.5
80	1.2	1.5	1.9	2.4	1.9	2.4	3.1	4.0	3.3	4.2	5.0	6.5	5.5	6.6	7.6	8.5
90	1.6	1.9	2.4	3.0	2.4	3.0	3.9	5.1	4.2	5.3	6.4	8.3	6.9	8.4	9.7	10.8
100	1.9	2.3	2.9	3.8	2.9	3.8	4.9	6.2	5.2	6.5	7.9	10.2	8.5	10.4	11.9	13.3
110	2.3	2.8	3.5	4.6	3.5	4.5	5.9	7.6	6.3	7.9	9.5	12.3	10.3	12.6	14.4	16.1
120	2.8	3.3	4.2	5.4	4.2	5.4	7.0	9.0	7.5	9.4	11.3	14.7	12.3	14.9	17.2	19.2
130	3.2	3.9	4.9	6.4	5.0	6.3	8.2	10.5	8.8	11.0	13.3	17.2	14.4	17.5	20.2	22.5
140	3.8	4.5	5.7	7.4	5.7	7.4	9.5	12.2	10.2	12.8	15.4	20.0	16.7	20.3	23.4	26.1
150	4.3	5.2	6.6	8.5	6.6	8.4	10.9	14.0	11.7	14.7	17.7	22.9	19.2	23.3	26.9	30.0
160	4.9	5.9	7.5	9.6	7.5	9.6	12.4	16.0	13.3	16.7	20.2	26.1	21.8	26.6	30.6	34.1
170	5.5	6.7	8.4	10.9	8.5	10.8	14.0	18.0	15.1	18.9	22.8	29.4	24.6	30.0	34.5	38.5
180	6.2	7.5	9.5	12.2	9.5	12.2	15.7	20.2	16.9	21.1	25.5	33.0	27.6	33.6	38.7	43.2
190	6.9	8.4	10.5	13.6	10.6	13.5	17.5	22.5	18.8	23.6	28.4	36.8	30.8	37.5	43.1	48.1
200	7.7	9.3	11.7	15.1	11.7	15.0	19.4	25.0	20.8	26.1	31.5	40.8	34.1	41.5	47.8	53.3
210	8.5	10.2	12.9	16.6	12.9	16.5	21.4	27.5	23.0	28.8	34.7	44.9	37.6	45.8	52.7	58.7
220	9.3	11.2	14.1	18.2	14.2	18.2	23.5	30.2	25.2	31.6	38.1	49.3	41.2	50.2	57.8	64.5
230	10.2	12.2	15.4	19.9	15.5	19.8	25.7	33.0	27.6	34.5	41.7	53.9	45.1	54.9	63.2	70.5
240	11.1	13.3	16.8	21.7	16.9	21.6	28.0	35.9	30.0	37.6	45.4	58.7	49.1	59.8	68.8	76.7
250	12.0	14.5	18.2	23.5	18.3	23.5	30.3	39.0	32.6	40.8	49.2	63.7	53.3	64.9	74.6	83.3
260	13.0	15.6	19.7	25.4	19.8	25.4	32.8	42.2	35.2	44.1	53.2	68.9	57.6	70.1	80.7	90.0
270	14.0	16.9	21.3	27.4	21.4	27.4	35.4	45.5	38.0	47.6	57.4	74.3	62.1	75.6	87.0	97.1
280	15.1	18.1	22.9	29.5	23.0	29.4	38.1	48.9	40.9	51.2	61.7	79.9	66.8	81.4	93.6	104.4
290	16.1	19.5	24.5	31.6	24.7	31.6	40.8	52.5	43.8	54.9	66.2	85.7	71.7	87.3	100.4	112.0
300	17.3	20.8	26.3	33.9	26.4	33.8	43.7	56.2	46.9	58.7	70.9	91.7	76.7	93.4	107.5	119.9

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**167**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**75**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.9	2.2	2.5	3.0	3.7	5.2	5.5	6.4
75	4.8	5.5	6.4	7.6	8.9	11.5	12.1	13.2
100	9.7	11.2	12.8	14.8	16.9	20.5	21.1	22.6
125	17.8	20.0	22.6	25.2	27.8	31.9	32.8	34.2
150	29.5	32.5	35.5	38.5	41.4	46.0	46.8	48.5
175	44.9	48.2	51.5	54.7	57.8	62.5	63.4	65.2
200	63.5	67.0	70.3	73.6	76.8	81.7	82.6	84.4
225	85.0	88.4	91.8	95.2	98.5	103.4	104.4	106.2
250	109.2	112.7	116.2	119.5	122.9	127.9	128.9	130.7
275	136.2	139.7	143.2	146.5	149.9	155.0	156.0	157.9
300	166.0	169.4	172.9	176.3	179.6	184.8	185.8	187.7

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	5.0	4.8	3.1	*6,800
75	11.4	10.8	7.6	*6,800
100	20.3	19.4	14.6	*6,800
125	31.7	30.6	24.8	*6,800
150	45.6	44.4	37.9	*6,800
175	62.2	60.8	54.0	*6,800
200	81.4	79.9	72.8	*6,800
225	103.1	101.6	94.3	*6,800
250	127.6	126.0	118.7	*6,800
275	154.7	153.1	145.7	*6,800
300	184.4	182.9	175.3	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*13800 lbs.
C.S.A.	*0.1450 sq. in.
R. (@ 25˚C)	0.0373 Ω / 1000’
R. (@ 75˚C)	0.0447 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.487”
CONDUCTOR DIAMETER	1.362”
SYSTEM WEIGHT	3115 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	2.8579 Lb/Ft
VERTICAL	7.278 Lb/Ft
TOTAL	8.119 Lb/Ft
SWING	21.44˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
489	NORMAL	692
603	EMERGENCY	768

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	3,576	2,893	2,463	1,970	2,881	2,259	1,878	1,463	1,748	1,302	1,056	829	925	723	615	487
ACTUAL SPAN (FEET)																
50	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.8	0.7	0.9	1.1	1.4	1.3	1.6	1.9	2.4
60	0.5	0.6	0.7	0.9	0.6	0.7	0.9	1.2	1.0	1.2	1.6	2.0	1.8	2.3	2.8	3.5
70	0.6	0.8	0.9	1.2	0.8	1.0	1.2	1.6	1.3	1.7	2.2	2.8	2.5	3.1	3.7	4.7
80	0.8	1.0	1.2	1.5	1.1	1.3	1.6	2.0	1.7	2.2	2.8	3.6	3.2	4.0	4.9	6.2
90	1.1	1.2	1.6	1.9	1.3	1.6	2.0	2.6	2.2	2.8	3.6	4.6	4.1	5.1	6.2	7.8
100	1.3	1.5	1.9	2.4	1.7	2.0	2.5	3.2	2.7	3.5	4.4	5.7	5.1	6.3	7.7	9.7
110	1.6	1.9	2.3	2.9	2.0	2.4	3.0	3.9	3.3	4.2	5.4	6.9	6.1	7.6	9.3	11.7
120	1.9	2.2	2.8	3.4	2.4	2.9	3.6	4.6	3.9	5.0	6.4	8.2	7.3	9.1	11.0	13.9
130	2.2	2.6	3.2	4.0	2.8	3.3	4.2	5.4	4.6	5.9	7.5	9.6	8.6	10.6	12.9	16.3
140	2.6	3.0	3.8	4.7	3.2	3.9	4.9	6.3	5.3	6.8	8.7	11.1	9.9	12.3	15.0	18.9
150	2.9	3.5	4.3	5.4	3.7	4.5	5.6	7.2	6.1	7.8	10.0	12.8	11.4	14.2	17.2	21.7
160	3.3	3.9	4.9	6.1	4.2	5.1	6.4	8.2	6.9	8.9	11.3	14.5	13.0	16.1	19.6	24.7
170	3.8	4.5	5.5	6.9	4.8	5.7	7.2	9.2	7.8	10.0	12.8	16.4	14.7	18.2	22.1	27.9
180	4.2	5.0	6.2	7.7	5.4	6.4	8.1	10.4	8.8	11.2	14.3	18.4	16.4	20.4	24.8	31.3
190	4.7	5.6	6.9	8.6	6.0	7.2	9.0	11.6	9.8	12.5	16.0	20.5	18.3	22.7	27.6	34.9
200	5.2	6.2	7.7	9.5	6.6	7.9	10.0	12.8	10.8	13.9	17.7	22.7	20.3	25.2	30.6	38.6
210	5.8	6.8	8.5	10.5	7.3	8.7	11.1	14.1	11.9	15.3	19.5	25.1	22.4	27.8	33.7	42.6
220	6.3	7.5	9.3	11.5	8.0	9.6	12.1	15.5	13.1	16.8	21.4	27.5	24.5	30.5	37.0	46.8
230	6.9	8.2	10.2	12.6	8.7	10.5	13.3	16.9	14.3	18.3	23.4	30.1	26.8	33.3	40.5	51.1
240	7.5	8.9	11.1	13.7	9.5	11.4	14.4	18.4	15.6	20.0	25.5	32.7	29.2	36.2	44.1	55.6
250	8.2	9.6	12.0	14.9	10.3	12.4	15.7	20.0	16.9	21.7	27.7	35.5	31.7	39.3	47.8	60.4
260	8.8	10.4	13.0	16.1	11.2	13.4	16.9	21.6	18.3	23.4	29.9	38.4	34.3	42.5	51.7	65.3
270	9.5	11.2	14.0	17.4	12.1	14.5	18.3	23.3	19.7	25.3	32.3	41.4	37.0	45.9	55.8	70.4
280	10.2	12.1	15.1	18.7	13.0	15.5	19.7	25.1	21.2	27.2	34.7	44.5	39.7	49.3	60.0	75.7
290	11.0	13.0	16.1	20.0	13.9	16.7	21.1	26.9	22.7	29.1	37.2	47.8	42.6	52.9	64.3	81.2
300	11.8	13.9	17.3	21.4	14.9	17.8	22.6	28.8	24.3	31.2	39.8	51.1	45.6	56.6	68.9	86.9

 Doc. # ST. 16.00.002

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	2.5	2.9	3.4	4.1	4.9	6.7	7.1	7.9
75	5.8	6.6	7.7	8.9	10.3	13.0	13.4	14.5
100	10.6	12.0	13.6	15.4	17.4	20.6	21.4	22.7
125	17.0	19.0	21.2	23.5	25.9	29.9	30.6	32.2
150	26.2	28.8	31.4	34.2	37.1	41.5	42.4	44.0
175	40.3	43.4	46.6	49.7	52.8	57.6	58.4	60.2
200	58.0	61.4	64.8	68.0	71.3	76.3	77.2	79.1
225	78.7	82.3	85.8	89.2	92.5	97.6	98.5	100.4
250	102.5	106.1	109.6	113.0	116.4	121.6	122.5	124.4
275	128.9	132.5	136.1	139.4	142.9	148.2	149.2	151.1
300	158.0	161.6	165.2	168.7	172.2	177.4	178.4	180.4

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	6.4	6.0	4.1	5,308
75	13.3	12.6	9.0	5,744
100	22.0	20.9	15.6	6,166
125	32.4	30.7	23.9	6,553
150	44.9	43.0	34.6	*6,800
175	61.2	59.0	49.9	*6,800
200	80.0	77.6	68.2	*6,800
225	101.5	98.9	89.2	*6,800
250	125.5	122.9	112.8	*6,800
275	152.2	149.4	139.3	*6,800
300	181.4	178.7	168.5	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*19500 lbs.
C.S.A.	*0.1785 sq. in.
R. (@ 25˚C)	0.0373 Ω / 1000’
R. (@ 75˚C)	0.0447 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.541”
CONDUCTOR DIAMETER	1.042”
SYSTEM WEIGHT	2422 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	2.5544 Lb/Ft
VERTICAL	6.014 Lb/Ft
TOTAL	6.834 Lb/Ft
SWING	23.01˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
528	NORMAL	739
647	EMERGENCY	819

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,329	3,496	2,971	2,373	3,340	2,601	2,153	1,675	2,330	1,756	1,435	1,131	1,486	1,145	974	821
ACTUAL SPAN (FEET)																
50	0.4	0.4	0.5	0.7	0.5	0.6	0.7	1.0	0.7	0.9	1.1	1.4	1.1	1.4	1.7	2.0
60	0.5	0.6	0.8	1.0	0.7	0.8	1.1	1.4	1.0	1.3	1.6	2.0	1.6	2.0	2.4	2.8
70	0.7	0.9	1.1	1.3	0.9	1.2	1.5	1.9	1.3	1.7	2.2	2.8	2.1	2.7	3.2	3.8
80	0.9	1.1	1.4	1.7	1.2	1.5	1.9	2.5	1.8	2.2	2.9	3.6	2.8	3.5	4.2	5.0
90	1.2	1.4	1.7	2.2	1.6	1.9	2.4	3.1	2.2	2.8	3.6	4.6	3.5	4.4	5.3	6.3
100	1.5	1.8	2.2	2.7	1.9	2.4	3.0	3.8	2.7	3.5	4.5	5.7	4.3	5.4	6.6	7.8
110	1.8	2.1	2.6	3.3	2.3	2.9	3.6	4.6	3.3	4.2	5.4	6.9	5.2	6.6	8.0	9.5
120	2.1	2.6	3.1	3.9	2.8	3.4	4.3	5.5	3.9	5.0	6.4	8.2	6.2	7.8	9.5	11.3
130	2.5	3.0	3.6	4.5	3.2	4.0	5.0	6.5	4.6	5.9	7.5	9.6	7.3	9.2	11.2	13.2
140	2.9	3.5	4.2	5.3	3.8	4.6	5.9	7.5	5.4	6.9	8.8	11.1	8.5	10.6	12.9	15.3
150	3.3	4.0	4.8	6.0	4.3	5.3	6.7	8.6	6.2	7.9	10.1	12.8	9.7	12.2	14.9	17.6
160	3.7	4.5	5.5	6.9	4.9	6.0	7.6	9.8	7.0	9.0	11.4	14.5	11.1	13.9	16.9	20.0
170	4.2	5.1	6.2	7.8	5.5	6.8	8.6	11.1	7.9	10.1	12.9	16.4	12.5	15.7	19.1	22.6
180	4.7	5.7	7.0	8.7	6.2	7.6	9.7	12.4	8.9	11.4	14.5	18.4	14.0	17.6	21.4	25.4
190	5.3	6.4	7.8	9.7	6.9	8.5	10.8	13.9	9.9	12.6	16.1	20.5	15.6	19.6	23.8	28.3
200	5.8	7.1	8.6	10.8	7.7	9.4	11.9	15.4	11.0	14.0	17.9	22.7	17.3	21.7	26.4	31.3
210	6.4	7.8	9.5	11.9	8.5	10.4	13.2	16.9	12.1	15.5	19.7	25.1	19.1	23.9	29.1	34.5
220	7.1	8.6	10.4	13.0	9.3	11.4	14.5	18.6	13.3	17.0	21.6	27.5	20.9	26.2	31.9	37.9
230	7.7	9.4	11.4	14.2	10.2	12.5	15.8	20.3	14.5	18.5	23.6	30.1	22.9	28.7	34.9	41.4
240	8.4	10.2	12.4	15.5	11.1	13.6	17.2	22.1	15.8	20.2	25.7	32.7	24.9	31.2	38.0	45.1
250	9.1	11.1	13.4	16.8	12.0	14.7	18.7	24.0	17.1	21.9	27.9	35.5	27.0	33.9	41.3	48.9
260	9.9	12.0	14.5	18.2	13.0	15.9	20.2	26.0	18.5	23.7	30.2	38.4	29.2	36.6	44.6	52.9
270	10.6	12.9	15.7	19.6	14.0	17.2	21.8	28.0	20.0	25.5	32.6	41.4	31.5	39.5	48.1	57.1
280	11.4	13.9	16.9	21.1	15.1	18.5	23.4	30.1	21.5	27.5	35.0	44.5	33.9	42.5	51.7	61.4
290	12.3	14.9	18.1	22.6	16.1	19.8	25.1	32.3	23.1	29.5	37.6	47.8	36.3	45.6	55.5	65.9
300	13.1	16.0	19.4	24.2	17.3	21.2	26.9	34.6	24.7	31.5	40.2	51.1	38.9	48.8	59.4	70.5

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.4	1.6	1.9	2.3	2.8	4.0	4.3	5.2
75	3.5	4.0	4.6	5.5	6.6	9.1	9.7	10.9
100	6.7	7.8	9.1	10.8	12.8	16.6	17.3	18.7
125	12.1	13.9	16.2	18.7	21.5	26.0	26.9	28.7
150	20.2	23.0	26.2	29.3	32.6	37.8	38.8	40.6
175	31.7	35.3	38.9	42.6	46.2	51.6	52.7	54.7
200	46.4	50.4	54.4	58.3	62.0	67.7	68.8	70.9
225	64.1	68.3	72.4	76.3	80.2	86.0	87.1	89.3
250	84.2	88.4	92.6	96.6	100.6	106.6	107.6	109.8
275	106.7	111.0	115.2	119.3	123.2	129.2	130.3	132.6
300	131.6	135.8	140.0	144.1	148.1	154.2	155.4	157.6

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.3	3.8	2.3	*6,800
75	9.6	8.8	5.6	*6,800
100	17.0	15.8	10.9	*6,800
125	26.8	25.1	18.6	*6,800
150	38.5	36.6	29.0	*6,800
175	52.4	50.3	42.0	*6,800
200	68.5	66.1	57.5	*6,800
225	86.9	84.4	75.4	*6,800
250	107.4	104.6	95.6	*6,800
275	130.1	127.3	118.2	*6,800
300	155.0	152.3	143.0	*6,800
* Note: Design Specification Constraint				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*13800 lbs.	TRANSVERSE	2.5390 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	*0.1450 sq. in.	VERTICAL	5.865 Lb/Ft			
R. (@ 25˚C)	0.0373 Ω / 1000'	TOTAL	6.691 Lb/Ft	528	NORMAL	739
R. (@ 75˚C)	0.0447 Ω / 1000'			647	EMERGENCY	819
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	23.41˚			
MESSENGER DIAMETER	0.487"					
CONDUCTOR DIAMETER	1.042"					
SYSTEM WEIGHT	2307 lbs / 1000'					

Note: Quantities identified with an " * " are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,127	3,414	2,956	2,421	3,846	3,149	2,706	2,195	3,017	2,386	1,998	1,574	2,056	1,561	1,279	1,007
ACTUAL SPAN (FEET)																
50	0.3	0.3	0.4	0.5	0.3	0.4	0.4	0.5	0.4	0.5	0.6	0.7	0.6	0.7	0.9	1.2
60	0.4	0.5	0.6	0.7	0.4	0.5	0.6	0.8	0.6	0.7	0.8	1.1	0.8	1.0	1.3	1.7
70	0.6	0.6	0.8	0.9	0.6	0.7	0.9	1.0	0.8	0.9	1.2	1.5	1.1	1.4	1.8	2.3
80	0.7	0.8	1.0	1.2	0.8	0.9	1.1	1.4	1.0	1.2	1.5	1.9	1.5	1.9	2.3	3.0
90	0.9	1.1	1.3	1.6	1.0	1.2	1.4	1.7	1.3	1.5	1.9	2.4	1.8	2.3	3.0	3.8
100	1.2	1.3	1.6	1.9	1.2	1.4	1.8	2.1	1.6	1.9	2.4	3.0	2.3	2.9	3.7	4.7
110	1.4	1.6	2.0	2.3	1.5	1.7	2.1	2.6	1.9	2.3	2.8	3.6	2.8	3.5	4.4	5.7
120	1.7	1.9	2.3	2.8	1.8	2.1	2.5	3.1	2.3	2.7	3.4	4.3	3.3	4.2	5.3	6.7
130	1.9	2.2	2.7	3.2	2.1	2.4	3.0	3.6	2.6	3.2	4.0	5.0	3.9	4.9	6.2	7.9
140	2.3	2.6	3.2	3.8	2.4	2.8	3.4	4.2	3.1	3.7	4.6	5.8	4.5	5.7	7.2	9.2
150	2.6	2.9	3.6	4.3	2.8	3.3	4.0	4.8	3.5	4.2	5.3	6.7	5.1	6.5	8.2	10.5
160	2.9	3.4	4.1	4.9	3.1	3.7	4.5	5.5	4.0	4.8	6.0	7.6	5.8	7.4	9.4	12.0
170	3.3	3.8	4.7	5.5	3.5	4.2	5.1	6.2	4.5	5.5	6.8	8.6	6.6	8.4	10.6	13.5
180	3.7	4.2	5.2	6.2	4.0	4.7	5.7	6.9	5.1	6.1	7.6	9.6	7.4	9.4	11.9	15.2
190	4.2	4.7	5.8	6.9	4.4	5.2	6.4	7.7	5.7	6.8	8.5	10.8	8.2	10.4	13.2	16.9
200	4.6	5.2	6.5	7.7	4.9	5.8	7.0	8.5	6.3	7.6	9.4	11.9	9.1	11.6	14.6	18.7
210	5.1	5.8	7.1	8.5	5.4	6.4	7.8	9.4	6.9	8.3	10.4	13.1	10.1	12.8	16.1	20.6
220	5.6	6.3	7.8	9.3	5.9	7.0	8.5	10.3	7.6	9.1	11.4	14.4	11.0	14.0	17.7	22.7
230	6.1	6.9	8.5	10.2	6.5	7.6	9.3	11.3	8.3	10.0	12.4	15.8	12.1	15.3	19.4	24.8
240	6.6	7.5	9.3	11.1	7.1	8.3	10.1	12.3	9.0	10.9	13.5	17.2	13.1	16.7	21.1	27.0
250	7.2	8.2	10.1	12.0	7.7	9.0	11.0	13.3	9.8	11.8	14.7	18.6	14.3	18.1	22.9	29.3
260	7.8	8.9	10.9	13.0	8.3	9.8	11.9	14.4	10.6	12.8	15.9	20.1	15.4	19.6	24.7	31.6
270	8.4	9.6	11.8	14.0	8.9	10.5	12.8	15.6	11.4	13.8	17.1	21.7	16.6	21.1	26.7	34.1
280	9.0	10.3	12.6	15.1	9.6	11.3	13.8	16.7	12.3	14.8	18.4	23.3	17.9	22.7	28.7	36.7
290	9.7	11.0	13.6	16.1	10.3	12.2	14.8	17.9	13.2	15.9	19.8	25.0	19.2	24.3	30.8	39.4
300	10.4	11.8	14.5	17.3	11.0	13.0	15.8	19.2	14.1	17.0	21.2	26.8	20.5	26.0	32.9	42.1

Supersedes 7/07 Issue – Revised Sag Tables

 Doc. # ST. 16.00.002

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.8	2.2	2.5	3.0	3.7	5.5	5.9	6.8
75	4.2	4.8	5.6	6.7	8.0	10.8	11.3	12.5
100	7.6	8.6	10.1	11.6	13.7	17.2	17.9	19.3
125	12.1	13.8	15.7	17.9	20.4	24.6	25.4	27.1
150	17.9	20.0	22.6	25.3	28.3	33.2	34.1	36.0
175	27.2	30.4	33.6	37.0	40.4	45.8	46.8	48.8
200	40.6	44.3	48.0	51.8	55.6	61.3	62.4	64.6
225	57.0	61.1	65.2	69.1	73.1	79.1	80.2	82.4
250	76.3	80.5	84.7	88.9	92.9	99.1	100.2	102.5
275	98.2	102.5	106.8	111.0	115.1	121.2	122.4	124.7
300	122.4	126.7	131.0	135.2	139.4	145.7	146.9	149.2

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	5.5	5.0	3.1	5,204
75	11.5	10.6	7.0	5,591
100	19.1	17.5	12.0	5,989
125	28.0	25.8	18.5	6,372
150	38.2	35.4	26.0	6,731
175	51.5	48.2	37.6	*6,800
200	67.2	63.6	52.2	*6,800
225	85.2	81.4	69.4	*6,800
250	105.4	101.3	88.9	*6,800
275	127.7	123.4	110.9	*6,800
300	152.2	147.7	135.1	*6,800
* *Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*19500 lbs.
C.S.A.	*0.1785 sq. in.
R. (@ 25˚C)	0.0527 Ω / 1000’
R. (@ 75˚C)	0.0629 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.541”
CONDUCTOR DIAMETER	0.937”
SYSTEM WEIGHT	2002 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	2.4501 Lb/Ft
VERTICAL	5.398 Lb/Ft
TOTAL	6.228 Lb/Ft
SWING	24.41˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
425	NORMAL	593
519	EMERGENCY	657

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,689	3,833	3,289	2,661	3,820	3,032	2,545	2,007	2,888	2,217	1,824	1,426	2,004	1,520	1,261	1,026
ACTUAL SPAN (FEET)																
50	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.8	0.6	0.7	0.9	1.1	0.8	1.0	1.3	1.6
60	0.5	0.6	0.7	0.9	0.6	0.7	0.9	1.2	0.8	1.0	1.3	1.6	1.2	1.5	1.8	2.3
70	0.7	0.8	0.9	1.2	0.8	1.0	1.2	1.6	1.1	1.4	1.7	2.2	1.6	2.0	2.5	3.1
80	0.9	1.0	1.2	1.5	1.1	1.3	1.6	2.0	1.4	1.8	2.3	2.9	2.1	2.6	3.3	4.0
90	1.1	1.3	1.6	1.9	1.4	1.6	2.0	2.6	1.8	2.3	2.9	3.6	2.6	3.3	4.1	5.1
100	1.4	1.6	1.9	2.4	1.7	2.0	2.5	3.2	2.2	2.8	3.5	4.5	3.2	4.1	5.1	6.3
110	1.7	2.0	2.3	2.9	2.1	2.5	3.0	3.9	2.7	3.4	4.3	5.5	3.9	4.9	6.2	7.6
120	2.0	2.3	2.8	3.4	2.5	2.9	3.6	4.6	3.2	4.0	5.1	6.5	4.6	5.9	7.3	9.0
130	2.3	2.7	3.2	4.0	2.9	3.4	4.2	5.4	3.8	4.7	6.0	7.6	5.4	6.9	8.6	10.6
140	2.7	3.2	3.8	4.7	3.3	4.0	4.9	6.3	4.4	5.5	6.9	8.8	6.3	8.0	10.0	12.3
150	3.1	3.6	4.3	5.4	3.8	4.6	5.6	7.2	5.0	6.3	7.9	10.1	7.2	9.2	11.5	14.1
160	3.5	4.1	4.9	6.1	4.4	5.2	6.4	8.2	5.7	7.2	9.0	11.5	8.2	10.4	13.1	16.1
170	4.0	4.7	5.5	6.9	4.9	5.9	7.2	9.2	6.5	8.1	10.2	13.0	9.3	11.8	14.7	18.1
180	4.5	5.2	6.2	7.7	5.5	6.6	8.1	10.4	7.2	9.1	11.4	14.6	10.4	13.2	16.5	20.3
190	5.0	5.8	6.9	8.6	6.2	7.3	9.0	11.6	8.1	10.1	12.7	16.3	11.6	14.7	18.4	22.6
200	5.5	6.5	7.7	9.5	6.8	8.1	10.0	12.8	8.9	11.2	14.1	18.0	12.8	16.3	20.4	25.1
210	6.1	7.1	8.5	10.5	7.5	9.0	11.1	14.1	9.8	12.3	15.6	19.9	14.2	17.9	22.5	27.7
220	6.7	7.8	9.3	11.5	8.3	9.8	12.1	15.5	10.8	13.5	17.1	21.8	15.5	19.7	24.7	30.3
230	7.3	8.6	10.2	12.6	9.0	10.8	13.3	16.9	11.8	14.8	18.7	23.8	17.0	21.5	27.0	33.2
240	8.0	9.3	11.1	13.7	9.8	11.7	14.4	18.4	12.9	16.1	20.3	26.0	18.5	23.4	29.4	36.1
250	8.6	10.1	12.0	14.9	10.7	12.7	15.7	20.0	14.0	17.5	22.0	28.2	20.1	25.4	31.9	39.2
260	9.3	10.9	13.0	16.1	11.5	13.8	16.9	21.6	15.1	18.9	23.8	30.5	21.7	27.5	34.5	42.4
270	10.1	11.8	14.0	17.4	12.4	14.8	18.3	23.3	16.3	20.4	25.7	32.8	23.4	29.7	37.2	45.7
280	10.8	12.7	15.1	18.7	13.4	16.0	19.7	25.1	17.5	21.9	27.6	35.3	25.2	31.9	40.0	49.2
290	11.6	13.6	16.1	20.0	14.4	17.1	21.1	26.9	18.8	23.5	29.7	37.9	27.0	34.2	42.9	52.7
300	12.4	14.6	17.3	21.4	15.4	18.3	22.6	28.8	20.1	25.2	31.7	40.6	28.9	36.6	45.9	56.4

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.2	1.3	1.6	1.8	2.3	3.4	3.7	4.4
75	2.8	3.2	3.7	4.4	5.5	7.9	8.4	9.7
100	5.4	6.2	7.3	8.9	10.7	14.4	15.2	16.8
125	9.6	11.2	13.1	15.5	18.2	23.0	24.0	25.8
150	16.0	18.5	21.5	24.7	28.2	33.7	34.8	36.8
175	25.4	28.9	32.8	36.6	40.6	46.4	47.5	49.7
200	38.2	42.4	46.7	50.9	55.0	61.2	62.4	64.7
225	53.9	58.6	63.0	67.3	71.6	78.0	79.2	81.5
250	72.2	76.9	81.6	86.0	90.4	96.8	98.0	100.4
275	92.9	97.7	102.2	106.8	111.1	117.7	118.9	121.3
300	115.8	120.5	125.2	129.6	133.9	140.6	141.8	144.4

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	4.0	3.5	2.0	6,791
75	8.9	7.9	4.8	*6,800
100	15.7	14.3	9.2	*6,800
125	24.6	22.7	15.8	*6,800
150	35.4	33.1	24.8	*6,800
175	48.2	45.6	36.5	*6,800
200	63.1	60.1	50.5	*6,800
225	79.9	76.8	66.7	*6,800
250	98.9	95.4	85.3	*6,800
275	119.8	116.2	106.0	*6,800
300	142.7	139.1	128.6	*6,800
* Note: Design Specification Constraint				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*13800 lbs.	**TRANSVERSE**	2.4343 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	*0.1450 sq. in.	**VERTICAL**	5.249 Lb/Ft			
R. (@ 25˚C)	0.0527 Ω / 1000’	**TOTAL**	6.086 Lb/Ft	425	**NORMAL**	593
R. (@ 75˚C)	0.0629 Ω / 1000’			519	**EMERGENCY**	657
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	24.88˚			
MESSENGER DIAMETER	0.487”					
CONDUCTOR DIAMETER	0.937”					
SYSTEM WEIGHT	1887 lbs / 1000’					

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,354	3,630	3,164	2,614	4,169	3,456	2,998	2,462	3,560	2,885	2,459	1,976	2,670	2,083	1,730	1,359
ACTUAL SPAN (FEET)																
50	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.5	0.3	0.4	0.5	0.6	0.4	0.5	0.7	0.9
60	0.4	0.4	0.5	0.6	0.4	0.5	0.6	0.7	0.5	0.6	0.7	0.9	0.6	0.8	1.0	1.2
70	0.5	0.6	0.7	0.9	0.5	0.7	0.8	0.9	0.7	0.8	0.9	1.2	0.9	1.1	1.3	1.7
80	0.7	0.8	0.9	1.1	0.7	0.9	1.0	1.2	0.9	1.0	1.2	1.5	1.1	1.4	1.7	2.2
90	0.9	1.0	1.2	1.4	0.9	1.1	1.3	1.6	1.1	1.3	1.6	1.9	1.4	1.8	2.2	2.8
100	1.1	1.2	1.5	1.8	1.1	1.3	1.5	1.9	1.3	1.6	1.9	2.4	1.8	2.2	2.7	3.5
110	1.3	1.5	1.8	2.1	1.4	1.6	1.9	2.3	1.6	1.9	2.3	2.9	2.1	2.6	3.3	4.2
120	1.5	1.8	2.1	2.5	1.6	1.9	2.2	2.8	1.9	2.3	2.8	3.4	2.5	3.1	3.9	5.0
130	1.8	2.1	2.5	3.0	1.9	2.3	2.6	3.2	2.3	2.7	3.2	4.0	3.0	3.7	4.6	5.8
140	2.1	2.4	2.9	3.5	2.2	2.6	3.0	3.8	2.6	3.1	3.8	4.7	3.5	4.3	5.3	6.8
150	2.4	2.8	3.3	4.0	2.5	3.0	3.5	4.3	3.0	3.5	4.3	5.4	4.0	4.9	6.1	7.8
160	2.8	3.2	3.7	4.5	2.9	3.4	4.0	4.9	3.4	4.0	4.9	6.1	4.5	5.6	6.9	8.8
170	3.1	3.6	4.2	5.1	3.2	3.9	4.5	5.5	3.9	4.5	5.5	6.9	5.1	6.3	7.8	10.0
180	3.5	4.0	4.7	5.7	3.6	4.3	5.0	6.2	4.3	5.1	6.2	7.7	5.7	7.0	8.7	11.2
190	3.9	4.4	5.3	6.4	4.0	4.8	5.6	6.9	4.8	5.7	6.9	8.6	6.4	7.8	9.7	12.5
200	4.3	4.9	5.8	7.1	4.5	5.3	6.2	7.7	5.3	6.3	7.7	9.6	7.1	8.7	10.8	13.8
210	4.7	5.4	6.4	7.8	4.9	5.9	6.8	8.5	5.9	6.9	8.5	10.5	7.8	9.6	11.9	15.2
220	5.2	6.0	7.1	8.5	5.4	6.5	7.5	9.3	6.4	7.6	9.3	11.6	8.6	10.5	13.1	16.7
230	5.7	6.5	7.7	9.3	5.9	7.1	8.2	10.2	7.0	8.3	10.2	12.6	9.4	11.5	14.3	18.3
240	6.2	7.1	8.4	10.2	6.5	7.7	8.9	11.1	7.7	9.1	11.1	13.8	10.2	12.5	15.6	19.9
250	6.7	7.7	9.1	11.0	7.0	8.4	9.7	12.0	8.3	9.8	12.0	14.9	11.1	13.6	16.9	21.6
260	7.3	8.3	9.9	11.9	7.6	9.0	10.5	13.0	9.0	10.6	13.0	16.2	12.0	14.7	18.3	23.3
270	7.8	9.0	10.6	12.9	8.2	9.7	11.3	14.0	9.7	11.5	14.0	17.4	12.9	15.8	19.7	25.2
280	8.4	9.7	11.4	13.8	8.8	10.5	12.1	15.1	10.4	12.3	15.1	18.7	13.9	17.0	21.2	27.0
290	9.0	10.4	12.3	14.9	9.4	11.2	13.0	16.1	11.2	13.2	16.1	20.1	14.9	18.2	22.7	29.0
300	9.7	11.1	13.1	15.9	10.1	12.0	13.9	17.3	12.0	14.2	17.3	21.5	15.9	19.5	24.3	31.1

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**167**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**75**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.4	1.7	2.0	2.5	3.1	4.8	5.3	6.1
75	3.4	4.0	4.6	5.5	6.8	9.5	10.1	11.3
100	6.1	7.1	8.2	9.7	11.5	15.1	15.8	17.4
125	9.7	11.2	12.8	14.9	17.4	21.7	22.6	24.4
150	14.3	16.2	18.5	21.1	24.1	29.2	30.2	32.3
175	21.4	24.1	27.2	30.6	34.2	40.0	41.0	43.3
200	32.2	35.9	39.7	43.8	47.8	54.1	55.3	57.6
225	46.3	50.6	55.1	59.4	63.7	70.3	71.5	73.9
250	63.5	68.2	72.8	77.4	81.8	88.6	89.9	92.3
275	83.3	88.2	92.9	97.6	102.0	108.8	110.2	112.7
300	105.5	110.4	115.2	119.8	124.3	131.3	132.6	135.1

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	5.0	4.6	2.6	5,164
75	10.7	9.6	5.9	5,531
100	17.8	16.0	10.3	5,919
125	26.0	23.5	15.8	6,301
150	35.4	32.2	22.3	6,667
175	47.3	43.4	31.9	*6,800
200	61.8	57.5	44.9	*6,800
225	78.4	73.7	60.2	*6,800
250	96.8	91.8	78.0	*6,800
275	117.4	112.0	98.0	*6,800
300	139.8	134.3	120.1	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*19500 lbs.	**TRANSVERSE**	2.5407 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	*0.1785 sq. in.	**VERTICAL**	5.367 Lb/Ft			
R. (@ 25˚C)	0.166 Ω / 1000’	**TOTAL**	6.238 Lb/Ft	200	**NORMAL**	280
R. (@ 75˚C)	0.195 Ω / 1000’			244	**EMERGENCY**	310
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	25.33˚			
MESSENGER DIAMETER	0.541”					
CONDUCTOR DIAMETER	1.028”					
SYSTEM WEIGHT	1793 lbs / 1000’					

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,684	3,828	3,284	2,656	3,813	3,025	2,538	2,001	2,878	2,209	1,817	1,420	1,994	1,513	1,256	1,022
ACTUAL SPAN (FEET)																
50	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.8	0.6	0.7	0.9	1.1	0.8	1.0	1.3	1.6
60	0.5	0.6	0.7	0.9	0.6	0.7	0.9	1.2	0.8	1.0	1.3	1.6	1.2	1.5	1.8	2.3
70	0.7	0.8	0.9	1.2	0.8	1.0	1.2	1.6	1.1	1.4	1.7	2.2	1.6	2.0	2.5	3.1
80	0.9	1.0	1.2	1.5	1.1	1.3	1.6	2.0	1.4	1.8	2.3	2.9	2.1	2.6	3.3	4.0
90	1.1	1.3	1.6	1.9	1.4	1.6	2.0	2.6	1.8	2.3	2.9	3.6	2.6	3.3	4.1	5.1
100	1.4	1.6	1.9	2.4	1.7	2.0	2.5	3.2	2.2	2.8	3.5	4.5	3.2	4.1	5.1	6.3
110	1.7	2.0	2.3	2.9	2.1	2.5	3.0	3.9	2.7	3.4	4.3	5.5	3.9	5.0	6.2	7.6
120	2.0	2.3	2.8	3.4	2.5	2.9	3.6	4.6	3.2	4.0	5.1	6.5	4.6	5.9	7.3	9.1
130	2.3	2.7	3.2	4.0	2.9	3.4	4.2	5.4	3.8	4.7	6.0	7.6	5.4	6.9	8.6	10.6
140	2.7	3.2	3.8	4.7	3.3	4.0	4.9	6.3	4.4	5.5	6.9	8.8	6.3	8.0	10.0	12.3
150	3.1	3.6	4.3	5.4	3.8	4.6	5.6	7.2	5.0	6.3	7.9	10.1	7.2	9.2	11.5	14.2
160	3.5	4.1	4.9	6.1	4.4	5.2	6.4	8.2	5.7	7.2	9.0	11.5	8.2	10.5	13.1	16.1
170	4.0	4.7	5.5	6.9	4.9	5.9	7.2	9.2	6.5	8.1	10.2	13.0	9.3	11.8	14.7	18.2
180	4.5	5.2	6.2	7.7	5.5	6.6	8.1	10.4	7.2	9.1	11.4	14.6	10.4	13.3	16.5	20.4
190	5.0	5.8	6.9	8.6	6.2	7.3	9.0	11.6	8.1	10.1	12.7	16.3	11.6	14.8	18.4	22.7
200	5.5	6.5	7.7	9.5	6.8	8.1	10.0	12.8	8.9	11.2	14.1	18.0	12.8	16.4	20.4	25.2
210	6.1	7.1	8.5	10.5	7.5	9.0	11.1	14.1	9.8	12.3	15.6	19.9	14.2	18.1	22.5	27.8
220	6.7	7.8	9.3	11.5	8.3	9.8	12.1	15.5	10.8	13.5	17.1	21.8	15.5	19.8	24.7	30.5
230	7.3	8.6	10.2	12.6	9.0	10.8	13.3	16.9	11.8	14.8	18.7	23.8	17.0	21.7	27.0	33.3
240	8.0	9.3	11.1	13.7	9.8	11.7	14.4	18.4	12.9	16.1	20.3	26.0	18.5	23.6	29.4	36.3
250	8.6	10.1	12.0	14.9	10.7	12.7	15.7	20.0	14.0	17.5	22.0	28.2	20.1	25.6	31.9	39.4
260	9.3	10.9	13.0	16.1	11.5	13.8	16.9	21.6	15.1	18.9	23.8	30.5	21.7	27.7	34.5	42.6
270	10.1	11.8	14.0	17.4	12.4	14.8	18.3	23.3	16.3	20.4	25.7	32.8	23.4	29.9	37.2	45.9
280	10.8	12.7	15.1	18.7	13.4	16.0	19.7	25.1	17.5	21.9	27.6	35.3	25.2	32.1	40.0	49.4
290	11.6	13.6	16.1	20.0	14.4	17.1	21.1	26.9	18.8	23.5	29.7	37.9	27.0	34.5	42.9	53.0
300	12.4	14.6	17.3	21.4	15.4	18.3	22.6	28.8	20.1	25.2	31.7	40.6	28.9	36.9	45.9	56.7

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.1	1.2	1.3	1.7	2.0	3.1	3.4	4.1
75	2.5	2.9	3.4	4.1	5.0	7.3	7.9	9.2
100	4.9	5.6	6.7	8.0	10.0	13.7	14.5	16.2
125	8.6	10.2	12.1	14.4	17.3	22.2	23.2	25.1
150	14.8	17.2	20.2	23.5	27.1	32.9	34.0	36.0
175	23.9	27.5	31.3	35.4	39.4	45.5	46.7	49.0
200	36.5	40.9	45.2	49.7	53.9	60.2	61.4	63.8
225	52.3	57.0	61.7	66.2	70.6	77.0	78.2	80.6
250	70.8	75.6	80.3	84.8	89.3	95.9	97.2	99.6
275	91.6	96.4	101.2	105.7	110.2	116.8	118.1	120.5
300	114.5	119.3	124.0	128.5	133.1	139.8	141.0	143.5

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.0	3.5	1.9	*6,800
75	8.9	7.8	4.7	*6,800
100	15.7	14.2	9.0	*6,800
125	24.6	22.6	15.6	*6,800
150	35.5	33.0	24.6	*6,800
175	48.4	45.5	36.1	*6,800
200	63.2	60.1	50.2	*6,800
225	80.0	76.7	66.5	*6,800
250	99.0	95.4	85.1	*6,800
275	119.9	116.2	105.7	*6,800
300	142.9	139.1	128.5	*6,800
* *Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*13800 lbs.	**TRANSVERSE**	2.5231 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	*0.1450 sq. in.	**VERTICAL**	5.218 Lb/Ft			
R. (@ 25˚C)	0.166 Ω / 1000’	**TOTAL**	6.096 Lb/Ft	200	**NORMAL**	280
R. (@ 75˚C)	0.195 Ω / 1000’			244	**EMERGENCY**	310
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	25.81˚			
MESSENGER DIAMETER	0.487”					
CONDUCTOR DIAMETER	1.028”					
SYSTEM WEIGHT	1678 lbs / 1000’					

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				**150**				**175**				**200**			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,454	3,727	3,257	2,701	4,312	3,592	3,129	2,584	3,550	2,876	2,451	1,969	2,659	2,073	1,722	1,352
ACTUAL SPAN (FEET)																
50	0.3	0.3	0.4	0.4	0.3	0.3	0.4	0.5	0.3	0.4	0.5	0.6	0.4	0.5	0.7	0.9
60	0.4	0.4	0.5	0.6	0.4	0.5	0.5	0.7	0.5	0.6	0.7	0.9	0.6	0.8	1.0	1.3
70	0.5	0.6	0.7	0.9	0.5	0.6	0.7	0.9	0.7	0.8	0.9	1.2	0.9	1.1	1.3	1.7
80	0.7	0.8	0.9	1.1	0.7	0.8	1.0	1.2	0.9	1.0	1.2	1.5	1.1	1.4	1.7	2.2
90	0.9	1.0	1.2	1.4	0.9	1.0	1.2	1.5	1.1	1.3	1.6	1.9	1.4	1.8	2.2	2.8
100	1.1	1.2	1.5	1.8	1.1	1.3	1.5	1.8	1.3	1.6	1.9	2.4	1.8	2.2	2.7	3.5
110	1.3	1.5	1.8	2.1	1.3	1.6	1.8	2.2	1.6	1.9	2.3	2.9	2.1	2.6	3.3	4.2
120	1.5	1.8	2.1	2.5	1.5	1.8	2.2	2.6	1.9	2.3	2.8	3.4	2.5	3.1	3.9	5.0
130	1.8	2.1	2.5	3.0	1.8	2.2	2.5	3.1	2.3	2.7	3.2	4.0	3.0	3.7	4.6	5.9
140	2.1	2.4	2.9	3.5	2.1	2.5	2.9	3.6	2.6	3.1	3.8	4.7	3.5	4.3	5.4	6.8
150	2.4	2.8	3.3	4.0	2.4	2.9	3.4	4.1	3.0	3.5	4.3	5.4	4.0	4.9	6.1	7.8
160	2.8	3.2	3.7	4.5	2.7	3.3	3.8	4.6	3.4	4.0	4.9	6.1	4.5	5.6	7.0	8.9
170	3.1	3.6	4.2	5.1	3.1	3.7	4.3	5.2	3.9	4.5	5.5	6.9	5.1	6.3	7.9	10.1
180	3.5	4.0	4.7	5.7	3.5	4.2	4.8	5.9	4.3	5.1	6.2	7.7	5.7	7.0	8.8	11.3
190	3.9	4.4	5.3	6.4	3.9	4.6	5.4	6.5	4.8	5.7	6.9	8.6	6.4	7.8	9.9	12.6
200	4.3	4.9	5.8	7.1	4.3	5.1	6.0	7.3	5.3	6.3	7.7	9.6	7.1	8.7	10.9	13.9
210	4.7	5.4	6.4	7.8	4.7	5.7	6.6	8.0	5.9	6.9	8.5	10.5	7.8	9.6	12.0	15.3
220	5.2	6.0	7.1	8.5	5.2	6.2	7.2	8.8	6.4	7.6	9.3	11.6	8.6	10.5	13.2	16.8
230	5.7	6.5	7.7	9.3	5.6	6.8	7.9	9.6	7.0	8.3	10.2	12.6	9.4	11.5	14.4	18.4
240	6.2	7.1	8.4	10.2	6.1	7.4	8.6	10.4	7.7	9.1	11.1	13.8	10.2	12.5	15.7	20.0
250	6.7	7.7	9.1	11.0	6.7	8.0	9.3	11.3	8.3	9.8	12.0	14.9	11.1	13.6	17.1	21.8
260	7.3	8.3	9.9	11.9	7.2	8.7	10.1	12.3	9.0	10.6	13.0	16.2	12.0	14.7	18.5	23.5
270	7.8	9.0	10.6	12.9	7.8	9.4	10.9	13.2	9.7	11.5	14.0	17.4	12.9	15.8	19.9	25.4
280	8.4	9.7	11.4	13.8	8.4	10.1	11.7	14.2	10.4	12.3	15.1	18.7	13.9	17.0	21.4	27.3
290	9.0	10.4	12.3	14.9	9.0	10.8	12.6	15.3	11.2	13.2	16.1	20.1	14.9	18.2	23.0	29.3
300	9.7	11.1	13.1	15.9	9.6	11.6	13.4	16.3	12.0	14.2	17.3	21.5	15.9	19.5	24.6	31.3

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.3	1.6	1.8	2.3	2.9	4.4	4.8	5.8
75	3.0	3.5	4.1	4.9	6.1	8.8	9.4	10.7
100	5.4	6.2	7.3	8.6	10.4	14.0	14.8	16.4
125	8.5	9.8	11.4	13.3	15.7	20.2	21.1	22.9
150	12.5	14.3	16.4	19.0	22.0	27.1	28.2	30.2
175	19.6	22.3	25.4	28.9	32.6	38.6	39.7	42.1
200	30.0	33.8	37.8	42.0	46.2	52.7	54.0	56.4
225	44.0	48.6	53.2	57.7	62.2	69.0	70.2	72.7
250	61.3	66.2	71.0	75.7	80.3	87.2	88.6	91.1
275	81.4	86.4	91.2	96.0	100.6	107.6	109.0	111.5
300	103.7	108.7	113.5	118.3	123.0	130.1	131.4	133.9

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	5.0	4.4	2.6	5,179
75	10.7	9.5	5.8	5,561
100	17.6	15.7	10.0	5,966
125	25.8	23.2	15.2	6,368
150	35.0	31.6	21.5	6,756
175	47.4	43.3	31.6	*6,800
200	61.9	57.5	44.5	*6,800
225	78.5	73.6	59.9	*6,800
250	97.0	91.8	77.8	*6,800
275	117.5	112.0	97.7	*6,800
300	140.0	134.3	119.9	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*19500 lbs.
C.S.A.	*0.1785 sq. in.
R. (@ 25˚C)	0.166 Ω / 1000’
R. (@ 75˚C)	0.195 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.541”
CONDUCTOR DIAMETER	0.728”
SYSTEM WEIGHT	1276 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	2.2411 Lb/Ft
VERTICAL	4.282 Lb/Ft
TOTAL	5.133 Lb/Ft
SWING	27.63˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
214	NORMAL	296
259	EMERGENCY	327

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	5,278	4,393	3,823	3,152	4,632	3,782	3,244	2,626	3,901	3,112	2,624	2,086	3,124	2,431	2,020	1,598
ACTUAL SPAN (FEET)																
50	0.3	0.3	0.4	0.5	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.8	0.5	0.6	0.8	1.0
60	0.4	0.5	0.6	0.7	0.5	0.6	0.7	0.9	0.6	0.7	0.9	1.1	0.7	0.9	1.1	1.4
70	0.6	0.7	0.8	1.0	0.7	0.8	1.0	1.2	0.8	1.0	1.2	1.5	1.0	1.2	1.6	2.0
80	0.8	0.9	1.1	1.3	0.9	1.1	1.3	1.6	1.1	1.3	1.6	2.0	1.3	1.6	2.0	2.6
90	1.0	1.1	1.4	1.7	1.1	1.3	1.6	2.0	1.3	1.6	2.0	2.5	1.7	2.1	2.6	3.3
100	1.2	1.4	1.7	2.1	1.4	1.7	2.0	2.5	1.6	2.0	2.4	3.1	2.0	2.5	3.2	4.0
110	1.5	1.7	2.0	2.5	1.7	2.0	2.4	3.0	2.0	2.4	2.9	3.7	2.5	3.1	3.8	4.9
120	1.8	2.0	2.4	3.0	2.0	2.4	2.8	3.5	2.4	2.9	3.5	4.5	2.9	3.6	4.6	5.8
130	2.1	2.3	2.9	3.5	2.3	2.8	3.3	4.1	2.8	3.4	4.1	5.2	3.4	4.3	5.4	6.8
140	2.4	2.7	3.3	4.1	2.7	3.3	3.9	4.8	3.2	3.9	4.8	6.1	4.0	5.0	6.2	7.9
150	2.8	3.1	3.8	4.7	3.1	3.7	4.4	5.5	3.7	4.5	5.5	7.0	4.6	5.7	7.2	9.0
160	3.1	3.6	4.3	5.3	3.5	4.2	5.1	6.3	4.2	5.1	6.2	7.9	5.2	6.5	8.1	10.3
170	3.6	4.0	4.9	6.0	4.0	4.8	5.7	7.1	4.8	5.8	7.0	8.9	5.9	7.3	9.2	11.6
180	4.0	4.5	5.5	6.7	4.5	5.4	6.4	7.9	5.3	6.5	7.9	10.0	6.6	8.2	10.3	13.0
190	4.4	5.0	6.1	7.5	5.0	6.0	7.1	8.9	5.9	7.2	8.8	11.2	7.4	9.1	11.5	14.5
200	4.9	5.6	6.8	8.3	5.5	6.6	7.9	9.8	6.6	8.0	9.7	12.4	8.2	10.1	12.7	16.1
210	5.4	6.1	7.5	9.1	6.1	7.3	8.7	10.8	7.3	8.8	10.7	13.7	9.0	11.2	14.0	17.7
220	5.9	6.7	8.2	10.0	6.7	8.0	9.6	11.9	8.0	9.7	11.8	15.0	9.9	12.3	15.4	19.5
230	6.5	7.3	8.9	11.0	7.3	8.8	10.4	13.0	8.7	10.6	12.9	16.4	10.8	13.4	16.8	21.3
240	7.1	8.0	9.7	11.9	8.0	9.6	11.4	14.1	9.5	11.6	14.0	17.8	11.8	14.6	18.3	23.2
250	7.7	8.7	10.6	13.0	8.7	10.4	12.3	15.3	10.3	12.5	15.2	19.3	12.8	15.8	19.9	25.1
260	8.3	9.4	11.4	14.0	9.4	11.2	13.3	16.6	11.1	13.6	16.4	20.9	13.8	17.1	21.5	27.2
270	9.0	10.1	12.3	15.1	10.1	12.1	14.4	17.9	12.0	14.6	17.7	22.6	14.9	18.5	23.2	29.3
280	9.6	10.9	13.2	16.3	10.9	13.0	15.5	19.2	12.9	15.7	19.0	24.3	16.0	19.8	24.9	31.5
290	10.3	11.7	14.2	17.4	11.7	13.9	16.6	20.6	13.8	16.9	20.4	26.0	17.2	21.3	26.7	33.8
300	11.1	12.5	15.2	18.7	12.5	14.9	17.8	22.1	14.8	18.0	21.9	27.9	18.4	22.8	28.6	36.2

Supersedes 7/07 Issue – Revised Sag Tables

 Doc. # ST. 16.00.002

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.7	0.8	1.0	1.2	1.4	2.3	2.5	3.2
75	1.7	1.9	2.3	2.8	3.5	5.3	5.9	7.1
100	3.2	3.8	4.4	5.4	6.8	10.2	11.0	12.7
125	5.6	6.6	7.8	9.6	12.0	16.9	18.0	20.2
150	9.1	10.8	13.0	15.8	19.3	25.6	26.8	29.3
175	14.5	17.2	20.6	24.6	29.0	36.1	37.4	40.1
200	22.4	26.5	31.1	35.9	40.9	48.4	49.8	52.6
225	33.7	38.8	44.2	49.4	54.7	62.5	64.0	66.7
250	48.1	53.8	59.5	65.0	70.3	78.2	79.8	82.7
275	65.0	71.0	76.8	82.4	87.8	95.9	97.3	100.2
300	84.2	90.2	96.0	101.6	107.0	115.1	116.6	119.5

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	3.4	2.8	1.4	6,726
75	7.4	6.2	3.4	*6,800
100	13.3	11.4	6.4	*6,800
125	20.8	18.1	10.9	*6,800
150	30.0	26.5	17.3	*6,800
175	40.8	36.8	25.9	*6,800
200	53.4	48.8	36.8	*6,800
225	67.6	62.6	50.0	*6,800
250	83.5	78.2	65.3	*6,800
275	101.2	95.5	82.4	*6,800
300	120.5	114.7	101.5	*6,800
** Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

PHYSICAL PROPERTIES	
R.B.S.	*13800 lbs.
C.S.A.	*0.1450 sq. in.
R. (@ 25˚C)	0.166 Ω / 1000’
R. (@ 75˚C)	0.195 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
MESSENGER DIAMETER	0.487”
CONDUCTOR DIAMETER	0.728”
SYSTEM WEIGHT	1161 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	2.2253 Lb/Ft
VERTICAL	4.133 Lb/Ft
TOTAL	4.994 Lb/Ft
SWING	28.30˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
214	**NORMAL**	296
259	**EMERGENCY**	327

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4,637	3,904	3,428	2,861	4,576	3,846	3,373	2,812	4,473	3,748	3,280	2,728	3,785	3,097	2,662	2,164
ACTUAL SPAN (FEET)																
50	0.2	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.4	0.4	0.3	0.4	0.4	0.5
60	0.4	0.4	0.5	0.6	0.4	0.4	0.5	0.6	0.4	0.4	0.5	0.6	0.4	0.5	0.6	0.8
70	0.5	0.6	0.7	0.8	0.5	0.6	0.7	0.8	0.5	0.6	0.7	0.8	0.6	0.7	0.9	1.1
80	0.6	0.7	0.9	1.0	0.6	0.8	0.9	1.1	0.7	0.8	0.9	1.1	0.8	0.9	1.1	1.4
90	0.8	0.9	1.1	1.3	0.8	1.0	1.1	1.3	0.9	1.0	1.2	1.4	1.0	1.2	1.4	1.7
100	1.0	1.2	1.4	1.6	1.0	1.2	1.4	1.7	1.1	1.2	1.4	1.7	1.2	1.5	1.8	2.2
110	1.2	1.4	1.7	2.0	1.2	1.4	1.7	2.0	1.3	1.5	1.8	2.1	1.5	1.8	2.1	2.6
120	1.4	1.7	2.0	2.3	1.5	1.7	2.0	2.4	1.5	1.8	2.1	2.5	1.8	2.1	2.5	3.1
130	1.7	2.0	2.3	2.7	1.7	2.0	2.3	2.8	1.8	2.1	2.5	2.9	2.1	2.5	3.0	3.7
140	2.0	2.3	2.7	3.2	2.0	2.3	2.7	3.2	2.1	2.4	2.8	3.4	2.4	2.9	3.5	4.2
150	2.2	2.6	3.1	3.6	2.3	2.6	3.1	3.7	2.4	2.7	3.3	3.9	2.8	3.3	4.0	4.9
160	2.6	3.0	3.5	4.1	2.6	3.0	3.5	4.2	2.7	3.1	3.7	4.4	3.1	3.8	4.5	5.5
170	2.9	3.3	4.0	4.7	2.9	3.4	4.0	4.8	3.1	3.5	4.2	5.0	3.6	4.3	5.1	6.2
180	3.2	3.7	4.5	5.2	3.3	3.8	4.5	5.4	3.4	3.9	4.7	5.6	4.0	4.8	5.7	7.0
190	3.6	4.2	5.0	5.8	3.7	4.2	5.0	6.0	3.8	4.4	5.2	6.2	4.4	5.3	6.4	7.8
200	4.0	4.6	5.5	6.5	4.1	4.7	5.5	6.6	4.2	4.9	5.8	6.9	4.9	5.9	7.1	8.6
210	4.4	5.1	6.1	7.1	4.5	5.2	6.1	7.3	4.7	5.4	6.4	7.6	5.4	6.5	7.8	9.5
220	4.8	5.6	6.7	7.8	4.9	5.7	6.7	8.0	5.1	5.9	7.0	8.3	6.0	7.1	8.6	10.5
230	5.3	6.1	7.3	8.5	5.4	6.2	7.3	8.7	5.6	6.4	7.7	9.1	6.5	7.8	9.4	11.4
240	5.8	6.7	8.0	9.3	5.8	6.8	8.0	9.5	6.1	7.0	8.4	9.9	7.1	8.5	10.2	12.4
250	6.2	7.2	8.6	10.1	6.3	7.4	8.7	10.3	6.6	7.6	9.1	10.8	7.7	9.2	11.1	13.5
260	6.7	7.8	9.3	10.9	6.9	8.0	9.4	11.2	7.2	8.2	9.8	11.7	8.3	10.0	12.0	14.6
270	7.3	8.4	10.1	11.8	7.4	8.6	10.1	12.1	7.7	8.9	10.6	12.6	9.0	10.8	12.9	15.7
280	7.8	9.1	10.8	12.6	7.9	9.2	10.9	13.0	8.3	9.6	11.4	13.5	9.6	11.6	13.9	16.9
290	8.4	9.7	11.6	13.6	8.5	9.9	11.7	13.9	8.9	10.2	12.2	14.5	10.3	12.4	14.9	18.2
300	9.0	10.4	12.4	14.5	9.1	10.6	12.5	14.9	9.5	11.0	13.0	15.5	11.1	13.3	15.9	19.4

Supersedes 7/07 Issue – Revised Sag Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	167	176	194
TEMP. ˚C	-18	0	15	32	50	75	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.0	1.1	1.3	1.6	2.0	3.4	3.7	4.8
75	2.0	2.4	2.9	3.5	4.4	6.8	7.4	8.9
100	3.7	4.3	5.0	6.1	7.6	11.0	11.9	13.7
125	5.9	6.7	7.9	9.5	11.5	16.1	17.0	19.1
150	8.4	9.7	11.4	13.4	16.2	21.6	22.7	25.1
175	11.6	13.4	15.6	18.4	21.7	28.0	29.2	31.8
200	17.5	20.3	23.6	27.5	31.9	39.2	40.7	43.6
225	26.0	30.0	34.6	39.5	44.5	52.6	54.1	57.1
250	37.8	43.0	48.4	53.9	59.4	67.8	69.4	72.4
275	52.9	58.8	64.7	70.6	76.2	84.7	86.3	89.4
300	70.9	77.2	83.2	89.2	94.8	103.4	105.0	108.2

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.3	3.6	1.9	5,085
75	9.2	7.8	4.2	5,401
100	15.4	13.1	7.4	5,751
125	22.7	19.3	11.4	6,111
150	30.8	26.5	16.1	6,469
175	39.8	34.6	21.6	*6,800
200	52.1	46.1	31.0	*6,800
225	66.0	59.3	42.7	*6,800
250	81.6	74.2	56.9	*6,800
275	98.8	91.0	73.1	*6,800
300	117.6	109.4	91.3	*6,800
* *Note: Design Specification Constraint*				

Supersedes 7/07 Issue – Revised Sag Tables

16.6 PREASSEMBLED LASHED AERIAL CABLE (PLAC)

Factory assembled shielded aerial cable shall be used as the second circuit on 15 kV pole lines or on those lines that may become 15 kV. It shall also be used where clearance to ground or clearance to buildings is questionable as well as for express feeder applications. In general, the preferred construction shall first utilize open wire crossarm construction followed by armless or spacer cable construction; however, aerial cable may be used as an alternate method to satisfy the above mentioned conditions. Factory assembled shielded aerial cable has a grounded metallic sheath and requires similar clearance to that specified for secondary, rather than for primary conductors. The metallic sheath is to be bonded at each splice and termination. Additionally, arresters shall be installed at each termination to provide the best surge protection possible. In order to properly do so, the termination must be placed on a bracket and not hung directly under the disconnect switch as shown on Page 16-320.

There are several standard pre-assembled aerial cables currently available (refer to Section 50 in UG Standards). These cables have a jacketed concentric neutral with 3 phase conductors and a EHS copperweld messenger held together with a covered copper binding tape. Cables have a 5000 lb. design tension. Consult Standards Engineering for Sag tensions and requirements for the larger sizes. Older pre-assembled aerial cable uses a copper tape shielding as opposed to a concentric neutral. The messenger can be utilized as the neutral conductor. The messenger shall be bonded to the secondary neutral, if present, at every pole. The messenger shall be bonded to a driven ground rod a minimum of every 800 feet.

Note: Certain existing circuits may utilize a ½" EHS copperweld messenger that requires either deadending at a pole location for splicing or double deadending to a figure 8 where mid-span splicing is necessary.

16.6.10 Aerial Cable Installation

Factory assembled shielded aerial cable should be pulled in and sagged as follows:

(a) Use large blocks at every pole with auxiliary roller near the cable reel to minimize bending of the cable.

(b) Have provisions for braking the cable reel.

(c) Pull in the cable using sufficient tension so that the cable is not bent sharply at any block.

(d) Pull the messenger to 5,000 lbs.

(e) Inspect deadends, angles, and guys. If guys have slipped or seriously cut into the wood, tighten, replace, or repair the fittings, then re-stress the messenger as in (d) above.

(f) Reduce the tension to the values specified (Pages 16-54 thru 16-56), clamp the messenger at each pole and complete the dead ends.

16.6.20 Cold Shrink Splices

New aerial cables are designed with a jacketed concentric neutral. Older aerial cables are copper tape shielded and unjacketed. For copper tape shielded, unjacketed cable, place a tape marker on the copper tape at the distance given in the instructions for the jacket cutback. Then make all other measurements from this tape marker.

Both splices and terminations shall be cold shrink. Each splice is to be externally bonded. The outer jacket in the splice kit must be replaced with a silicon outer jacket (Std. Item UR49D) since the outer jacket in the splice kit is not UV resistant. Follow the instructions in 16.7.30 for installing the splice and for grounding and bonding.

Supersedes 7/12 Issue – Revised text in section 16.6.

16.6.30 Splice Installation For Copper Tape Shielded Aerial Cable

The instructions packed with the kit are for jacketed concentric neutral (JCN) cable. Use the kit instructions with the following modifications for copper tape shielded aerial cable:

A. Make the copper tape cutback 3½ inches from the jacket cutback. There will be 3 inches of semi-con showing when complete.

   1. For unjacketed cable, place a tape marker on the copper tape shield at the dimension given in the instructions for the Jacket Cutback. Then make all other measurements from this tape marker.

B. Grounding And Bonding – Refer To Figure 14

   The #4 solid bond wires will be used to exit the splice and may exit the splice on either side.

   1. Make a protective bedding for C crimp connectors at the end of the splice where the #4 solid bond wires will exit by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

   2. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

   3. Starting on the side opposite where the #4 solid bond wires will exit, wrap one braid around the cable at least 1 complete wrap, in complete contact with the copper tape. Fold the braid over at 45 degrees so the tail is now parallel to the cable, with the tail toward the splice. Secure with a constant force spring (Std. Item US1_). This spring should be placed at the end of the copper tape (toward the splice) leaving space for the second one next to it. A couple laps of vinyl tape may be placed over the spring if desired.

   4. Extend the braid along the splice, then folding and wrapping it around the copper tape on the second side. This time, after the turn around the cable is made, fold the braid again, with the tail pointing toward the splice. Secure with a constant force spring. A couple laps of vinyl tape may be placed over the spring if desired.

   5. Repeat the last two steps with the second braid. The braid's tails should be on opposite sides of the splice. Be sure the wrap of each braid is in complete contact with the copper tape shield. If there is not sufficient room, trim back the cable jacket to expose additional copper tape, but keep this additional jacket cutback to a minimum.

   6. Connect each #4 solid bond wires to the respective tails of the tinned braids with C crimp connectors (Std. Item S14__) of the proper size. File out any sharp edges after crimping.
   7. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

   8. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh (barber pole style) to secure the mesh prior to installing the outer jacket.

Supersedes 1/06 Issue – Added Splicing Information For Preassembled Lashed Aerial Cable

9. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

10. Apply the mastic supplied with the splice kit at the cleaned area under and over the #4 solid bond wires.

11. Install and shrink the outer jacket tube, being sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

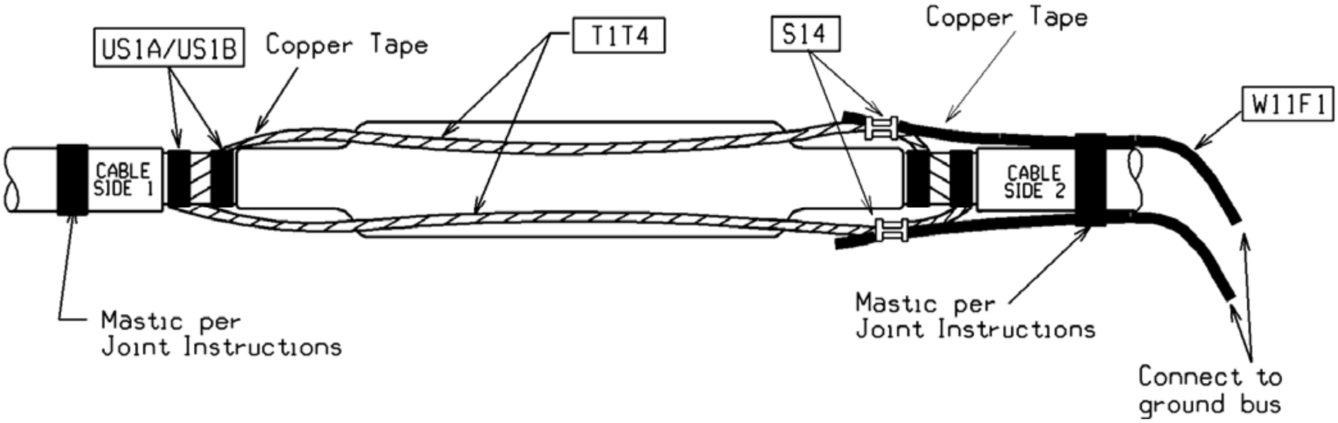


Figure 14

Replace the EDPM (black rubber) jacket supplied in the joint kit with an overall silicone jacket (Std. Item UR49D). Connect the bond wires exiting the splice to the messenger wire and/or other grounded conductor.

16.6.40 Constant Spring Force Connection Installation

The **only** acceptable method of braid to shield connection is the following:

1. Clean the copper tape or lead where the connection is to be made.

2. Hold the braid perpendicular to the cable and make at least one complete wrap around the cable. Refer to Figure 15.

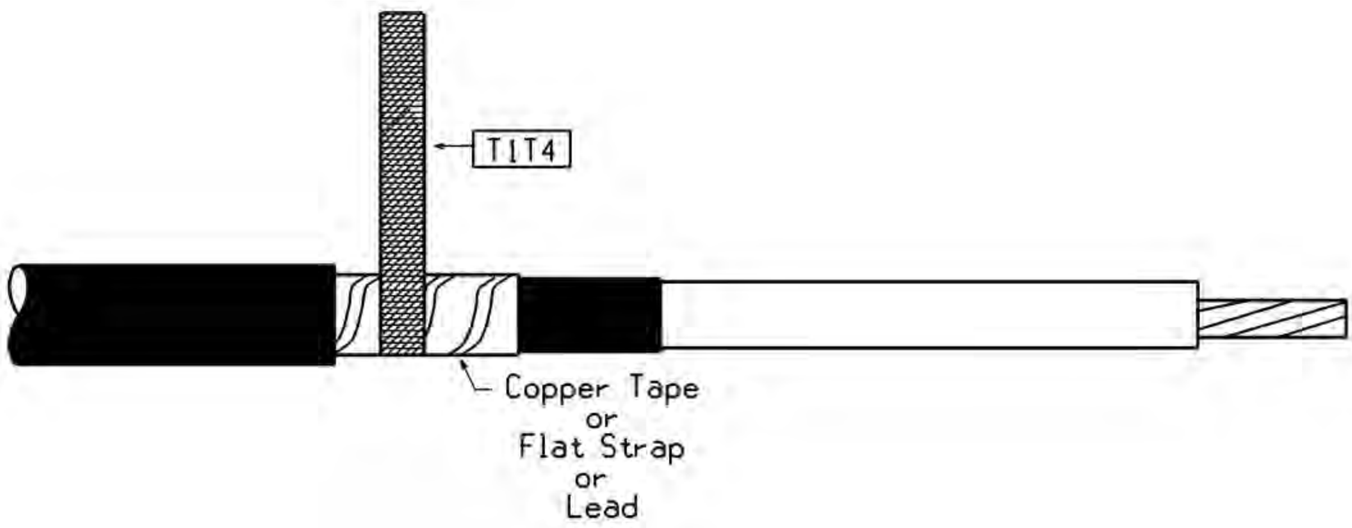


Figure 15

3. Fold the braid over itself at 45 degrees, bringing the long end parallel with the cable. Refer to Figure 16.

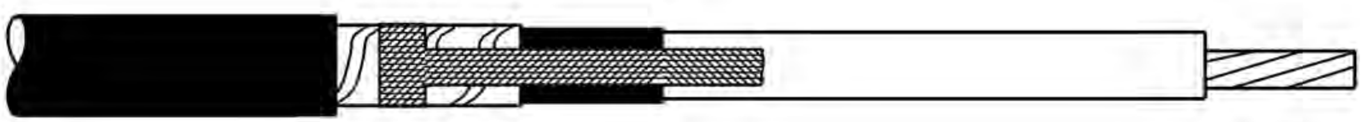


Figure 16

4. Wrap the constant force spring over the braid where it is wrapped around the cable. Use up all of the spring. Refer to Figure 17.

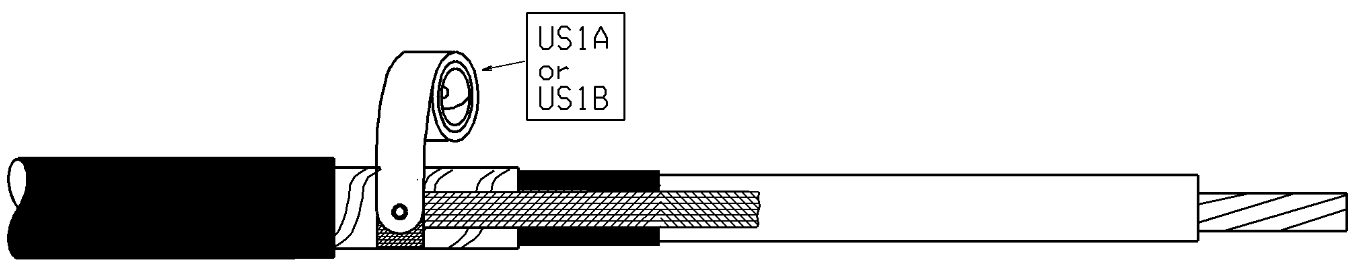


Figure 17

5. If necessary, one to two laps of vinyl tape (Std. Item T2W1) may be placed over the spring to hold it in place. Refer to Figure 18.

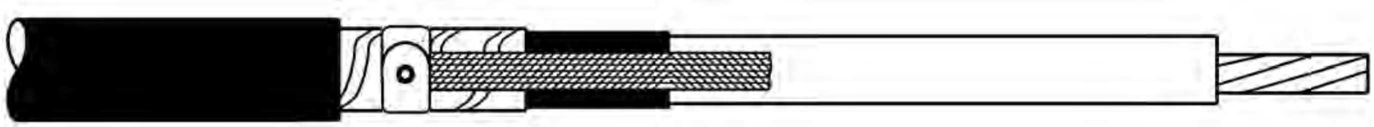


Figure 18

This connection method provides sufficient contact area of the braid to the cable shield and keeps the high resistance spring out of the electrical circuit. The spring is used solely as the mechanical force for the connection.

Supersedes 1/06 Issue – Added Constant Spring Force Detail For Preassembled Lashed Aerial Cable

The traditional method of connecting the braid to the copper tape or lead has been to place one wrap of the constant force spring around the cable, then lay the braid over the spring parallel to the run of cable and then continue wrapping the spring around the cable until all the spring is used up. This connection depends on the spring to carry current from the cable shield to the braid, since the spring is the only material in contact with the shield. **This practice is no longer acceptable as** the spring steel has a relatively high resistance.

16.6.50 Terminations For Copper Tape Shield

In order to adapt the termination kit for use on cables rated for 5 kV through 25 kV with copper tape shield, an accessory kit will be necessary. This kit contains a solder blocked ground braid and constant force spring. Follow the instructions below for preparation of the cable and installation of the ground braid. The instructions packed with the accessory kit are for a different type of cable.

Select the accessory kit based upon the O.D. over the shield of the cable, as listed in the following table.

Table 3

Shield O.D.	Accessory Kit (Std. Item)
0.82” – 1.63”	UR47T4
1.15” – 2.42”	UR47T5

If the cable has fabric or tape semi-con, this material shall be cut back ¼ - ½ inch more than specified here-in for extruded semi-con layers. The exposed portion of the fabric tape semi-con shall then be wrapped with semi-con tape (Std. Item T1S) applied half lapped, until the specified semi-con cutback is reached. This tape shall then be trimmed square to the cable at the required cutback.

A. Prepare Cable:

1. Check to be sure cable size fits within kit range as shown in Table 1 (cover page) of the termination instructions packaged with the kit.

2. Prepare cable using dimensions shown in Figure 19. Be sure to allow for the depth of the terminal lug and growth of Aluminum Lug (if used – see chart below). If necessary to prevent tape shield from unraveling, TEMPORARILY hold down the edge with a single wrap of vinyl electrical tape.

Table 4

Aluminum Cable Size	#2 – 350 kcMil	400 – 650 kcMil	750 – 1000 kcMil
Growth Allowance	0.25”	0.50”	0.75”

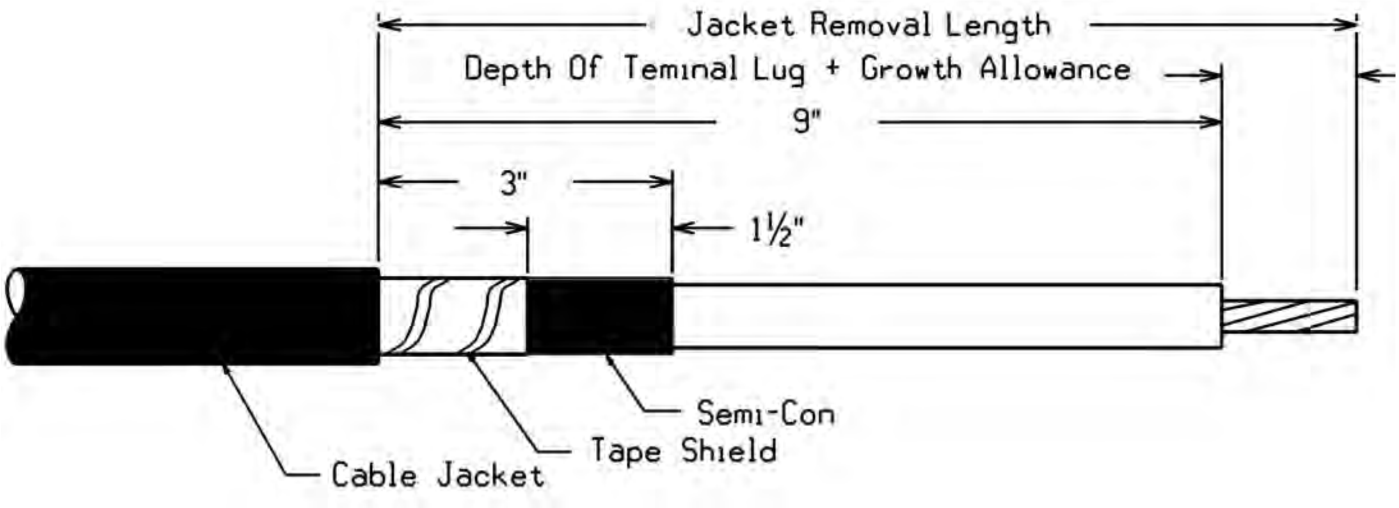


Figure 19

B. Install Ground Braid:

1. Select one of the mastic strips from the termination kit and remove the white release liners. Using light tension, apply a single wrap of mastic around the cable jacket ¼ inch from the cut edge. Cut off excess mastic. See Figure 20.

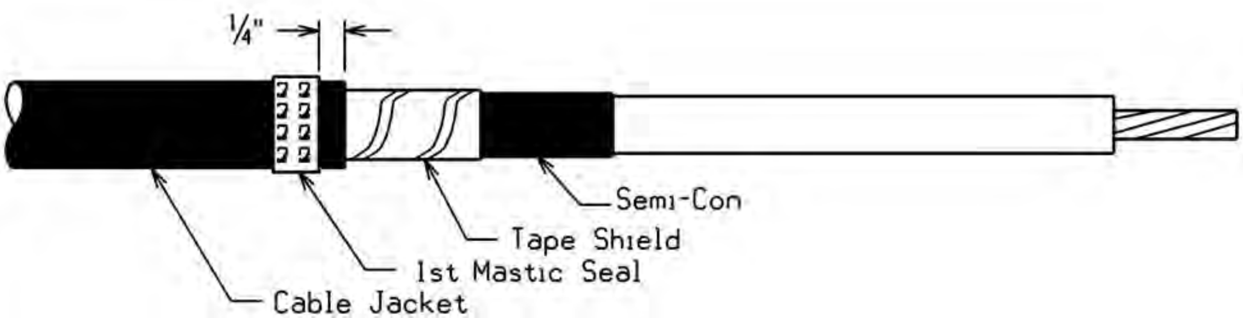


Figure 20

2. Position pre-formed "U" shaped ground braid over tape shield directly adjacent to the cable jacket cut edge. The long tails should extend over the cable jacket, with the solder block of one tail positioned over the mastic. Secure this tail to the cable jacket with a vinyl tape marker, located 4½ inches from the edge of the cable semi-con. See Figure 21.

   Note: Position this vinyl tape with care as it will serve as the marker for final termination location on the cable.

Supersedes 1/06 Issue – Added Termination Information For Preassembled Lashed Aerial Cable

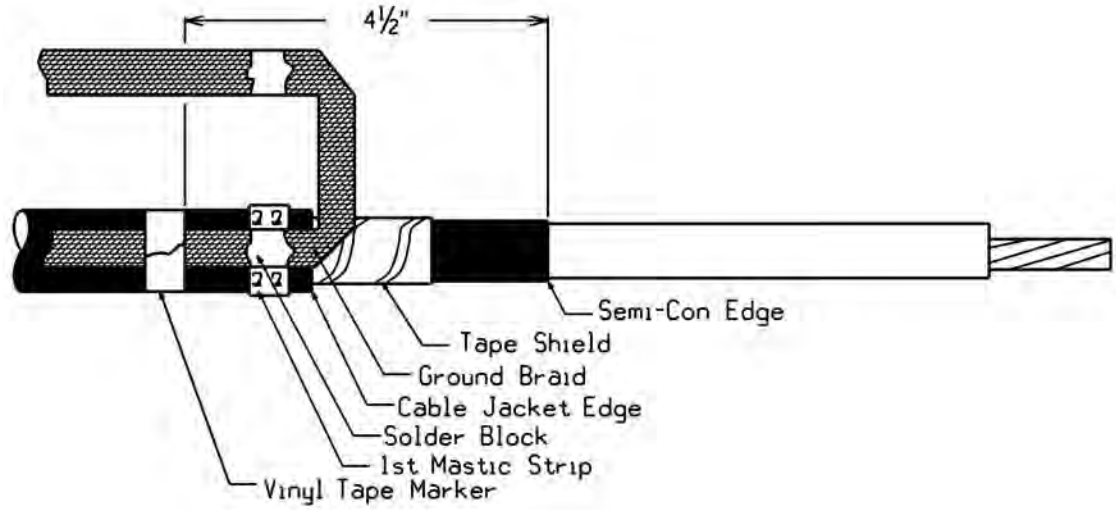


Figure 21

3. Wrap the ground braid around the tape shield and secure with a constant force spring. Using the second mastic strip from the termination kit, remove the liners and wrap mastic over the solder blocks and the first mastic strip. If the solder blocks overlap each other, mastic must be applied between the solder blocks as well as over them. See Figure 22.

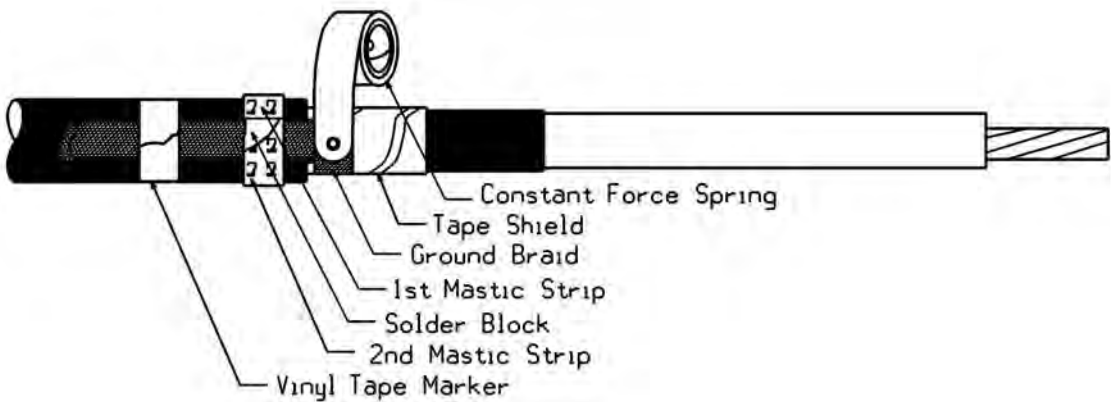


Figure 22

4. Wrap two half-lapped layers of vinyl tape around the mastic seal, constant force spring and exposed metallic shield. Do not allow the vinyl tape to lap onto the cable semi-con. **Note:** If vinyl tape was used to hold the copper tape in place in Step 2, remove it just prior to applying this tape. See Figure 23.

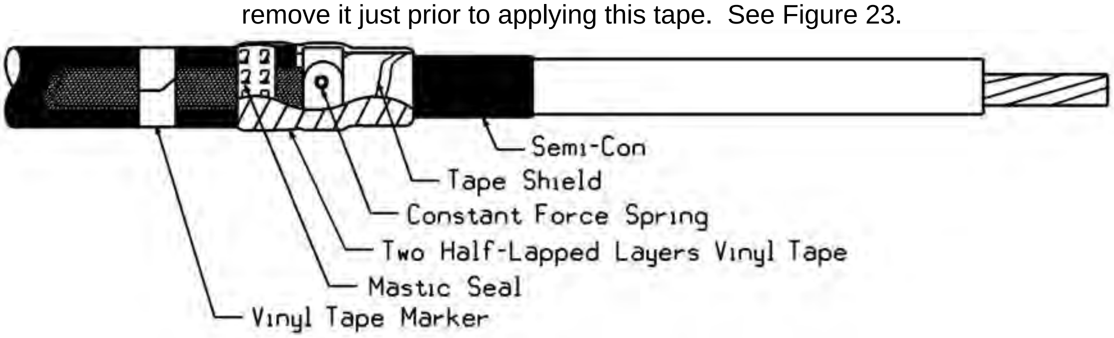


Figure 23

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*16890 lbs.	**TRANSVERSE**	2.5251 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	*0.1145 sq. in.	**VERTICAL**	7.307 Lb/Ft			
R. (@ 25˚C)	0.0526 Ω / 1000’	**TOTAL**	8.031 Lb/Ft	359	**NORMAL**	577
R. (@ 75˚C)	Ω / 1000’			446	**EMERGENCY**	626
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	19.06˚			
MESSENGER DIAMETER	0.4330”					
COMPLETE DIAMETER	2.5655”					
SYSTEM WEIGHT	3,834 lbs / 1000’					

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	2.76	3.12	3.36	3.84	4.44	5.28	5.76	6.24
75	6.24	6.96	7.68	8.52	9.60	11.04	11.76	12.48
100	11.40	12.48	13.68	15.00	16.44	18.36	19.32	20.28
125	18.12	19.80	21.24	23.04	24.84	27.24	28.44	29.64
150	26.64	28.80	30.60	32.76	34.92	37.68	39.00	40.44
175	38.64	41.16	43.44	45.84	48.36	51.48	52.92	54.36
200	53.76	56.64	59.16	61.80	64.44	67.80	69.48	71.04
225	71.52	74.64	77.40	80.16	83.04	86.52	88.20	89.88
250	91.92	95.16	98.04	100.92	103.92	107.52	109.20	110.88
275	114.72	118.08	120.96	123.96	126.96	130.80	132.48	134.28
300	139.92	143.28	146.28	149.40	152.40	156.24	158.04	159.84

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	5.28	5.40	3.72	5647
75	11.40	11.52	8.28	5931
100	19.32	19.44	14.64	6222
125	29.04	29.04	22.56	6496
150	40.20	40.20	32.28	6745
175	54.36	54.24	45.24	*6800
200	70.92	70.80	53.76	*6800
225	89.88	89.76	79.32	*6800
250	110.88	110.76	99.96	*6800
275	134.28	134.16	123.00	*6800
300	159.84	159.72	148.32	*6800
** Note: Design Specification Constraint*				

Supersedes 1/06 Issue – Revised Sag / Tension And Conductor Properties Tables

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	*16890 lbs.	TRANSVERSE	1.409 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	*0.1145 sq. in.	VERTICAL	7.130 Lb/Ft			
R. (@ 25˚C)	0.0526 Ω / 1000’	TOTAL	7.568 Lb/Ft	333	NORMAL	547
R. (@ 75˚C)	Ω / 1000’			416	EMERGENCY	593
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	11.12˚			
MESSENGER DIAMETER	0.4330”					
COMPLETE DIAMETER	3.228”					
WEIGHT	5,010 lbs / 1000’					

Note: Quantities identified with an “ * “ are for the messenger only. All other quantities are specified for the complete spacer cable system.

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	4894	4596	4353	4111	4783	4536	4336	4136	4688	4485	4320	4155	4610	4442	4306	4169
ACTUAL SPAN (FEET)																
50	3.8	4.1	4.3	4.6	3.9	4.1	4.3	4.6	4.0	4.2	4.4	4.5	4.1	4.2	4.4	4.5
60	5.5	5.9	6.2	6.6	5.7	6.0	6.3	6.6	5.8	6.1	6.3	6.5	5.9	6.1	6.3	6.5
70	7.5	8.0	8.5	9.0	7.7	8.1	8.5	8.9	7.9	8.2	8.6	8.9	8.0	8.3	8.6	8.9
80	9.8	10.5	11.1	11.7	10.1	10.6	11.1	11.7	10.3	10.8	11.2	11.6	10.5	10.9	11.2	11.6
90	12.4	13.3	14.0	14.8	12.7	13.4	14.1	14.8	13.0	13.6	14.2	14.7	13.3	13.8	14.2	14.7
100	15.4	16.4	17.3	18.3	15.7	16.6	17.4	18.2	16.1	16.8	17.5	18.1	16.4	17.0	17.5	18.1
110	18.6	19.8	20.9	22.1	19.0	20.1	21.0	22.1	19.4	20.3	21.1	22.0	19.8	20.5	21.2	21.9
120	22.1	23.6	24.9	26.3	22.7	23.9	25.0	26.3	23.1	24.2	25.2	26.1	23.6	24.5	25.2	26.1
130	26.0	27.6	29.2	30.9	26.6	28.0	29.4	30.8	27.2	28.4	29.5	30.7	27.7	28.7	29.6	30.6
140	30.1	32.1	33.9	35.8	30.8	32.5	34.1	35.8	31.5	32.9	34.3	35.6	32.1	33.3	34.3	35.5
150	34.6	36.8	38.9	41.1	35.4	37.3	39.1	41.0	36.1	37.8	39.3	40.8	36.9	38.2	39.4	40.8
160	39.3	41.9	44.2	46.8	40.3	42.5	44.5	46.7	41.1	43.0	44.7	46.4	41.9	43.5	44.9	46.4
170	44.4	47.3	49.9	52.8	45.5	47.9	50.2	52.7	46.4	48.6	50.5	52.4	47.3	49.1	50.6	52.4
180	49.8	53.0	56.0	59.2	51.0	53.7	56.3	59.1	52.1	54.5	56.6	58.8	53.1	55.0	56.8	58.7
190	55.4	59.1	62.4	66.0	56.8	59.9	62.8	65.8	58.0	60.7	63.1	65.5	59.1	61.3	63.2	65.4
200	61.4	65.4	69.1	73.1	62.9	66.3	69.5	73.0	64.3	67.2	69.9	72.6	65.5	67.9	70.1	72.5
210	67.7	72.1	76.2	80.6	69.4	73.1	76.7	80.4	70.8	74.1	77.1	80.0	72.2	74.9	77.3	79.9
220	74.3	79.2	83.6	88.5	76.1	80.3	84.2	88.3	77.8	81.4	84.6	87.8	79.3	82.2	84.8	87.7
230	81.3	86.5	91.4	96.7	83.2	87.7	92.0	96.5	85.0	88.9	92.4	96.0	86.7	89.8	92.7	95.9
240	88.5	94.2	99.5	105.3	90.6	95.5	100.1	105.1	92.5	96.8	100.7	104.5	94.3	97.8	100.9	104.4
250	96.0	102.2	108.0	114.2	98.3	103.7	108.7	114.0	100.4	105.1	109.2	113.4	102.4	106.1	109.5	113.3
260	103.8	110.6	116.8	123.6	106.4	112.1	117.5	123.3	108.6	113.6	118.1	122.6	110.7	114.8	118.4	122.5
270	112.0	119.3	126.0	133.2	114.7	120.9	126.7	133.0	117.1	122.5	127.4	132.3	119.4	123.8	127.7	132.1
280	120.4	128.2	135.5	143.3	123.3	130.0	136.3	143.0	126.0	131.8	137.0	142.2	128.4	133.1	137.4	142.1
290	129.2	137.6	145.3	153.7	132.3	139.5	146.2	153.4	135.1	141.4	147.0	152.6	137.8	142.8	147.3	152.4
300	138.2	147.2	155.5	164.5	141.6	149.3	156.5	164.2	144.6	151.3	157.3	163.3	147.4	152.8	157.7	163.1

Supersedes 7/07 Issue – Revised Sag / Tension And Conductor Properties Tables

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	3.6	4.1	4.4	5.0	5.6	6.4	7.1	7.6
75	8.4	9.2	10.0	11.0	12.1	13.3	14.3	15.0
100	15.2	16.6	17.8	19.2	20.6	22.2	23.5	24.5
125	24.5	26.3	27.8	29.6	31.4	33.3	34.7	35.8
150	36.1	38.3	40.2	42.1	44.2	46.3	48.0	49.2
175	50.2	52.6	54.7	57.0	59.2	61.5	63.3	64.7
200	66.6	69.2	71.5	73.9	76.3	78.8	80.8	82.2
225	85.4	88.2	90.6	93.2	95.8	98.3	100.4	101.9
250	106.7	109.6	112.1	114.7	117.4	120.1	122.2	123.7
275	130.2	133.2	135.8	138.6	141.2	144.0	146.2	147.8
300	156.1	159.2	161.9	164.8	167.5	170.4	172.6	174.2

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	5.0	4.9	4.2	5431
75	11.2	10.9	9.5	5523
100	19.4	19.2	17.0	5615
125	30.0	29.6	26.9	5698
150	42.7	42.4	39.0	5767
175	57.6	57.1	53.5	5825
200	74.6	74.3	70.2	5872
225	94.0	93.5	89.3	5910
250	115.7	115.1	110.6	5941
275	139.6	139.0	134.3	5967
300	165.7	165.2	160.3	5988
** Note: Design Specification Constraint*				

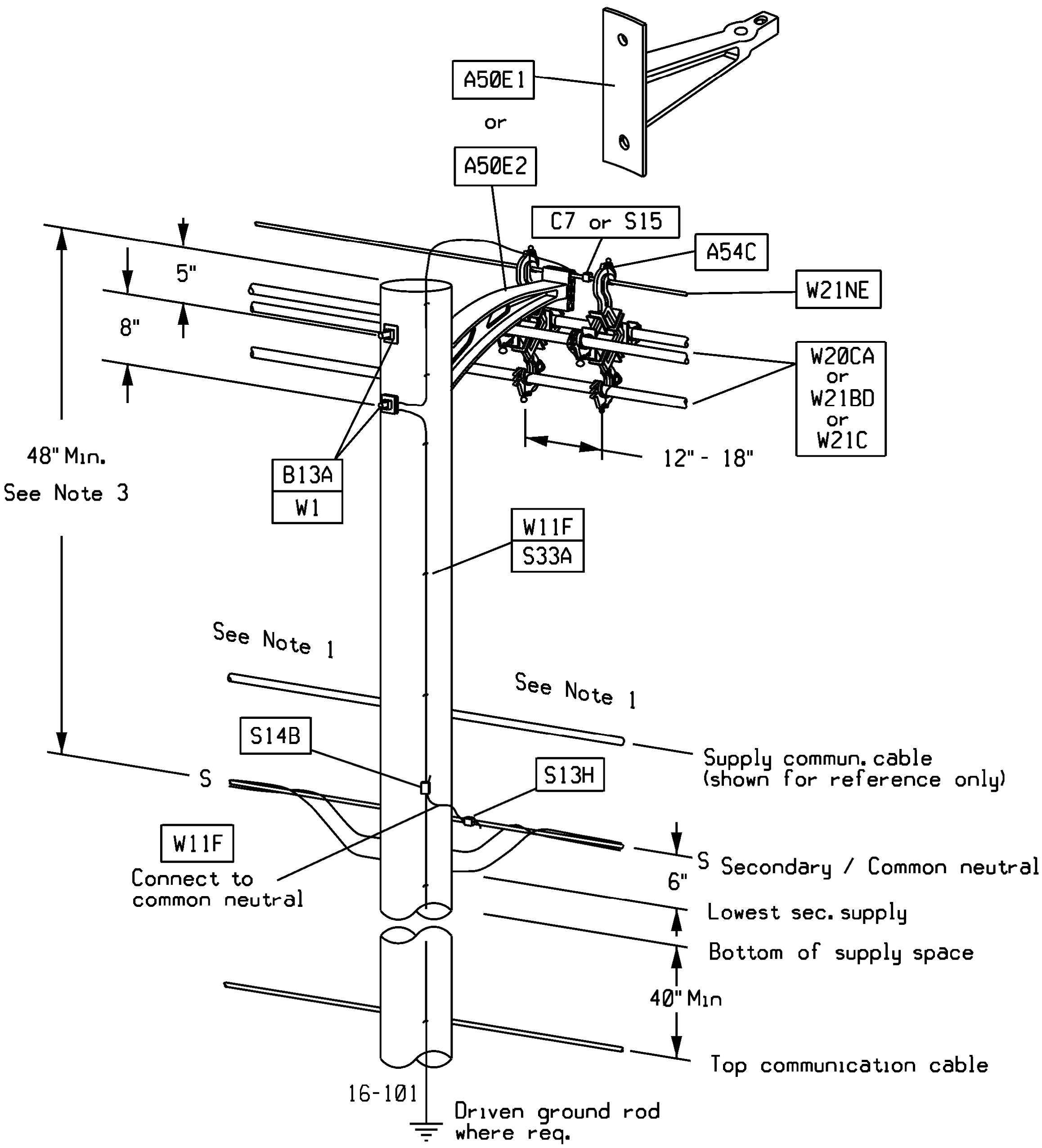
Supersedes 7/07 Issue – Revised Sag / Tension And Conductor Properties Tables

Spacer Cable Construction Drawings

15 kV & Below Grounded Distribution Systems

Doc. # ST. 16.00.003

MU = @16-101B(X)C(Y)	0-15 kV, (X) = Brkt. Length, (Y) = Wire Size



Notes:

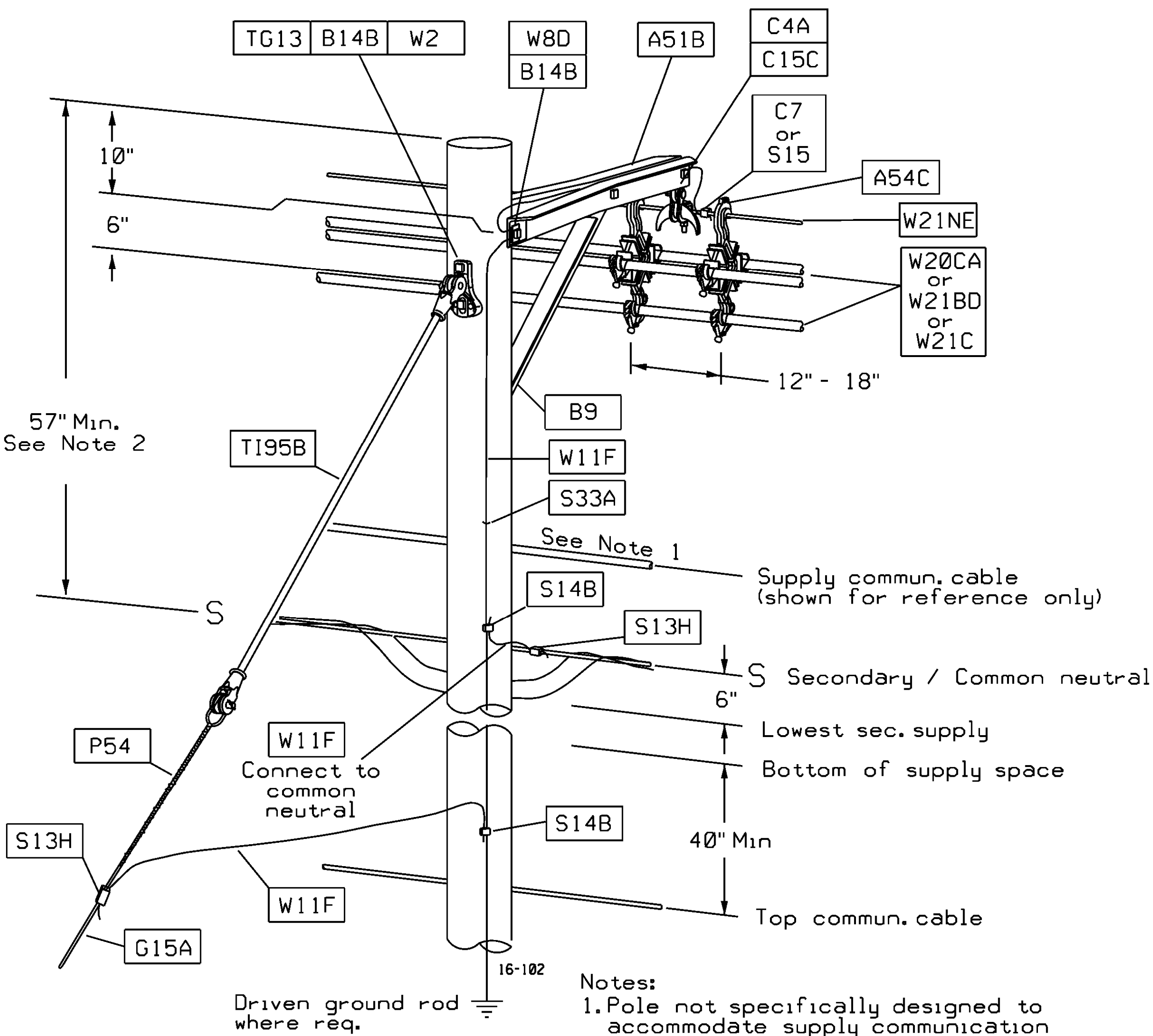
1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. •For reference purposes, 24" tangent bracket design depicted in installation below (STD ITEM A50E2).
3. Minimum dimension based on 1/0 spacer cable conductor on a 40/40 J.O. Pole.

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

15KV STRAIGHT LINE POLE WITH 14" OR 24" TANGENT MAX. LINE ANGLE 6°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	16-101		

MU = @16-102C(Y)	0-15 kV, 44” Tan., (Y) = Wire Size

Supersedes 7/09 Issue - Updated Spacer cable STD ID’s



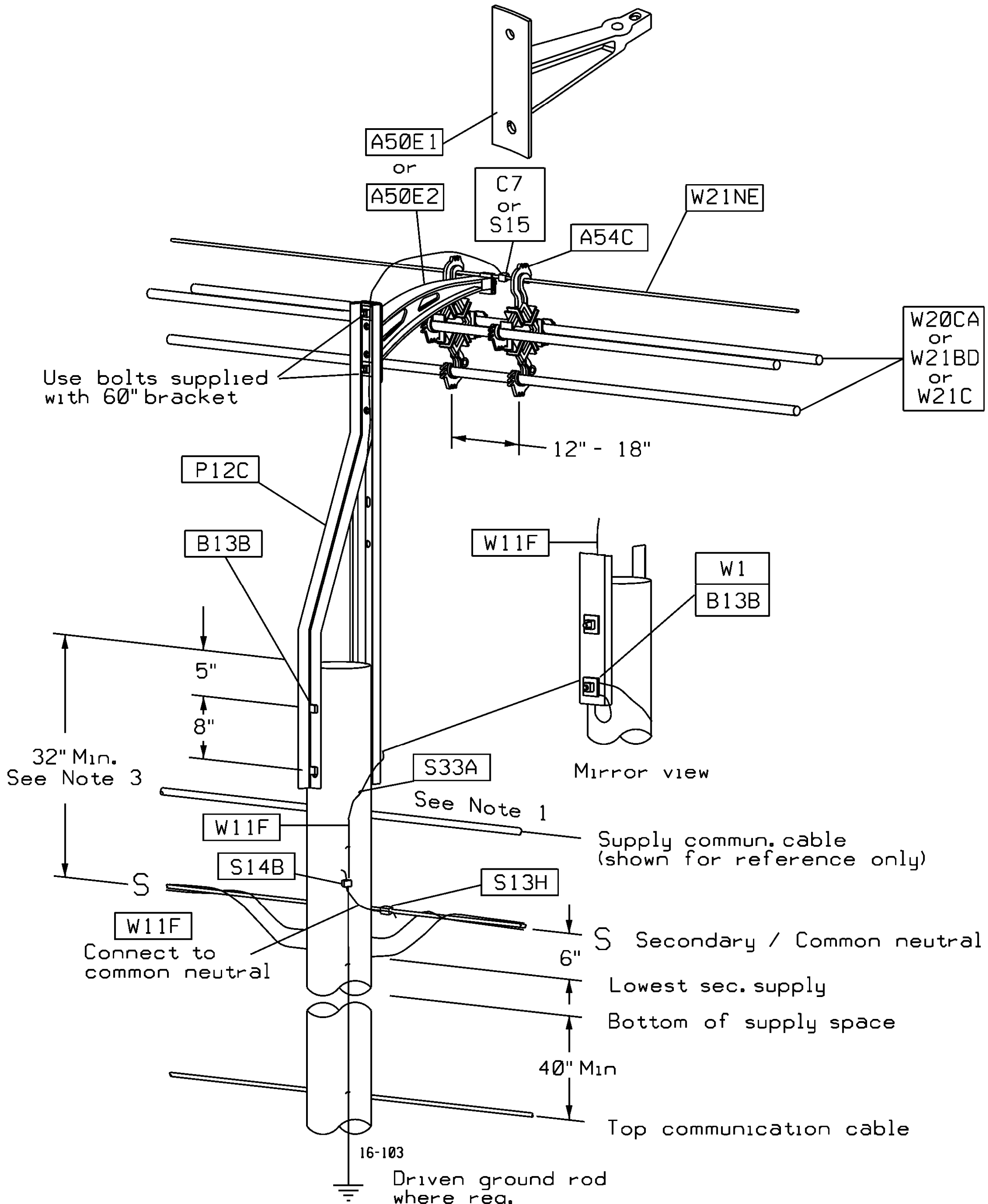
Notes:

1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. Minimum dimension based on 1/0 spacer cable conductor on a 40/40 J.O. Pole.

15KV STRAIGHT LINE POLE WITH 44” TANGENT MAX. LINE ANGLE 6°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-102	ISSUE 7/10

Doc. # ST. 16.00.003

MU = @16-103B(X)C(Y)	0-15 kV, (X) = Brkt. Length, (Y) = Wire Size



Supersedes 7/09 Issue - Updated Spacer cable STD ID's

Notes:

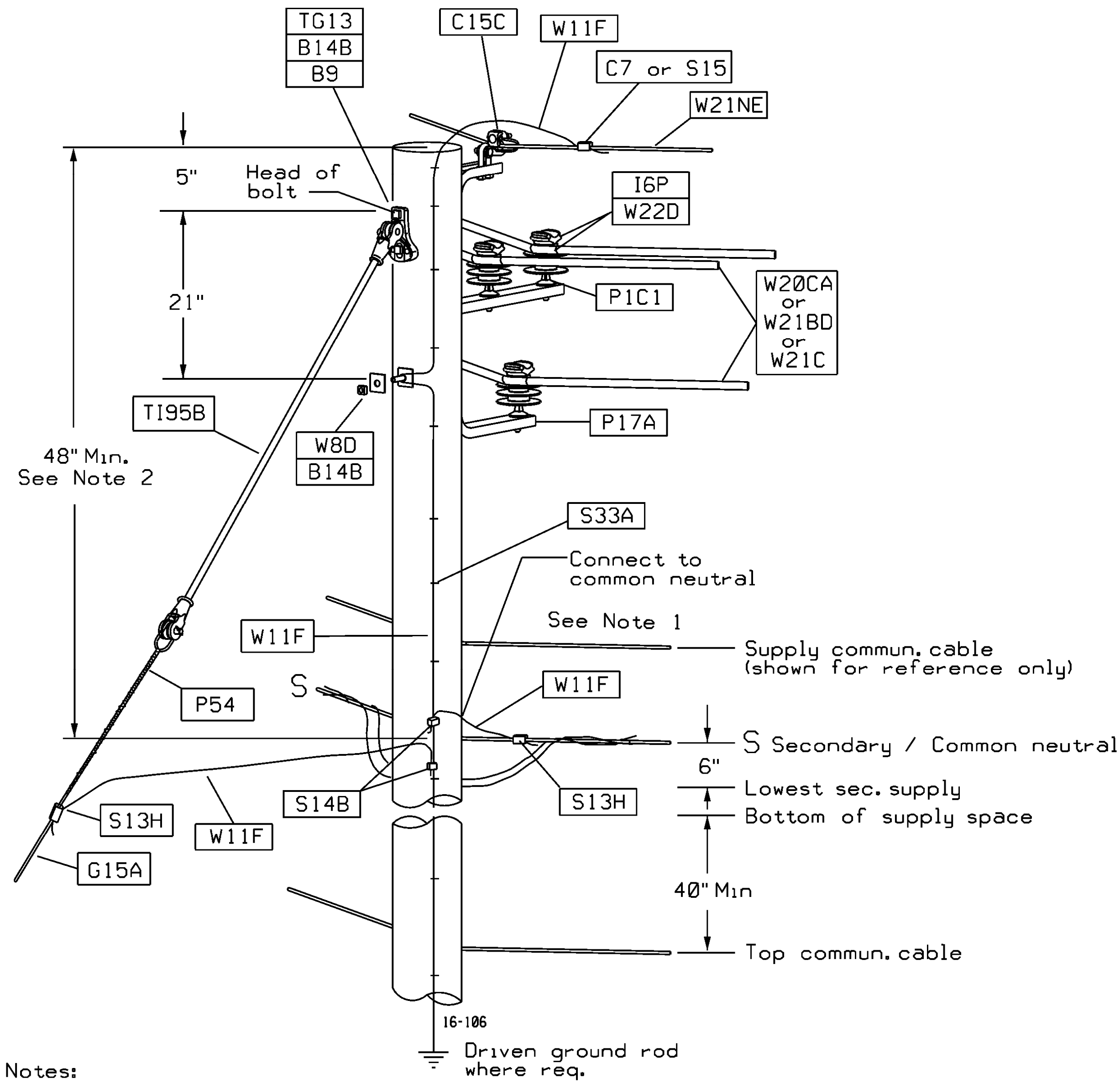
1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. "For reference purposes, 24" tangent bracket design shown below as default (STD ITEM A50E2).
3. Minimum dimension based on 40/40 J.O. Pole.

15KV STRAIGHT LINE POLE WTIH 14" OR 24" TANGENT ON POLE TOP EXTENSION MAX. LINE ANGLE 6°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	16-103		

Doc. # ST. 16.00.003

MU = @16-106C(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/09 Issue - Updated Spacer cable STD ID's



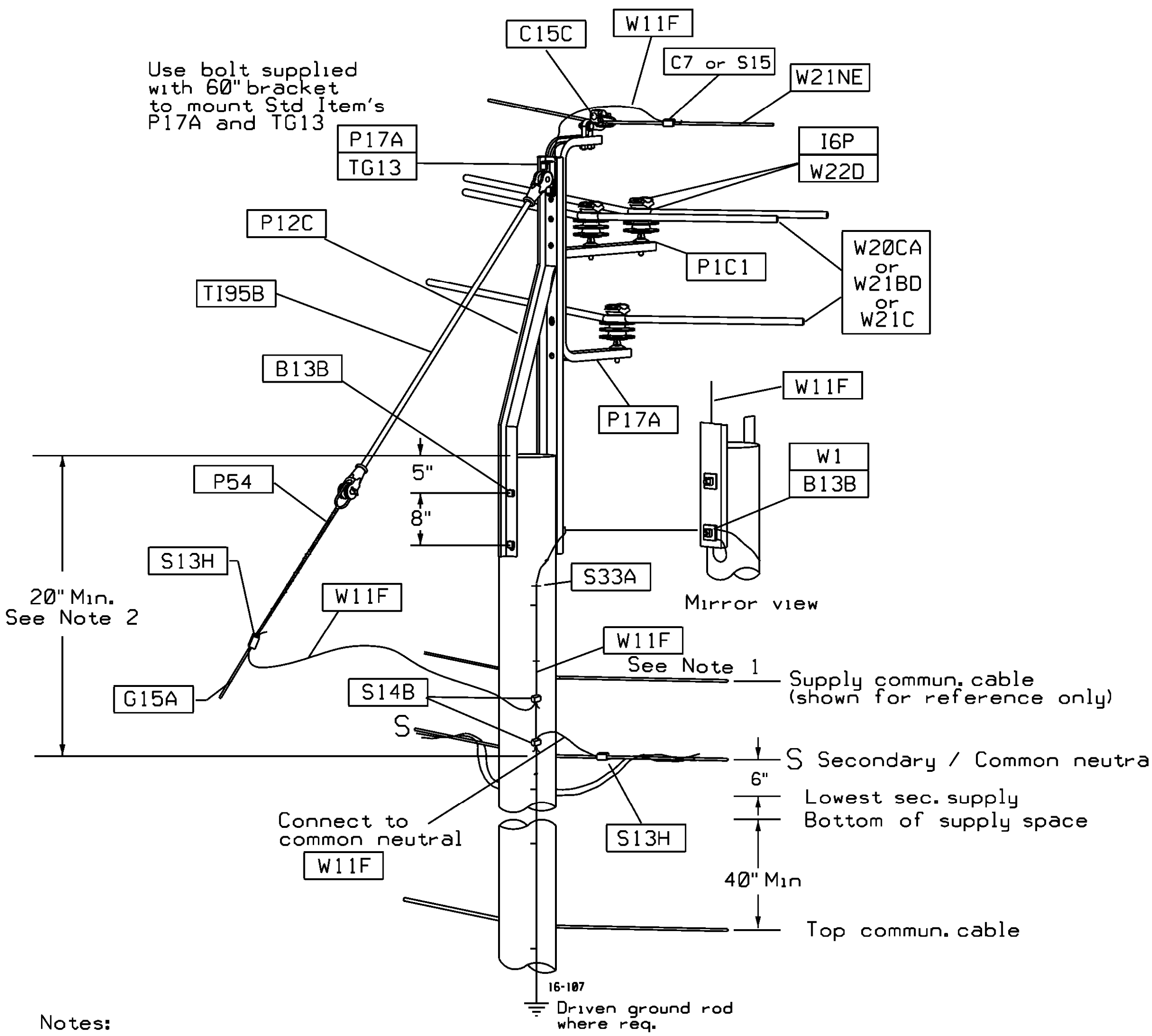
Notes:

1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. Minimum dimension based on 1/0 spacer cable conductor on a 40/40 J.O. Pole.

15KV LINE ANGLE POLE WITH E – BRACKET
LINE ANGLES 7° - 30°

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	16-106	7/10 12/12

MU = @16-107C(Y)	0-15 kV (Y) = Wire Size



Notes:

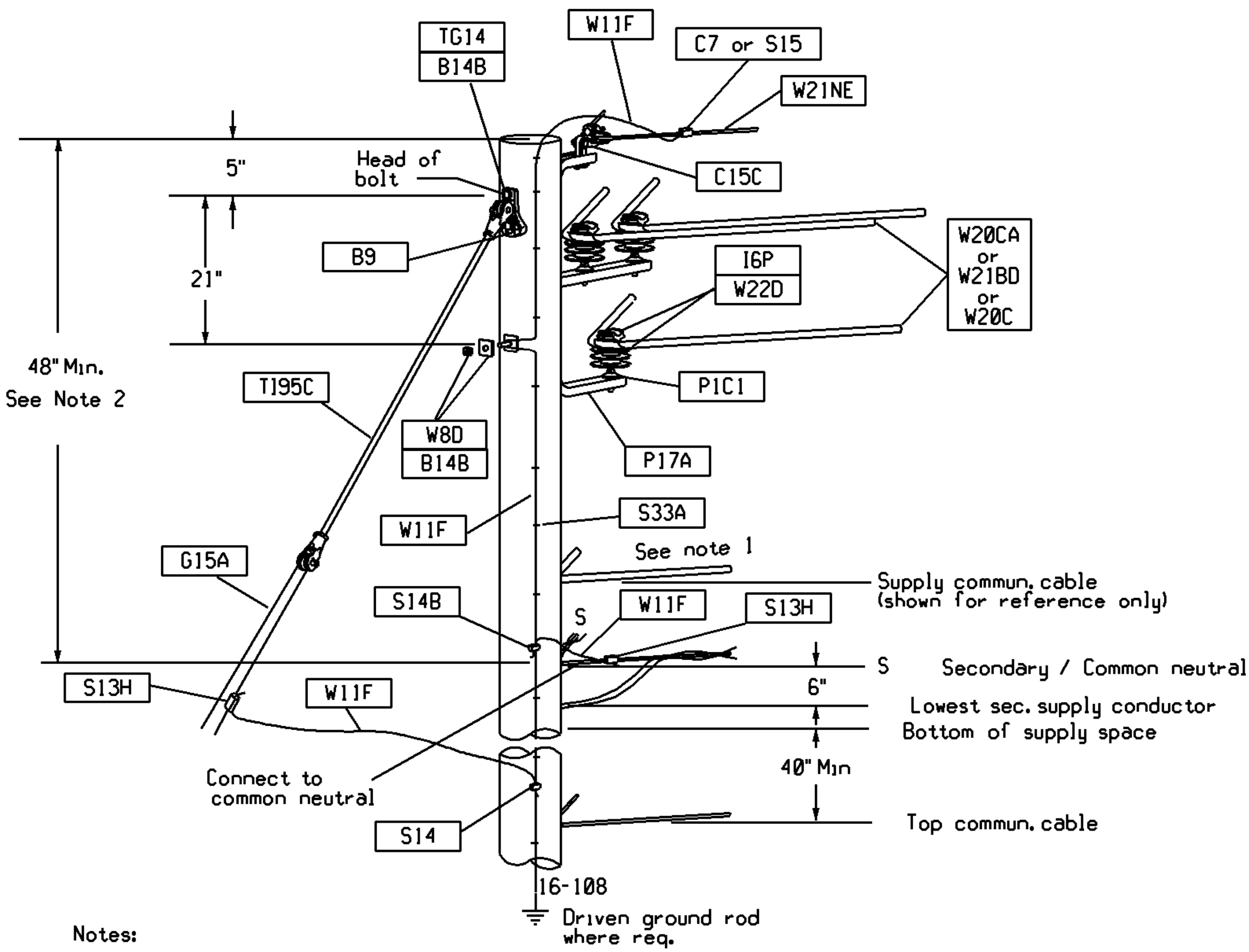
1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. Minimum dimension based on 1/0 spacer cable conductor on a 40/40 J.O. Pole.

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

15KV LINE ANGLE POLE WITH E – BRACKET ON POLE TOP EXTENSION LINE ANGLES 7° - 30°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	16-107		

MU = @16-108C(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/09 Issue - Updated Spacer cable STD ID's



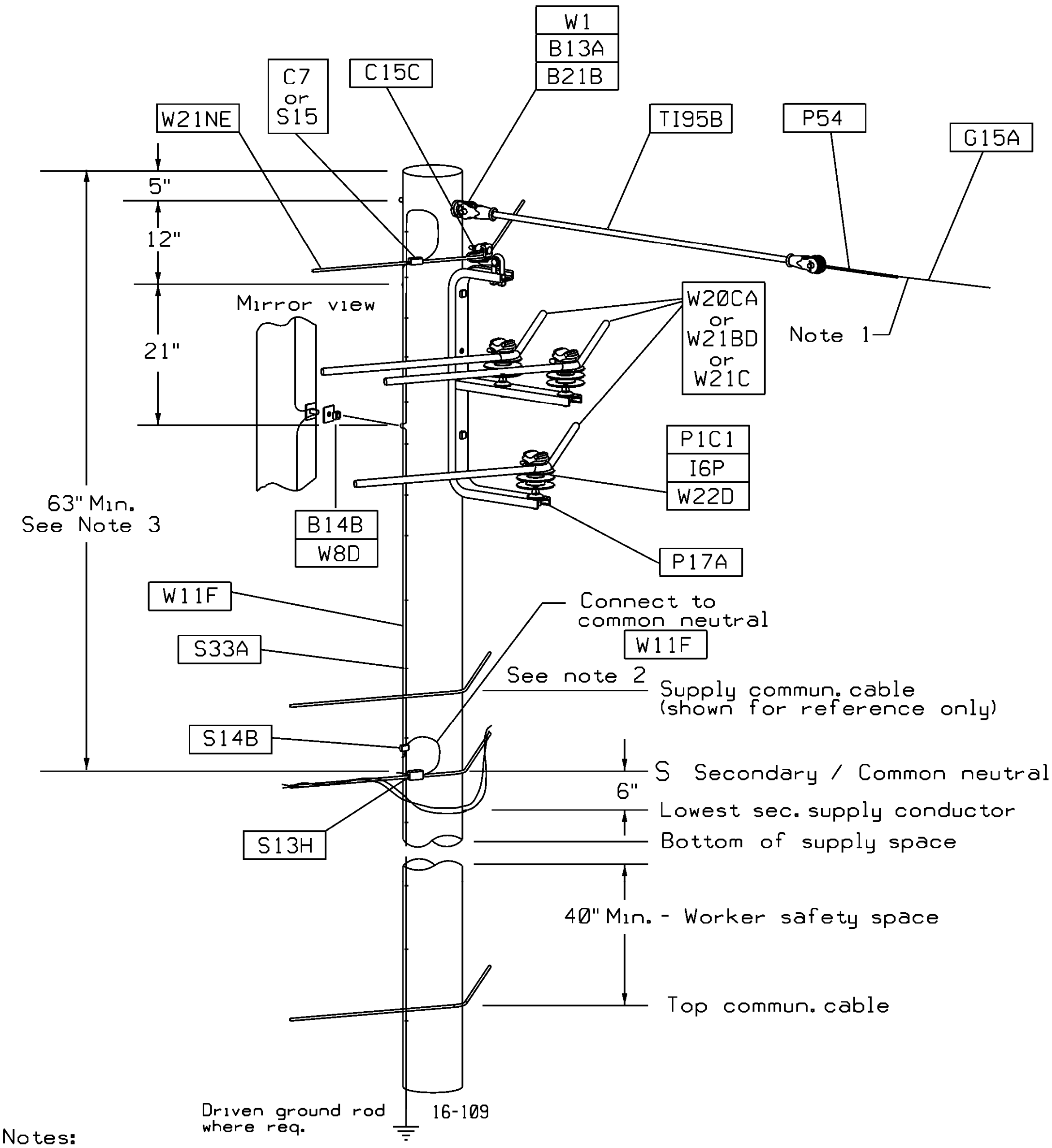
Notes:

1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. Minimum dimension based on 1/0 spacer cable conductor on a 40/40 J.O. Pole.

15KV LINE ANGLE POLE WITH E – BRACKET – HEAVY CORNER LINE ANGLES 31° - 60°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-108	ISSUE 7/10

 Doc. # ST. 16.00.003

MU = @16-109C(Y)	0-15 kV (Y) = Wire Size



Notes:

1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. Guy per section 3 - Guying.
3. Minimum dimension based on a 40/40 J.O. Pole.

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

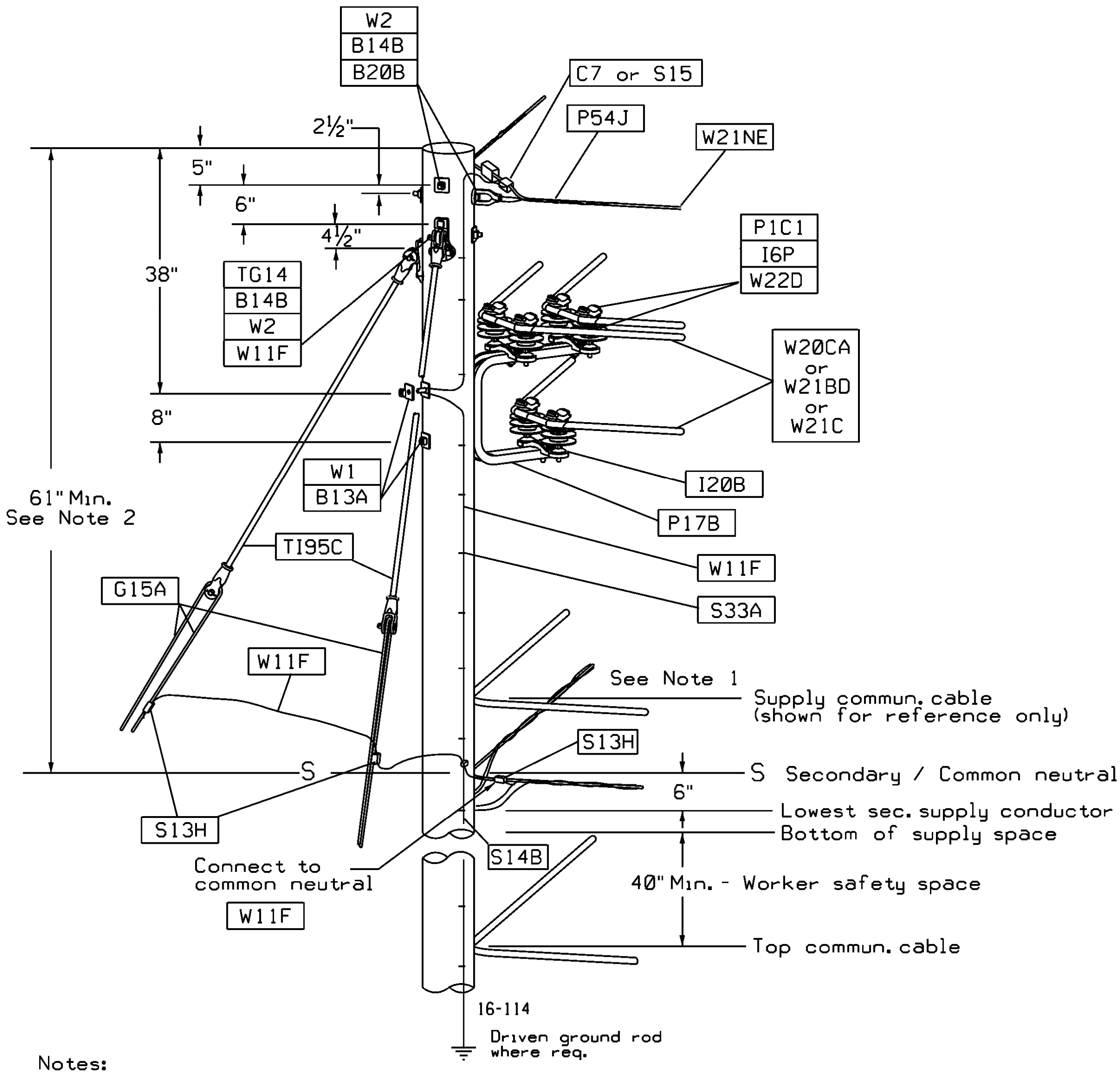
15KV LINE ANGLE POLE WITH E – BRACKET – 45° PULL INTO POLE

ISSUE	PAGE NUMBER		
7/10	16-109	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

 Doc. # ST. 16.00.003

MU = @16-114C(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/09 Issue - Updated Spacer cable STD ID's



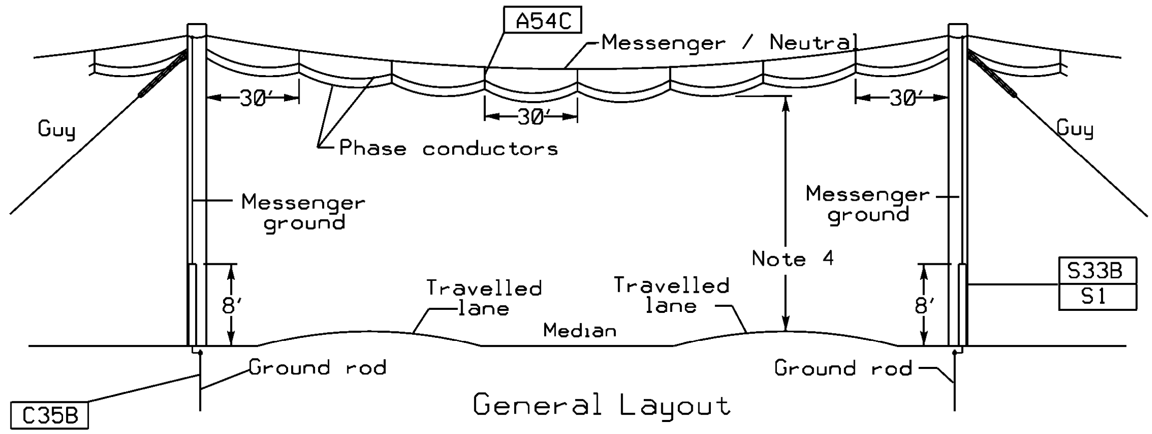
Notes:

1. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
2. Minimum dimension based on 40/40 J.O. Pole.

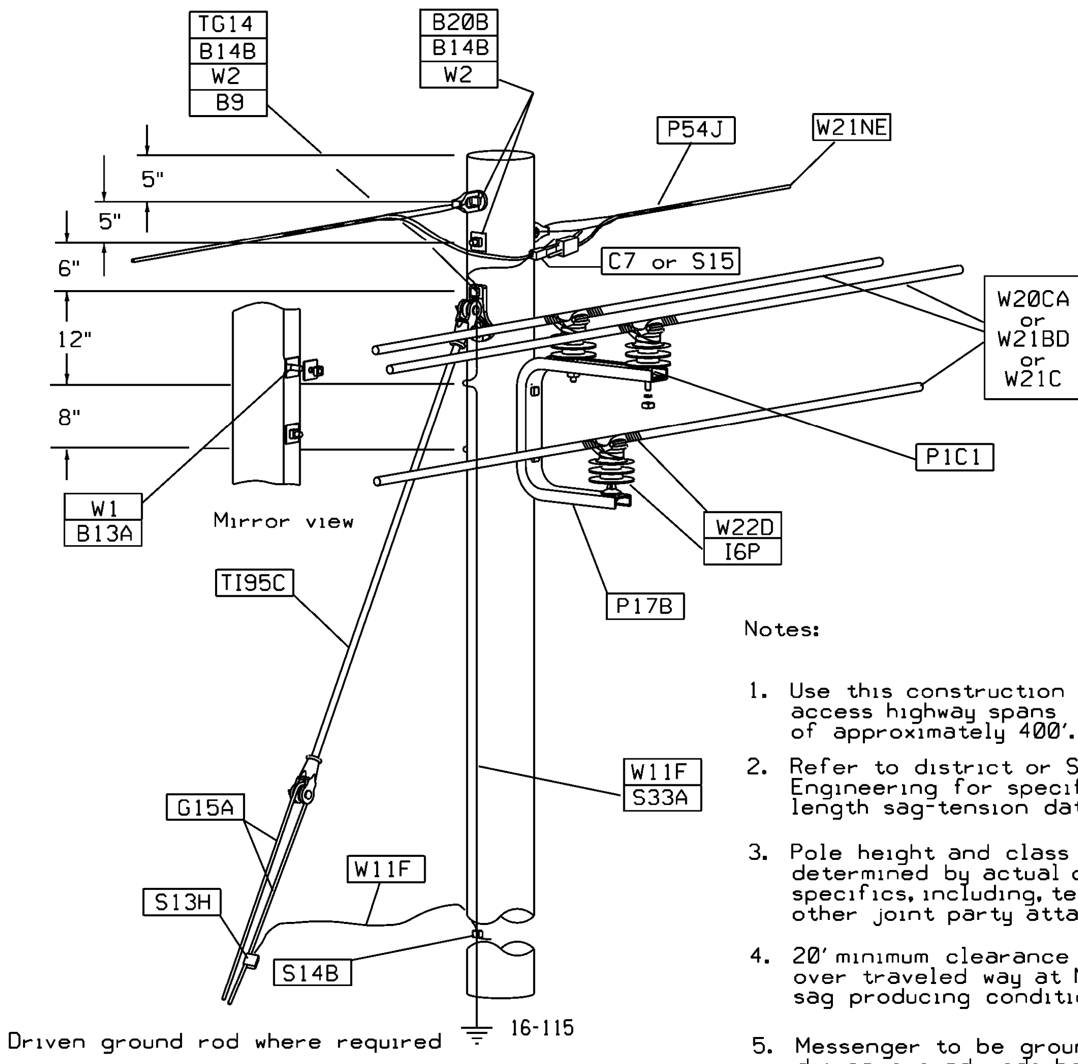
15KV LINE POLE WITH C – BRACKET – LINE ANGLES 61°-90°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-114	ISSUE 7/10

Doc. # ST. 16.00.003

MU = @16-115C(Y)	0-15 kV (Y) = Wire Size



General Layout



Crossing Pole Detail

Notes:

1. Use this construction for limited access highway spans of approximately 400'.
2. Refer to district or Standards Engineering for specific span length sag-tension data.
3. Pole height and class to be determined by actual crossing specifics, including, terrain and other joint party attachments.
4. 20' minimum clearance required over traveled way at NESC worst sag producing condition.
5. Messenger to be grounded to driven ground rods both sides of crossing.

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

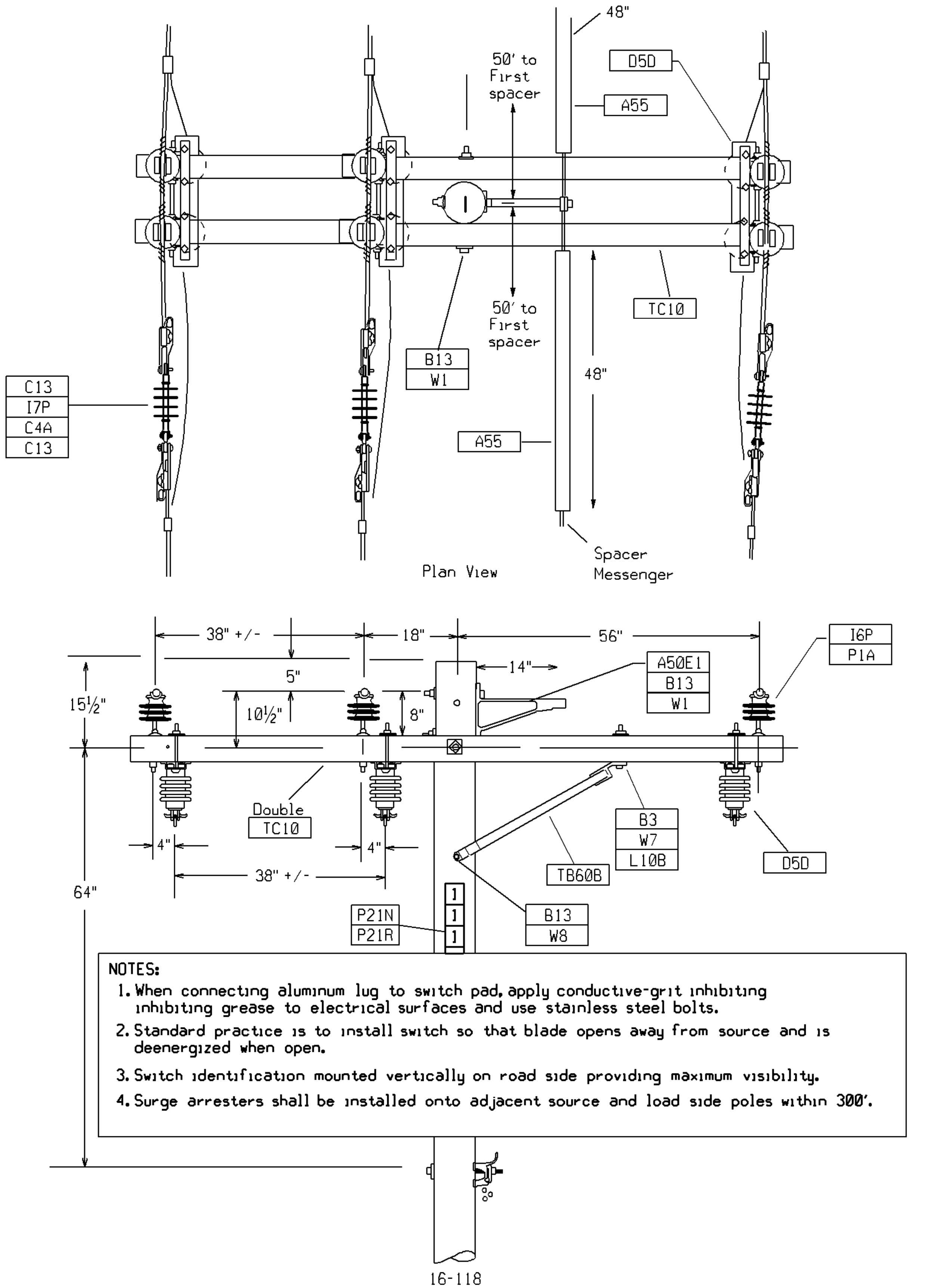
15KV LINE POLE WITH C – BRACKET – HIGHWAY CROSSING POLE

ISSUE	PAGE NUMBER		
7/10	16-115	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Doc. # ST. 16.00.003

MU = @16-11810D15K	UNDERARM DISC, 0º-10º, 15KV	MU = @16-1181120D15K	UNDERARM DISC, 11º-20º, 15KV

Supersedes 7/08 Issue - Updated MU.



NOTES:

1. When connecting aluminum lug to switch pad, apply conductive-grit inhibiting inhibiting grease to electrical surfaces and use stainless steel bolts.
2. Standard practice is to install switch so that blade opens away from source and is deenergized when open.
3. Switch identification mounted vertically on road side providing maximum visibility.
4. Surge arresters shall be installed onto adjacent source and load side poles within 300′.

15KV UNDERSLUNG 15KV DISCONNECT SWITCH TANGENT LINE AND ANGLES 0˚ - 6˚

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-118	7/09

MU = @16-122SCLBSW15KV	SC, PREASSB SW LOADBREAK, 15KV

Pole on either side of switch pole must be 40 Ft. Minimum

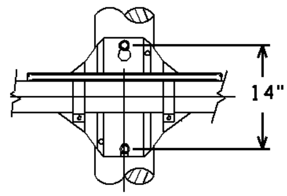


Figure 1
Pole Mounting Detail

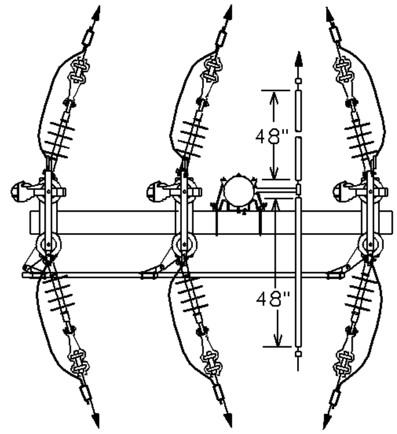


Figure 2 - Plan View

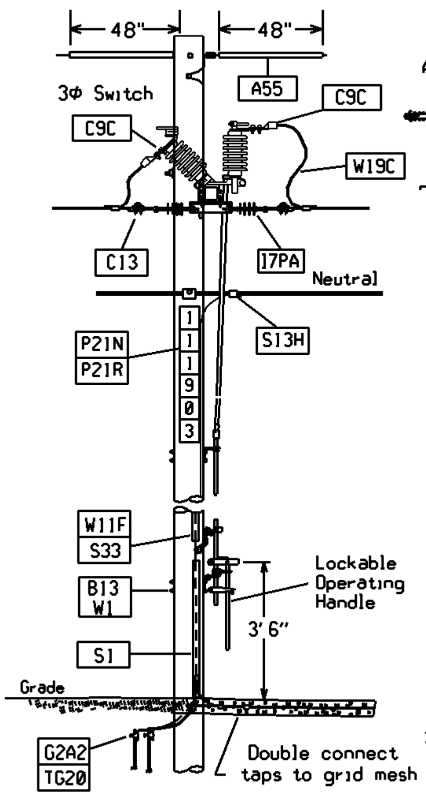


Figure 3

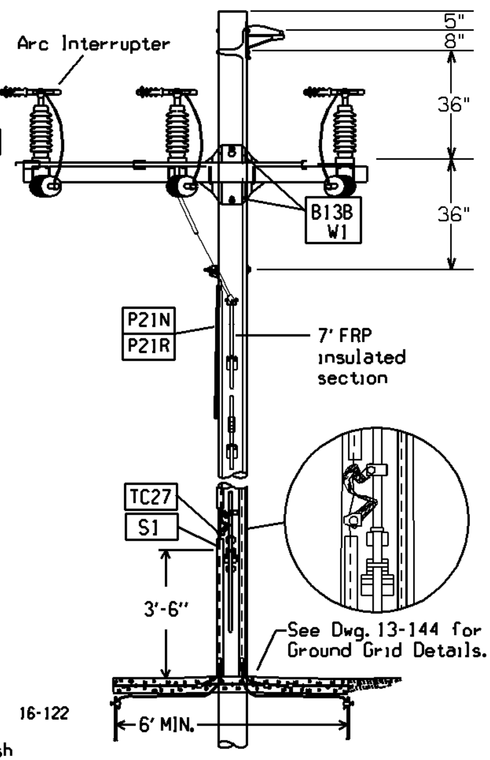


Figure 4

NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use 5/8" thru bolts to mount operating rod guides.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechanism shall be locked in the open or closed position.
8. Switch identification mounted vertically on road side providing maximum visibility.

Supersedes 7/08 Issue - Updated MU

MU = @16-123SCLBSW15KVWXA	SC, PREASSB SW LOADBREAK 15KV WITH CROSSARM

Poles on either side of switch must be 40 Ft. (Minimum)

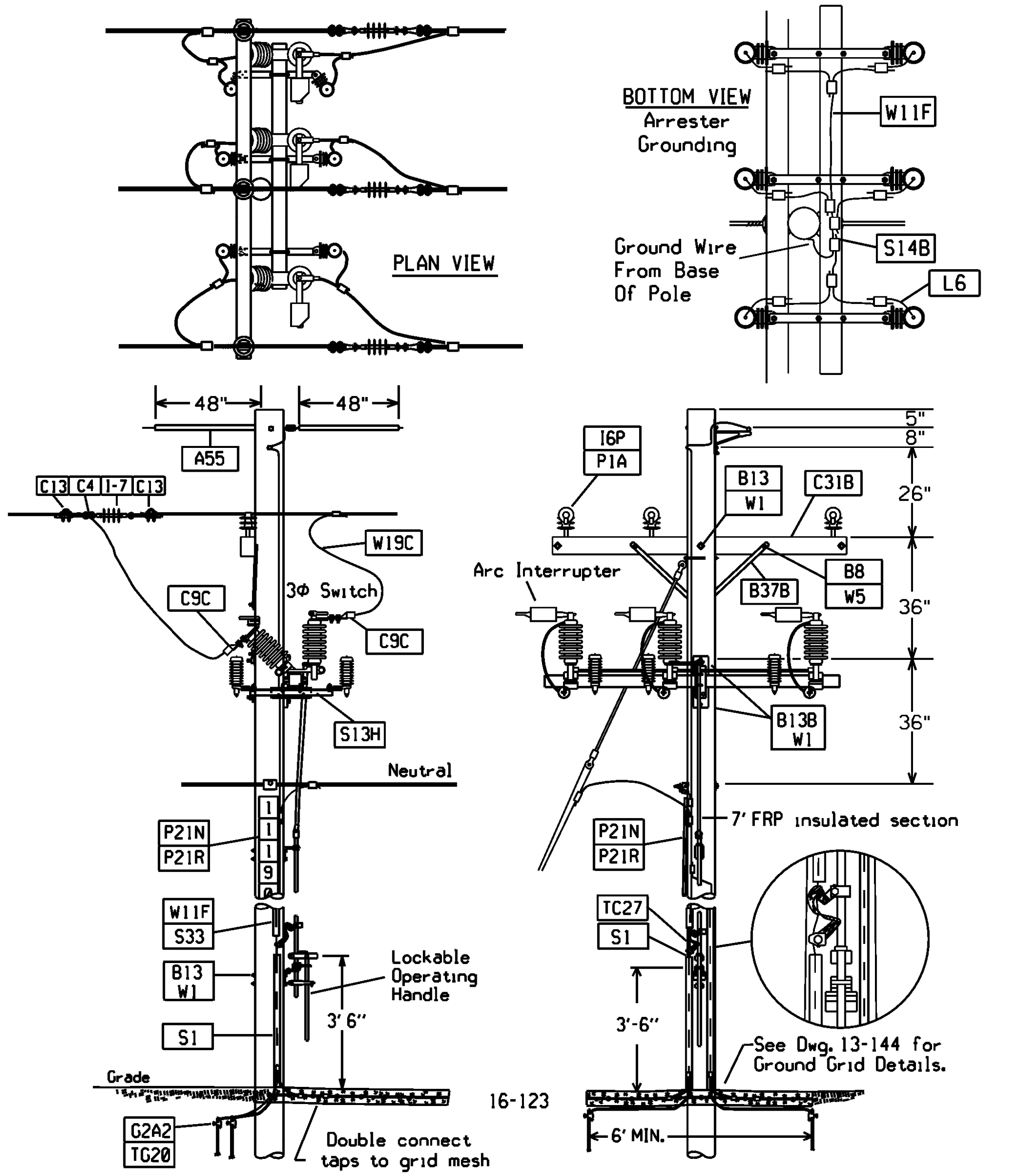


Figure 1 Figure 2

NOTES:

1. Surge arresters shall be installed onto the loadbreak arrester provisions provided or onto adjacent source and load side poles within 300'.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees. 0° to 10° angle drawing shown.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechansim shall be locked in the open or closed position.
8. Switch identification mounted vertically on road side providing maximum visibility.

Supersedes 7/08 Issue - Updated MU.

 Doc. # ST. 16.00.003

MU = @16-124SCXALBSW15KV	SC – CROSSARM, PREASSB SW, LOADBREAK, 15KV

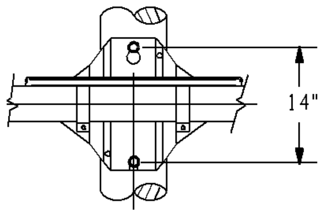


Figure 1
Pole Mounting Detail

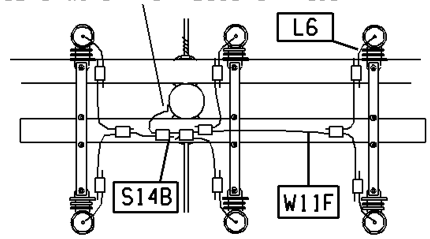


Figure 2
Bottom View - Arrester Grounding

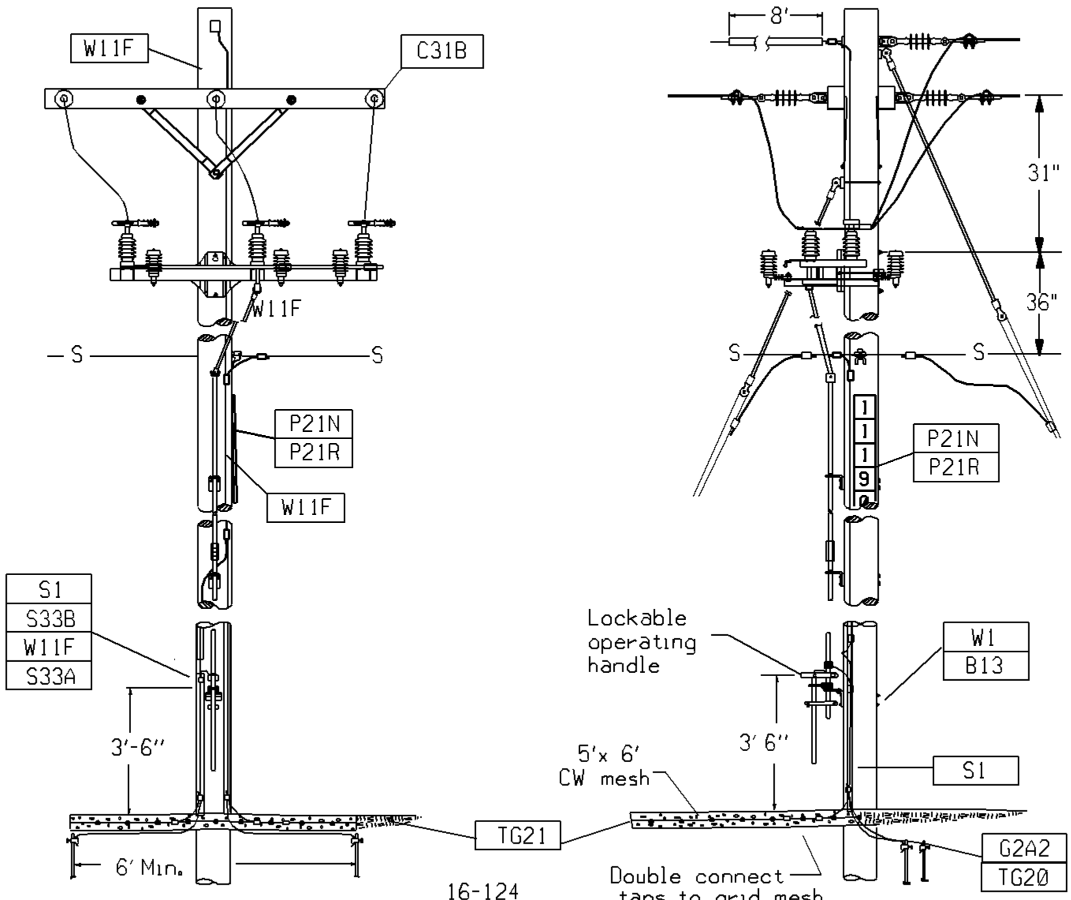


Figure 3

16-124

Figure 4

NOTES:

1. Surge arresters shall be installed onto the loadbreak arrester provisions provided or onto adjacent source and load side poles within 300'.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use S30 stud at riser switches only where termination may not be stripped.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees. 0° to 10° angle drawing shown.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechansim shall be locked in the open or closed position.
8. Switch identification mounted vertically on road side providing maximum visibility.

Supersedes 1/06 Issue – Revised Construction Detail And Surge Arrester Application - Refer To 9-2XX For Maximum Span Calculation Detail

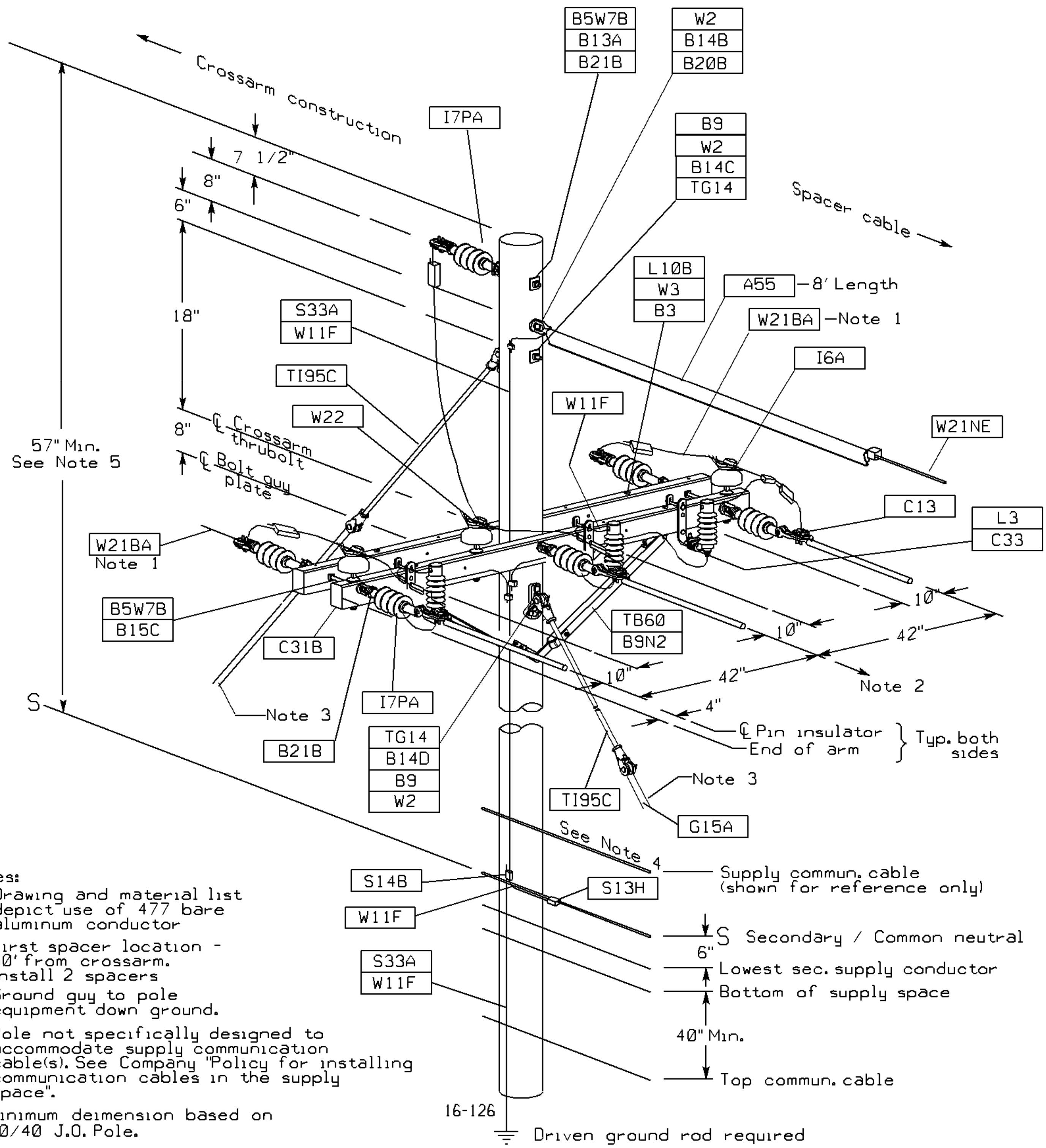
15KV PREASSEMBLED LOADBREAK SWITCH – SPACER CABLE TO CROSSARM CONSTRUCTION DEADEND – HORIZONTAL MOUNTED

ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	16-124		

Doc. # ST. 16.00.003

MU = @16-126C(Y)	0-15kV (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.

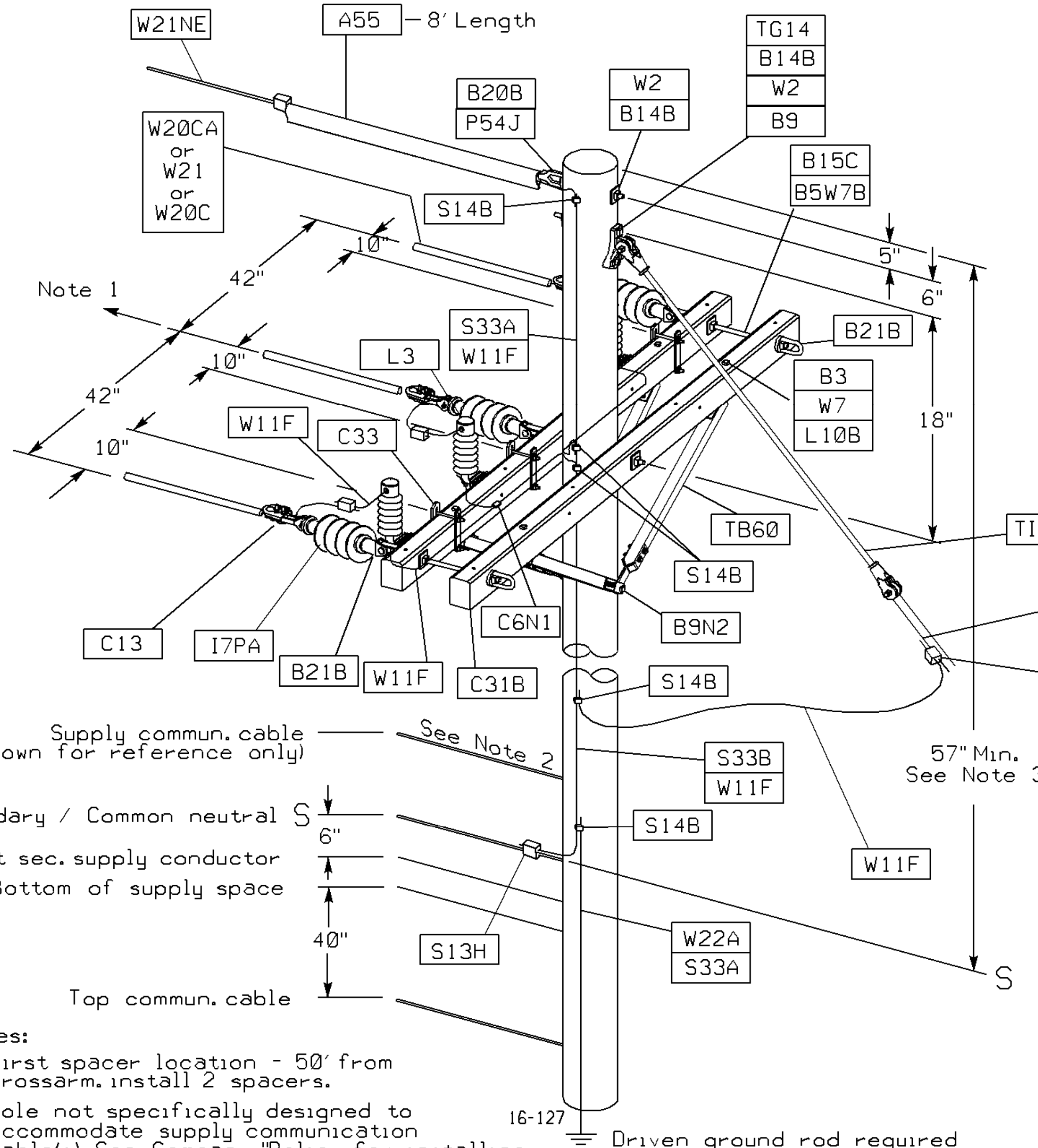


Notes:

1. Drawing and material list depict use of 477 bare aluminum conductor
2. First spacer location - 50' from crossarm. install 2 spacers
3. Ground guy to pole equipment down ground.
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
5. Minimum deimension based on 40/40 J.O. Pole.

15KV LINE POLE – DEADEND – SPACER CABLE TO CROSSARM CONSTRUCTION			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 16-126	ISSUE: 7/09

MU = @16-127C(Y)	0-15 kV (Y) = Wire Size



Notes:

1. First spacer location - 50′ from crossarm. install 2 spacers.
2. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
3. Minimum dimension based on 40/40 J.O. Pole.

Supersedes 7/08 Issue - Updated MU.

15KV LINE POLE DEADEND – END OF LINE

ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	16-127		

APPLICATION – Use when field conditions do not readily allow for incoming and outgoing spacer cable systems to phase. Phase identification by pole stenciling of incoming and outgoing systems is recommended. The typical phasing diagram is shown below. Construction details of Transition Pole are shown on the Page 16-131.

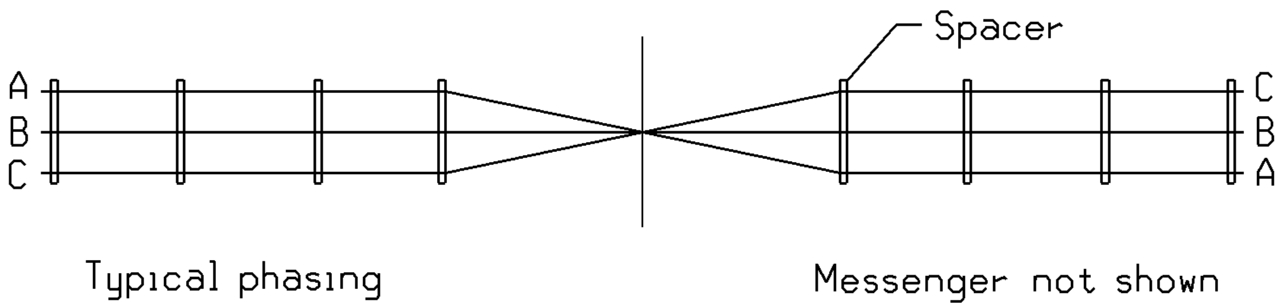
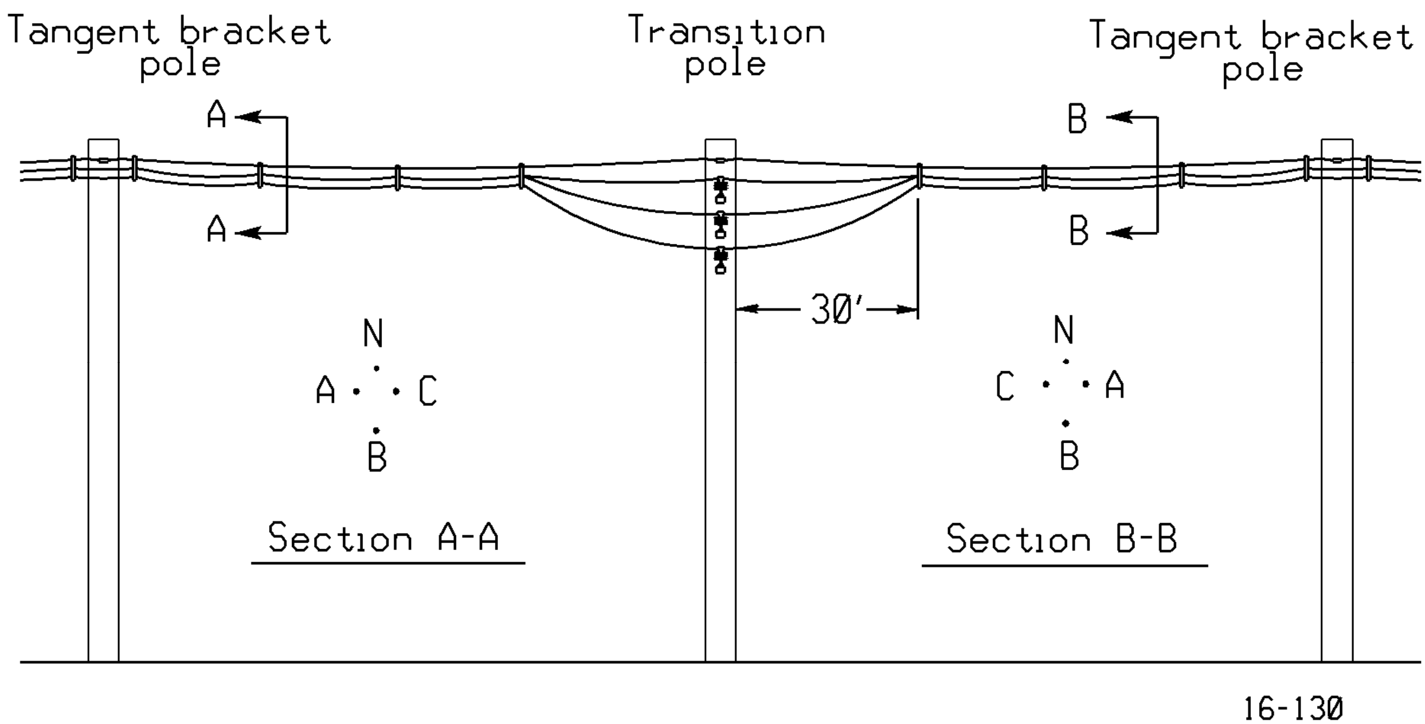
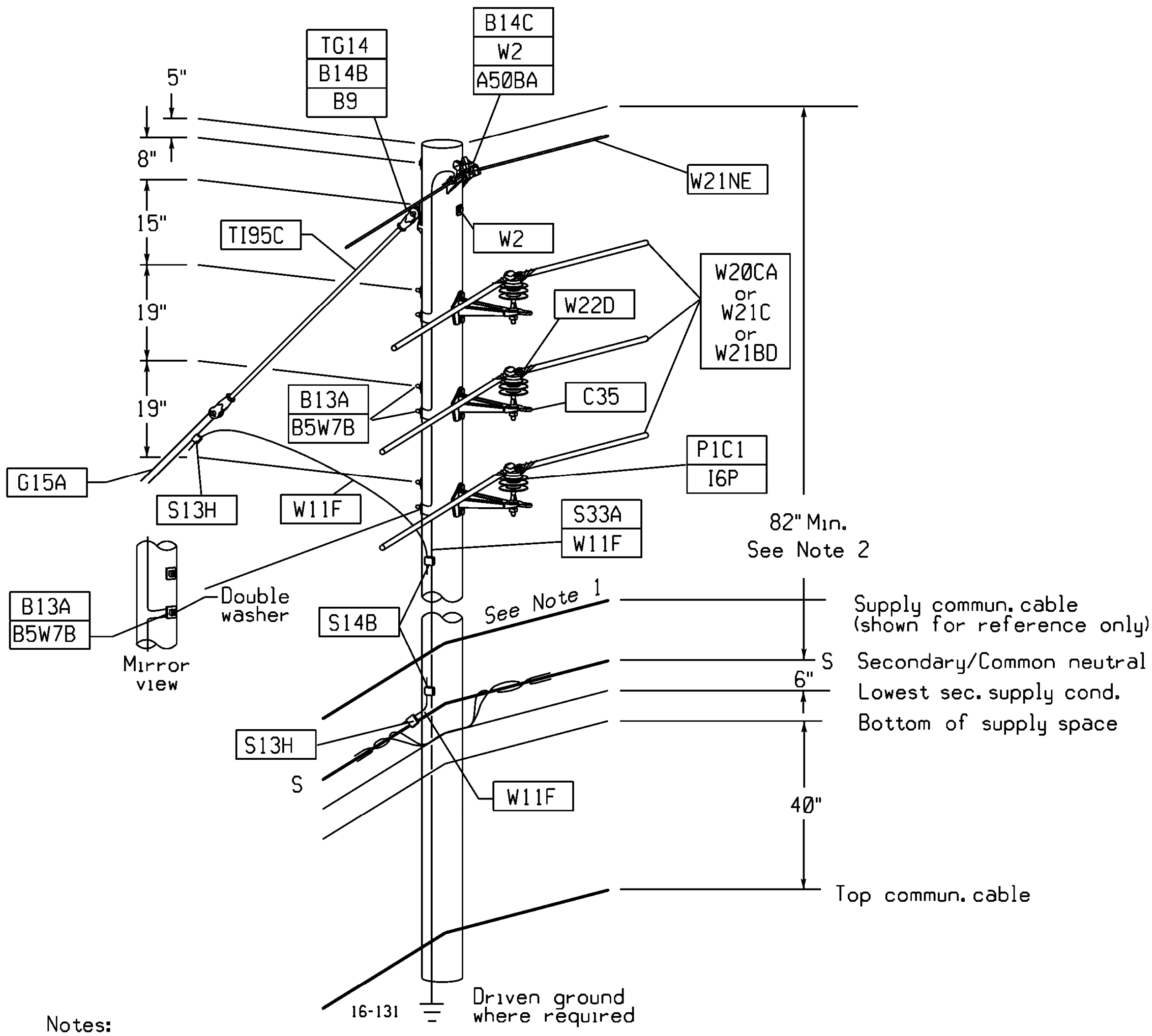


Figure 1 - Typical Phasing Diagram



General Arrangement

MU = @16-131C(Y)	0-15 kV (Y) = Wire Size



Supersedes 7/09 Issue - Updated Spacer cable STD ID's

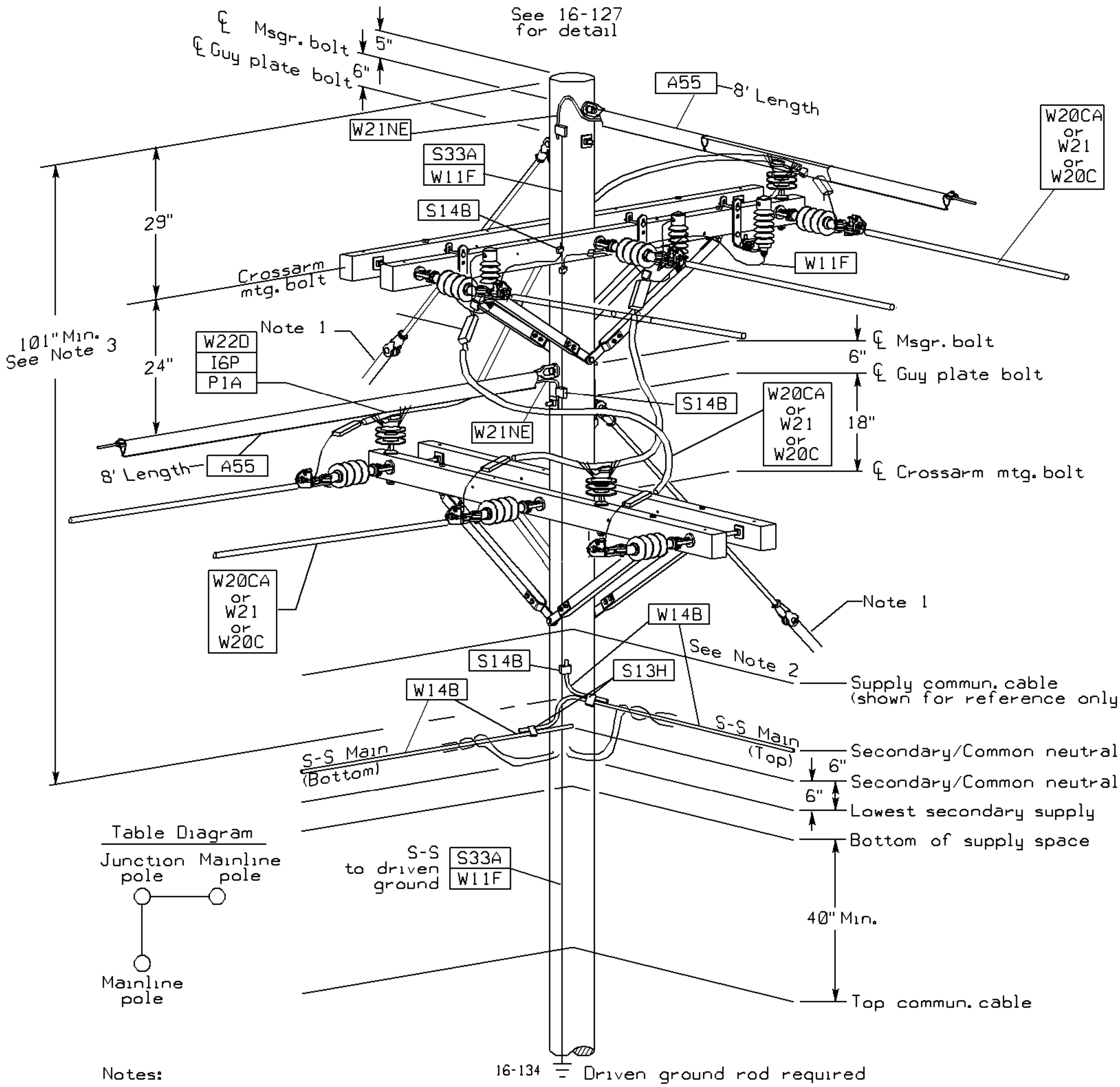
Notes:

1. Pole not specifically designed to accommodate supply communication. See Company "Policy for installing communication cables in the supply space".
2. Minimum dimension based on 40/40 J.O. Pole.

Doc. # ST. 16.00.003

MU = @16-134C(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.



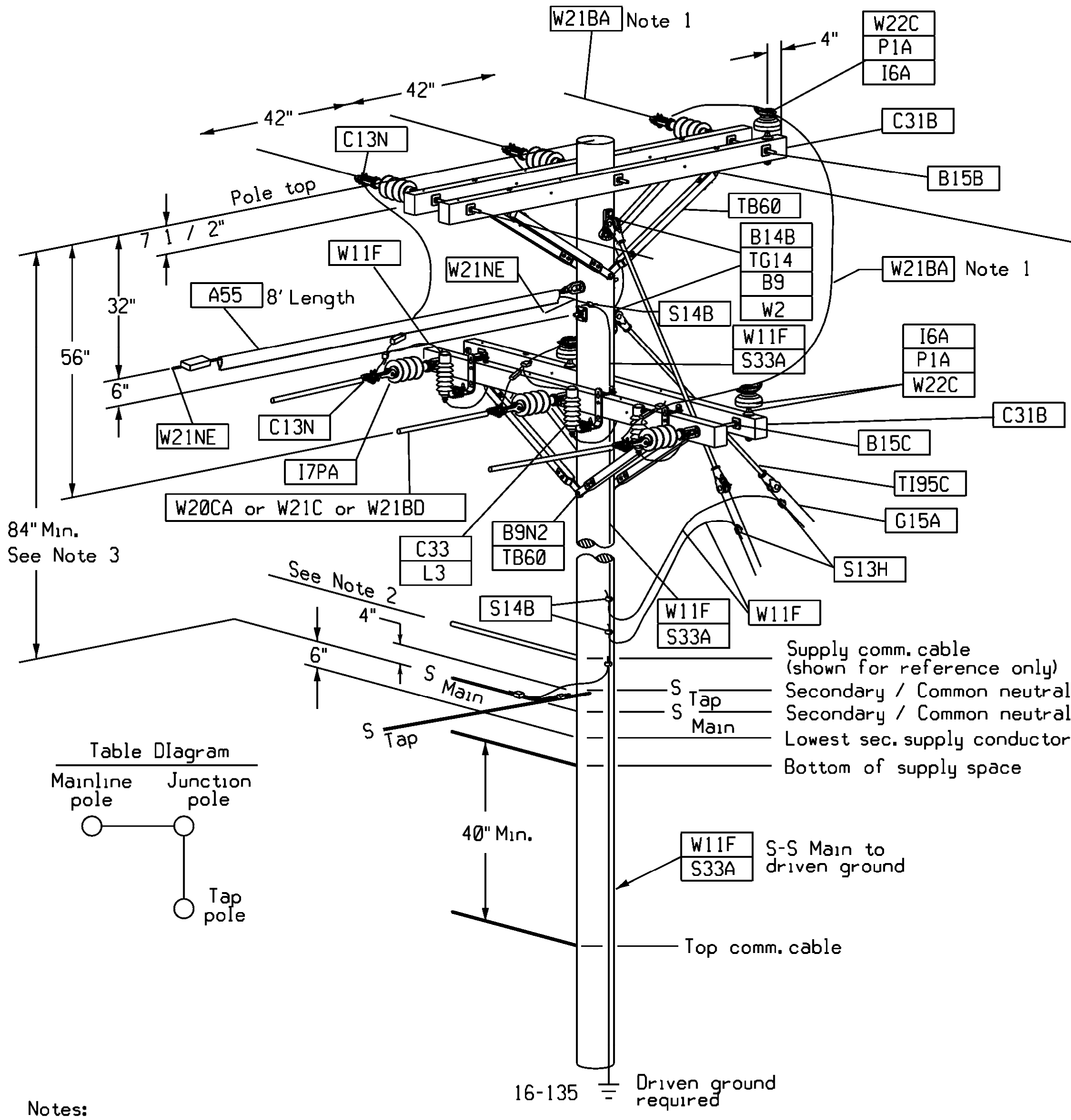
Notes:

1. Ground guy to pole equipment down ground.
2. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing cdommunication cables in the supply space".
3. Minimum dimension based on a 45/40 J.O. Pole.

15KV JUNCTION POLE – TWO WAY
BUCKARM SPACER CABLE DE TO SPACER CABLE DE – LINE ANGLES 61° - 120°

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-134	7/09

MU = @16-135C(Y)	0-15 kV (Y) = Wire Size



Supersedes 7/09 Issue - Updated Spacer cable STD ID's

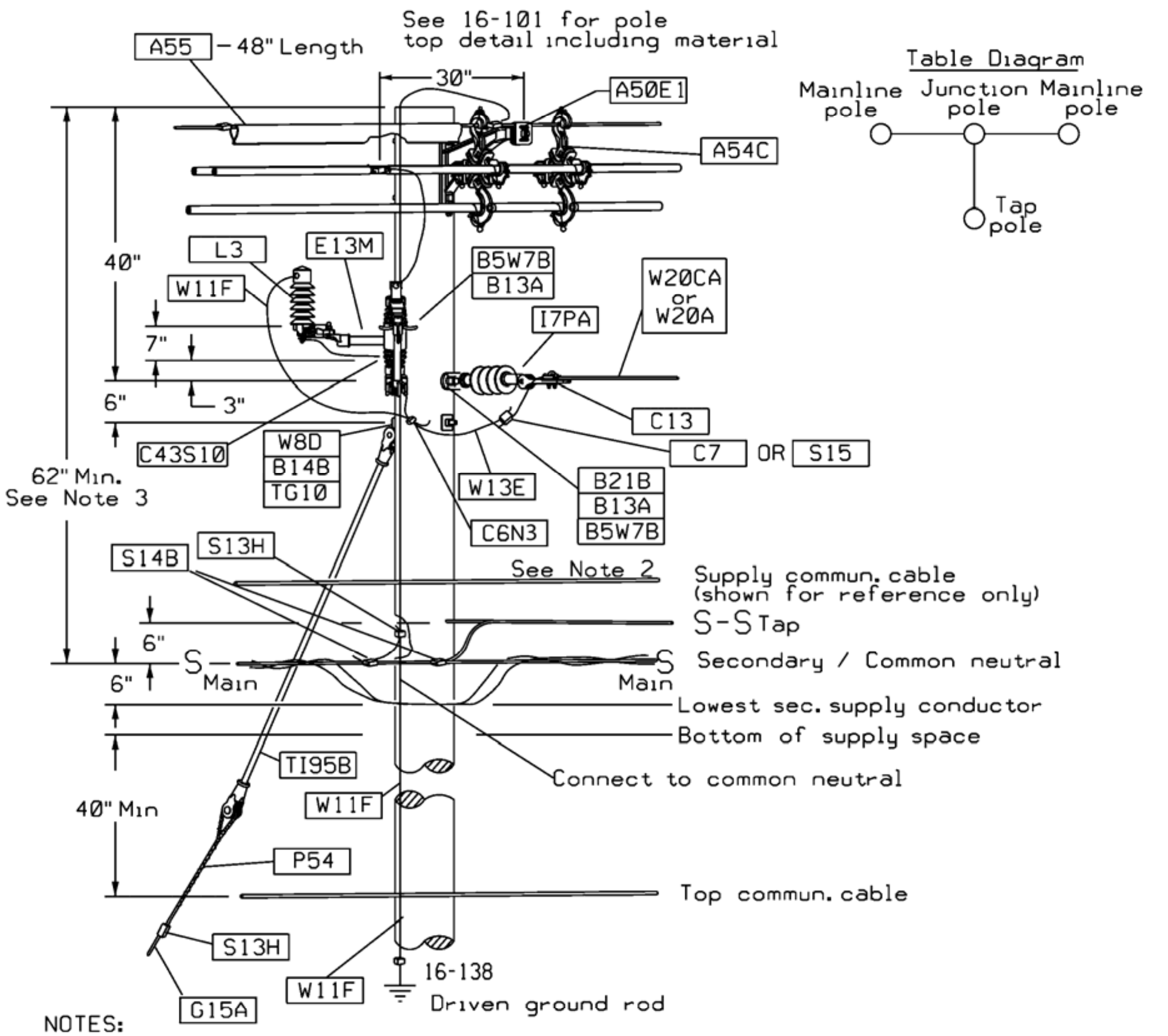
Notes:

1. Drawing and material list depicts use of 477 bare alum. conductor.
2. Pole not specifically designed to accommodate supply communication. See Company "Policy for installing communication cables in the supply space".
3. Minimum dimension based on a 45/40 J.O. Pole.

 Doc. # ST. 16.00.003

MU = @16-138W1/0TC(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/09 Issue – Corrected STD Id's for Spacer cable, arrester/cutout tap wire, and connectors.

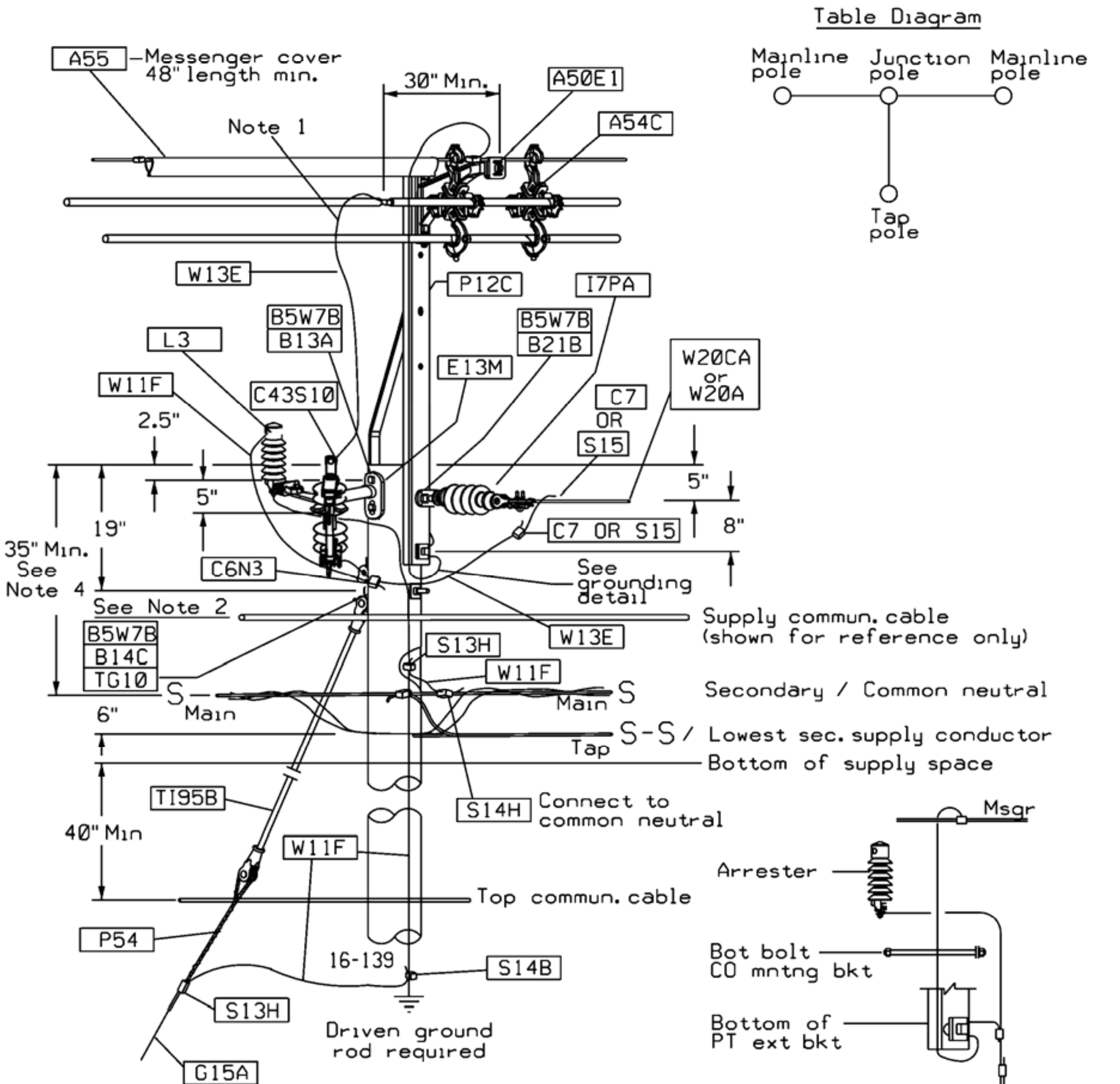


NOTES:

1. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35KV)
2. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing cdommunication cables in the supply space".
3. Minimum dimension based on a 40/40 J.O. Pole.

15KV JUNCTION POLE THREE WAY 14" TANGENT BRACKET TO SINGLE PHASE TAP			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER **16-138**	ISSUE **7/10**

MU = @16-139W1/0TC(Y)	0-15 kV (Y) = Wire Size



NOTES:

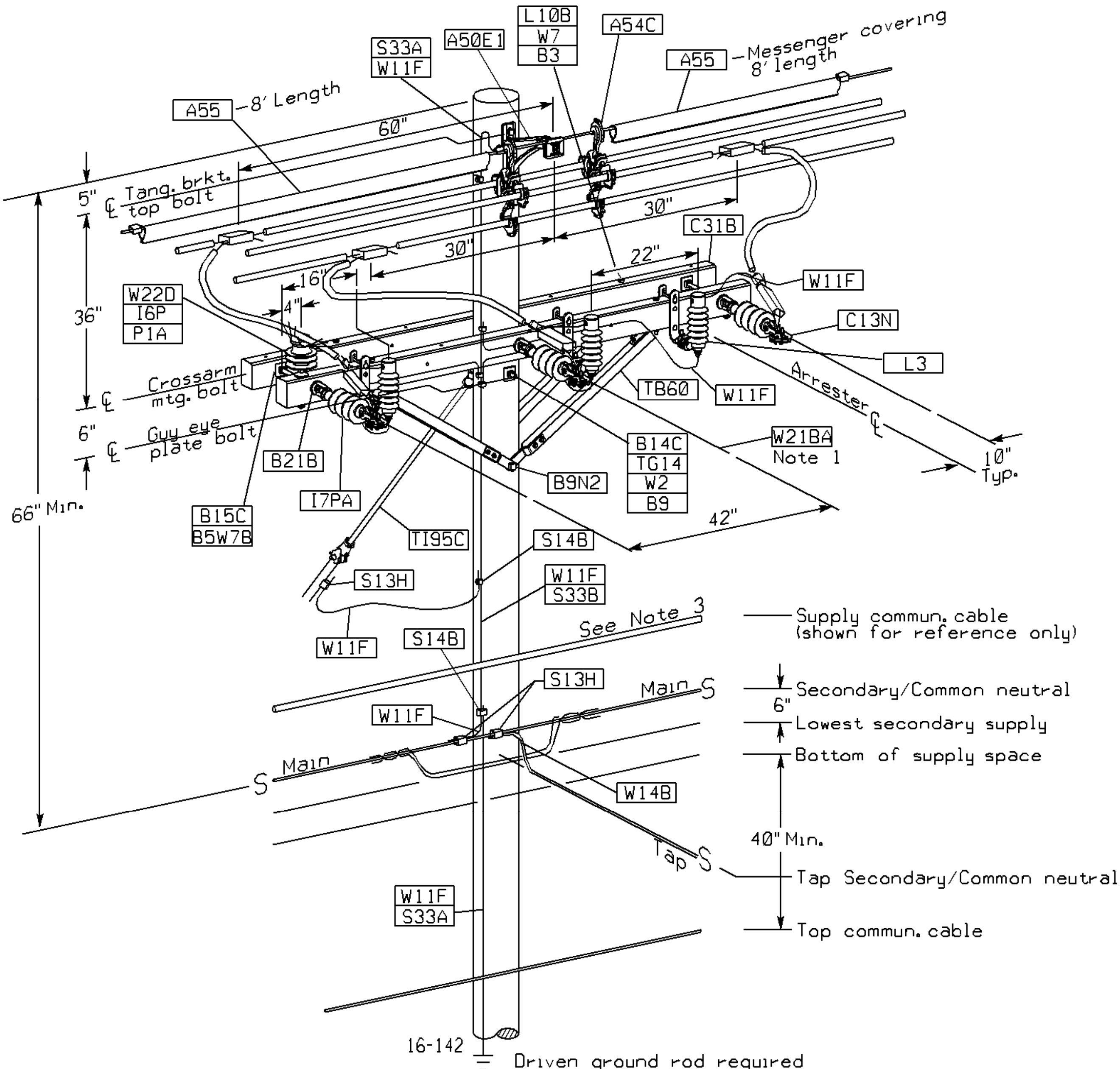
1. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35KV)
2. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing cdommunication cables in the supply space".
3. Existing 35' Pole - old agreements & setting depth.
4. Minimum dimension based on 40/40 J.O. Pole.

Supersedes 7/09 Issue – Corrected STD Id's for spacer cable. arrester/cutout tap wire. and connectors.

15KV JUNCTION POLE – THREE WAY
SPACER CABLE MAINLINE USING POLE TOP EXTENSION TO SINGLE PHASE TAP

ISSUE	PAGE NUMBER		
7/10	16-139	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @16-142C(Y)	0-15 kV (Y) = Wire Size
MU = @16-1422PHC(Y)	0-15 kV 2 Ph. Jct., (Y) = Wire Size



NOTES:

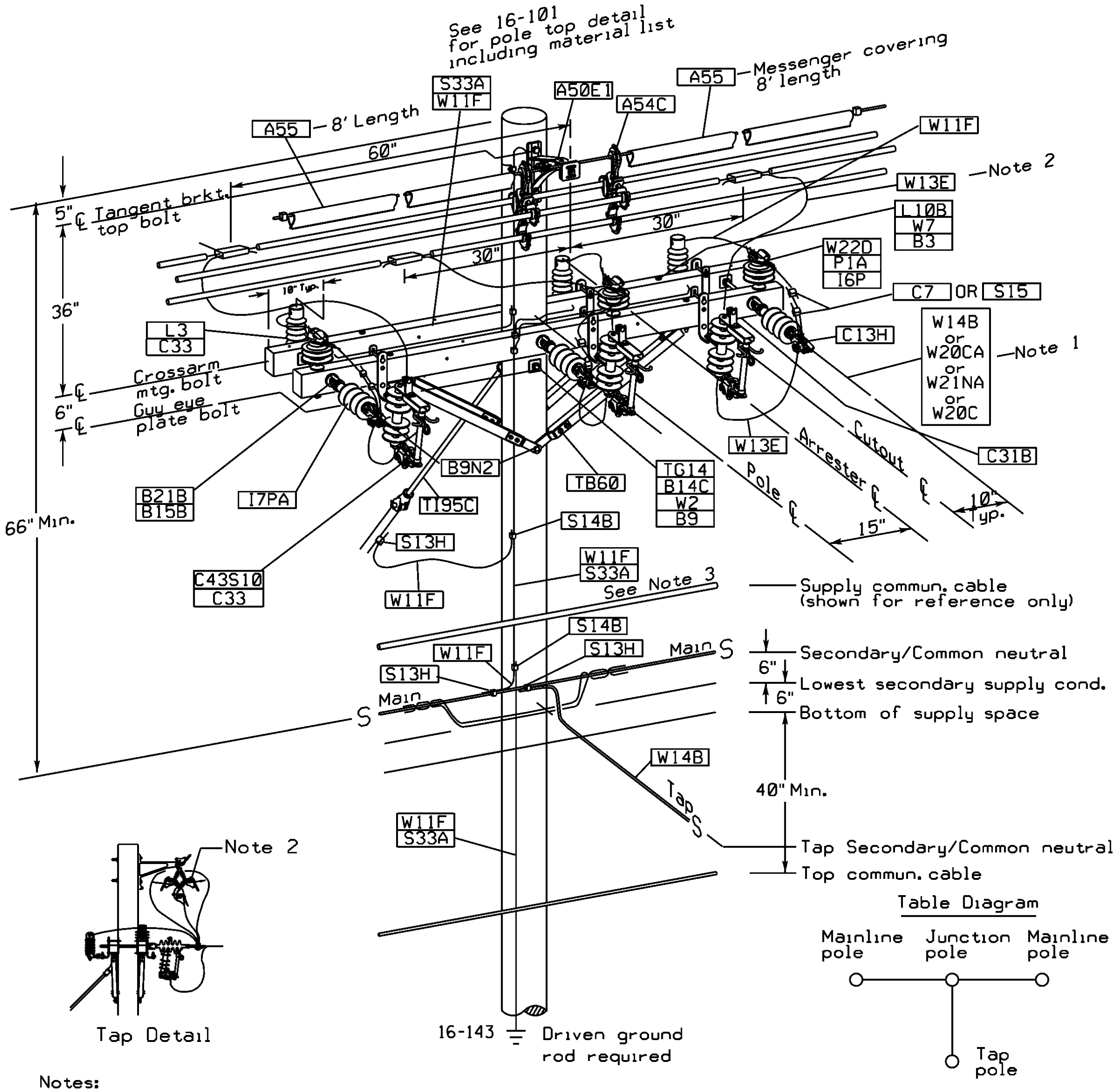
1. Drawing and material list depicts use of 477 bare alum. conductor.
2. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35KV)
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing cdommunication cables in the supply space".

Supersedes 7/08 Issue - Updated MU.

15KV JUNCTION POLE – THREE WAY – SPACER CABLE MAINLINE WITH TANGENT BRACKET TO CROSSARM CONSTRUCTION (UNFUSED)

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	16-142	7/09

 Doc. # ST. 16.00.003



Notes:
1. Drawing and material list depicts use of 1 / 0-6201 bare or tree wire.
2. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV).
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

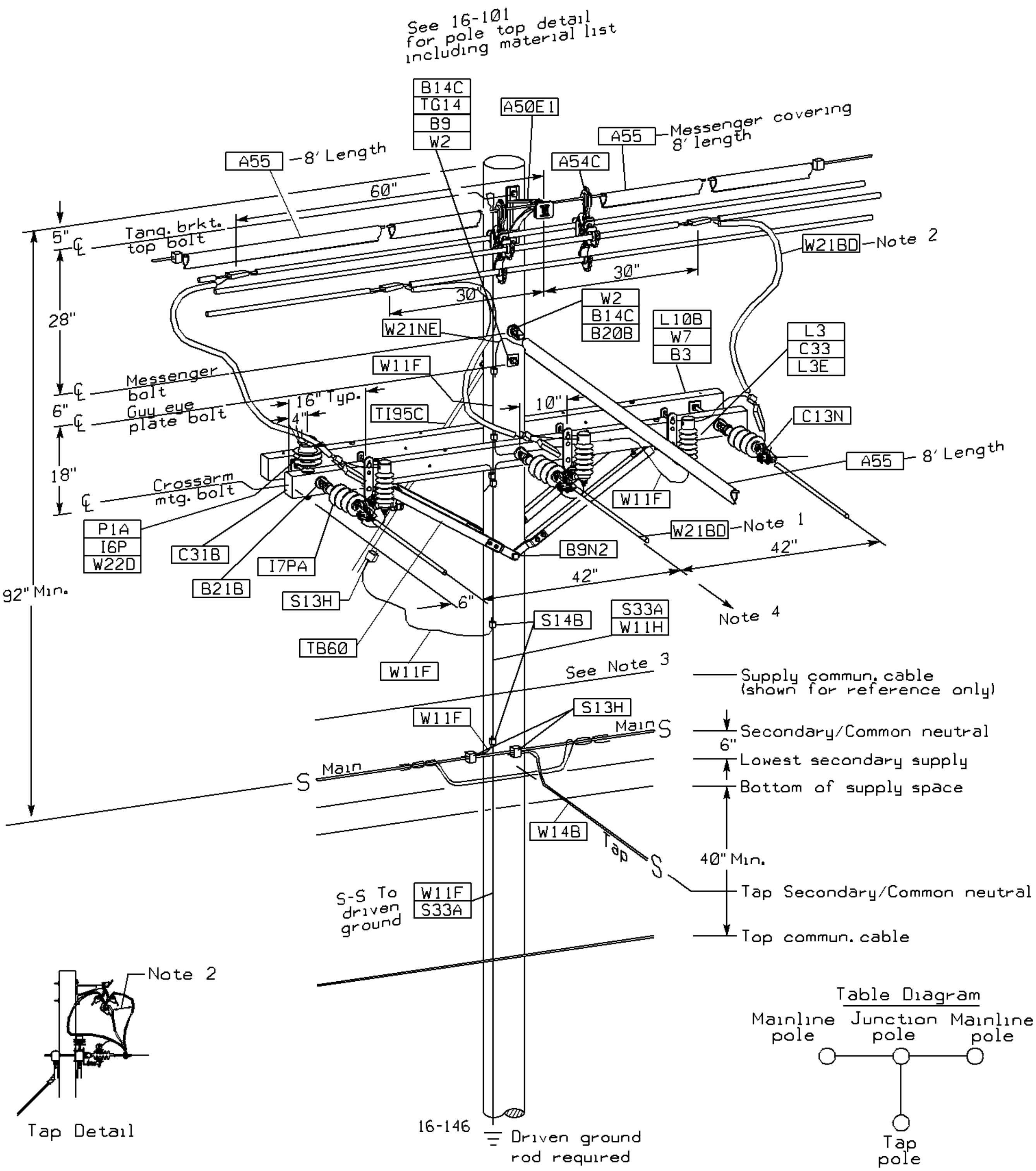
Supersedes 7/09 Issue – Corrected STD Id's for spacer cable, arrester/cutout tap wire, and connectors.

15KV JUNCTION POLE – THREE WAY - SPACER CABLE MAINLINE WITH TANGENT BRACKET TO CROSSARM CONSTRUCTION (FUSED)			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	16-143		

Doc. # ST. 16.00.003

MU = @16-146C(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.



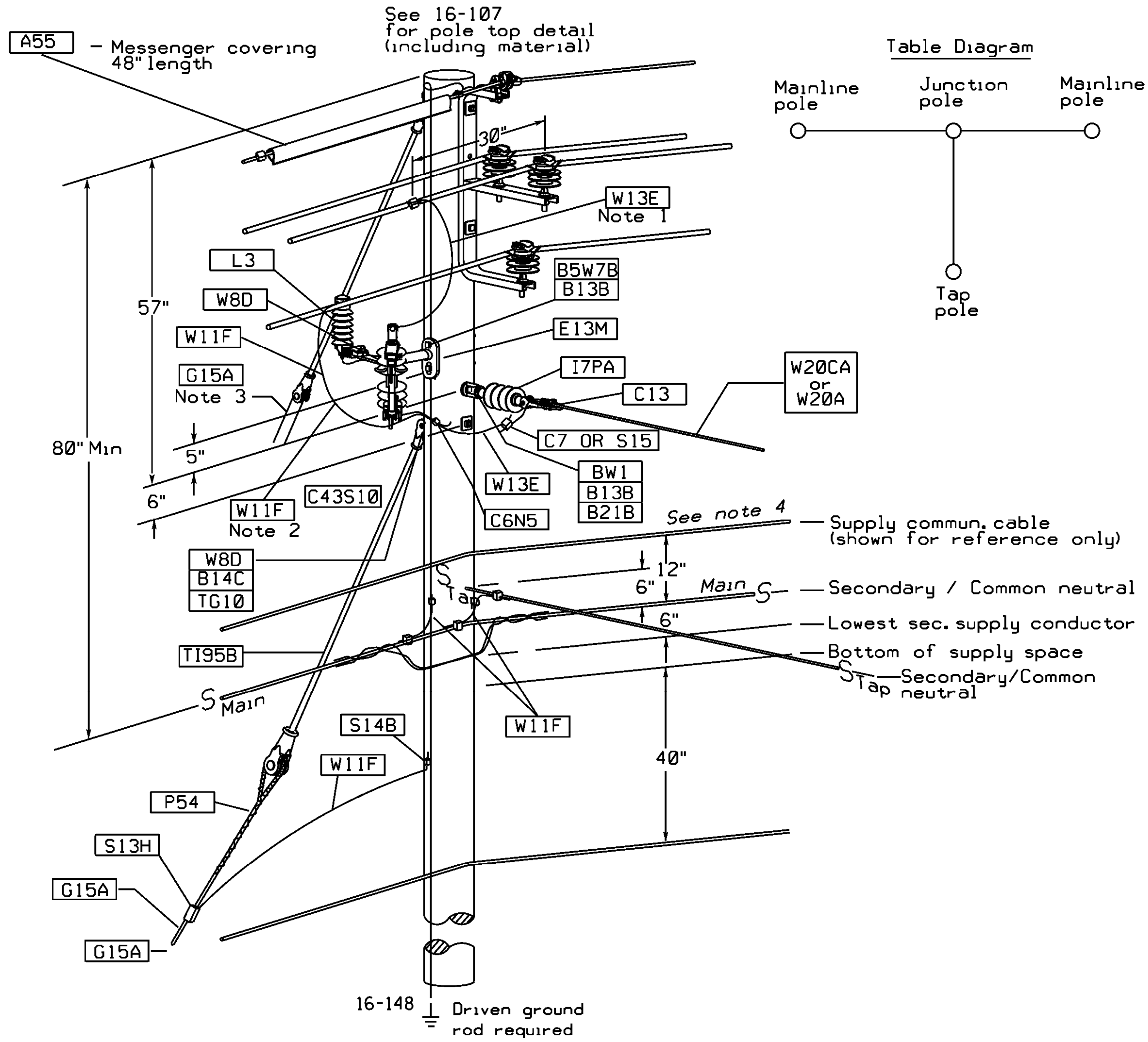
Notes:

1. Drawing and material list depicts use of 477 spacer cable.
2. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV).
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
4. First spacer location - 50′ from crossarm. Install 2 spacers.

 Doc. # ST. 16.00.003

MU = @16-148CW1/0TC(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/09 Issue – Corrected STD Id's for spacer cable, arrester/cutout tap wire, and connectors.



Notes:

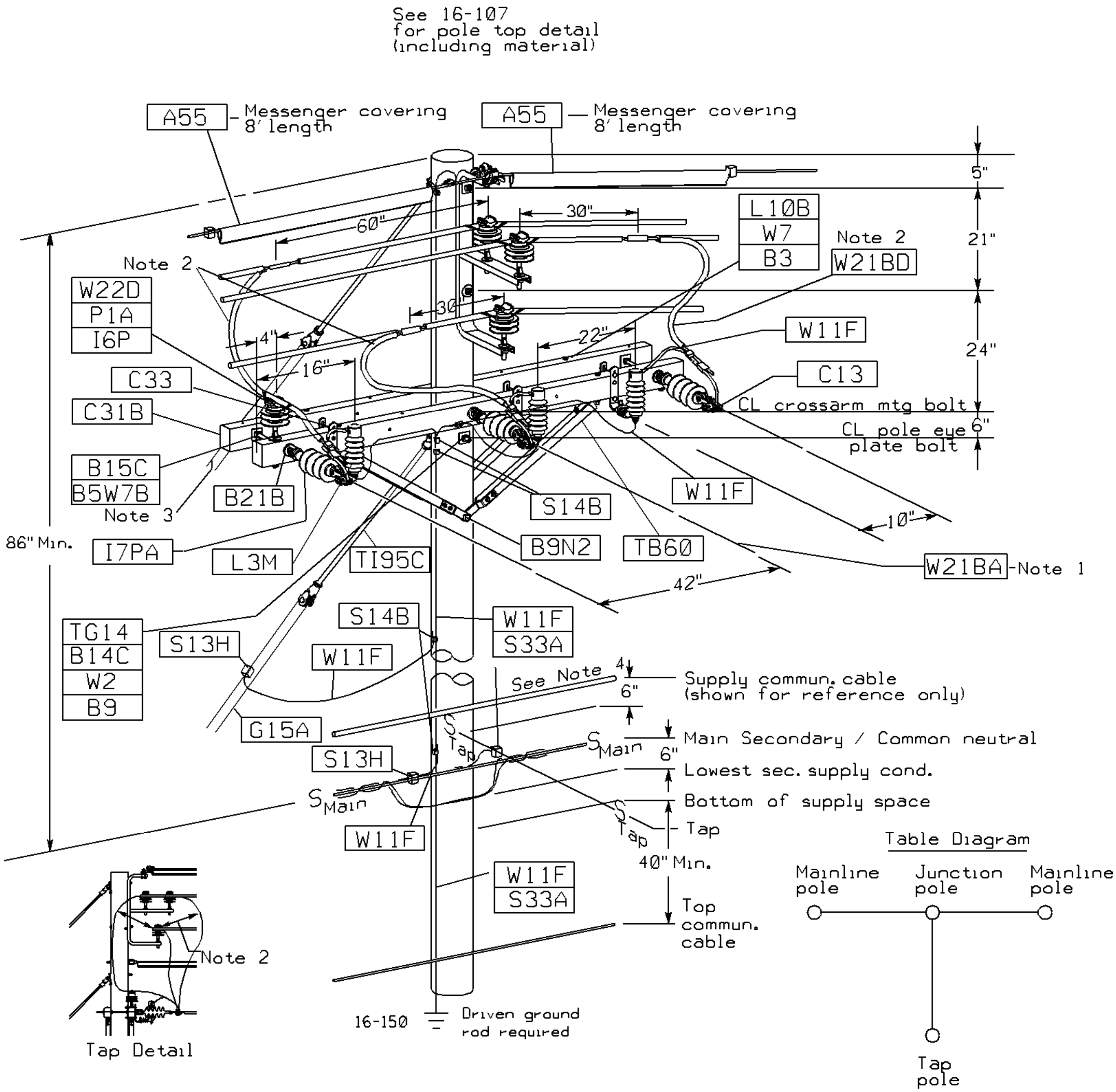
1. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
2. Train under bracket body and connect to pole down-ground
3. Ground guy to pole equipment down ground.
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

<table>
<tr><td colspan="4">15KV JUNCTION POLE – THREE WAY
E – BRACKET (1° – 60°) TO SINGLE PHASE TAP</td></tr>
<tr><td>ISSUE</td><td>PAGE NUMBER</td><td rowspan="2">OVERHEAD
CONSTRUCTION STANDARD</td><td rowspan="2">Liberty Utilities</td></tr>
<tr><td>7/10</td><td>16-148</td></tr>
</table>

Doc. # ST. 16.00.003

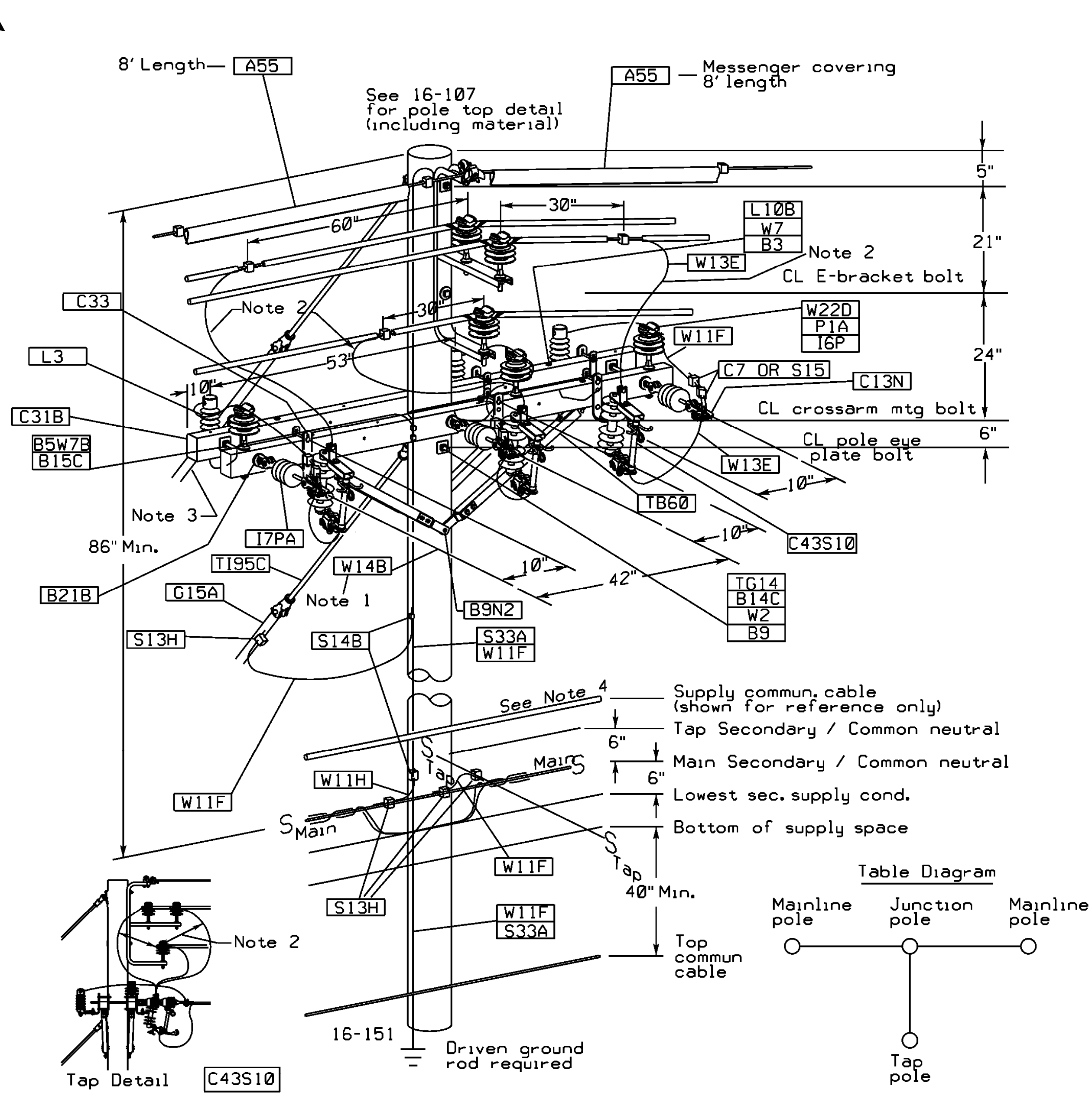
MU = @16-150C(Y)	0-15 kV (Y) = Wire Size
MU = @16-1502PHC(Y)	0-15 kV 2PH Jct., (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.



Notes:

1. Drawing and material list depicts use of 477 bare alum conductor
2. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
3. Ground guy to pole equipment down ground.
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "policy for installing communication cables in the supply space".



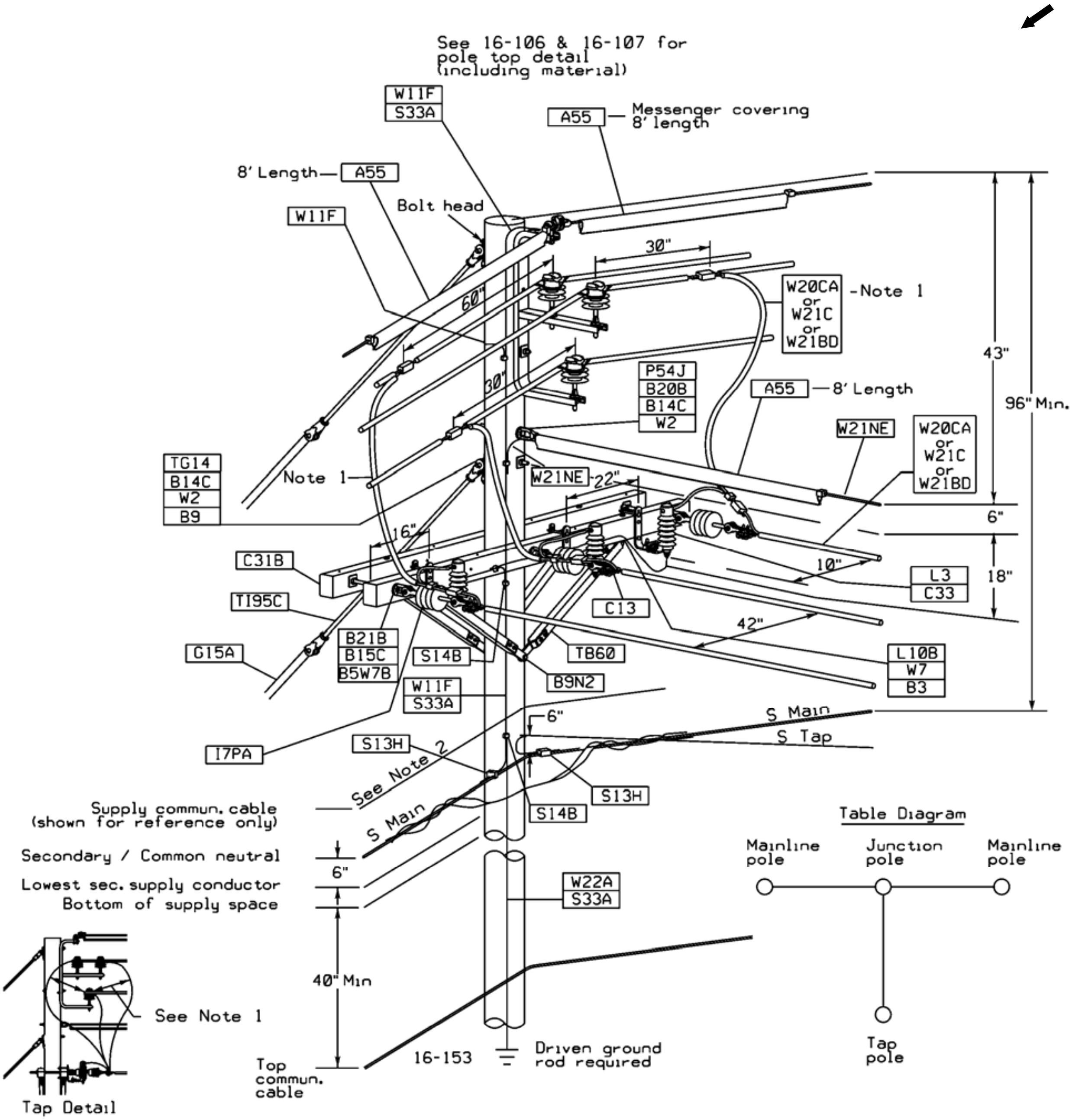
Supersedes 7/09 Issue – Corrected STD Id's for arrester/cutout tap wire and connectors.

NOTES:
1. Drawing and material list depicts use of 1/0 6201 bare alum conductor on tap line.
2. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
3. Ground guy to pole equipment down ground.
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "policy for installing communication cables in the supply space".

15KV JUNCTION POLE – THREE WAY – SPACER CABLE E – BRACKET MAINLINE TO THREE PHASE CROSSARM TAP (FUSED)			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/10	16-151		

 Doc. # ST. 16.00.003

MU = @16-153C(Y)	0-15 kV (Y) = Wire Size



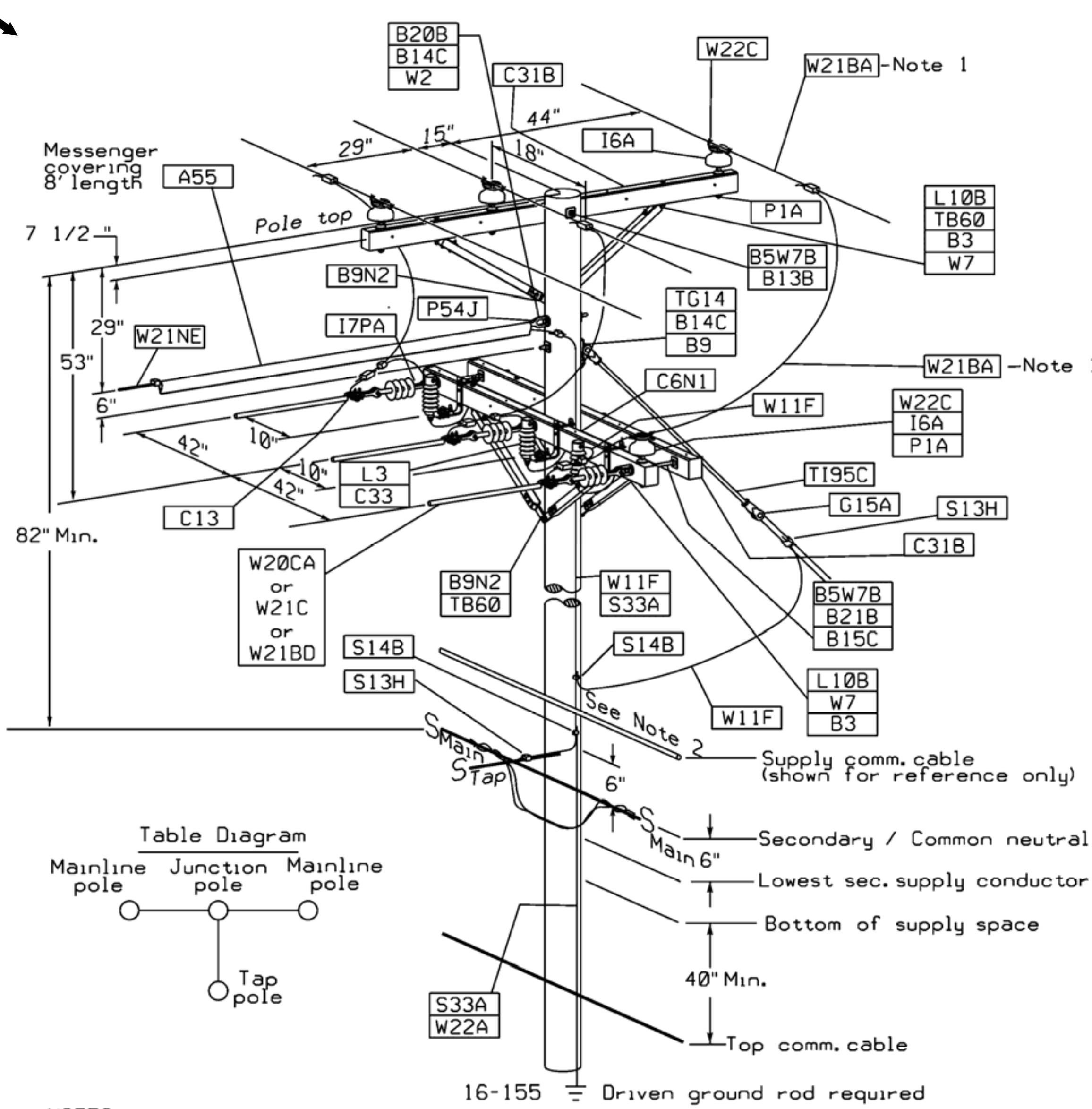
NOTES:

1. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
2. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

15KV JUNCTION POLE – THREE WAY – SPACER CABLE E –BRACKET MAINLINE TO THREE PHASE CROSSARM TAP (UNFUSED)

MU = @16-155C(Y)	0-15 kV 0º to 10º, (Y) = Wire Size
MU = @16-15511C(Y)	0-15 kV 11º to 20º, (Y) = Wire Size
MU = @16-15521C(Y)	0-15 kV 21º to 45º, (Y) = Wire Size
MU = @16-15546C(Y)	0-15 kV 46º to 60º, (Y) = Wire Size



NOTES:

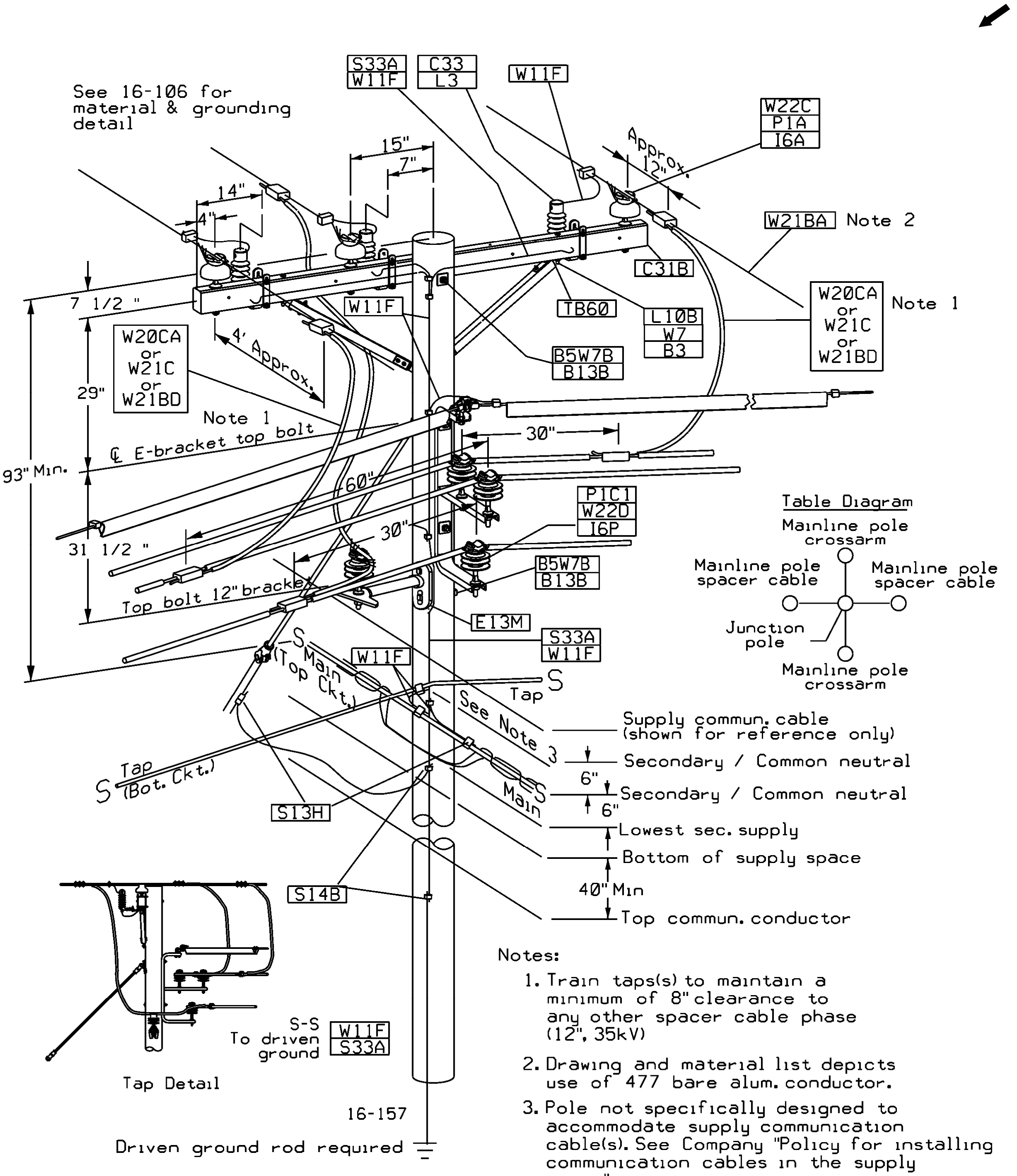
1. Drawing and material list depicts use of 477 bare alum conductor.
2. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

<table>
<tr><td colspan="4">15KV JUNCTION POLE – THREE WAY – THREE PHASE CROSSARM MAINLINE TO SPACER CABLE TAP</td></tr>
<tr><td>ISSUE
7/10</td><td>PAGE NUMBER
16-155</td><td>OVERHEAD
CONSTRUCTION STANDARD</td><td>Liberty Utilities</td></tr>
</table>

MU = @16-157C(Y)	0-15 kV (Y) = Wire Size

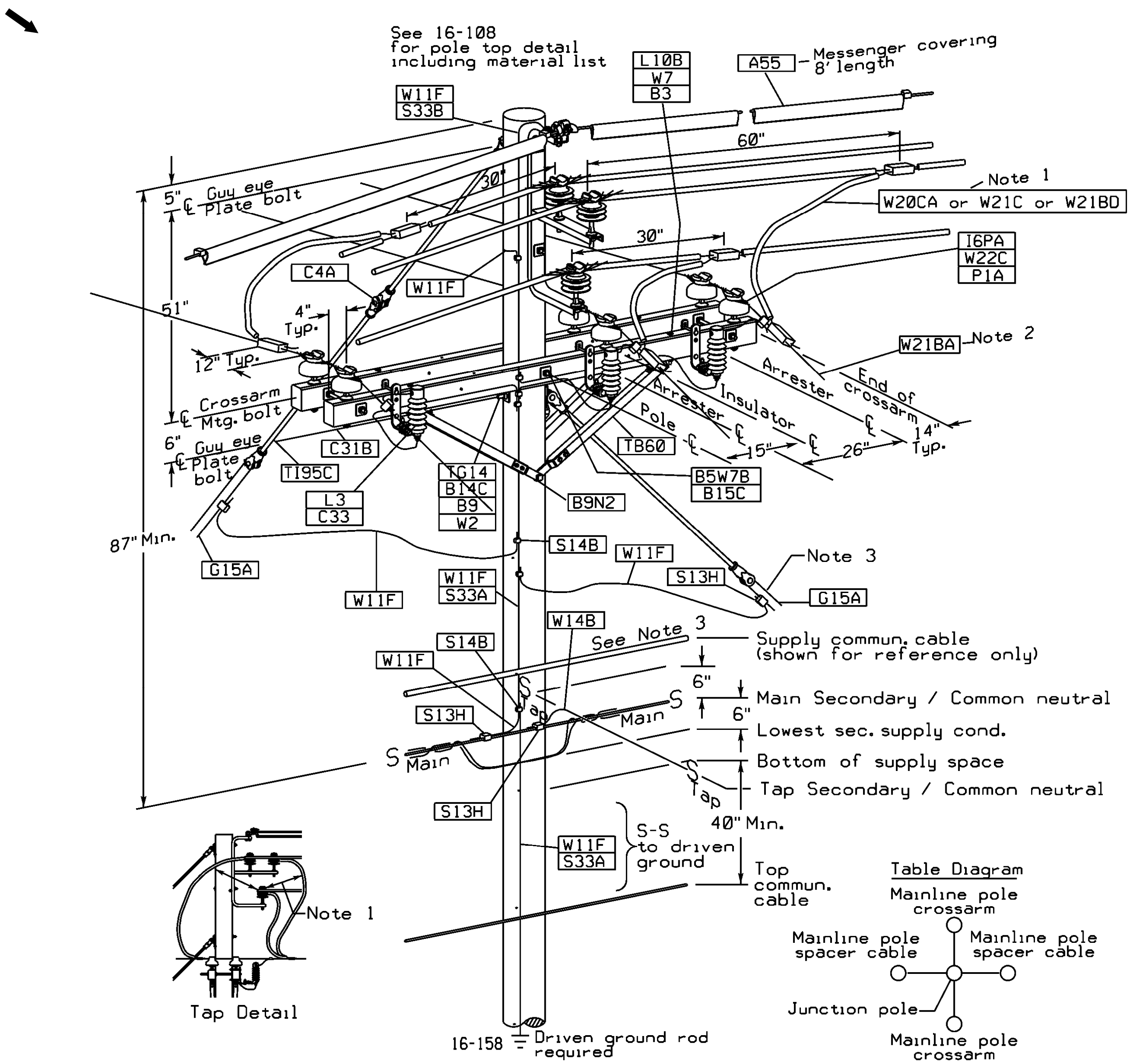
Supersedes 7/09 Issue - Updated Spacer cable STD ID's



Notes:

1. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
2. Drawing and material list depicts use of 477 bare alum. conductor.
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

MU = @16-158C(Y)	0-15 kV (Y) = Wire Size

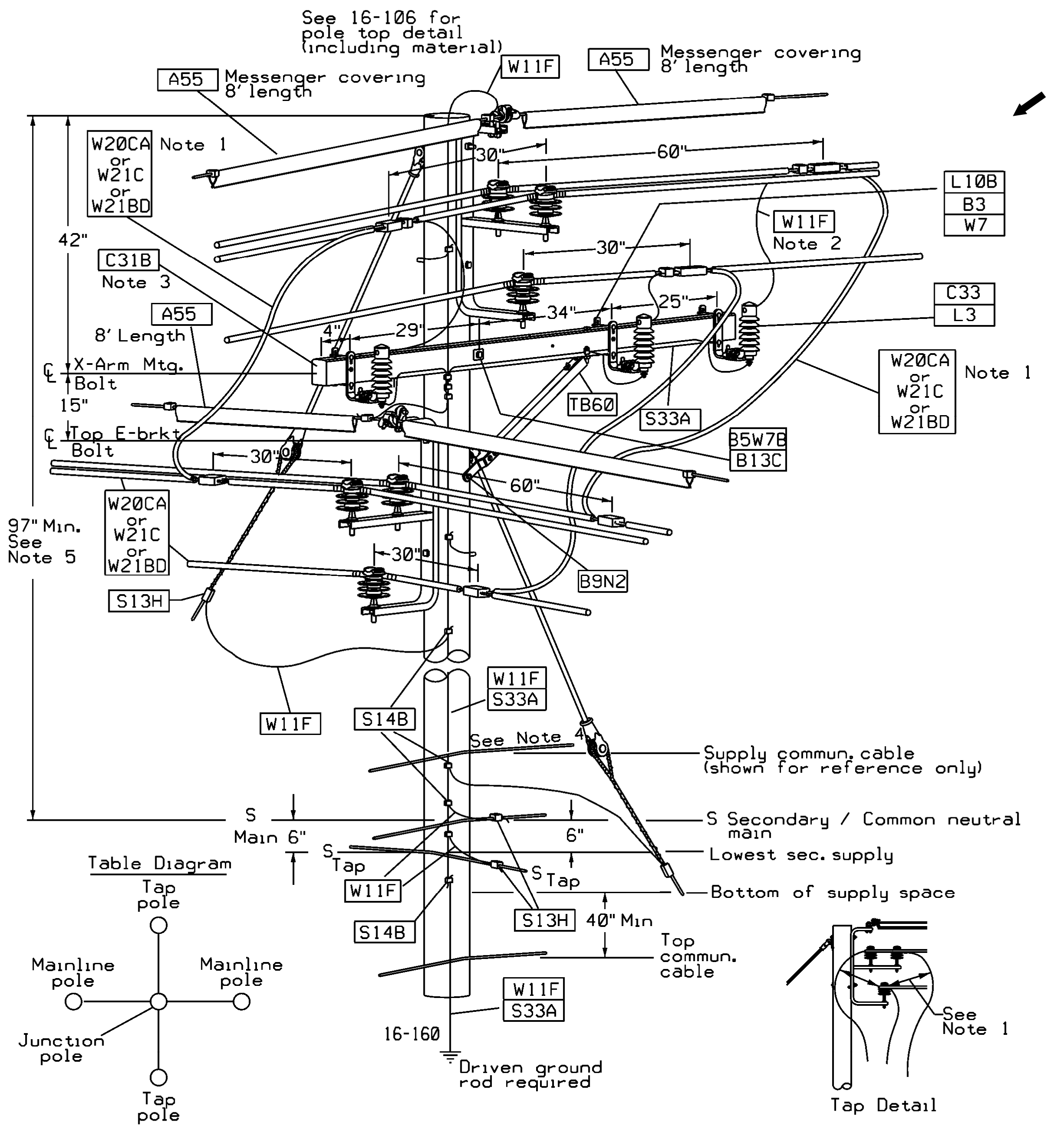


Notes:

1. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV).
2. Drawing and ML depicts use of bare 477kcmil alum. on crossarms.
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

MU = @16-160C(Y)	0-15 kV (Y) = Wire Size



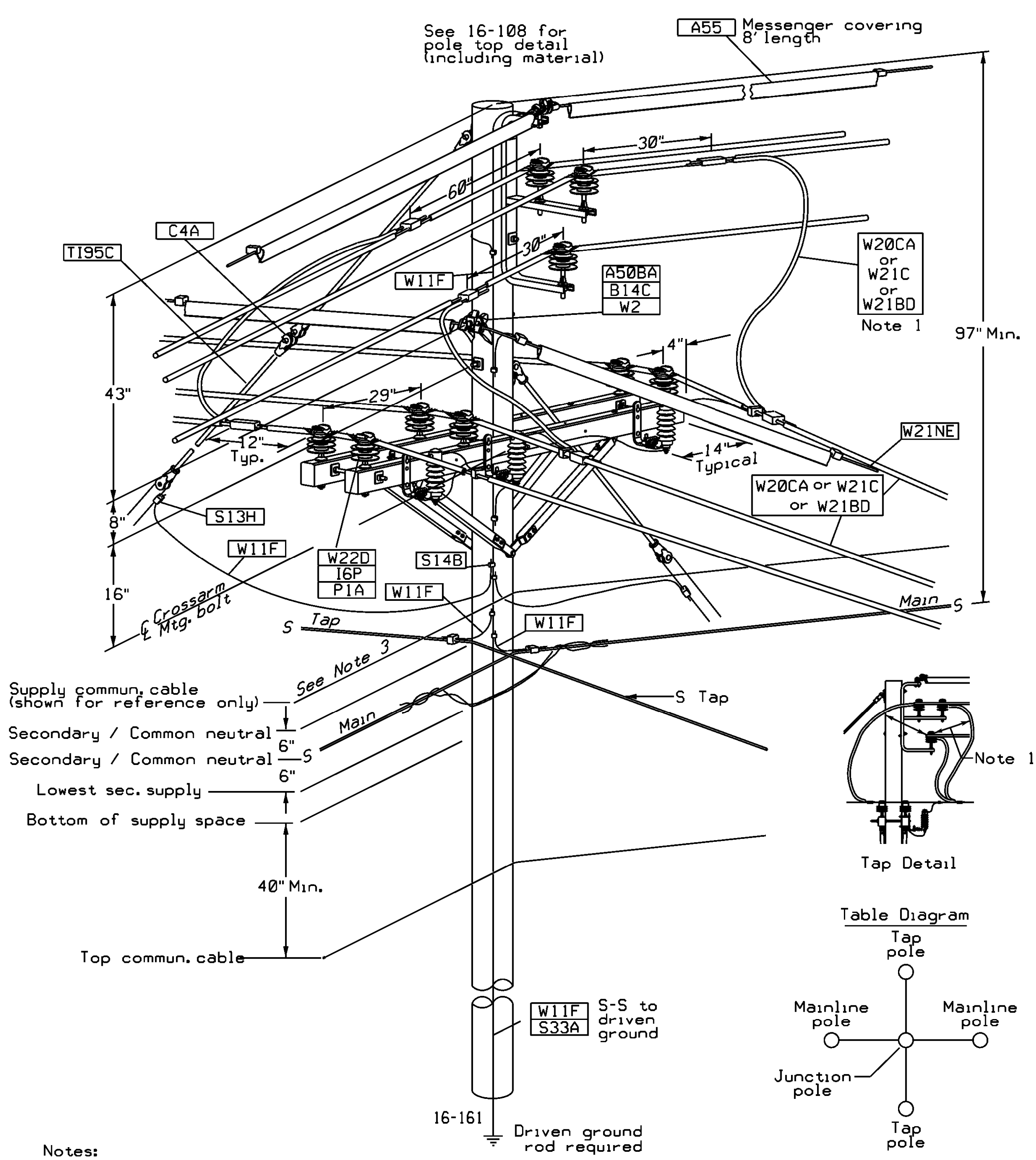
Notes:

1. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV).
2. Use #4 cov CU for arrester pri tap leads.
3. Crossarm "semi-outrigged"
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
5. Minimum dimension based on a 45/40 J.O. Pole.

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

15KV JUNCTION POLE – FOUR WAY – SPACER CABLE E – BRACKET TO SPACER CABLE E – BRACKET (LINE ANGLES 7˚ – 30˚)			
		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	16-160	7/10

MU = @16-161C(Y)	0-15 kV (Y) = Wire Size



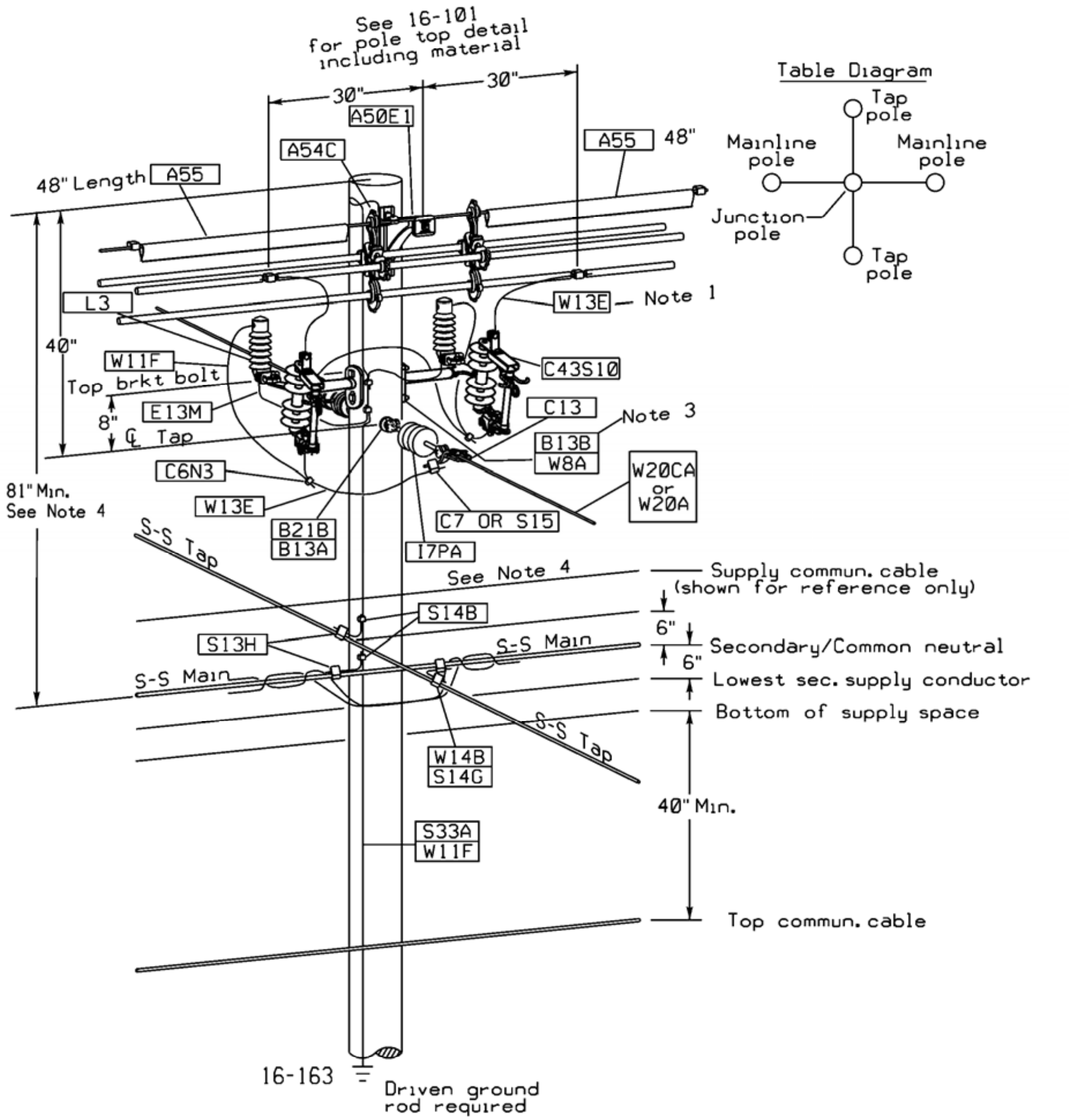
Notes:
1. Train taps(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV).
2. Drawing and material list depicts use of 477 compact 15 kv spacer cable.
3. Pole not specifically designed to accomodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

Supersedes 7/09 Issue - Updated Spacer cable STD ID's

<table>
<tr><td colspan="4">15KV JUNCTION POLE – FOUR WAY – SPACER CABLE E –BRACKET MAINLINE TO SPACER CABLE CROSSARM TAP</td></tr>
<tr><td>ISSUE
7/10</td><td>PAGE NUMBER
16-161</td><td>OVERHEAD
CONSTRUCTION STANDARD</td><td>Liberty Utilities</td></tr>
</table>

MU = @16-163C(Y)	0-15 kV (Y) = Wire Size

Supersedes 7/09 Issue – Corrected STD Id's for spacer cable, arrester/cutout tap wire, and connectors.

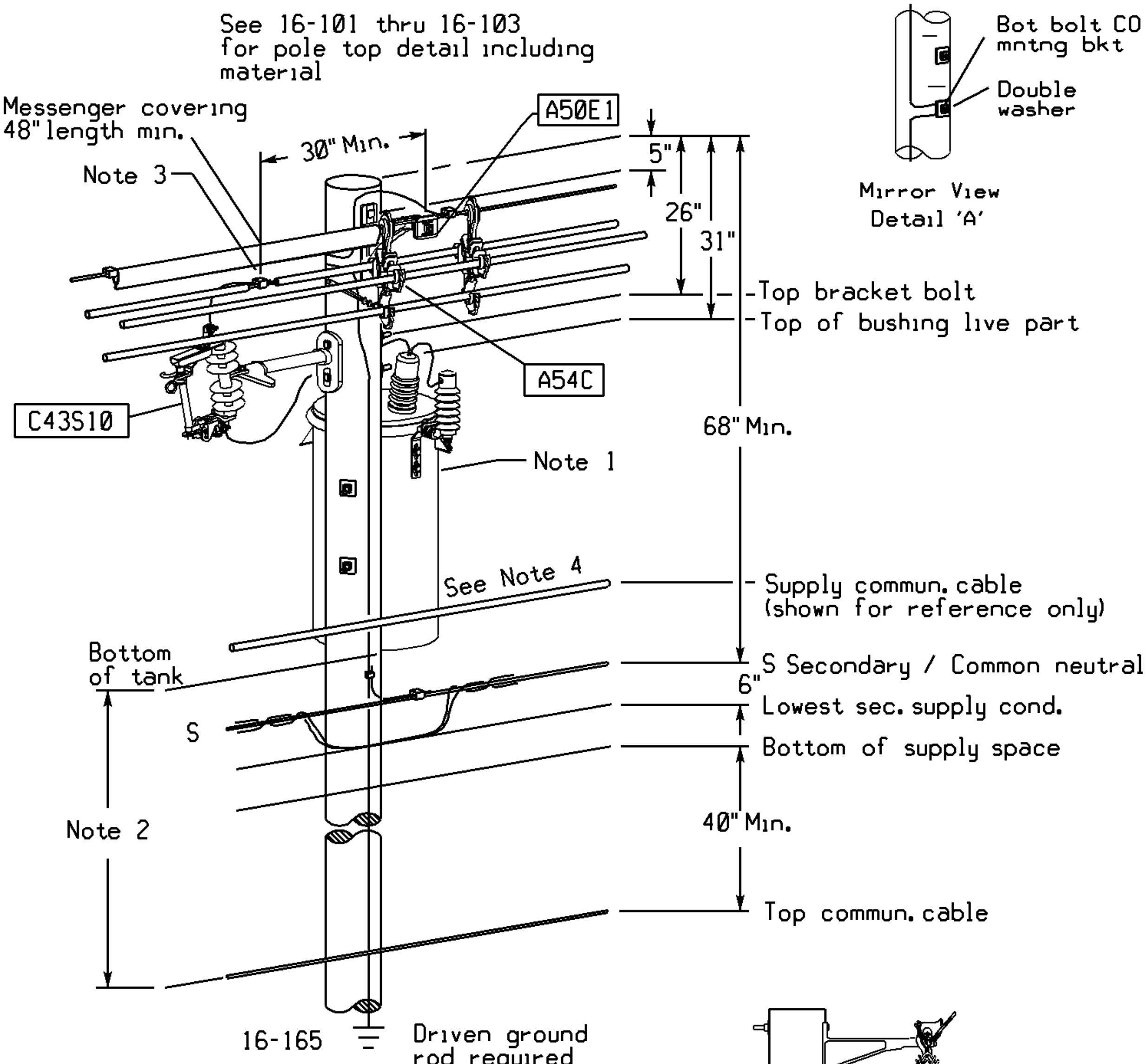


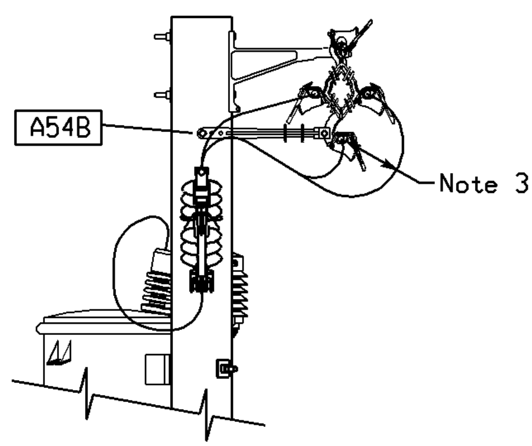
Notes:

1. Train taps to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kv).
2. Use 2 round washers on bottom bolt for grounding.
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables In the supply space".
4. Minimum dimension based on a 45/45 J.O. Pole.

<table>
<tr><td colspan="4">15KV JUNCTION POLE – FOUR WAY – 14" OR 24" TANGENT BRACKET TO SINGLE PHASE TAPS</td></tr>
<tr><td rowspan="2">Liberty Utilities</td><td rowspan="2">OVERHEAD
CONSTRUCTION STANDARD</td><td>PAGE NUMBER</td><td>ISSUE</td></tr>
<tr><td>16-163</td><td>7/10</td></tr>
</table>

Doc. # ST. 16.00.003





Tap Detail

Notes:

1. Secondary transformer connections not shown.
2. Maintain 30" min. - bottom tank to top communication cable.
3. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV).
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

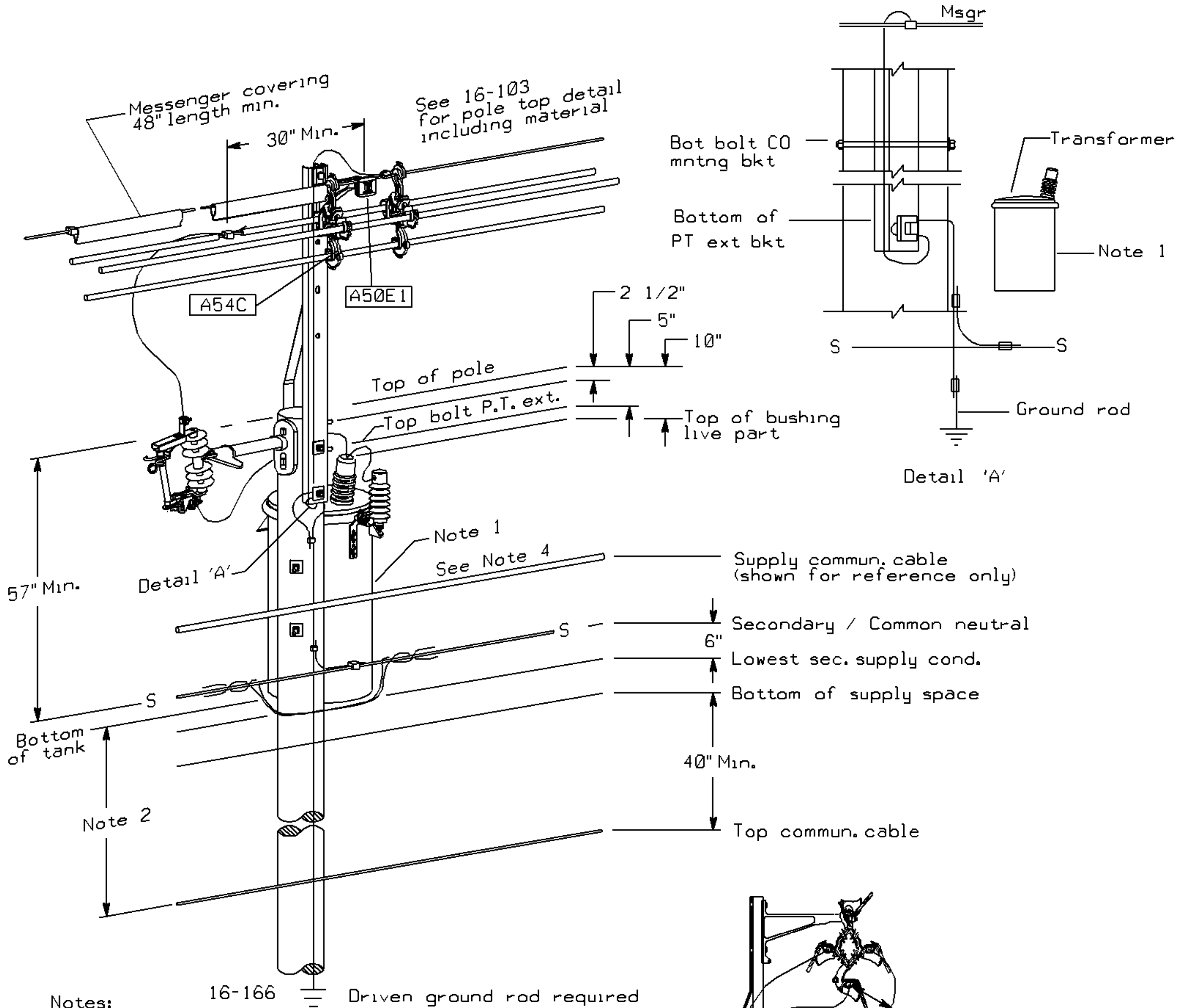
Supersedes 7/07 Issue – Revised Dimensional Detail.

15KV LINE POLE – SINGLE PHASE TRANSFORMER

ISSUE	PAGE NUMBER		
7/08	16-165	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

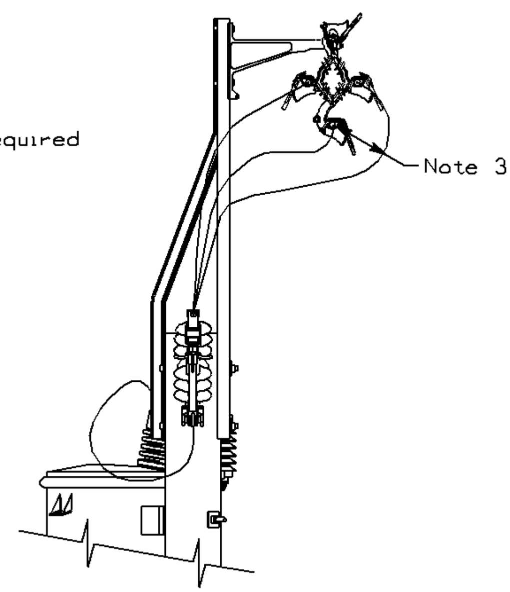
 Doc. # ST. 16.00.003

Supersedes 1/06 Issue – Revised Construction Detail - Refer To Page 9-2XX For Maximum Span Calculation Detail

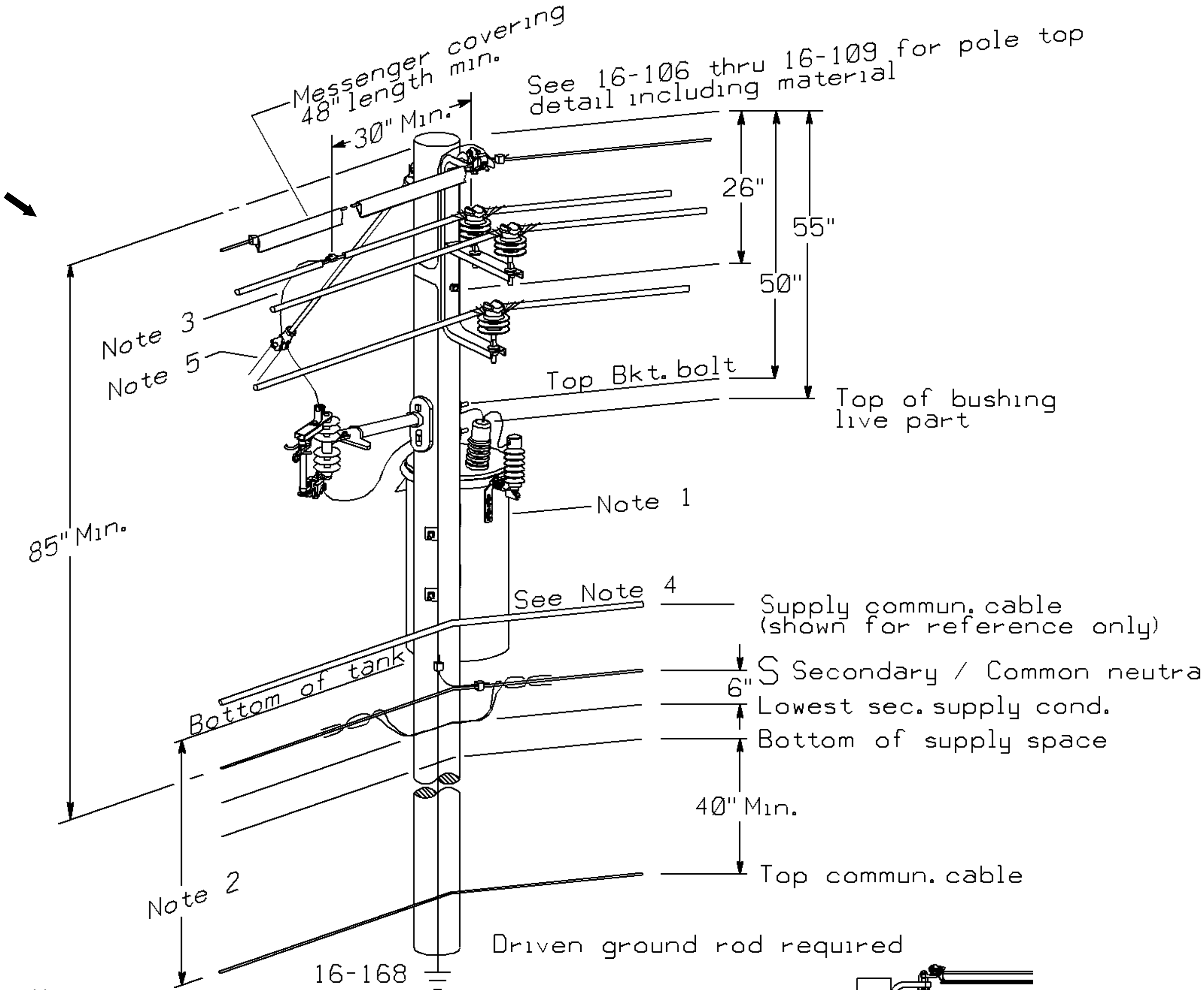


Notes:

1. Secondary transformer connections not shown.
2. Maintain 30" min. - bottom tank to top communication cable
3. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
4. Pole not specifically designed to accommodate supply communication Cable(s). See Company "Policy for installing communication cables in the supply space".

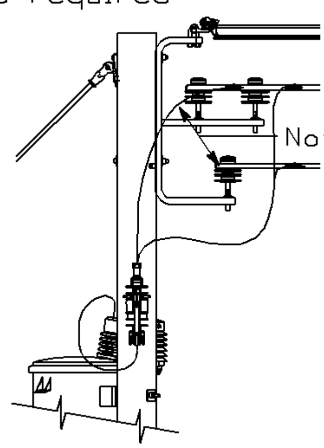


Tap Detail



Notes:

1. Secondary transformer connections not shown.
2. Maintain 30" min. - bottom tank to top communication cable
3. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
5. Ground guy to pole equipment down ground.

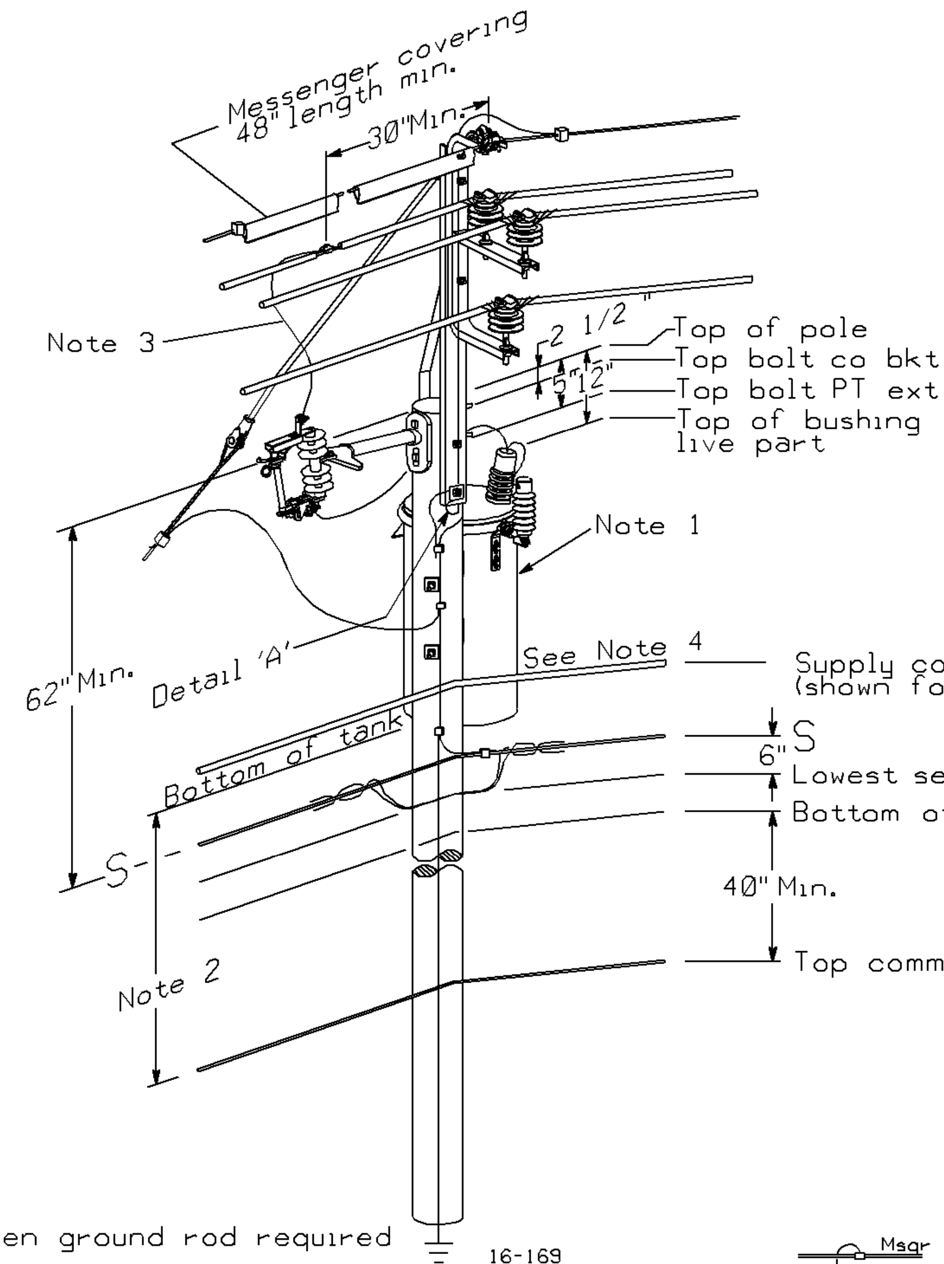


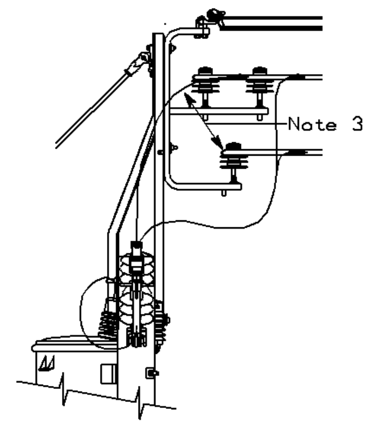
Tap Detail

Supersedes 7/07 Issue – Revised Dimensional Detail.

15KV LINE POLE – SINGLE PHASE TRANSFORMER WITH E – BRACKET			
ISSUE	**PAGE NUMBER**	**OVERHEAD CONSTRUCTION STANDARD**	Liberty Utilities
7/08	**16-168**		

Supersedes 7/07 Issue – Revised Dimensional Detail.

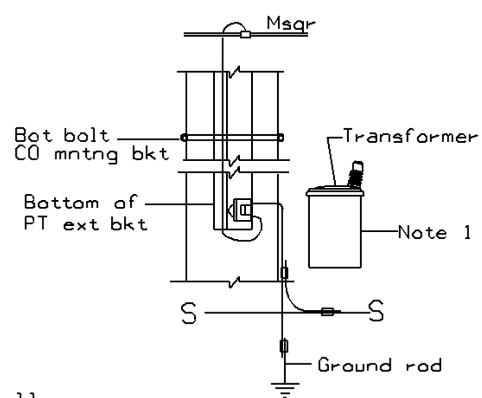




Tap Detail

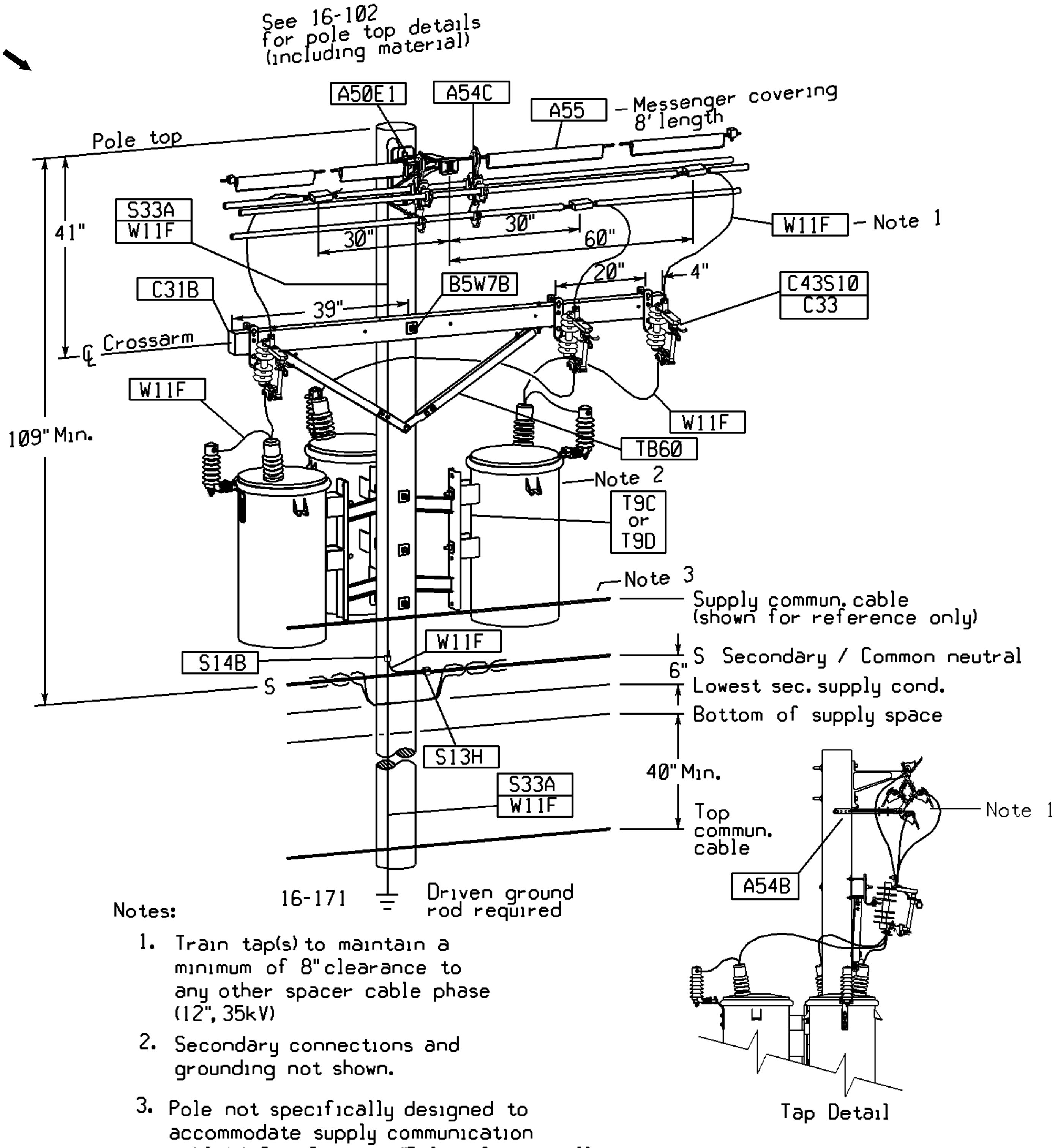
Notes:

1. Secondary transformer connections not shown.
2. Maintain 30" min. - bottom tank to top communication cable
3. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
4. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".



Detail 'A'

15KV LINE POLE – SINGLE PHASE TRANSFORMER WITH E – BRACKET ON POLE TOP EXTENSION			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-169	ISSUE 7/08



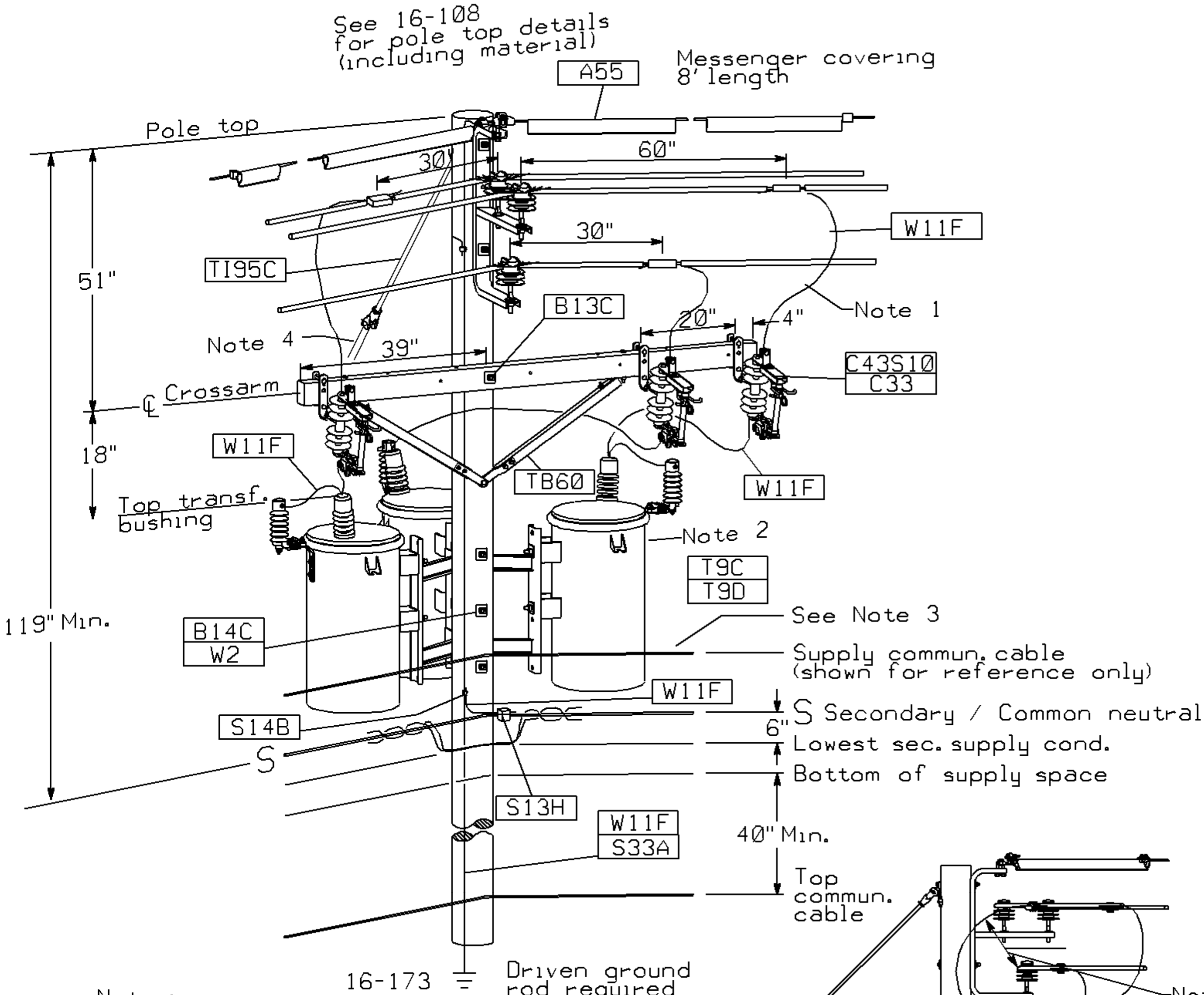
Notes:

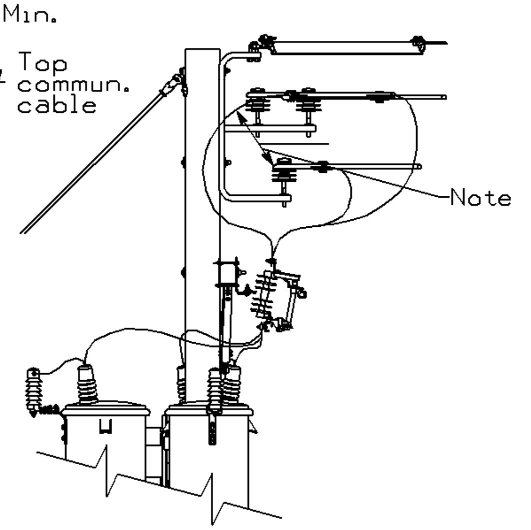
1. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
2. Secondary connections and grounding not shown.
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".

Supersedes 7/07 Issue – Revised Dimensional Detail.

15KV STRAIGHT LINE POLE – THREE PHASE TRANSFORMER BANK

ISSUE	PAGE NUMBER		
7/08	16-171	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities





Tap Detail

Notes:

1. Train tap(s) to maintain a minimum of 8" clearance to any other spacer cable phase (12", 35kV)
2. Secondary connections and grounding not shown.
3. Pole not specifically designed to accommodate supply communication cable(s). See Company "Policy for installing communication cables in the supply space".
4. Ground guy to pole equipment down ground.

15KV LINE ANGLE POLE – THREE PHASE TRANSFORMER BANK

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	16-173	7/08

Spacer Cable Construction Drawings

23 kV & 35 kV Grounded Distribution Systems

MU = @16-201SCLBSW35KV	SC PREASSB SW, LOADBREAK, 35KV

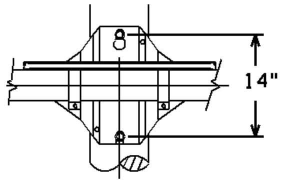


Figure 1
Pole Mounting Detail

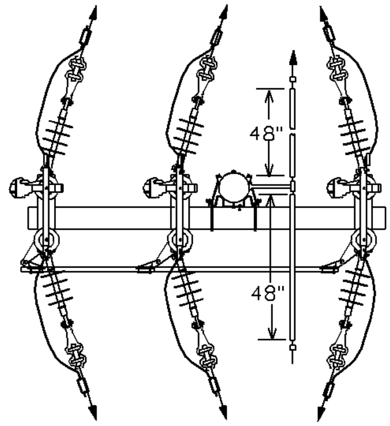
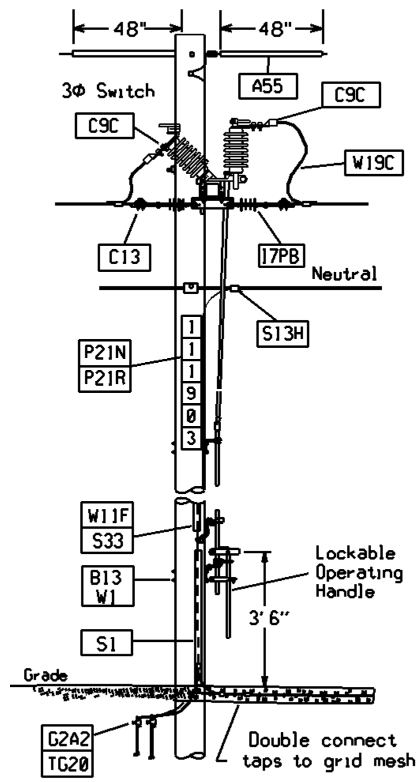


Figure 2 - Plan View



16-201

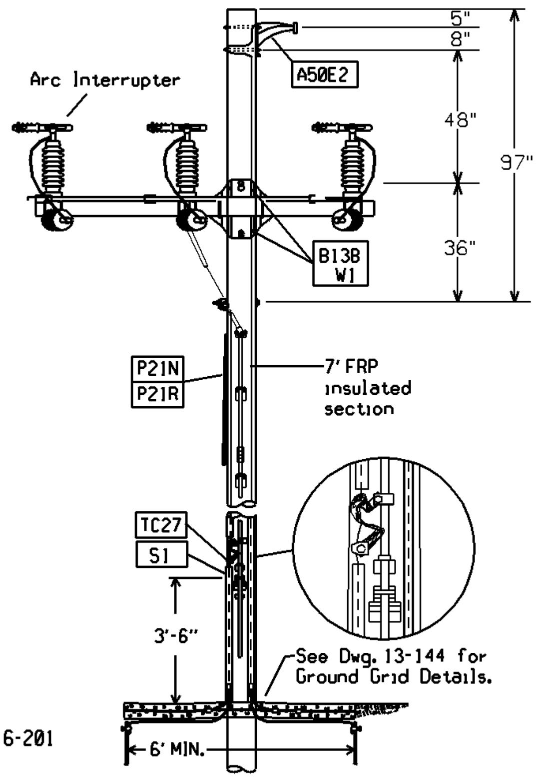


Figure 3

Figure 4

NOTES:

1. Surge arresters shall be installed onto adjacent source and load side poles within 300'.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6" of bare conductor at the switch terminals for grounding purposes. Use 5/8" thru bolts to mount operating rod guides.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20 degrees.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechanism shall be locked in the open or closed position.
8. Switch identification mounted vertically on road side providing maximum visibility.

Supersedes 7/08 Issue - Updated MU.

35KV PREASSEMBLED LOADBREAK SWITCH			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-201	ISSUE 7/09

Doc. # ST. 16.00.004

MU = @16-205C(Y)	0-35 kV, 24" Tan., (Y) = Wire Size

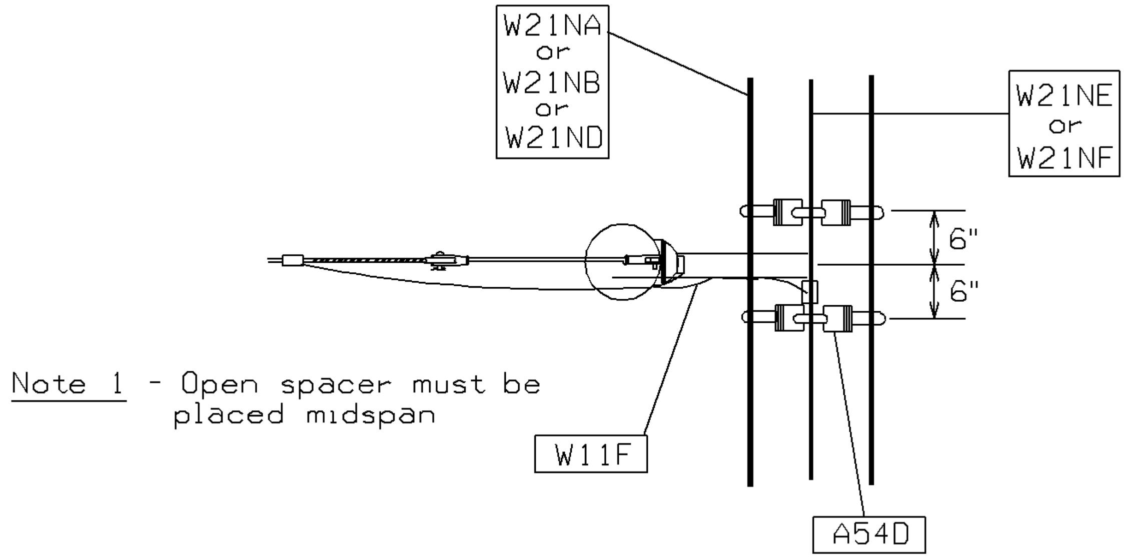
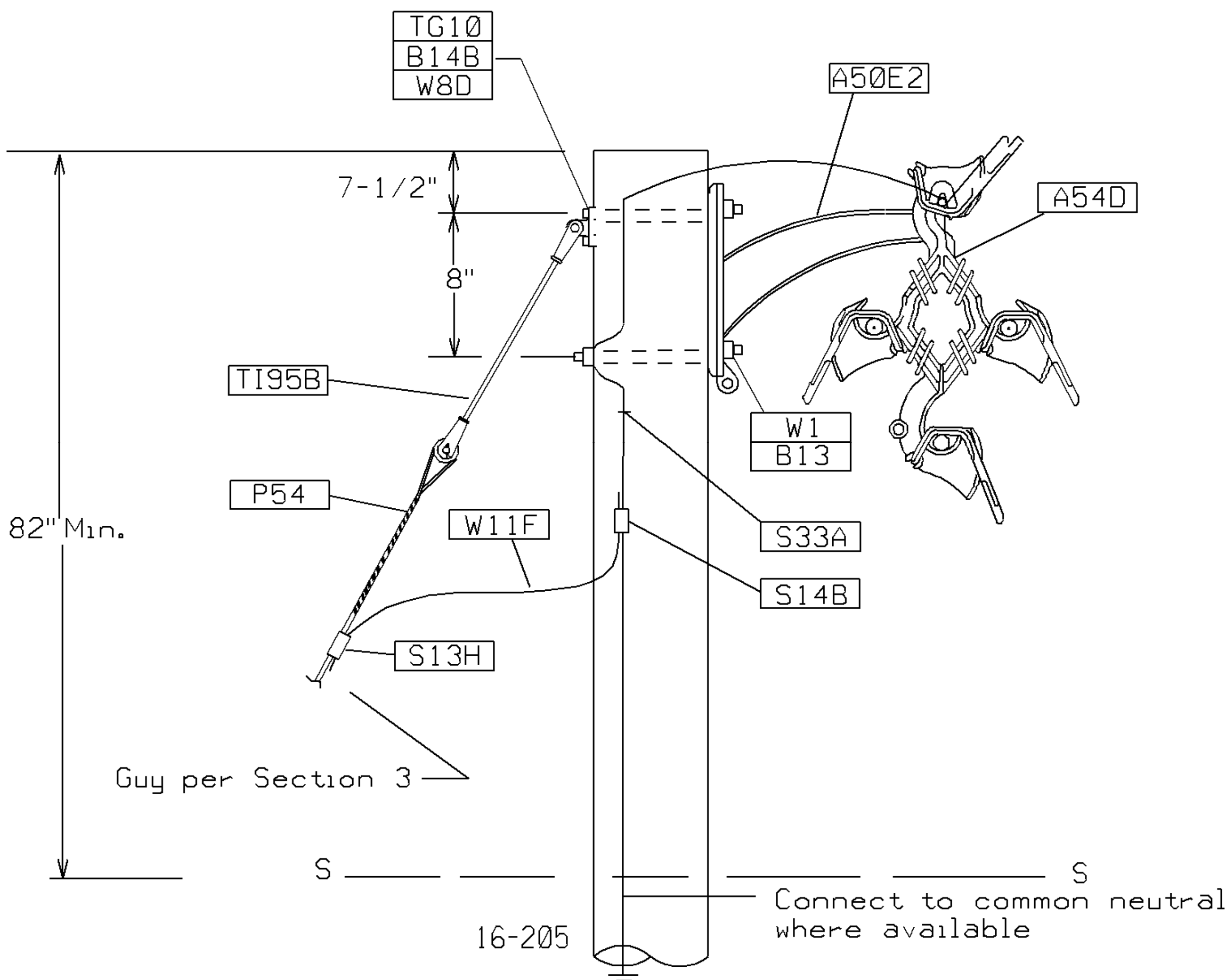


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV LINE POLE ATTACHMENT FOR 40' OR 45' POLE

ISSUE	PAGE NUMBER		
7/09	16-205	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Doc. # ST. 16.00.004

MU = @16-206C(Y)	0-35 kV, 24" Tan., (Y) = Wire Size

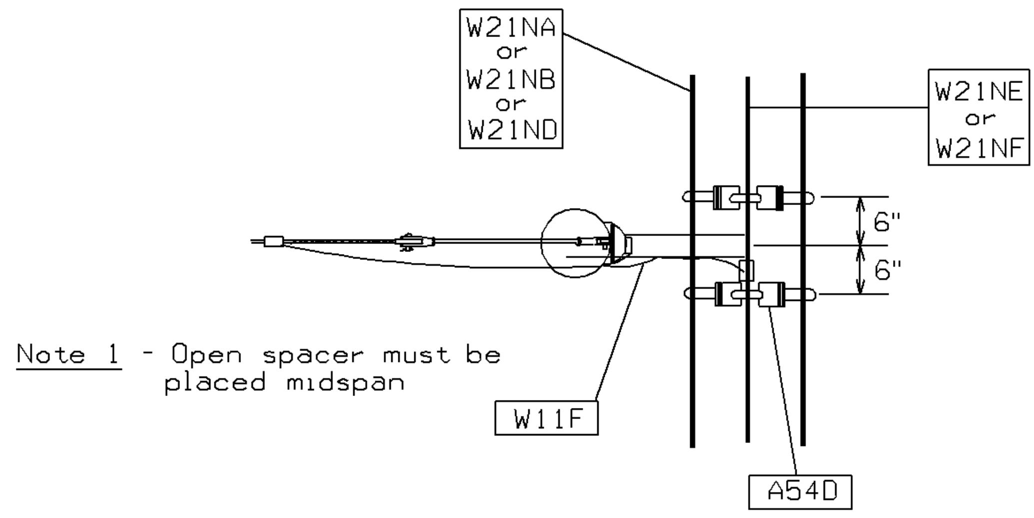
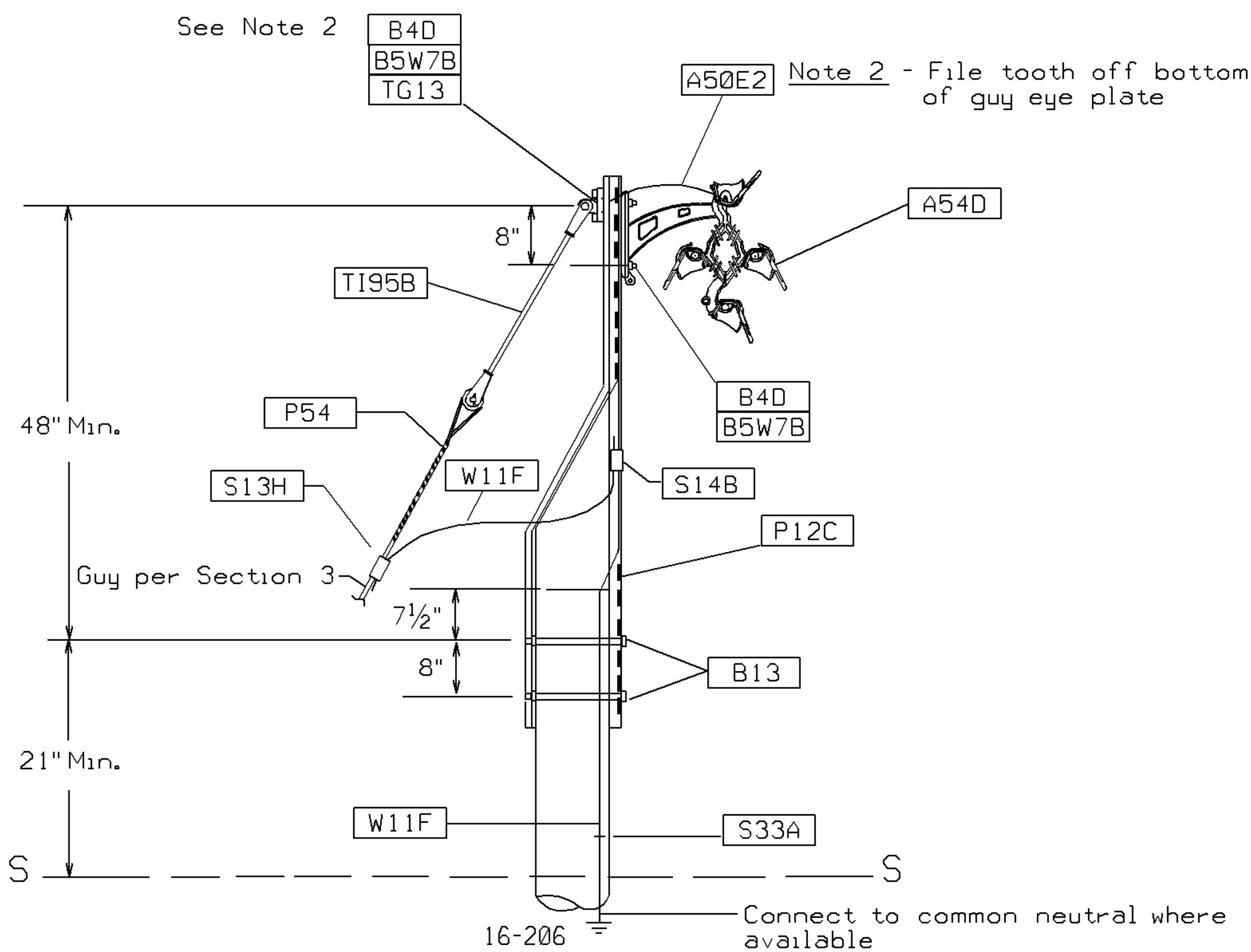


Figure 1 - Top View

Supersedes 7/08 Issue - Updated MU.



35KV LINE POLE ATTACHMENT WITH POLE TOP EXTENSION FOR 35' OR 40' POLE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-206	7/09

 Doc. # ST. 16.00.004

MU = @16-210C(Y)	0-35 kV, 44" Tan., (Y) = Wire Size

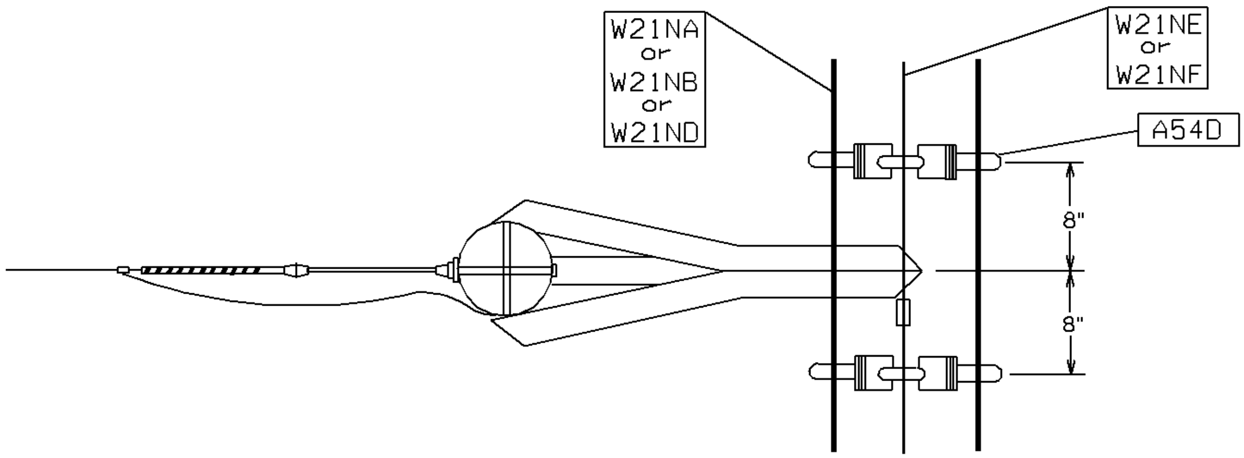
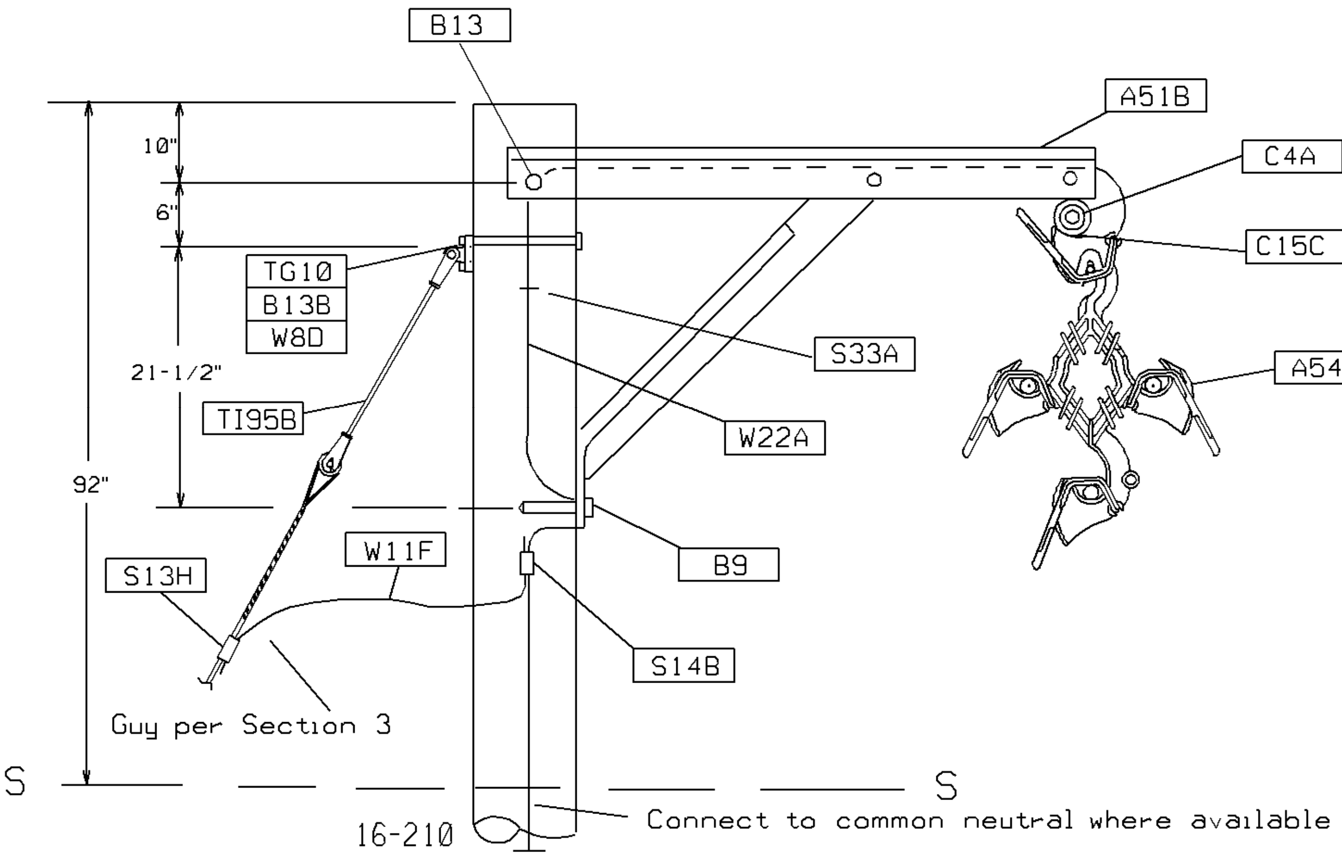


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV LINE POLE ATTACHMENT – 44" EXTENSION BRACKET

ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	16-210		

MU = @16-213C(Y)	0-35 kV, C Brkt., (Y) = Wire Size

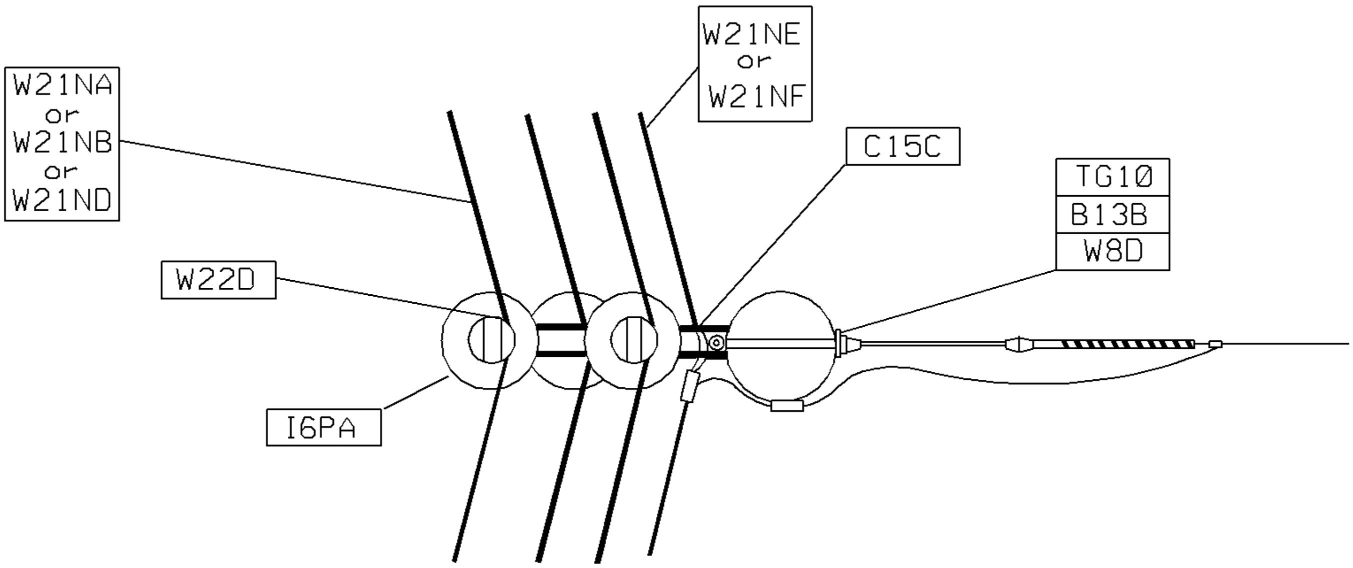
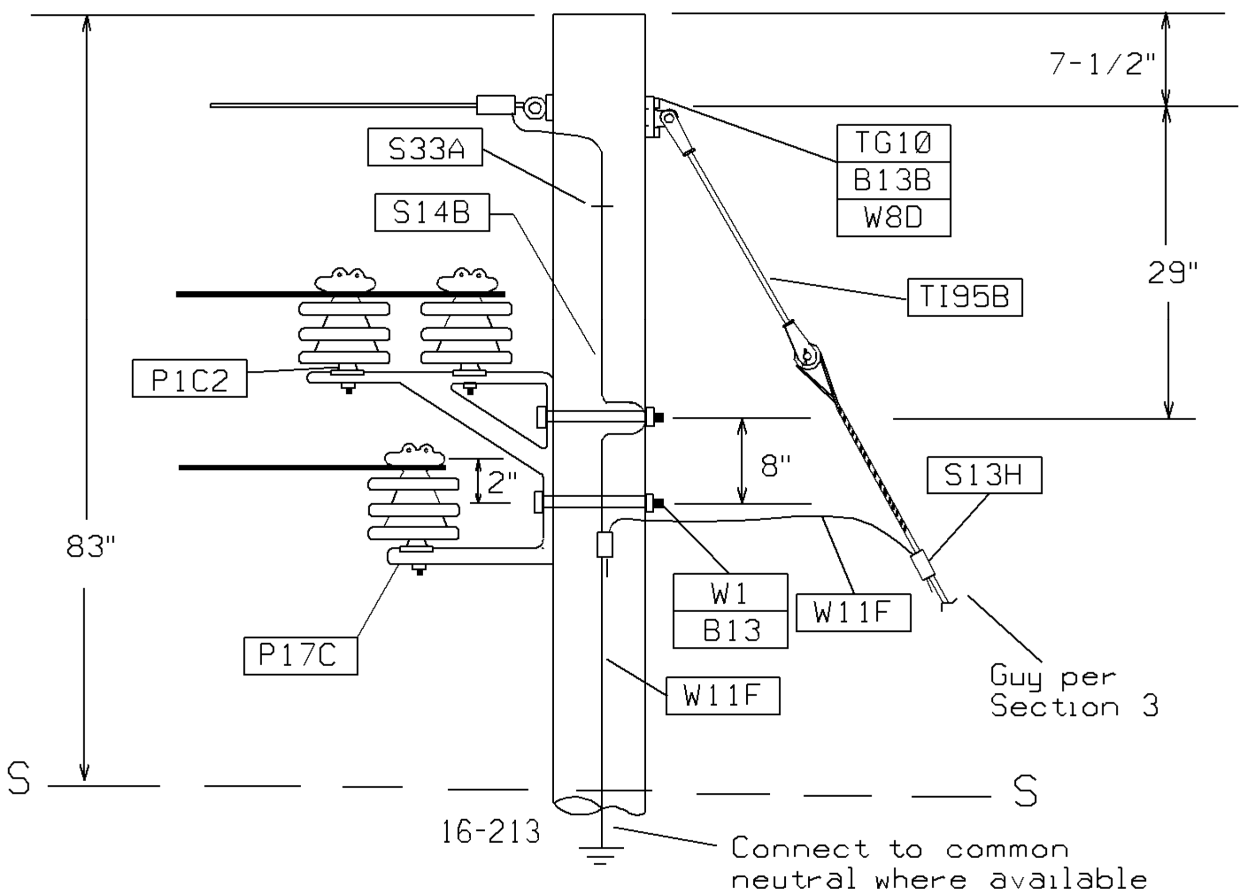


Figure 1 - Top View

Supersedes 7/08 Issue - Updated MU.



35KV CORNER POLE ATTACHMENT FOR 40' OR 45' POLE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-213	ISSUE 7/09

 | Doc. # ST. 16.00.004

MU = @16-214C(Y)	0-35 kV, C Brkt., (Y) = Wire Size

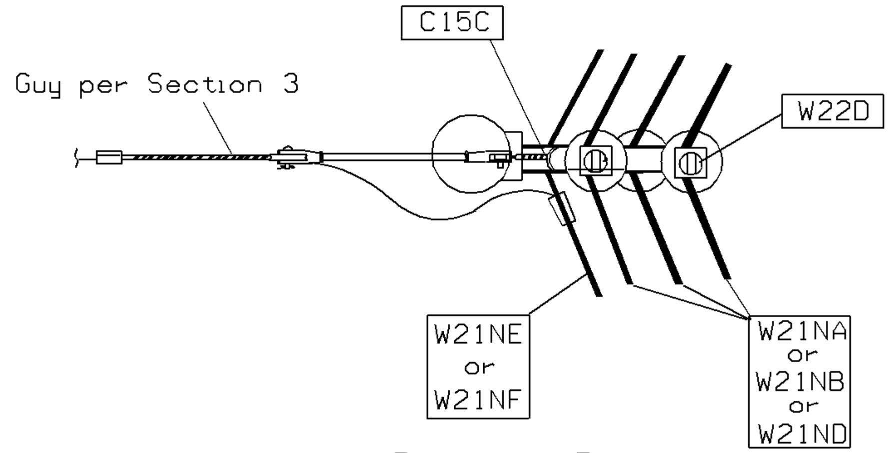
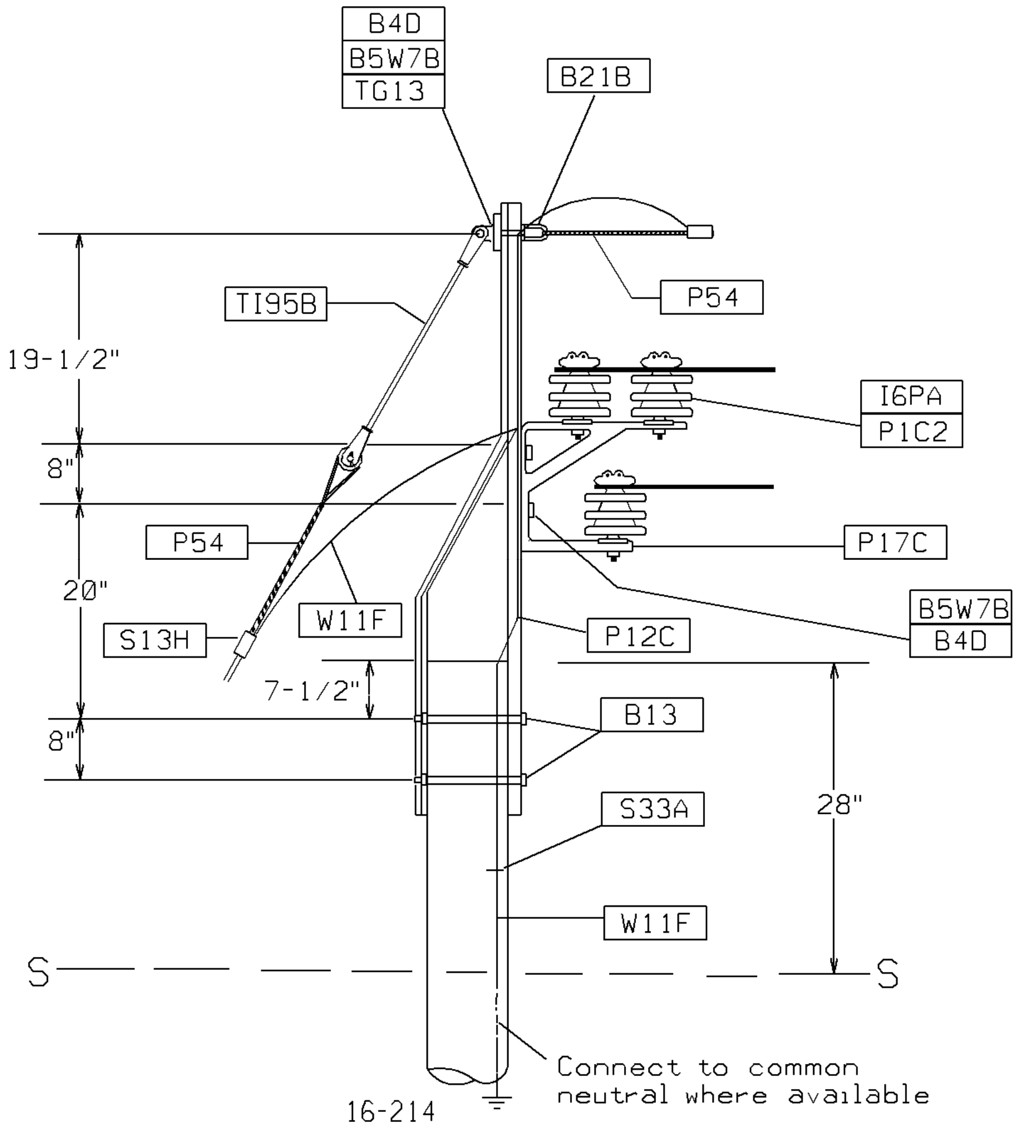


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV CORNER POLE ATTACHMENT USING POLE TOP EXTENSION FOR 35' POLE			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	16-214		

MU = @16-217C(Y)	0-35 kV, C Brkt., (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.

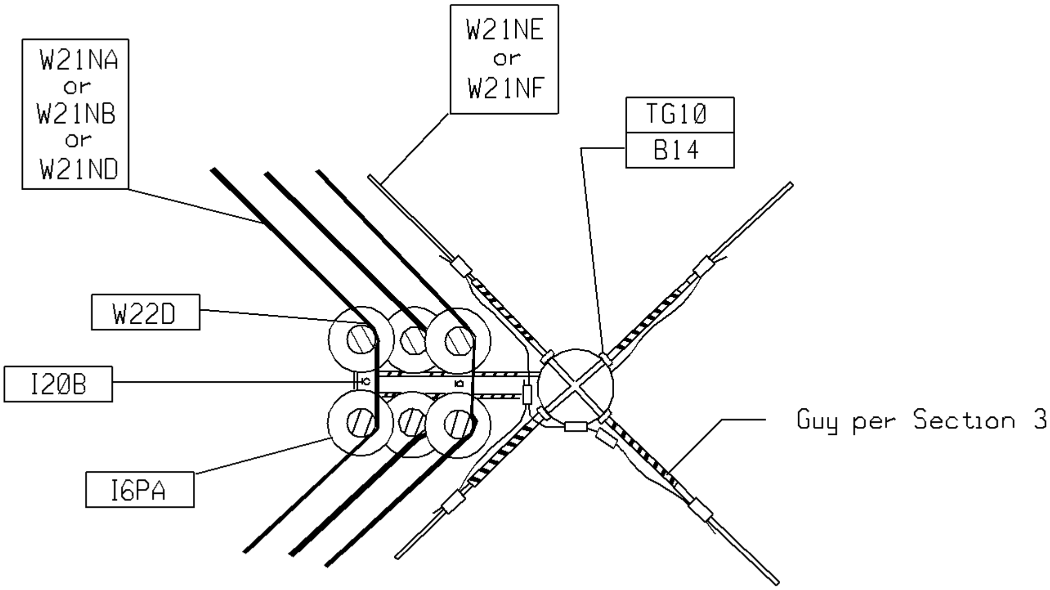
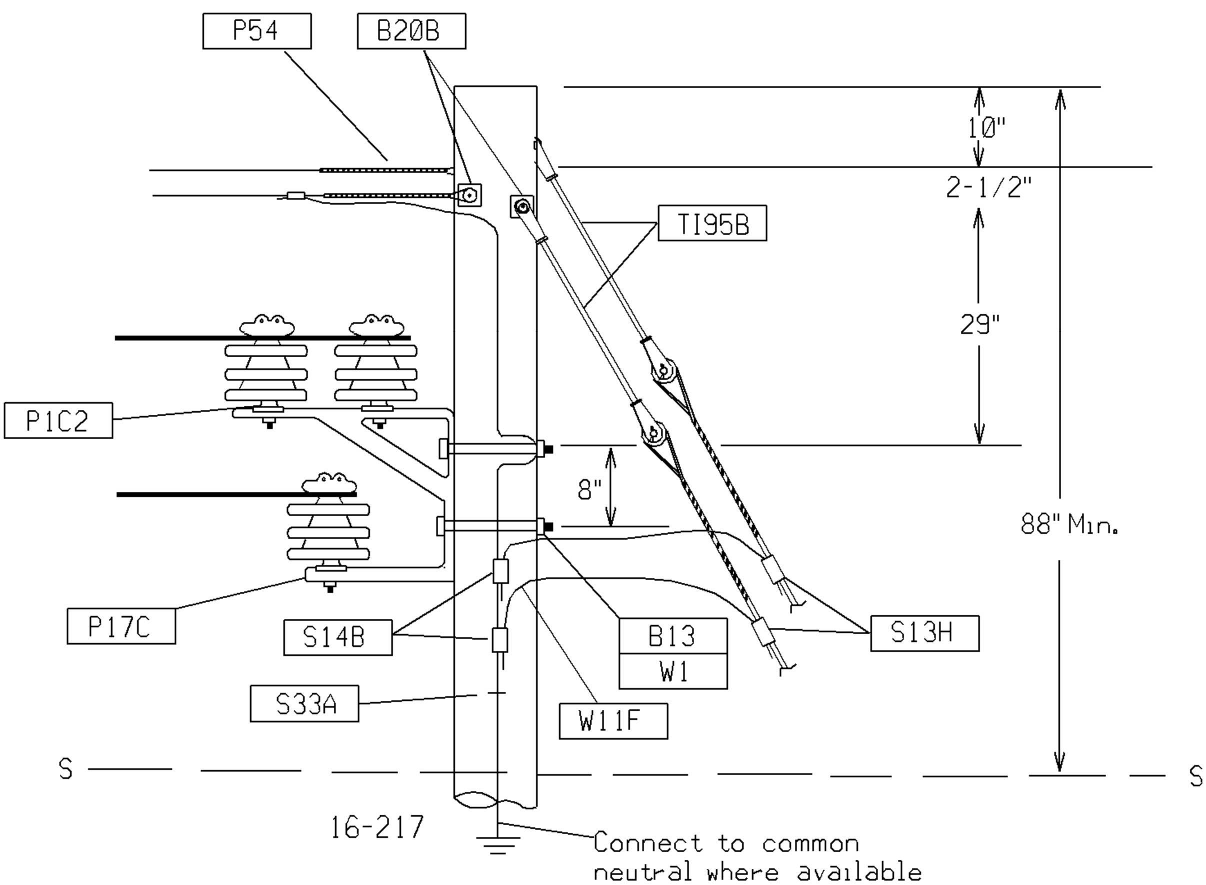


Figure 1 - Top View



35KV CORNER POLE ATTACHMENT FOR 40' OR 45' POLE – LINE ANGLES 61° - 90°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-217	ISSUE 7/09

MU = @16-220C(Y)	0-35 kV, Crossarm., (Y) = Wire Size

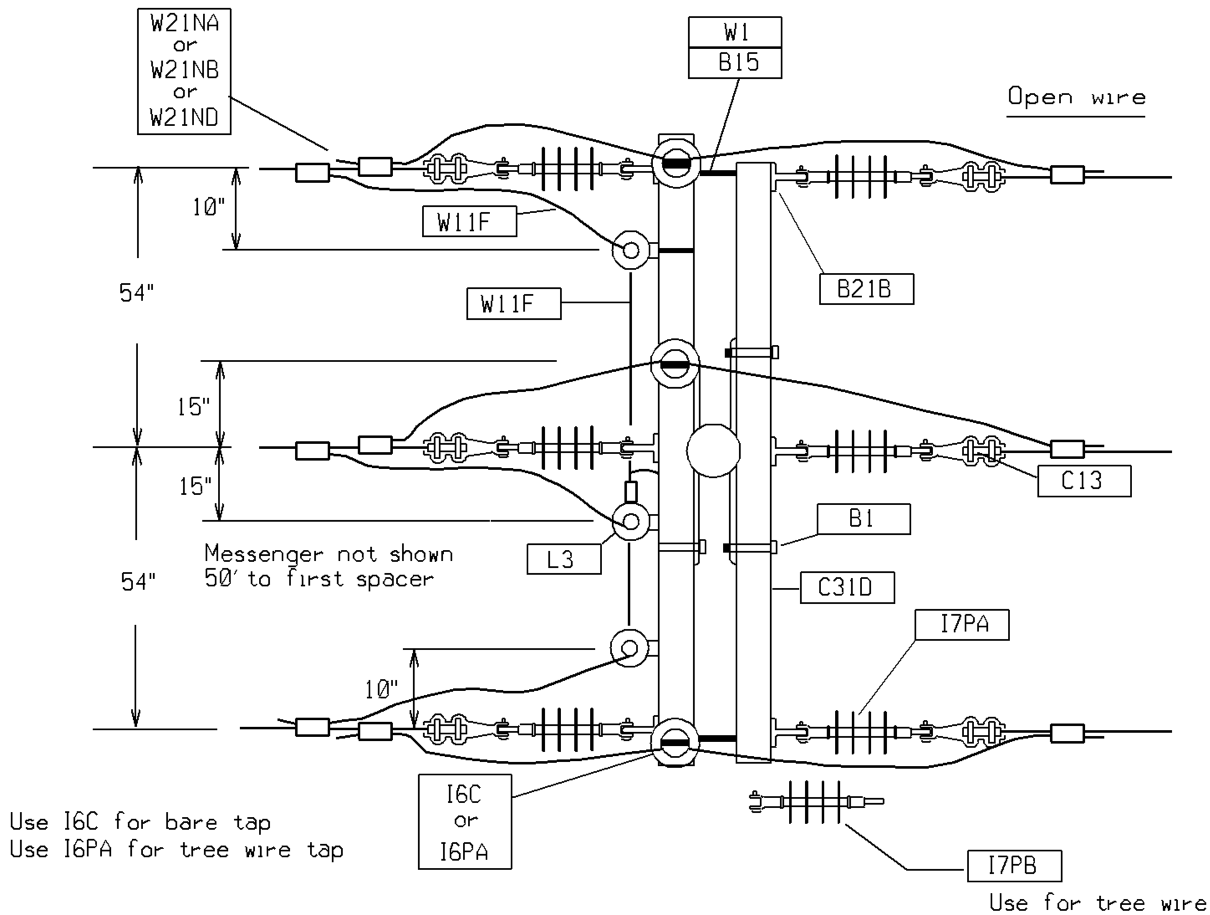
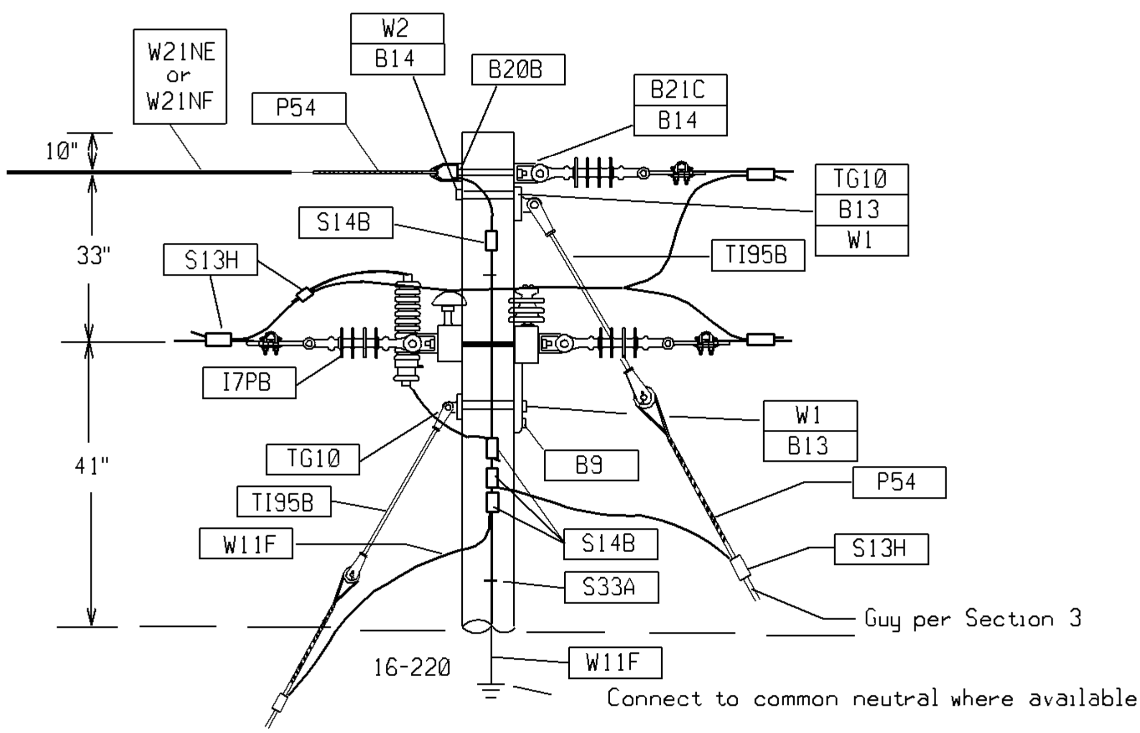


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35 KV CONNECTION TO OPEN WIRE FOR 40' OR 45' POLE

ISSUE	PAGE NUMBER		
7/09	16-220	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

 Doc. # ST. 16.00.004

MU = @16-223C(Y)	0-35 kV, DE., (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.

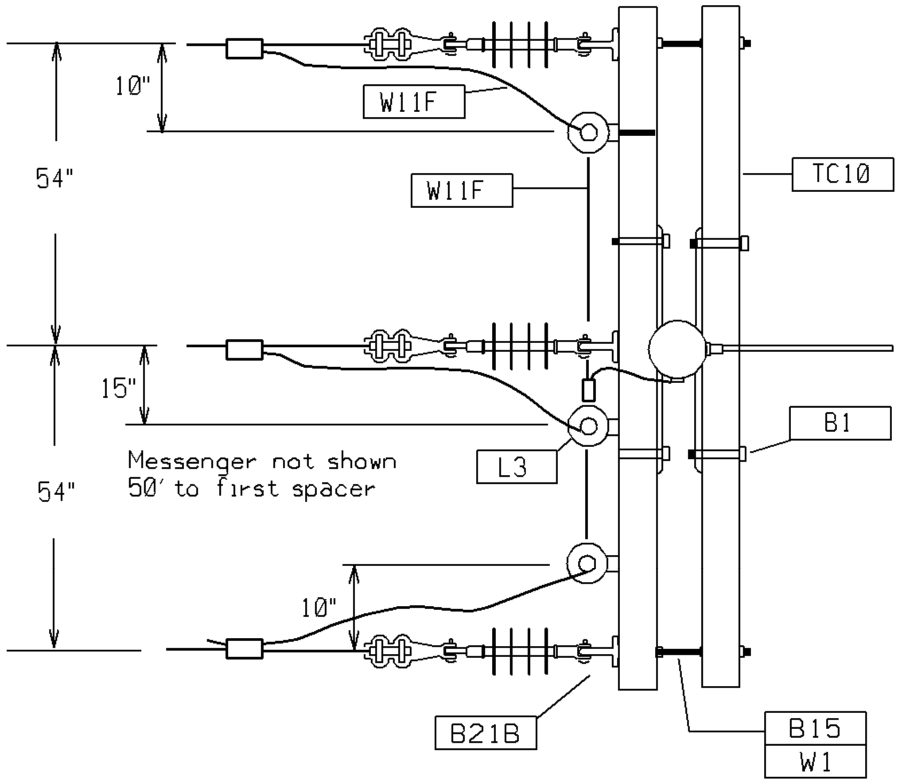
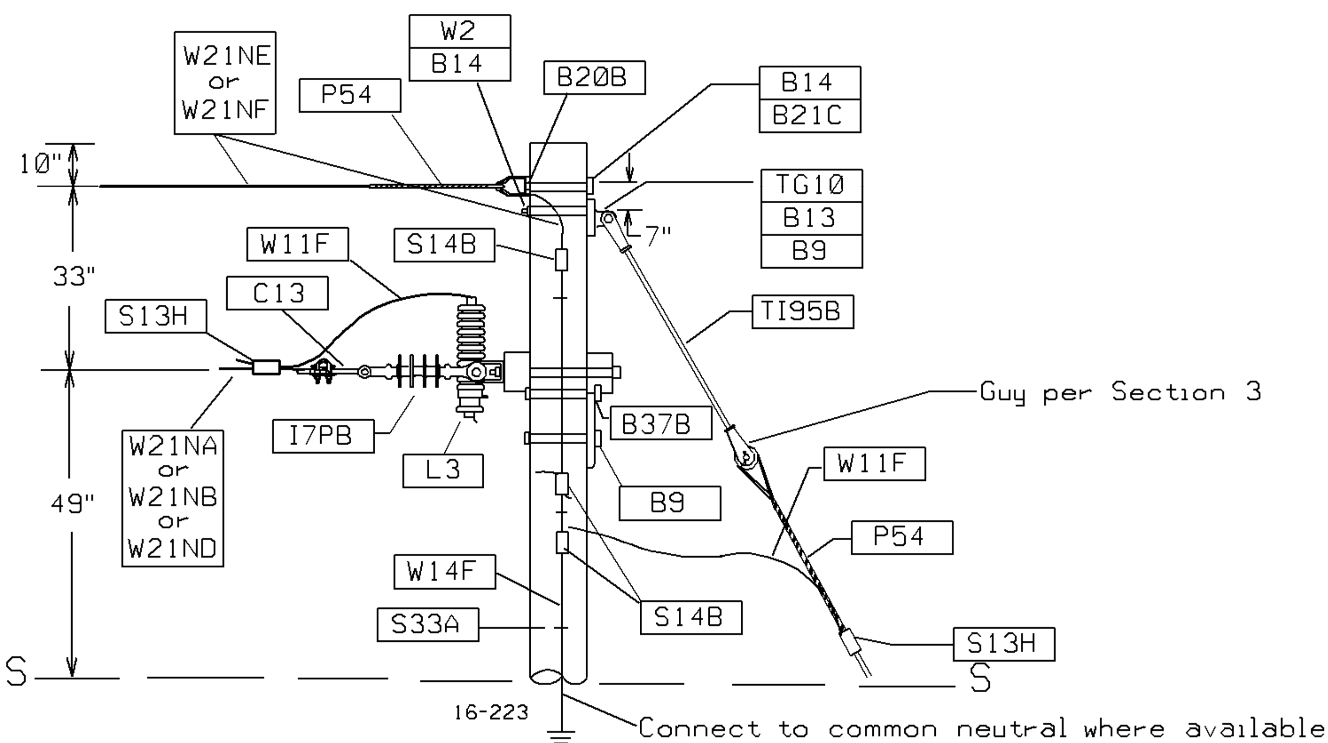


Figure 1 - Top View



35KV DEADEND CONSTRUCTION FOR 40' OR 45' POLE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-223	7/09

 Doc. # ST. 16.00.004

MU = @16-226W1/0TC(Y)	0-35 kV, 24" Tan., (Y) = Wire Size

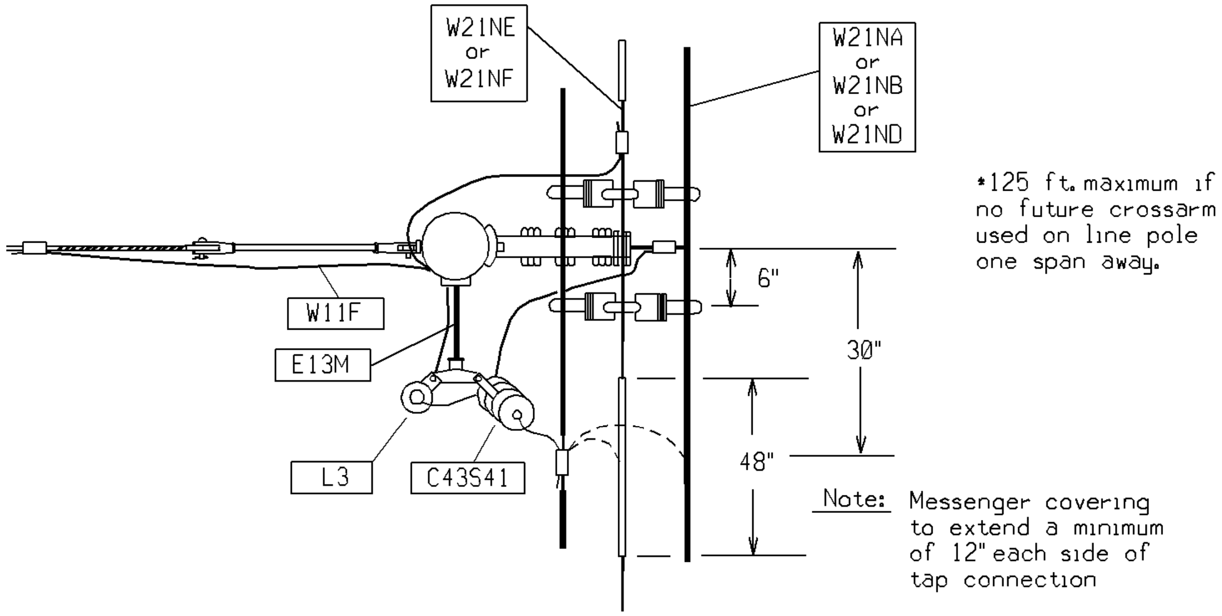
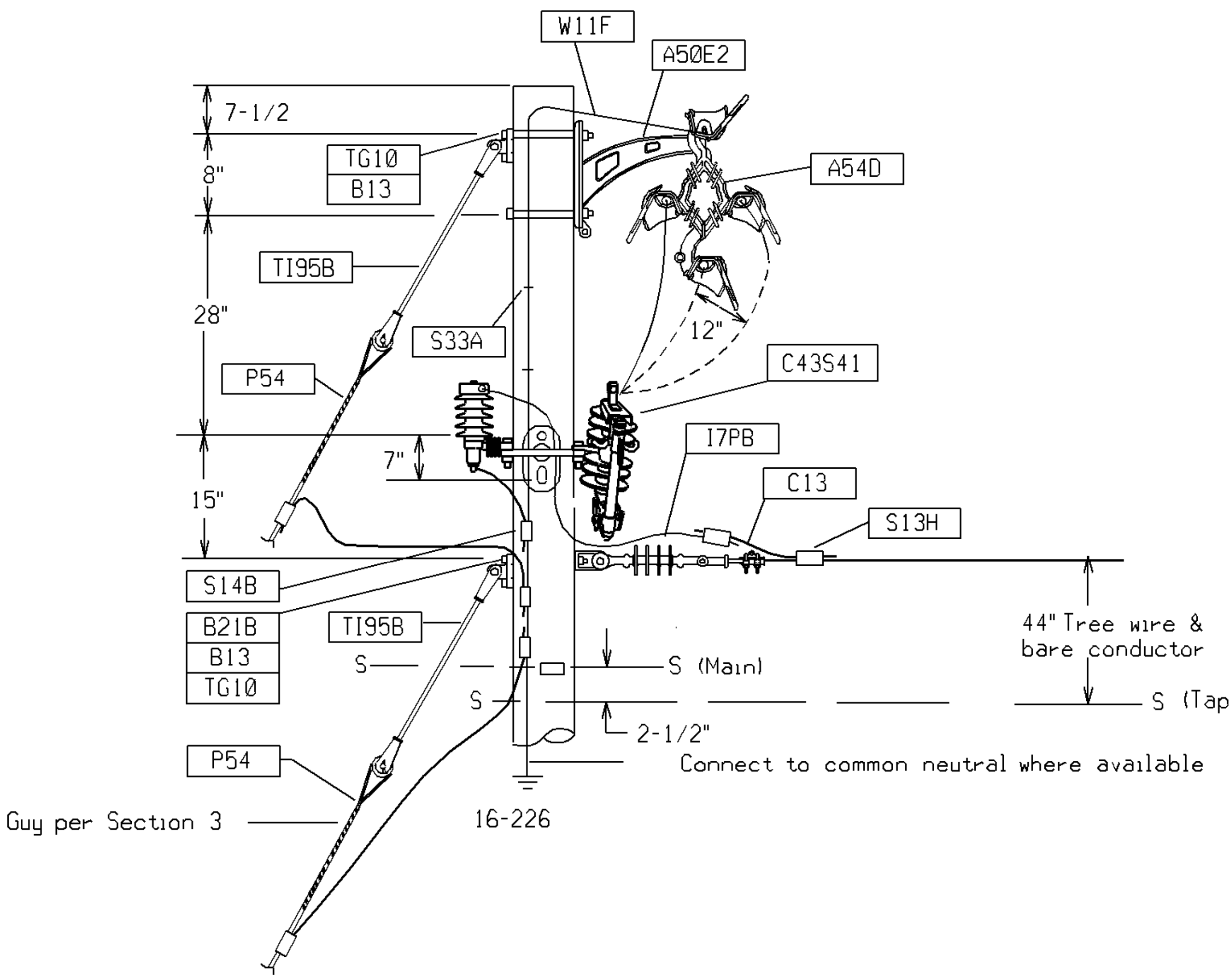


Figure 1 - Top View

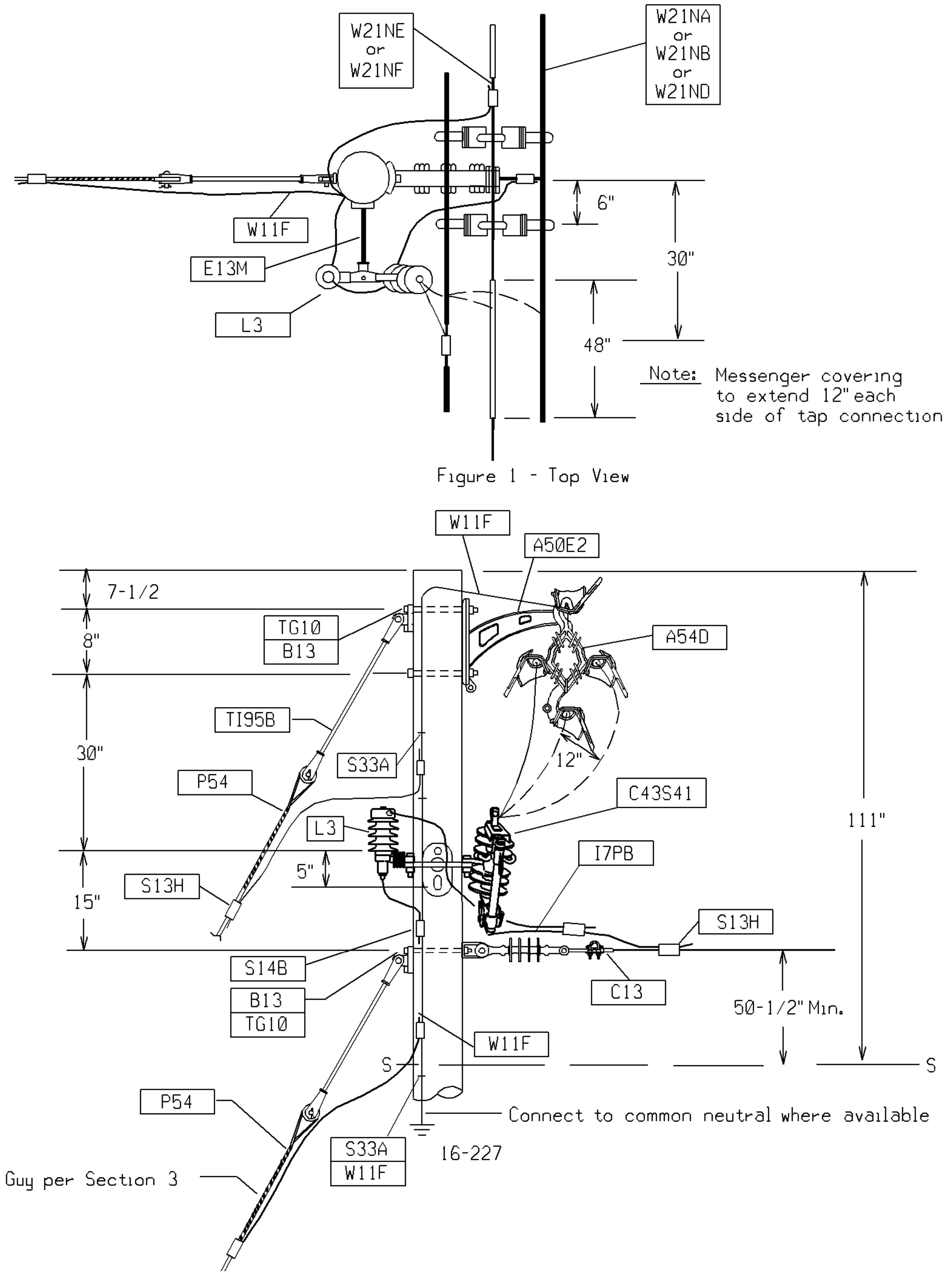


Supersedes 7/08 Issue - Updated MU.

35KV LINE POLE ATTACHEMENT TO SINGLE PHASE OPEN WIRE TAP FOR 40' POLE

ISSUE	PAGE NUMBER		
7/09	16-226	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Supersedes 1/06 Issue – Revised Construction Detail and Guying - Refer To Page 9-2XX for Maximum Span Calculation Detail



35KV LINE POLE ATTACHEMENT TO SINGLE PHASE OPEN WIRE TAP FOR 45' POLE

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-227	7/07

Doc. # ST. 16.00.004

MU = @16-228W1/0TC(Y)	0-35 kV, 24" Tan., (Y) = Wire Size

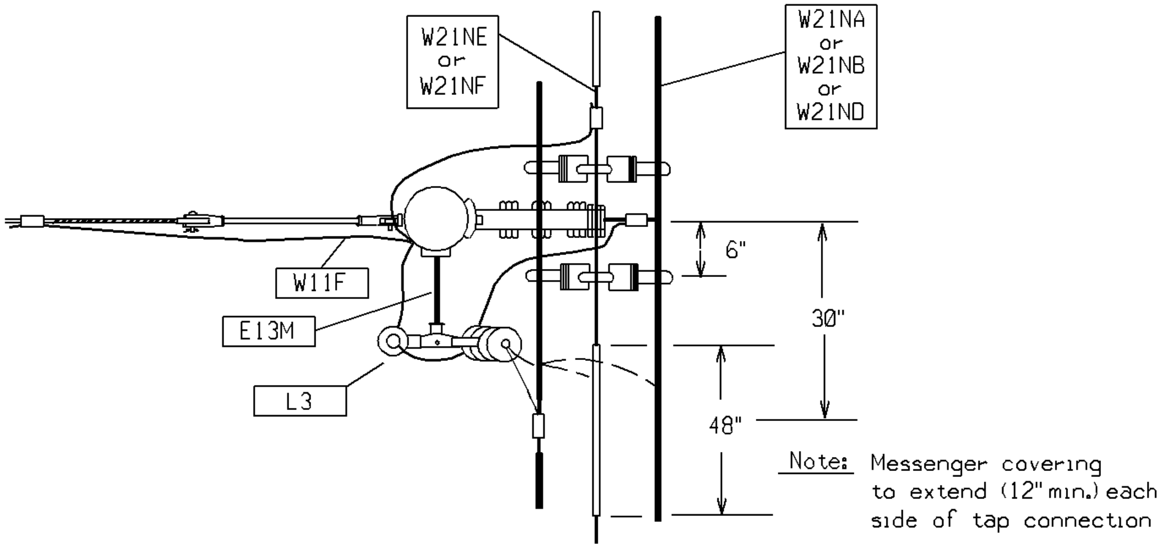
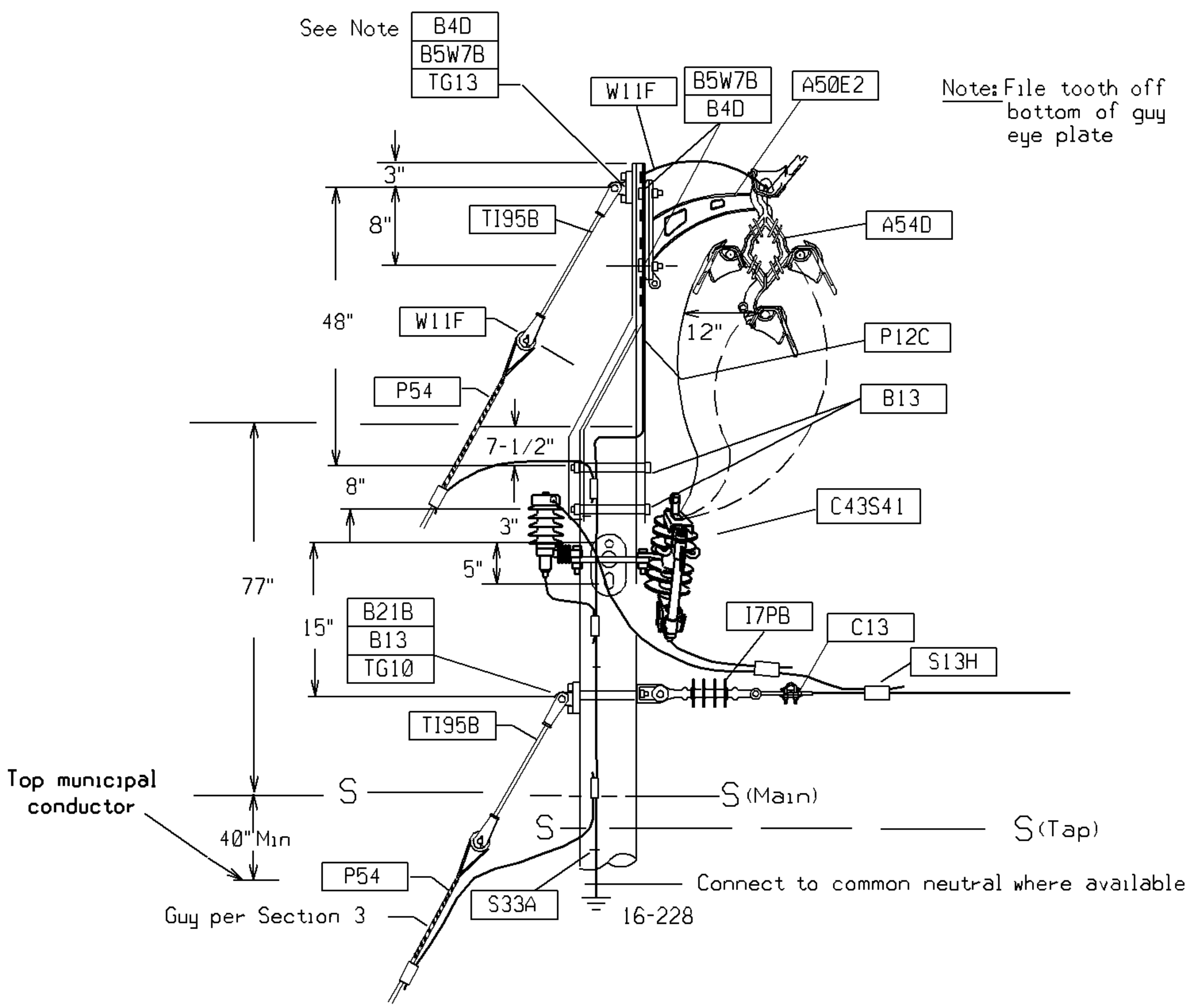


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV LINE POLE ATTACHEMENT TO SINGLE PHASE OPEN WIRE TAP FOR 40' POLE WITH POLE TOP EXTENSION

ISSUE	PAGE NUMBER		
7/09	16-228	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @16-232W1/0TC(Y)	0-35 kV, C Brkt., (Y) = Wire Size

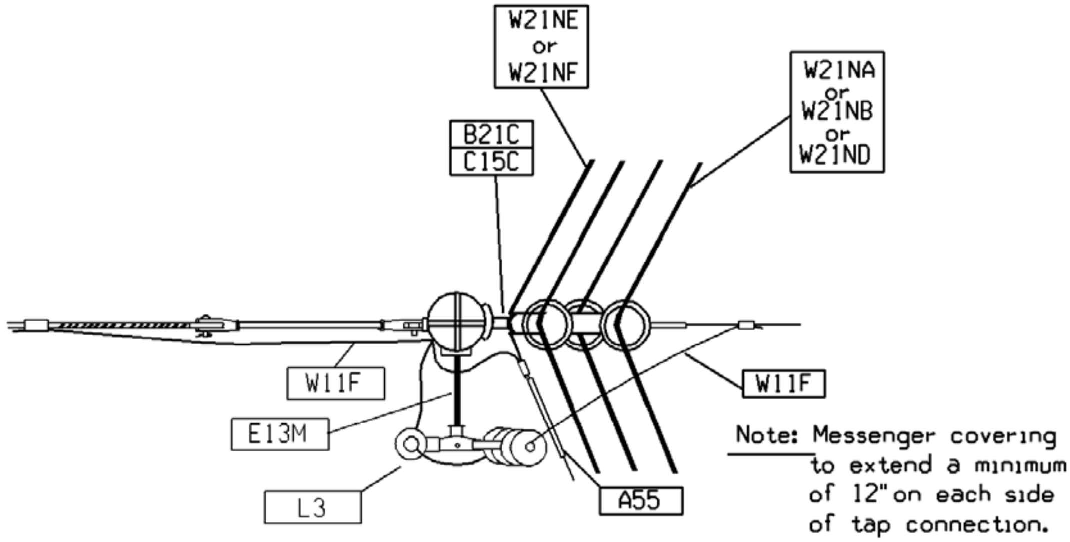
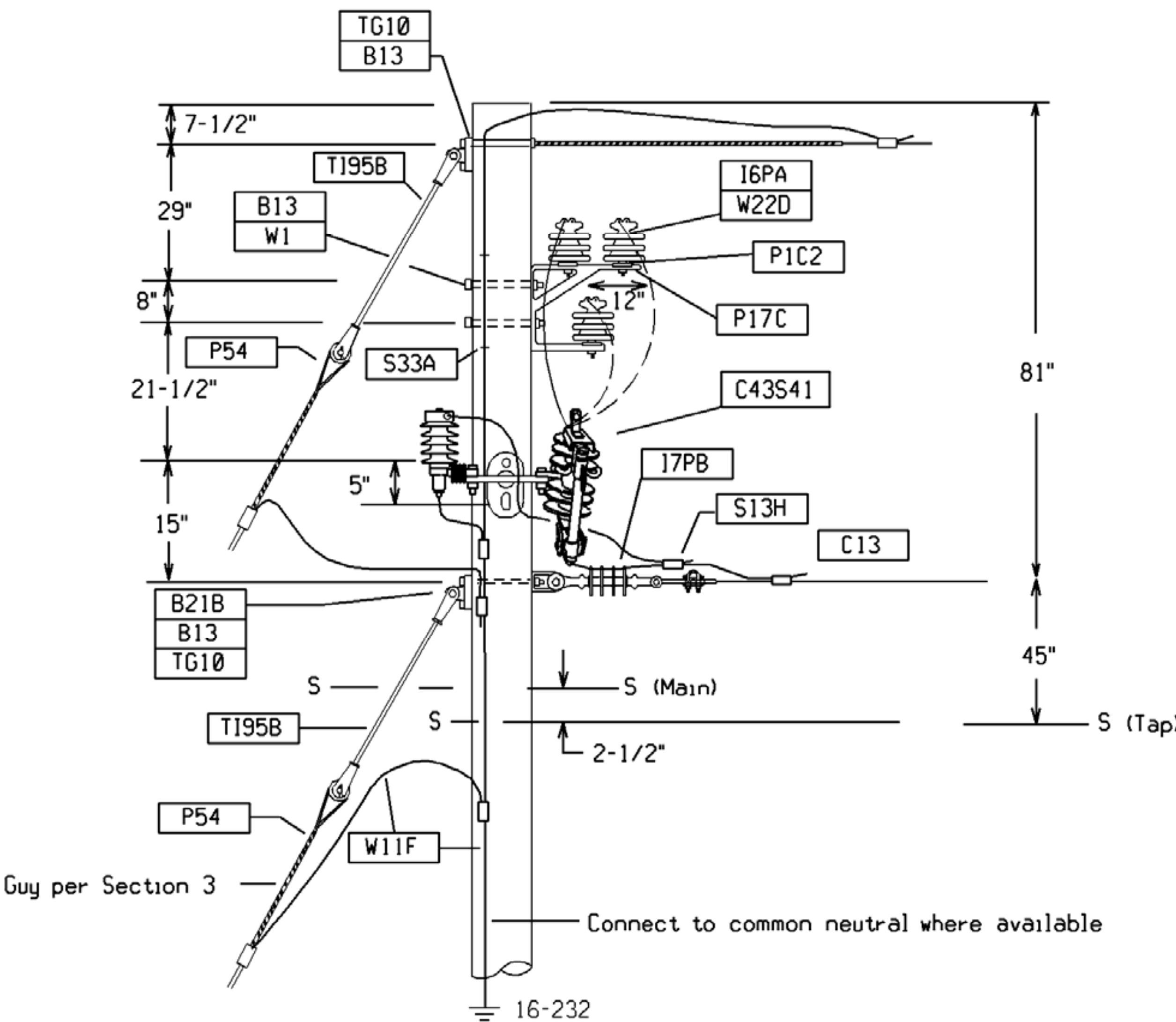


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV CORNER POLE ATTACHEMENT TO SINGLE PHASE OPEN WIRE TAP FOR 45' POLE

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 16-232	ISSUE: 7/09

 Doc. # ST. 16.00.004

MU = @16-233W1/0TC(Y)	0-35 kV, C Brkt., (Y) = Wire Size

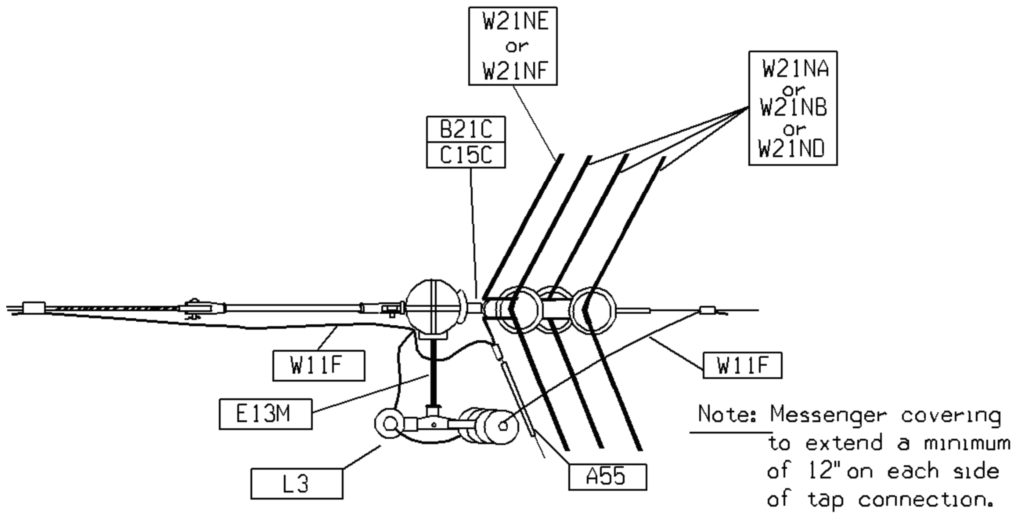
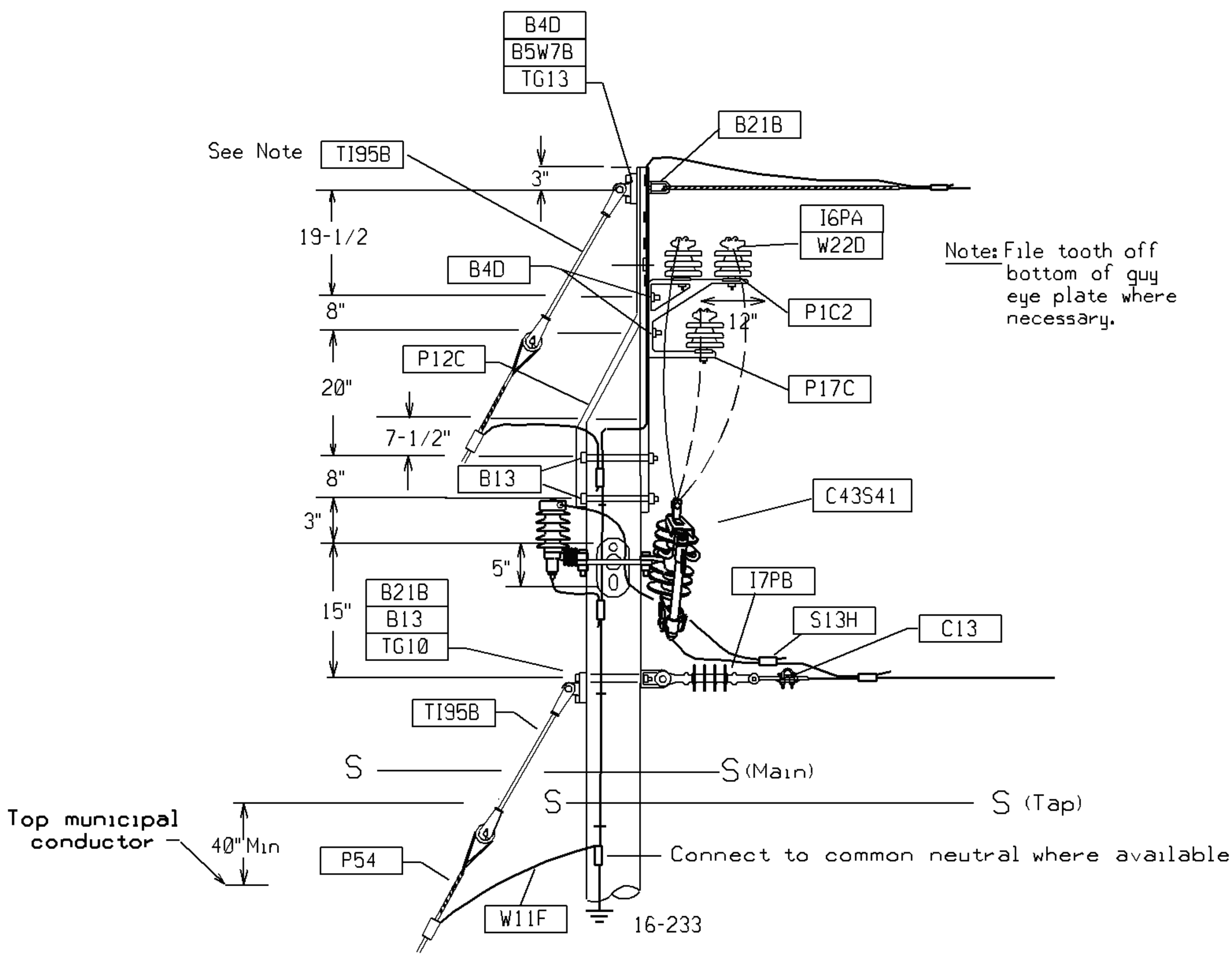


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV CORNER POLE ATTACHEMENT TO SINGLE PHASE OPEN WIRE TAP FOR 40' POLE WITH POLE TOP EXTENSION			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	16-233		

MU = @16-236C(Y)	0-35 kV, 24" Tan., (Y) = Wire Size	MU = @16-2362PHC(Y)	0-35 kV, 24" Tan., 2 Ph. Jct., (Y) = Wire Size

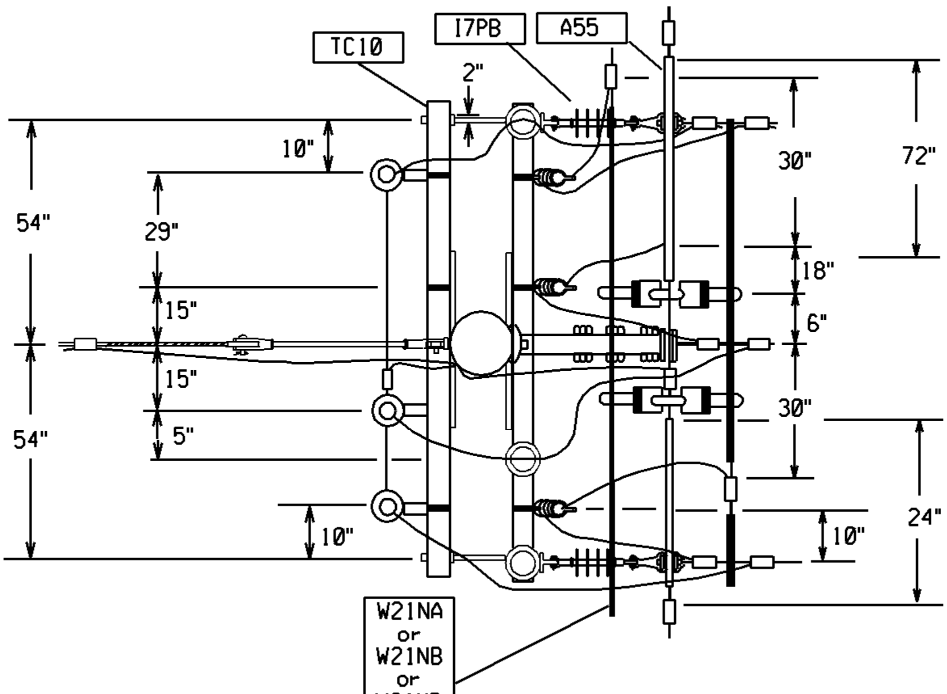
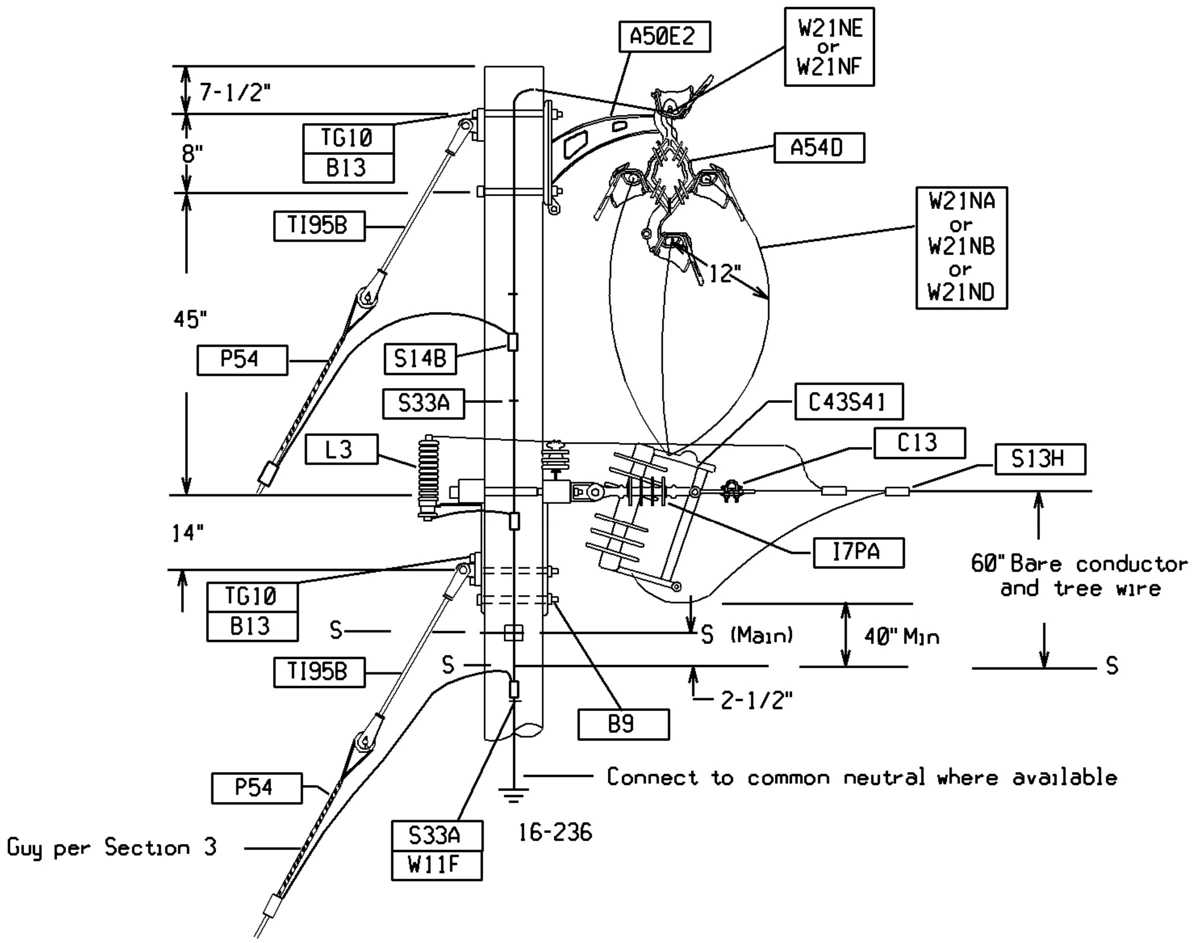


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV LINE POLE ATTACHEMENT TO THREE PHASE OPEN WIRE TAP FOR 45' POLE

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-236	7/09

 | Doc. # ST. 16.00.004

MU = @16-237C(Y)	0-35 kV, 24" Tan., (Y) = Wire Size

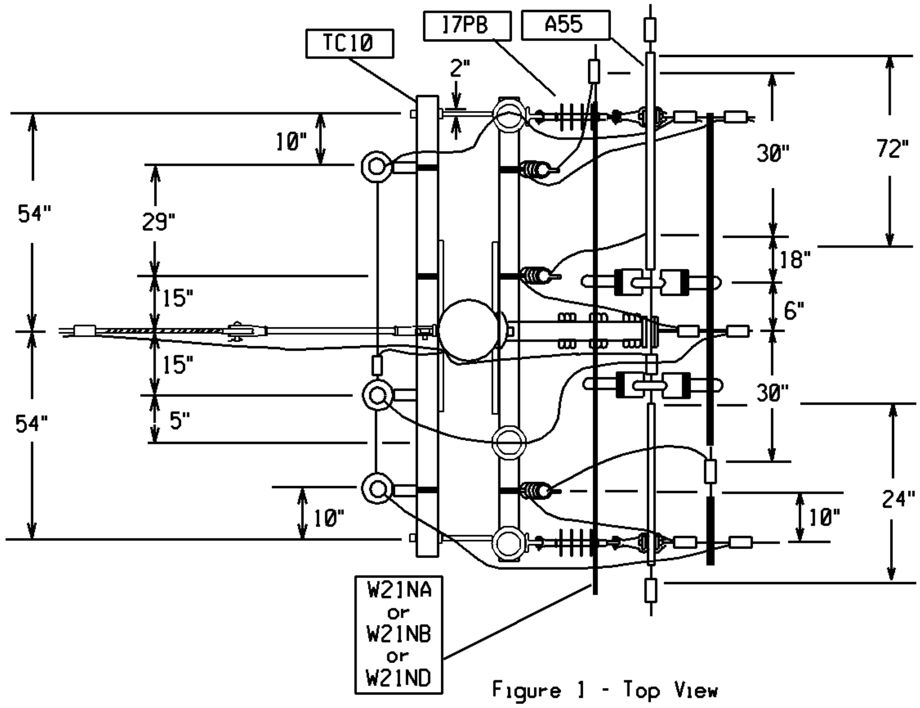
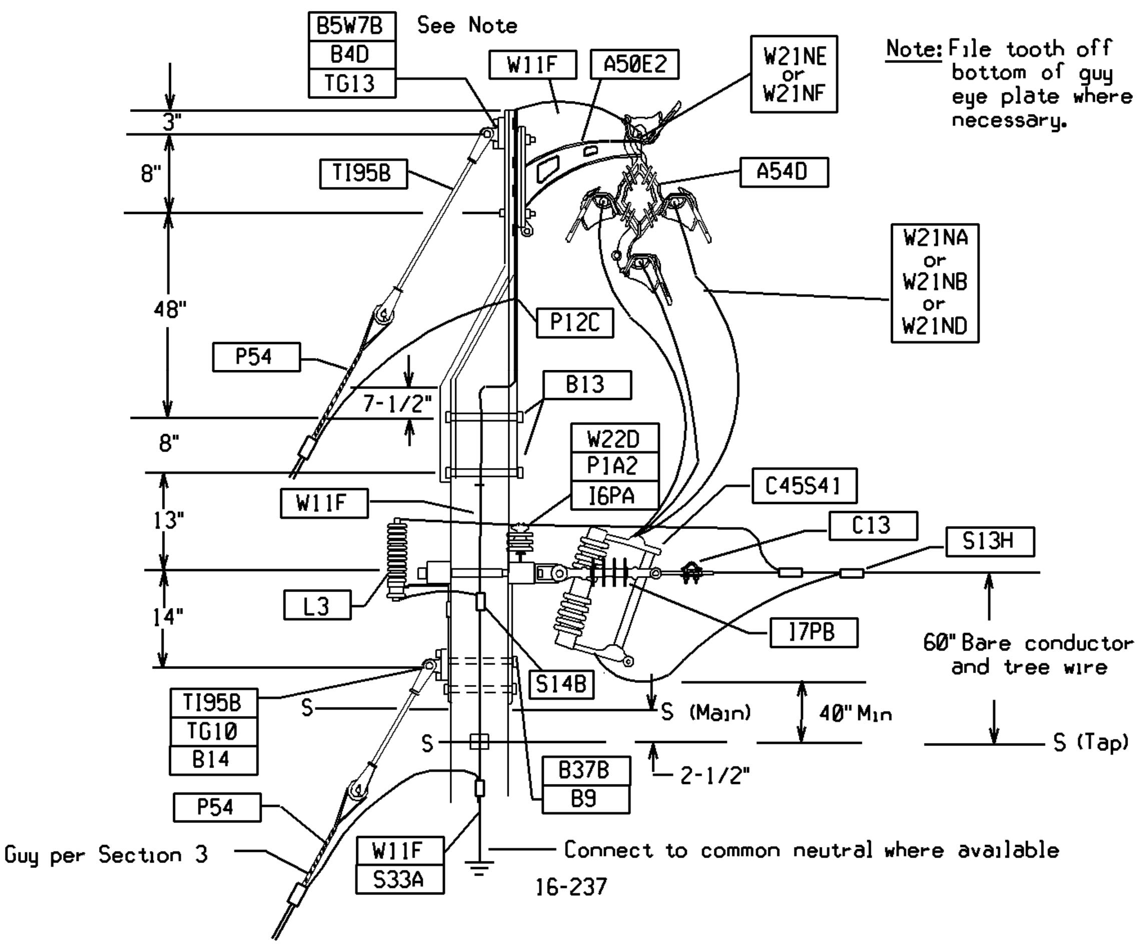


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

Doc. # ST. 16.00.004

MU = @16-240C(Y)	0-35 kV, 24" Tan., (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.

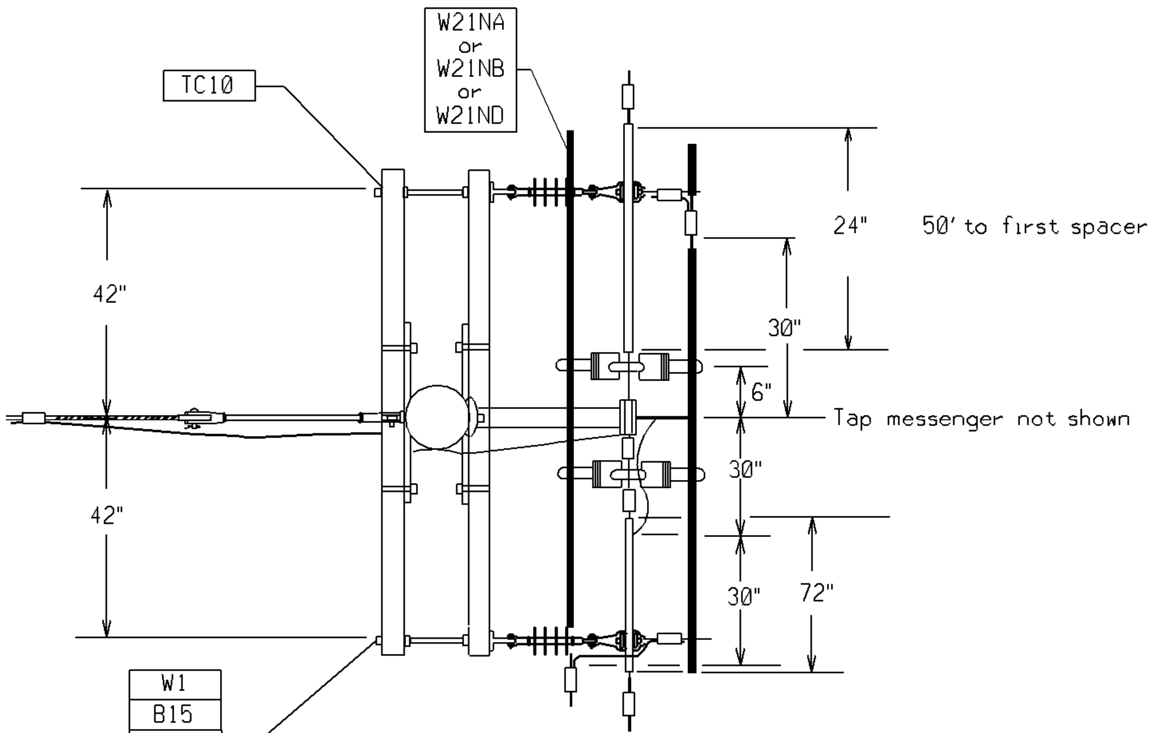
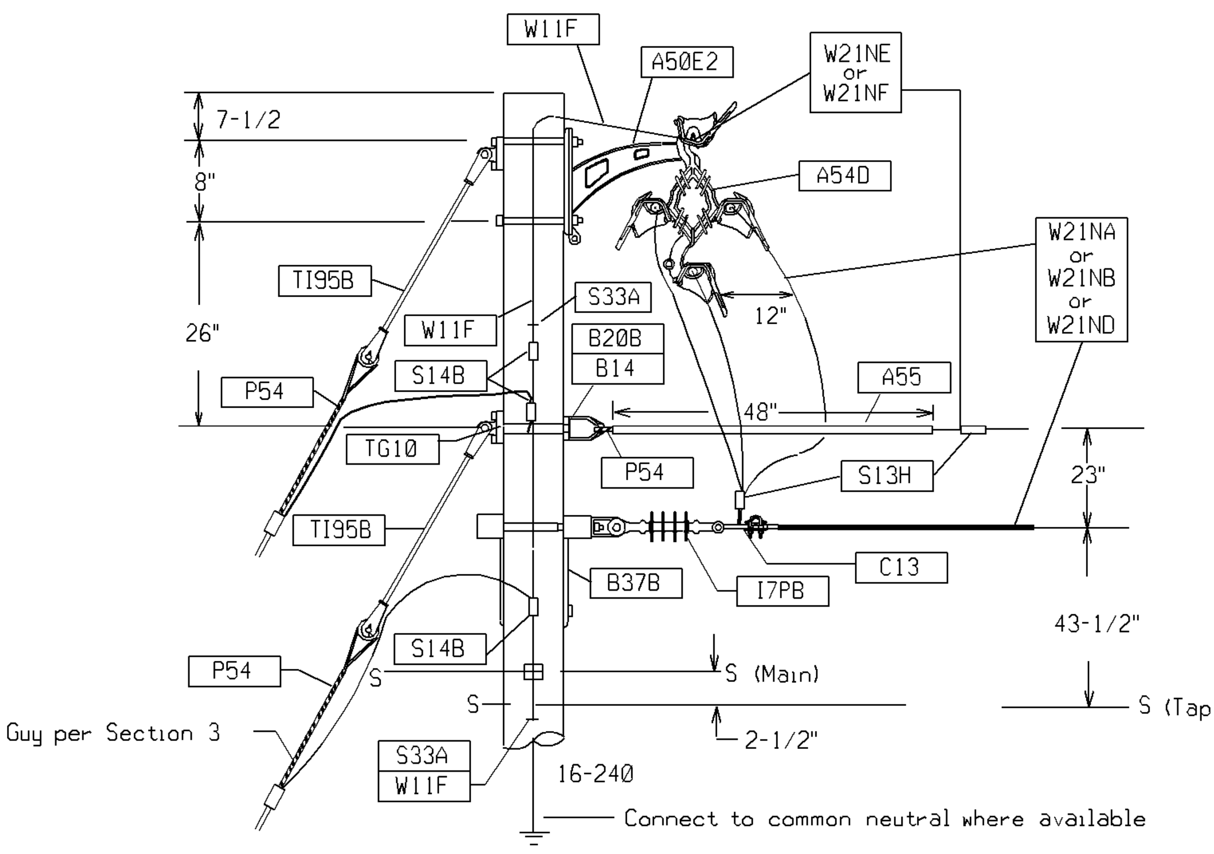


Figure 1 - Top View



35KV LINE POLE ATTACHEMENT TO THREE PHASE SPACER CABLE TAP FOR 40' OR 45' POLE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 16-240	ISSUE: 7/09

 Doc. # ST. 16.00.004

MU = @16-243C(Y)	0-35kV, E Brkt., (Y) = Wire Size	MU = @16-2432PHC(Y)	0-35 kV, E Brkt., 2 Ph. Jct., (Y) = Wire Size

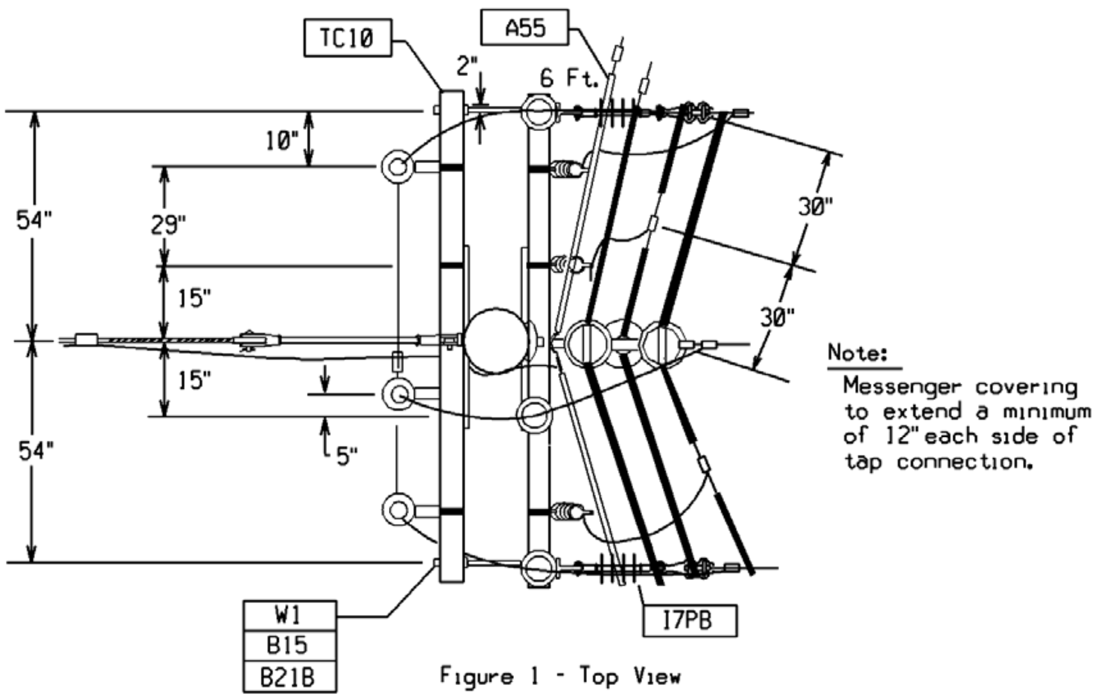
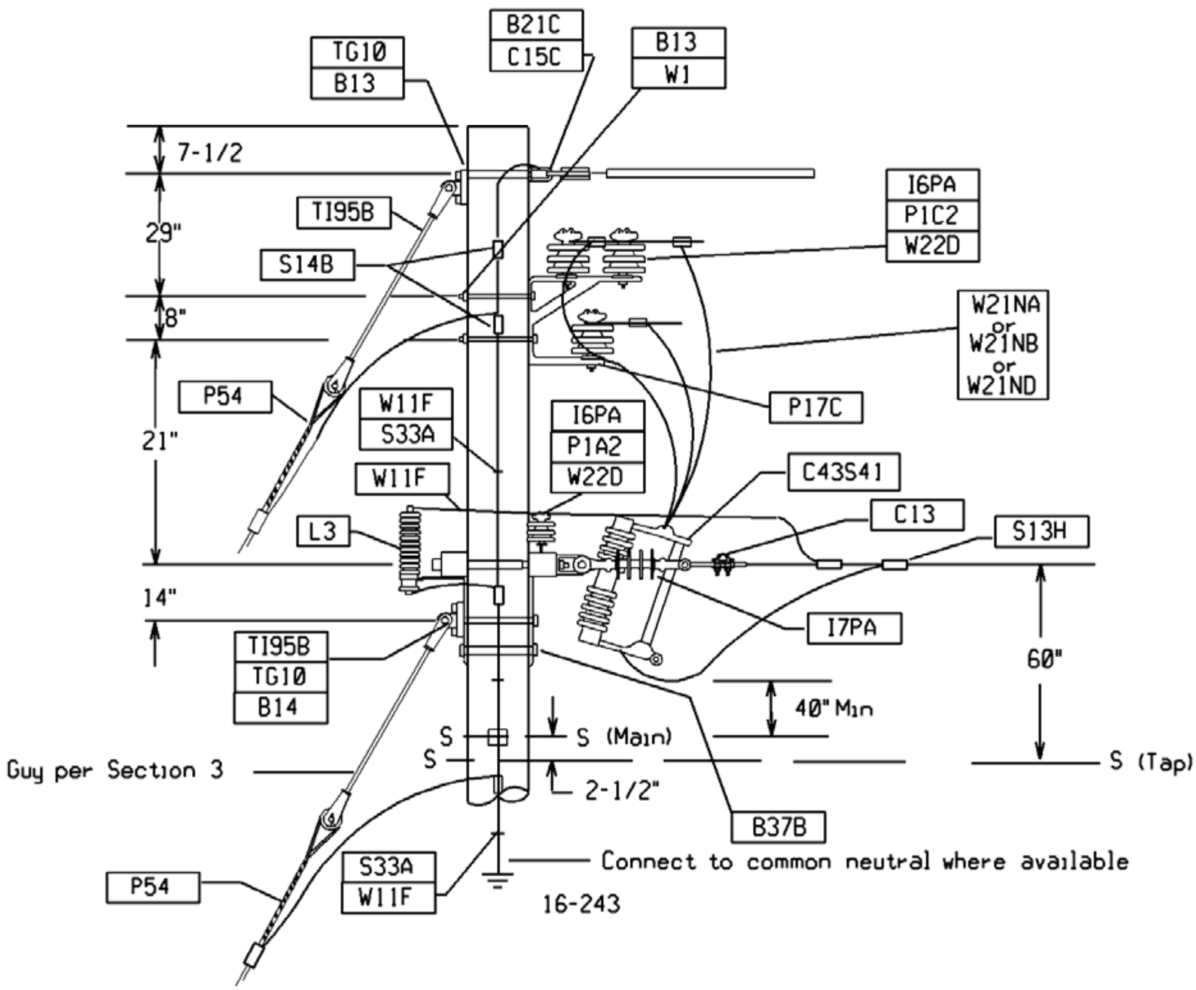


Figure 1 - Top View



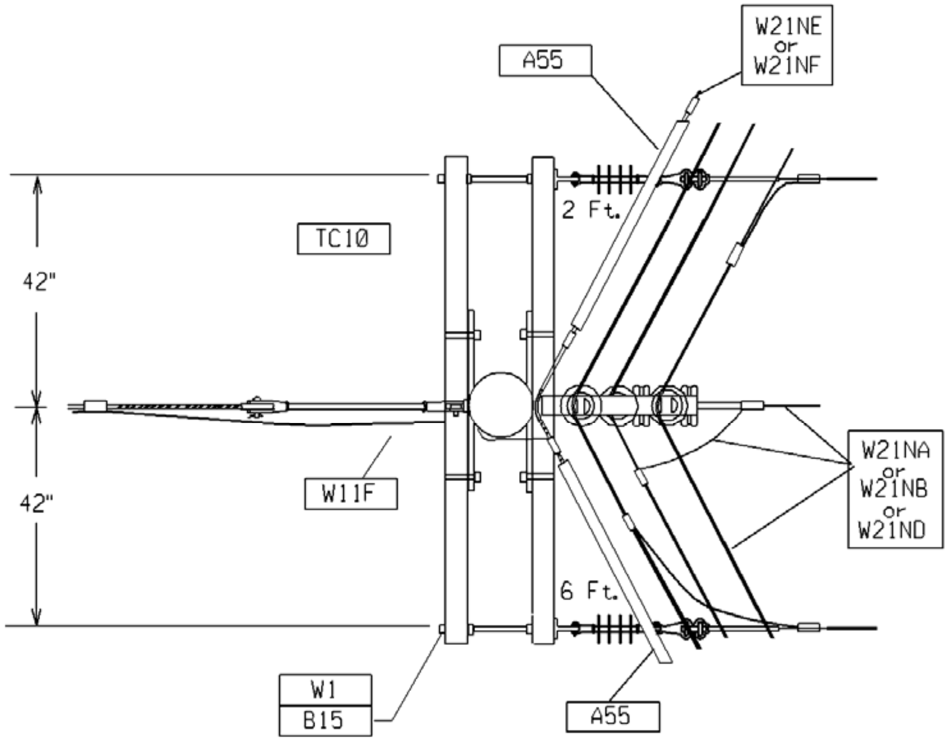
Supersedes 7/08 Issue - Updated MU.

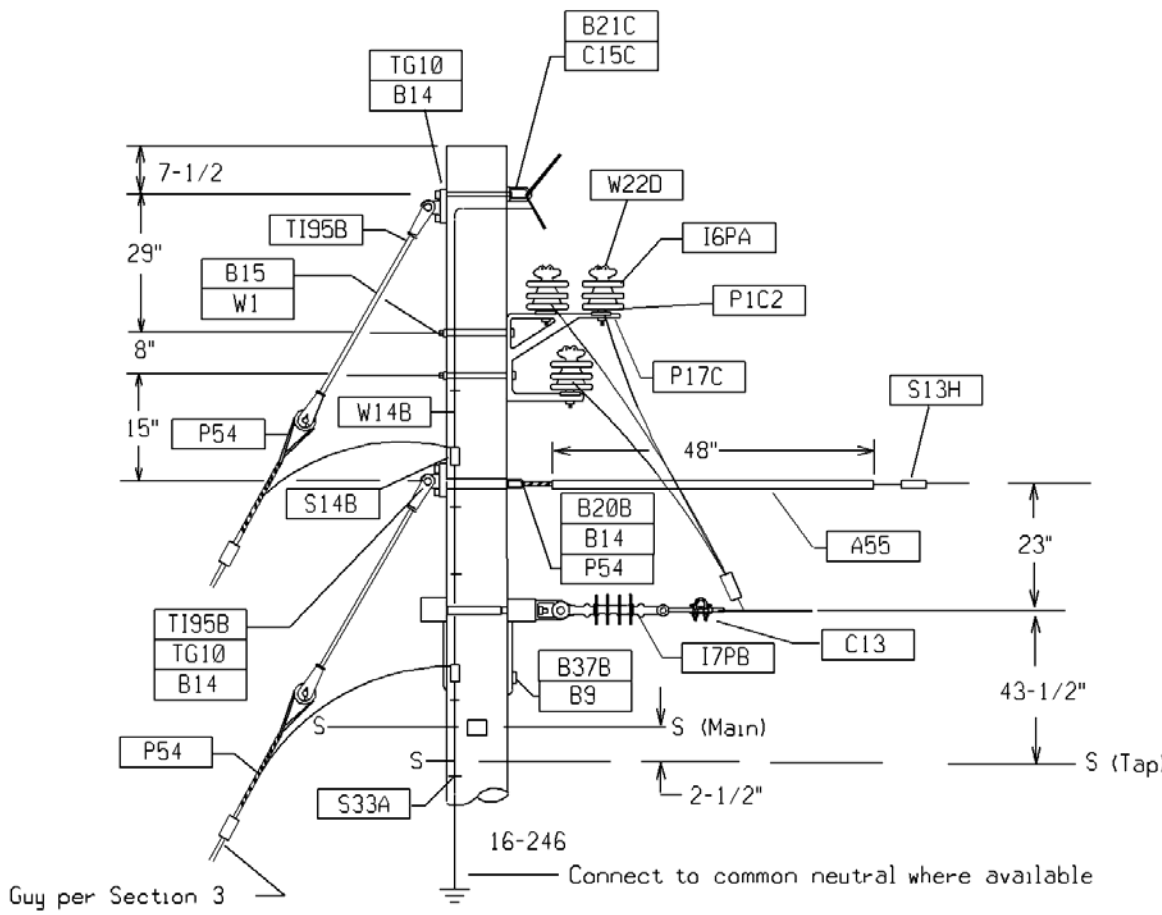
35KV CORNER POLE ATTACHMENT TO THREE PHASE OPEN WIRE TAP FOR 45' POLE – LINE ANGLES 7° – 60°

ISSUE	PAGE NUMBER		
7/09	16-243	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @16-246C(Y)	0-35 kV, E Brkt., (Y) = Wire Size

Supersedes 7/08 Issue - Updated MU.





35KV CORNER POLE ATTACHMENT TO THREE PHASE SPACER CABLE TAP FOR 45' POLE

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-246	ISSUE 7/09

 Doc. # ST. 16.00.004

MU = @16-249C(Y)	0-35 kV, Crossarm, (Y) = Wire Size	MU = @16-249(X)C(Y)	0-35 kV, Crossarm, (X) = 11/21/46, (Y) = Wire Size

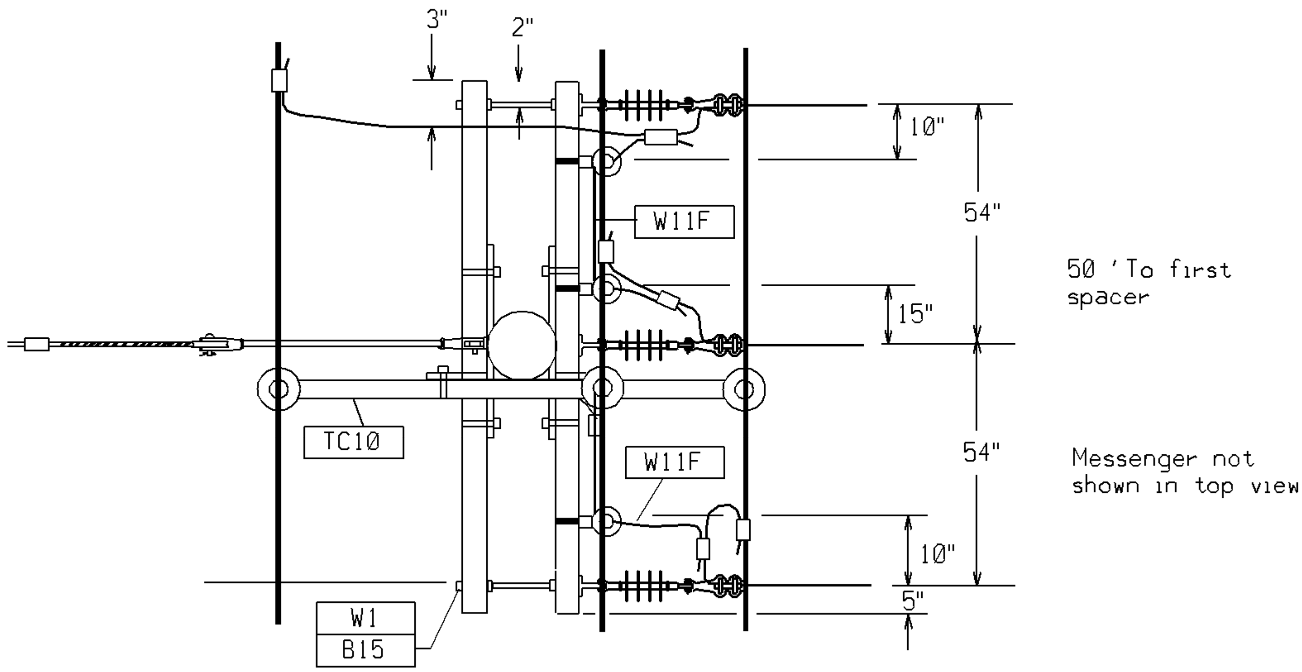
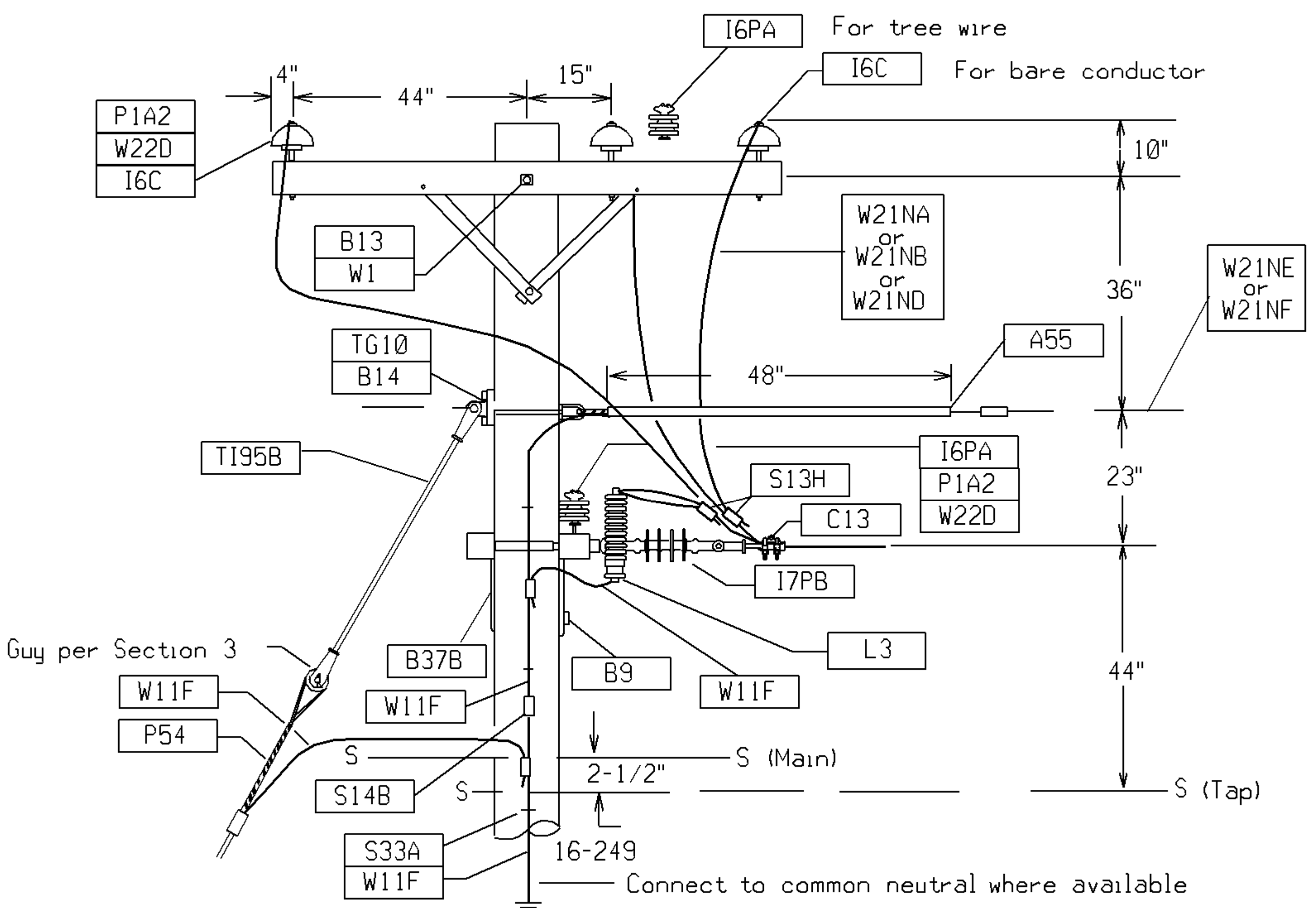


Figure 1 - Top View



Supersedes 7/08 Issue - Updated MU.

35KV OPEN WIRE STRAIGHT LINE TO THREE PHASE SPACER CABLE TAP

ISSUE	PAGE NUMBER		
7/09	16-249	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @16-252C(Y)	0-35 kV, C Brkt., (Y) = Wire Size

Supersedes 7/07 Issue - Updated MU.

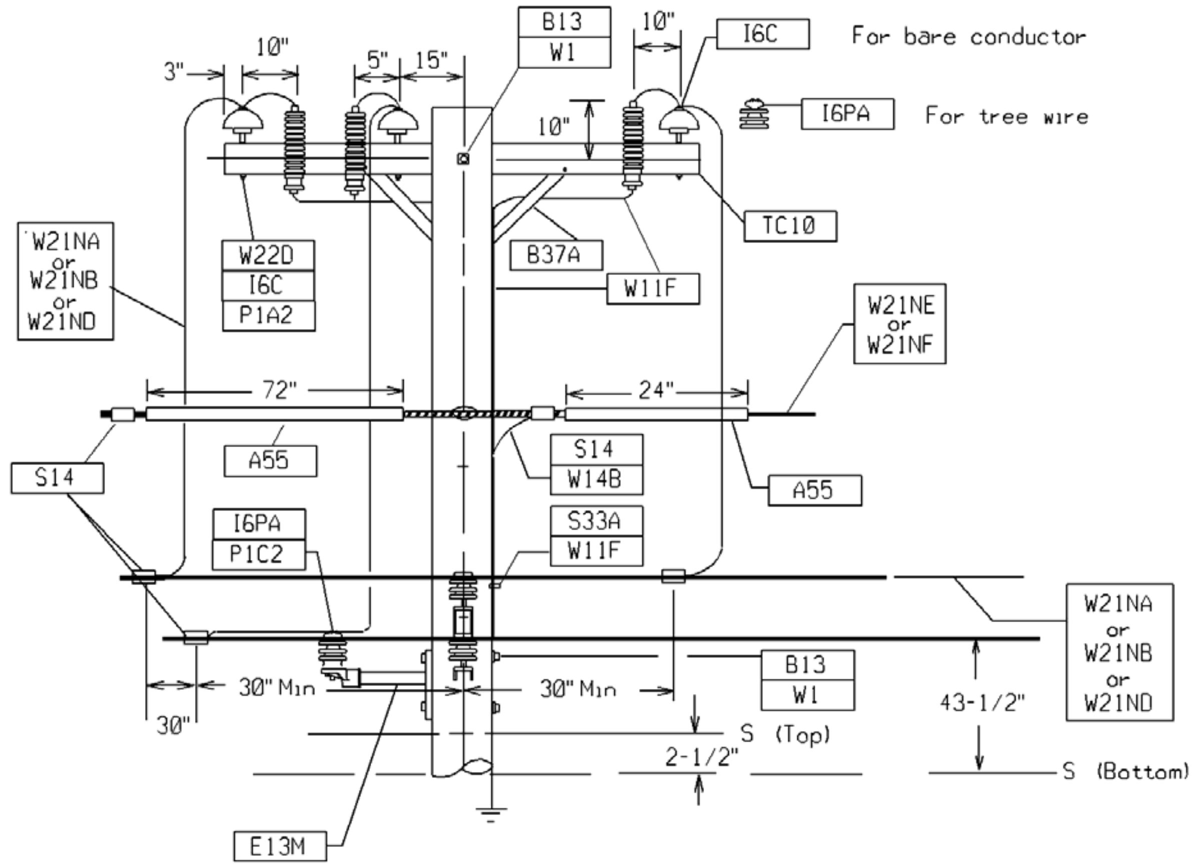
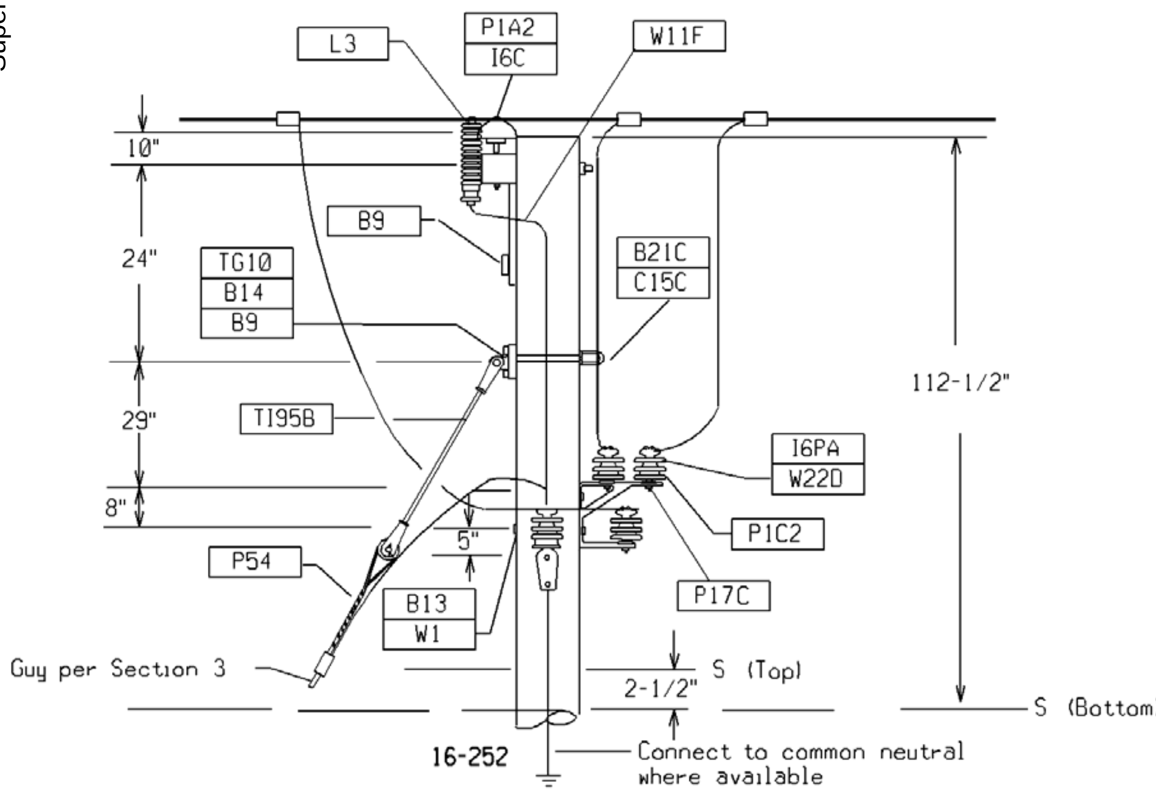


Figure 1 - Front View



35KV FOUR WAY JUNCTION
CROSSARM CONSTRUCTION TO SPACER CABLE WITH 45' POLE

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-252	7/09

 | Doc. # ST. 16.00.004

MU = @16-255C(Y)	0-35 kV, C Brkt., (Y) = Wire Size

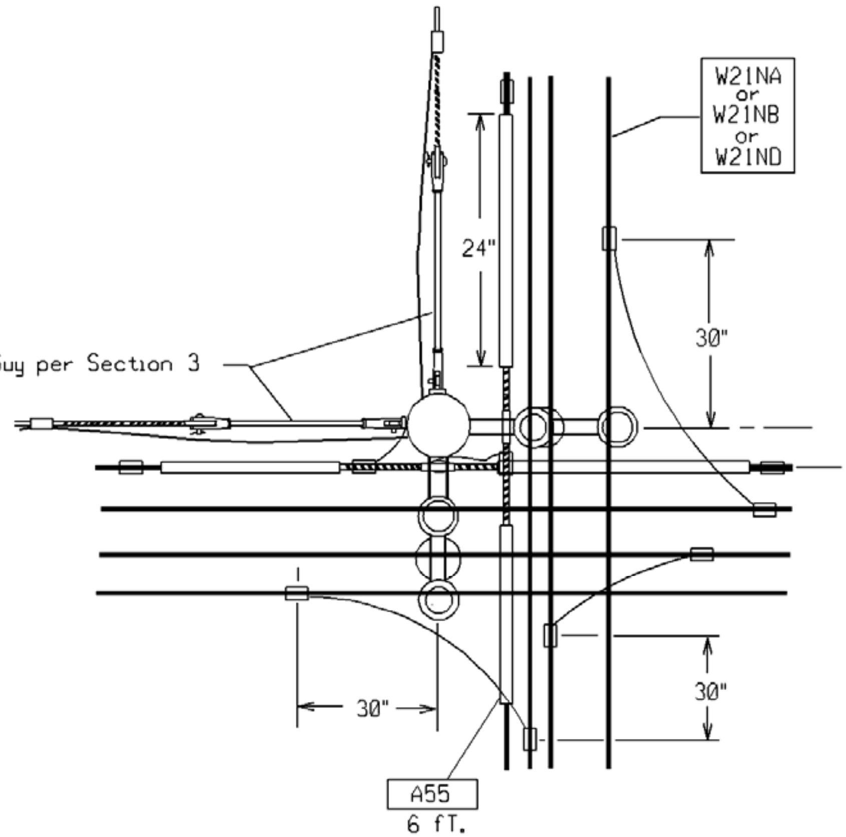
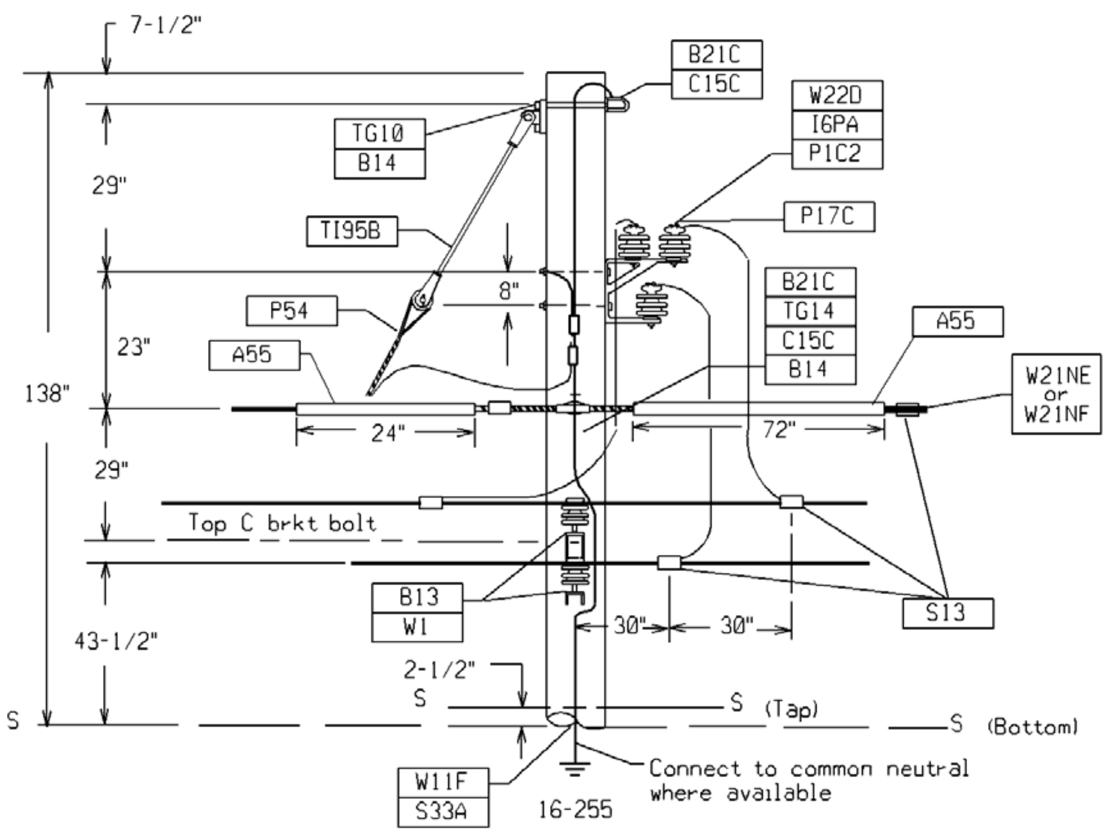


Figure 1 - Top View



16-255

Supersedes 7/08 Issue - Updated MU.

35KV FOUR WAY JUNCTION – SPACER CABLE TO SPACER CABLE WITH 45' POLE

ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	16-255		

 Doc. # ST. 16.00.004

Supersedes 1/06 Issue – Revised Construction Detail - Refer To Page 9-2XX for Maximum Span Calculation Detail

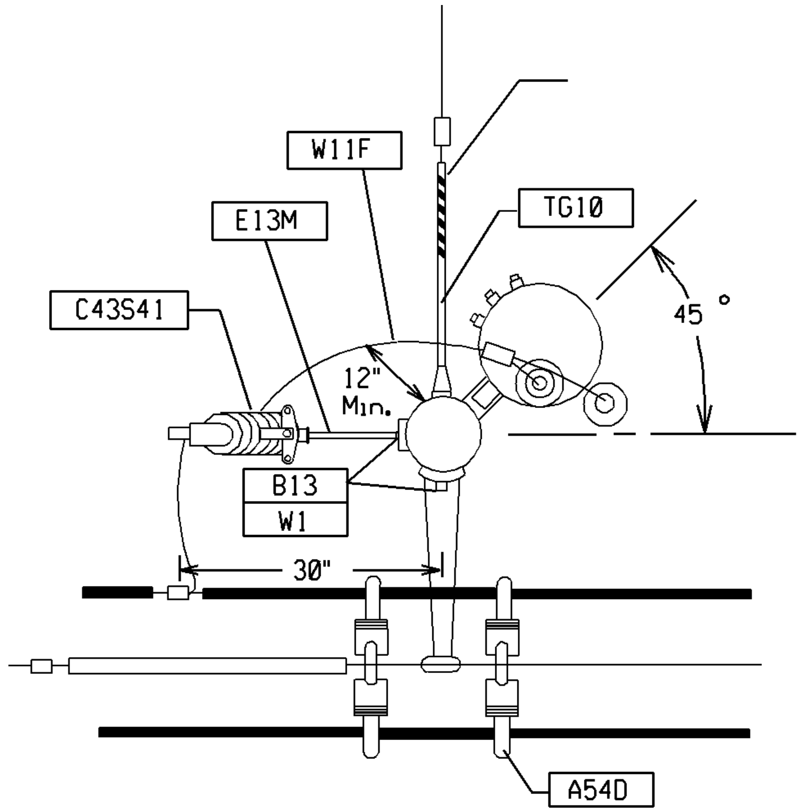
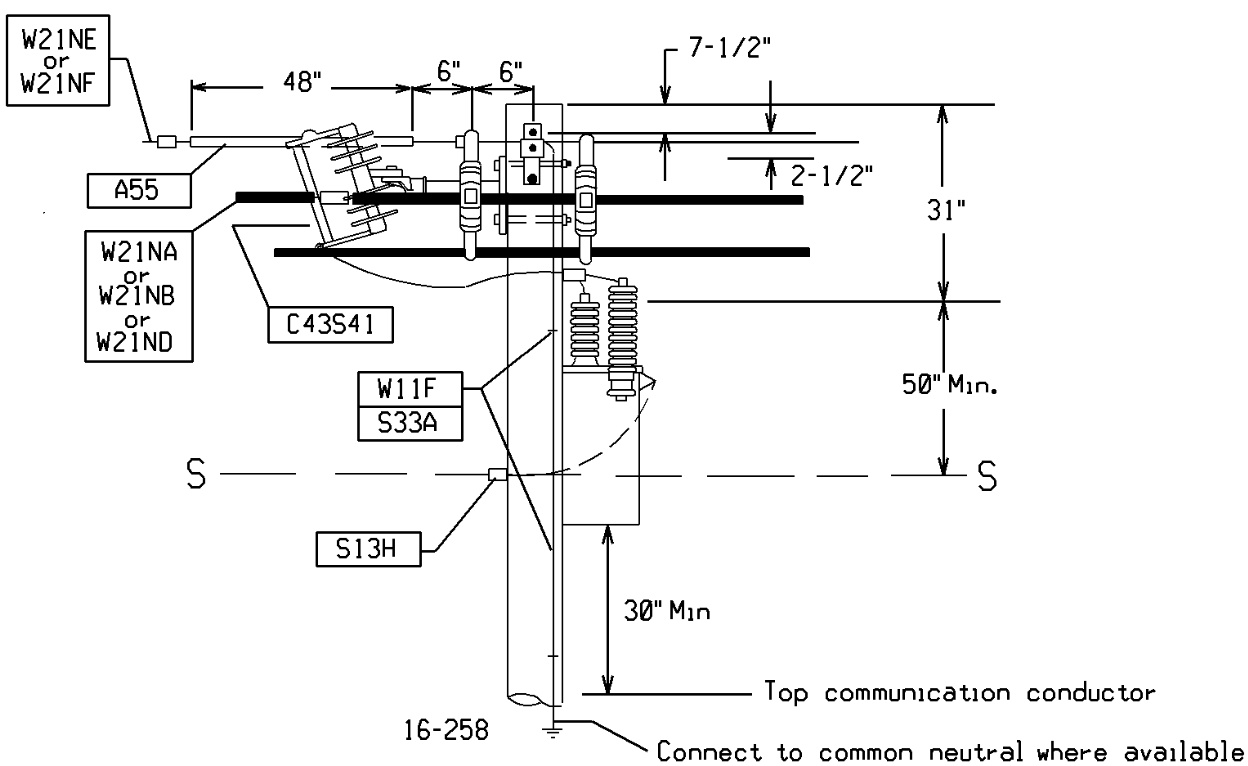
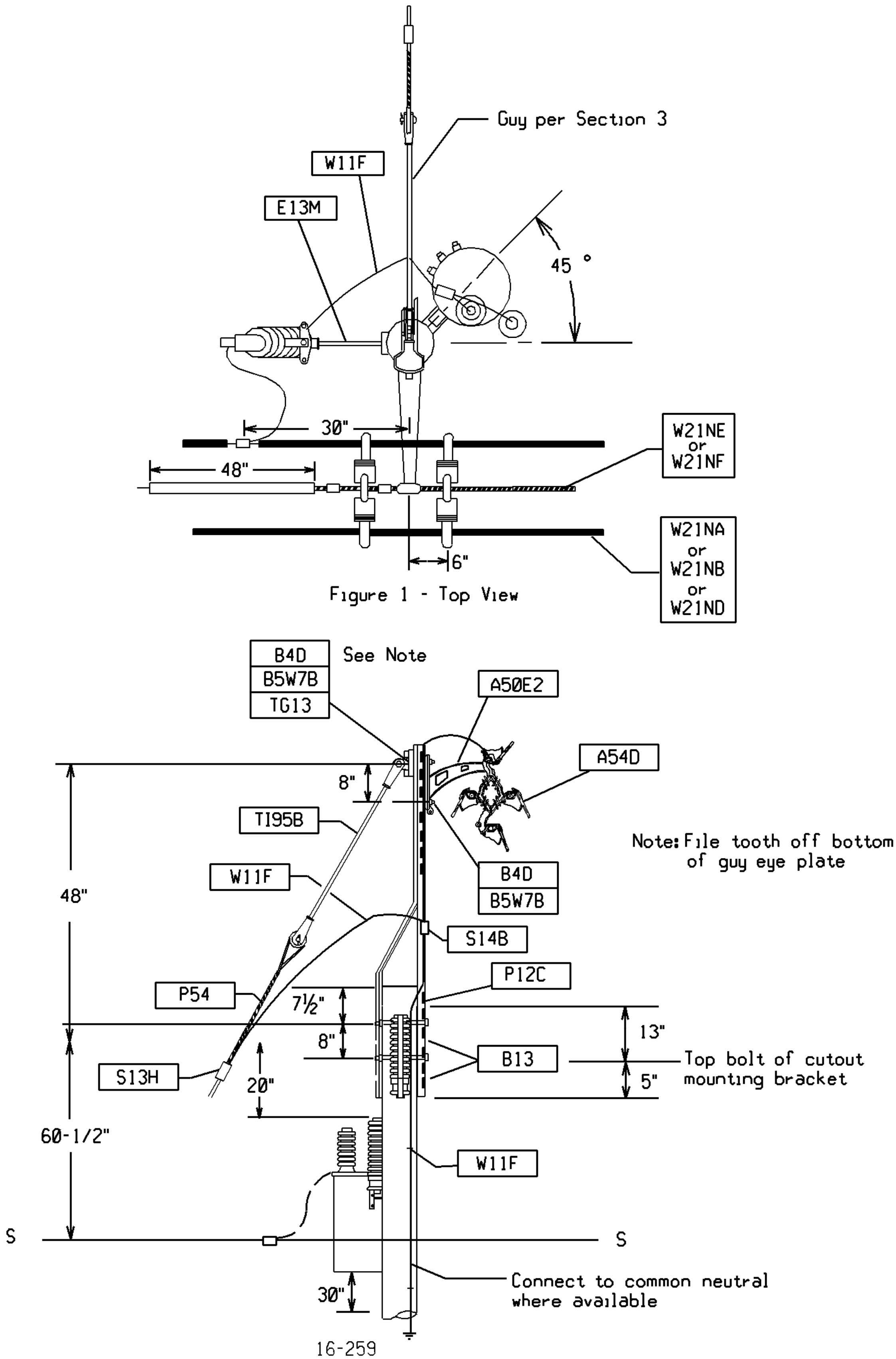


Figure 1 - Top View



35KV TRANSFORMER INSTALLATION SINGLE PHASE FOR 40' OR 45' POLE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		16-258	7/13



Supersedes 1/06 Issue – Revised Construction Detail - Refer To Page 9-2XX for Maximum Span Calculation Detail

35KV TRANSFORMER INSTALLATION SINGLE PHASE
FOR 40' POLE WITH POLE TOP EXTENSION

ISSUE	PAGE NUMBER		
7/13	16-259	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

 Doc. # ST. 16.00.004

Supersedes 1/06 Issue – Revised Construction Detail - Refer To Page 9-2XX for Maximum Span Calculation Detail

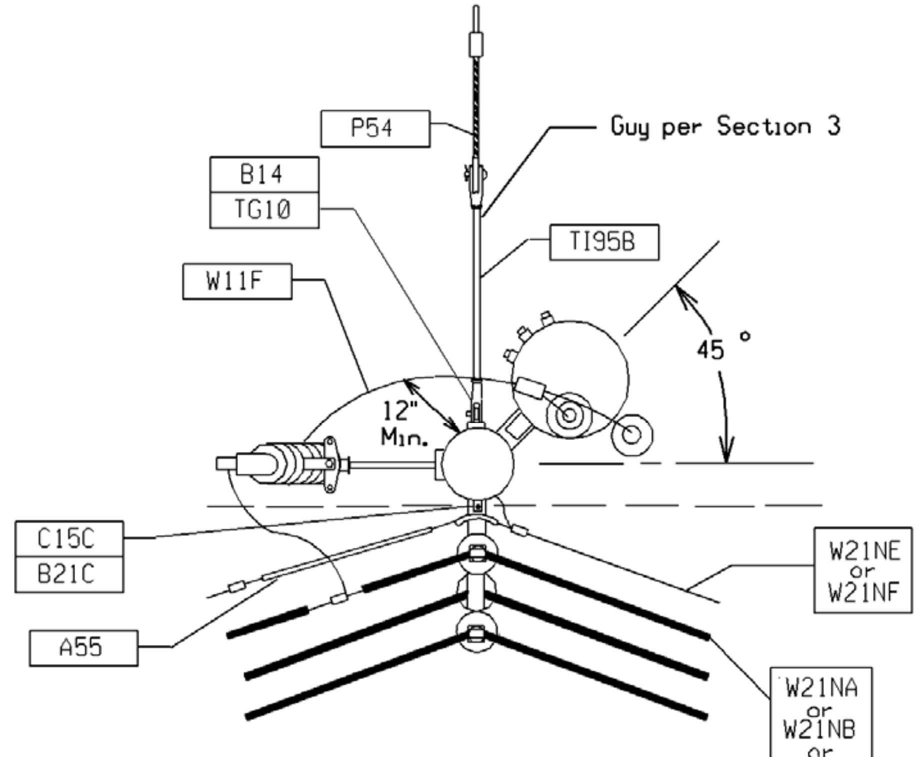
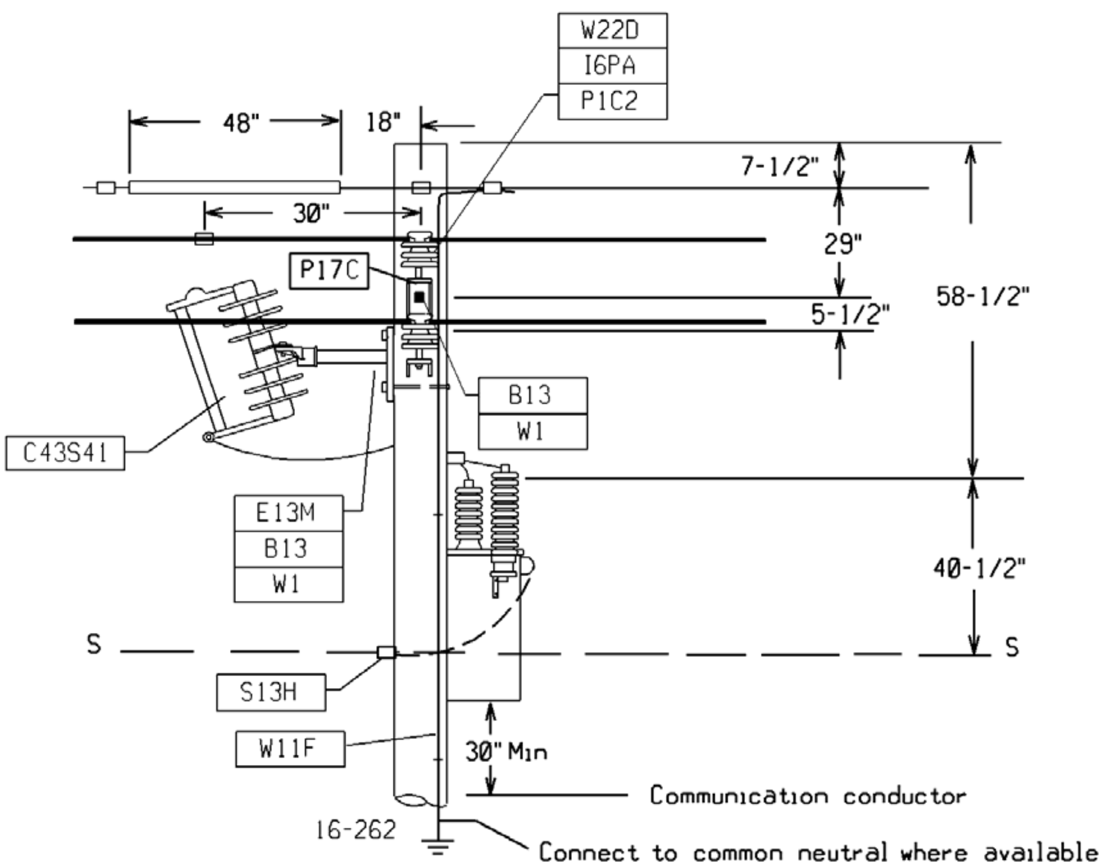


Figure 1 - Top View



35KV TRANSFORMER INSTALLATION SINGLE PHASE FOR 40' POLE – LINE ANGLES 7° – 60°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-262	ISSUE 7/07

 Doc. # ST. 16.00.004

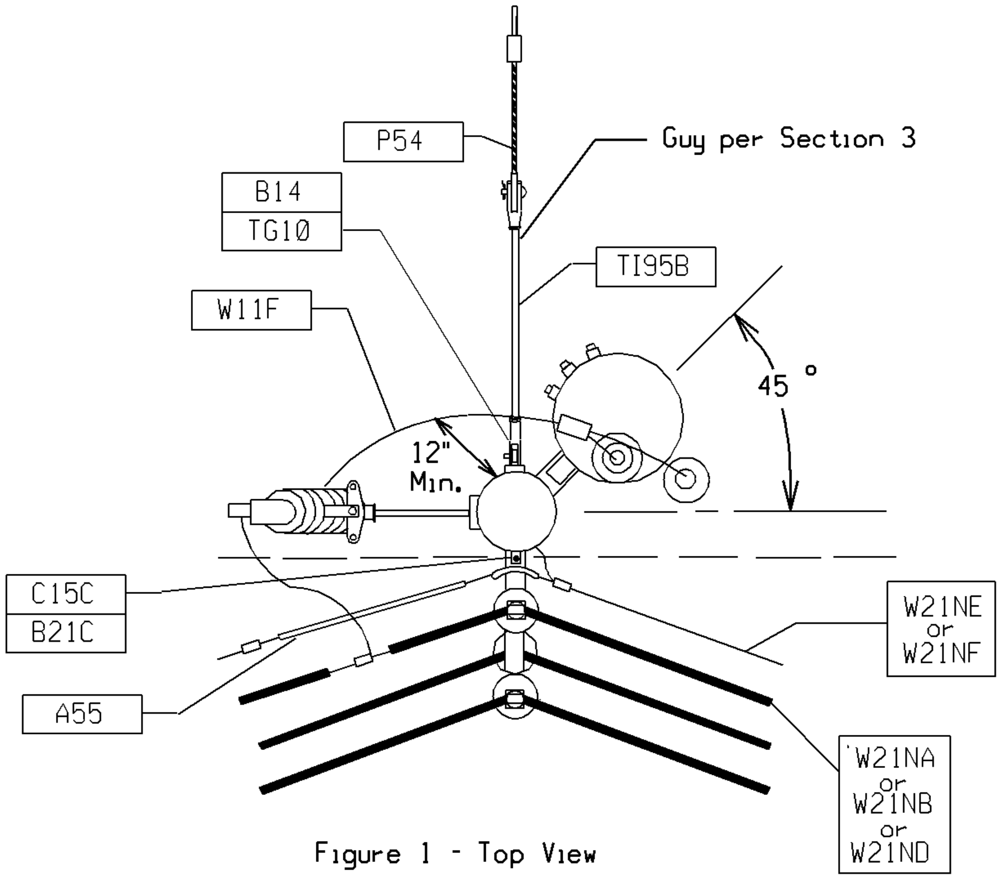
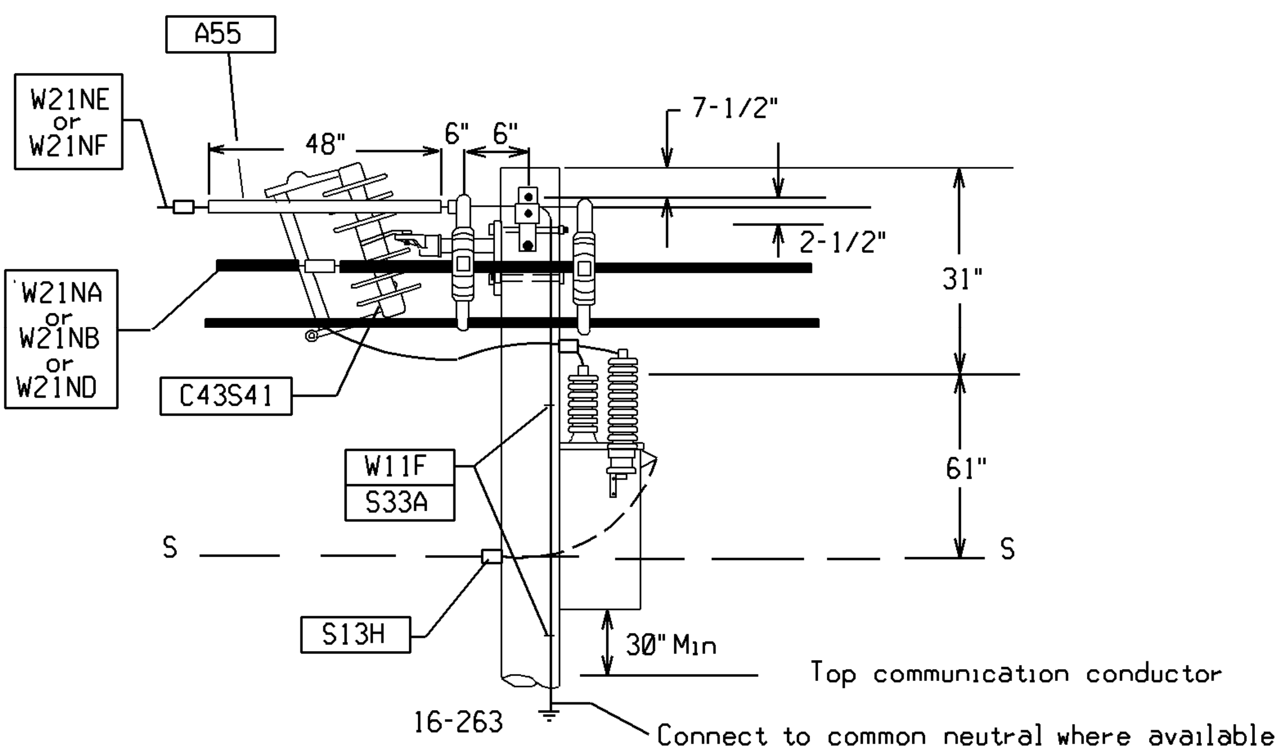


Figure 1 - Top View



Supersedes 1/06 Issue – Revised Construction Detail - Refer To Page 9-2XX for Maximum Span Calculation Detail

35KV TRANSFORMER INSTALLATION SINGLE PHASE FOR 45' POLE – LINE ANGLES 7° – 60°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	16-263		

Supersedes 1/06 Issue – Revised Construction Detail - Refer To Page 9-2XX for Maximum Span Calculation Detail

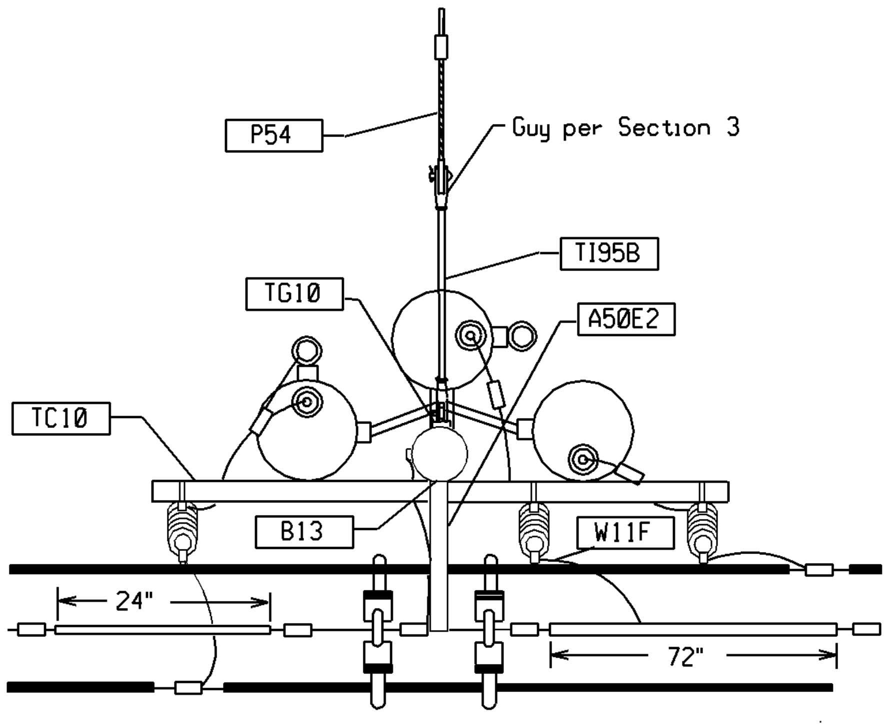
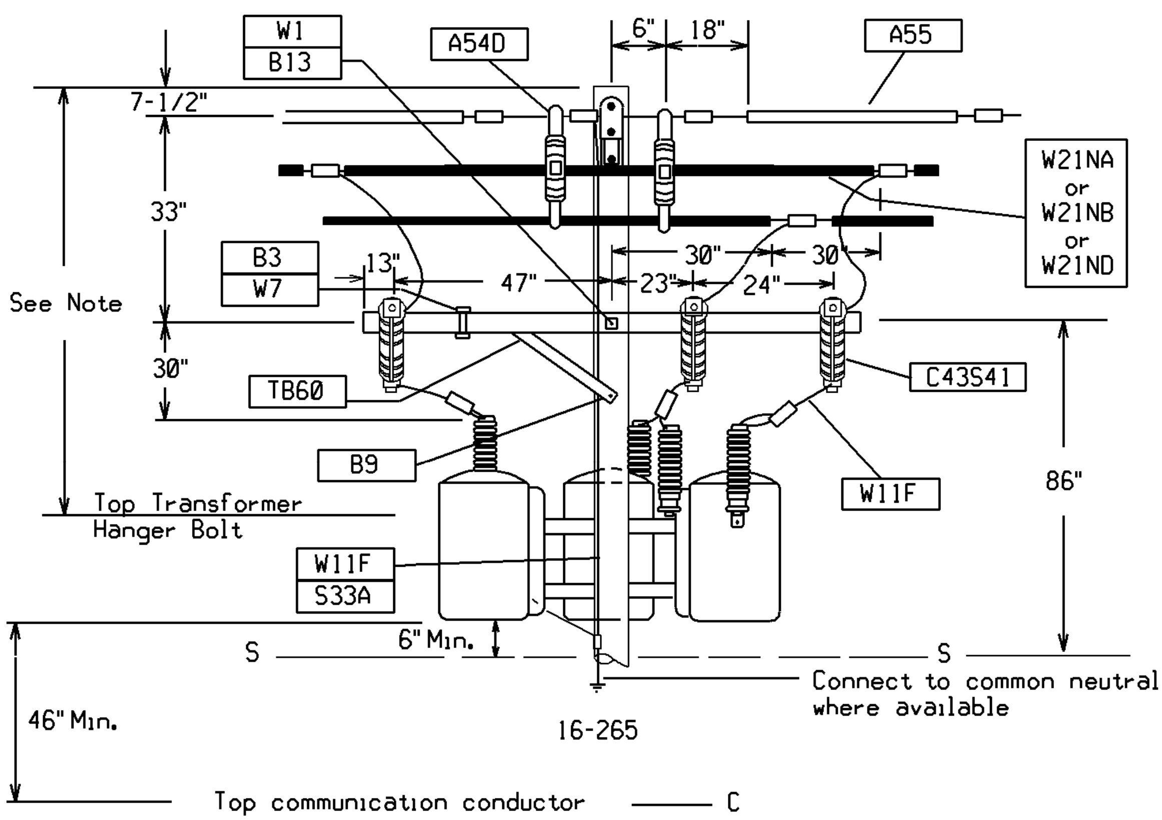


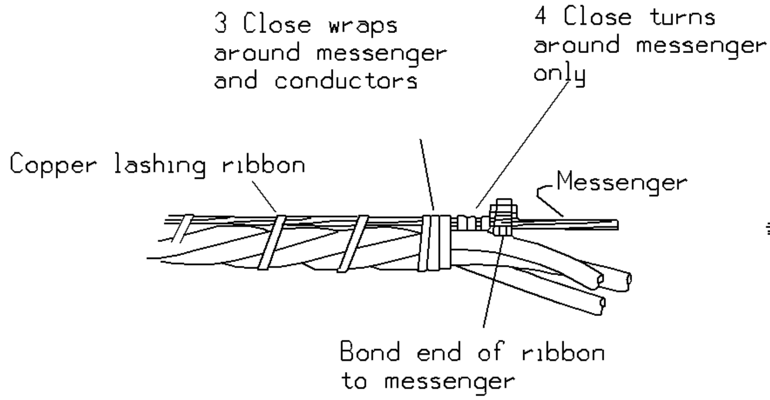
Figure 1 - Top View



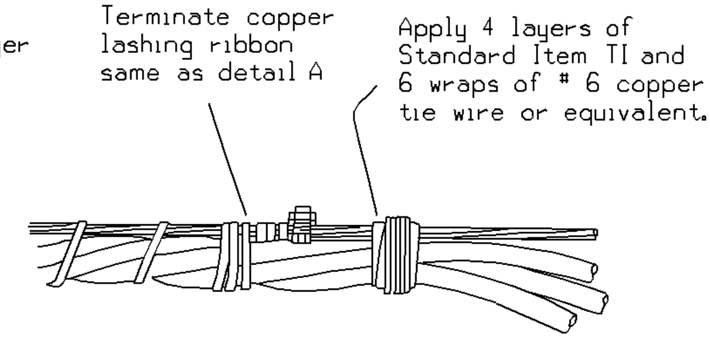
Note: See Section 2 - Poles / Hardware for class of pole.

Aerial Cable Construction Drawings

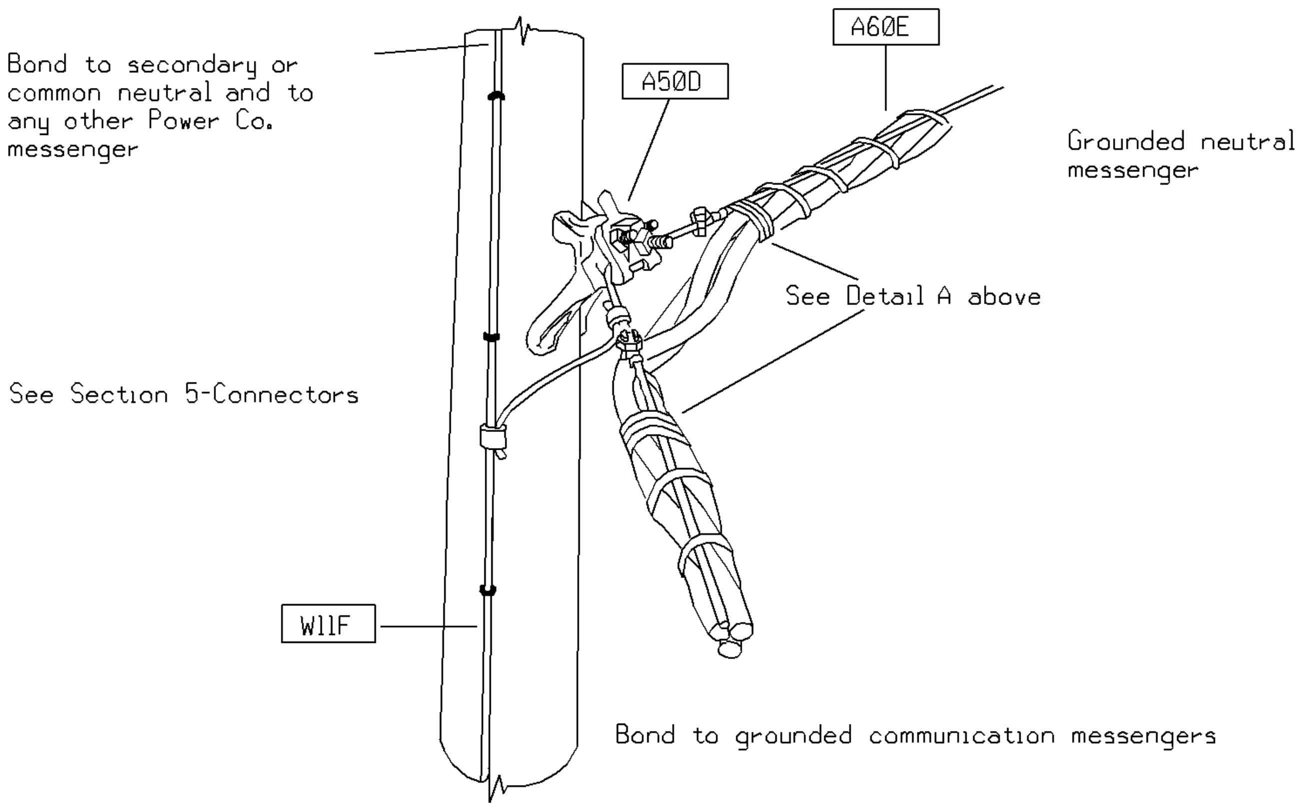
CU = PBSCHA
CU = PBSCA



Detail A



Detail B



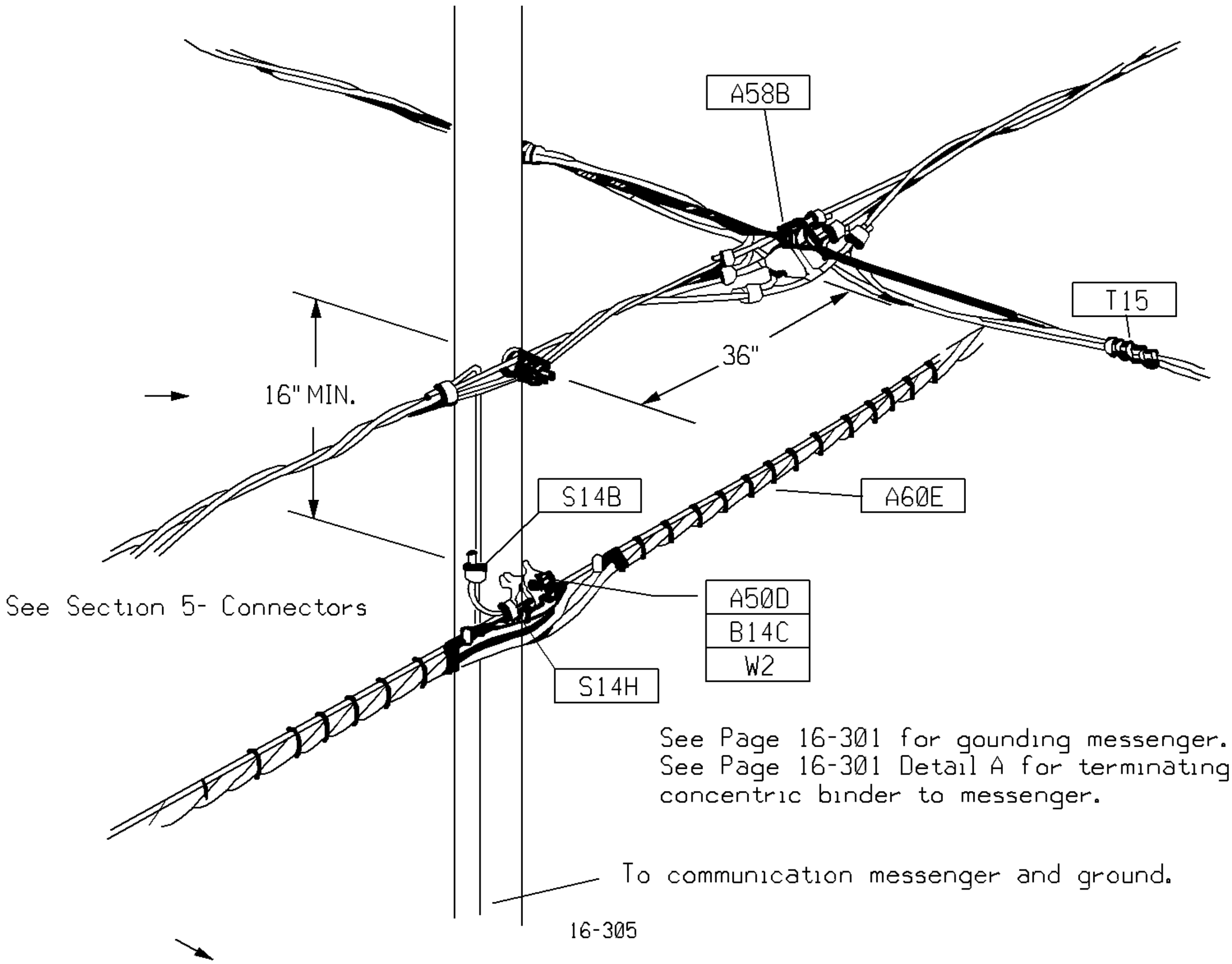
16-301

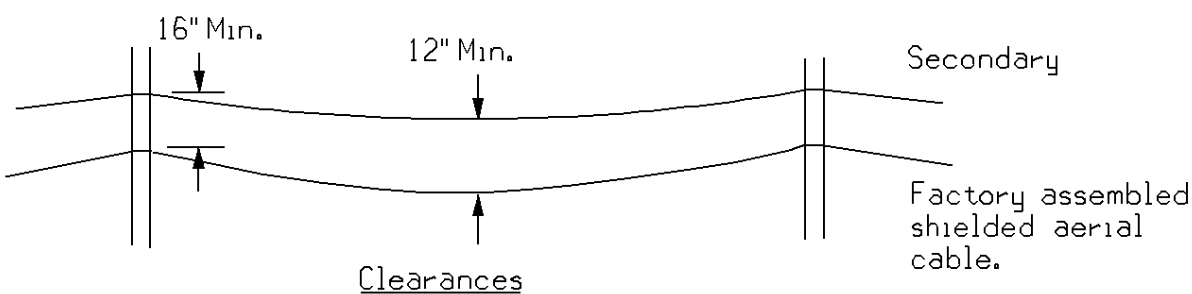
Angles 0 to 35

Supersedes 1/06 Issue – Revised Construction Detail

DETAILS OF ATTACHMENT, BONDING, AND TERMINATION OF CONCENTRIC BINDER TO NEUTRAL			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-301	ISSUE 7/07

MU = @16-305





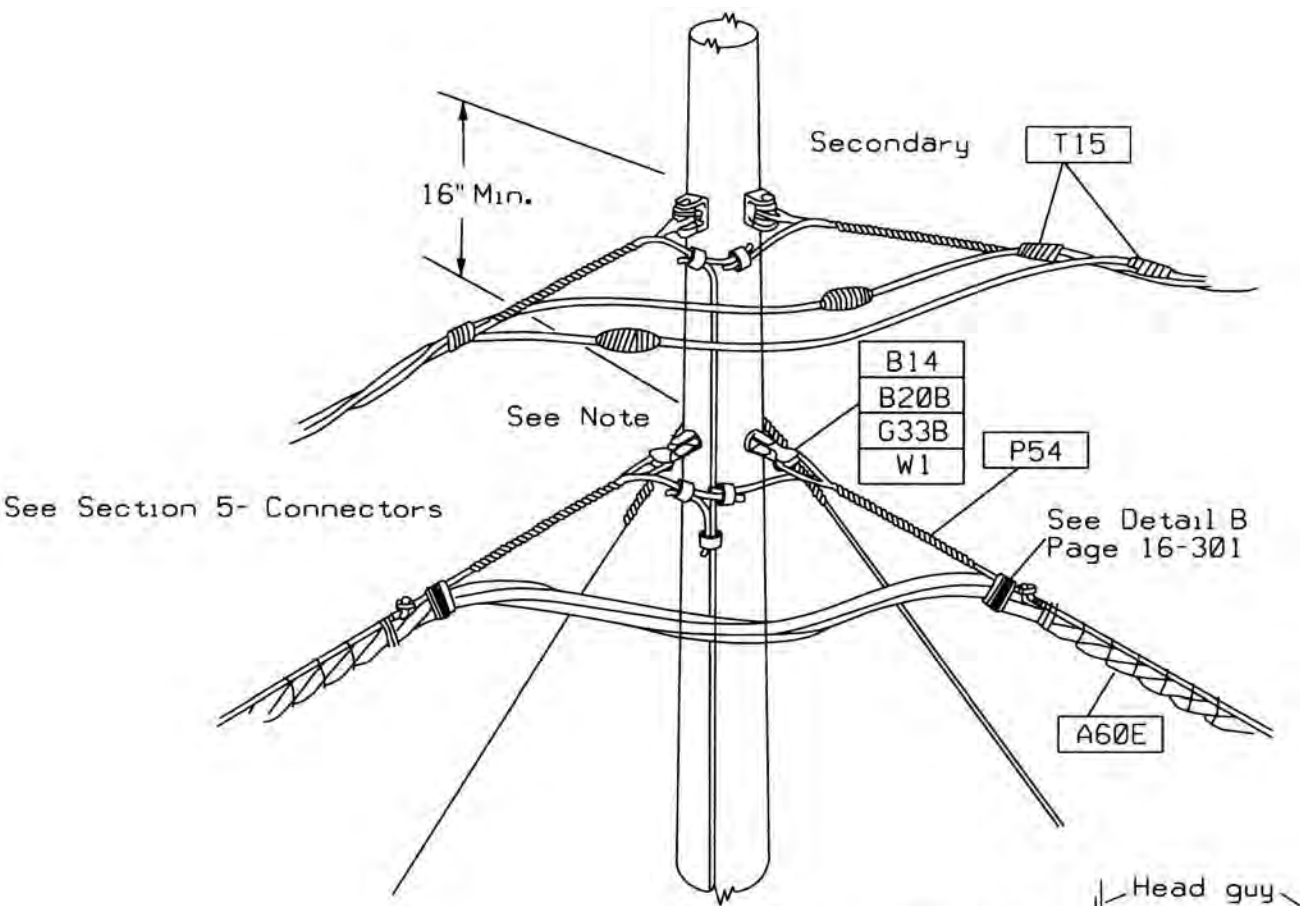
Notes:

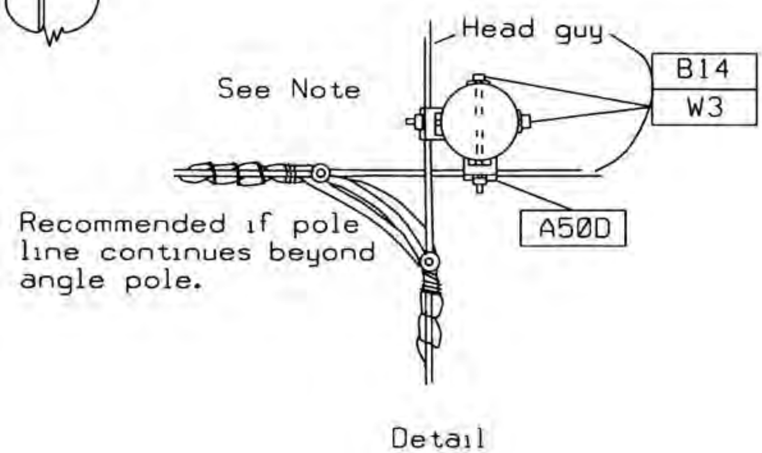
1. Where factory assembled shielded aerial cable is installed, limit the midspan taps on secondary to those 3 ft. from the pole.

2 Bond the messenger of the factory assembled shielded aerial cable to the secondary or common neutral at each transformer, at ends of each secondary, and elsewhere to provide a bond on every fourth pole.

Supersedes 1/06 Issue – Revised Construction Detail

MU = @16-310WDE	30º-90º, With DE	MU = @16-310ALT	30º-90º, With A50D





Supersedes 7/08 Issue - Updated MU.

Note:

2 guys are required if L/H is less than 60% (75% at a R.R. crossing). Log anchor may also be required. It is preferable to install head guys to lower point on adjacent pole as per detail A, or one head guy and one anchor guy.

 | Doc. # ST. 16.00.005

MU = @16-315

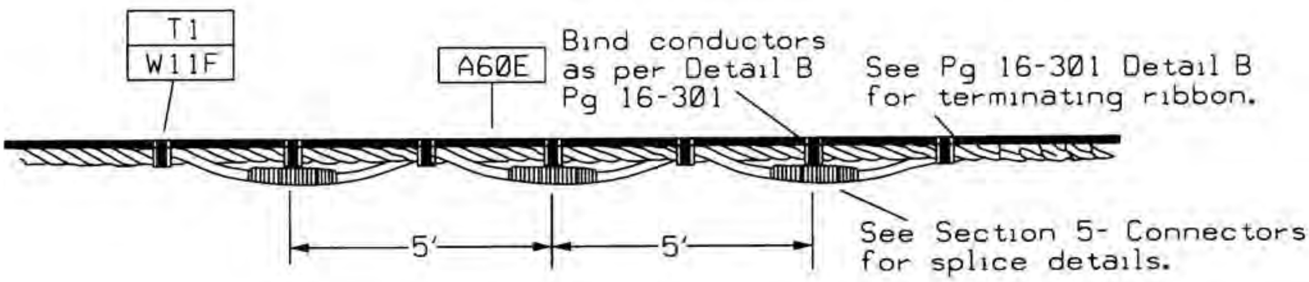
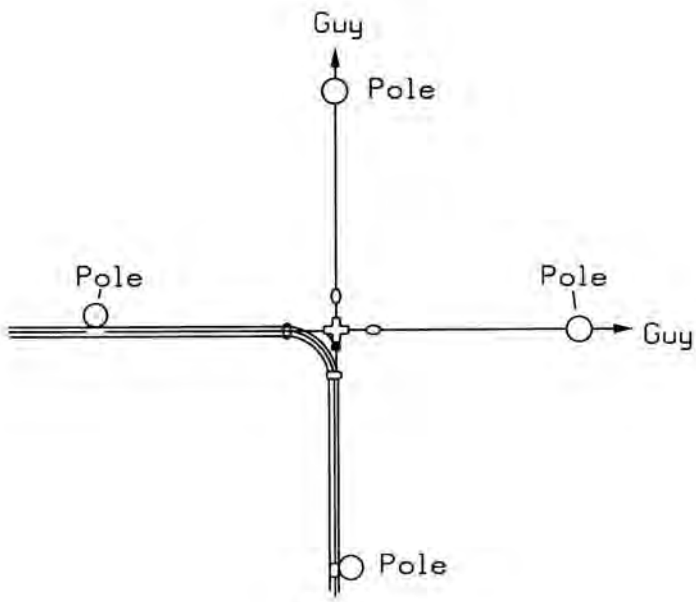


Fig. I



Plan

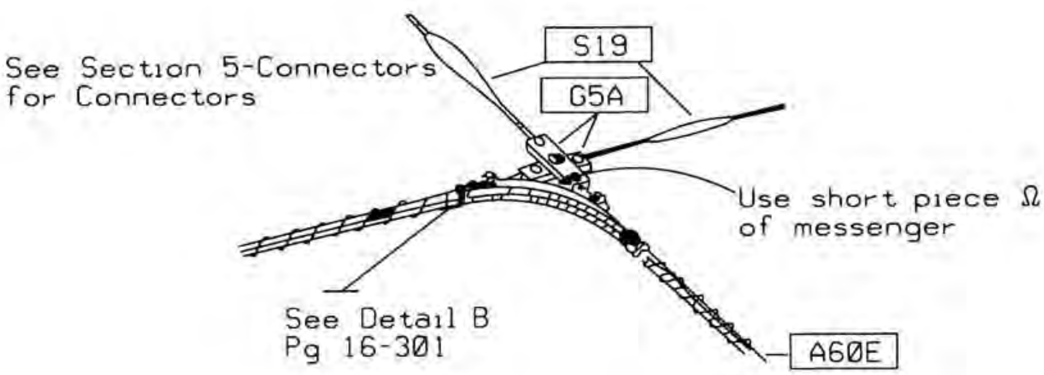


Fig. II

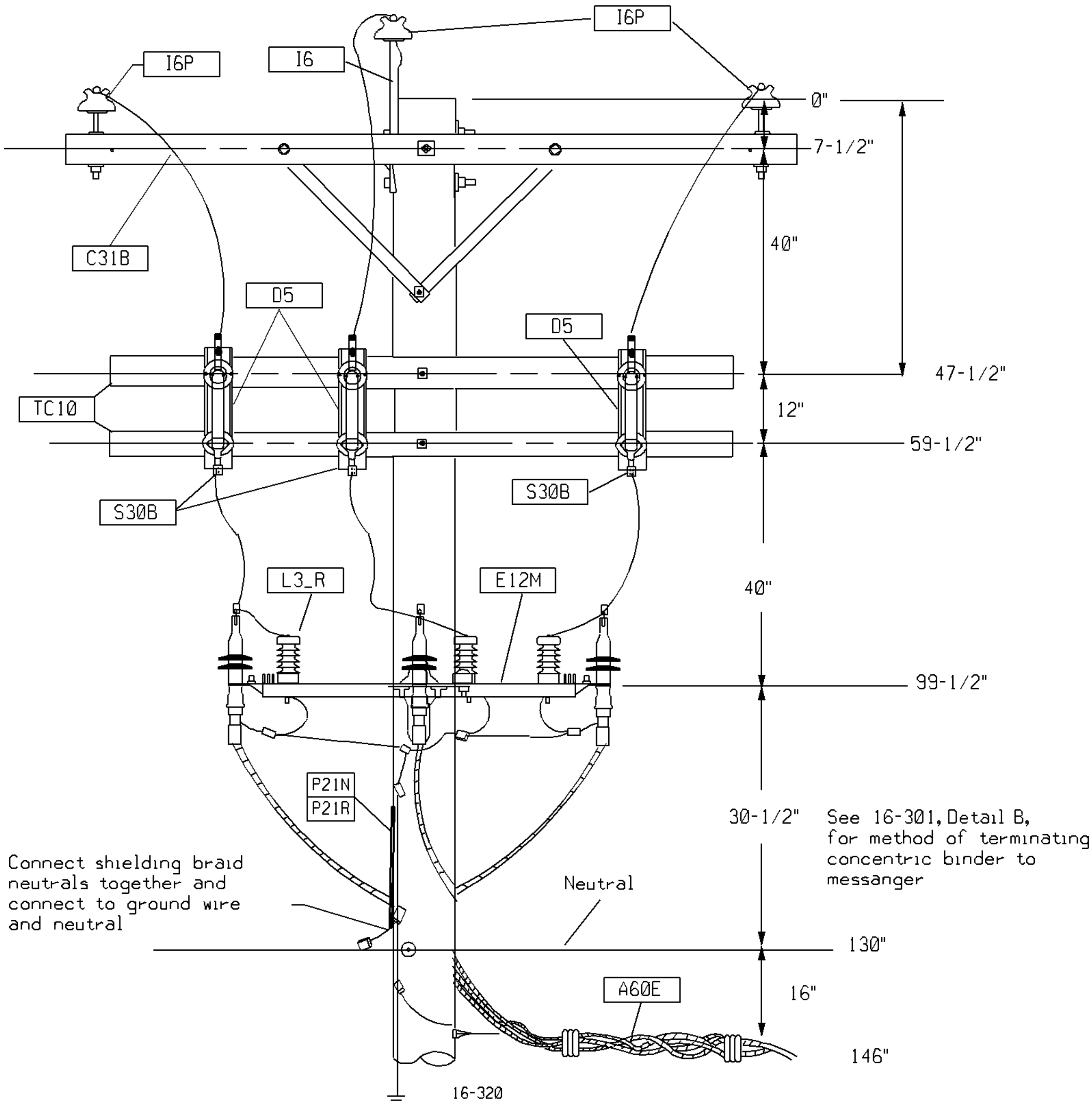
Supersedes 1/06 Issue – Revised Construction Detail

15KV STRAIGHT SPLICE AND MID-SPAN CORNER DETAILS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	16-315		

 Doc. # ST. 16.00.005

MU = @16-320

Supersedes 1/06 Issue – Revised Construction Detail

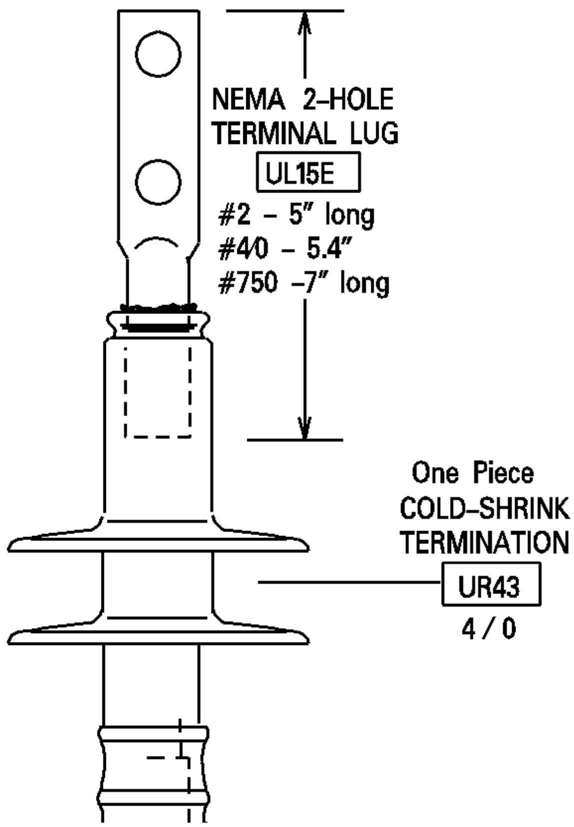


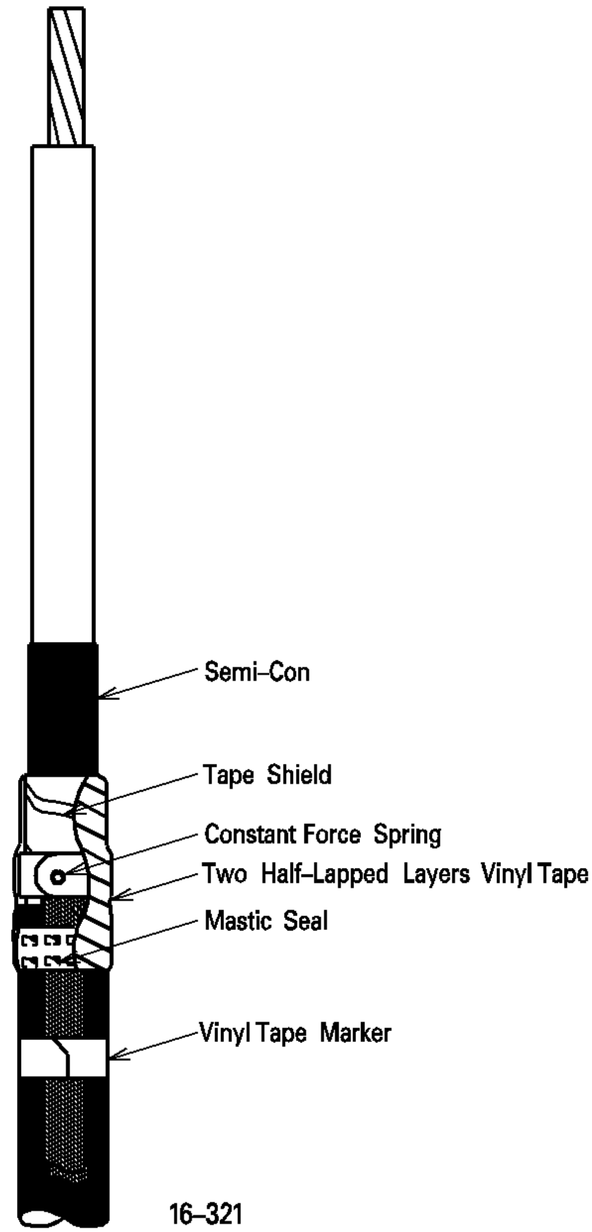
Notes:

1. Secondary can be accommodated on this pole. The preferred arrangement is to avoid secondary.
2. See Section 18 - Risers for lightning arrester and disconnect switch connection assemblies as well as for equipment mount and equipment mount adapter assembly.
3. See Section 5 - Connectors for outdoor taped cable termination details and for premolded modular cable termination details.
4. Switch identification mounted vertically on road side providing maximum visibility.

15KV PREASSEMBLED LASHED AERIAL CABLE TO OPEN WIRE			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 16-320	ISSUE 7/07

New Construction Drawing Illustrating PLAC Cold Shrink Termination Detail





REQUIRED MATERIALS:

- 3M Cold-Shrink Termination Kit UR44C
- Black Friction tape T1A
- Black Vinyl electrical tape T2W
- Terminating connector UL15E
- Copper-braid grounding tape T1T5 (shielded cable (PLAC) only)
- Grounding connector S14
- Cable Identif.tag UP21 (if required)

Cold-Shrink Terminations are recommended for the Outdoor termination of Insulated and shielded standard cables. Properly installed terminations will provide the required electrical stress relief and resistance to water and moisture ingress. Some taping may be required where cold-shrink termination does not cover terminal connector barrel.

NOTES:

- Avoid knife damage to the conductor strands and the insulation layers.
- Determine required cable length by training the cable into its final proposed position before cutting.
- ALL traces of removed SemiConductive layer MUST be removed from the underlying insulation layer to prevent tracking and termination failure.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
6	7/13	• Revised text in 16.47 and Section 16.6 • Revised description on page 16-153 and Index page 16-ii. • Revised Drawing on page 16-220. • Revised Description in Title block on pages 16-258 & 16-259.	Robert Johnson	Robert Johnson Program Manager CQ&EM Standards, Policies & Codes
5	7/12	• Revised sag/tension tables for all spacer cables to reflect revised application of "k" factor for spacer cable in 2012 NESC. • Updated Spacer cable ampacities ratings. • Revised Pg. 16.47, Sect. 16.6 to include Multiple aerial cable sizes.	Paul Anundson Dave Allen	Susan Fleck VP of Standards, Policies, and Codes
4	7/11	• Amended explanation of how to properly cover tap leads on spacer cable (16.20.I.6)	Mike Brigandi	Susan Fleck VP of Standards, Policies, and Codes
3	7/10	• Corrected STD Id's for spacer cable, and/or arrester/cutout tap wire and connectors on pages 16-101, 16-102, 16-103, 16-106, 16-107, 16-108, 16-109, 16-114, 16-115, 16-131, 16-134, 16-135, 16-138, 16-139, 16-143, 16-148, 16-151, 16-153, 16-155, 16-157, 16-158, 16-160, 16-161, 16-163. • Revised sag/tension and conductor properties tables on Pages 16-55 and 16-56	Mike Brigandi Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods
2	7/09	• Revised CUs/MUs on pages 16-101, 16-102, 16-103, 16-106, 16-107, 16-108, 16-109, 16-114, 16-115, 16-118, 16-122, 16-123, 16-126, 16-127, 16-131, 16-134, 16-135, 16-138, 16-139, 16-142, 16-146, 16-148, 16-150, 16-153, 16-155, 16-157, 16-158, 16-160, 16-161, 16-163, 16-201, 16-205, 16-206, 16-210, 16-213, 16-214, 16-217, 16-220, 16-223, 16-226, 16-228, 16-232, 16-233, 16-236, 16-237, 16-240, 16-243, 16-246, 16-249, 16-252, 16-255, 16-310. • Revised drawing details on pages 16-138, 16-139, 16-148, and 16-163.	Mike Brigandi	Allen Chieco, Director of Distribution Standards and Work Methods
1	7/08	• Revised Dimensional Details and added notes on pages 16-101, 16-102, 16-103, 16-106, 16-107, 16-108, 16-109, 16-114, 16-126, 16-127, 16-131, 16-134, 16-135, 16-138, 16-139, 16-160, 16-163. • Updated Std. Item Identifiers on page 16-123. • Revised dimensional detail on pages 16-142, 16-143, 16-146, 16-148, 16-150, 16-	John-Paul Knauss	Allen Chieco, Director of Distribution Standards and Work Methods

		151, 16-153, 16-155, 16-157, 16-158, 16-161, 16-165, 16-168, 16-169, 16-171, 16-173.		

Supersedes 6/17 Issue – Updated index.

17.0. GENERAL

This Standard covers the engineering practices for application of poles used jointly by the Company's electric supply facilities, communications company facilities and other facilities.

If two or more entities must install overhead lines on the same street, it is usually in the public interest to install them on joint use poles. On the Company's system, the terms for this joint use are covered by agreements between the joint users. This Section covers the special requirements for such poles.

Depending on the geographic location of the poles, reference should be made to the applicable Joint Use or Joint Ownership Agreement, the applicable Intercompany Operating Procedures (IOPs), and applicable Distribution Pole Attachment or Aerial License Agreements for details of ownership, division of costs, division of work responsibilities, rental or licensing fees, and other detailed terms and conditions.

17.1. POLES

17.1.10 General

Contact should be made with the telephone and CATV companies serving the area, to determine their requirement or possible short-term future need for pole space, before poles are installed. Poles should be installed to provide space for foreign or joint use only when there is an agreement with another entity to share use of the pole, in which the other entity agrees to rent or license space on the pole(s) or purchase an ownership interest in the pole(s).

The Company shall not accept the cost of added space without compensation, even when the costs are low. Future plans should be based on the Company needs only, unless there are written commitments from others to rent or license space or to purchase an ownership interest.

After each entity has identified its need for space, new poles shall be selected from the Allocated Space Tables located on Pages 17-100 and 17-101. Joint poles or poles with extra height should be used depending on how these poles meet needs for clearance of all the users that have agreed to rent or license space or to purchase an ownership interest.

The necessity of replacing jointly owned poles shall be mutually agreed on by the joint owners, in writing, in each specific case. Either joint owner shall at any time change the location of or remove any jointly owned pole without the written consent of the other party.

17.1.20 Pole Strength

The class of pole (pole strength) can be determined from the calculations and Tables in Section 3-Guying for storm guys and Section 2-Poles/Hardware.

This calculation will need the cooperation of the communication facility owner(s) to determine present and future wind loads under heavy loading conditions.

As an alternate practice to installing stronger poles, the line may be guyed for transverse load every second or third pole.

17.2 GUYS

Each entity shall provide guys of sufficient strength to hold the unbalanced load of its own wires and attachments (See Section 3-Guying).

Joint anchors and rods shall be used whenever practical and in any case Distribution Design shall arrange the exact location of each anchor. Triple thimble eyes are the standard anchor rod eye nuts.

Supersedes 6/17 Issue – Text change.

17.3 CLIMBING SPACE

Adequate clearances for climbing shall be provided as shown on Page 7-127. Care shall be taken when installing services, street lights, risers, etc. so that full climbing space is available to line workers from all attaching entities.

17.4 CLEARANCES

Clearances between communication space and electric supply space attachments are shown on Page 17-102. Reference should also be made to Section 7-Clearances.

Communications messengers in the communication space shall have a vertical spacing of 12 inches (center-to-center) at the pole. To avoid a pole replacement, provided other NESC requirements are satisfied and the new attacher, adjacent attachers and the joint pole owner agree, Liberty Utilities will allow a reduction in vertical spacing between communication messengers to not less than 6 inches at the pole. If the spacing of 12 inches at the pole between communication messengers can be achieved without pole replacement, then the spacing of 12 inches shall be maintained. Communications conductors, cables and equipment of one communication utility to those of another shall have at least 4" clearance (surface-to-surface) anywhere in the span.

17.5 LOCATION OF ATTACHMENTS

Cooperative effort is needed to avoid placing heavy communication equipment on power company poles with cable risers or equipment that will make climbing difficult. The appearance of individual poles and the whole pole line should also be considered.

Communication equipment, such as CATV, power supplies, telephone air dryers, telephone stands, antennas, etc., shall be installed on joint poles in accordance with Pages 17-105 thru 17-110 or special drawings approved by Standards Engineering.

In general, avoid placing risers for multiple entities on one pole. When this is not practical, install them per Section 18-Risers as well as Section 48-Risers of the Underground Construction Standards manual.

Supersedes 6/17 Issue – Added pages and respaced.

17.6 DISTRIBUTION WOOD POLE MOUNTED METERED POWER SUPPLY AND ANTENNA INSTALLATIONS (DAS): 15 kV MAXIMUM

17.6.10 Application

This Section describes the general requirements and shows the typical construction and clearances for distribution wood pole mounted, metered, secondary service to power supplies and communication equipment for distributed antenna systems (DAS). These Construction Standards are intended to allow DAS access without risking system reliability or employee safety.

17.6.20 General

All installations shall be made in compliance with all applicable codes including the National Electrical Safety Code (NESC), National Electrical Code (NEC), with local wiring inspector requirements and with applicable service requirements from the Company's tariffs. Currently, in New Hampshire these include the current "Specifications for Electrical Installations" (ESB 750) book. Installation and maintenance will be performed in compliance with Occupational Safety and Health Administration (OSHA) and Liberty Utilities Safety requirements for work in energized areas. The communication entity shall contact the Company office serving the area involved and also obtain agreement from all other affected pole occupants and/or owners. The communication entity shall submit all appropriate documentation in a timely fashion to allow for necessary engineering and determination of make ready work costs for each pole. All approved poles will require an attachment agreement with Liberty Utilities and shall obtain permission from the local municipality.

17.6.30 Location

Poles selected for communication mounted equipment shall be relatively "clean" poles, and new antenna installations are not allowed on distribution poles that contain any of the following:

- Any primary connected equipment (transformers, switches, regulators, reclosers, capacitors, etc.) operating over 600 Volts.
- Any other communication equipment or antenna belonging to Liberty Utilities or another entity (i.e. CATV power pack supplies, telephone air dryers or stands, etc.)
- Any pole with a primary riser, three-phase secondary riser, multiple secondary riser, or a single-phase secondary riser with conductors greater than 4/0 in size.
- Locations that cannot be accessed by a standard bucket truck, max pole height of 50 feet.
- Three and four way primary junction poles.
- Poles that would require guying and anchoring to be added or upgraded to support wire and equipment loads until rights are subsequently secured and guying and anchoring is installed.
- Poles with existing riser congestion (all utilities) that encircles more than 40% or pole circumference.
- Attachments to poles on private property are not allowed.
- DAS attachments to street light brackets are not allowed.

17.6.40 Division of Responsibility

Attachers Requirements

A.) A professional engineer licensed in the state where the attachment is proposed must evaluate each antenna model with respect to pole class. Items to be evaluated include, but are not limited to, pole weight loading, wind and ice loading, RF emission compliance, and NESC compliance. The professional engineer must stamp and sign off on design before construction can begin. The approved designs can be reused for different installations provided that the professional engineer specifications and all other requirements in this standard are met. However, each installation will require a pole inspection and guying evaluation performed by Liberty Utilities and an intermodulation frequency analysis conducted by the attacher.

B.) At the cost of the attacher, a study of the pole adequacy and integrity with the new equipment installed will be performed.

C.) Attacher pays all costs of the attacher for the new pole, transfer work and make-ready work before any work is to begin.

Attacher shall provide and install the following – construction notes

D.) Weatherhead in a location suitable to form a drip-loop and to make secondary connections.

E.) Conduit shall be two inch PVC, heavy wall sunlight resistant (6 % - 7% titanium dioxide by weight), Schedule 40 as per ANSI/NEMA TC 2-2003. Conduit riser shall be installed bell end down and extend **4 inches** above the secondary or neutral height. Riser shall be installed on the pole opposite the flow of traffic.

F.) Disconnect and overcurrent protection shall be limited to a 30 A maximum service rating and should be located in a separate compartment from the meter socket.

G.) Grounding shall consist of #4 covered, soft drawn copper down ground (Std. Item W11F), and copper or bronze connectors, and copperclad 5/8 inch diameter x 8 foot length ground rod(s). An additional ground rod shall be installed if it is necessary to lower the resistance to earth. All equipment shall be bonded to the grounding system. The communication company shall leave enough grounding conductor coiled at the location of the weatherhead for final connection by the electric company to their aerial ground wire/system neutral conductor. This ground arrangement shall apply unless local requirements specify otherwise.

H.) A single power supply shall be located on the back side of the pole away from vehicular traffic with a maximum weight not to exceed 670 lbs. All mounting equipment shall be galvanized steel construction. These shall be secured to the pole with galvanized hardware of adequate strength for the load.

I.) If needed, an antenna shall be mounted via an approved method at the top of the distribution pole. The antenna maximum weight shall not exceed 110 lbs. and the maximum height shall be 104 inches including any mounting hardware. The minimum horizontal clearances between the antenna and any primary conductor shall be as follows see CS drawing # 17-109A.

J.) All devices are to be mounted over one another on the same side of the pole. Arrange all pole equipment to allow at least one clear third of pole, dimensions per NESC climbing space.

K.) Radio Frequency (RF) radiation warning signage as required by OSHA shall be present and visible to persons working near antenna. Requester must submit documents that state the RF output of antenna for each location.

L.) If needed, a cable shall be directly routed from the power supply inside a 2 inch PVC conduit that is schedule 40 minimum as well as sunlight and weather resistant.

M.) If needed, fiber shall be directly routed from the power supply to the splice box inside a 2 inch PVC riser guard that is schedule 40 minimum as well as sunlight and weather resistant.

Metering Requirements

N.) Services to power supplies shall be single phase, three wire and shall be metered.

O.) All pole mounted installations and orientation of the meter socket must be approved by Liberty Utilities metering prior to installation.

P.) Meter shall not be installed on poles unless the control unit itself is also installed on the pole. The meter location for the pole mounted control units should be at least at the 5 foot level.

Q.) An approved lever operated manual bypass is required on sockets. 100 amp sockets may be supplied with non-locking jaws. Sockets greater than 100 amps must be supplied with locking jaws.

R.) Supply wire for connection to leads from secondary shall be minimum #10 solid copper 600V insulated conductors, type RHW-2 or THWN, and made with UL approved connectors.

S.) Each power supply shall be metered, and requires a ring-less meter socket and pole mounted bracket. Meter is Form 2S, UL approved, sealable, with safety arc shield and approved single-handled operated bypass. Use of an automatic by-pass is not permitted. The meter socket will be located on the quarter of the pole opposite of traffic flow. Liberty Utilities will own and install the meter, attachee is responsible for acquiring and installing equipment.

T.) Any vegetation management is the responsibility of the pole attaching entity.

Following the municipal wiring inspector’s approval of the construction by others, the Company shall provide all connections to the secondary supply conductors including the communication company’s grounding conductor. Attacher shall allow enough service entrance cable slack so Liberty Utilities crews can attach the power and neutral leads to the system without splicing. The Company will also set the meter with a polycarbonate cover.

Note: All work performed in or above the “Communication Worker Safety Zone” shall be completed by an electrically qualified worker meeting NESC and OSHA requirements. Further detail can be referenced in ESB #750 or the Electric Service Information and Requirements documents.

17.7 ALL-DIELECTRIC FIBER OPTIC (ADFO) CABLE IN THE SUPPLY SPACE

17.7.10 General

This fiber section covers the installation of all-dielectric fiber optic (ADFO) communication cables in the supply space of distribution poles with supply line voltages of 34.5 kV or less. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.

The Company allows the installation of ADFO communication cables in the supply space of distribution poles. Such installations must comply with the requirements detailed below, with the NESC and with any applicable federal, state or local regulations.

Under the NESC, a communication cable may be installed in the supply space; however, such a cable is considered part of the supply space. This means that the Communication Worker Safety Zone requirements between this communications cable in the supply space and communication space attachments apply when a separate communication space is required on the pole. This also means that workers installing and maintaining this cable in the supply space must meet the more stringent worker training and equipment requirements for work in the supply space. These requirements come from the NESC and OSHA, as well as by state and local regulations.

17.7.20 Approved Installation

Per Company requirements, ADFO cable is the only type of fiber cables that may be installed in the supply space. An ADFO cable is entirely dielectric including being supported on a messenger that is entirely dielectric. The key distinguishing feature of this type of cable is that the entire cable assembly is dielectric. A cable assembly that contains any metallic component cannot be considered all-dielectric.

The other type of fiber cable, an effectively grounded cable, is a communication cable that is supported on a messenger and is effectively grounded throughout its length. In general, the Company shall not allow the installation of any communication cables with a metallic component in the supply space even if that cable is effectively grounded.

17.7.30 Location on Pole

The Company will designate the location on each pole for any communication cables installed in the supply space. In general, this cable shall be the next cable above the existing neutral or secondary cable. Where there are multiple communication cables in the supply space, to the extent practical, this location should be in the same relative position on adjacent poles.

cables at the pole is preferred. Where this is not possible, the owner of the communication cable may install an ADFO cable on an offset bracket to obtain a 12 inch minimum horizontal separation from the neutral or secondary cable. The bracket should be installed immediately above the neutral or secondary cable. Grounding of this bracket is not required.

17.7.40 Clearances

The NESC imposes no minimum clearance requirement between an ADFO cable and some classes of cables in the supply space. In particular, the NESC does not specify clearances between an ADFO cable in the supply space and any other cable in the supply space up to and including, the 15 kV class. The NESC also does not specify clearances between an ADFO cable and supply cables in the 23 kV or 34.5 kV classes where the cables are owned by the same entity. However, the NESC does specify clearance requirements between an ADFO cable and supply cables in the 23 kV or 34.5 kV classes where the cables are owned by different entities.

Where the NESC does not specify clearances, maintaining the ability of all parties to safely work on their cables is still a primary concern. Therefore, ADFO cables shall be installed with a minimum 12 inch separation at the pole, in any direction, from the electric neutral or secondary cables. To allow work on the communication cable without requiring the Company to cover its primary electric supply cables or other exposed parts, an ADFO cable in the supply space shall be installed with a 30 inch minimum separation in any direction from any primary cable or other exposed part at the pole.

Where the NESC specifies clearances, at a minimum those clearances shall be followed. This type of installation may be approved by Distribution Design based on a review of the specific proposed installation. If a request for this type of installation is received, consult Standards Engineering for specific applicable requirements.

17.7.50 Sag and Tension

An ADFO cable installed in the supply space should be sagged to approximately match the sag of the existing secondary or neutral cable with both cables at final sag condition at 60°F/15°C. The communication cable's owner shall provide the Company with appropriate sag and tension data for the cable used. The owner of the communication cable is responsible for costs associated with the additional space required to accommodate cables that do not follow this recommended practice.

17.7.60 Worker Qualifications

The installation, maintenance, modification and removal of cables or equipment in the supply space must be done by workers qualified to work in that space. The owner of the communication cable shall ensure that the workers installing its fiber in the supply space understand and meet the requirements of the NESC (Part 4) and OSHA (Parts 1910 and 1926), and that various states and localities each impose requirements on employers for the training, qualification, equipment and practices of workers in the supply space. The Company expects that the owner of the communication cable will assure compliance with all applicable NESC, OSHA, state and local requirements by the workers installing the communication cable(s) in the supply space and their employer.

Supersedes 1/06 Issue – Repaging.

17.8 WOOD DISTRIBUTION POLE MOUNTED SECURITY AND SURVEILLANCE CAMERAS

17.8.10 General

This Section covers installation details for wood distribution pole mounted security and surveillance cameras.

All third party use of Liberty Utilities poles will be authorized by written agreement. Occupancy fees are routinely assessed for use of Liberty Utilities facilities (e.g., poles), however, such fees may be waved for municipal or law enforcement short term (temporary) installations. Unless waived by Liberty Utilities Security or Business Services, permanent installations including those of municipalities and law enforcement agencies are subject of occupancy fees. In addition to occupancy fees, the applicant (requestor) shall reimburse Liberty Utilities for support services (e.g. field surveys, make ready work, etc.) and energy supply costs for such installations. Energy cost shall be per Company tariffs. Municipal franchise agreements and/or pole permits should be reviewed to determine municipal rights regarding use of Company facilities. Unless otherwise noted below, Liberty Utilities Telecommunication Attachment Department shall hold all Agreements, retain and invoice for appropriate occupancy and support service fees. Energy cost shall be managed and invoiced through Business Services.

NOTE: Many poles are jointly owned with the Telephone Company. Liberty Utilities cannot unilaterally authorize use of joint owned poles, e.g., application must also be made to and authorization received from our joint pole owner.

17.8.20 Location on Pole

The security and surveillance cameras shall be installed at least 12 inches below the lowest communication cable.

17.8.30 Division of Responsibility

A.) A rain tight weatherhead shall be mounted in a location suitable for the Company to form a driploop and to make secondary connections (See Page 17-118).

B.) Service entrance cables shall be #10 stranded copper, insulated THWN, THHN, or SE conductor suitable for outdoor use. The cable shall include two black insulated conductors and one white insulated conductor and shall extend a minimum of 24 inches beyond the weatherhead to form a driploop and to make secondary connections.

C.) Electric service conduit shall be 1inch PVC schedule 40, at a minimum, sunlight and weather resistant as well as direct and weather sealed to the meter socket enclosure. Conduit straps shall not be placed at intervals exceeding 30 inches.

D.) An approved meter socket shall be installed on the quarter of the pole away from vehicular traffic. The meter shall be a ringless socket sealable style with a safety arc shield and an approved single handle-operation bypass; use of an automatic bypass is not permitted. The meter socket shall be approved by an Authority of Higher Jurisdiction (AHJ) accepted organization concerned with product evaluation and carry the label of that agency.

E.) Bracket system, (Std. Item C39E or equivalent), for mounting the socket to the pole (See Page 17-107). Attach the bracket to the pole with galvanized lag screws and the socket to the bracket with stainless steel bolts, nuts and lock washers. In the event that a 120/208 V meter is installed, a 5th terminal is required.

New construction standard for pole mounted security and surveillance cameras.

F.) Disconnect and overcurrent protection shall be limited to a 30 A maximum service rating and may be located in a separate compartment from the meter socket.

G.) Grounding shall consist of #4 covered, soft drawn copper down ground (Std. Item W11F), and copper or bronze connectors, and copperclad 5/8 inch diameter x 8 foot length ground rod(s). An additional ground rod shall be installed if it is necessary to lower the resistance to earth. All equipment shall be bonded to the grounding system. The owner of the Security or Surveillance camera shall leave enough grounding conductor coiled at the location of the weatherhead for final connection by the electric company to their aerial ground wire/system neutral conductor. This ground arrangement shall apply unless local requirements specify otherwise.

H.) A single power supply shall be located on the back side of the pole away from vehicular traffic with a maximum weight not to exceed 670 lbs. All mounting equipment shall be galvanized steel construction.

17.8.40 <u>Law Enforcement Requests For Criminal or Investigational Surveillance</u>

The Company supports all efforts related to national security (homeland security) and Law enforcement investigations. All such requests shall be directed to Liberty Utilities Corporate Security, due to confidentiality requirement of these requests, Corporate Security will be responsible arranging Liberty Utilities support services and for maintaining all records associated with law enforcement requests and the subsequent installation of these technical surveillance devices.

17.8.50 <u>Other Municipal Requests</u>

The Company supports municipal public service efforts (e.g. traffic control, building/parking lot security, etc.). Consistent with existing franchise agreements and Liberty Utilities operational needs, Liberty Utilities will authorize municipal camera installations. All such requests shall be directed to Business Services.

New construction standard for pole mounted security and surveillance cameras.

MASSACHUSETTS, NEW HAMPSHIRE AND RHODE ISLAND					
Pole Length (Feet)	**[1]Ownership Percentage (Elec./Comm.)**	**Normal setting Depth (Feet - Inches)**	**Communication Maximum Height (Inches)**	**Electric Minimum Height (Inches)**	**Electric Maximum Space (Inches)**
35	35/35	6’-0”	254”	294”	54”
40	40/40	6’-0”	284”	324”	84”
40	40/35	6’-0”	254”	294”	114”
40	35/40	6’-0”	314”	354”	54”
45	40/45	6’-6”	338”	378”	84”
45	45/45	6’-6”	311”	351”	111”
45	45/40	6’-6”	284”	324”	138”
45	45/35	6’-6”	254”	294”	168”
50	45/50	7’-0”	365”	405”	111”
50	50/50	7’-0”	338”	378”	138”
50	50/45	7’-0”	311”	351”	165”
50	50/40	7’-0”	284”	324”	192”
50	50/35	7’-0”	254”	294”	222”

NEW YORK					
Pole Length (Feet)	**[1]Ownership Percentage (Elec./Comm.)**	**Normal setting Depth (Feet - Inches)**	**Communication Maximum Height (Inches)**	**Electric Minimum Height (Inches)**	**Electric Maximum Space (Inches)**
[2]Poles Set Prior To 1975 And Independent Telephone Poles Set Prior To1986					
35	35/35	6’-0”	258”	298”	50”
40	40/40	6’-0”	288”	328”	80”
40	40/35	6’-0”	258”	298”	110”
40	35/40	6’-0”	318”	358”	50”
45	45/45	6’-6”	315”	355”	107”
45	45/40	6’-6”	288”	328”	134”
45	45/35	6’-6”	258”	298”	164”
[3]Jointly Owned Poles Set After 1975					
35	35/35	6’-0”	268”	308”	40”
40	40/40	6’-0”	276”	316”	92”
45	45/45	6’-6”	299”	339”	123”
45	45/40	6’-6”	276”	316”	146”
45	40/45	6’-6”	330”	370”	92”
[4]Jointly Owned Poles Set After 1986					
40	40/40	6’-0”	257”	297”	103”
45	45/45	6’-6”	280”	320”	134”
45	45/40	6’-6”	257”	297”	157”
45	45/35	6’-6”	311”	351”	103”

Supersedes 1/06 Issue – Table correction.

NOTES:

1. 45/40 indicates a 45 foot pole where the communication company pays for and occupies the space as if it were a 40 foot joint pole. 40/45 indicates a 45 foot pole where the Company pays for and occupies the space as if it were a 40 foot joint pole.

2. Space available on existing jointly owned poles including New York Telephone Company poles set before May of 1975, and Independent Telephone poles set before August of 1986.

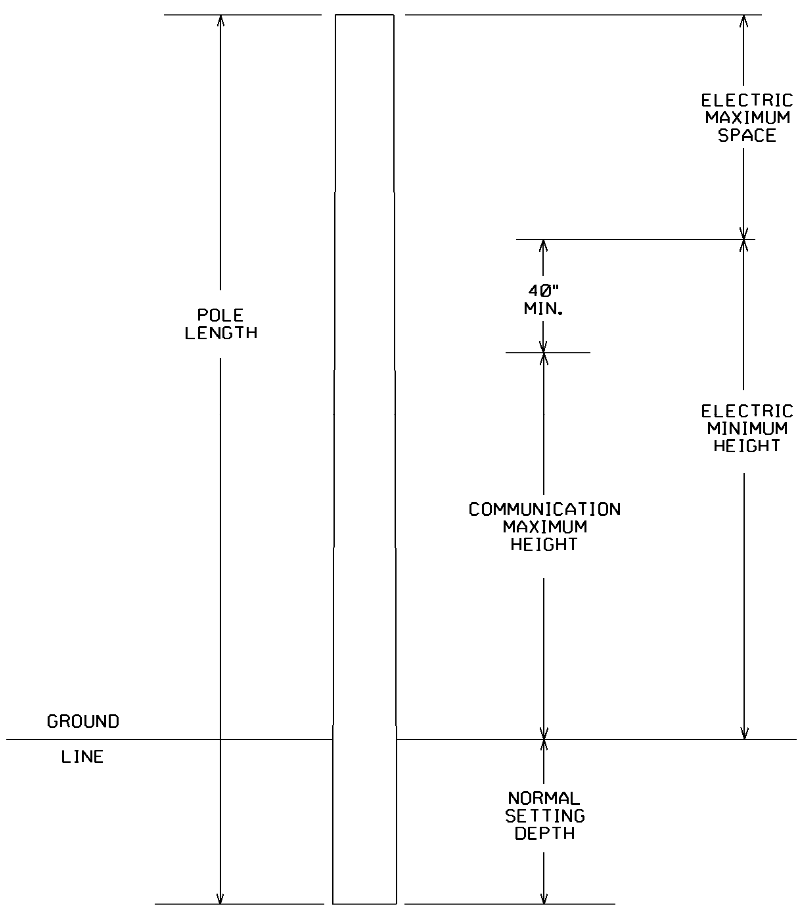
3. Allocated space on poles owned jointly with New York Telephone Company Set after April of 1975.

4. Allocated space on poles jointly owned by the Company and Independent Telephone Company set after August of 1986.

5. To minimize pole replacements each party shall rearrange its attachments on existing poles to provide space for the other party, within the limits of each company's construction standards, regardless of allocated space shown.

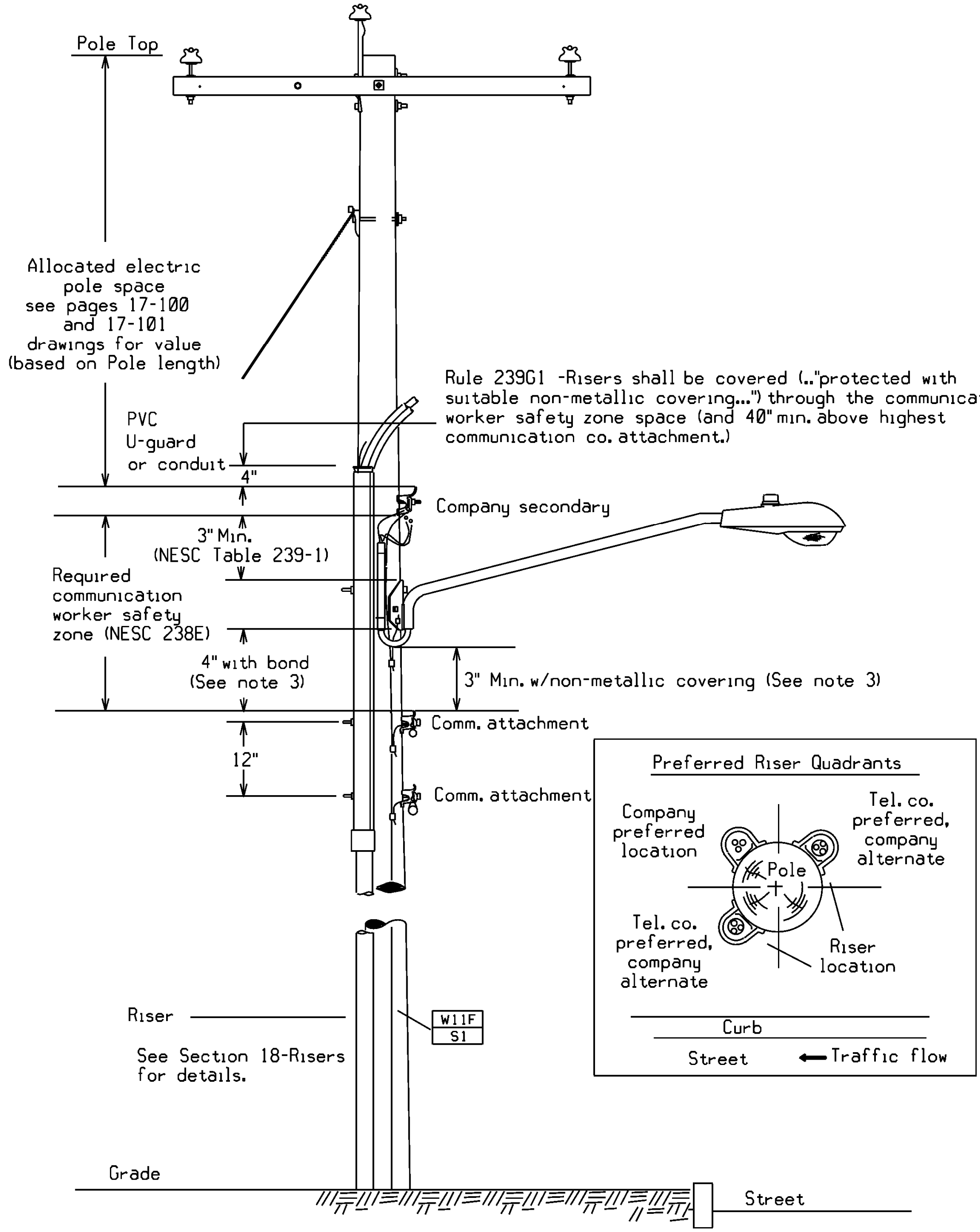
6. Generally, to meet in-span ground clearance requirements, communication companies must install their cables on the pole at least 18 feet above ground. If the communication cable can be installed on the pole at less than 18 feet above ground clearance (for example, 15 feet required in rear lots), the extra pole space is divided equally between the joint owners 1-½ feet to each. If ground clearance forces telephone companies upwards (say a 3 foot high knoll), each company may be required to give up equal space (1-½ feet) or use a 5 foot higher pole.

JOINT POLE SPACE ALLOCATION



Supersedes 1/06 Issue – New drawing.

 Doc. # ST. 17.00.002



Supersedes 1/06 Issue – Revised Notes, NESC References & Streetlight Information.

Notes:

1. Related NESC References:

- Preferred Levels: Supply conductors should be carried at the higher level. (NESC Rule 220B1).
- Vertical runs of supply conductors shall have a clearance of 2” from communication messengers, cables, attachment bolts and hardware, except ground wires may have a clearance of 1” from messengers, cables, attachment bolts and hardware. (NESC Rule 239G5).

New Page – Contains Additional Notes From Page 17-102.

- Within 8' of the ground, all vertical conductors and cables shall be appropriately guarded. Supply conductors shall be in metallic conduits and ground wires shall be guarded using ground wire molding. (NESC Rule 239D).

2. Minimum Attachment Heights: See Section 7 – Clearances for information about clearances above ground and minimum attachment heights.

3. Outdoor Lighting and Communications:

- For new installations:
  - Streetlight brackets shall be bonded to the secondary or system neutral and drip loops shall be covered with non-metallic flexible conduit.
  - Vertical clearance between the grounded streetlight bracket and the communication messengers, cables, attachment bolts or hardware shall be at least 4".
  - Vertical clearance between the drip loop, covered with non-metallic flexible conduit, and the communication messengers, cables, attachment bolts or hardware shall be at least 3".

- For existing installations:
  - If the streetlight bracket is not bonded to the secondary or system neutral, maintain 20" vertical clearance between the streetlight bracket and the communication messengers, cables, attachment bolts and hardware. If the streetlight bracket is bonded to the system neutral, vertical clearance between the streetlight bracket and the communication messengers, cables, attachment bolts or hardware may be reduced to 4".
  - If the drip loop is not covered with non-metallic flexible conduit, maintain 12" vertical clearance between the drip loop and the communication messengers, cables, attachment bolts and hardware. If the drip loop is covered with non-metallic flexible conduit, vertical clearance between the drip loop and the communication messengers, cables, attachment bolts or hardware may be reduced to 3".

- Streetlights should be mounted in the Communication Worker Safety Zone (CWSZ) between the supply and communication spaces on the pole. Streetlights may be mounted between communication messengers and cables only where streetlights mounted in the CWSZ cannot provide adequate illumination. When such installations must be made:

  - The streetlight bracket shall be grounded and the vertical clearance between the grounded streetlight bracket and the communication messengers, cables, attachment bolts or hardware above and below the streetlight shall be at least 4".
  - The drip loop shall be covered with non-metallic flexible conduit and the vertical clearance between the covered drip loop and the communication messengers, cables, attachment bolts or hardware shall be at least 3".
  - A CWSZ shall be established between (i) the communication attachment above the streetlight and (ii) the electric primary, neutral and secondary wires.

- See Section 19 – Lighting - OH for additional notes regarding out door lighting on joint use poles, including: bracket location and restraint and protection of supply conductors.

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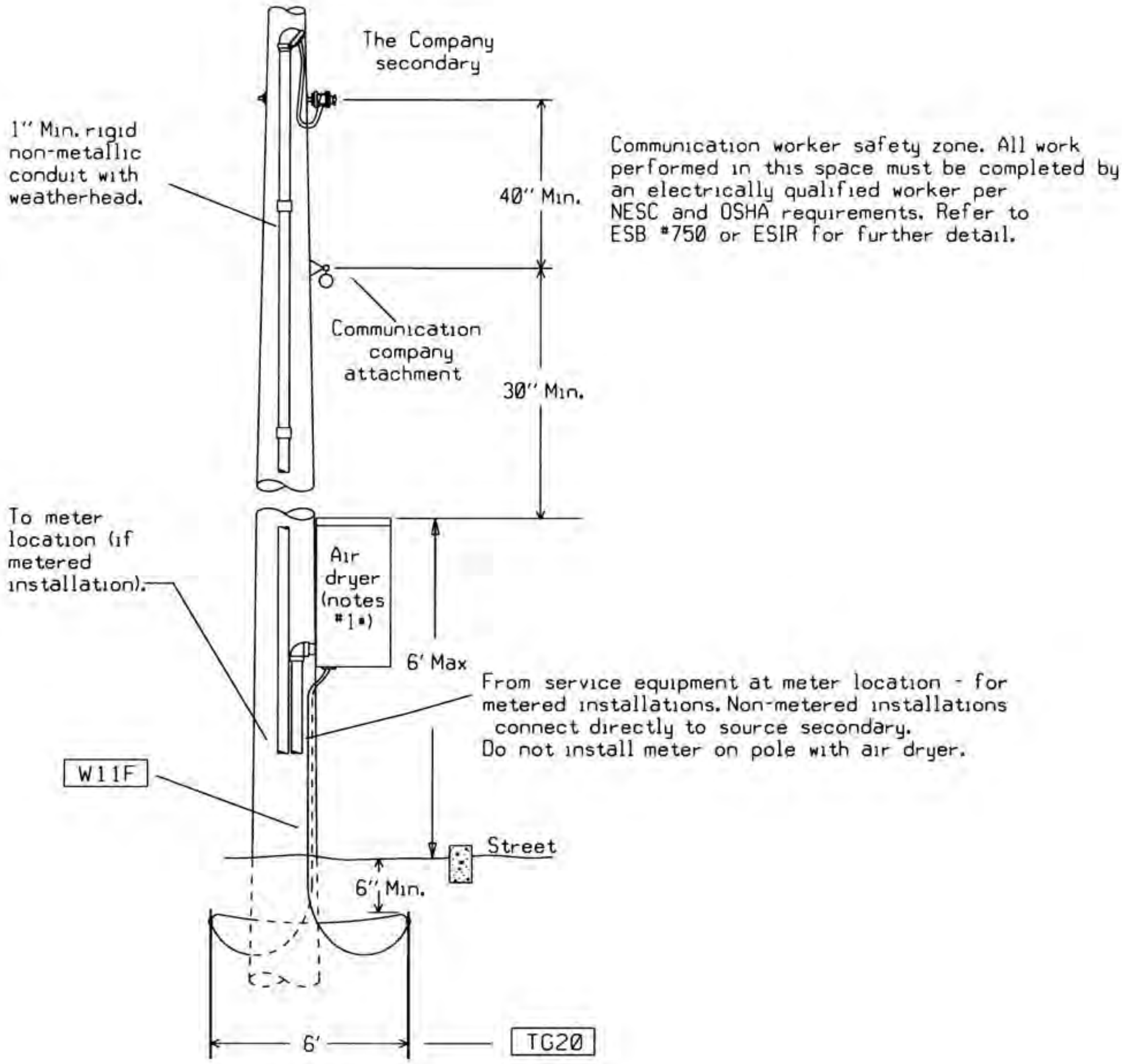

Note:

1. Air Dryer and attachments (conduit, supply conductor and grounding) shall be furnished and installed by communication company.
2. Avoid dryer installation on poles requiring repeated climbing, junction poles, or poles used for other equipment. Billing meteringequipment shall not be located on the same pole.
3. The supply conductor (furnished by communication company) shall be 600V TW cable long enough to extend 3' above the Company secondary.
4. Communication Co. to provide NEC approved service equipment if flate rate billed. If metered, service equipment to be located at meter location. See ESB #750 figure 29, or Information and Requirements for Electric Service Figure 904 depending on location.

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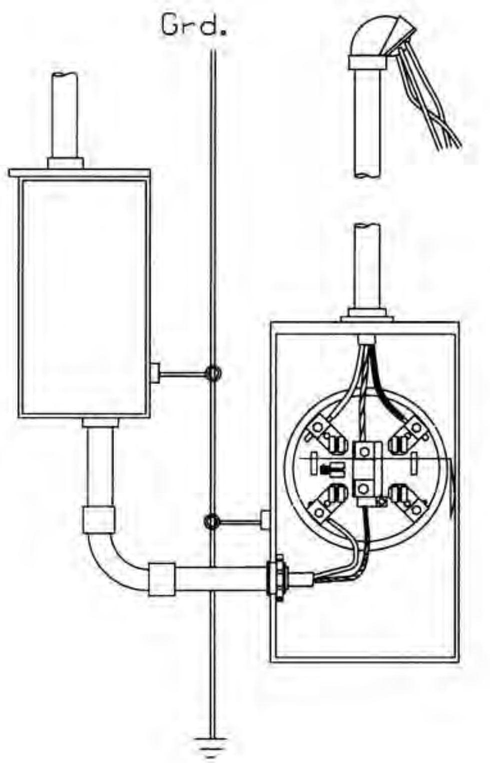
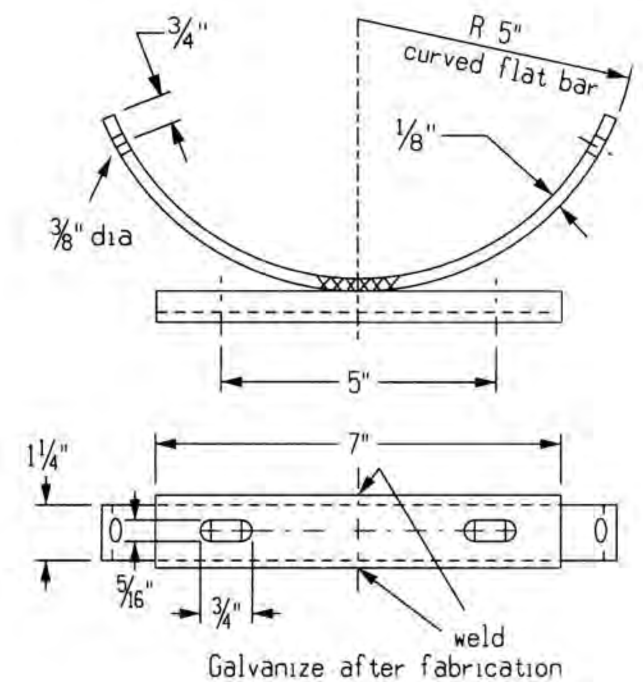
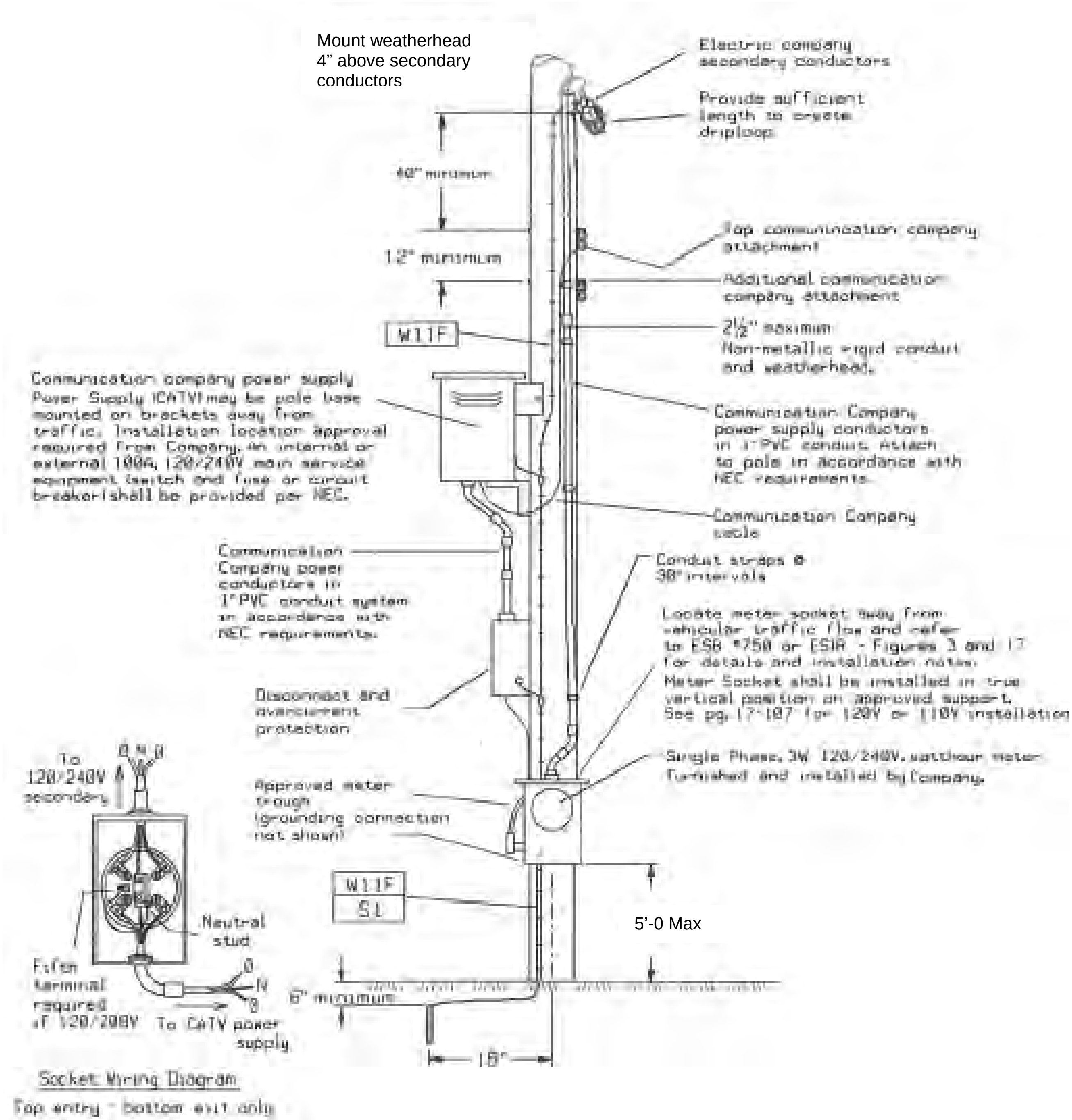
 | Doc. # ST. 17.00.002





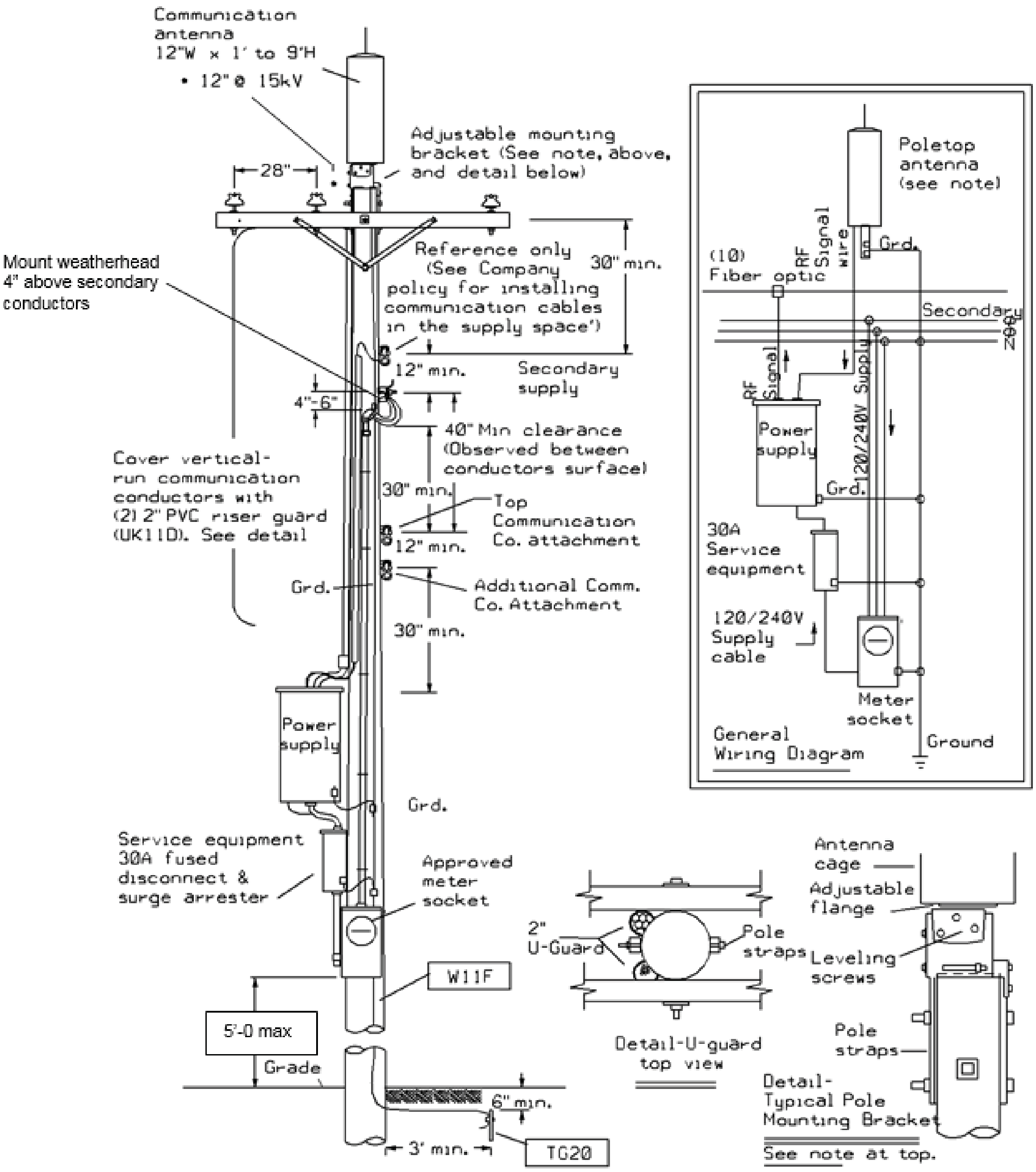
METER SOCKET BRACKET AND CONNECTIONS FOR POLE MOUNTED METER INSTALLATIONS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
1/06	17-107		



Notes:

1. All new or replacement power supplies are to be metered. Communication Co. power supply installations should be avoided on poles with other equipment. Poles should be accessible by bucket and the proposed installation shall be field reviewed and approved by the Company and any joint pole owners prior to work.
2. Communication Co. shall furnish, install, own, and maintain all material and equipment shown above except as noted. Refer to ESB #750 or electric service information.

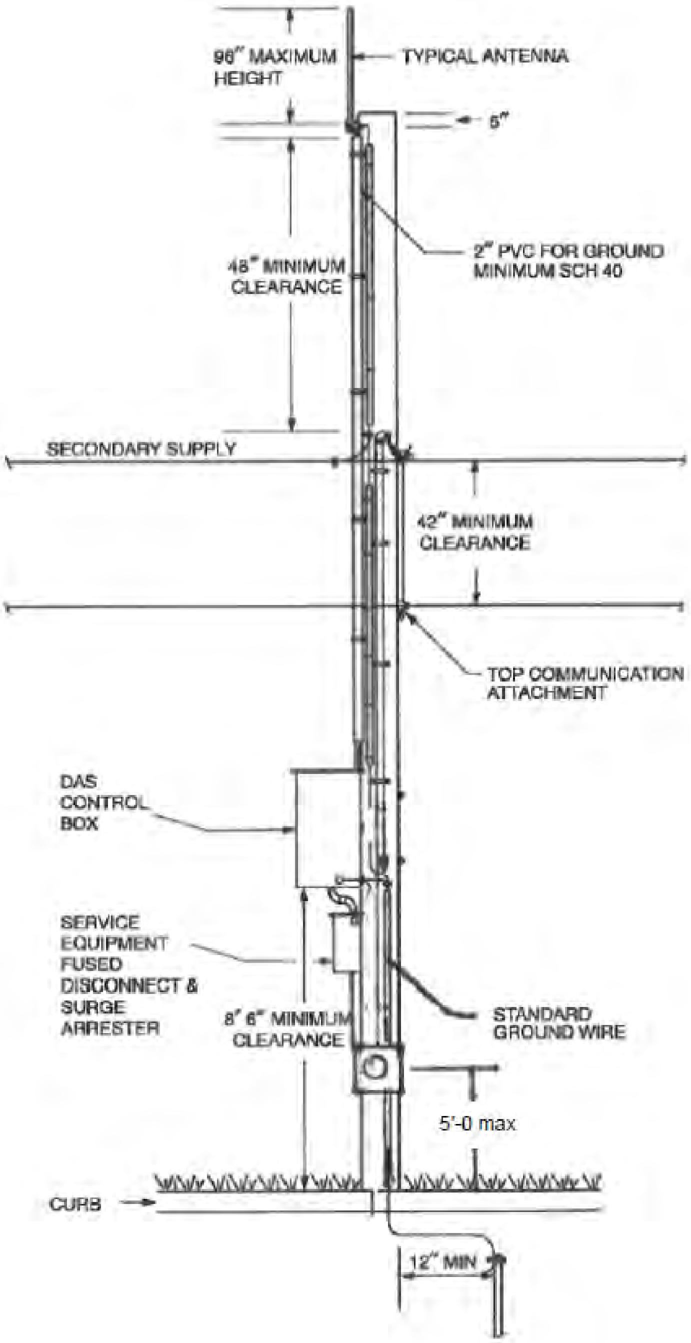
Printed Copies of this document are not document controlled. Refer to Liberty Utilities Engineering and Operations website for the latest version. Controlled Documents are maintained by Engineering Standards, Policies, and Codes.	Doc. #ST 17.00.003

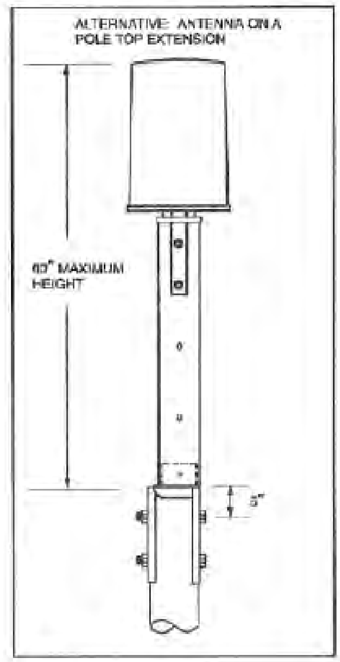


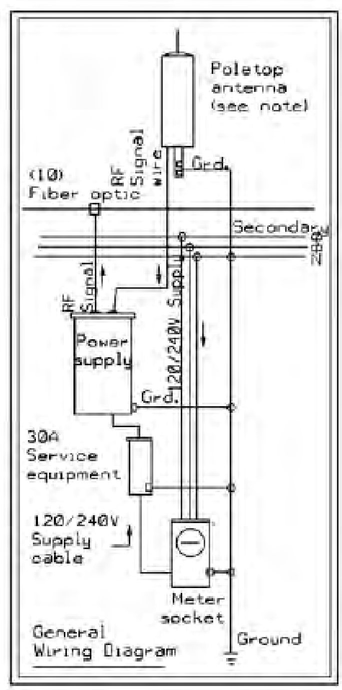
Notes:

1. This arrangement is representative of a typical installation. Similar wireless pole top equipment may be accommodated while maintaining the specified clearance requirements. Relocating existing facilities, pole replacement, or installing alternate equipment shall be considered when required.
2. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.

 Doc. #ST 17.00.003





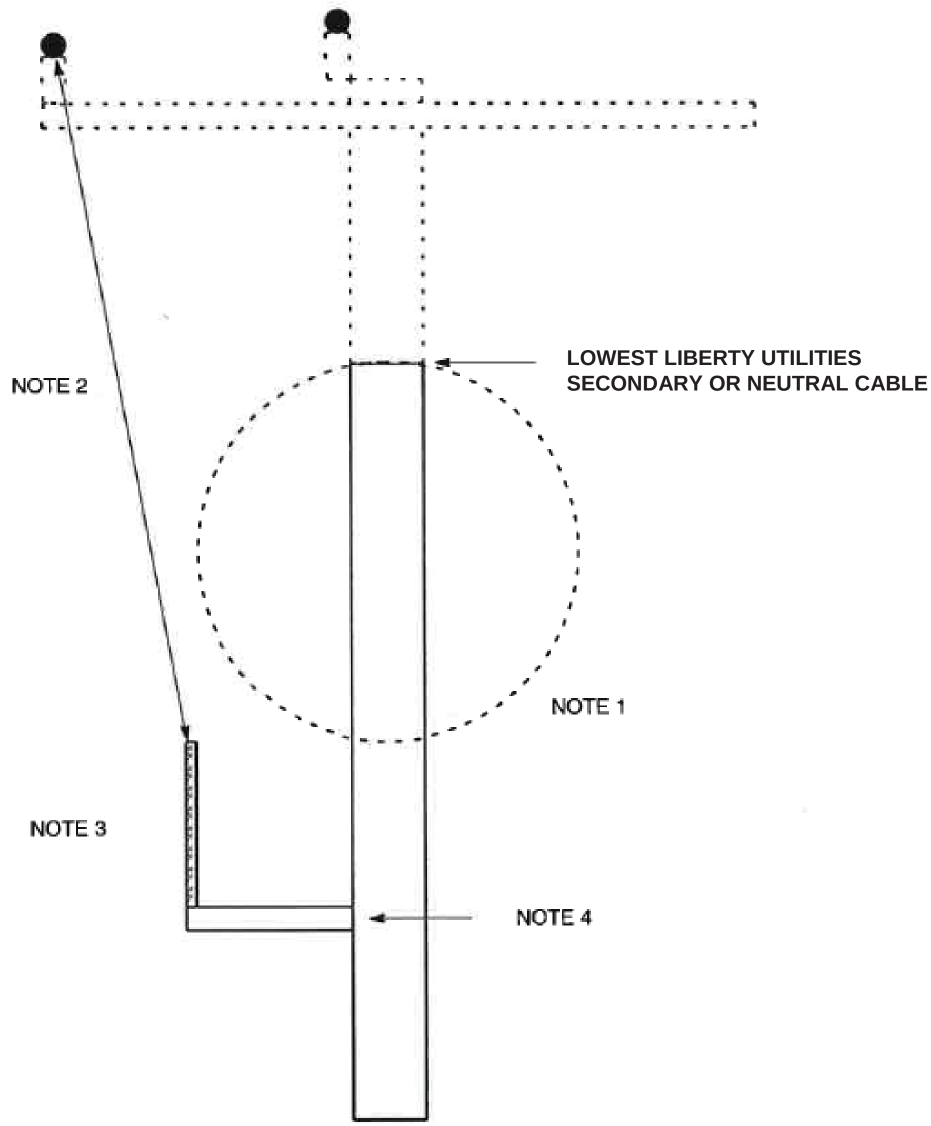


Notes:

1. This arrangement is representative of a typical installation. Similar wireless pole top equipment may be accommodated while maintaining the specified clearance requirements. Relocating existing facilities, pole replacement, or installing alternate equipment shall be considered when required.

15KV MAX. DISTRIBUTION POLE MOUNTED ANTENNA INSTALLATION (SECONDARY VOLTAGE AREA)			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
6/17	17-109B		

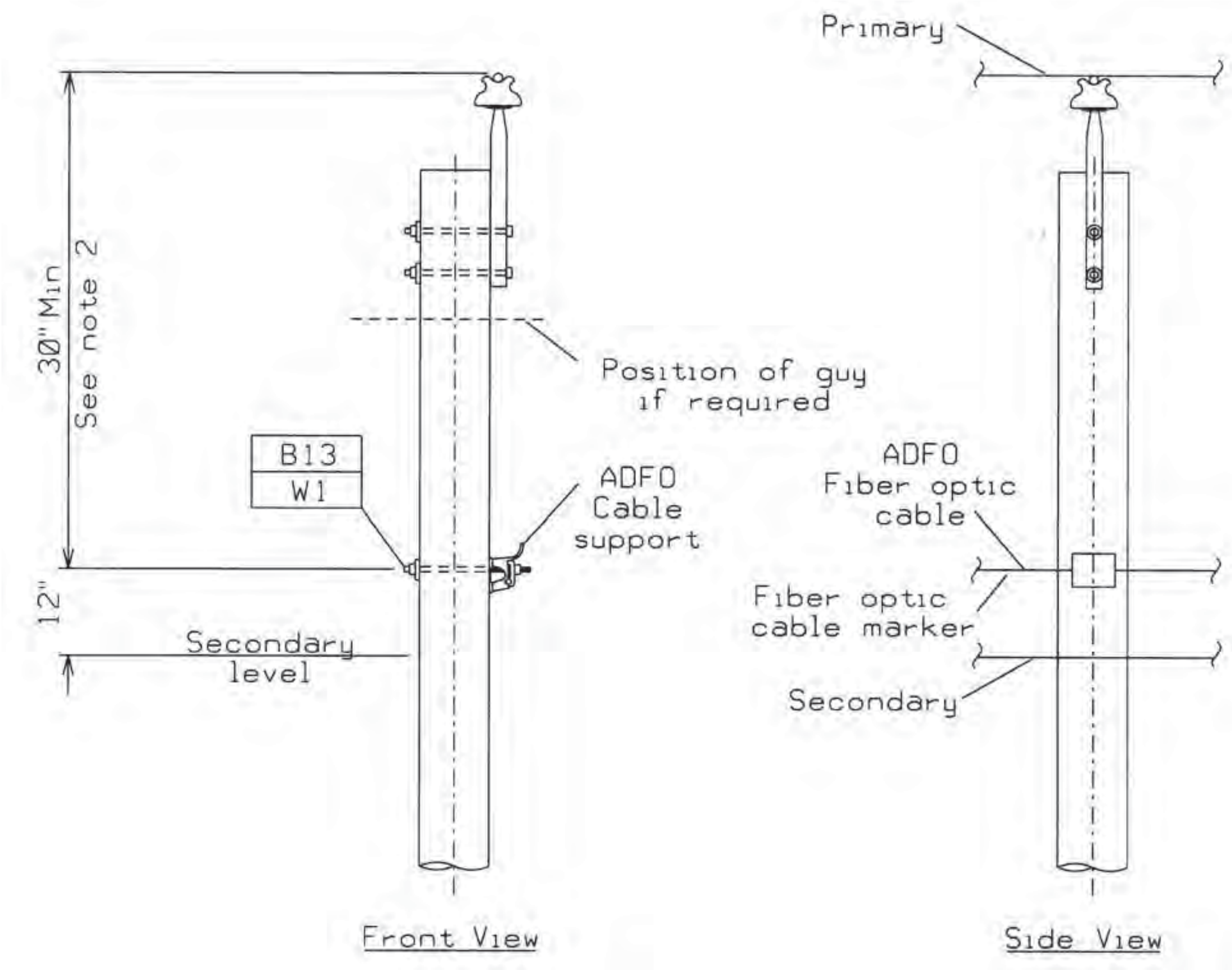
 | Doc. #ST 17.00.003



Non–pole top antenna clearance from pole, primary (or reserved primary space), and secondary conductors

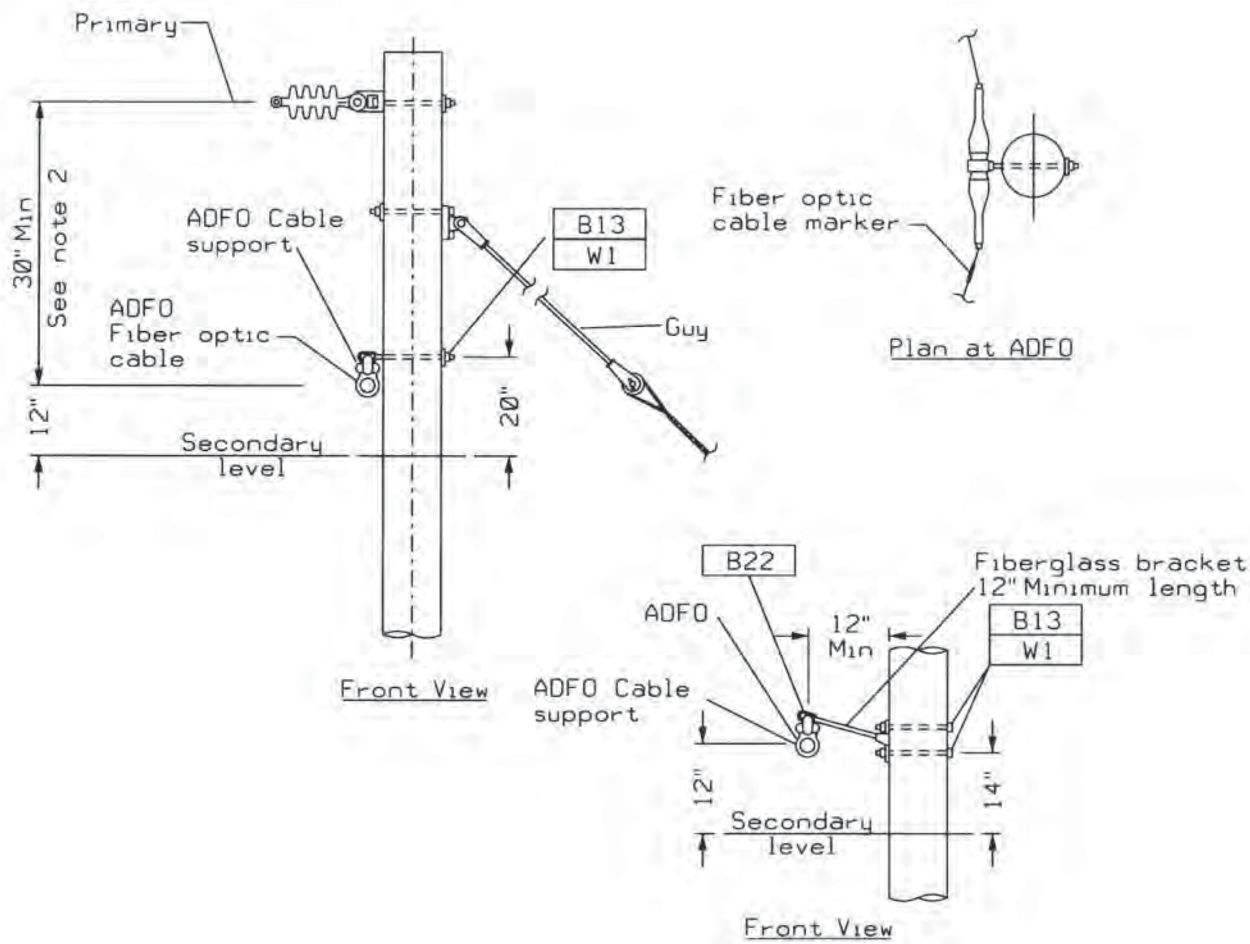
Notes:

1. Reserved primary space requirement shall be identified by Liberty Utilities engineering based on the type of construction that is expected for the pole.
2. Six feet minimum clearance to nearest energized primary wire or tap.
3. Antenna mast or panel is on opposite side of pole from cable.
4. Bracket mounting height below secondary must allow these two clearances for any antenna design.



Notes:

3. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
4. Maximum line angle for ADFO = 20 degrees.
5. ADFO communication cables may be installed in the supply space of distribution poles <u>only</u> by attachers having an agreement allowing such attachments made prior to January 1, 2010.

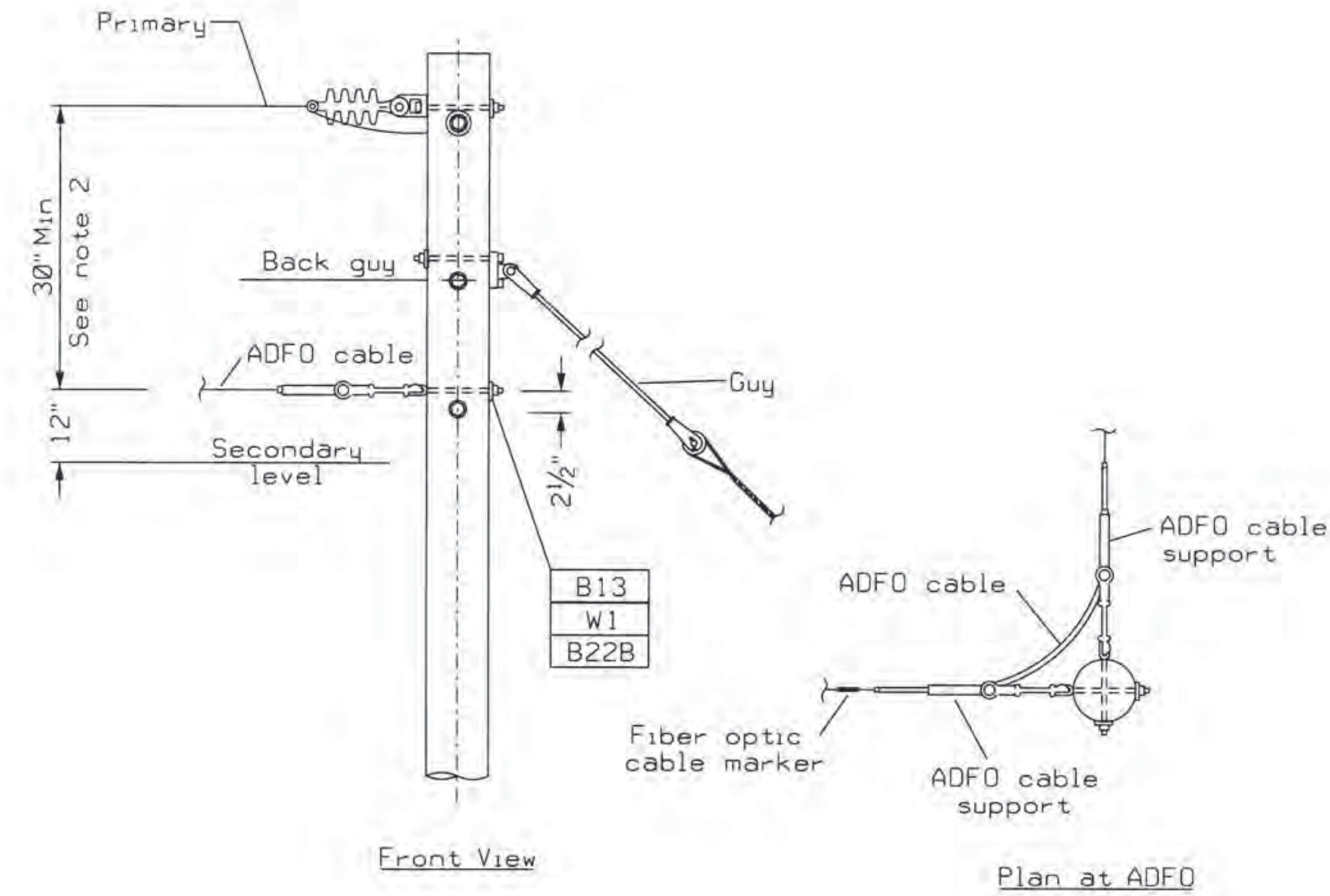


Notes:

1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 30 degrees.
3. Item 5, fiberglass bracket, is for use on tangent and angle structures only. Not for use on deadends.
4. ADFO communication cables may be installed in the supply space of distribution poles <u>only</u> by attachers having an agreement allowing such attachments made prior to January 1, 2010.

SINGLE PHASE ANGLE WITH ALL DIELECTRIC FIBER OPTIC (ADFO) CABLE BETWEEN PRIMARY AND SECONDARY ATTACHMENTS

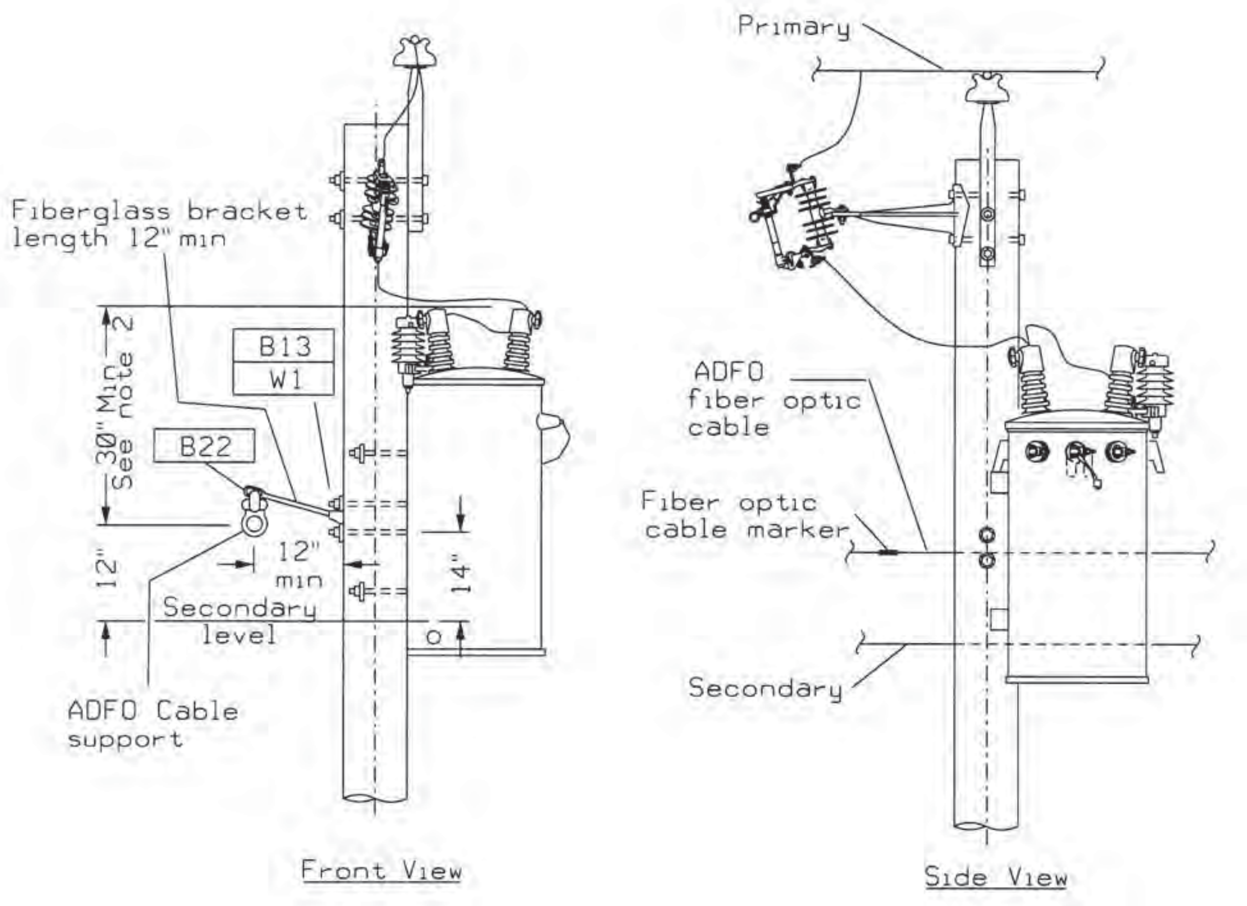
ISSUE	PAGE NUMBER		
1/06	17-111	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities



Notes:

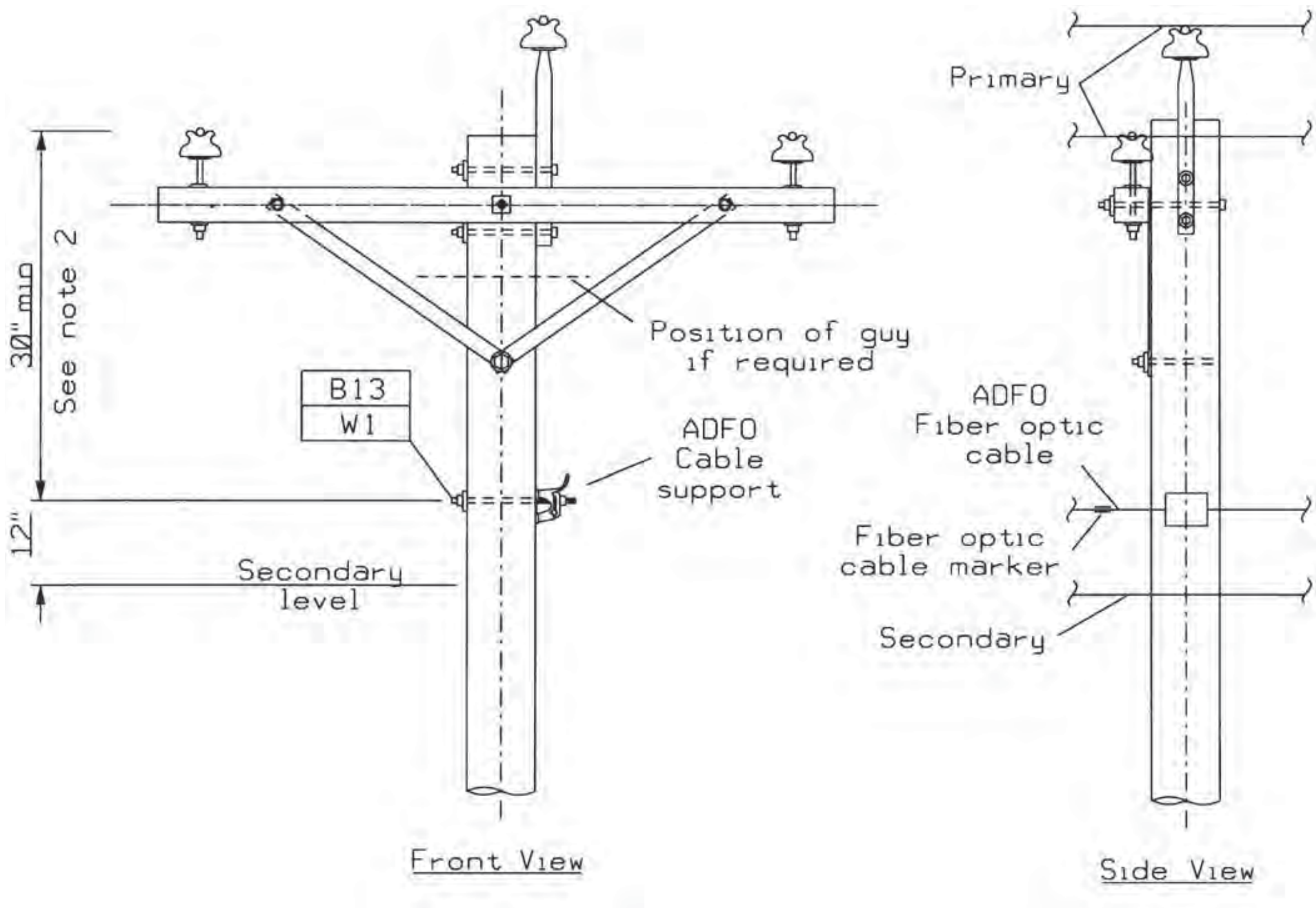
1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 90 degrees.
3. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.

SINGLE PHASE CORNER DEADEND WITH ALL DIELECTRIC FIBER OPTIC CABLE BETWEEN PRIMARY AND SECONDARY ATTACHMENTS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 17-112	ISSUE 1/06



Notes:

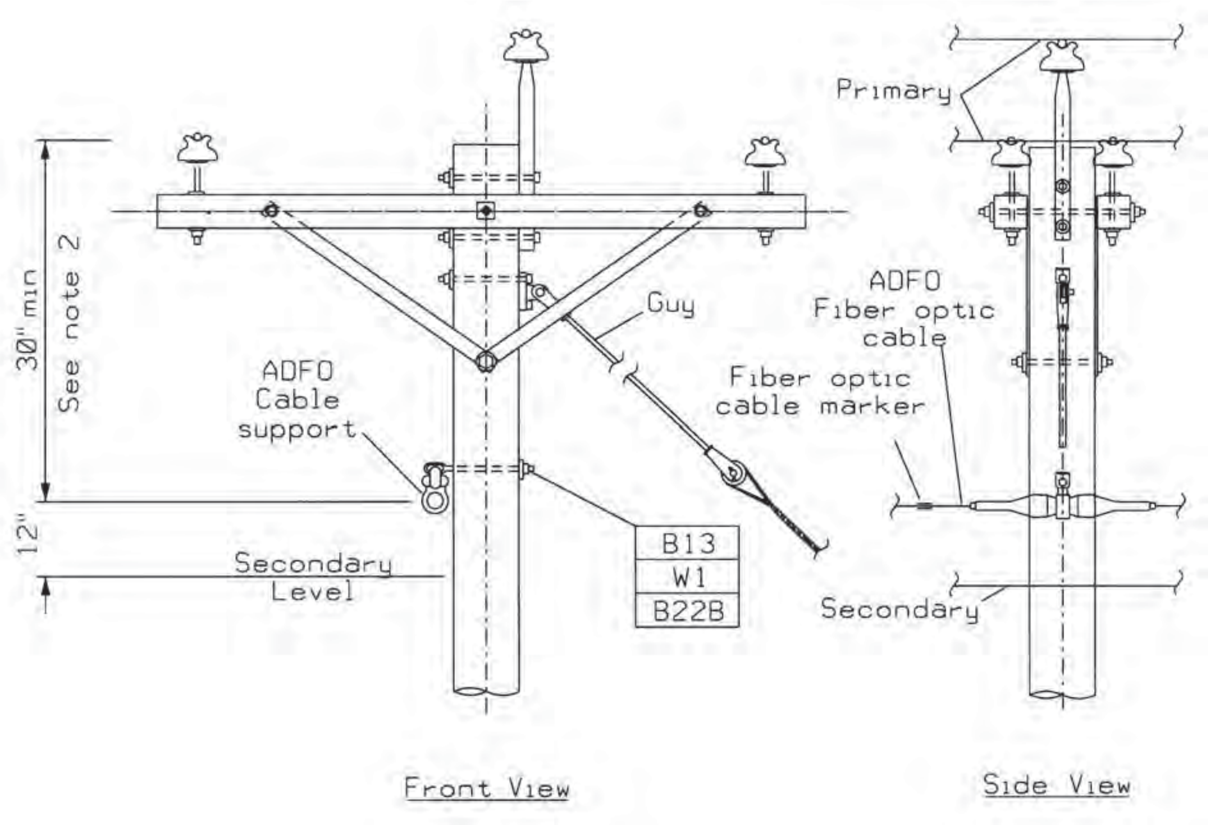
1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 30 degrees.
3. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.



Notes:

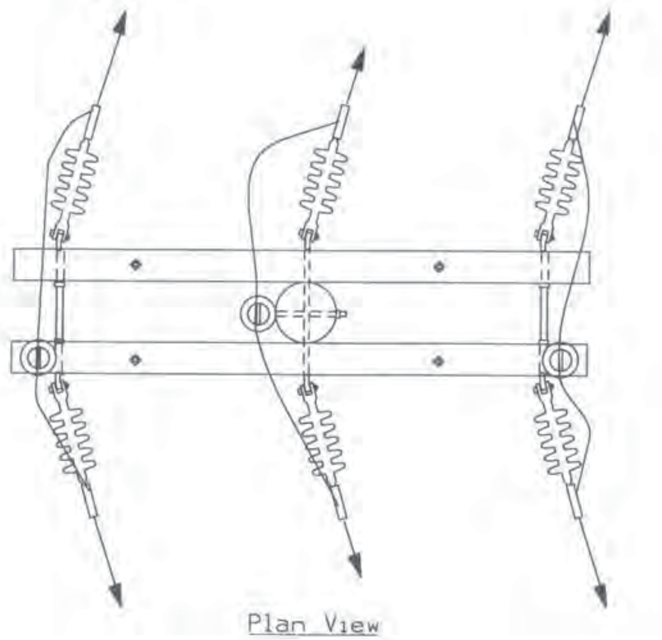
1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 20 degrees.
3. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.

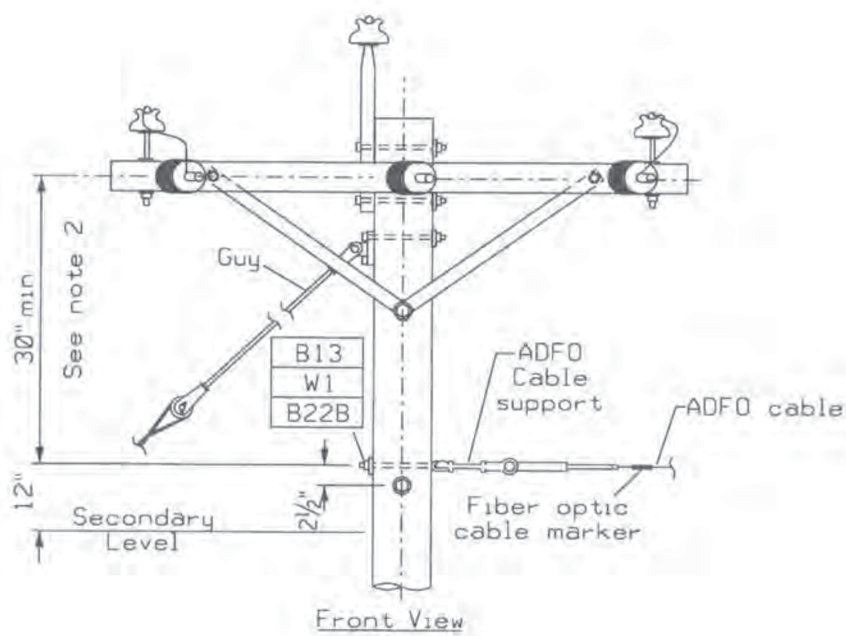
THREE PHASE TANGENT SINGLE CROSSARM WITH ALL DIELECTRIC FIBER OPTIC (ADFO) CABLE BETWEEN PRIMARY AND SECONDARY ATTACHMENTS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 17-114	ISSUE 1/06



Notes:

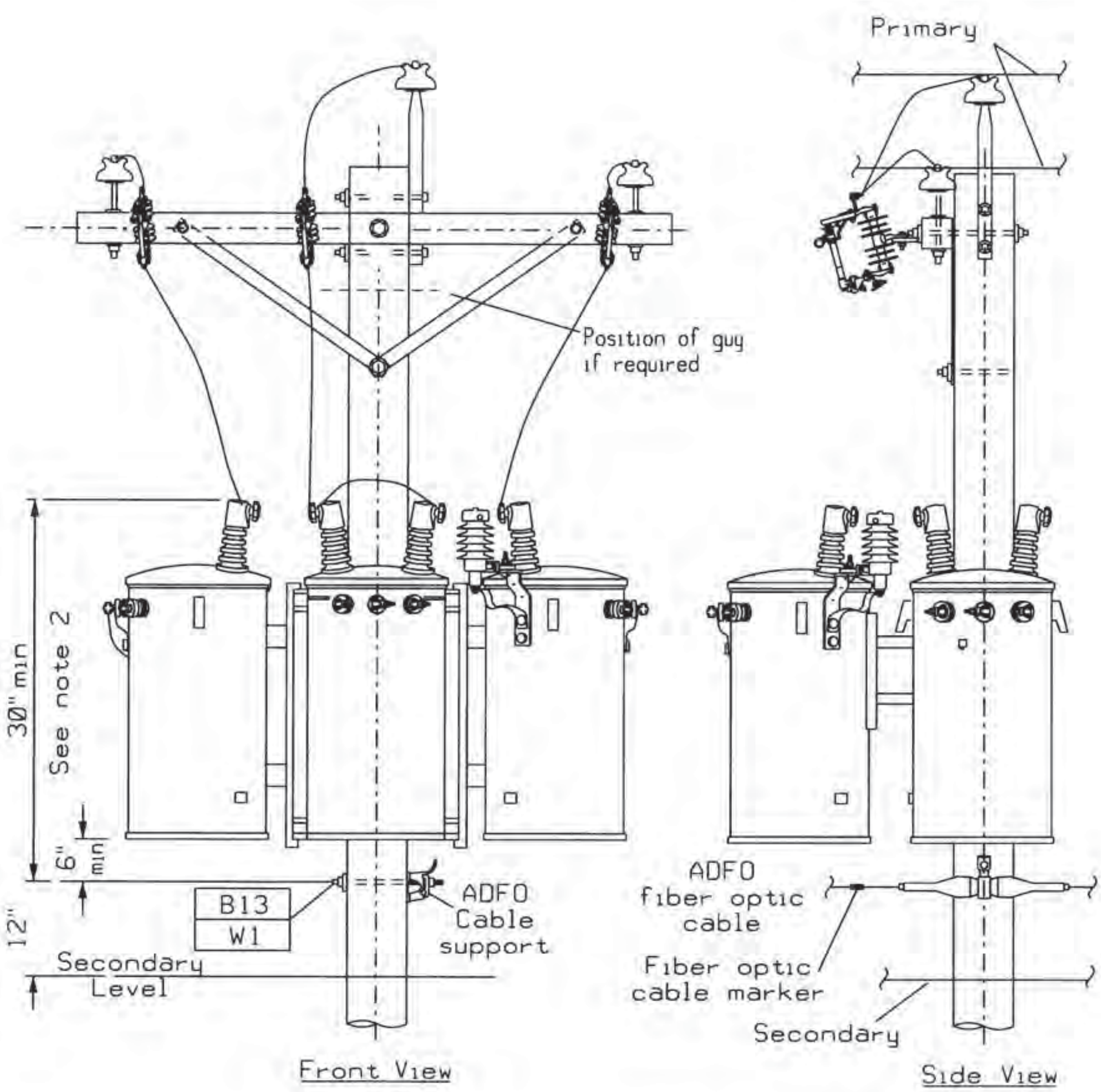
1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 30 degrees.
3. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.





Notes:

1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 30 degrees.
3. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.

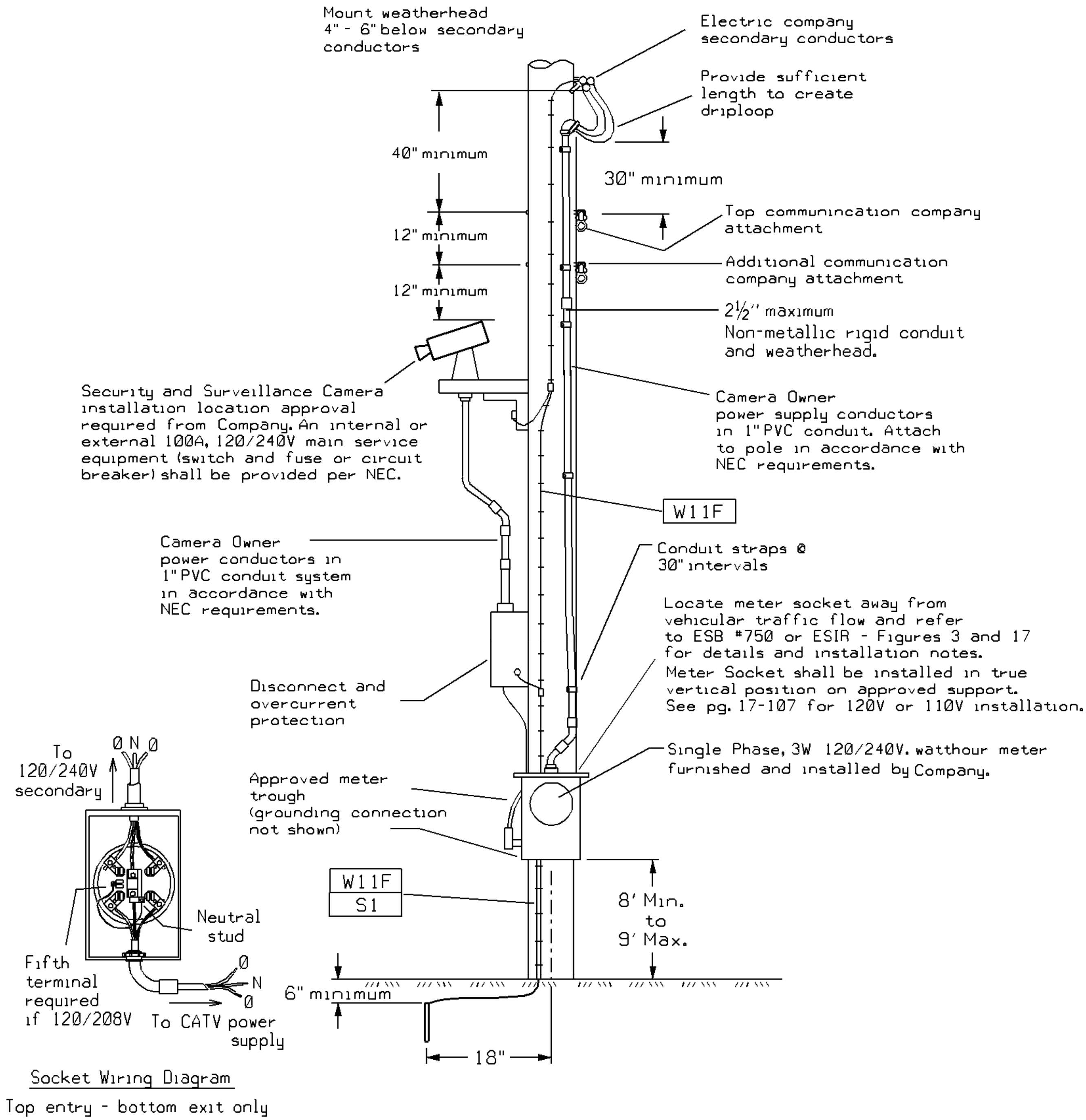


Notes:

1. Distance between primary wire and ADFO cable shall be a minimum of 30 inches in any direction.
2. Maximum line angle for ADFO = 20 degrees.
3. ADFO communication cables may be installed in the supply space of distribution poles only by attachers having an agreement allowing such attachments made prior to January 1, 2010.

THREE PHASE TANGENT WITH TRANSFORMERS AND ALL DIELECTRIC FIBER OPTIC (ADFO) CABLE BETWEEN PRIMARY AND SECONDARY ATTACHMENTS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
1/06	17-117		

New construction drawing.



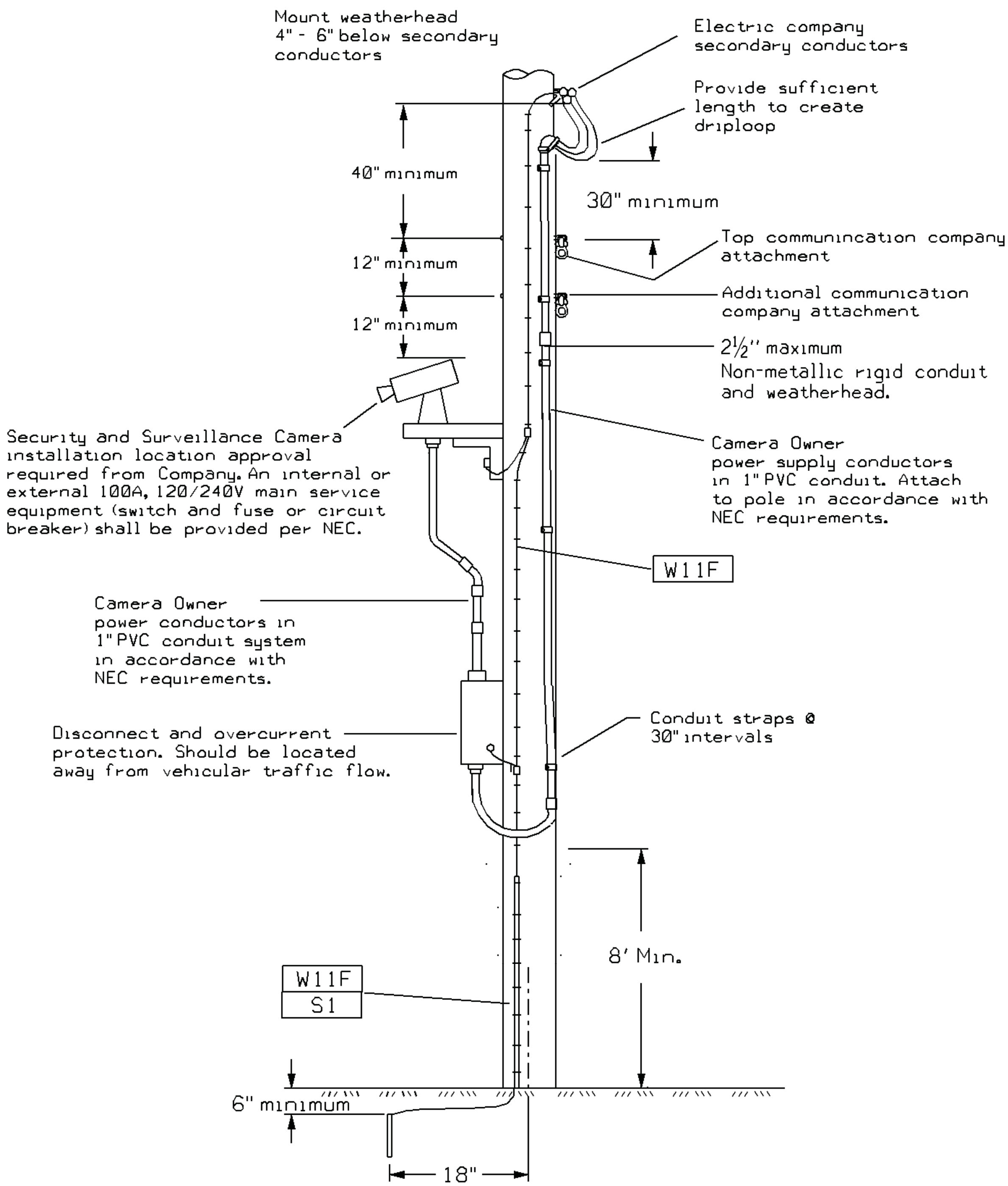
Notes:

1. Camera power supply installations should be avoided on poles with other equipment. Poles shall be accessible by bucket and the proposed installation shall be field reviewed and approved by the Company and any joint pole owners prior to work.

2. Camera owner shall furnish, install own and maintain all material and equipment shown above except as noted. Refer to ESB #750 or electric service information requirements (ESIR) Figure 923 depending on location.

DISTRIBUTION WOOD POLE MOUNTED SECURITY OR SURVEILLANCE CAMERA METERED SERVICE

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	17- 118	7/07



New construction drawing.

Notes:

1. Camera power supply installations should be avoided on poles with other equipment. Poles shall be accessible by bucket and the proposed installation shall be field reviewed and approved by the Company and any joint pole owners prior to work.

2. Camera owner shall furnish, install own and maintain all material and equipment shown above except as noted. Refer to ESB #750 or electric service information requirements (ESIR) Figure 923 depending on location.

DISTRIBUTION WOOD POLE MOUNTED SECURITY OR SURVEILLANCE CAMERA NON-METERED SERVICE			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	17-119		

Version	Date	Modification	Author(s)	Approval by (Name/Title)
3	6/17	• Updated communication antenna installation requirements for poles	Robert Johnson	Robert Johnson
2	7/12	• Added communication messenger spacing requirement in section 17.4.	Paul Anundson	Susan Fleck, VP of Standards, Policies & Codes
1	07/10	• Revised section 17.7.10 and drawings 17-109 through 17-117 to limit supply space communication cables to agreements made prior to January 1, 2020. • Revised drawing on page 17-102 and associated notes on new page 17-103.	Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/11 Issue – Added Section 18.9 & Drawing 18-370; Revised Drawing 18-128.

Supersedes 1/06 Issue – Updated index.

18.0 GENERAL

The following Standard is the practice to be followed when designing and installing single-phase or three-phase risers on the Company's distribution system operating at 35kV and below. This Standard shall apply to primary and secondary single phase or three-phase risers installed by both the Company and/or customers. Further details for primary pole-tops are in Section 9 - Primaries.

All risers shall demonstrate the protective fusing and surge arrester protection as shown on the accompanying construction drawings. Primary dips shall be protected at each end-riser with surge arresters and isolating disconnects. Non-fused disconnects (Std. Item D5) may be used for simple sectionalizing or where over-current protection is better provided elsewhere.

Installations and ownership of customer service laterals and risers generally are the responsibility of the customer and shall be in compliance with Company requirements.

18.1 TERMINATIONS

Exposed cable ends shall never be left unsealed. High voltage applications (above 600V) are provided with terminating kits designed to seal the cable end, increase surface leakage current distance (by use of weathershed skirts), and provide electrical stress relief. Dielectric stress introduced by abrupt separation of the ground-potential shield from the outside of the cable could lead to early failure of the termination.
Low voltage or secondary cables (600V or less) can be sealed while energized with cold-shrink-end caps (Std. Item UC90).

Any de-energized cable, whether it is still on the reel in the yard or recently installed and awaiting terminations, shall have cold-shrink end caps applied to all exposed cable ends. Tape wraps are not adequate for sealing out moisture.

Final termination assembly should be kept relatively straight and as vertical as practical. Rain shield skirts should never be oriented more than 45 degrees from a vertical orientation. The cable should first be trained into final position before application of the termination kit to minimize subsequent bending stress on the termination/connector assembly. All cables shall be tagged.

Terminations for #2 underground cables shall consist of a bayonet, or pin, style compression connection where bolted vise connectors are utilized to secure arrester and tap leads located within the appropriate animal guard (refer to Page 18-104 for details).

Terminations for underground cables larger than #2 shall utilize NEMA pad style compression connections where arrester and tap leads are secured using the appropriate size primary connection as outlined in Section 5 - Connectors (refer to Page 18-107 for details).

Refer to Page 18-104 for termination and concentric neutral connection and wiring detail for #2 underground riser cables and Page 18-107 for underground riser cables that are larger than #2. Further termination detail can be found in Section 37 - Terminations in the Underground Construction Standards manual.

18.2 CABLES

The following cables are standard for all normal in-conduit or direct burial 15-35 kV underground circuits. Detailed descriptions of these and other underground cables are shown in Section 35 - Cables in the Underground Construction Standards manual.

Table 1
Standard Primary Conductors

Voltage (kV)	Conductor	Packaging	Std. Item
15	#2 AL	3-1/C Parallel	UC11BJ
15	#2 CU	1-1/C	UC11BK
15	#2 CU	3-1/C Parallel	UC11BL
15	#4/0 CU	3-1/C Parallel	UC11E
15	350 CU	3-1/C Parallel	UC12F
15	500 AL	3-1/C Parallel	UC12GG
15	500 CU	3-1/C Parallel	UC17
15	750 AL	3-1/C Parallel	UC12HG
15	1000 AL	3-1/C Parallel	UC12TA
15	1000 AL	1-1/C	UC12TB
15	1000 CU	3-1/C Parallel	UC12TC
25	#1/0 CU	3-1/C Parallel	UC23CJ
25	#4/0 CU	3-1/C Parallel	UC23EC
25	350 AL	3-1/C Parallel	UC23FA
25	350 CU	3-1/C Parallel	UC23FJ
25	500 AL	3-1/C Parallel	UC23GA
25	500 CU	3-1/C Parallel	UC23GJ
25	1000 CU	3-1/C Parallel	UC23TC
25	1000 AL	3-1/C Parallel	UC23TA
35	#1/0 AL	1-1/C	UC35C1
35	#1/0 AL	3-1/C Parallel	UC35C3
35	#2/0 CU	3-1/C Parallel	UC35DJ
35	500 CU	3-1/C Parallel	UC35GJ
35	750 CU	3-1/C Parallel	UC35HJ
35	1000 CU	3-1/C Parallel	UC35TC
35	1000 AL	3-1/C Parallel	UC35TJ

18.2.10 Cable Ampacity

Allowable ampacity varies widely due to different cable arrangements. Ampacity is affected by the proximity and loading of adjacent circuits, ambient temperatures, etc. Contact Standards Engineering for ampacity ratings of circuits as necessary.

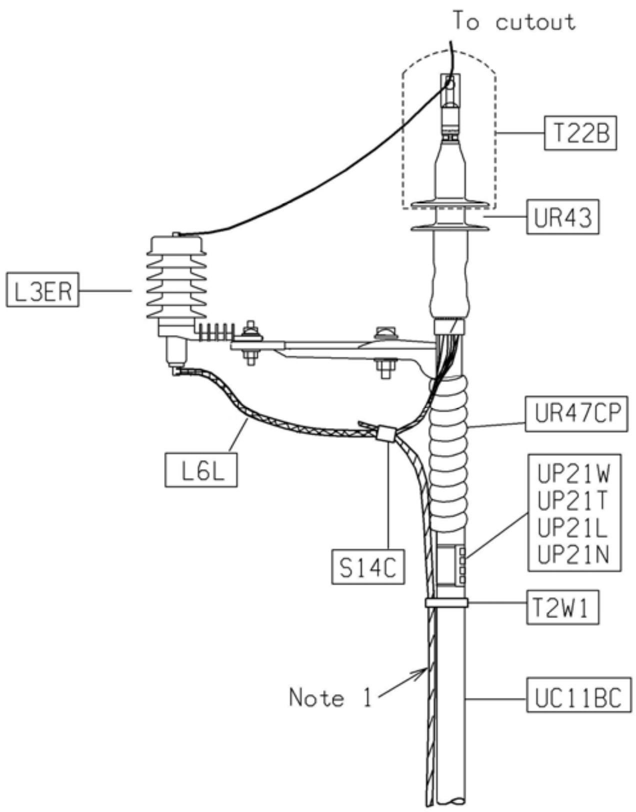
18.2.20 Cable Identification Tags

Primary riser terminations shall be labeled in accordance with Section 35.16.10 (Terminations). Secondary riser terminations shall be labeled in accordance with Section 35.16.20.

Supersedes 7/09 Issue - Added termination labeling requirement (Section 18.2.20).

18.3 ARRESTERS

Arresters at locations other than the cable termination point do not adequately protect the cable. One significant variable under user control is total connection lead length. This is comprised of the line lead length and the ground lead length. Line lead length is the distance from the phase conductor tap to the line terminal of the arrester. The ground lead length is the distance that the surge current flows from the arrester ground to the common ground/neutral connection with the cable metallic shield. By keeping the total connection lead length as short as possible, the total impressed transient voltage developed by the arrester installation is minimized. A minimum margin of protection greater than or equal to 20% is required for sufficient protection. Additionally, riser type surge arresters denoted with a yellow band are required for all riser pole applications.



Note1: Continue to system neutral and driven ground rod.

Caution: *This is a current carrying portion of the cable; make all connections prior to energizing.*

Figure 1 - Grounding for riser arresters.

18.4 ANIMAL GUARDS

Animal guards shall be installed on all riser pole terminators to protect terminations from incidental flashover. The guard shall be placed over the top skirt of the termination.

Supersedes 7/09 Issue - Minor editorial change.

18.5 RISER GUARDS

Vertical electrical supply conductors on riser poles shall be protected by a covering that gives suitable mechanical protection to a minimum of 4 inches above secondary cables for primary risers, and a minimum of 40 inches above communication cables for a secondary riser. For primary risers, the first 8 feet above ground shall be galvanized steel. The remainder shall be either u-duct or Schedule 40 PVC conduit. For secondary risers, Schedule 80 PVC conduit may be used as an alternate for the first 8 feet above ground. The remaining cable covering shall be either u-duct or Schedule 40 PVC conduit.

Risers should be located on the pole in the safest available position with respect to climbing space and exposure to traffic damage (NESC Rule 362-A).

To prevent induction heating, all 3 cables of a three-phase circuit shall be installed in a single galvanized steel conduit. Where a galvanized steel conduit is used, it shall be bonded to the down ground as shown in Figure 2. This connection shall be made utilizing a compression connector. All spare galvanized steel riser pipes shall be bonded in the same manner.

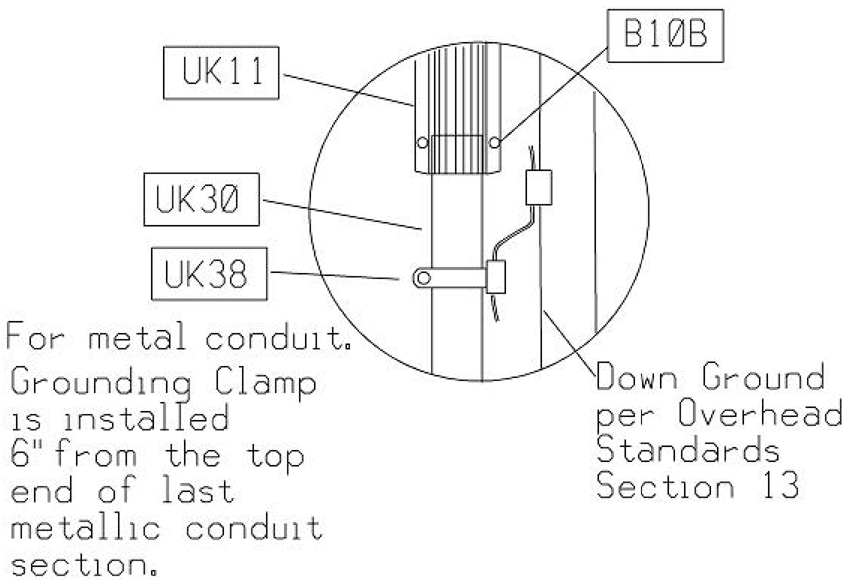


Figure 2 - Grounding detail for galvanized steel riser conduit.

Drawing 18-112 displays an alternate riser construction using conduit standoff brackets. This construction can be used where the riser will not interfere with pedestrian or vehicular traffic. Using conduit standoff brackets allows for easier pole climbing and easier pole replacement. U-guard (Std. Item UK11) shall be used at riser locations above the specified 8 foot minimum section of conduit to the point of secondary/neutral bracket installation where conduit (schedule 80 PVC or galvanized steel) is not used to cover the riser cables to the point of secondary/neutral bracket installation.

Supersedes 7/09 Issue - corrected requirements for covering riser cables in the neutral space; other editorial changes.

Supersedes 7/09 Issue - Added clarification on which foam to use for riser conduit sealing.

18.6 CONDUIT SEALING

All conduits used for risers and all spare riser pipes shall be sealed to prevent water from entering the conduit. Use Std. Item UF10 to seal all riser conduits at the top of the last piece of conduit used. This UV-resistant expanding foam can be applied in temperatures ranging from 41˚F to 95˚F and can withstand temperatures as low as -22˚F and as high as 176˚F after it has cured. The foam should be stored in a warm environment before applying as the foam tends to become clogged in the nozzle if kept in cooler storage areas. **Do not** use Std Item UF20 to seal riser conduits. UF20 is for fire sealing conduits in manholes and does not contain a UV inhibitor.

18.7 RISER ACCESSIBILITY

When constructing risers in backyards or other locations where the riser is not accessible by bucket truck, the riser shall be built so that it is easily climbable. Use of conduit standoff brackets (see Drawing 18-112 for details) are strongly recommended in these situations.

18.8 RAISING TERMINATIONS ON A POLE

This may be done to accommodate new attachments on a pole, to increase ground clearance of lines or when relocating a pole. This work may include replacing a pole with a taller pole or rearranging facilities on an existing pole.

18.8.10 Primary Cable in Conduit

Single phase and three phase #2 cable can be spliced on the pole. Splices must be located above the 8' galvanized steel conduit and shall be staggered if 3 phases are being spliced such that all of the splices are completely covered by the riser guard (u-duct). If the riser is located at the bottom of a hill where water in the conduit is an issue, install a pull box at the base of the riser to allow water to drain (see alternate detail on most riser construction drawings).

For cables larger than #2, the cable shall be replaced from the first existing access point away from the pole (padmounted switchgear, handhole/manhole, pull box, etc.).

18.8.20 Direct Buried Primary Cable (Non-Company Standard)

When the primary underground cable away from the pole is direct buried, replacing the cable from the pole to an existing access point requires excavation. A galvanized steel sweep and riser pipe are required for all risers; install these items when relocating terminations on the pole if they were not previously installed. To minimize the required excavation either:

A. Direct bury the splices:
Splice the new cables to the existing cables near the base of the pole beyond the underground end of the riser sweep pipe, or

B. Install a new handhole or pull box:
Install a new handhole or pull box at the underground end of the riser sweep pipe near the base of the pole along the route of the existing cable and splice the new cables to the existing cables at the handhole or pull box. Install new riser and terminations at the new primary level on the pole. Refer to Standards Section 33.0.10 to select the appropriate handhole or pull box for the location, voltage, and cable size.

18.8.30 Secondary Risers

Secondary cables may be spliced on the pole to allow secondary riser connections to be raised on a pole. Splice the new cable to the existing cable using underground splices. Stagger the individual splices on the pole so they will fit under the u-guard. Install the splices below communication wires and at least 8 feet above ground. Install new connections at the new secondary level on the pole.

18.8.40 Cost Allocation

Refer to the applicable Company tariff for cost assignment(s) for the work to be performed.

If there are no tariff restrictions, the Company will perform this work and either: (i) the Company is responsible for the costs of the work or (ii) the Customer is responsible for the costs of the work, or (iii) the costs of the work may be paid by a third party as part of a reimbursable project (e.g. reimbursable highway project, third party attachment make-ready, etc.).

18.9 RISERS IN SUBSTATIONS

In general, design of substation facilities is the responsibility of the substation engineering group. However, the installation of cable risers inside substations shall comply with the requirements of Underground Distribution Standards with regards to cable terminations, lightning protection, grounding and cable support.

Refer to drawings 48-370 and 48-371.

18.9.10 Terminations

All terminations are to be cold shrink type, standard item UR44_ or UR45_. Lugs shall be standard item UL15_ for copper conductor and standard item UL16_ for aluminum. Do not substitute other lugs as these may not be sealed to prevent water intrusion into the conductor strands. Install an animal guard, standard item T22B on the termination. For additional information, see Section 37 of the Underground Construction Standards.

18.9.20 Lightning Arresters

A riser class lightning arrester, standard item UL3_, shall be mounted immediately adjacent to each cable termination. Install a flex ground lead, standard item L6 or L6L, from the ground terminal to station ground bus. Use #2 soft drawn, covered lead wire, standard item W13E to connect the arrester to the phase. Both the phase lead and the ground lead should be as short as possible for the best cable insulation protection.

18.9.30 Grounding

The concentric neutral from each phase termination is to be connected to the 4/0 copper ground bus. The ground bus should be connected to the below grade ground grid in a minimum of 2 places. For optimal cable insulation protection, connect the concentric neutral and the arrester ground lead to the station ground bus using a single connector, standard item S14J. If the concentric neutral leads need to be extended, see Table 2 in Section 37 of the Underground Construction Standards.

Supersedes 7/09 Issue: Added Section 18.9.

18.9.40 **Cable Support**

Install cable positioners to support the weight of the cable. Install a minimum of 1 positioner a maximum of 2" below the bottom of the termination. Install additional positioners such located so that the maximum distance from grade to the first positioner is less than 10' and the distance between positioners does not exceed 7'. These positioners are necessary to prevent excessive cable movement during fault current events which can put undue stress on the connection points. Do not use the lug to support the weight of the cable.

18.9.50 **Riser Conduit**

Install a fairleader, standard item UK49B, to protect the cable from damage due to contact with the edge of the conduit. Fill the space between the fairleader and the cable with expanding foam, standard item UF10. For metallic riser conduit, install a grounding clamp, standard item UK38_ and connect it to the station ground grid with 4/0 copper wire, standard item W19G.

18.9.60 **Bus Supports**

The maximum distance between the terminal lug on the top of the terminator and the first support for the station bus is 5'. This maximum distance is required to prevent undue forces from being imposed on the terminal lug / cable during high current faults. If the distance to the first bus support exceeds 5', install additional supports as needed.

18.9.70 **Minimum Approach Distance**

The first disconnecting means above the cable termination must be sufficiently far from the termination to allow connection / disconnection of the termination without violating the minimum approach distance as stated in the Safety Manual. This clearance will also be required to cable testing and maintenance. To determine the appropriate distance, add 3'6" to the minimum approach distance as stated in the safety manual for the circuit voltage.

7/12 New Page

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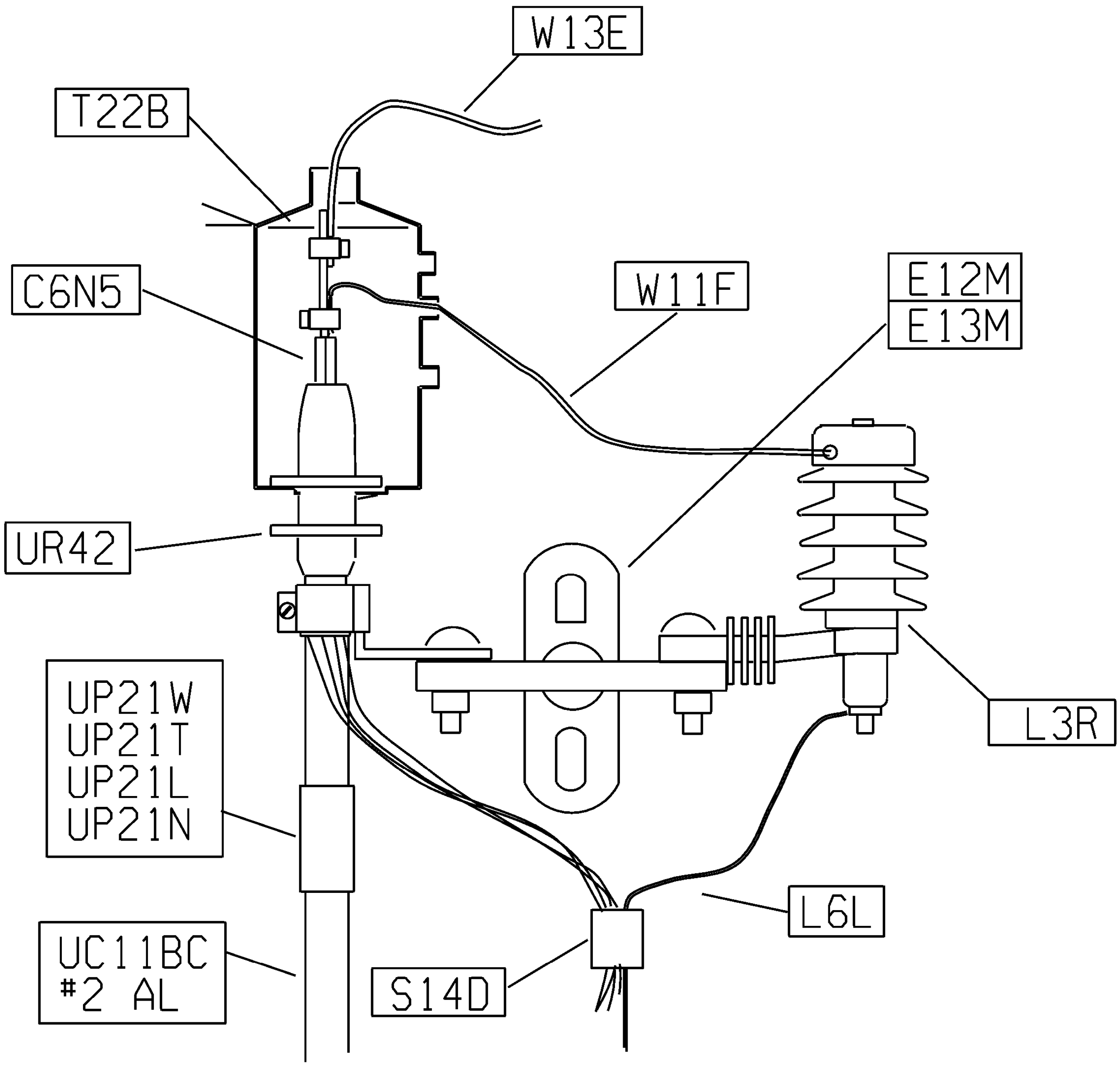
CU = CCSCT15K2R	Cold Shrink Cable Termination 15kV #2AL 1PH Riser
CU = PE12M	Equipment Mount Fiberglass 3PH
CU = PE13M	Equipment Mount Fiberglass 1PH
CU = CAL(X)KRPNE	Arrester Lightning (X)kV UG Riser MOV (X) = Voltage Rating

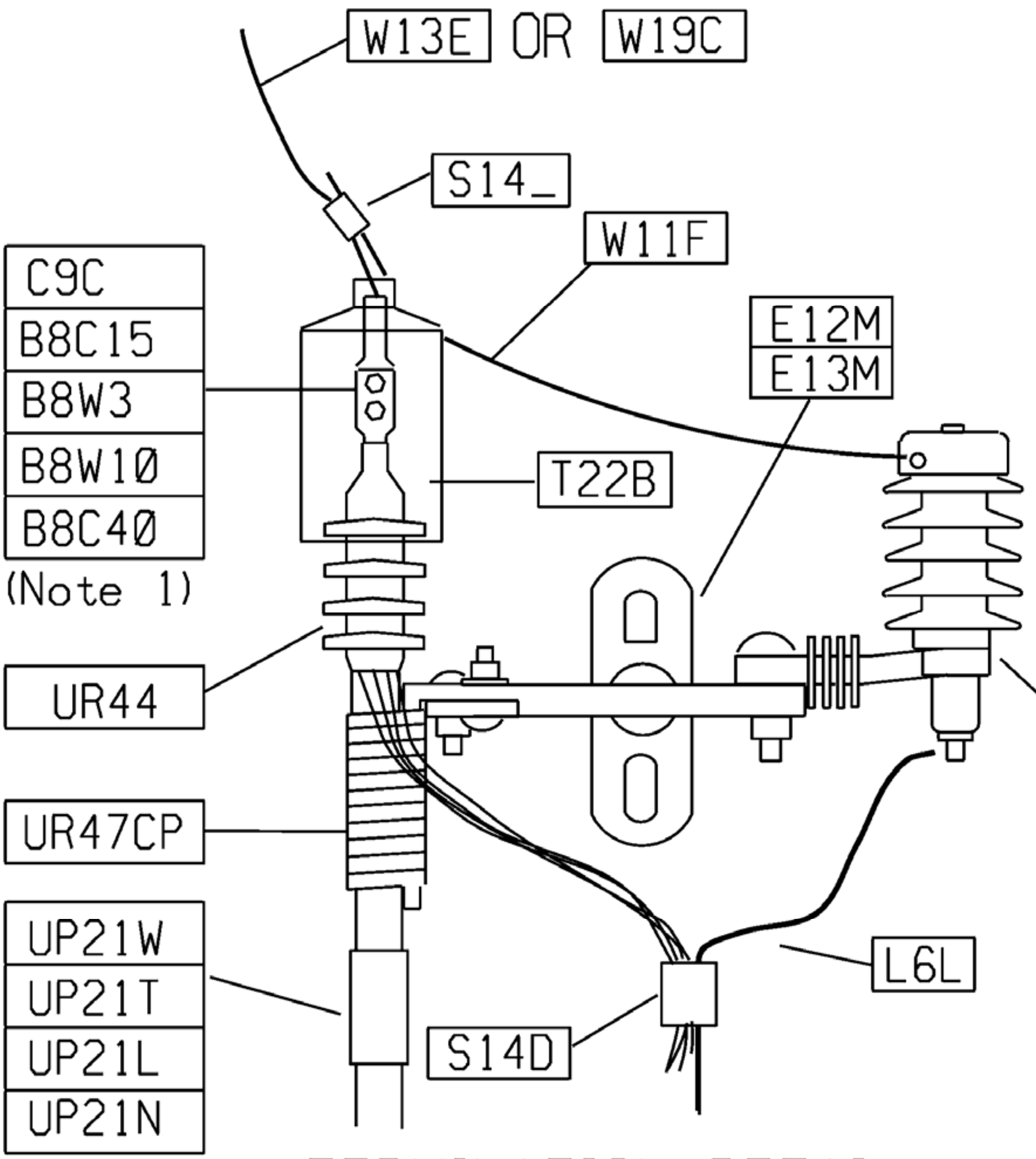
Supersedes 7/09 Issue - Corrected placement of animal guard on termination; corrected tap wire Std Item #.



TERMINATION DETAIL

Note: For #2 UG cable connections only. Larger UG cables shall utilize NEMA pad style compression connectors as outlined Section 18.1/ 48.1 Terminations (Refer to Page 18-107 for detail).

CU = CCSCT(X)K(Y)R	Cold Shrink Cable Termination (X)kV (Y) Riser, (X) =Voltage Rating, (Y) = Cable Size
CU = CCSCT35K1/0ARNE	Cold Shrink Cable Termination 35kV 1/0AL Riser 1Ph
CU = PE12M	Equipment Mount Fiberglass 3PH
CU = PE13M	Equipment Mount Fiberglass 1PH
CU = CAL(X)KRPNE	Arrester Lightning (X)kV UG Riser MOV (X) = Voltage Rating

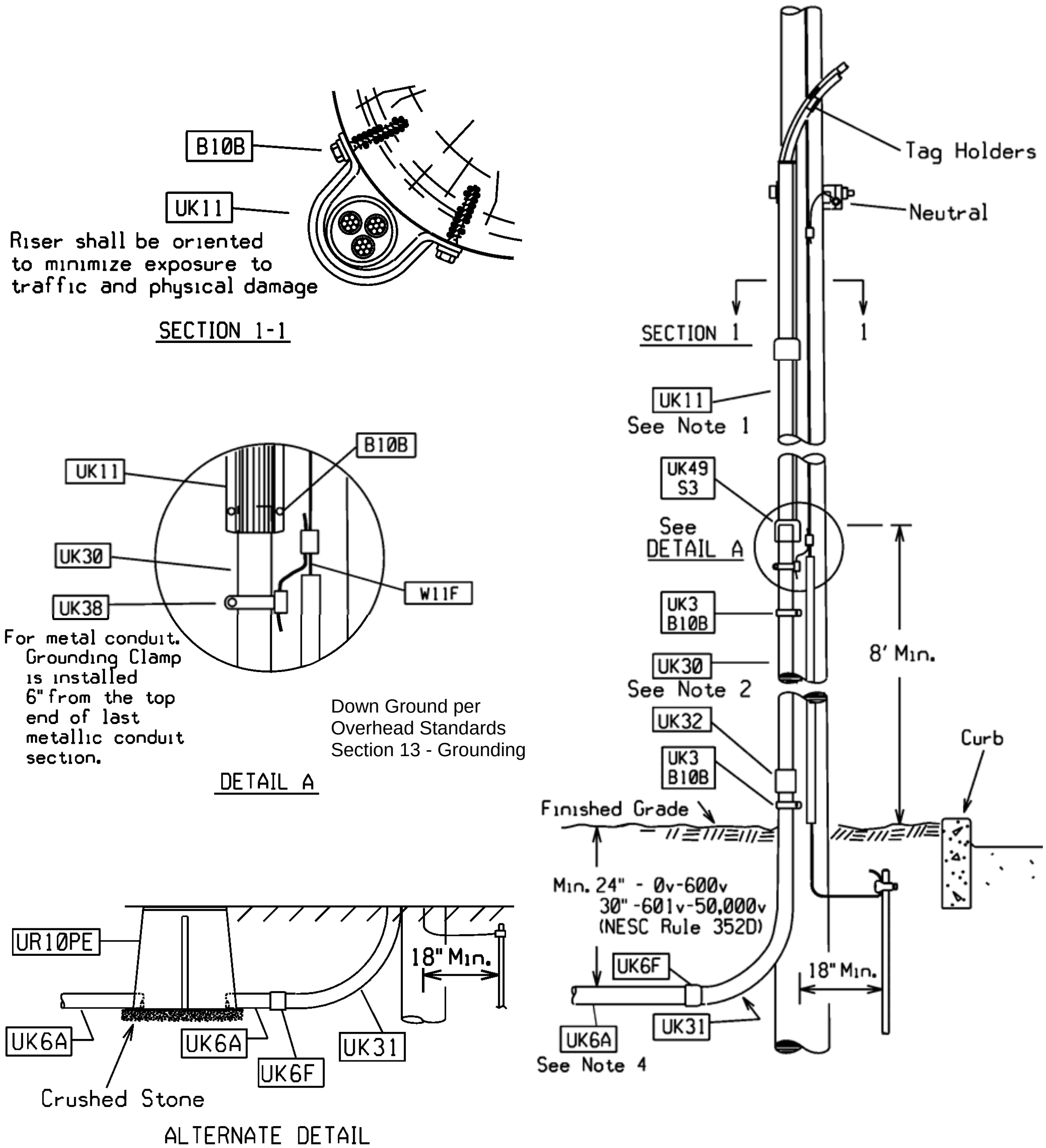


TERMINATION DETAIL

Supersedes 7/09 Issue - Corrected tap wire Std Item #.

Note: Refer to Drawing 5-148 for terminal connector installation notes.

CU = SER-UG-OH,(X)PH-SEC,(Y)A	Service UG to OH, (X) Phase, to Sec, (Y) Amp, (X) = 1 or 3, (Y) = 200, 400
CU = SER-UG-OH,(X)PH-TRANS,(Y)A	Service UG to OH, (X) Phase, to Transformer, (Y) Amp, (X) = 1 or 3, (Y) = 200, 400, 800

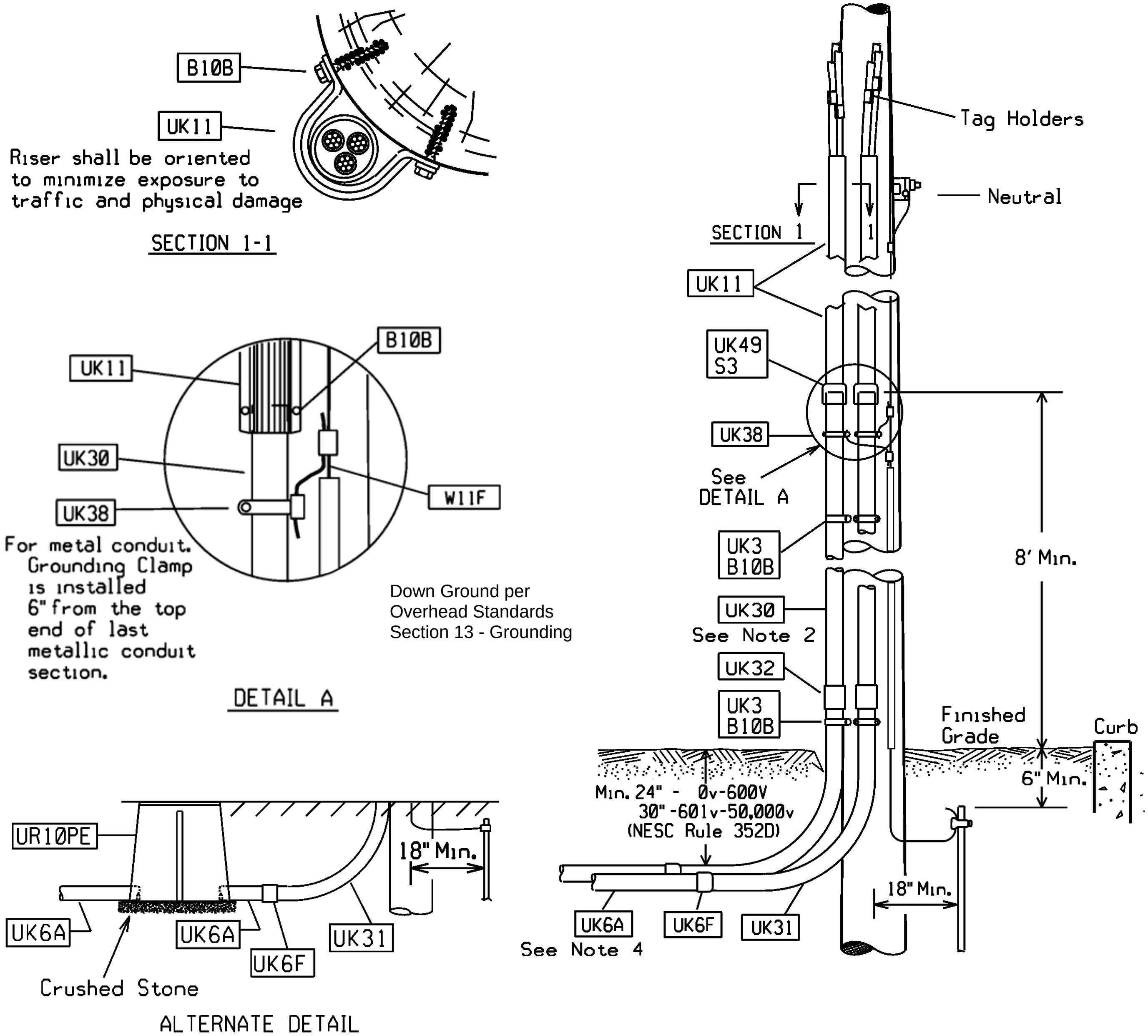


Supersedes 7/11 Issue – Replaced Item UR10PE with UR10F.

Notes:

1. Install riser guard sections bell-end down.
2. The service lateral cable, conduit, ground clamp and short section of grounding conductor shall be furnished by the customer. Liberty Utilities will install ground rod and complete bonding requirements.
3. If the ends of the customer owned service lateral cables are without suitable moisture preventing seals, (e.g. rubber caps or taped) DO NOT ATTACH. Notify supervisor immediately.
4. Omit conduit on direct buried installations and install a leader guard (Std. Item UK49) in place of the conduit adapter (Std. Item UK6F).
5. To prevent induction heating of the metallic conduit do not separate the phase conductors of a three-phase circuit into separate conduits.
6. On poles not accessible by bucket truck, “The number, size, and location of riser ducts or guards shall be limited to allow adequate access for climbing”, (NESC Rule 362B).

SEE PAGE 18-109 FOR CUS



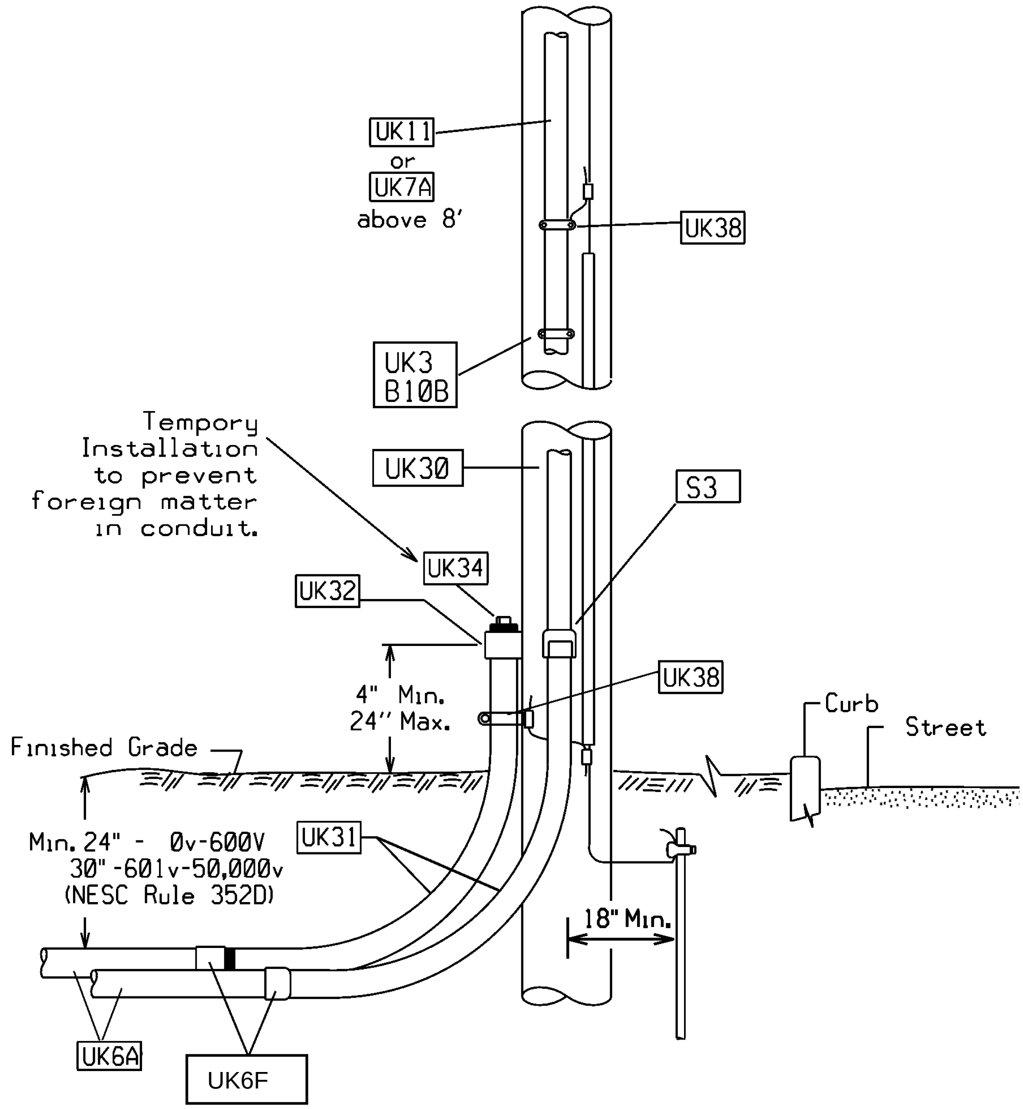
Supersedes 7/11 Issue – Replaced Item UR10PE with UR10F.

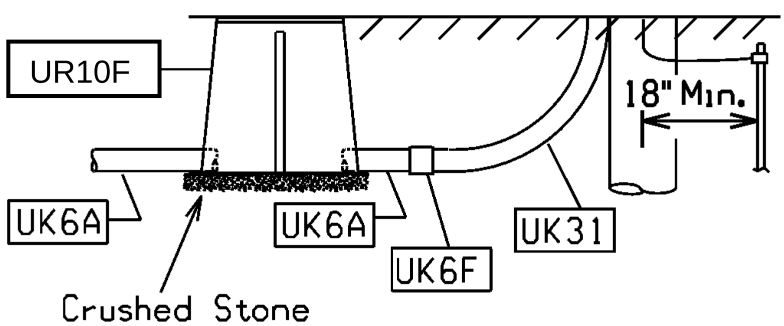
Notes:

1. On poles not accessible by bucket truck, "The number, size, and location of riser ducts or guards shall be limited to allow adequate access for climbing", (NESC Rule 362B).
2. The service lateral cable, conduit, ground clamp and short section of grounding conductor shall be furnished by the customer. Liberty Utilities will install ground rod and complete bonding requirements.
3. If the ends of the customer owned service lateral cables are without suitable moisture preventing seals, (e.g. rubber caps or taped) DO NOT ATTACH. Notify supervisor immediately.
4. Omit conduit on direct buried installations and install a leader guard (Std. Item UK49) in place of the conduit adapter (Std. Item UK6F).
5. To prevent induction heating of the metallic conduit do not separate the phase conductors of a three phase circuit into separate conduits.
6. May put risers of different VOLTAGES on the same pole

CU = SER-UG-OH,(X)PH-SEC,(Y)A	Service UG to OH, (X) Phase, to Sec, (Y) Amp, (X) = 1 or 3, (Y) = 200, 400
CU = SER-UG-OH,(X)PH-TRANS,(Y)A	Service UG to OH, (X) Phase, to Transformer, (Y) Amp, (X) = 1 or 3, (Y) = 200, 400, 800

Supersedes 7/12 – Replaced UR10PE with UR10PF.

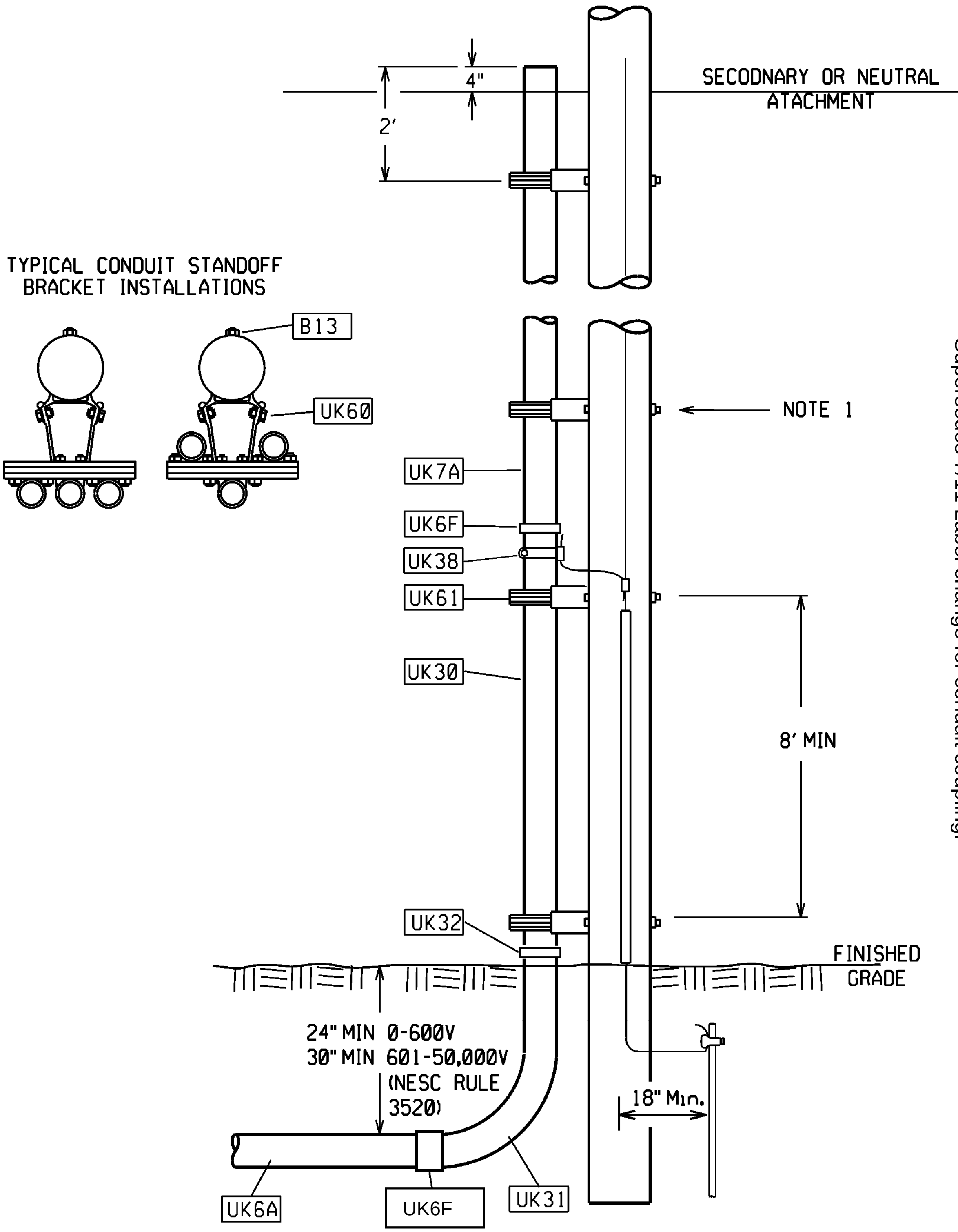




ALTERNATE DETAIL

TYPICAL CONDUIT TERMINATION DETAIL FOR SPARE CONDUIT

CU = RCSBUK60	Riser Conduit Standoff Bracket Pole Mount
CU = RCSK(X)(Y)	Riser Conduit Strap Kits (X) = Std. ID, (Y) = Conduit Size



Supersedes 7/11 Label change for conduit coupling.

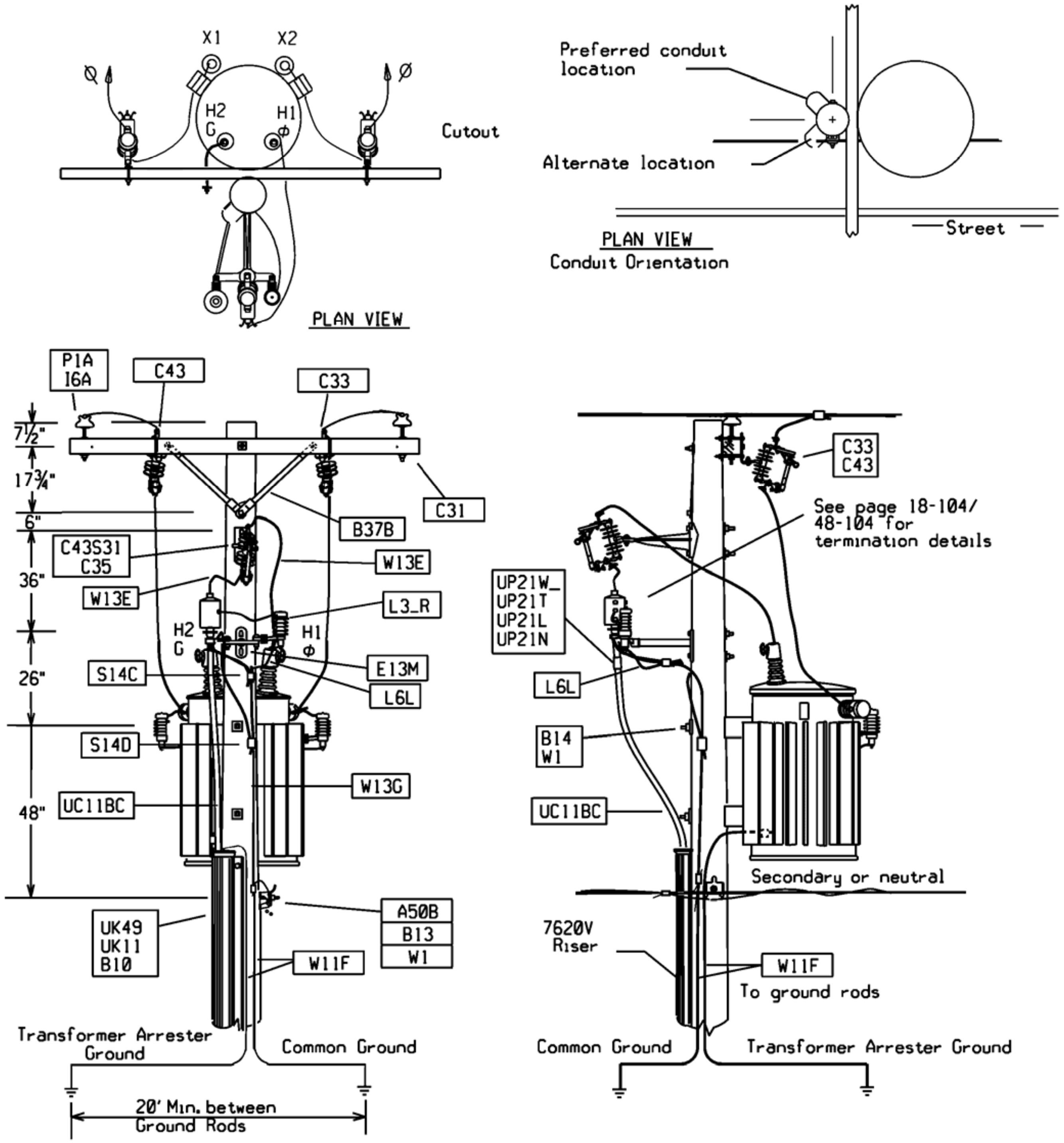
Notes:

1. Install the intermediate standoff bracket equidistant from the upper and lower brackets.
2. Riser pipes shall be bonded to the down ground - see Drawing 18-111/48-111 for details.

RISER INSTALLATION WITH CONDUIT STANDOFF BRACKETS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/12	18-112		

RISER MU = @18-125CC(Y)K(I)(X)	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Riser Guard
RISER MU = @18-125CC(Y)K(I)(X)C	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit
RATIO MU = @(W)K(X)P(Y)S(Z)T1PSU(A)(B)	(W) kVA Size, (X) Pri Code, (Y) Sec Code, (Z) Tap Code, 1 Phase, (A) Source Voltage, (B) Load Voltage

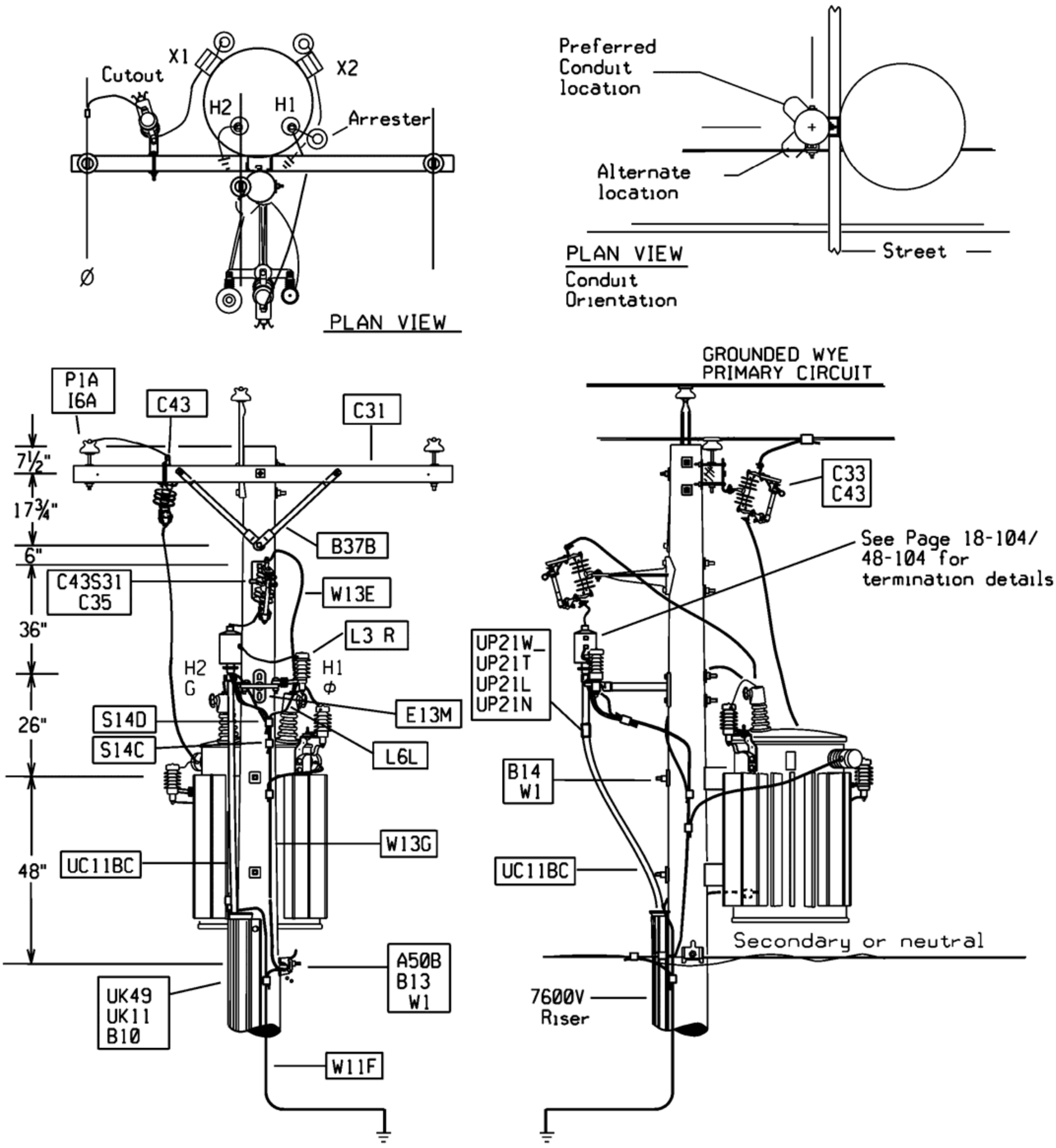
Supersedes 7/09 Issue - Moved transformer cutouts to other side of pole to reduce tap length; corrected animal guard position.



Note:
Remove high-side arresters on transformer (at H1 and if one exists at H2). Connect H2, concentric neutral, and riser arrester lead to the common ground. Connect the low-side arresters on the transformer (at X1 and X2) and the tank ground to the separate transformer ground. DO NOT connect common ground or transformer arrester ground to the secondary/neutral.

SINGLE PHASE STEP-UP 5 kV DELTA X 15 kV WYE TRANSFORMER INSTALLATION AND SINGLE CABLE RISER			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 18-115	ISSUE 7/11

RISER MU = @18-125CC(Y)K(I)(X)	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Riser Guard
RISER MU = @18-125CC(Y)K(I)(X)C	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit
RATIO MU = @(W)K(X)P(Y)S(Z)T1PSU(A)(B)	(W) kVA Size, (X) Pri Code, (Y) Sec Code, (Z) Tap Code, 1 Phase, (A) Source Voltage, (B) Load Voltage

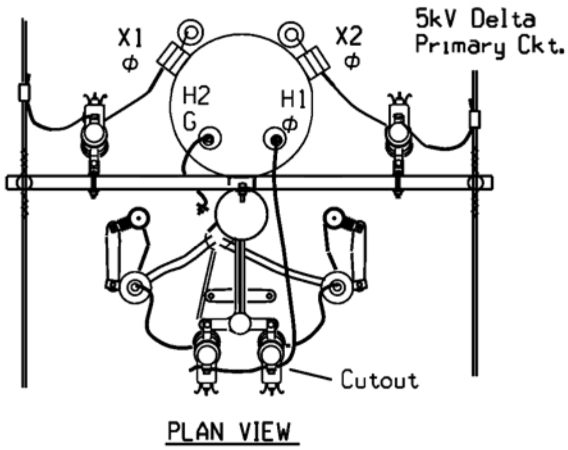


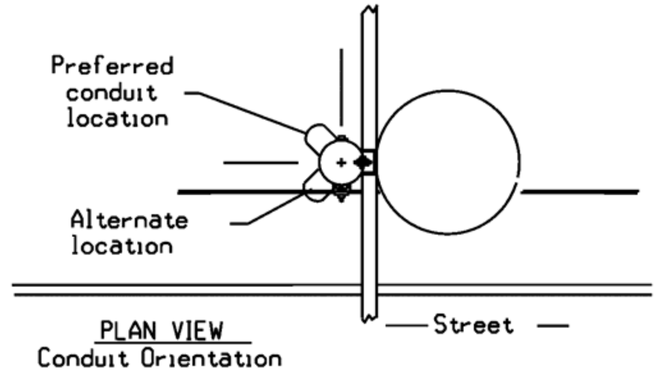
NOTES: Continue concentric neutral to system neutral using a conductor of equivalent size to the UG cable concentric neutral (i.e. #2 or 2/0).

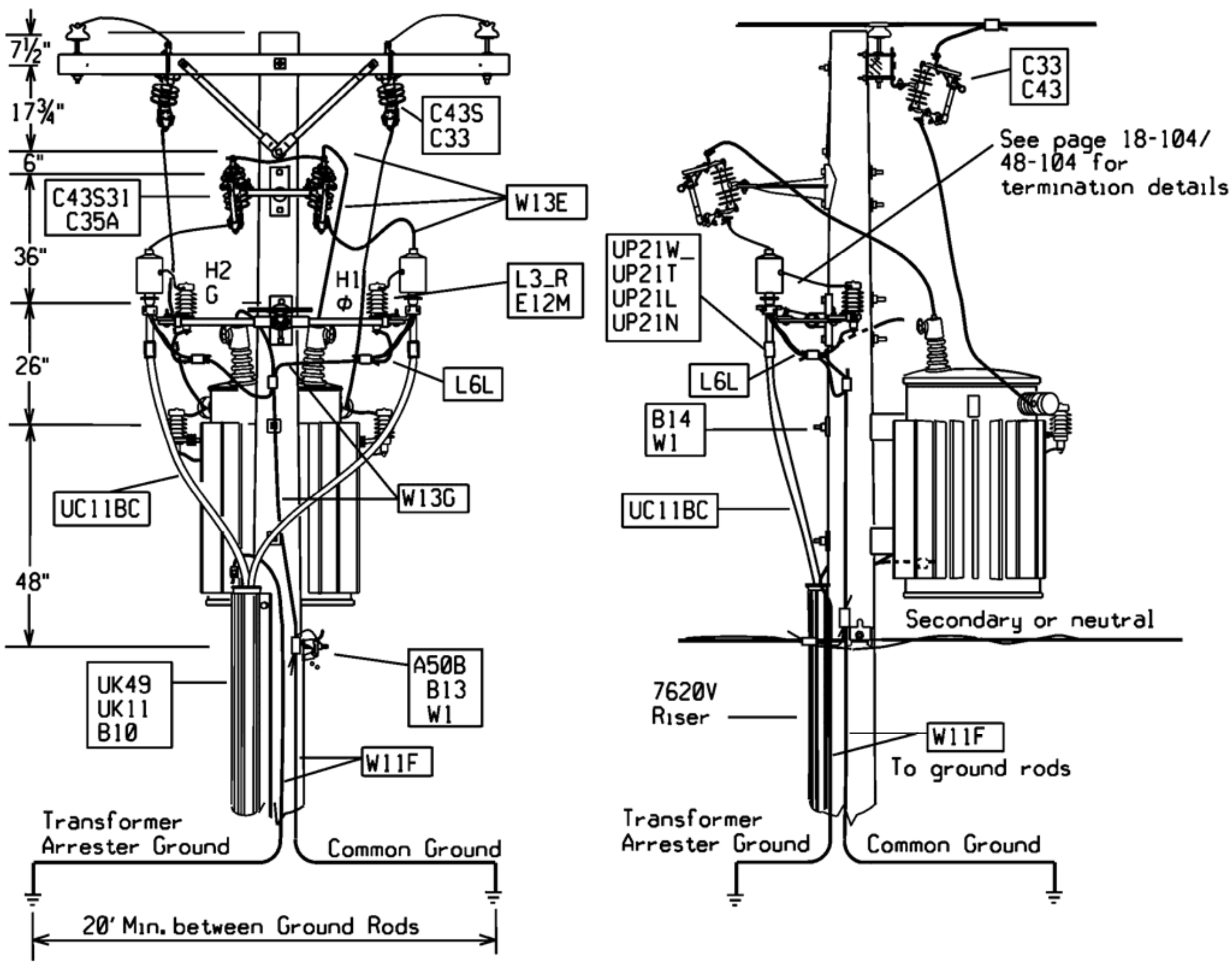
Supersedes 7/09 Issue - Moved transformer cutouts to other side of pole to reduce tap length; corrected animal guard position.

<table>
<tr><td colspan="4">SINGLE PHASE STEP-UP 5 kV WYE X 15 kV WYE
TRANSFORMER INSTALLATION AND CABLE RISER</td></tr>
<tr><td>ISSUE</td><td>PAGE NUMBER</td><td rowspan="2">OVERHEAD
CONSTRUCTION STANDARD</td><td rowspan="2">Liberty Utilities</td></tr>
<tr><td>7/11</td><td>18-116</td></tr>
</table>

Supersedes 7 7/09 Issue - Moved transformer cutouts to other side of pole to reduce tap length; corrected animal guard position.



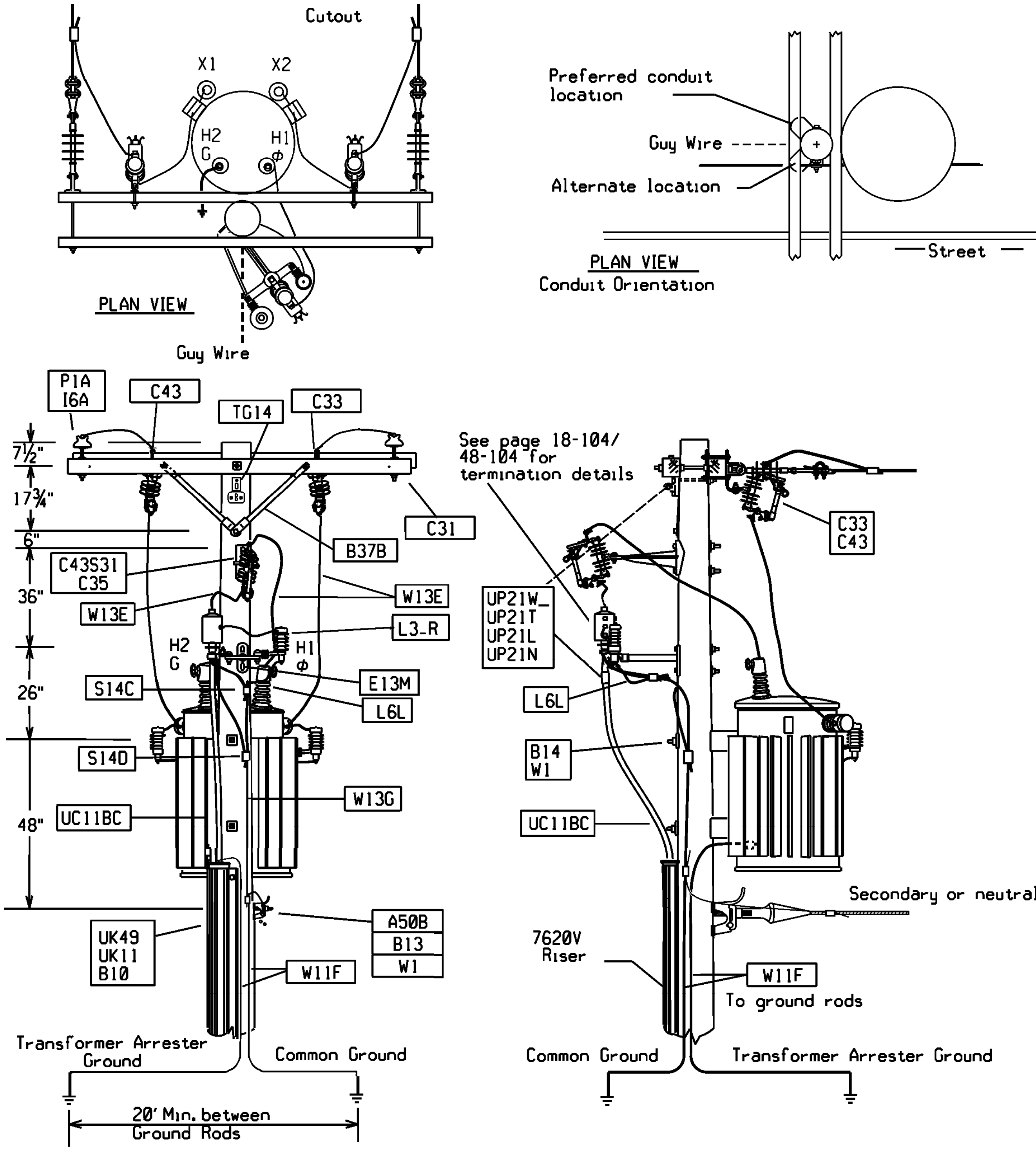




Note:
Remove high-side arresters on transformer (at H1 and if one exists at H2). Connect H2, concentric neutral, and riser arrester lead to the common ground. Connect the low-side arresters on the transformer (at X1 and X2) and the tank ground to the separate transformer ground. DO NOT connect common ground or transformer arrester ground to the secondary/neutral.

SINGLE PHASE 5kV DELTA x 15kV WYE STEP-UP RATIO TRANSFORMER WITH DOUBLE SINGLE PHASE 200A CABLE RISER			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 18-117	ISSUE 7/11

MU = @18-125CC(Y)K(I)(X)	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X)Fuse Type, In Riser Guard
MU = @18-125CC(Y)K(I)(X)C	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit



New drawing.

Note:
Remove high-side arresters on transformer (at H1 and if one exists at H2). Connect H2, concentric neutral, and riser arrester lead to the common ground. Connect the low-side arresters on the transformer (at X1 and X2) and the tank ground to the separate transformer ground. DO NOT connect common ground or transformer arrester ground to the secondary/neutral.

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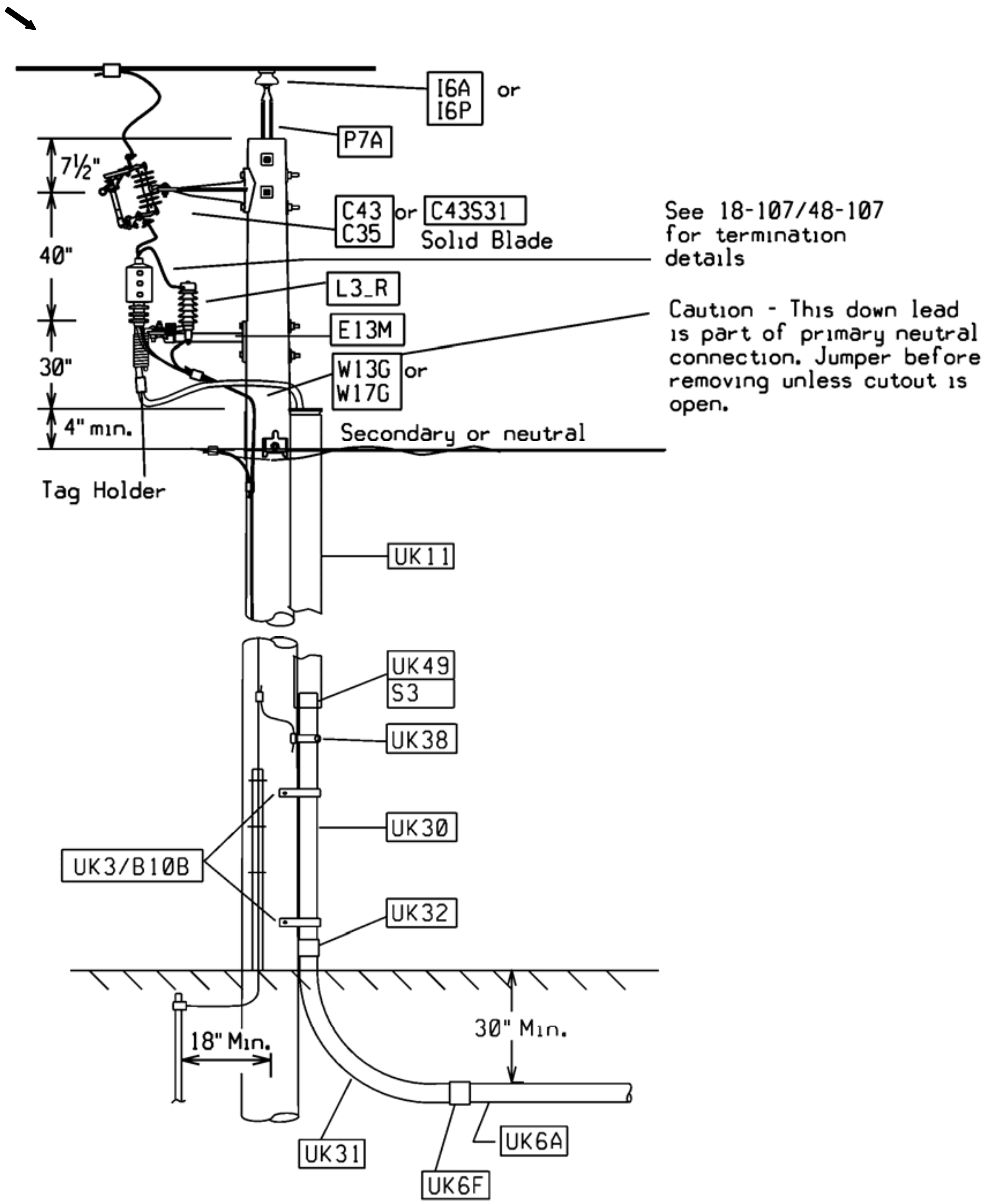
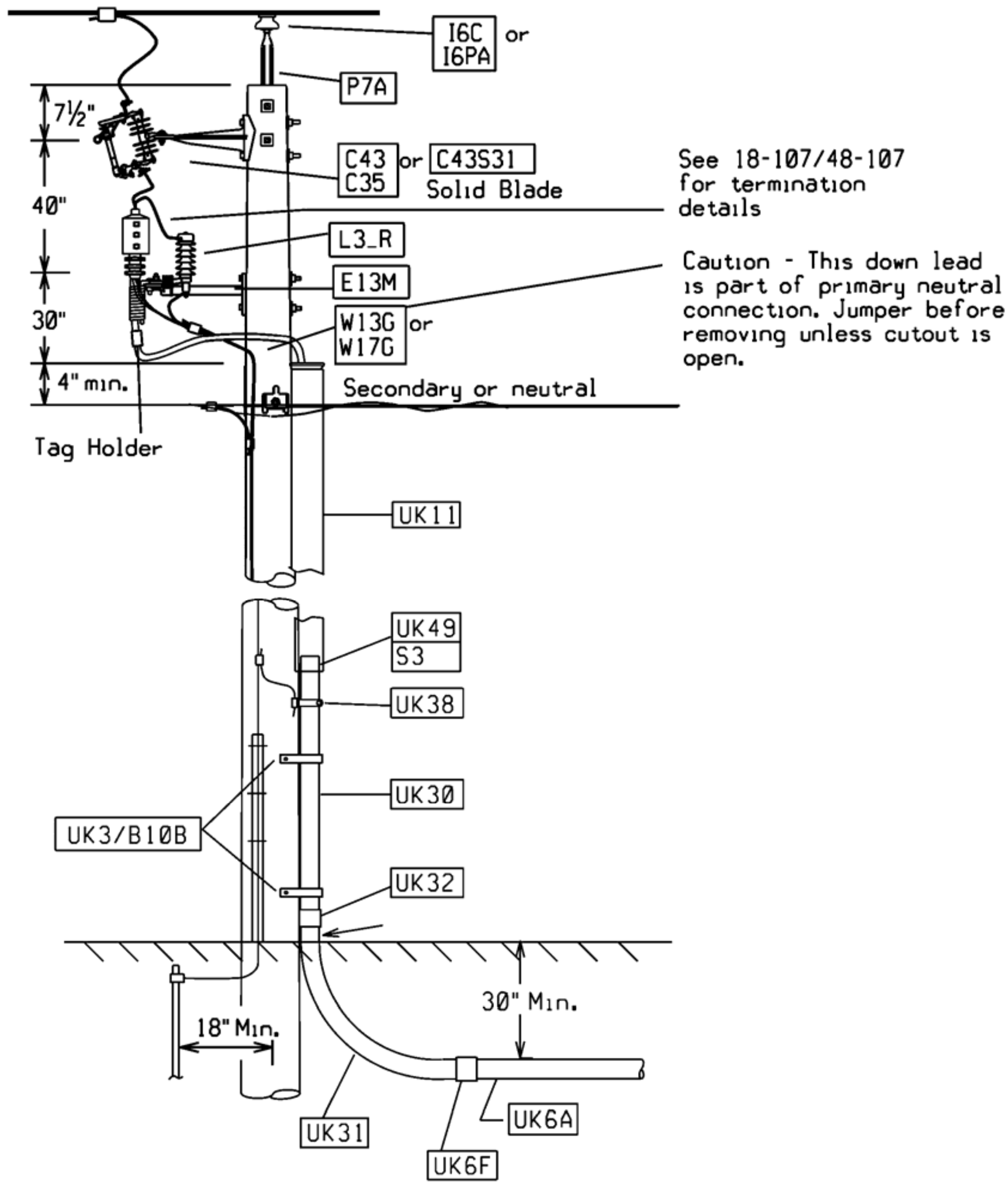
MU = @18-125CC(Y)K(I)(X)	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X)Fuse Type, In Riser Guard
MU = @18-125CC(Y)K(I)(X)C	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit



Supersedes 7/11 Issue – Removed Alternate Detail.

MU = @18-125CC27K(I)(X)	Single Phase Riser, 35kV, (I) Cutout Body Size, (X) Fuse Type, In Riser Guard
MU = @18-125CC27K(I)(X)C	Single Phase Riser, 35kV, (I) Cutout Body Size, (X) Fuse Type, In Conduit

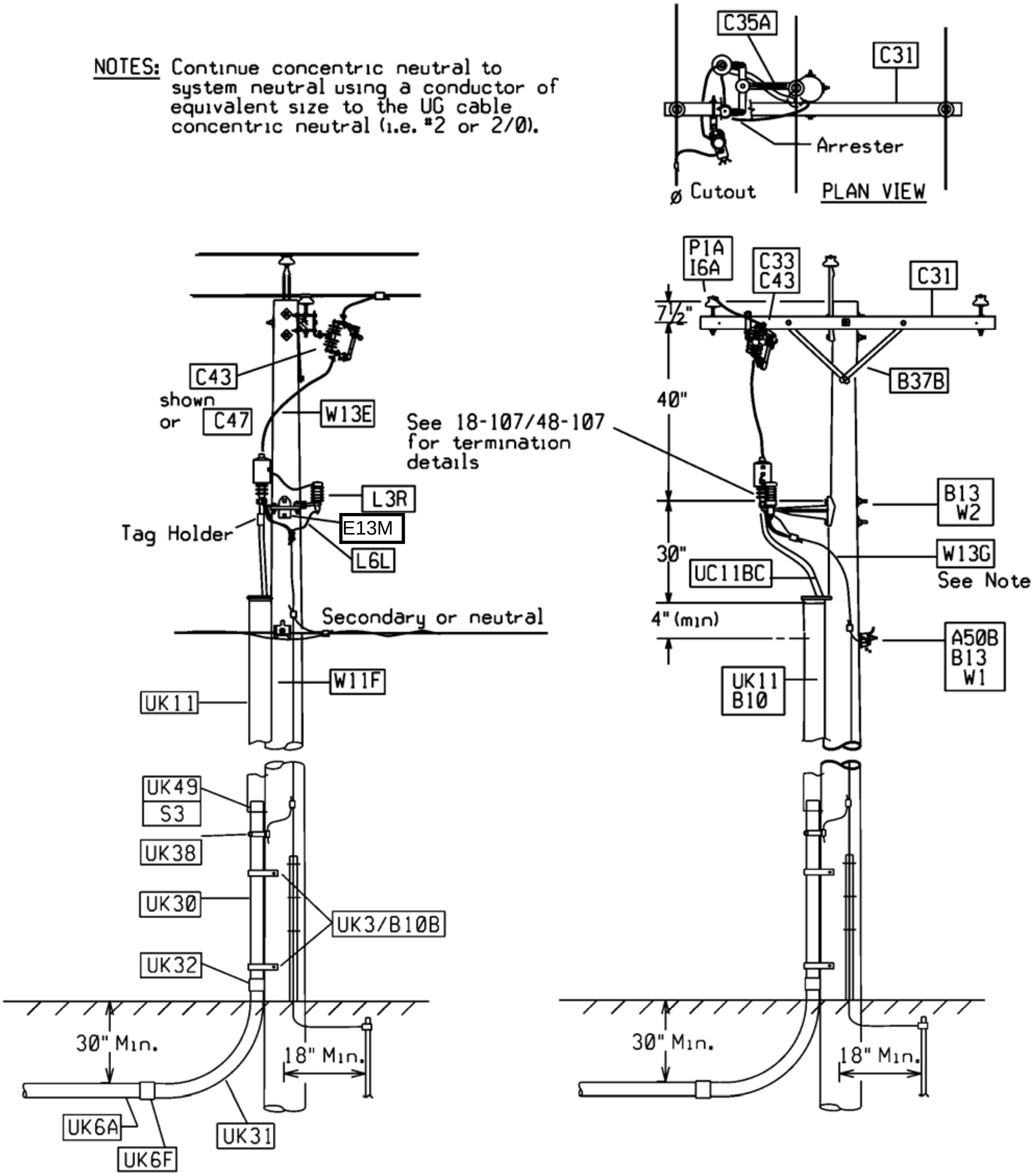


Supersedes 7/11 Issue – Removed Alternate Detail.

SINGLE PHASE OPEN WIRE RISER WITH FUSED CUTOUT - 35KV
MAINTENANCE ONLY

MU = @18-125CC(Y)K(I)(X)	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X)Fuse Type, In Riser Guard
MU = @18-125CC(Y)K(I)(X)C	Single Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit

NOTES: Continue concentric neutral to system neutral using a conductor of equivalent size to the UG cable concentric neutral (i.e. #2 or 2/0).



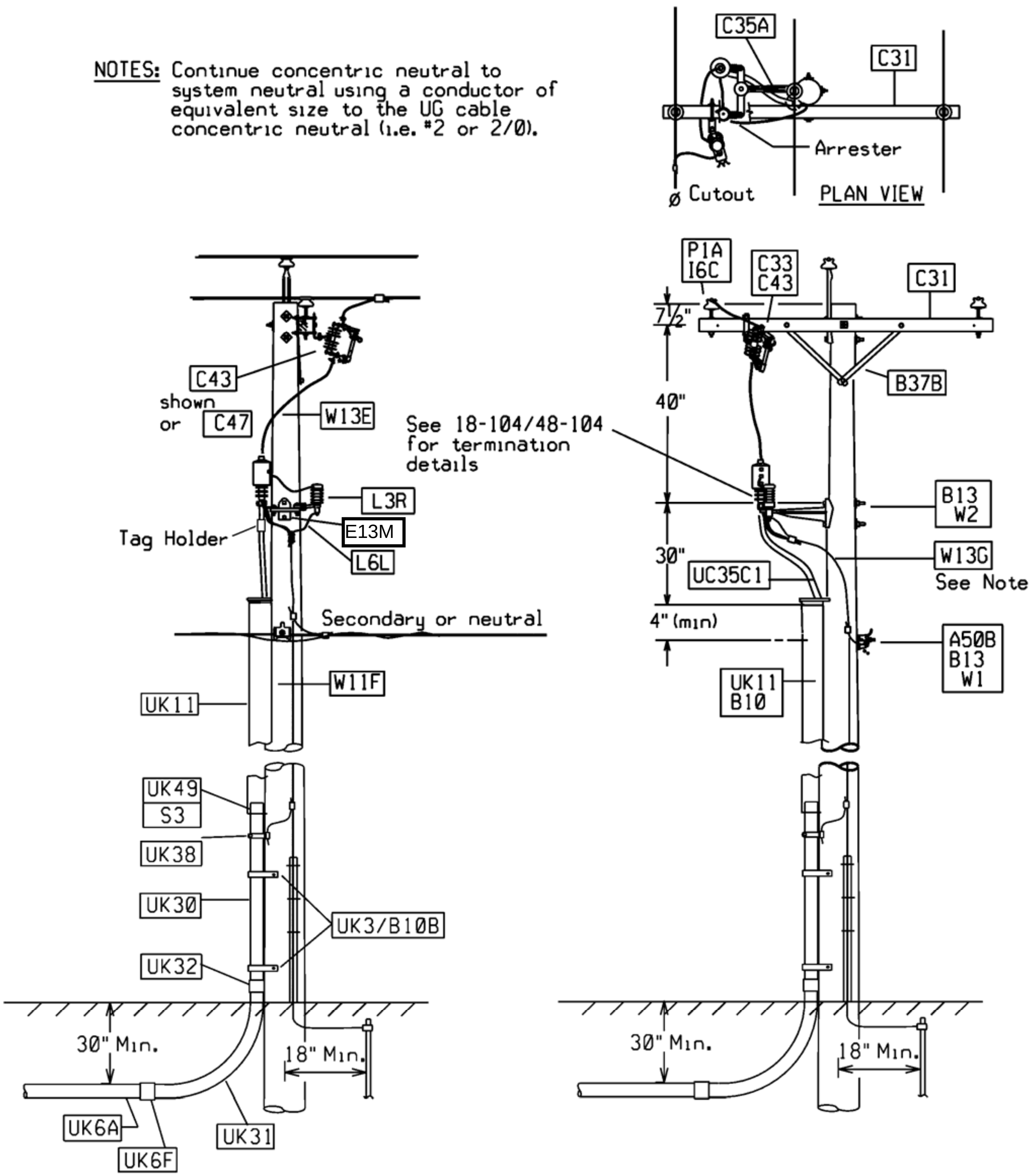
Supersedes 7/11 Issue – Replaced terminator bracket with E13M.

SINGLE PHASE RISER WITH CROSSARM MOUNTED FUSED CUTOUT - 15KV

ISSUE	PAGE NUMBER		
7/13	18-125	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

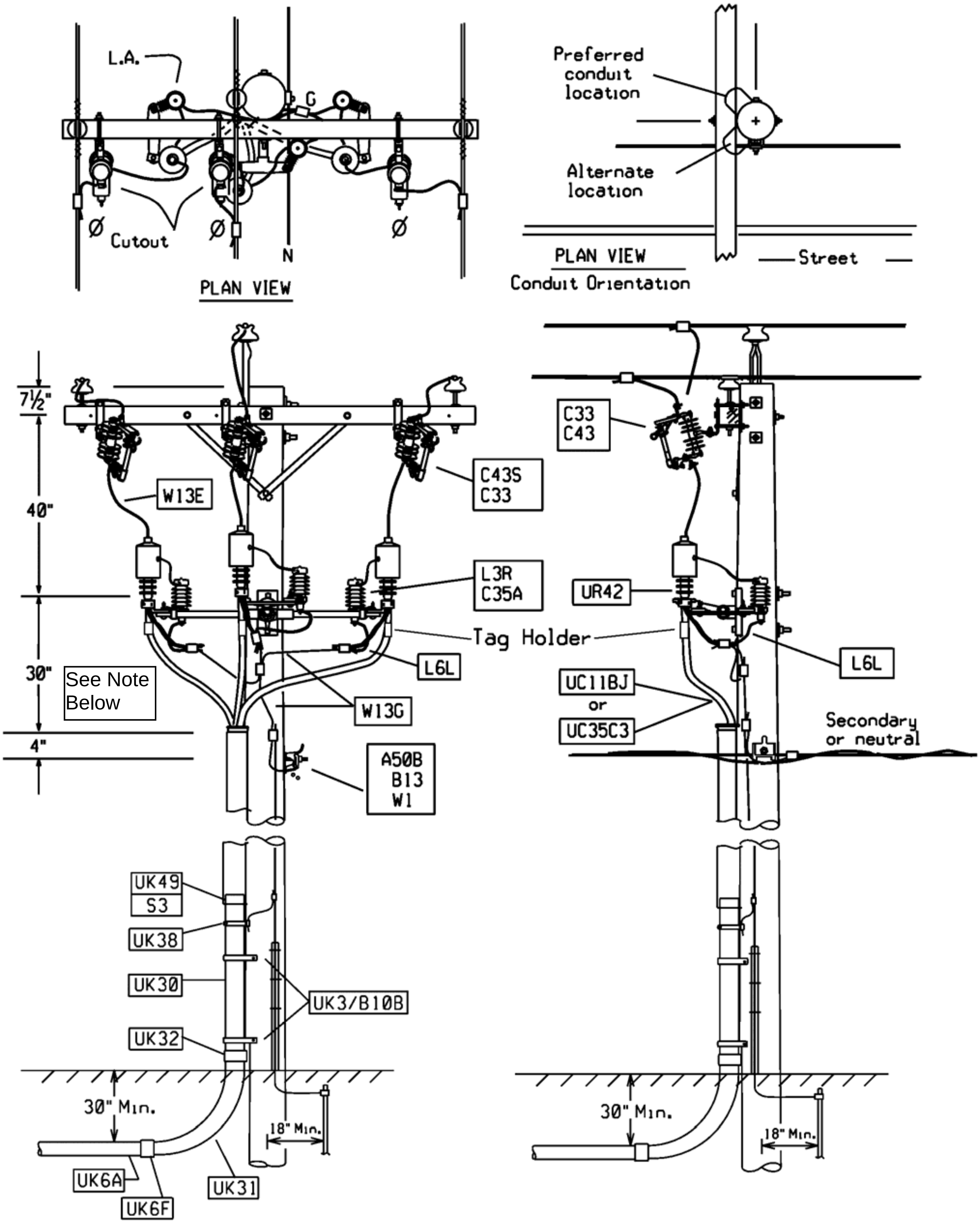
MU = @18-125CC27K(I)(X)	Single Phase Riser, 35kV, (I) Cutout Body Size, (X) Fuse Type, In Riser Guard
MU = @18-125CC27K(I)(X)C	Single Phase Riser, 35kV, (I) Cutout Body Size, (X) Fuse Type, In Conduit

NOTES: Continue concentric neutral to system neutral using a conductor of equivalent size to the UG cable concentric neutral (i.e. #2 or 2/0).



Supersedes 7/11 Issue – Replaced terminator bracket with E13M.

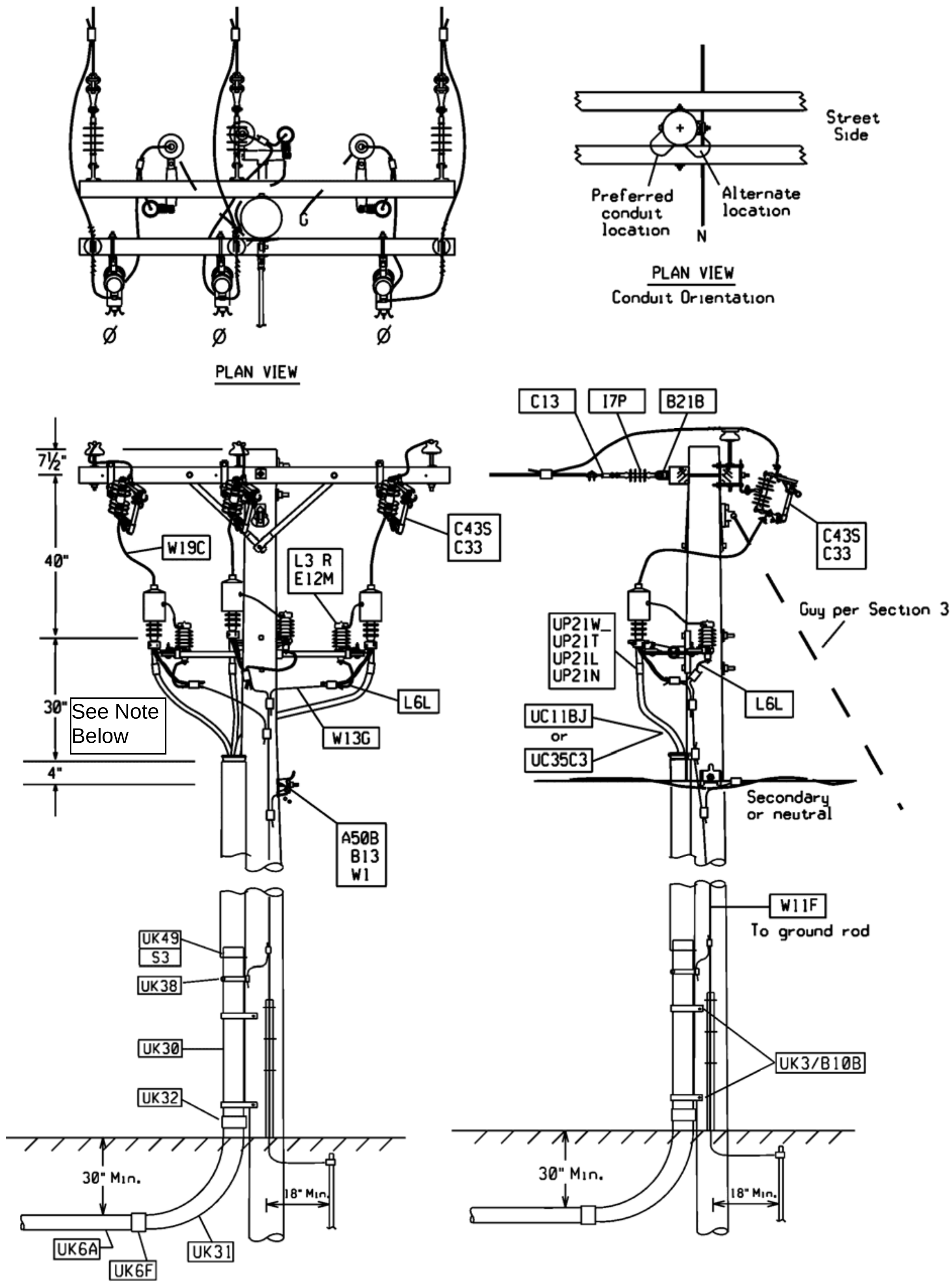
MU = @18-126CC(Y)K(I)(X)	3 Ph Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Riser Guard
MU = @18-126CC(Y)K(I)(X)C	3 Ph Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit



Supersedes 7/11 Issue – Added note for 30" spacing.

Note: Increase pole spacing to 50" when installing cables 500 kcmil or greater.

MU = @18-126CC(Y)K(I)(X)	3Ph Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Riser Guard
MU = @18-126CC(Y)K(I)(X)C	3Ph Phase Riser, (Y) Insulation Rating, (I) Cutout Body Size, (X) Fuse Type, In Conduit

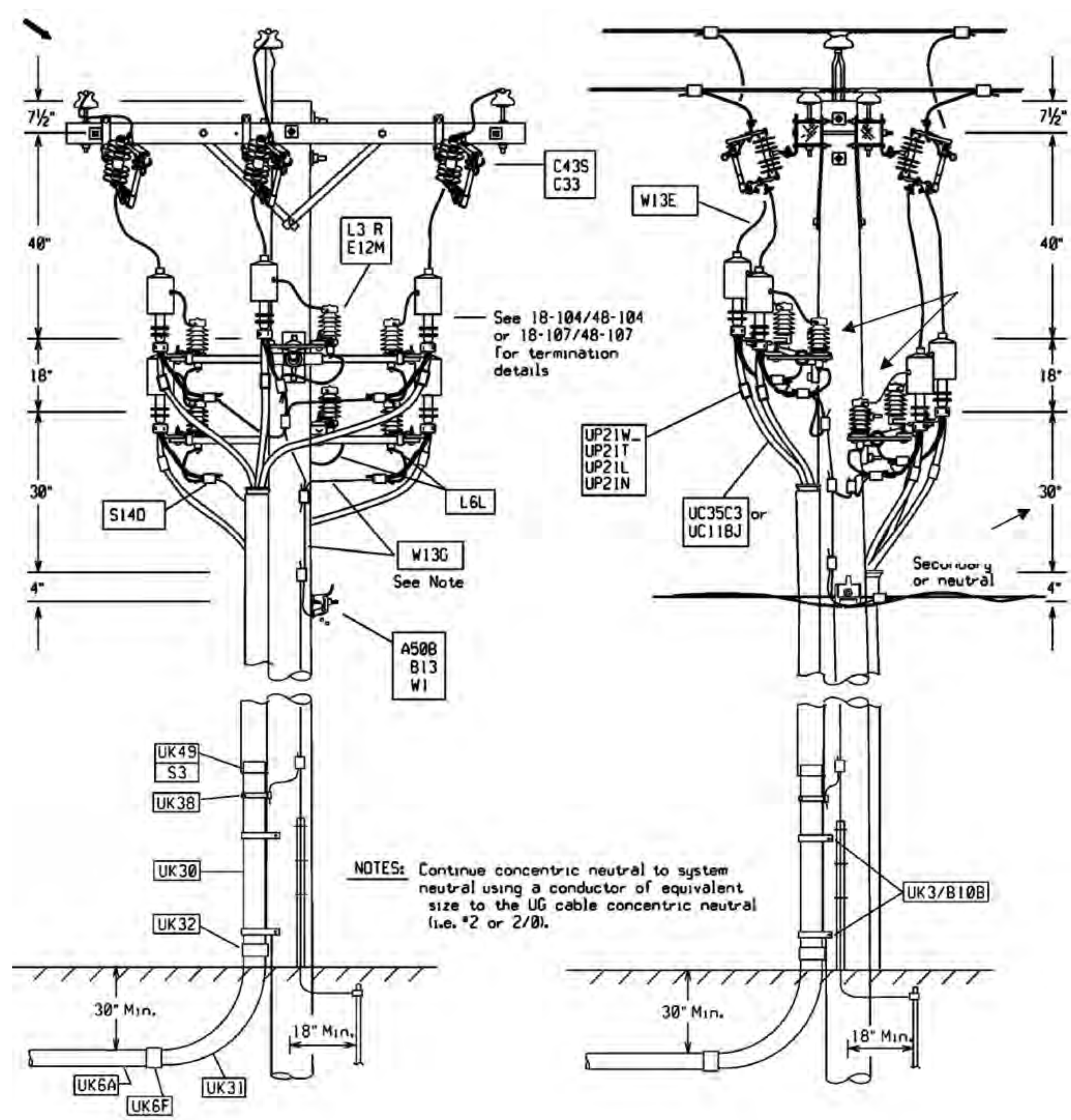


Note: Increase pole spacing to 50” when installing cables sized 500 kcmil or larger.

Supersedes 7/11 Issues - Added note for 30” pole spacing.

15 – 35 kV THREE PHASE RISER DEADEND POLE WITH FUSED CUTOUTS 200 A MAXIMUM			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 18-127	ISSUE 7/13

SEE PAGE 18-126 FOR MACROS



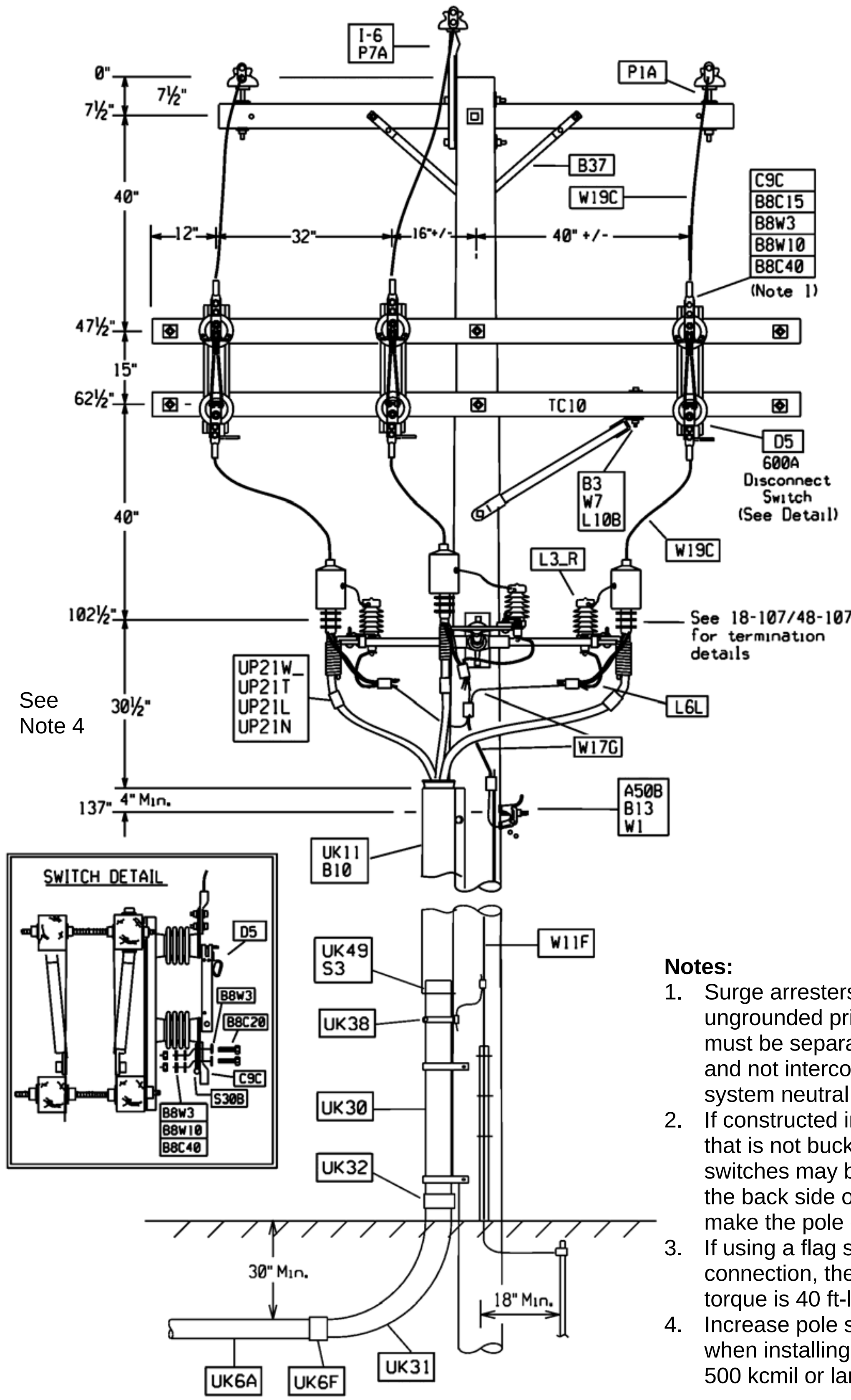
Supersedes 7/12 Issue – Offset position of riser brackets.

IMPORTANT: Installation of risers on separate poles is the preferred construction and this standard should only be used when other options are not practical.

NOTES:
1. Use the middle position of the riser bracket arm when installing arresters on both brackets in order to have enough clearance between the upper arrester ground lead and lower arrester primary tap.
2. Increase pole spacing to 50" when installing cables sized 500 kcmil or larger.

MU = @18-335(W) Add C If In Conduit	3 Ph Riser, 600A, (W) = A, B, C Cable Size with A = 500, B = 750, C = 1000, 15kV
MU = @18-335(W)35KV Add C If In Conduit	3 Ph Riser, 600A, (W) = A, B, C Cable Size with A = 500, B = 750, C = 1000, 35kV

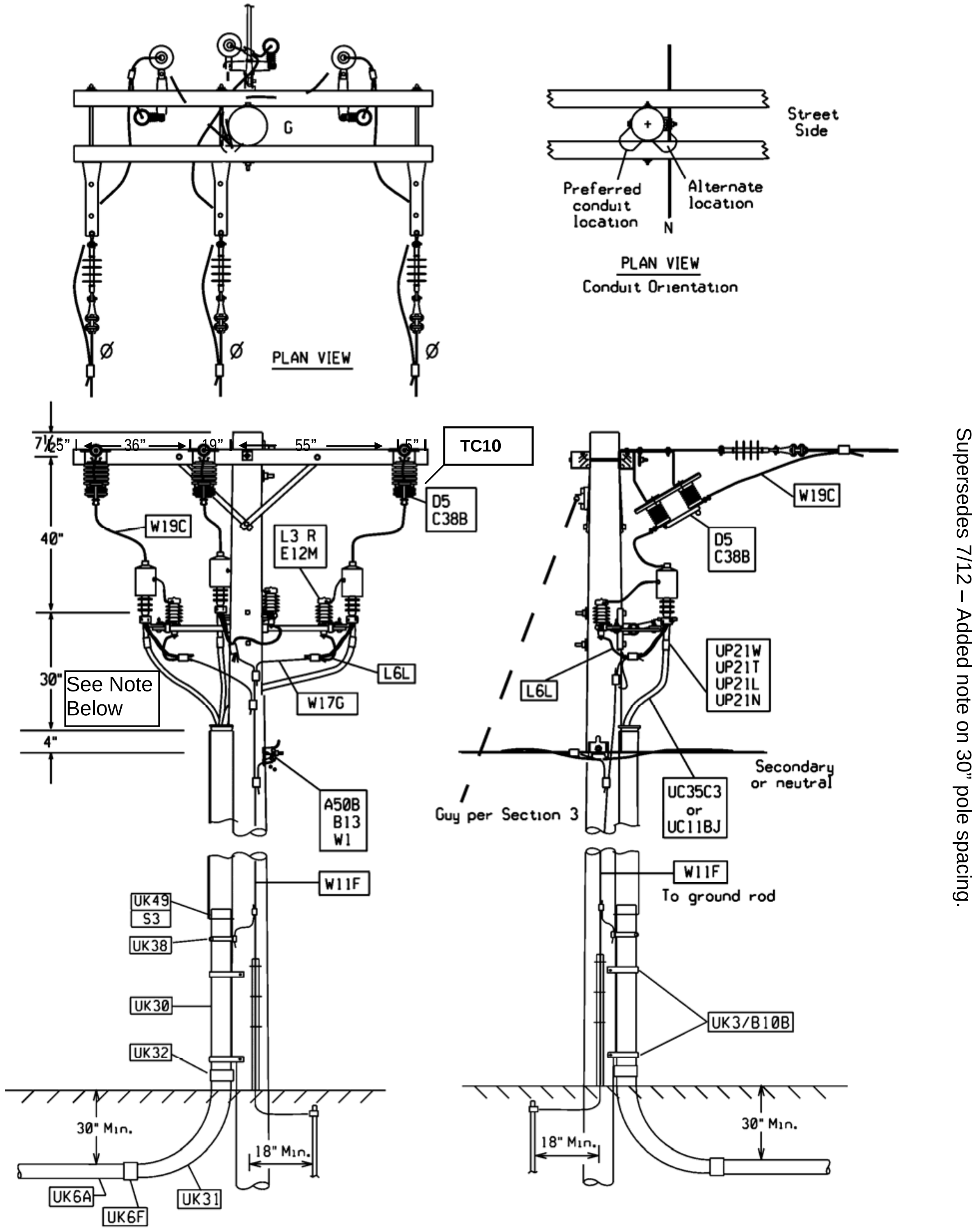
Supersedes 7/11 Issue - Added Note 4 on pole spacing.



Notes:

1. Surge arresters connected to ungrounded primary circuits must be separately grounded and not interconnected to the system neutral and ground.
2. If constructed in a location that is not bucket accessible, switches may be placed on the back side of the pole to make the pole easier to climb.
3. If using a flag style terminal connection, the required torque is 40 ft-lbs.
4. Increase pole spacing to 50" when installing cables sized 500 kcmil or larger.

MU = @18-336(W) Add C If In Conduit	3 Ph Riser, 600A, (W) = A, B, C Cable Size with A = 500, B = 750, C = 1000, 15kV
MU = @18-336(W)35KV Add C If In Conduit	3 Ph Riser, 600A, (W) = A, B, C Cable Size with A = 500, B = 750, C = 1000, 35kV

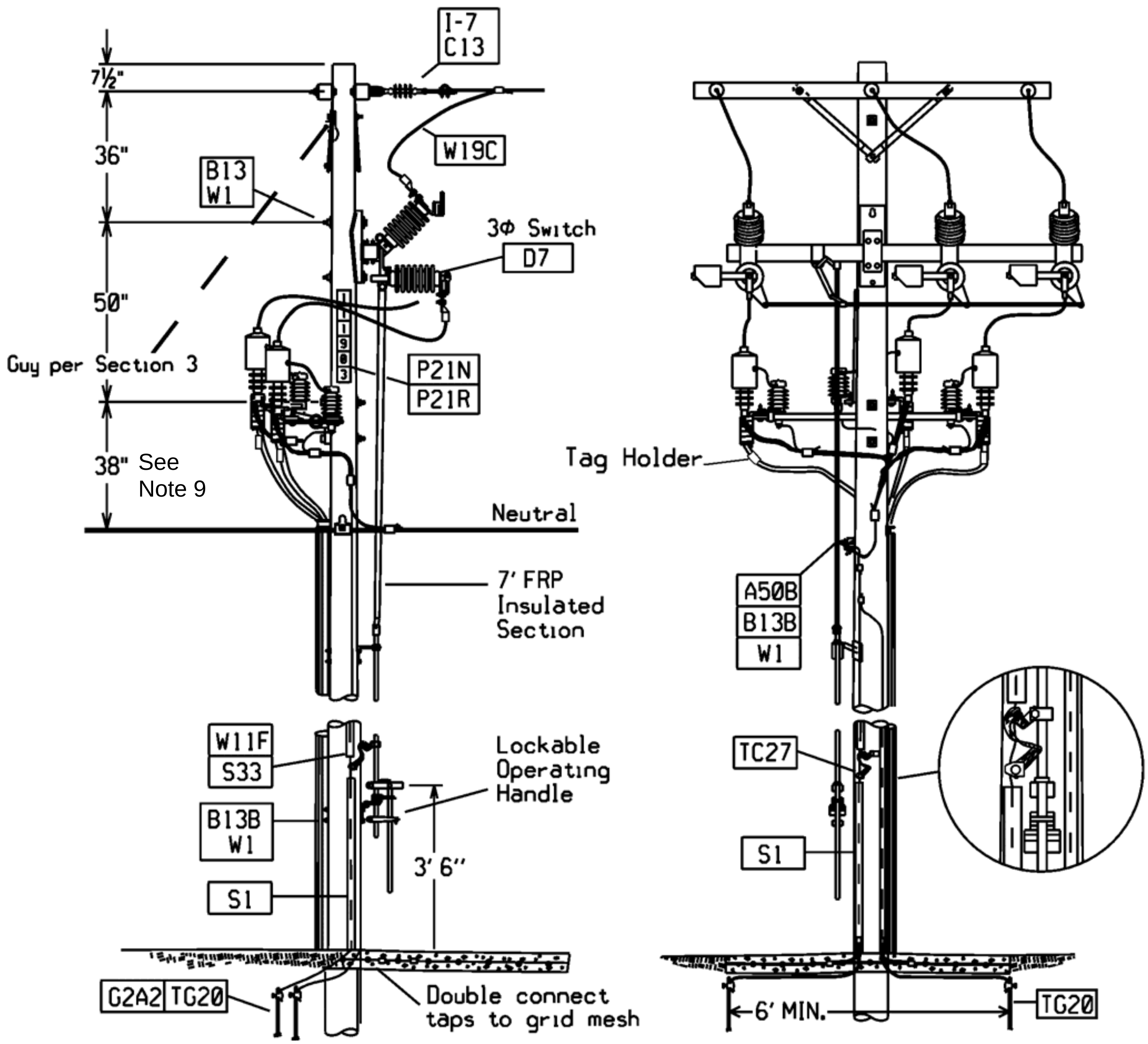


Supersedes 7/12 – Added note on 30" pole spacing.

Note: Increase pole spacing to 50" when installing cables 500 kcmil or greater.

THREE PHASE PRIMARY 600A DEADEND RISER WITH DISCONNECT SWITCHES			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/12	18-336		

MU = @18-337LBSW(Y)(W)	3Ph Riser 600A Loadbreak, (Y) = Voltage, (W) = A, B, C Cable Size with A = 500, B = 750, C = 1000
MU = @18-337LBSW(Y)(W)C	3Ph Riser 600A Loadbreak, (Y) = Voltage, (W) = A, B, C Cable Size with A = 500, B = 750, C = 1000, In Conduit

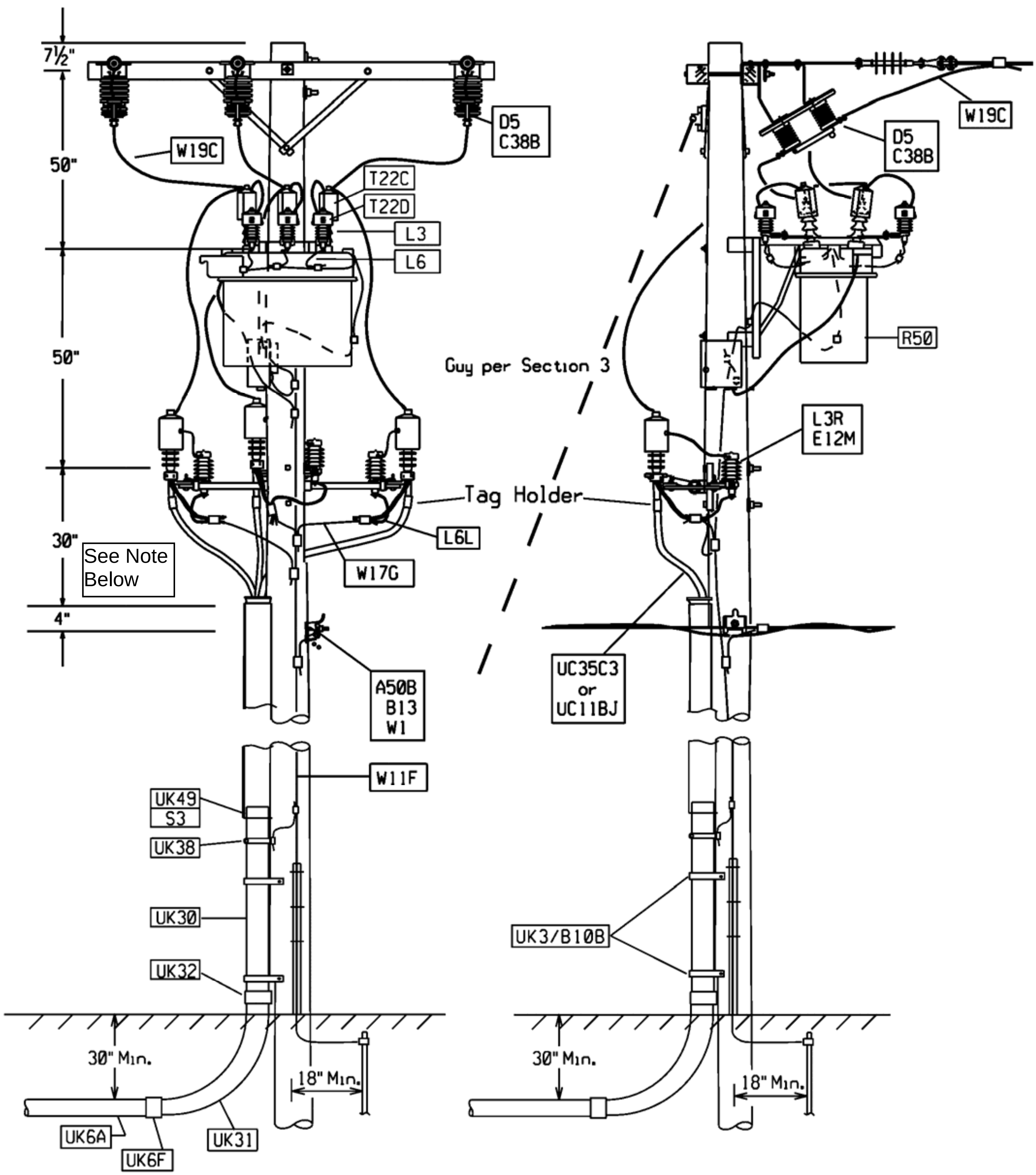


Supersedes 7/11 Issues – Added Note 9 on pole spacing.

NOTES:

1. Surge arresters shall be installed onto the source side pole within 300 feet. The riser type surge arresters shall be installed onto the load side protecting both the switch and underground cable.
2. Use stainless steel bolts (Item B8C) when connecting copper lugs (Item C9C) to switch pads.
3. On covered tap conductors, provide 6 inches of bare conductor at the switch terminals for grounding purposes. Use 5/8" thru bolts to mount operating rod guides.
4. Primary conductors shall never be installed to only one side of the switch as maximum deadend loading will be exceeded.
5. DO NOT install switch on a pole where the construction angle is greater than 20°.
6. Lifting straps shall be removed after installation is complete.
7. Operating mechanism shall be locked in the open or closed position.
8. Switch identification shall be mounted vertically on the road side to provide maximum visibility.
9. Increase pole spacing to 50" when installing cables 500 kcmil or larger.

MU = @18-353(W)C50B(X)	3 Ph Riser, 600A (X) = A, B, C Cable Size with A = 500, B = 750, C = 1000, (X) = Fuse Link 15kV
MU = @18-353(W)C50(X)C	3 Ph Riser, 600A (X) = A, B, C Cable Size with A = 500, B = 750, C = 1000, (X) = Fuse Link 15kV In Conduit



Supersedes 7/11 Issues - Added note for 30" pole spacing.

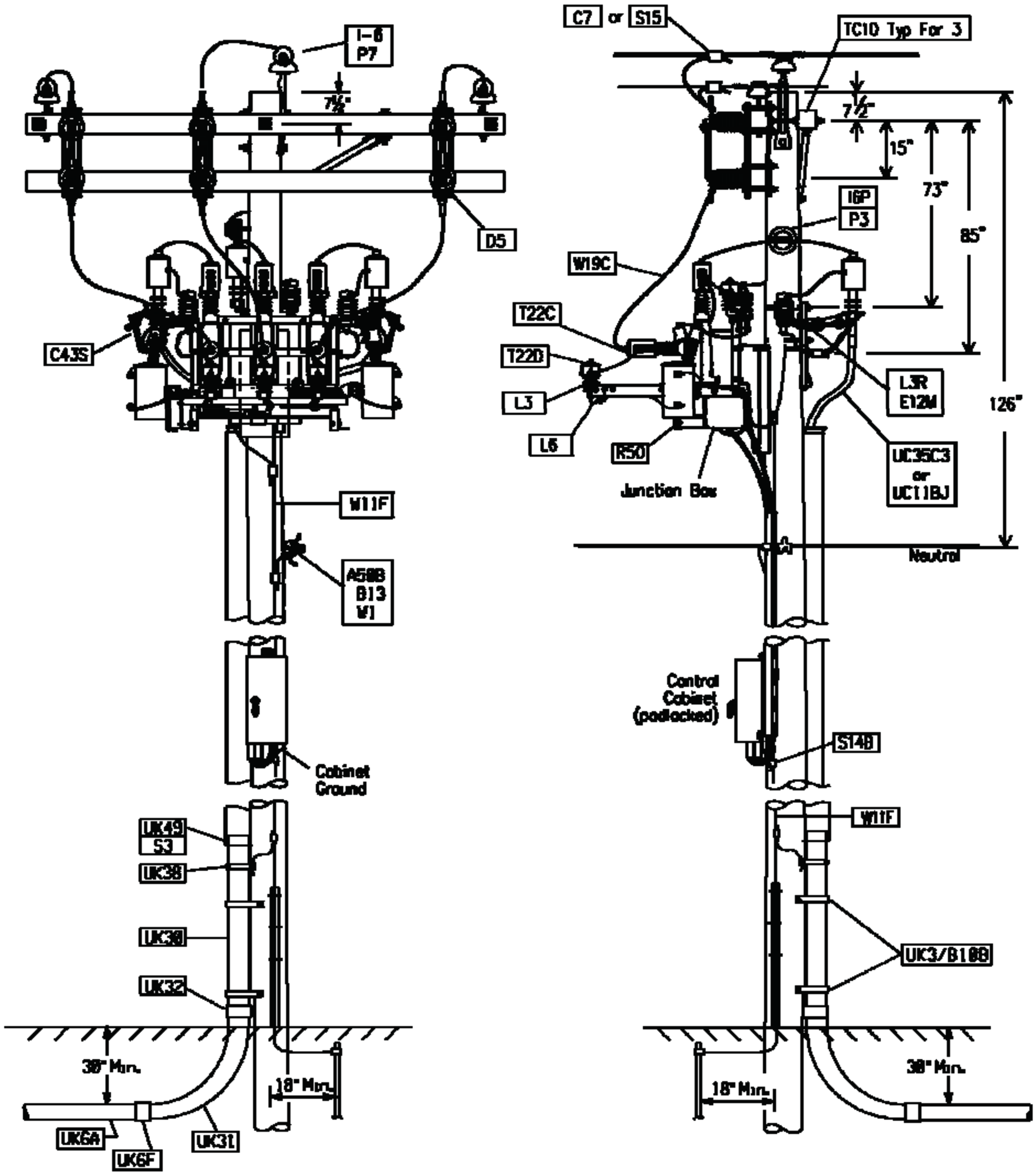
Note: Increase pole spacing to 50" when installing cables 500 kcmil or greater.

THREE PHASE DEADEND RISER WITH RECLOSER AND DISCONNECT SWITCHES

ISSUE	PAGE NUMBER		
7/13	18-340	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Doc. # ST.18.00.002

7/12 Issue – New Page



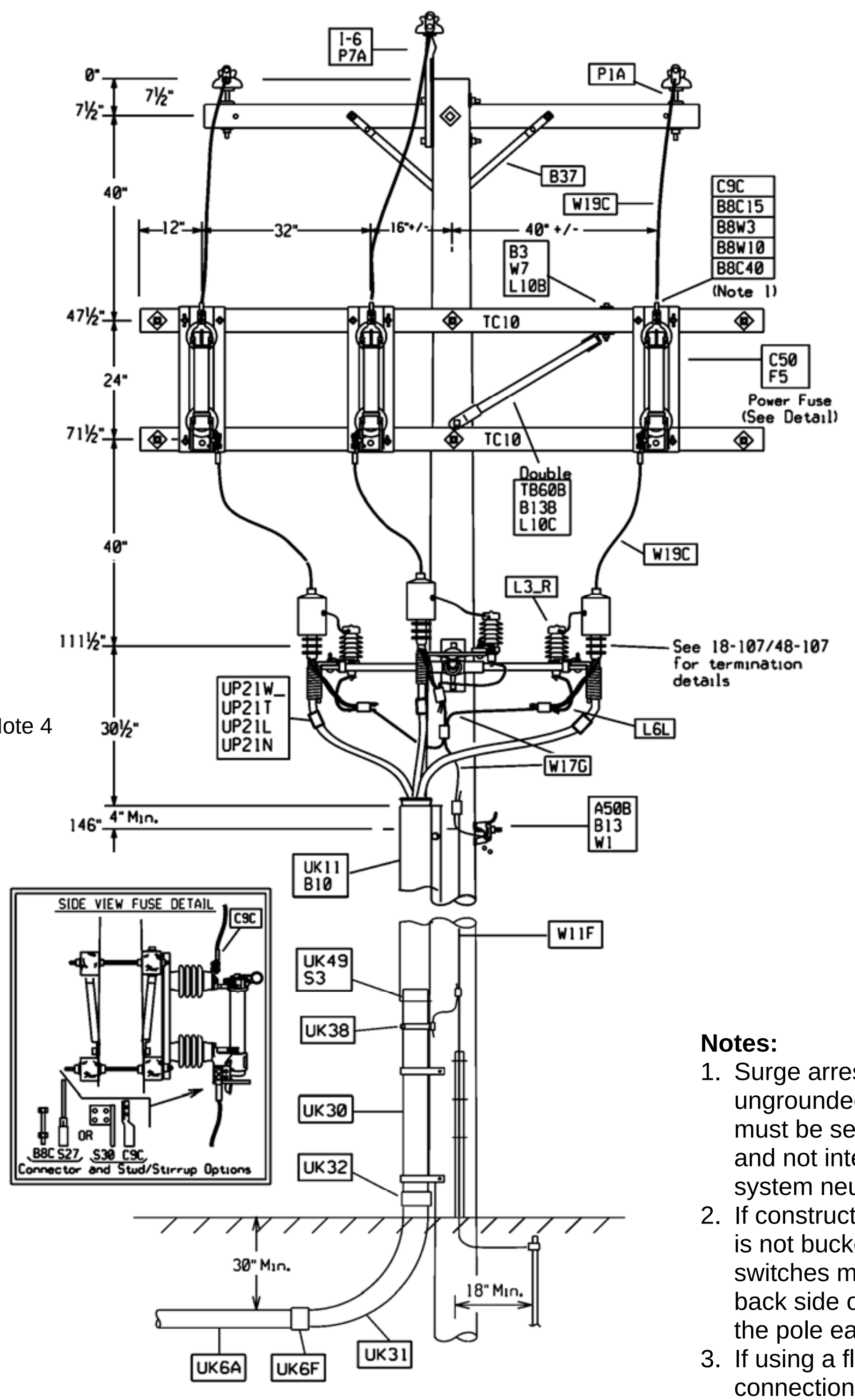
NOTES: Refer to section 12 for notes and details of recloser.

THREE PHASE RISER WITH RECLOSER AND DISCONNECT SWITCHES ON OPEN WIRE (0 TO 10 DEGREES)			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 18-341	ISSUE 7/13

MU = @18-353(W)C50B(X)	3 Ph Riser, 600A (X) = A, B, C Cable Size with A = 500, B = 750, C = 1000, (X) = Fuse Link 15kV
MU = @18-353(W)C50(X)C	3 Ph Riser, 600A (X) = A, B, C Cable Size with A = 500, B = 750, C = 1000, (X) = Fuse Link 15kV In Conduit

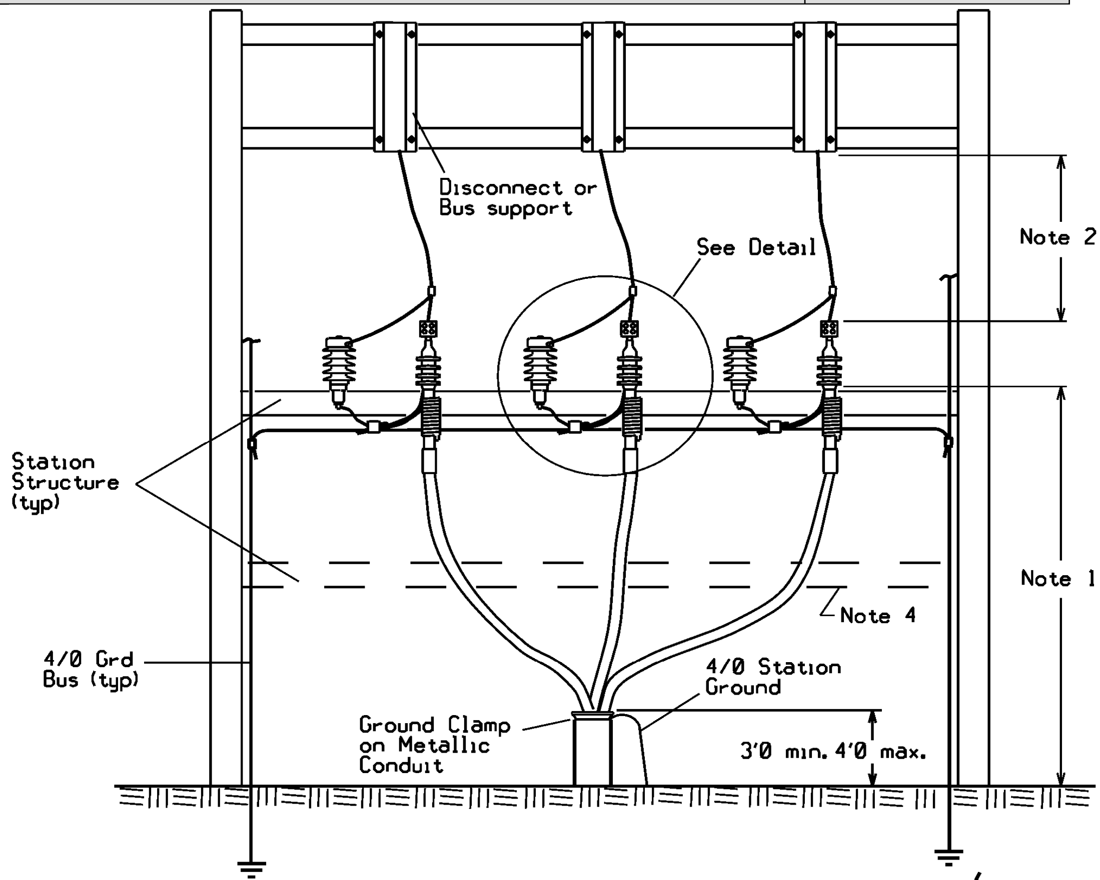
Supersedes 7/11 Issue - Added Note 4 for pole spacing.

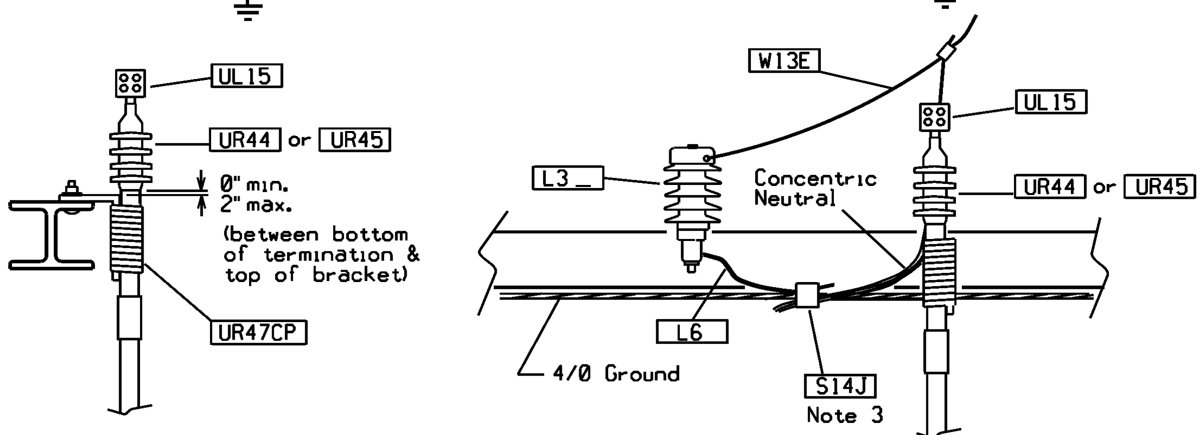
See Note 4



Notes:

1. Surge arresters connected to ungrounded primary circuits must be separately grounded and not interconnected to the system neutral and ground.
2. If constructed in a location that is not bucket accessible, switches may be placed on the back side of the pole to make the pole easier to climb.
3. If using a flag style terminal connection, the required torque is 40 ft-lbs.
4. Increase pole spacing to 50" when installing cables 500 kcmil or larger.





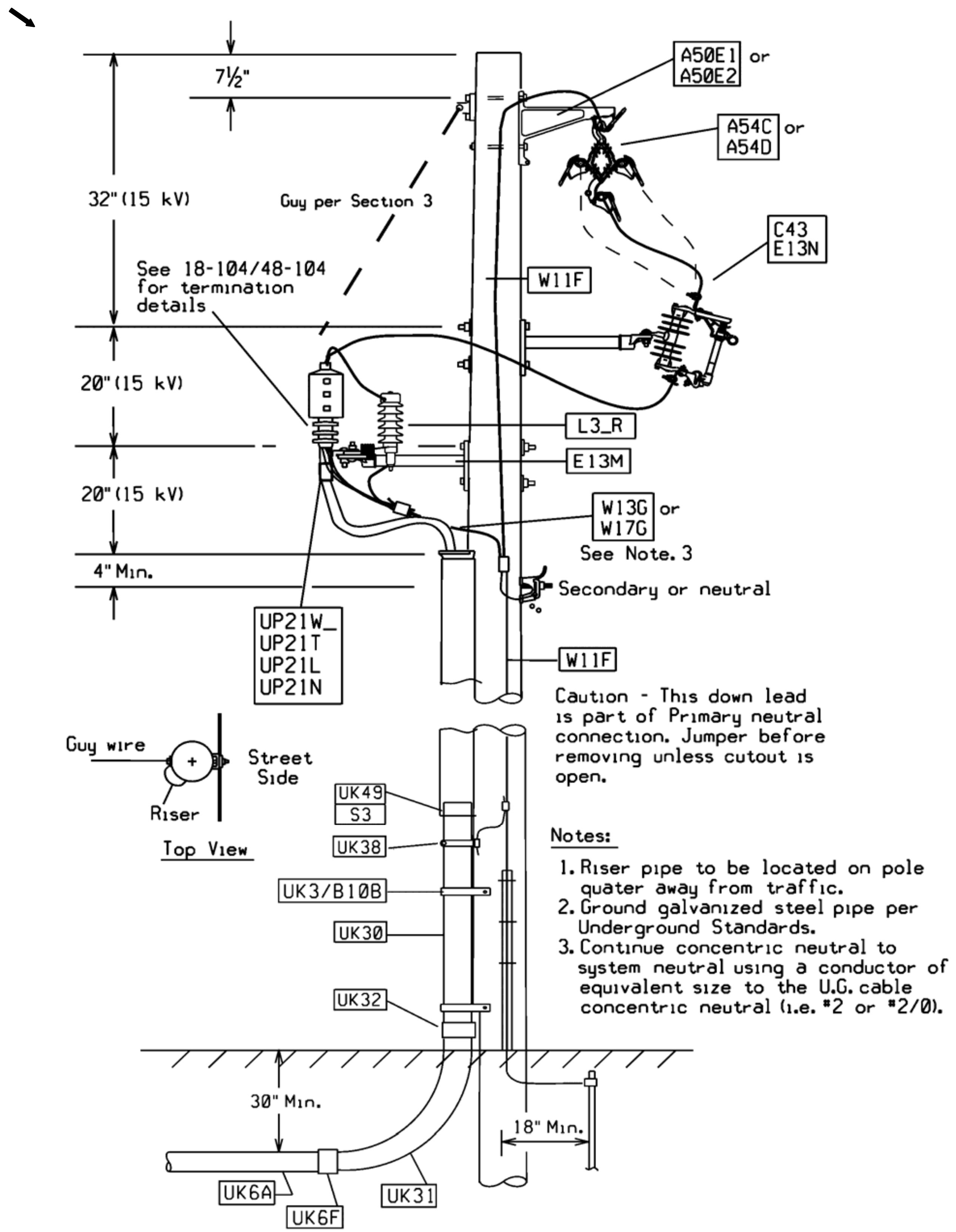
DETAIL

Notes:

1. Distance to live parts per ST.02.00.002 – Electrical Station Clearances.
2. Maximum distance to bus support is 5'. Allow sufficient distance between the disconnect device and the cable termination for maintenance and cable testing without violating Minimum Approach Distance. Add 3'6" to the Minimum Approach Distance values in the employee safety handbook.
3. Run 4/0 horizontal ground in web if an I beam, or underneath other supporting structure. Connect arrester ground lead and concentric neutral to ground bus with single C crimp connector, standard item S14J. Keep leads as short as possible
4. . If the distance from grade to the termination support is greater than 10', install additional structural members below and hold cable with cable positioner, standard item UR47CP. The distance between cable positioners shall not exceed 7'

Doc. # ST.18.00.002

SEE PAGE 18-125 FOR MUS



Caution - This down lead is part of Primary neutral connection. Jumper before removing unless cutout is open.

Notes:

1. Riser pipe to be located on pole quater away from traffic.
2. Ground galvanized steel pipe per Underground Standards.
3. Continue concentric neutral to system neutral using a conductor of equivalent size to the U.G. cable concentric neutral (i.e. #2 or #2/0).

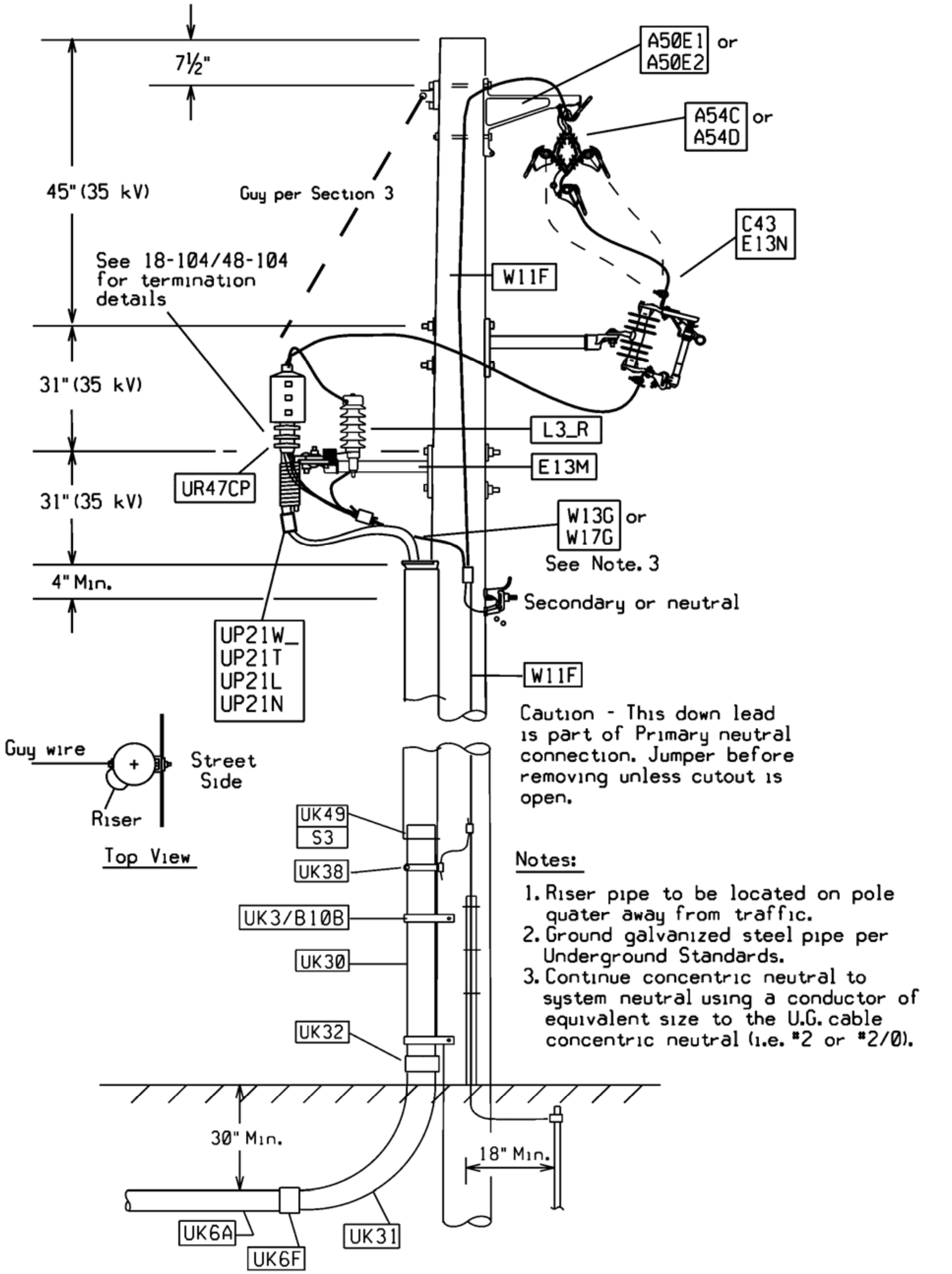
Supersedes 7/09 Issue -Added ground rod 18" requirement; removed guy materials; corrected animal guard position.

SINGLE PHASE SPACER CABLE RISER - 15KV

ISSUE	PAGE NUMBER		
7/11	18-400	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

SEE PAGE 18-125M FOR MUS

Supersedes 7/09 Issue -Added ground rod 18" requirement; removed guy materials; corrected animal guard position.



Caution - This down lead is part of Primary neutral connection. Jumper before removing unless cutout is open.

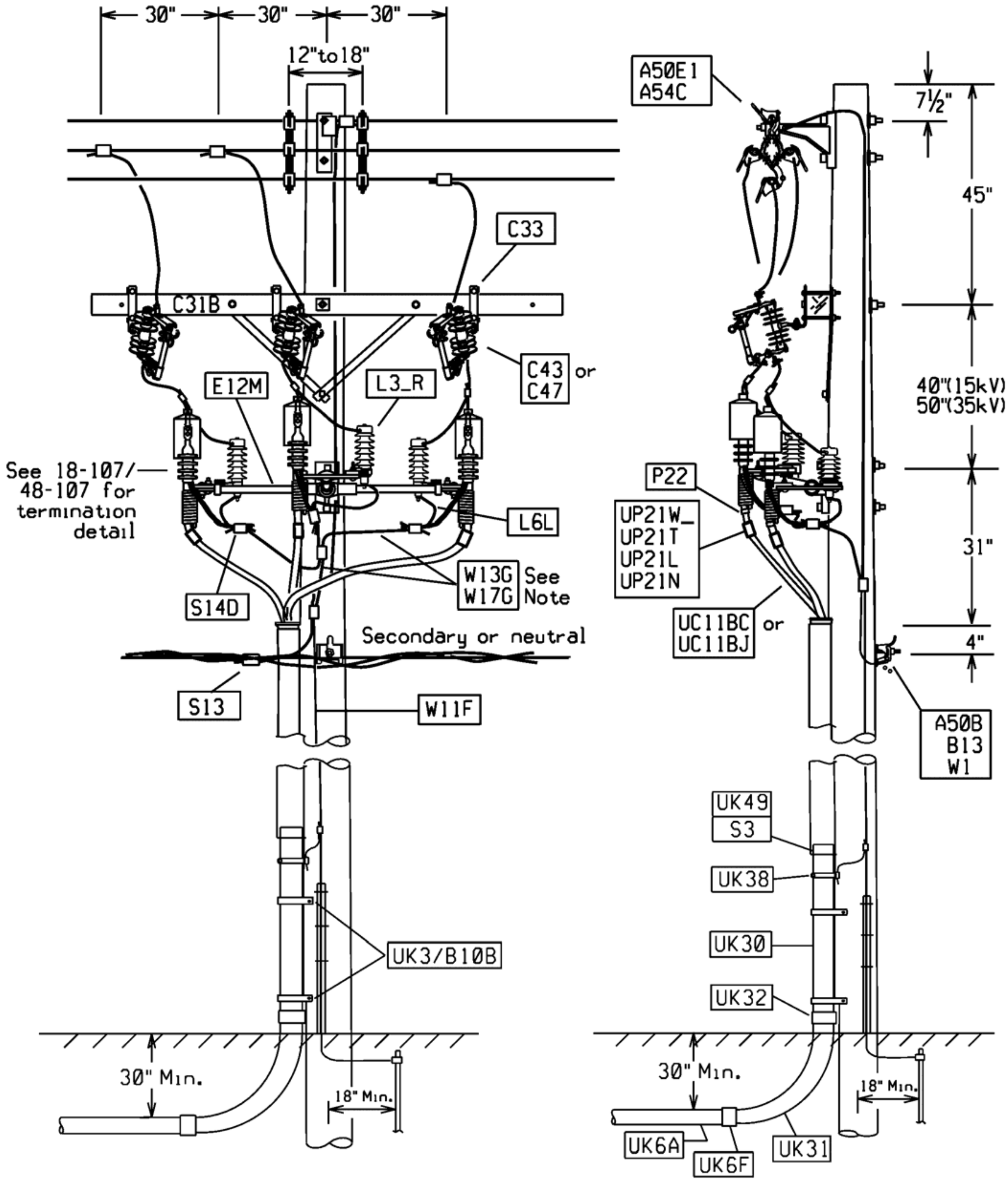
Notes:

1. Riser pipe to be located on pole quater away from traffic.
2. Ground galvanized steel pipe per Underground Standards.
3. Continue concentric neutral to system neutral using a conductor of equivalent size to the U.G. cable concentric neutral (i.e. #2 or #2/0).

SINGLE PHASE SPACER CABLE RISER - 35KV **MAINTENANCE ONLY**			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		18-400M	7/11

Doc. # ST.18.00.002

SEE PAGE 18-126 FOR MUS



Supersedes 7/09 Issue - Added ground rod 18" requirement, corrected spacer and connection clearances; corrected animal guard position.

NOTES: Continue concentric neutral to system neutral using a conductor of equivalent size to the UG cable concentric neutral (i.e. #2 or 2/0).

<table>
<tr><td colspan="4">THREE PHASE SPACER CABLE RISER - 15-35kV</td></tr>
<tr><td>ISSUE</td><td>PAGE NUMBER</td><td rowspan="2">OVERHEAD
CONSTRUCTION STANDARD</td><td rowspan="2">Liberty Utilities</td></tr>
<tr><td>7/11</td><td>18-405</td></tr>
</table>

Version	Date	Modification	Author(s)	Approval by (Name/Title)
4	7/13	• Minor text change to Stds. 18-109, 18-110 and 18-111. • Revised Std. 18-124 & 18-124M • Revised Std. 18-128 • Added note for pole spacing for stds. 18-126, 18-127,18-128,18-335,18-336, 18-337, 18-340 and 18-353 • Added new Standard 18-341 • Remove Pages 18-734,-735,-736, -737 not used in NH	Robert Johnson	Robert Johnson Program Manager CQ&EM, Standards, Policies, and Codes
3	7/12	• Minor text change for 18-111, 18-112 and 18-336 • Std 18-128 is being reviewed for clearances and position of riser brackets. • New Std 18-370 for sub-station risers	Hernan Yepez Tim Hayden	
2	7/11	• Added requirement for ground rod placement (18" from center of pole) on drawings where the ground rod is shown. • Removed guy wire materials on drawings where guys are shown - refer to Section 3 for all guying requirements. • Minor editorial corrections in the text portion of the section. • Corrected animal guard placement on most drawings where terminations are shown.	Katie Croteau	
1	7/09	• Text portion of the section has been completely re-written in order to combine what was previously in Section 18 and Section 48. • Updates were made to all drawings that were previously in Section 18. Some of the drawings that had previously been in Section 48 are now in this section. • Brand new drawings were introduced - particularly 18-112, 18-124M, 18-125M, 18-340, and 18-400M. • Many of the CUs and MUs listed on the drawings have either been added or updated.	Katie Croteau	Allen Chieco, Director of Distribution Standards and Work Methods

 | Doc. # ST. 19.00.001

Supersedes 1/07 Issue - Updated page numbers.

19.1 GENERAL

This Standards section provides installation details about all types of outdoor lighting installations installed on wooden distribution poles. This section applies to all new and replacement installations and existing installations when relocated on its present pole or transferred to a new pole.

19.2 LUMINAIRES SELECTION

The State of New Hampshire has enacted “Dark Skies” legislation (House Bill 585-FN) which requires Liberty Utilities to use only luminaires which restrict the amount of light output allowed to go upward towards the sky.
To comply with this legislation, the following is effective immediately in New Hampshire:

1. We can no longer install any roadway luminaires in New Hampshire with semi-cutoff optics.
2. Existing semi-cutoff luminaires in service can remain in service until failure or until removed for any reason.
3. All new and replacement horizontal roadway luminaire installations shall use luminaires with cutoff (flat glass) optics.
4. Semi-cutoff luminaires returned from the field shall be disposed of for scrap metal value. Do not return to inventory.

See STANDARDS Section 46 for detailed information on application of horizontal roadway and floodlight luminaires.

All horizontal roadway and floodlight luminaires have the date of manufacture identified inside the luminaire. Luminaires that fail within five years of the date of manufacture should be returned to Stores for possible warranty credit.

Supersedes 07/08 Issue – General revision.

19.3 BRACKETS

Table 1 identifies the horizontal roadway luminaire loading allowed on standard wood pole street lighting brackets.

Table 1

STD. Item	Bracket	Use For:
SB04	4’ Upsweep	50 W – 400 W roadway luminaires
SB06	6’ Upsweep	50 W – 250 W roadway luminaires
SB06A	6’ Tapered Elliptical	400 W & 1,000 W roadway luminaires
SB08	8’ Upsweep with Underbrace	50 W – 250 W roadway luminaires
SB08A	8’ Tapered Elliptical	400 W & 1,000 W roadway luminaires
SB10	10’ Tapered Truss	50 W – 400 W roadway luminaires
SB12	12’ Tapered Truss	50 W – 400 W roadway luminaires
SB16	16’ Tapered Truss	50 W – 400 W roadway luminaires
SB20	20’ Tapered Truss	50 W – 400 W roadway luminaires

All brackets removed from service shall be inspected and returned to Stores for reuse, or disposed of for scrap metal value if found to be an obsolete design or damaged. All 1-1/4 inch aluminum brackets and all steel brackets shall be disposed of for scrap metal value.

19.4 OUTDOOR LIGHTING FIXTURE CONDUCTORS

All street and floodlight luminaire installations shall use 2-1/C #10 AWG copper conductors – BLACK-WHITE twisted pair (STD Item SY4A2) to connect the luminaire to the secondary supply.

19.5 MUNICIPAL OWNED STREET LIGHTING EQUIPMENT INSTALLED ON COMPANY OWNED DISTRIBUTION POLES

This section outlines municipal and company responsibilities for the installation, removal, and maintenance of municipal owned street lighting equipment which is installed in the electric supply space on company owned distribution poles.

Standards: All municipal owned street lighting attachments shall be in compliance with the applicable provisions of the National Electric Safety Code (NESC), latest edition, and the applicable National Grid Construction Standards.

Municipal Owned Equipment: The municipal shall be responsible to own, operate, and maintain all equipment beyond the street light service taps. This shall include, but not be limited, to the following:

1. Supplying all materials and labor.

2. Transferring the street light attachment to a new pole in the event of a pole replacement.

3. Relocating the street light attachment to accommodate other construction activities on the pole.

4. Emergency 24 hour response to remove or make safe the street light attachment in the event of a broken pole.

NOTE: In an emergency, company personnel may perform any municipal street light work deemed necessary to maintain public or employee safety.

Clearances: Clearances to other pole attachments, as specified in National Grid Construction Standards Section 19, shall be maintained. Municipal owned street lights, when installed or relocated, shall be installed below the secondary conductors.

Final Connections: Company personnel shall make all connections and disconnections of municipal owned street light fixture conductors to the company owned secondary conductors. The municipal is never allowed to perform any work on company owned secondary conductors.

Grounding: The municipal is responsible to ground the street light bracket in accordance with National Electric Safety Code requirements and National Grid Construction Standards Section 19.

In-Line Fused Disconnect: The municipal shall install an in-line fuse holder and midget cartridge style fuse on every street light immediately after the tap connections to the company secondary conductors. The in-line fuse holder shall be secured to the pole using a spring loaded conduit clip or galvanized staple. This fuse, in addition to providing electrical protection, shall serve as a future disconnect point for the municipal owned street light. Once installed, the municipal may disconnect or reconnect a municipal owned street light only by means of the in-line fuse holder.

Labeling: The municipal is responsible to label municipal owned street light luminaires in accordance with National Grid Construction Standards to identify luminaire ownership and maintenance responsibility.

Mechanical Protection: The municipal is responsible to install mechanical protection on the luminaire fixture conductors in accordance with National Grid Construction Standards Section 19.

Safety: All municipal work shall be completed in compliance with National Grid safety rules.

Worker Qualifications: All municipal work shall be completed by personnel qualified to work in the electric supply space on a distribution pole.

Supersedes 7/08 Issue – General revision. Added details on municipal street lighting installations.

This section covers clearances required for all street lighting and flood lighting equipment installed within the electric supply space on wood distribution poles from energized primary, secondary, and communications conductors. (35kV distribution maximum – effectively grounded)

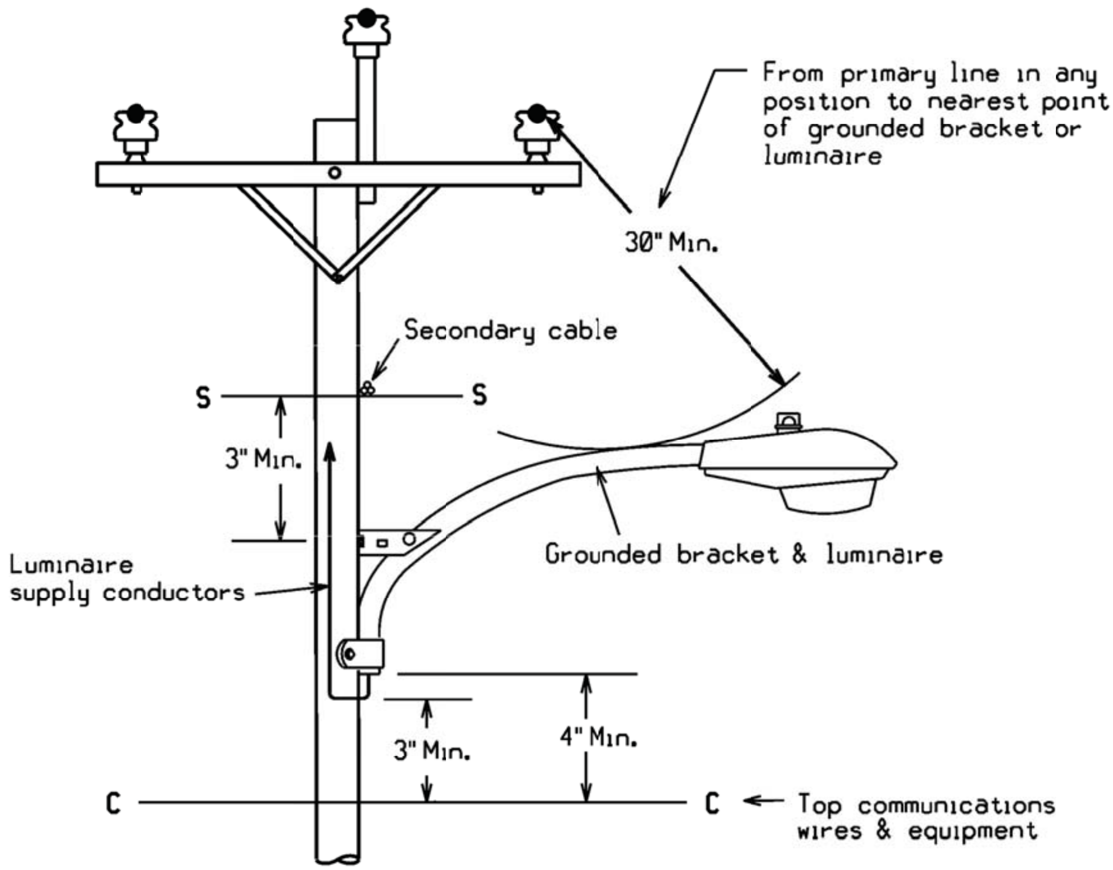


Figure 1 – Clearances from Overhead Conductors

1. Primary Conductors – Maintain minimum 30-inch clearance from any primary conductor or cable to nearest point of grounded luminaire or bracket.

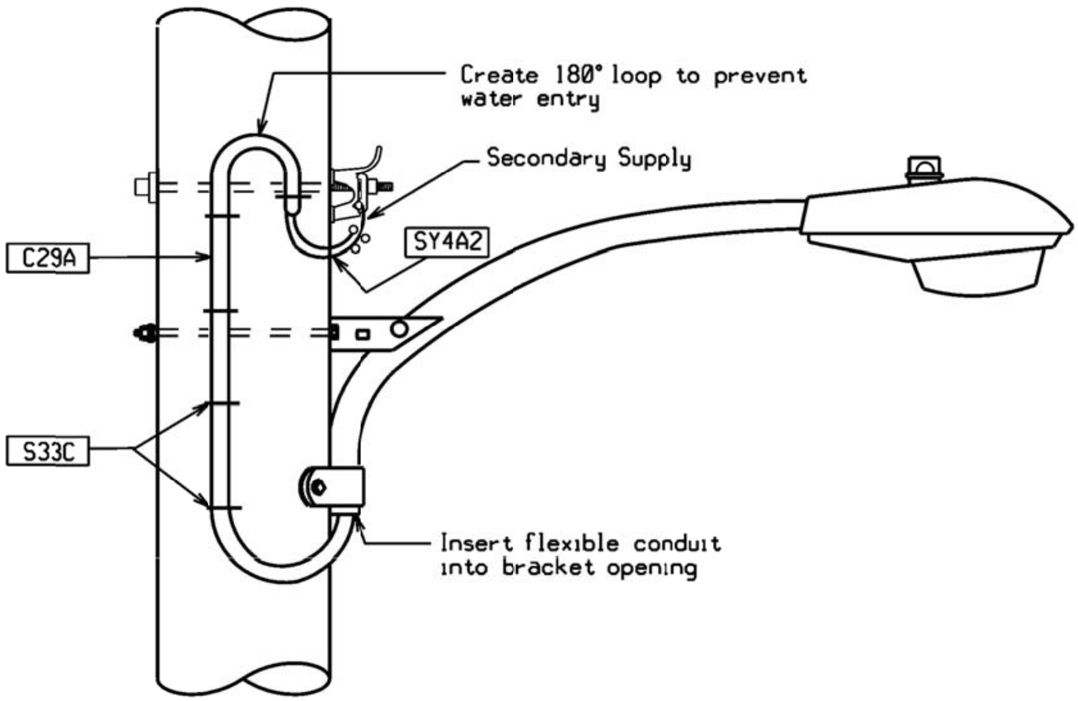
2. Secondary Conductors – Maintain minimum 3-inch vertical clearance from secondary wires or cable to nearest point of grounded luminaire bracket. (NESC Table 239-1)

3. Communications Cables – Maintain minimum 4-inch vertical clearance from closest communication cable to nearest point of grounded luminaire bracket. (NESC Table 238-2)

   Maintain minimum 3-inch clearance from closest communications cable to nearest point of luminaire supply conductors drip loop. Luminaire supply conductors must be covered with non-metallic flexible conduit. (NESC 238D)

4. See Standards Section 17 for additional information on Clearances.

Supersedes 7/08 Issue – Information formerly on page 19-1.



New page.

Figure 2 – Mechanical Protection of Outdoor Lighting Fixture Conductors

1. NESC Table 239G1 requires that all luminaire supply conductors (#10 AWG) shall have mechanical protection (1/2" non-metallic flexible conduit) installed from the point where they leave the pole end of the bracket to the connection to the secondary supply in order to take advantage of the clearance dimensions shown on Standards page 19-100.

2. Insert the non-metallic flexible conduit into the bracket opening and extend up the pole to above the secondary supply.

3. Create a 180 degree loop at the secondary supply to prevent rain water from becoming trapped inside the flexible conduit.

4. Secure the non-metallic flexible conduit with galvanized staples spaced 12-inches apart or closer as necessary.

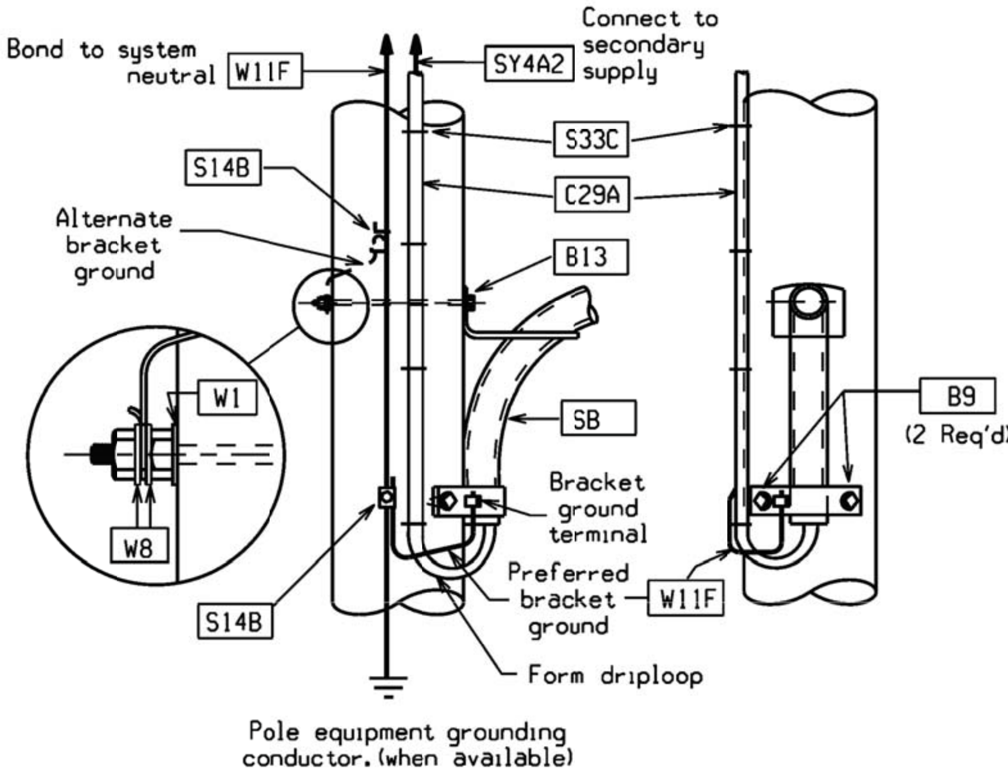


Figure 3 – Street Light Installation Using Upsweep or Tapered Elliptical Bracket

1. Before installation, always check luminaire nameplate to insure desired wattage and operating voltage.

2. Follow manufacturer's guidelines (supplied with every luminaire) for proper installation. Level luminaire using slipfitter hardware supplied.

3. Adequate clearances from overhead conductors must be maintained. See Standards page 19-100 for details.

4. Install ½" flexible conduit to protect wiring. See Standards page 19-101 for details.

5. All installations require one 5/8 inch square head machine bolt and two 1/2 inch x 4 inch lag screws. Both required lag screws must be installed in order for bracket to withstand horizontal wind loading forces. Never drive lag screws during bracket/luminaire installation with lamp installed. Lamp life will be reduced. Always install photoelectric control last.

6. Every bracket shall be grounded. Connect #4 AWG copper bracket grounding conductor to the pole equipment grounding conductor when available. Otherwise, connect bracket equipment ground conductor to system neutral.

7. All luminaries come equipped with a factory installed, black plastic, or metal, wildlife guard which is designed to prevent birds from entering the luminaire at the opening where the bracket is inserted. To insure luminaire reliability, make sure this guard remains in place after the luminaire is attached to the bracket.

8. When opening the luminaire's lower door, never allow the door to freely swing open.

Supersedes 7/08 Issue – Information formerly on page 19-400.

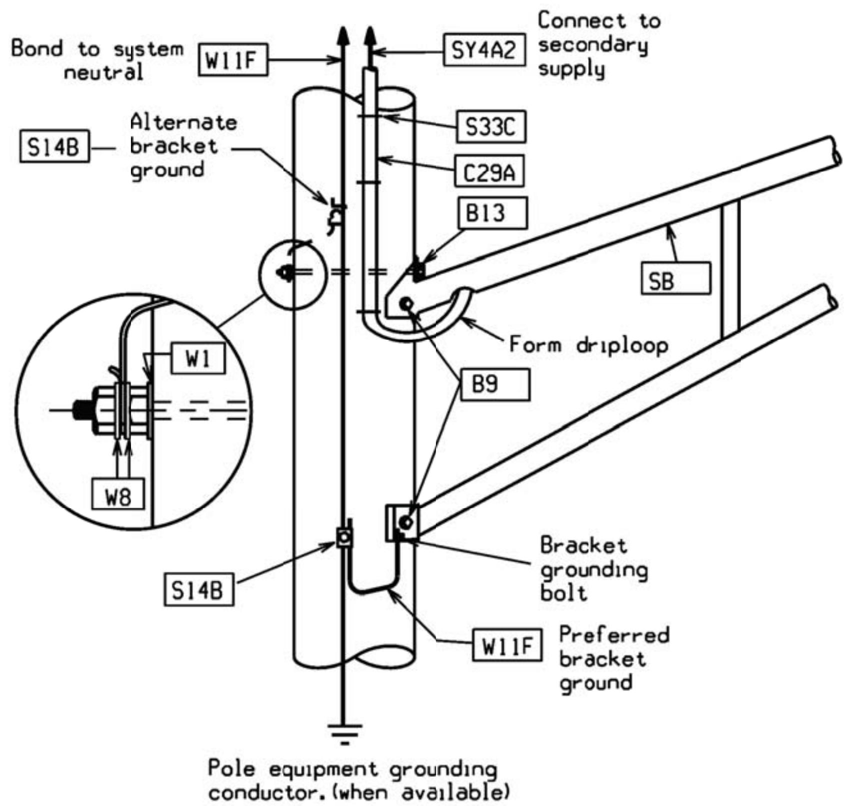


Figure 4 – Street Light Installation Using Tapered Truss Bracket

1. Before installation, always check luminaire nameplate to insure desired wattage and operating voltage.

2. Follow manufacturer's guidelines (supplied with every luminaire) for proper installation. Level luminaire using slip fitter hardware supplied.

3. Adequate clearances from overhead conductors must be maintained. See Standards page 19-100 for details.

4. Install ½" flexible conduit to protect wiring. See Standards page 19-101 for details.

5. All installations require one 5/8 inch square head machine bolt and four 1/2 inch x 4 inch lag screws. All required lag screws must be installed in order for bracket to withstand horizontal wind loading forces. Never drive lag screws during bracket/luminaire installation with lamp installed. Lamp life will be reduced. Always install photoelectric control last.

6. Every bracket shall be grounded. Connect #4 AWG copper bracket grounding conductor to the pole equipment grounding conductor when available. Otherwise, connect bracket equipment ground conductor to system neutral.

7. All luminaries come equipped with a factory installed, black plastic, or metal, wildlife guard which is designed to prevent birds from entering the luminaire at the opening where the bracket is inserted. To insure luminaire reliability, make sure this guard remains in place after the luminaire is attached to the bracket.

8. When opening the luminaire's lower door, never allow the door to freely swing open.

9. Never install a tapered truss bracket with any conductor located between the upper and lower truss members.

Supersedes 7/08 Issue – Information formerly on page 19-401.

Supersedes 7/07 Issue – Information formerly on page 19-402.

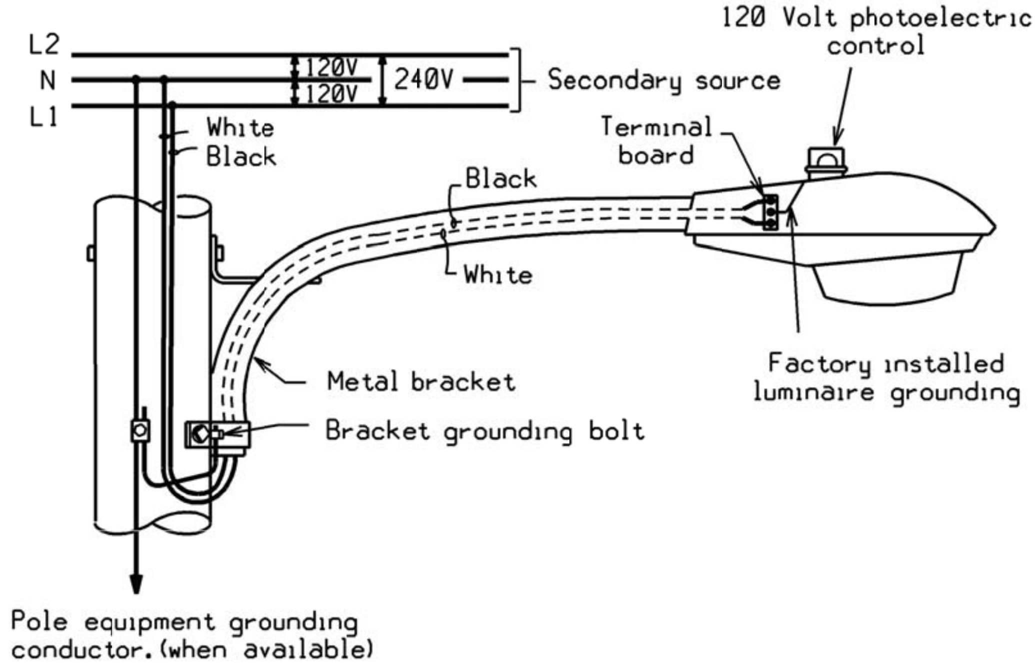
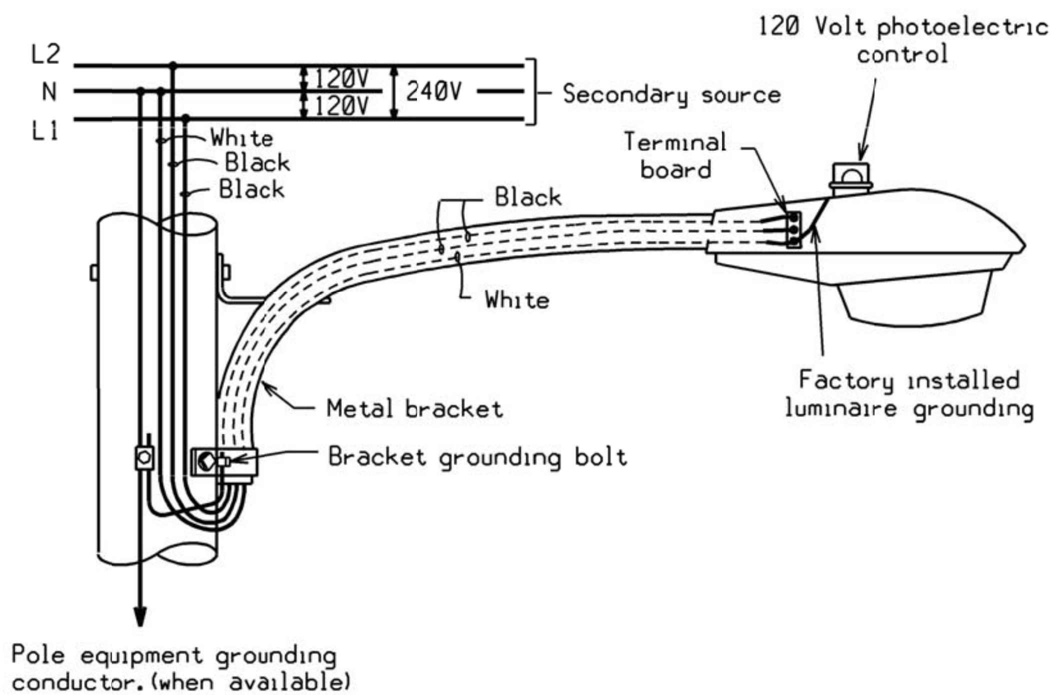


Figure 5 - Wiring Diagram for 120 Volt Street Light Luminaire



1. The ballast operates at 240 volts and is connected between “L1” and “L2”. The photoelectric control switches the “L1” line only and is factory connected for 120 volt between “L1” and “N”.

Figure 6 - Wiring Diagram for 120/240 Volt Street Light Luminaire

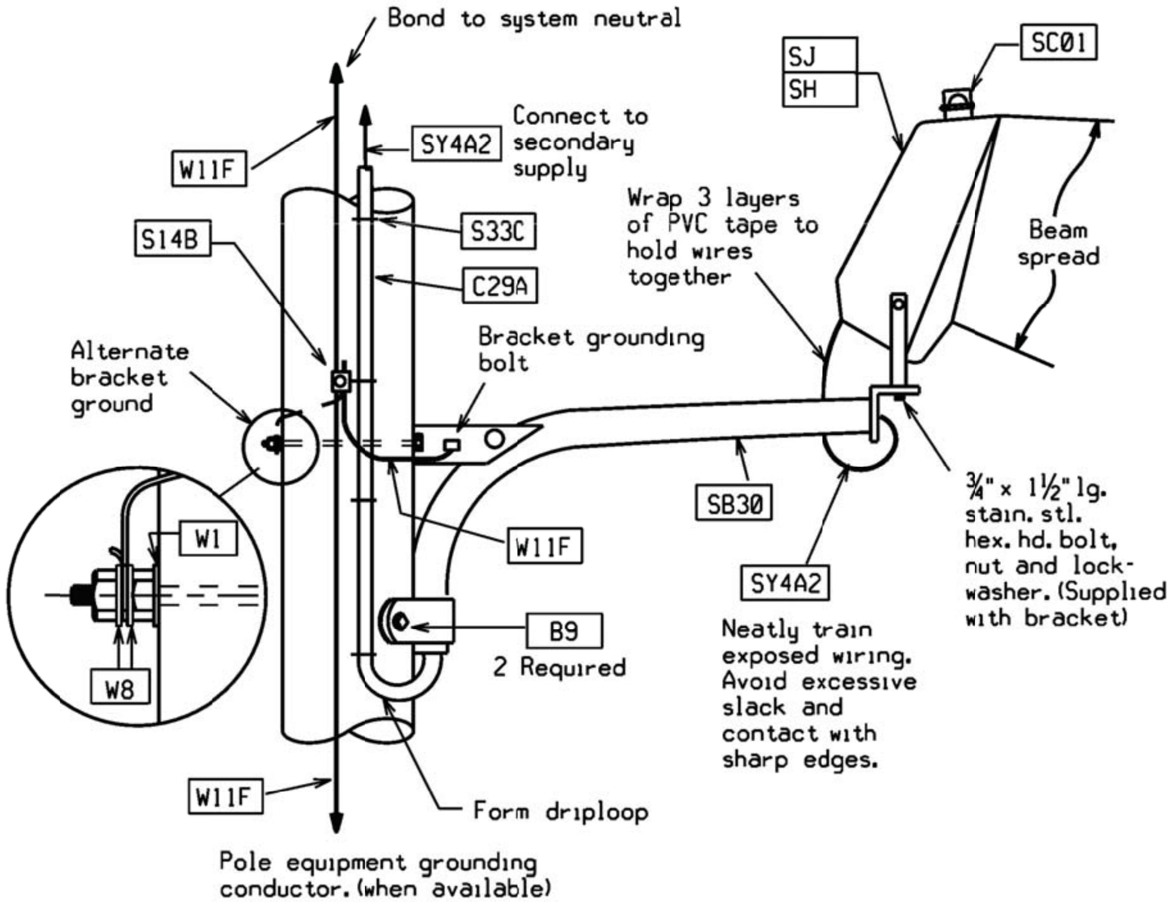


Figure 7 – Single Floodlight Installation on Wood Pole

1. Before installation, always check luminaire nameplate to insure desired wattage and operating voltage.

2. Follow manufacturer's guidelines (supplied with every luminaire) for proper installation.

3. Adequate clearances from overhead conductors must be maintained. See Standards page 19-100 for details.

4. Install ½" flexible conduit to protect wiring. See Standards page 19-101 for details.

5. All installations require one 5/8 inch square head machine bolt and two 1/2 inch x 4 inch lag screws. Both required lag screws must be installed in order for bracket to withstand horizontal wind loading forces. Never drive lag screws during bracket/luminaire installation with lamp installed. Lamp life will be reduced. Always install photoelectric control last.

6. Every bracket shall be grounded. Connect #4 AWG copper bracket grounding conductor to the pole equipment grounding conductor when available. Otherwise, connect bracket equipment ground conductor to system neutral.

Supersedes 7/08 Issue – Information formerly on page 19-410.

Supersedes 1/08 Issue – Information formerly on page 19-411.

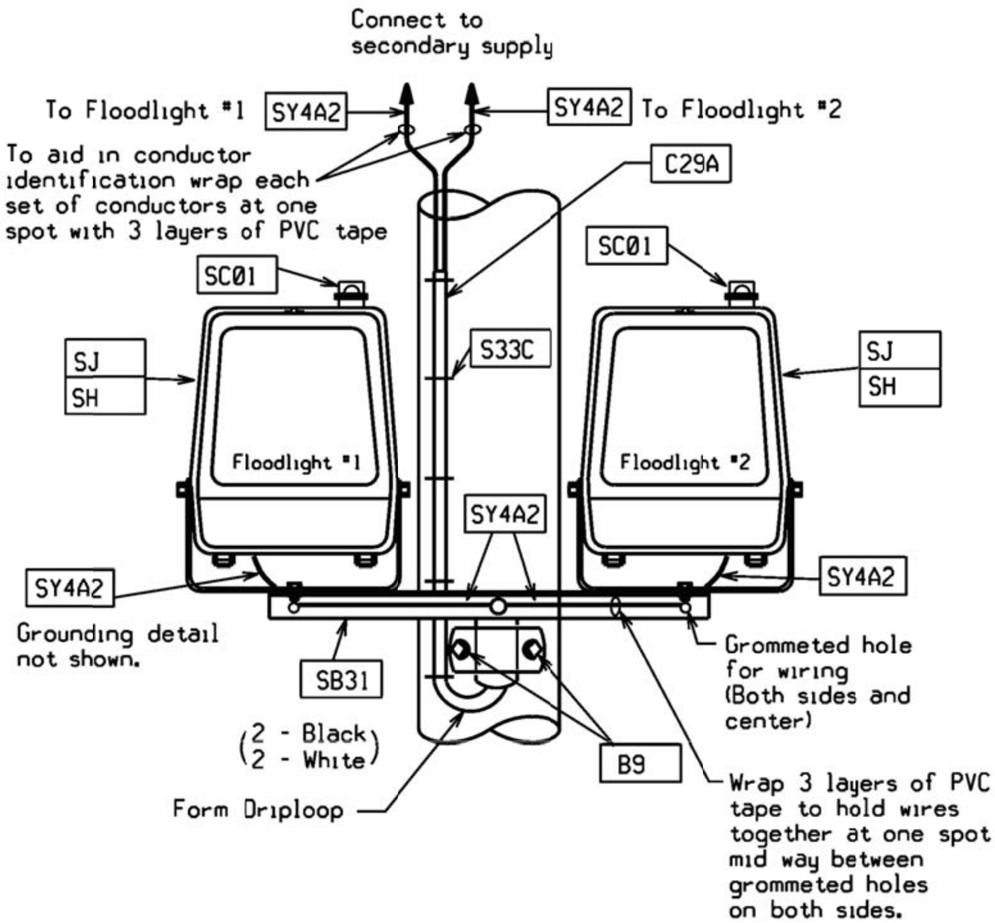


Figure 8 – Twin Flood Light Installation on Wood Pole

1. Before installation, always check luminaire nameplate to insure desired wattage and operating voltage.

2. Follow manufacturer's guidelines (supplied with every luminaire) for proper installation.

3. Adequate clearances from overhead conductors must be maintained. See Standards page 19-100 for details.

4. Install ½" flexible conduit to protect wiring. See Standards page 19-101 for details.

5. All installations require one 5/8 inch square head machine bolt and two 1/2 inch x 4 inch lag screws. Both required lag screws must be installed in order for bracket to withstand horizontal wind loading forces. Never drive lag screws during bracket/luminaire installation with lamp installed. Lamp life will be reduced. Always install photoelectric control last.

6. Every bracket shall be grounded. Connect #4 AWG copper bracket grounding conductor to the pole equipment grounding conductor when available. Otherwise, connect bracket equipment ground conductor to system neutral.

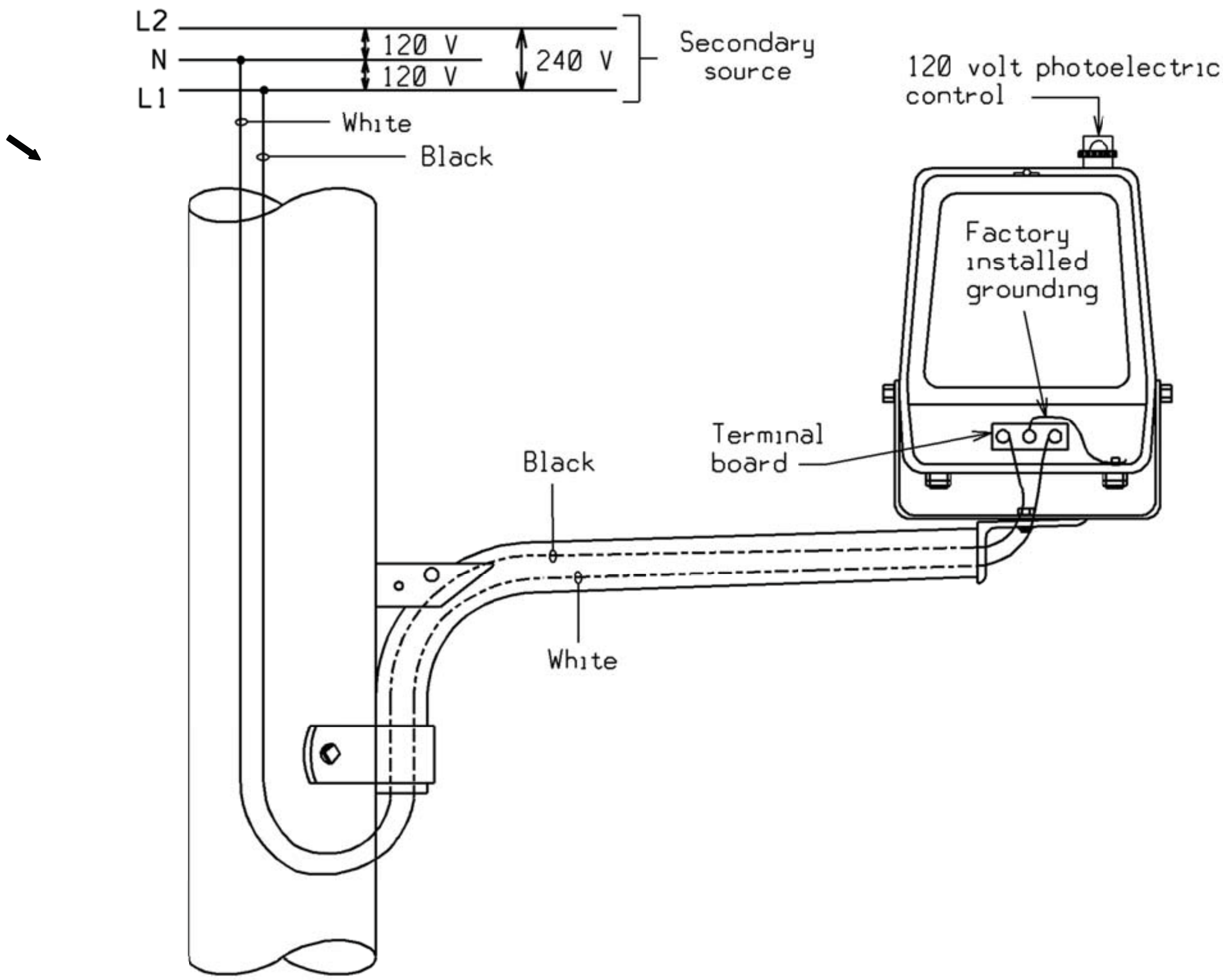


Figure 9 - Wiring Diagram for 120 Volt Flood Light Luminaire

Supersedes 7/07 Issue – Information formerly on page 19-412.

Supersedes 7/08 Issue – Information formerly on page 19-420.

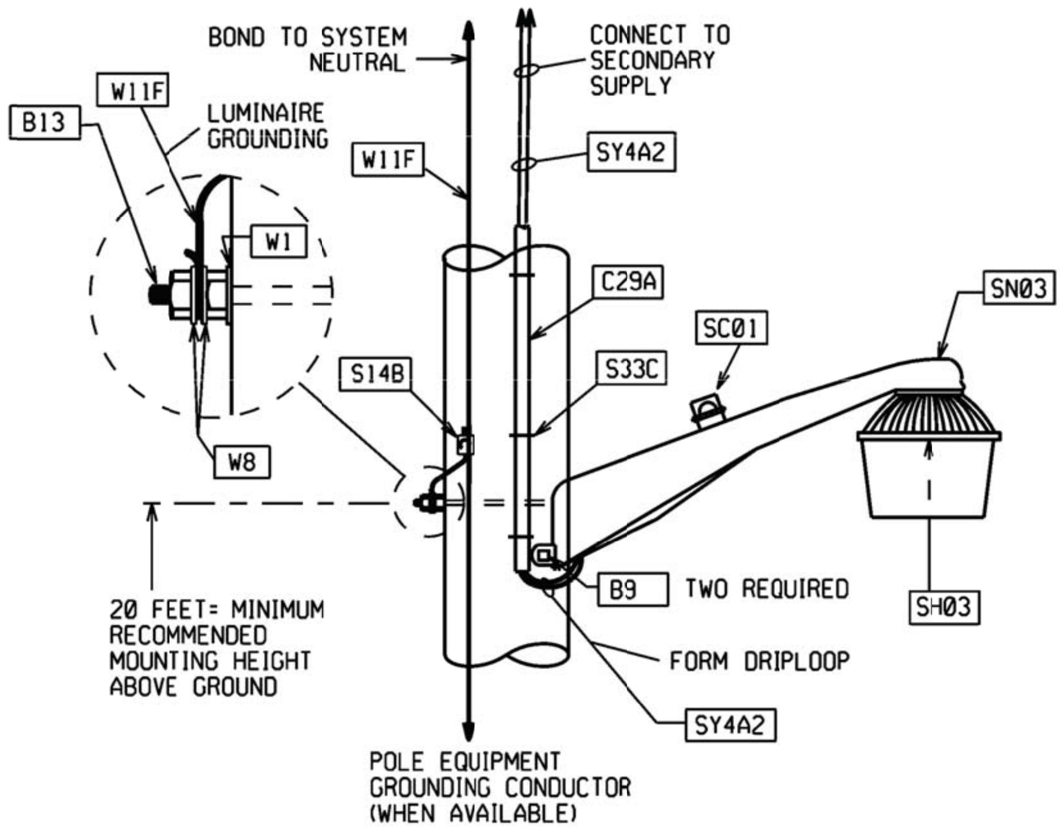


Figure 10 – Residential Security Luminaire Installation on Wood Pole

1. Before installation, always check luminaire nameplate to insure desired wattage and operating voltage.

2. Follow manufacturer's guidelines (supplied with every luminaire) for proper installation.

3. Adequate clearances from overhead conductors must be maintained. See Standards page 19-100 for details.

4. Install ½" flexible conduit to protect wiring. See Standards page 19-101 for details.

5. All installations require one 5/8 inch square head machine bolt and two 1/2 inch x 4 inch lag screws. Both required lag screws must be installed in order for bracket to withstand horizontal wind loading forces. Never drive lag screws during bracket/luminaire installation with lamp installed. Lamp life will be reduced. Always install photoelectric control last.

6. Every bracket shall be grounded. Connect #4 AWG copper bracket grounding conductor to the pole equipment grounding conductor when available. Otherwise, connect bracket equipment ground conductor to system neutral.

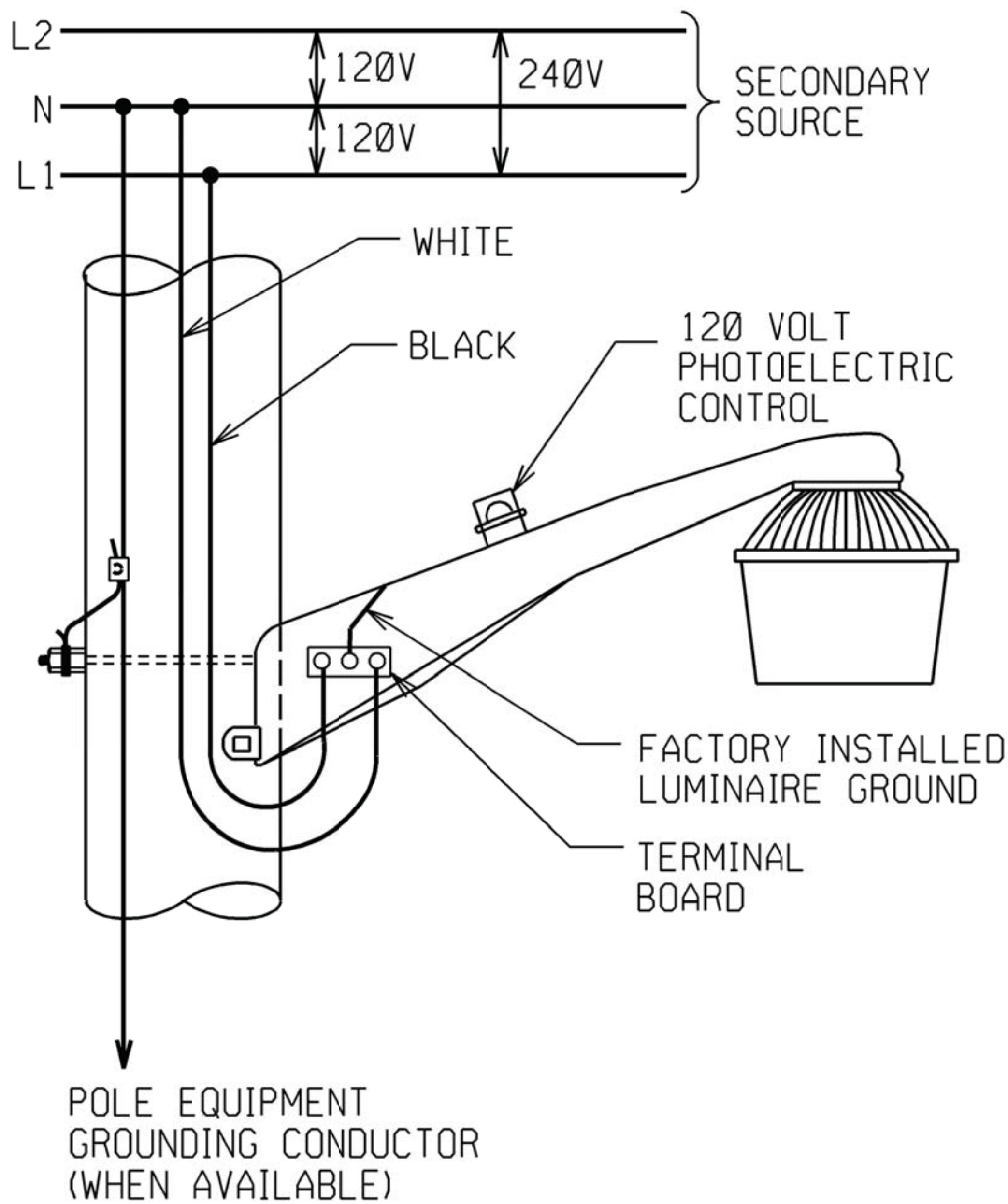


Figure 11 – Wiring Diagram for 120 Volt Residential Security Luminaire

Supersedes 7/07 Issue – Information formerly on page 19-421.

Supersedes 7/08 Issue – Information formerly on page 19-440.

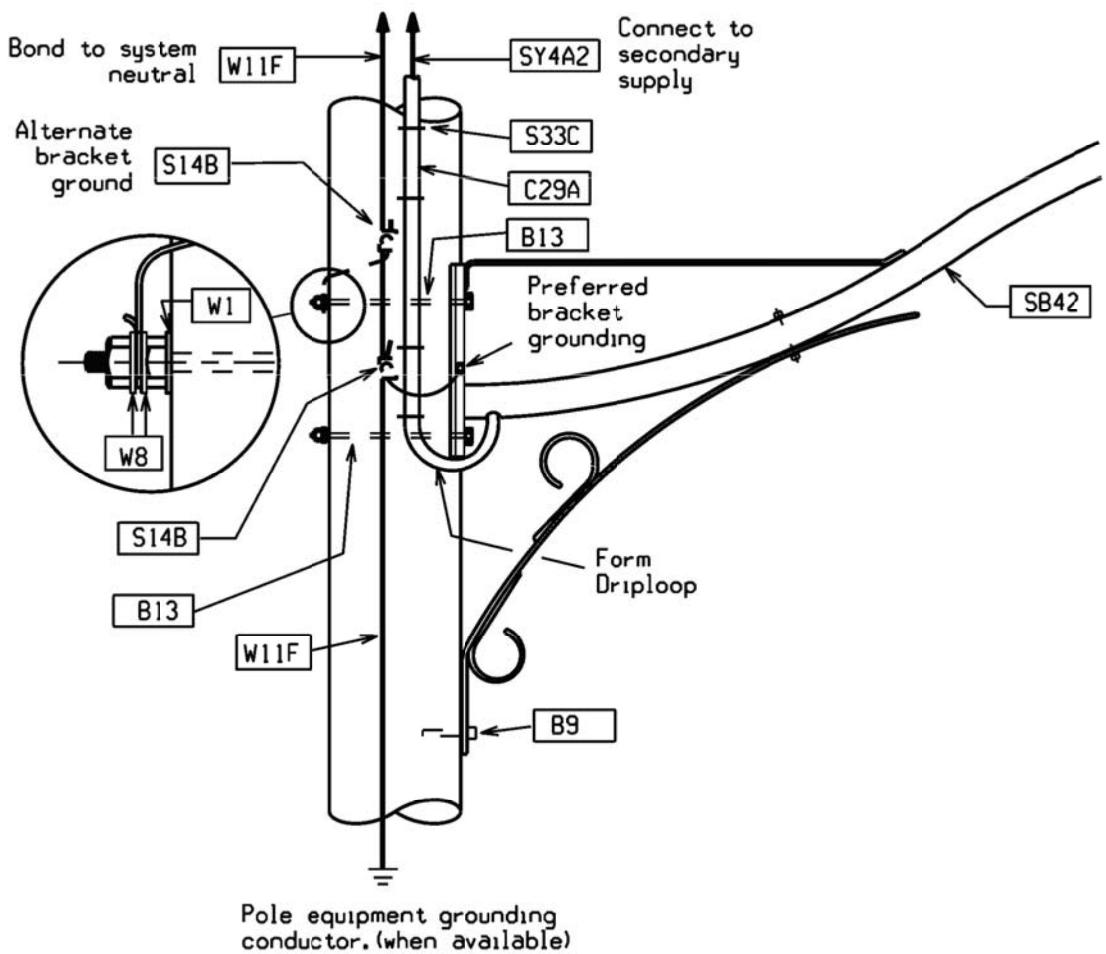


Figure 12 – Teardrop Luminaire Installation on Wood Pole

1. Before installation, always check luminaire nameplate to insure desired wattage and operating voltage.

2. Follow manufacturer's guidelines (supplied with every luminaire) for proper installation.

3. Adequate clearances from overhead conductors must be maintained. See Standards page 19-100 for details.

4. Install ½" flexible conduit to protect wiring. See Standards page 19-101 for details.

5. All installations require two 5/8 inch square head machine bolt and one 1/2 inch x 4 inch lag screws. All required bolts and lag screws must be installed in order for bracket to withstand horizontal wind loading forces. Never drive lag screw during bracket/luminaire installation with lamp installed. Lamp life will be reduced. Always install photoelectric control last.

6. Every bracket shall be grounded. Connect #4 AWG copper bracket grounding conductor to the pole equipment grounding conductor when available. Otherwise, connect bracket equipment ground conductor to system neutral

 | Doc. # ST. 19.00.003

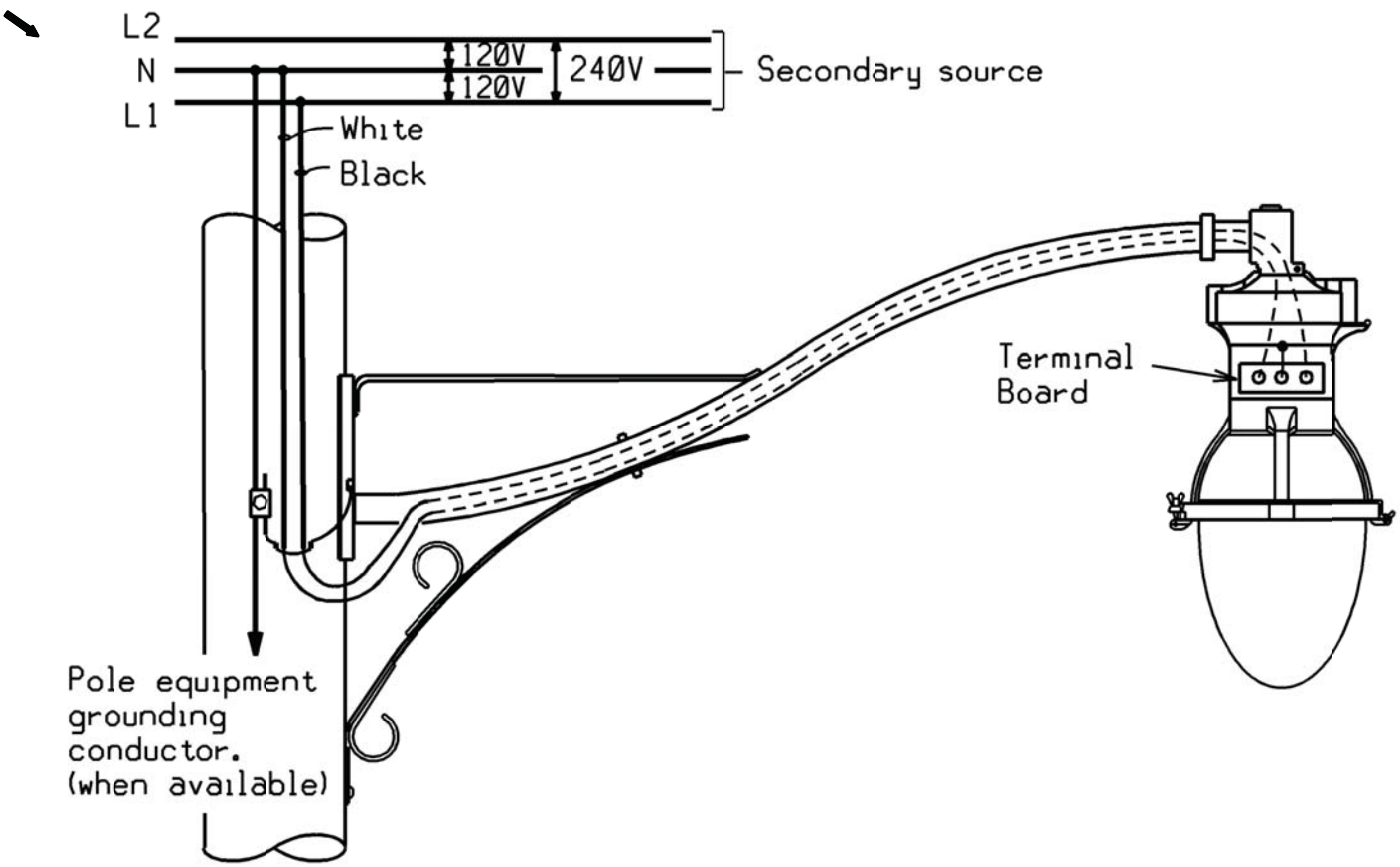


Figure 13 – Wiring Diagram for 120 Volt Teardrop Luminaire

Supersedes 7/08 Issue – Information formerly on page 19-441.

New page.

"Metropolitan" pre-stressed concrete lighting poles are available for use only in upstate New York and only as a replacement for existing steel street lighting poles that have an overhead electric supply. They are not available for any new lighting installations.

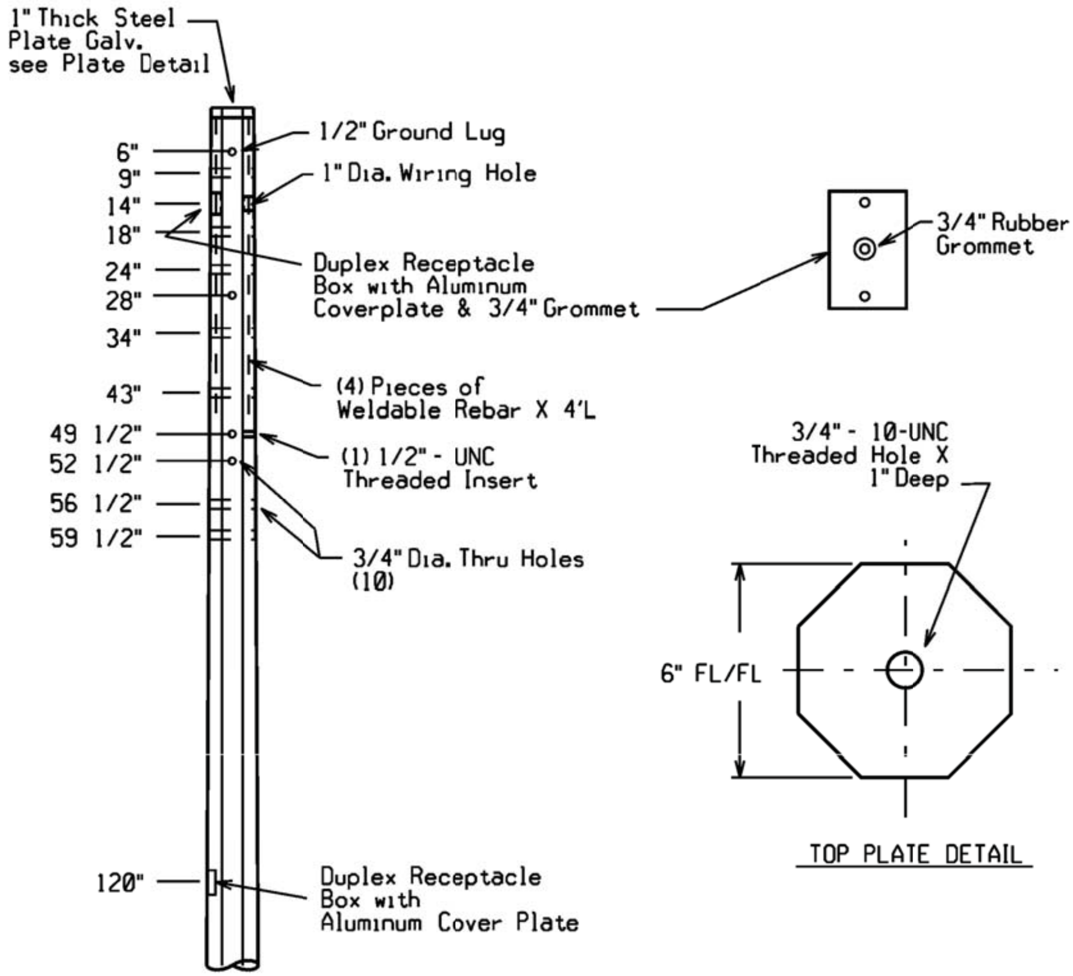


Figure 14 – Metropolitan Pre-stressed Concrete Pole – Pole Top Detail

1. Pole is factory drilled to accommodate multiple pole top wiring arrangements. See Table 2 for intended hole usage. Pole has multiple pieces of steel rebar. Field drilling of pre-stressed concrete poles is not allowed for any reason.

2. Pole will accommodate multiple arm styles. See Standards Section 49 for arm details.

3. Guying is required on all corner poles with an angle of greater than 25 degrees and on all dead end poles.

4. No other cable attachments are allowed (no CATV, communications, etc.) All municipal attachments such as banners, flowerpots, signs, etc. must have Standards Engineer approval.

5. Ground metal arm and luminaire housing with #6 AWG copper conductor (STD Item SY6AG). Connect to ground lug on pole shaft.

Table 2 – Factory Hole Locations and Usage – (measured from top of pole)

Hole Location	Hole Type	Hole Usage
0”	¾” threaded hole	Located in pole top cap to accept pin type insulator for overhead cable attachment
6”	½” ground lug	Use to ground metal arm and luminaire.
9”	3/4” diameter thru hole	Arm mounting – for STD Item ST09X1, ST09X2, ST09X3, & ST09X4 arms
14”	1” diameter wiring hole	Future use – Available to supply luminaire with underground electric source
14”	duplex receptacle box	Available to route festoon outlet wiring within the pole shaft
18”	3/4” diameter thru hole	Arm mounting – for STD Item ST09X1, ST09X2, ST09X3, & ST09X4 arms
24”	3/4” diameter thru hole	Overhead supply cable attachment
28”	3/4” diameter thru hole	Overhead supply cable attachment
34”	3/4” diameter thru hole	Arm mounting – for STD Item ST09X2 arm (lower truss member)
43”	3/4” diameter thru hole	Arm mounting – for STD Item ST09X2 arm (lower truss member)
49-1/2”	1/2” threaded insert	Arm mounting - for STD Item ST09X3 & ST09X4 arms (curved scroll brace)
49-1/2”	3/4” diameter thru hole	Guy wire attachment
52-1/2”	3/4” diameter thru hole	Guy wire attachment
56-1/2”	3/4” diameter thru hole	Guy wire attachment
59-1/2”	3/4” diameter thru hole	Guy wire attachment
120”	duplex receptacle box	Festoon outlet box

New page.

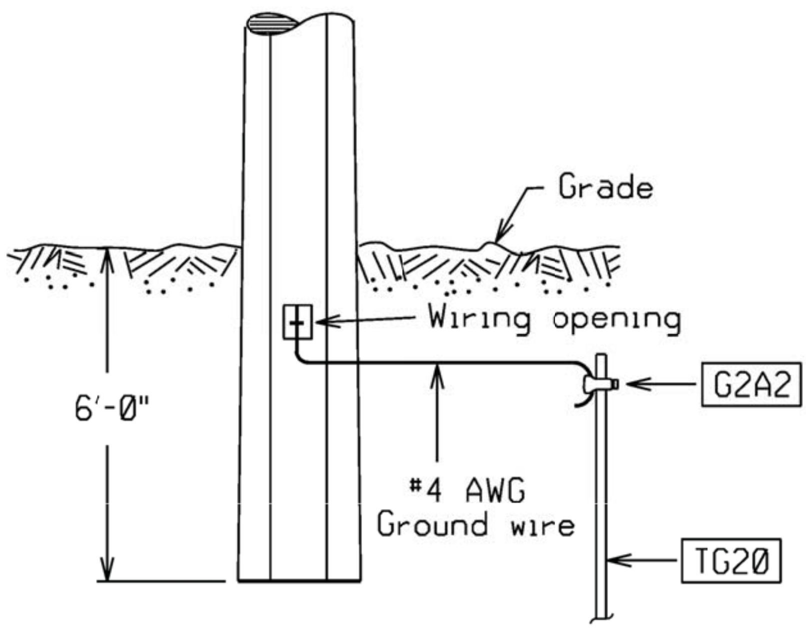


Figure 15 – Metropolitan Pre-stressed Concrete Pole – Pole Bottom Detail

1. Minimum burial depth = 6 feet.
2. Install pole numbers (STD Item SX20) in accordance with Standards page 46-301. Pole has a smooth finish.
3. install ground rod at each pole location and connect #4 AWG copper ground wire (supplied with pole).

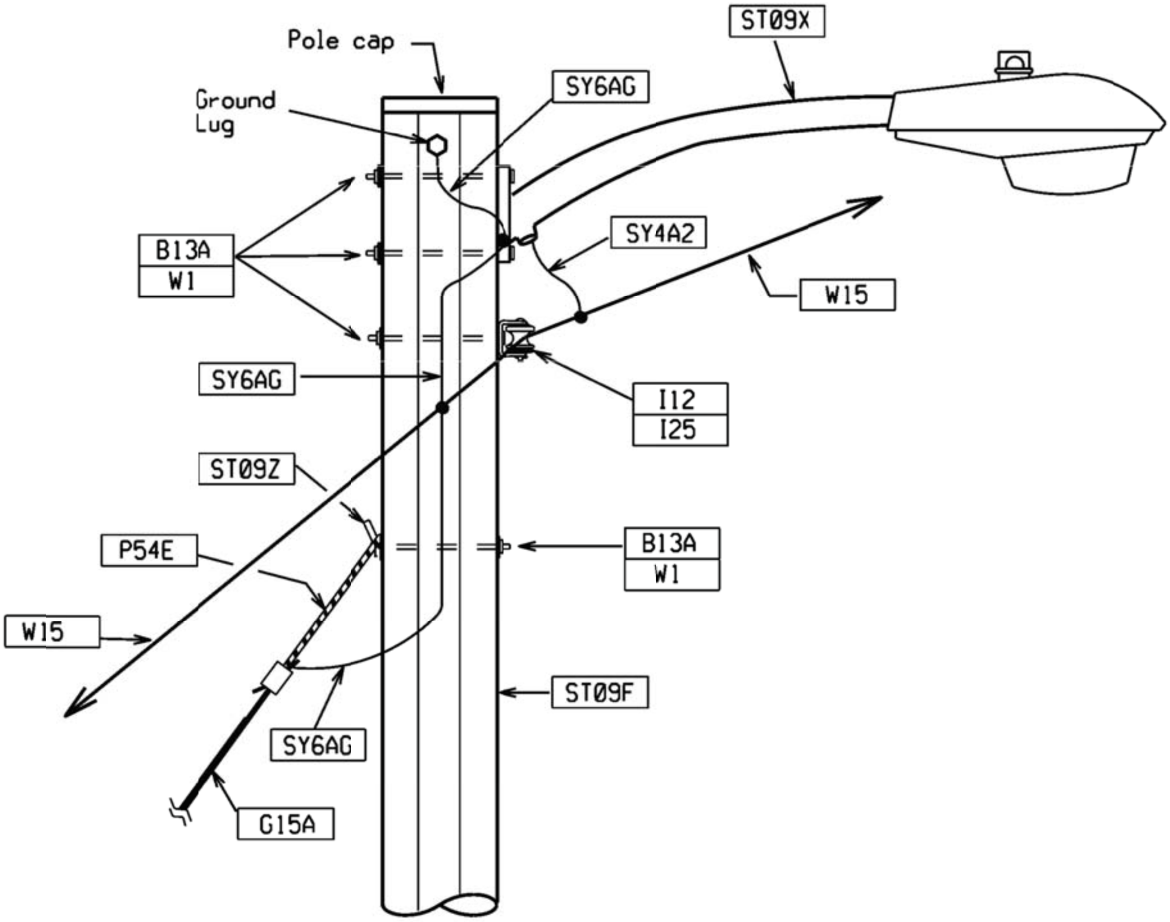


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Figure 16 – Typical Guy Wire and Overhead Cable Attachment Detail

1. Pole is factory pre-drilled to accept various secondary cable attachment needs including a dead end or a secondary junction. Use spool insulator(s) with bracket(s) (STD Items I25, I12 or I11A) as needed.

2. Pole will also accept secondary cable attachment at the pole top using an 8” insulator pin and pin type insulator (STD Items I6A & P1C1).

3. Install secondary spacer (STD Item A58B) to insure conductor separation at tap locations. Insulate secondary connections using secondary connector covers (STD Item C60R).

4. Install guying as needed in accordance with standard secondary guying practices as outlined in Standards Section 3. The STD Item ST09Z guy hook shall be used for attachment to concrete a pole and will accommodate either a standard guy wrap or fiberglass rod. Guy may be grounded by connecting to the ground lug near the pole top.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2	07/13	• Reorganized entire section • Added information on municipal owned street lights. Added information on pre-stressed concrete pole installation.	Robert Johnson	Robert Johnson Program Manager
1	07/08	• Added NESC references and revised dimensions in Figure 1. • Revised mercury vapor luminaire disposal instructions under 19.1.60. • Replaced MU codes with CU codes in Tables 2 and 3 • Replaced MU codes with CU codes in Table 4 • Replaced CU code in Table 5 • Replaced CU codes in Table 6 • Replaced CU codes in Table 7 • Changed to ½" flexible conduit under on pages 19-400, 19-401, 19-410, 19-411, 19-420, 19-430, 19-440.	Frederick Kippen	Al Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/08 Issue – Revised names of Drawings 2-105 and 2-106.

Supersedes 7/11 Issue – Revised 2.1.20 Reflectors for NH.

2.0 GENERAL

This Section covers the selection and installation of distribution poles and hardware for use on the overhead distribution systems. To ensure that the structural integrity is economically maintained for the expected life of the equipment, all wood products are treated with an acceptable preservative. Currently, pentachlorophenol (penta) preservative is purchased. The use of such equipment is most critical for maintaining a safe, reliable, and efficient overhead distribution system.

2.1 POLE SPECIFICATION AND IDENTIFICATION

Distribution poles shall be solid wood, fiberglass (fiber-reinforced polymer), or metal and in accordance with applicable standards such as ANSI Standard O5.1, Company MS2005, and MS2010. In general, poles listed on Page 2-101 are used for distribution circuits. However, where taller poles are required or pole loading is such that larger poles are required, poles traditionally stocked for transmission or sub-transmission structures may be used. Distribution pole strengths are designated by “class” 1 through 6. These classes establish pole circumference minimums.

2.1.10 Pole Numbering

Each pole carrying Company attachments shall be Company identified and individually numbered on the road-side face of the pole, approximately 7 feet above grade, as shown on Drawing 2-111. On privately owned poles, which have Company equipment attached, a single letter “P” shall be installed below the pole number. Main junction and equipment support poles may also be identified by having the line number placed above the pole number.

Each individual pole line (8 or more poles) shall have poles consecutively numbered beginning at its origination from the main line. Short branch lines expected to never contain more than eight poles shall be sub-numbered from the tap pole.

2.1.20 Reflectors

In New Hampshire, pole reflectors (STD Item # Z12A White, #Z12C Yellow) are not required on poles. Pole reflectors could be installed on company poles if requested by a state or municipal authority or may be used where deemed appropriate. For installation of reflectors see as follows:

Reflective Color – On ramps, freeways, divided highways, and one-way streets, reflective material shall face oncoming traffic and shall be colored white on the right side of the roadway and yellow on the left side of the roadway. On two-way undivided roadways, reflective material shall be colored white and shall be placed on poles to the right of, and facing, oncoming traffic on each side of the road. Install reflectors, vertically, facing traffic, centered 4 feet above grade.

2.1.30 Phase and Feeder Numbering

Phase and feeder identification, when requested, is shown on Drawing 2-112. For new construction, the first pole out of a substation shall always include phase markings. Prior to any work on multi-phase lines, phase identification shall always be confirmed with proper testing equipment (e.g. phase tester).

2.2 POLE LENGTH

The pole length and the available Company space on the pole shall be selected so that there is adequate clearance for all Company conductors and equipment that may reasonably be needed in the future. Space should be provided for communication circuits only if the communication company has arranged for joint ownership of the pole. Refer to Section 17 - Joint Use - for more information on pole ownership.

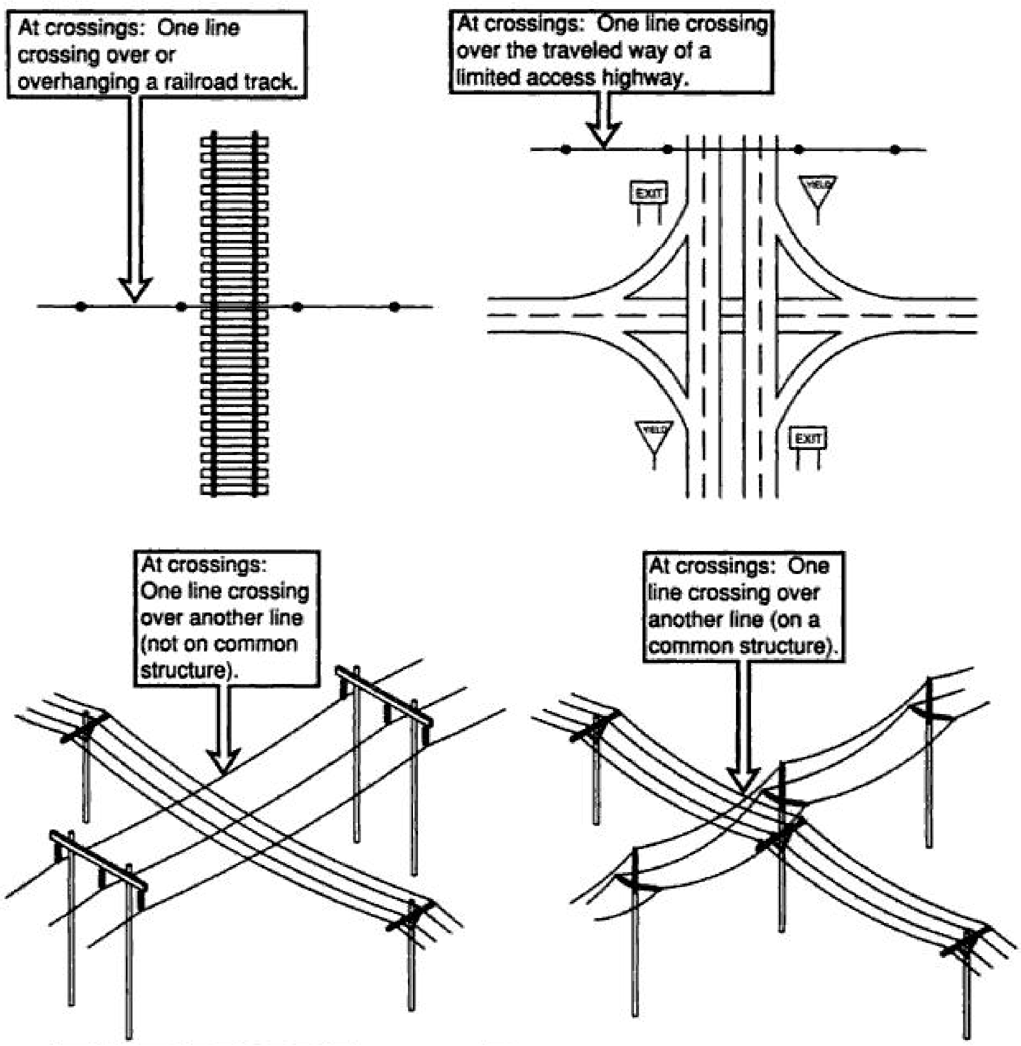
The conductor profile should also be considered in selecting pole length. If poles are set less than 150 feet apart, a difference of more than 5 feet in elevation should be avoided. For longer spans, this difference may be increased proportionately. If it is not possible to stay within these limits, it may be necessary to check the stringing and final tensions and to deadend conductors to avoid uplift or excessively heavy downward loads.

2.3 POLE STRENGTH

2.3.10 National Electric Safety Code Construction Grades and Overload Factors

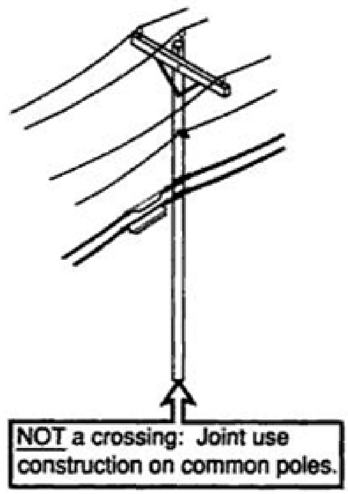
The relative order of grades for supply and communication conductors and supporting structures is B, C, and N, with Grade B being the highest. Liberty Utilities structures are typically built to Grade C except where Grade B is required per the NESC.

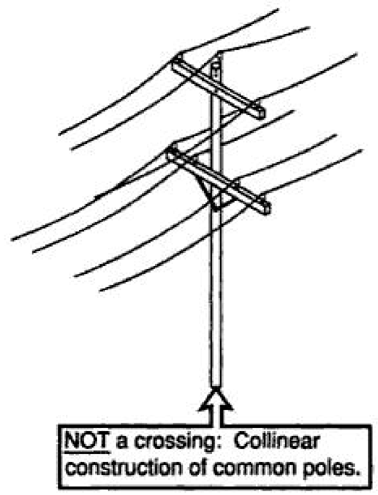
Grade B construction is primarily required at crossings. Refer to the following figures for where Grade B is required. For crossings where one line crosses over another, Grade B is required for the top line only. The bottom line need only have the grade of construction that would be required if the line at the higher level were not there.



The following two figures are examples where Grade B construction is **not** required:

Supersedes 7/08 Issue – Added NESC Construction Grade information and figures.





Breaking strengths of poles are shown on Page 2-101. The appropriate NESC overload factors and strength factors for structures and supported facilities not exceeding 60 feet above ground or water level are shown in Table 1 and Table 2. In the application of overload factors and strength factors, the objective is to design a structure with resistance greater than the maximum load expected during the lifetime of the structure and to design the structure with an acceptable level of safety and reliability. Final design loading is calculated by multiplying the transverse, vertical, and longitudinal forces by these overload factors and by installing appropriate guying per the requirements in Section 3. Spacing of holes shall be drilled on centers at least 4 inches apart when drilled on the same plane and holes located on opposing planes shall be drilled on centers at least four hole diameters apart. NOTE: On joint owned poles, the joint pole owner should be consulted for minimum spacing requirements relating to attachments located in the "communication space".

Table 1

Overload Factors			
	Grade B	Grade C	
		At crossings	Elsewhere
Vertical Loads	1.50	1.90**	1.90**
Transverse Loads			
Wind	2.50	2.20	1.75
Wire Tension	1.65	1.30*	1.30*
Longitudinal Loads			
In General	1.10	No requirement	No requirement
At Deadends	1.65	1.30*	1.30*

* For metal or prestressed concrete, portions of structures, crossarms, guys, foundations, and anchors, use a value of 1.10
** For metal, prestressed concrete, or fiber-reinforced polymer portions of structures and crossarms, guys, foundations, and anchors, use a value of 1.50

Table 2

Strength Factors		
	Grade B	Grade C
Wood Structures	0.65	0.85
Metal, Fiber-Reinforced Polymer Structures	1.0	1.0

Supersedes 7/08 Issue – Added alternate pole information under 2.3.30; some sections were renumbered due to addition of NESC info.

2.3.20 Transverse Strength

Poles with heavy wire loading on lines should be checked for unbalanced load due to wind. See Section 3 for transverse loading and guying calculations.

2.3.30 Deadend and Angle Strength

Poles at deadends and angles shall be guyed as specified in Section 3. If guys are not practical, the bearing of the soil rather than the pole strength is usually the critical value. In general, unbalanced loads at 60˚F shall not exceed 300 pounds. Slack spans should be used to limit unbalanced loading. Other options such as alternate poles (laminated wood, steel, etc) or concrete embedment can be considered. Contact Distribution Standards Engineering for assistance with pole selection or other options.

2.3.40 Vertical Strength

When transformers or other such equipment approaches their maximum size and there are other loads from down guys, change of grade, etc., heavier poles may be required. Heavy anchor guys should be avoided on these particular poles. Head guys or slack spans are recommended to keep the size of the anchor guy at a minimum.

Poles with heavy vertical loads may require additional support to prevent the pole from tipping or sinking into the ground. A footing and appropriate backfill such as #2 crushed stone is recommended where there is good reason to doubt the bearing of the soil. Particular weights can be determined through various standard or material specification sections or by checking nameplate information.

2.4 POLE SETTING

Any permits or rights-of-way required from authorities or property owners regarding pole location, digging, tree trimming, and/or conductor installation shall be obtained before proceeding with the work. The communication companies shall be notified and provision made for joint occupancy, if desired, before pole installation plans are issued.

For depth of setting into earth, rock, or wet soil, see Page 2-101. The general setting depth of a pole into earth is 10% of its total length plus two feet. The depth of holes on slopes shall be measured from the low or downhill side of the pole. For solid rock, granite, or basalt, blasting or rock drilling may not be practical, and poles may be installed in rock anchored mounts as shown on Drawing 2-105. Consult with Standards Engineering for poles that will be located in very wet or standing water areas, as they may require the use of multiple pole guys or foundation supports.

Every effort should be made to set poles so that the resulting line will be as straight, orderly, and inconspicuous as possible. The poles shall be vertical and in line with each other when the conductors have been installed. This requires care and judgment when raking poles against the pull and towards the uphill side on slopes, tamping backfill, and in using appropriate backfill such as #2 crushed stone when necessary. Increased setting depth should be considered where soil conditions may be unreliable. Poles that tip after installation should be straightened and thoroughly retamped, and/or appropriate backfill such as #2 crushed stone shall be used if necessary. For additional structural support the use of Rainbow pole setting foam is approved for use, refer to manufacturer's instructions or Standards Engineering before use. The diameter of the hole shall be large enough to permit free entrance of the butt, and to permit tamping throughout the entire depth. Sides of the hole shall be straight.

Pole gains shall normally be faced away from deadends, long spans, or other construction. They shall be faced away from crossings (where one line crosses over or under another line). This arrangement is recommended even when construction does not require crossarms. Pole gains should alternate direction faced along the line. This improves the crossarm resistance to unbalanced longitudinal loads such as in the event of partial line failures.

2.5 POLE LOCATION

Poles should be located where they can best serve both present and future customer requirements, where appearance is not objectionable to the community, where they are not likely to have to be moved in the near future, and where they are least likely to be struck by motor vehicles. Adequate conductor clearances, per Section 7, must be maintained. Poles shall not be set closer than 6 inches from the street side of a curb.

When staking out new lines or when rebuilding on streets with existing poles, the overall appearance of the line after completion should be considered. Existing poles should be used when practical, but installing more poles than necessary must be avoided. Frequent road crossings should also be avoided.

Poles and accompanying guys set in alleys, parking lots, and similar areas should be located to minimize vehicle damage. If necessary, arrange for guard rail installation, concrete bumpers, or other protection to minimize vehicle damage to poles and guys in these areas. Special attention shall be given to guard poles holding overhead primary equipment.

Pole line layout must include planning for future buildings or structures along the property lines or, if local ordinances specify, along the established building line. If it is likely that a new structure will be erected in the foreseeable future, the right-of-way should be adequate enough to provide required clearances for such structure.

2.6 POLE ATTACHMENTS

No attachments to poles owned by others (foreign poles) shall be made until proper approval has been obtained. Likewise, attachments to Company owned poles by other companies, other than those specifically approved in a joint agreement with the communication companies, shall not be made on Company poles without prior approval.

In addition, permanent pole steps shall not be utilized on wood distribution poles.

2.7 WOOD POLE SALVAGE

When a wood distribution pole that has been in service for less than ten years needs to be removed, one should consider reusing the pole if the following conditions are met.

1. The pole shall be at least a 35 foot, class 5 pole.
2. The pole shall be in sound condition. It shall be free from surface defects that would interfere with climbing. It shall also be free of surface rot, butt decay, ragged or decayed roof, and with no sign of longitudinal cracks or crossbreaks.
3. The pole shall also be of standard framing.

2.8 ALTERNATIVE POLES

Alternative poles including fiberglass and metal per appropriate material specifications can be purchased and installed resulting in a cost effective installation.

2.8.10. Fiberglass Poles

Lightweight easy to handle fiberglass poles can be selected for difficult locations including rights-of-ways, wetlands, and backyards. Unique environmental conditions including woodpecker attack may also warrant a fiberglass pole installation.

Supersedes 7/08 Issue – Removed spacer cable restriction from fiberglass pole use.

2.8.20. Metal Poles

Metal poles can be selected for installation locations when increase pole strength requirements are necessary due to heavy equipment loading, environmental loading, or where guying cannot be accomplished. Since these poles are designed specific, all specifications and moments shall be calculated and provided to supplier for appropriate fabrication. Metal pole installations will require additional insulation equipment such as fiberglass crossarms and brackets, insulators, and additional surge arresters to maintain appropriate lightning insulation values. In addition, metal poles shall not be installed in heavily corrosive environments which results in oxidation.

2.8.30. Attachments

Most standard, non-cleated line hardware can be used on alternative poles with conventional fasteners and installation practices. Structural attachments must be made with through bolts and square washers which enhances the load-bearing capacity interface. Fiberglass crossarms and fiberglass armless brackets shall be used. Fiberglass crossarms include centermounts for attaching and down grounds shall be installed using nylon clips with self tapping screws. Equipment and line attachment bolts may, when practical utilize the standard evenly spaced step bolt holes. Except for un-guyed installations, the same wood pole burial depth and backfill requirements exist.

2.8.40. Unguyed Poles

For installations where guying is not an option due to structures near the pole or other objects restricting guy wire placement, an unguyed pole can be installed. Contact Distribution Standards Engineering for available pole options.

2.9 POLE LINE HARDWARE

Pole line hardware will be of a type specifically developed for utility pole line installation in accordance with industry specifications.

2.9.10 Crossarms

Overhead distribution crossarms shall be solid wood or fiberglass and in accordance with applicable standards such as Company MS2121 and MS2142. Both wood and fiberglass crossarms can be installed on any type of pole (wood, fiberglass, steel, etc.), however, fiberglass arms are not designed to be used for alley-arm construction.

For installations above 2000 lbs. tension, Engineering shall make sure that the conductor tension under NESC heavy loading conditions obtained from Section 6 is less than the permissible deadend loading per conductor of the crossarm assembly. However, if the conductor tension is limited to 2000 lbs, the NESC allows the use of double wood crossarm or equivalent strength fiberglass assemblies for Grade B and C. In addition, the deadend span should be less than the maximum span length allowed due to vertical crossarm strength limitations. However, this is seldom a limiting factor in distribution design.

For Grade B construction, the NESC requires the use of double wood or equivalent strength fiberglass crossarms at each crossing structure, at deadends, and at corners where line angles exceed 20 degrees. Under similar conditions, where brackets are used to support conductors and there is no crossarm below, double brackets or a support assembly equivalent in strength to double wood crossarms shall be used (NESC 261D5c). Wires, conductors, or other cables of one line are considered to be at crossings when they cross over another line, whether or not on a common supporting structure, or when they cross over or overhang on a railroad track or the

Supersedes 7/08 Issue - added 2.8.40: added useage information for crossarms.

traveled way of a limited access highway or navigable waterways requiring waterway crossing permits. Joint-use or collinear construction in itself is not considered to be at crossings (refer to Section 2.3.10 above for more information).

2.9.20 Vertical Strength of Wood Crossarms

The NESC requires that the sum of each vertical load attached to a crossarm assembly, multiplied by the loads appropriate NESC vertical overload factor (Table 1), and the load's distance to the center of the crossarm assembly not exceed the permitted vertical moment capacity of the crossarm.

Vertical loads on the crossarm assembly per NESC include;
1. The weight of the conductors.
2. The weight of a 250 lb line worker.
3. The self-weight of the crossarm.
4. The weight of other hardware including cutouts.

Depending on this information, the maximum span length allowed for various conductors can be obtained by using the following formula:

∑Applied vertical load moments ≤ Permitted vertical moment capacity

$$((D_1 + D_2) \times S \times W \times F_V) + M_E \leq N \times M_V \times F_S$$

S = Weight span length (ft.)
D_1, D_2 = distance of conductor from center of the crossarm (ft., see Figure 1)
N = number of crossarms
W = unit weight of conductor (lbs/ft.)
M_E = moment due to weight of equip. attached to crossarm (ft.-lbs.)
M_v = vertical moment capacity of the crossarm with predrilled holes
$M_v = F_b \times X_v$ (ft.-lbs.)
X_v = vertical section modulus of the crossarm (in.^{3})
$X_v = (bd^3 - ba^3 - ad^3)/6d$
b = width(in., top of arm), d = depth(in., face of arm)
a = diameter (in.) of crossarm mounting holes
F_b = the designated modulus of rupture for crossarms
(ANSI 05.1 → F_b = 8,000 lbs/in^2)
F_S = NESC strength factor
F_V = NESC vertical overload factor

2.9.30 Longitudinal Strength of Wood Crossarms

It may be assumed that longitudinal loads do not contribute to the vertical loading on crossarm assemblies. However applied vertical loads do have to be considered when determining the permitted longitudinal load of a crossarm assembly. Depending on this information, the following relationship needs to be satisfied to avoid overloading the wood fibers of crossarms:

$$\frac{\sum \text{Applied Vertical Load Moments}}{\text{Permitted Vertical Moment Capacity}} + \frac{\sum \text{Applied Longitudinal Load Moments}}{\text{Permitted Longitudinal Moment Capacity}} \leq 1$$

Applied vertical load moments and permitted vertical moment capacity were defined in 2.9.20 above. Applied longitudinal load moments and permitted longitudinal moment capacity for deadend crossarm assemblies are as follows:

Supersedes 7/08 Issue - Text shift.

$\sum$Applied longitudinal load moments = $(D_1 + D_2) \times L \times F_{OL}$
Permitted longitudinal moment capacity = $N \times M_h \times F_S$

L = permissible deadend loading per conductor (lbs.)
D_1, D_2 = distance of conductor from center of the crossarm (ft., see Figure 1)
N = number of crossarms
M_h = longitudinal moment capacity of the crossarm with predrilled holes
$M_h = F_b \times X_h$ (ft.-lbs.)
X_h = longitudinal section modulus of the crossarm (in.^{3})
$X_h = (db^3 - ab^3 - da^3)/6b$
b = width(in., top of arm), d = depth(in., face of arm)
a = diameter (in.) of crossarm mounting holes
F_b = the designated modulus of rupture for crossarms
(ANSI 05.1 → F_b = 8,000 lbs/in^2)
F_S = NESC strength factor
F_{OL} = NESC longitudinal overload factor

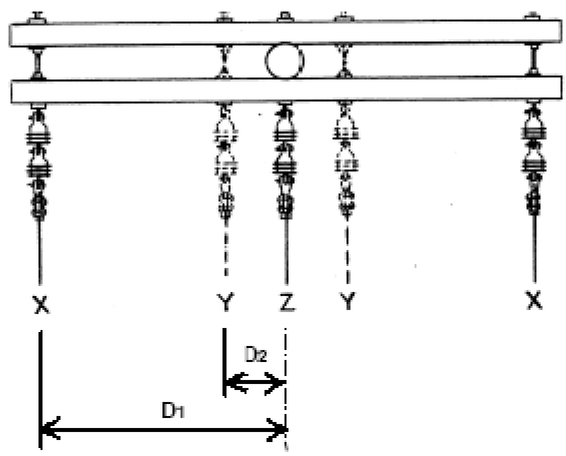


Figure 1

Supersedes 7/08 Issue - Text shift.

2.9.40 Crossarm Braces

The NESC requires all crossarms to be securely supported by bracing, if necessary, to support all loads including the weight of line workers. Wood crossarm braces shall be used for all standard construction installations increasing the pole top distribution insulation level.

2.9.50 Insulators

The operating performance of overhead distribution lines is dependent upon the quality of the line insulators. Line insulators can be porcelain or polymer. Polymer (HDPE) pin type insulators for distribution are available and shall be used with all new and existing covered conductors including tree wire, spacer cable, and older polyethylene covered conductor. HDPE insulators and conductor coverings are dielectrically compatible with neither one being electrically over-stressed. During insulator replacement, always examine existing conductor covering for erosion, cracks, or puncture holes. If significant damage exists, install a porcelain radio free insulator and skin the covering back at least 30 inches on each side.

A #4 solid, soft drawn, thermoplastic rubber (TPR) covered aluminum tie wire is available and is the only tie wire that shall be used with all HDPE insulators with unskinned, covered aluminum or unskinned, covered copper conductors. The TPR covering provides similar dielectric characteristics and a slip-proof grip on covered conductors.

HDPE insulators can be used on bare conductors in areas where vandalism occurs provided environmental contamination doesn't exist and conductor operating temperatures are below 100°C.

2.9.60 Pole Top Extension

Pole top extensions shall be installed only on sound wood poles. The wood pole top should be squared off to accept the adapter base bracket and to facilitate installation; the base component may be installed onto the pole first, before the wood or fiberglass extending member is attached.

Do not use pole top extensions (wood or fiberglass) at deadends or Grade B locations (e.g. crossings). Transverse loading shall be limited to 1600 lbs (applied 12 inches below top of extension) in compliance with NESC overload factors in Table 1.

2.9.70 Raptor Protection

One or more state and federal laws legally protect many species of birds in the Company's service territory. So that the Company complies with laws and regulations protecting these birds, it is necessary to follow appropriate procedures regarding raptor protection. A 60" separation between energized and/or grounded facilities is generally recognized. Since this is rarely encountered on distribution lines, covers can be installed to prevent simultaneous contact between energized and/or grounded facilities.

Any distribution pole with an active nest or confirmed nesting attempts should be reported to Environmental. The distribution pole may need to be modified per appropriate raptor construction drawings as determined appropriate in consultation with Environmental.

Supersedes 7/08 Issue - Text shift; ,minor editorial changes.

2.10 POLE CLASSIFICATION

Selecting the proper class pole is an important decision in distribution design. The pole class is mainly dependent upon the loading that the pole must withstand under NESC heavy loading conditions. Conductor loading, equipment loading, and downward forces caused by guying, must all be considered in order to select the proper class of pole.

This section will include methods of determining the class of an unguyed pole considering conductor loading and equipment loading only. See Section 3 for determining the class of a guyed pole.

2.10.10 Example

Given:

Determine the class of pole required to support the following wires and equipment on a 40 foot, unguyed wood pole with a 150 foot wind span for Grade C construction (non-crossing) under heavy loading conditions.

3-336.4 kcmil Al AAC bare conductors - 33.5’ attachment height
(Outside phases are the same horizontal distances from the pole, therefore no bending moment is created)
3/C-1/0 triplex secondary - 27.3’ attachment height
0.750-1/4” messenger (CATV) - 24.0’ attachment height
134-216 fiber optic and 1/4” messenger telephone cable - 23.0’ attachment height
400 pair, #22 AWG and 3/8” messenger telephone cable - 21.0’ attachment height
1-50 kVA single-phase transformer - 29.5’ attachment height
- 16” from the center of transformer to the center of pole

Step	Action	Use
1	Check the pole strength due to the transformer vertical load: The weight of the transformer is 640 lbs. Check the allowable weight that can be mounted from 4.5 feet (54 inches) from the top of the pole by using Table 3. Try Class 5 first.	Transformer weight = 640 lbs Allowable weight = **2085 lbs** Class 5 is adequate for vertical load.
2	Calculate the groundline moment due to the conductor wind load.	Moment = $F_w \times S_w \times W_w \times H$ F_w = NESC overload factor for wind load S_w = wind span length (ft) W_w = transverse conductor loading (lbs/ft) (Section 6 & 10 and Table 7) H = conductor attachment height (ft) 3-primaries - 3 x 1.75 x 150 x 0.5556 x 33.5 = 14657.42 1-secondary - 1.75 x 150 x 0.6600 x 27.3 = 4729.73 1-CATV - 1.75 x 150 x 0.6900 x 24.0 = 4347.00 1-Fiber optic tel. cable - 1.75 x 150 x 0.6600 x 23.0 = 3984.75 1-400 pair tel. cable - 1.75 x 150 x 1.1150 x 21.0 = 6146.44 Total groundline moment = **33865.34 (ft-lbs)**

Supersedes 7/08 Issue - text shift

3	Calculate the groundline moment due to the equipment wind load.	Moment = $F_w \times W_e \times H$ F_w = NESC overload factor for wind load W_e = transverse equipment loading (lbs) (Table 6) H = equipment attachment height (ft) 1-50 kVA single-phase xfmr - 1.75 x 44 x 29.5 = 2271.5 Total groundline moment = **2271.5 (ft-lbs)**
4	Calculate the bending moment due to the equipment offset.	Moment = $F_v \times$ weight of equipment $\times$ (d/12) F_v = NESC overload factor for vertical loads d = distance from the center of equipment to the center of pole (inches) 1-50 kVA single-phase xfmr - 1.90 x 640 x 16/12 = 1621.33 Total bending moment = **1621.33 (ft-lbs)**
5	Calculate the pole's groundline moment due to the wind load.	Use Table 4. Try Class 5 first. Total groundline moment = **2468.00 (ft-lbs)**
6	Calculate total applied moment at groundline.	33865.34 + 2271.5 + 1621.33 + 2468 = **40226.17 ft-lbs**
7	Find the permitted moment of pole at groundline by using Table 5.	40 foot Class 5 pole = 51680 ft-lbs Permitted moment > Calculated moment **51680 ft-lbs > 40226.17 ft-lbs** **Since the permitted moment capacity of the wood pole at groundline is larger than the applied moments, 40 foot Class 5 is adequate**

Supersedes 7/08 Issue - text shift

Table 3										
MAXIMUM ALLOWABLE WEIGHT OF EQUIPMENT										
POLE SIZE/CLASS	**DISTANCE FROM TOP OF POLE TO THE TOP MOUNTING BOLT OF THE EQUIPMENT**									
	SINGLE MOUNT WOOD POLES					**CLUSTER MOUNT WOOD POLES**				
	24”	**36”**	**54”**	**60”**	**84”**	**24”**	**36”**	**54”**	**60”**	**84”**
35/1	5220	5580	6165	6365	7300	6960	7440	8220	8490	9730
35/2	4250	4530	5020	5190	5975	5665	6040	6695	6920	7970
35/3	3405	3640	4025	4170	4800	4540	4850	5370	5560	6395
35/4	2675	2870	3190	3305	3805	3570	3830	4255	4410	5070
35/5	2060	2220	2460	2555	2955	2750	2955	3280	3405	3940
40/1	4445	4705	5150	5320	6020	5925	6270	6870	7100	8030
40/2	3620	3840	4215	4345	4930	4825	5120	5620	5795	6575
40/3	2900	3085	3400	3510	3980	3870	4115	4535	4680	5310
40/4	2300	2435	2680	2770	3160	3065	3245	3575	3695	4215
40/5	1770	1880	2085	2155	2460	2360	2510	2780	2875	3280
45/1	3920	4135	4500	4620	5180	5225	5510	6000	6165	6905
45/2	3190	3390	3685	3790	4260	4255	4520	4915	5055	5685
45/3	2560	2710	2960	3030	3410	3416	3615	3945	4040	4545
45/4	2015	2140	2335	2405	2720	2690	2855	3110	3210	3630
45/5	1555	1660	1815	1870	2120	2075	2210	2420	2495	2825
50/1	3505	3685	3995	4100	4560	4675	4915	5325	5465	6080
50/2	2840	3010	3255	3345	3720	3790	4015	4345	4460	4960
50/3	2280	2410	2615	2690	2990	3040	3210	3485	3585	3985
50/4	1805	1900	2075	2125	2385	2410	2535	2765	2830	3180
50/5	1390	1480	1610	1650	1855	1855	1975	2150	2205	2475
	SINGLE MOUNT FIBERGLASS POLES					**CLUSTER MOUNT FIBERGLASS POLES**				
35/4	2740	2760	2800	2810	2895	3653	3680	3733	3747	3860
40/3	2380	2390	2415	2420	2475	3173	3187	3220	3227	3300
45/2	2580	2585	2605	2615	2660	3440	3447	3473	3487	3547

1. This table can be used for both Grade B and Grade C construction.
2. Based on 2’ lug spacing (for 3’ lug spacing see note 4).
3. Assumed that the bottom attachment point is the critical location for eccentric loading (2% deflection).
4. For 167kVA (219A) regulator cluster mounts add 5% to the values shown above (or multiply by 1.05) due to 3’ lug spacing.
5. Fiberglass pole information is from Roark, deflection for cantilever with applied moment

Supersedes 7/08 Issue - text shift.

Table 4
Distribution Pole Groundline Moments Due To Wind Load (ft-lbs)
(Set in Earth)

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
35 foot	2505	2330	2155	1979	1804	1643
40 foot	3399	3166	2934	2701	2468	2236
45 foot	4449	4151	3830	3532	3234	2936
50 foot	5665	5264	4864	4492	4120	-----
55 foot	7017	6529	6040	5586	-----	-----
60 foot	8535	7950	7364	6778	-----	-----
65 foot	10225	9533	8842	-----	-----	-----
70 foot	12091	11285	10479	-----	-----	-----

Multiply these values by 1.26 for Grade C at-crossings and 1.43 for Grade B.

Table 5
Distribution Pole Permitted Groundline Moments (ft-lbs)
(Set in Earth)

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
35 foot	105188	86488	70125	56100	44413	35063
40 foot	122400	100640	81600	65280	51680	40800
45 foot	139613	114793	93075	74460	58948	46538
50 foot	156825	128945	104550	83640	66215	-----
55 foot	174038	143098	116025	92820	-----	-----
60 foot	191250	157250	127500	102000	-----	-----
65 foot	208463	171403	138975	-----	-----	-----
70 foot	225675	185555	150450	-----	-----	-----

Multiply these values by 0.765 for Grade B for wood structures
Multiply these values by 1.0 for fiberglass poles

Supersedes 7/08 Issue - text shift

Table 6

Transverse Equipment Loading For 4 lbs/sq. ft. Wind Load

EQUIPMENT	*Effective Area (sq. ft.)*	*Load Reduction Factor*	*Reduced Eff. Area (sq. ft.)*	*Transverse Equipment Load (lbs)*
Capacitor Bank 450kVAR Sw.	3	90%	3	12
Capacitor Bank 1200kVAR Sw.	7	85%	6	24
Floodlight (All)	3	90%	3	12
Gang Operated Switch	18	90%	16	65
Primary Metering	7	85%	6	24
Recloser three-phase	4	90%	4	16
Regulator - 76kVA(100A) single-phase	12	85%	10	40
Regulator - 167kVA(219A) single-phase	15	85%	13	52
Regulator - 3-76kVA(100A) three-phase	24	85%	20	80
Regulator - 3-167kVA(219A) three-phase	30	85%	26	104
Streetlight (All)	4	85%	3	13
Trans. single phase up to 75kVA	12	90%	11	44
Trans. single phase 100kVA and up	17	90%	15	60
Transformer 3-100kVA and up	34	90%	31	124

Table 7

Common Telephone & CATV Cables Transverse Load Factor (Wind)

Description		**Conductor Diameter (in.)**	**Transverse Load (lbs. /ft.)**
#22 AWG and 3/8" Messenger	200 Pair	1.815	0.938
	300 Pair	2.115	1.038
	400 Pair	2.345	1.115
#24 AWG and 3/8" Messenger	600 Pair	2.295	1.098
	900 Pair	2.685	1.228
Fiber Optic and ¼" Messenger (non-armored)	3-36	0.640	0.547
	38-72	0.739	0.580
	74-84	0.781	0.594
	86-96	0.820	0.607
	98-108	0.850	0.617
	110-120	0.889	0.630
	122-132	0.931	0.644
	134-216	0.979	0.660
	218-264	1.045	0.682
Fiber Optic and 3/8" Messenger (non-armored)	144	1.159	0.720
Fiber Optic Self Supporting Figure "8" Cable (non-armored)	2-72 & 2-36	0.949	0.650
	74-84	0.991	0.664
	86-96	1.030	0.677
	98-108	1.060	0.687
	110-120	1.099	0.700
	122-132	1.141	0.714
	134-144	1.189	0.730
¼" Messenger (CATV)	0.750	1.069	0.690
	0.635	0.883	0.628
	0.500	0.751	0.584
	0.412	0.652	0.551

BLANK

CU = PW(A)(B)	Distribution Wood Pole, (A)=Pole Length, (B)=Pole Class

ANSI 05.1 POLE CLASS (see Note 2)	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6
Minimum Top Circumference	27 in.	25 in.	23 in.	21 in.	19 in.	17 in.
Minimum Top Diameter	8.6 in.	8 in.	7.3 in.	6.7 in.	6 in.	5.4 in.
Breaking load in lbs. @ 2 feet from top for unguyed poles set in earth at standard setting depth	4500 #	3700 #	3000 #	2400 #	1900 #	1500 #

Southern Yellow Pine and Douglas Fir Poles (Ultimate Fiber/Bending Stress = 8000 psi)									
Pole Length (Feet)	Setting Depth (Feet)			Minimum Circumference in inches as measured 6 feet from the pole butt					
	In Earth	In Rock	Wet Soil						
35	6	4	8	39	36.5	34	31.5	29	27
40	6	4	8	41	38.5	36	33.5	31	28.5
45	6.5	4.5	8.5	43	40.5	37.5	35	32.5	30
50	7	4.5	9	45	42	39	36.5	34	-----
55	7.5	5	9.5	46.5	43.5	40.5	38	-----	-----
60	8	5.5	10	48	45	42	39	-----	-----
65	8.5	6	10.5	49.5	46.5	43.5	-----	-----	-----
70	9	6.5	11	51	48	45	-----	-----	-----

Western Red Cedar Poles (Ultimate Fiber/Bending Stress = 6000 psi)									
Pole Length (Feet)	Setting Depth (Feet)			Minimum Circumference in inches as measured 6 feet from the pole butt					
	In Earth	In Rock	Wet Soil						
35	6	4	8	42.5	40	37.5	34.5	32	30
40	6	4	8	45	42.5	39.5	36.5	34	31.5
45	6.5	4.5	8.5	47.5	44.5	41.5	38.5	36	33
50	7	4.5	9	49.5	46.5	43.5	40	37.5	-----
55	7.5	5	9.5	51.5	48.5	45	42	-----	-----

1. See Page 2-102 for weights for common pole sizes and wood species and Section 22.
2. Class and technical data taken from current ANSI specification 05.1. Poles are classed according to minimum size and minimum breaking load capacity. All poles of the same class shall have the same strength. Pole species of lower ultimate fiber (bending) strength will be larger in diameter than stronger/harder specie poles.
3. Basic formulas for area and diameter calculations are: $A=\pi r^2$, $C=\pi D$, and $D=C/\pi$.
4. Poles that are to be located in areas that are very wet or in areas that have standing water should be referred to Standards Engineering as they may require the use of multiple pole guys or foundation supports.

POLE LENGTH (Feet)	CENTER OF GRAVITY (Measured in feet from butt)	AVERAGE WEIGHT IN POUNDS					
	FULL LENGTH TREATED SOUTHERN YELLOW PINE POLES						
		CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6
20		-----	-----	-----	-----	330	284
25		-----	-----	674	573	490	422
30		-----	-----	921	784	660	550
35	16	1567	1343	1155	1004	862	742
40	18.5	1884	1622	1403	1219	1059	921
45	20.5	2222	1911	1664	1444	1274	1114
50	22	2585	2214	1925	1687	1494	-----
55	23	2990	2590	2245	1945	-----	-----
60	14 & 45	3755	3260	2820	2450	-----	-----
65	14 & 47.5	4265	3695	3205	-----	-----	-----
70	15 & 50	4805	4170	3610	-----	-----	-----
	FULL LENGTH TREATED WESTERN RED CEDAR POLES						
30		-----	-----	645	540	440	370
35	16	1055	880	750	660	570	495
40	17.5	1320	1145	970	790	705	615
45	19.5	1585	1365	1145	1010	880	-----
50	21.5	1760	1585	1365	1230	1145	-----
55	23	2025	1760	1540	1410	-----	-----
	FIBERGLASS POLES						
35	17.5	-----	-----	-----	350	-----	-----
40	20	-----	-----	450	-----	-----	-----
45	22.5	-----	700	-----	-----	-----	-----

1. Detailed wood pole specifications are published in ANSI 05.1 and by The American Wood Preserver's Association (AWPA).
2. When lifting poles, care must be taken to avoid excessive bending and the possibility of cracking. Poles shorter than 60 feet may be picked up at the center of gravity of the pole. Poles 60 feet and longer shall be picked up at two points, listed in the above Table under Center Of Gravity.
3. Extremely wet wood poles may exceed maximum weights by 100-300 pounds.

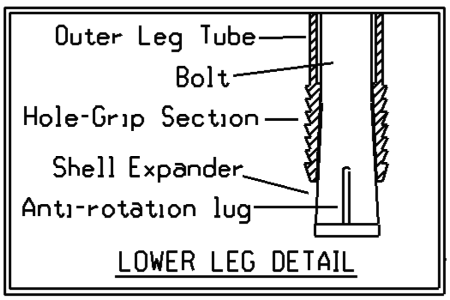
CU = PMNT3P14A	3 Anchor Leg
CU = PMNT4P14A	4 Anchor Leg
CU = PMNT5P14A	5 Anchor Leg

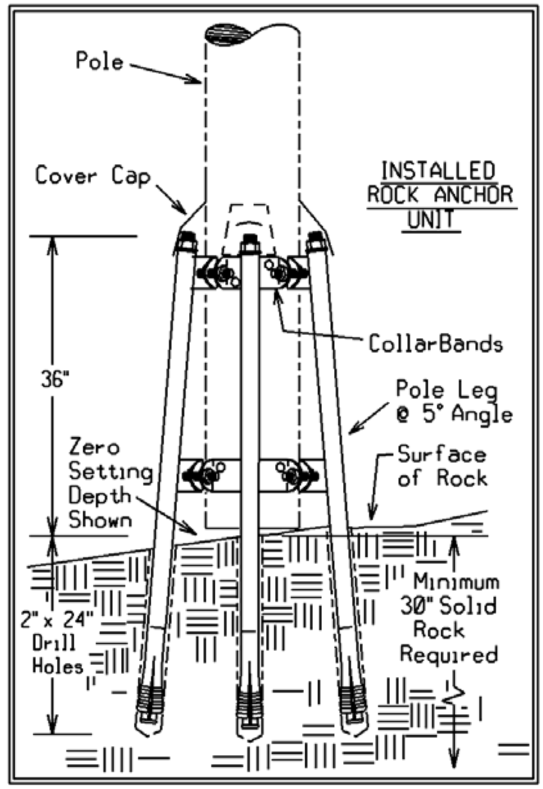
When Distribution poles are to be set in areas where sound bedrock is at or near the surface, the pole rock anchor (Item P14A) is recommended. Rock anchors may be installed above or below grade and, when properly installed, provide anchorage equaling or exceeding standard soil installations.

Failure to use all of the packaged hardware or to adhere to the following procedure will result in an improper installation.

The anchor assembly may be bonded to grounding conductors but shall not be considered as a grounding component.

The Drilling Template (Items P14AT - P14CT) must be ordered separately and shall be retained for future re-use.





Selection and Installation

1. Location must allow 24” deep anchor leg holes drilled into (a 30” minimum thickness of) strong, solid rock. Pole butt must rest on rock surface at some point and rock shall slope not more than 3” across pole diameter. Non-solid rock or soil overburden must be removed to expose the solid rock. Pole anchor may be installed above or below grade but the legs shall be installed into 24” of solid rock. Reduced or zero setting depth may reduce pole length required, allowing selection of a shorter pole.

2. Measure pole butt diameter approximately 6” from butt end to determine the number of anchor legs required. For 8” to 12” diameter poles, use 3 anchor legs. 11” to 16” diameter poles, use 4 legs. 15” to 20” diameter poles, use 5 legs.

3. Adjust the Drilling Template to the pole butt diameter (as measured 6” from butt end). Place the template on the rock and adjust to level. Drill the first hole (sloping outward) at the highest hole location (if location is not level) to a 24” depth. Dill holes must be in solid, hard rock.

4. Place two anchor legs into drilled holes and loosely connect their collarbands.

5. Install pole in place, plumb, and hold in position. Install remaining anchor leg(s) and tighten interconnecting band bolts - sufficiently to slightly deflect band collars.

6. Rigorously tighten the large nuts at the top of anchor legs to force open the expansion shields at leg bottom ends. If sufficient force (torque) is not developed, unsound rock is indicated.

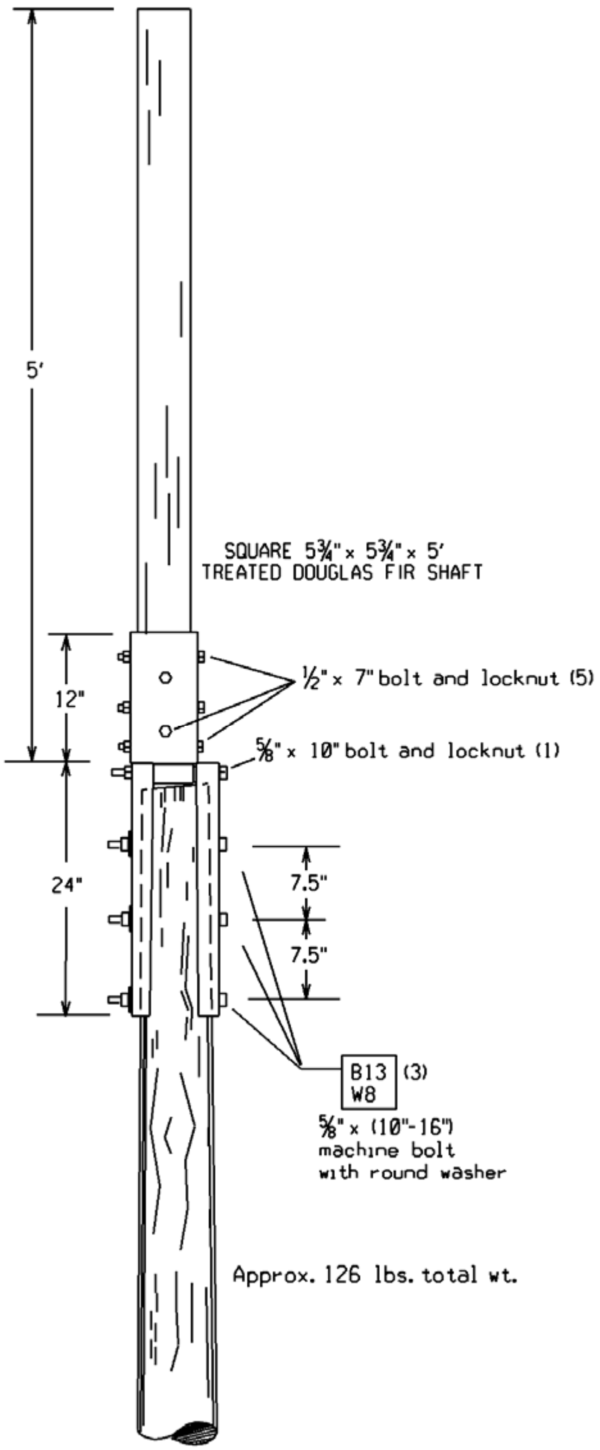
7. Install **all** remaining lag bolts.

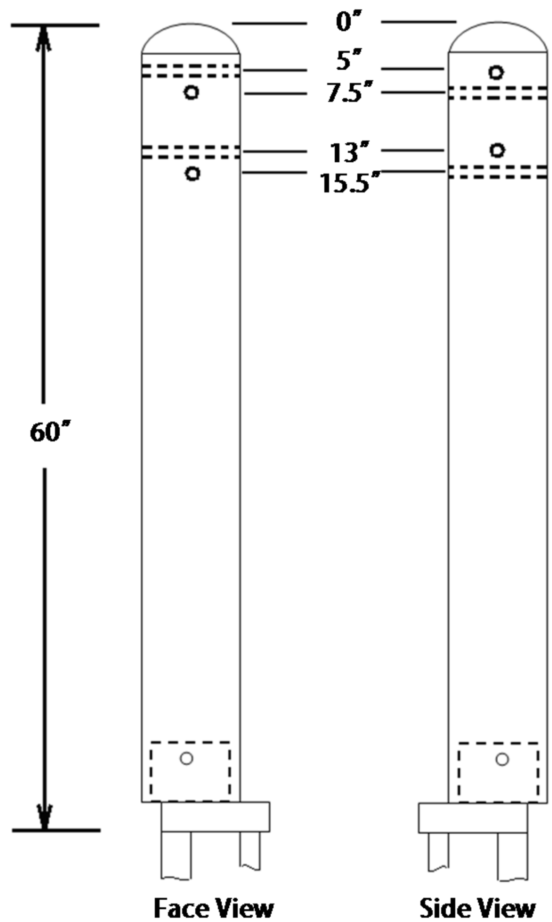
8. Install anchor leg top covers. Install rock anchor identification tag (Std Item P25) just below the pole number tags. The identification tag is especially important if rock anchor assembly is buried in the future and may not be visible. Anchor bolt holes may be grouted where ice may be a concern.

9. Guy all angles and deadends as required per Section 3.

Supersedes 7/08 Issue - Updated Std Item Numbers; edited notes.

CU = POLE-2-106TOPEXTP12A	Wood Pole Top Extension
CU = POLE-2-106TOPEXTP12A1	Fiberglass Pole Top Extension



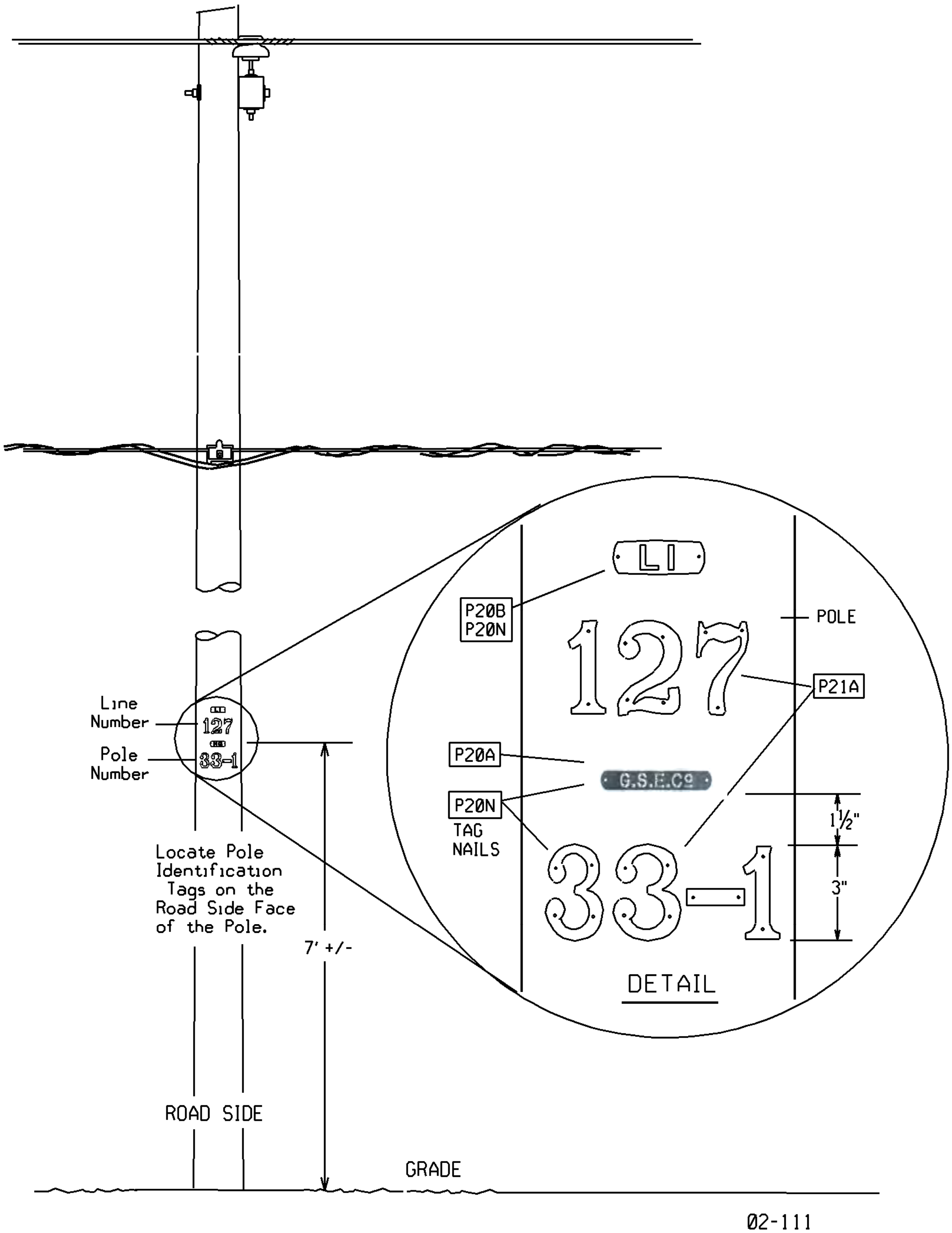


Drilled holes in fiberglass pole top extension follow Liberty Utilities wood pole drilling pattern.

NOTE: Pole top extensions are not to be used where Grade B Construction is required.

Doc. # ST. 02.00.001

CU = PNWP	Stenciling Or Re-stenciling Existing Poles (Labor Only)

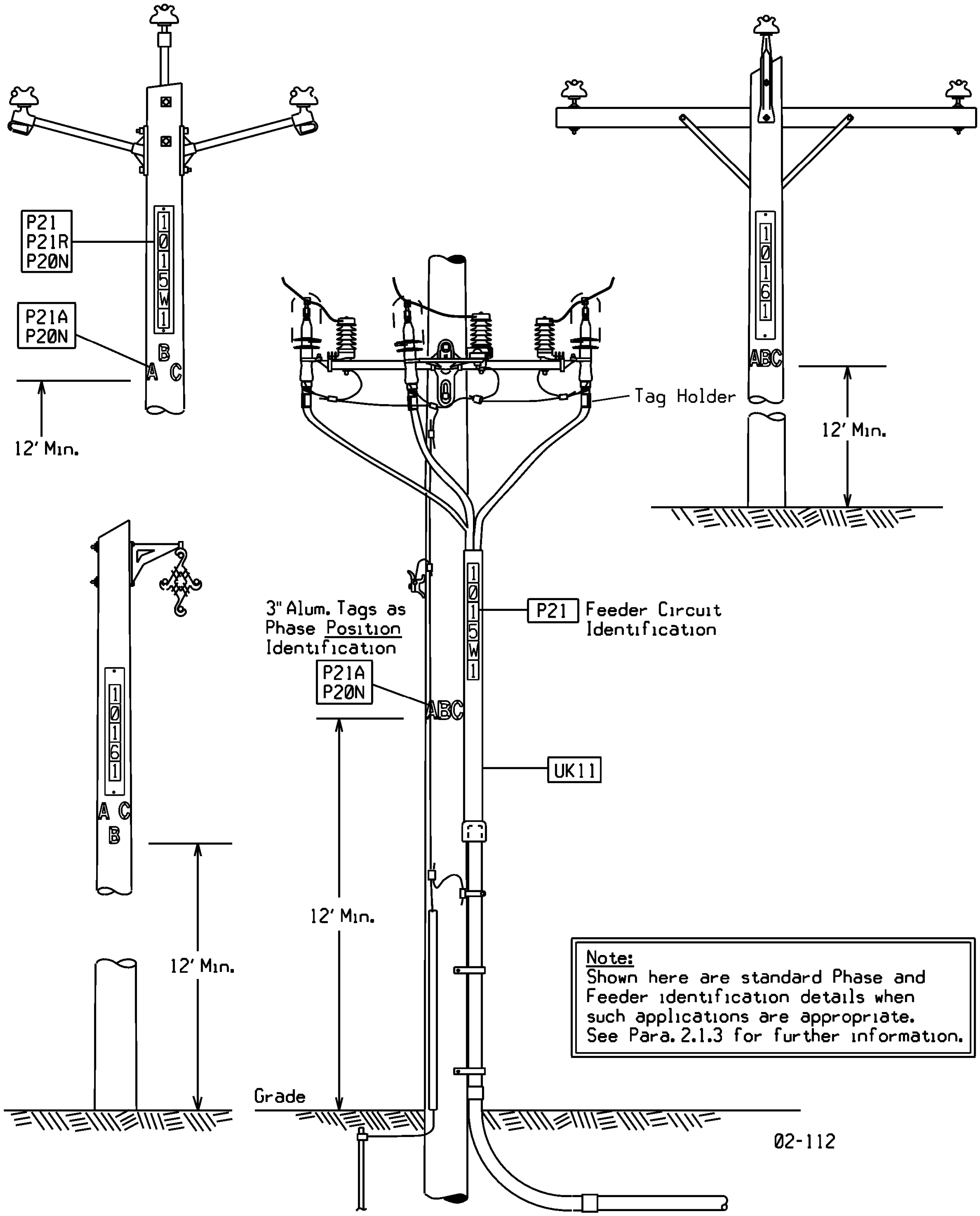


Supersedes 1/07 Issue – Changed Company Tag Name

METHOD OF POLE NUMBERING WOOD POLES

ISSUE	PAGE NUMBER		
7/08	2-111	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Supersedes 7/08 Issue - corrected drawing title.

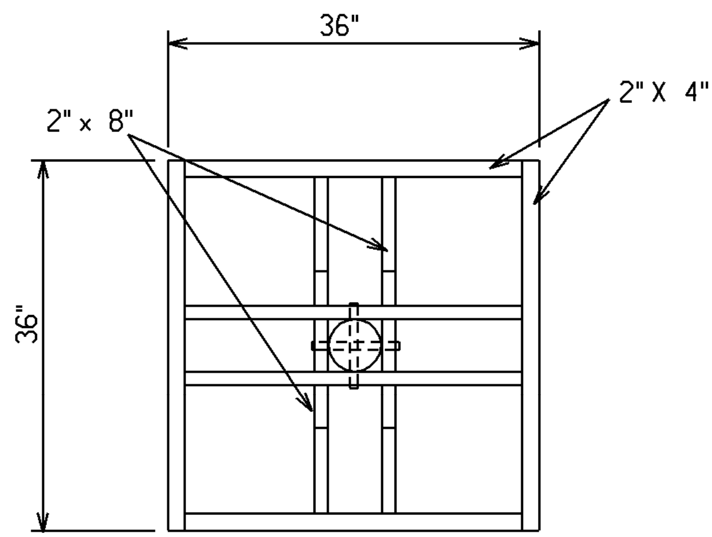


Note:
Shown here are standard Phase and Feeder identification details when such applications are appropriate. See Para. 2.1.3 for further information.

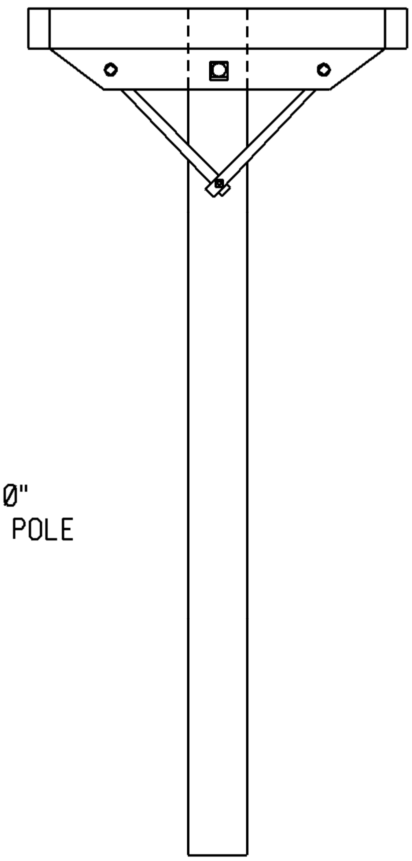
PHASE AND FEEDER IDENTIFICATION

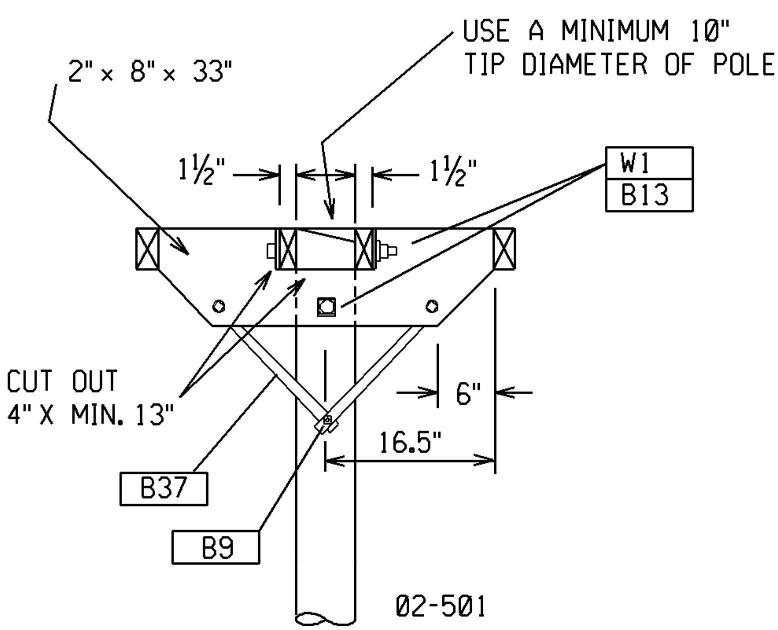
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		2-112	7/11

 Doc. # ST. 02.00.001



PLAN VIEW





SIDE VIEW

New Construction Drawing

NOTES:

1. Platform shall be installed onto a separate pole set adjacent to line.
2. Platform shall utilize pressure treated lumber and all joints shall be properly fastened using #8 x 3" galvanized wood screws and glue. All screw holes shall be predrilled to prevent splitting.
3. Staple a 36" x 36" piece of 2" x 4" galvanized wire mesh over the top of the platform using 1" galvanized wire staples (fencing staples).

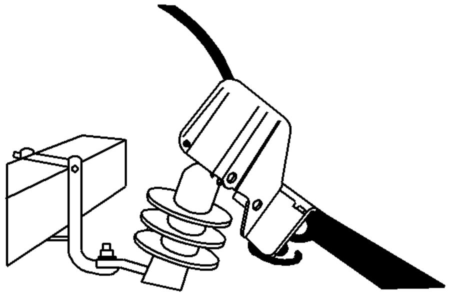
RAPTOR NESTING PLATFORM

ISSUE	PAGE NUMBER		
7/08	2-501	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

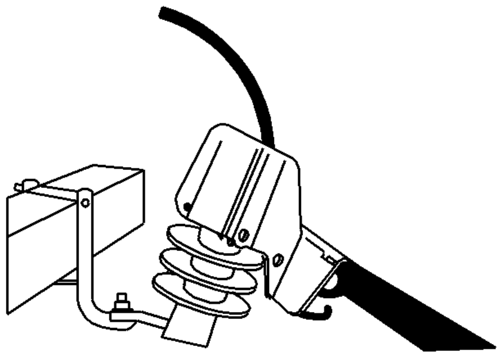
CU = CT23A	3/8" Stinger Cover
CU = CT23B	5/8" Stinger Cover
CU = CT23C	3/4" Stinger Cover
CU = CCPWT45	Cutout Cover

1. Install stinger cover onto cutout tap.

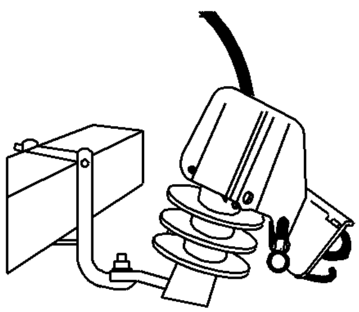
2. Use a shotgun hotstick - the holes in the top lip are designed to fit a shotgun. From the front of the cutout, guide the cover so the tap passes through the slit in the back as shown in this picture.



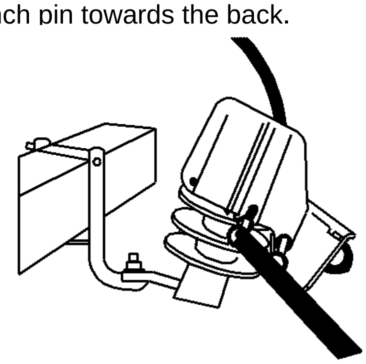
3. Now set the cover down on the cutout.



4. Install snap fit pins with a shotgun stick.



5. Finished installation. The 5.5-inch pin is installed towards the front of the cutout and the 3.5-inch pin towards the back.

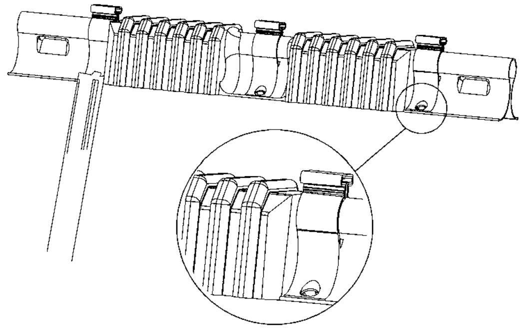


New Construction Drawing

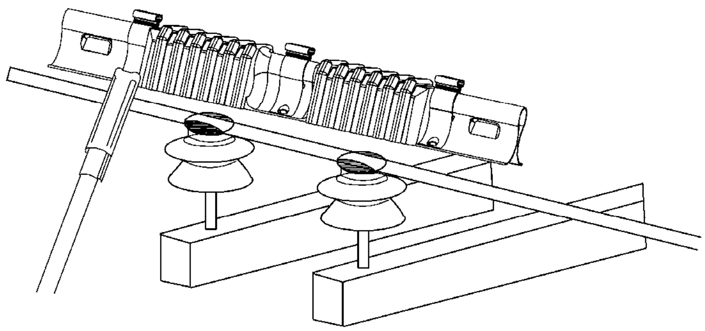
CU = CPWR32P	Cover

Cover Installation – STD Item T40

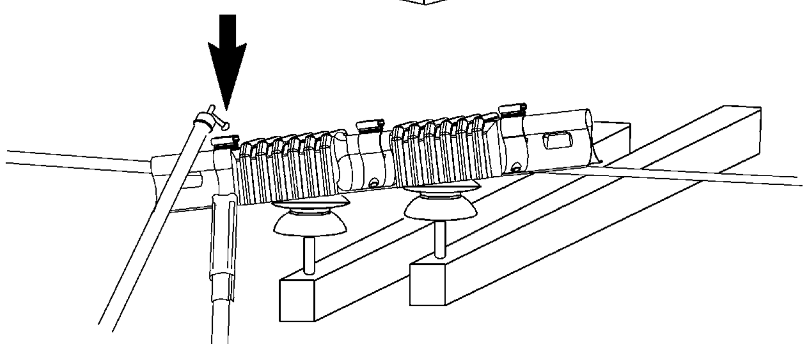
1. Secure cover to shotgun type hotstick through one of the four outside holes provided in the omega clip.



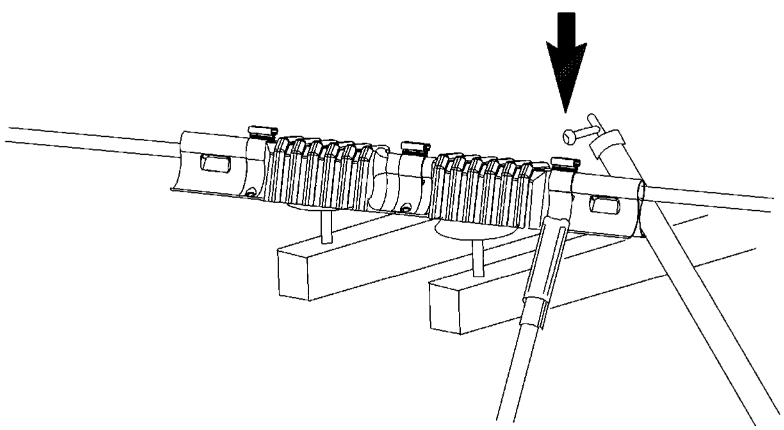
2. Drape the cover over the insulators and straddle the conductor.



3. Secure cover to conductor by taking a second hotstick and pushing down at the top of the clip. Disconnect hotsticks.



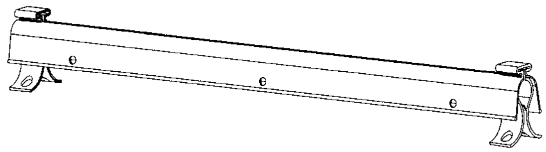
4. Secure hotstick to omega clip at opposite end of cover. Repeat step 3.

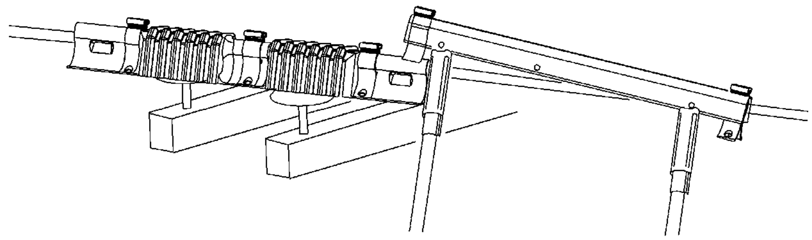


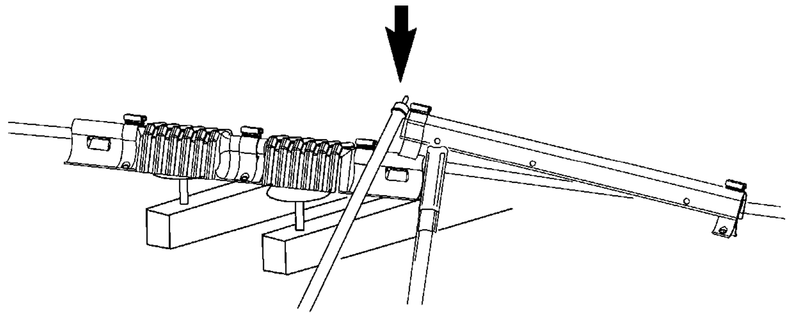
New Construction Drawing

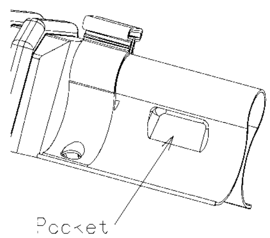
Arm Installation – STD Item T43

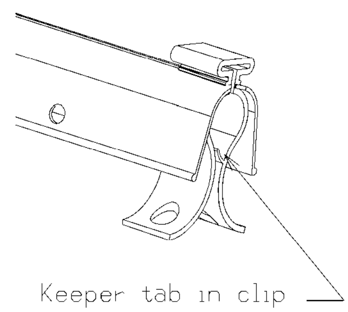
5. Secure the hotsticks in the holes along the arm. Clip over and into the pockets on the cover by taking a second hotstick and pushing down at the top of the clip. Make sure "keeper" tab in clip sits into the pocket of the cover.



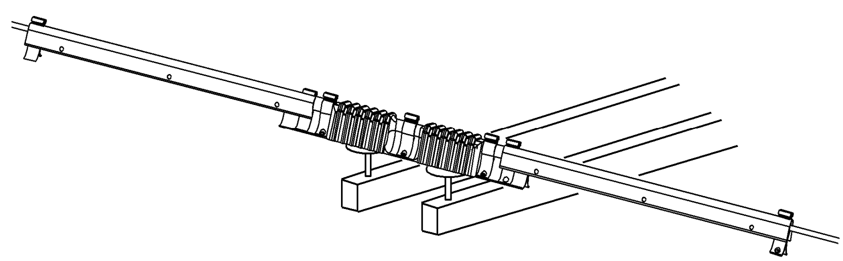








6. Installation complete.



New Construction Drawing

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1	7/13	• New Version of Document	Robert Johnson	Robert Johnson Program Manager

20.0 GENERAL

20.0.10 Design

This section includes the basic design and construction necessary for new and existing standard overhead distribution lines operating at voltages above 15 kV to 35 kV. The distribution line utilizes crossarm and armless configurations for single and multiple phases built to 35 kV primary distribution specifications. A 25 kV distribution line will be built to 35 kV specifications even if it is operated at 25 kV.

The layout and design of distribution primary circuits should be made as part of an area plan, taking into consideration both present and future loads, and supply sources. Certain guiding policies are discussed in the Engineering Department Procedures (EDP).

20.0.20 Definitions

For the purpose of simplifying the terminology to be used in various descriptions of the following drawings, the definitions below serve as a guide:

25 kV - This designation is generally referred to primary circuit voltages from above 15 kV to 25 kV regardless if the system is effectively grounded or noneffectively grounded.

35 kV - This designation is generally referred to primary circuit voltages from above 25kV to 35 kV regardless if the system is effectively grounded or noneffectively grounded.

20.0.30 Coordination With Other Parties

Contact shall occur with communication companies and municipalities during the initial planning stages so that all parties may properly coordinate their required activities. Construction shall be coordinated to allow for maximum system reliability.

20.1 DESIGN OF PRIMARY FEEDERS

The standard 3 phase distribution feeder shall be 4 wire grounded wye with a neutral. The objective is to secure aesthetically appearing distribution lines that will provide maximum service reliability at a reasonable cost. This can be attained by routing feeders through minimum tree and traffic exposure, employing the proper type of conductors for the conditions along the route, and providing circuit capacity for normal and reasonably probable contingency conditions, including anticipated load growth.

20.1.10 Routing

The route of the feeder should be such that normally only one distribution circuit is placed on a pole line. Where this is not possible, an effort should be made such that one feeder shall serve the local load while additional express feeders in spacer cable configuration are carried through the area.

When feeder construction is necessary along the route of an existing subtransmission circuit, consider underbuilding the subtransmission circuit verses installing a duplicate pole line or major undergrounding. Vertical clearance between upper and lower circuits are recommended for worker safety and must meet NESC codes along with any local working agreements. Consult Engineering Departments for attachment approvals, recommend clearance between circuits, and working agreements.

20.1.20 <u>Basic Impulse Insulation Level (BIL)</u>

BIL refers to the level of overvoltage that equipment on the system is designed to withstand. Surge arresters, coordinated to the BIL of the equipment, are installed to limit the overvoltages on equipment by discharging surge current to ground.

Wood pole tops, phase-to-phase and phase-to-ground distances across cross-arms and poles, are designed to coordinate with the impulse withstand characteristics of the insulators and to provide a minimum 150 kV insulation impulse withstand value. This impulse level is based on the assumed impulse flashover strength of 20 inches or more of wood. Where lightning arresters are used and where grounding conductors are installed, the 20 inches of wood requirement does not apply for the particular conductor having the arrester. In locations where sufficient wood separation is not obtainable, the use of fiberglass strain insulators shall be installed. Fiberglass guy strain insulators shall be installed onto all new primary guy installations maintaining BIL requirements. When designing and constructing pole tops, steel crossarm braces, steel hardware, ground wires, guy wires, etc., may short out the insulation that is provided by air and wood. See Section 7 for additional information and drawings.

20.1.30 <u>Size and Loading of Conductors</u>

The initial load on the conductors of the feeder main and branches shall be limited to allow reasonable load growth before the maximum normal peak load limit is reached. This initial load value should allow for a minimum of 10 years of additional expected load growth. The current values for normal and emergency loads are based on consideration of economy with respect to losses and the thermal limits of the conductor. See Section 6-Primary Conductors.

A. <u>Size of Main Line Conductors</u>

Generally, 25-35kV new main line feeders shall utilize 477 kcmil All Aluminum (AAC) primary conductors. Additional conductors are available upon engineering approval. Existing conductors of adequate size may serve for part of any feeder main (see Section 20.3.50) and use of any other conductor size for this purpose will be considered on a case-by-case basis. See Section 6-Primary Conductors for additional information.

B. <u>Size of Branch Line Conductors</u>

Generally, three phase branches shall utilize #1/0 All Aluminum Alloy Conductor (AAAC) or 477 kcmil All Aluminum Conductor (AAC) primary conductors.

Generally, single phase branches shall use #1/0 AAAC conductor for expected loading up to 100A. Loadings may require the addition of one or more phases to maintain feeder balancing.

In existing branch circuits that have a conductor smaller than #2 where it is not economically feasible to reconductor the line or convert it to a higher voltage, step -down transformers (ratio) should be installed.

C. Size of Grounded Neutral Conductors

Maintain a common neutral with **minimum splices** for effectively grounded circuits. Note: See Sections 13.4 and 13.5 for information on the bonding of circuit neutrals.

All neutral conductors shall be #1/0 aluminum except when a larger size is either existing or necessary as part of a secondary system. Example: #4/0 AAAC is used with 336.4 kcmil multiplex. Use of a larger neutral conductor, or use of any other secondary cable configuration or size, requires that National Electric Safety Code (NESC) clearances for that particular construction be met.

Although not recommended, if existing primary conductors are **smaller** than #1/0 aluminum or equivalent and a neutral conductor exists, it should be used if it is equal size or larger than the primary conductor.

If existing primary conductors are equal to or **larger** than #1/0 aluminum or equivalent and a neutral; conductor exists, it should be used if it is at least equivalent to #1/0 aluminum or #3 copper (#2 ACSR- aluminum cable steel reinforce **-** is acceptable).

20.1.40 Voltage Regulation and Flicker

It is suggested that a voltage profile be run for each feeder so that regulation can be reviewed.

Voltage regulation on the primary feeder shall be such that voltage to customers can be maintained to the following acceptable levels on a 120 V base:

Range	Service Voltage	
	Minimum	Maximum
A	114	126
B	110	127

Table 1

Electric distribution systems should be design and operated to meet the voltage level requirements of Range A in Table 1. Users' electrical equipment of all types will generally be designed to give satisfactory performance in this range.

Maintaining voltages levels within Range A on all parts of the system at all times cannot be assured. As a result of the economics of operations, there may be some system voltages that fall in the extremes of Range B and even beyond. When voltages extend into Range B during normal conditions or for an extended period of time they should be corrected immediately to conform to Range A requirements by using interim measures, and plans for a permanent solution should be developed.

Voltages on lines serving loads such as motors, welders, etc., should be checked to see that any flicker does not exceed the limits given in Section 10. Loads that may cause excessive flicker should be referred to the Distribution Engineering Department.

20.1.50 Radio and Television Interference

Radio and television interference can be caused by loosely connected equipment and materials allowing arcing between parts. The higher the primary voltage, the greater the possibility of creating radio and television interference. This interference can be controlled by taking reasonable care to minimize the creation of sharp projections of energized parts by properly applying insulator ties, by making certain all bolted connections on structures are properly tightened, and by maintaining suitable clearances of pole hardware.

20.2 POLE TOPS

The following can be used for pole top constructions and pole considerations.

20.2.10 Selection of Sole Owned and Jointly Owned Poles

There is no standard pole height or class that can positively meet all construction conditions without causing unnecessary expense. Selection of pole height and class requires the coordination of all pole users. Once the correct pole height and class is determined for the most common pole in the project, the remaining pole heights and classes should be easily determined with small changes made to the original calculations. See Section 2 for pole selection information.

Existing poles in sound condition and in the proper locations should be used if pole loading and minimum clearance requirements can be met for the facilities that are being installed.

Prior to changing a jointly owned pole, it should be determined that the communications company is not occupying the Company's space. If the pole must be replaced, or if new poles are to be installed, they shall be selected to provide clearances specified for present and future needs following the Joint Use Contractual Agreements. The Company may be entitled to reimbursement of transfer costs.

Whenever present and future construction requires more pole space, wood pole top extensions should be considered before a new larger pole is installed.

20.2.20 Crossarm Construction

The standard primary 3 phase construction is bare wire on a crossarm, which for a straight line pole consists of a 2-pin-10 foot wood crossarm with wood braces and a 24 inch steel pole top pin, steel crossarm pins, porcelain pin-type insulators for above 15kV to 35kV distribution. This type of construction is also recommended for long span rural lines, for lines in heavy industrial areas, and for locations where its appearance is not objectionable. It may also be necessary to continue this type of construction on existing lines that are rebuilt to maintain consistency of existing crossarm construction. See 9-400 series.

At line angles over 20 degrees, primary deadends, railroad crossings, and limited access highway crossings, double crossarms are required (NESC 261.D.5.c). Double crossarms are also required at navigable waterways requiring waterway crossing permits (NESC 241.C).

Other crossarm sizes and arrangements may be used as field conditions require. They are:

1. Six -Pin Heavy Duty (HD) Crossarm (10 foot) – Use for 3000 lbs Deadends construction.
2. Extension Arms (Alley Arms) – Use when this is the only practical method of obtaining clearance from trees, buildings, etc., or for reducing or eliminating an angle in the line. In general, two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress, which may be caused by one extension arm in a straight line. Side guys or equivalent may be required to support the unbalanced load of a series of extension arms. (9-440 series)
3. Offset Arms – Use 6 pin with wood braces when the full offset of an extension arm is not required. Refer to Section 7 for adequate BIL separation. See 9-441 for Offset Arm construction drawings.

20.2.30 Armless Construction

Single phase armless (vertical) construction, utilizing steel pole top pin, is recommended. Pages 9-700 series have various diagrams pertaining to effectively grounded circuits.

20.2.40 Spacer Cable Construction

Spacer Cable construction is preferred for distribution lines when NESC Clearances, Tree Trimming Clearances, and Right of Way Issues can not be resolved with the recommended crossarm or armless types of construction. It may also be selected for an additional express feeder purpose and/or **to improve reliability in an area**

20.2.50 Phase Position

Circuits should hold the same relative phase position throughout their entire length as far as practicable following the guidelines shown on Page 20-105. Where there is an established policy on phase position in any operating area, it may be continued.

20.3 TYPES OF CONDUCTORS

The type of conductor shall be selected as follows:

20.3.10 Bare Conductors

Bare open wire primary conductors shall be used where tree conditions do not exist, or where tree conditions are not expected to exist for many years. These areas include roads along cultivated fields, orchards and vineyards, heavily pave areas, and areas regularly trimmed by others. In such areas, these lines are almost trouble-free and they represent the most economical type of construction.

20.3.20 Covered Conductors

PE covered conductor is not approved for new installations but for maintenance purposes only. This conductor is designed to withstand a limited amount of incidental contact.

20.3.30 Tree Conductor

Tree conductor is an approved conductor for new installations on crossarms and armless construction. This conductor is designed to withstand incidental tree contact but is not intended to be installed to permanently eliminate tree trimming. Tree conductor may also be installed when local municipal ordinances mandates that covered primary conductors be installed.

Tree conductor is the only wire to be used in a spacer cable configuration. Spacer cable configuration provides maximum reliability and is to be used in heavy tree areas but is not intended to be installed to permanently eliminate tree trimming. See Section 16-Aerial/Spacer Cable. Tree conductor in a spacer cable configuration is also approved for express or multiple feeder installation on existing poles.

Although tree conductor offers some electrical protection, **it is not an insulated conductor**. It must be treated as a bare conductor during installation and maintenance.

Tree conductor contains a layer of semi-conducting material at the aluminum conductor surface. **WARNING: When skinning these conductor coverings, do not allow the removed covering to contact equipment grounds or adjacent live phase conductors as an electrical flash may result.**

20.3.40 Preassembled Lashed Aerial Cable (PLAC)

Preassembled Lashed Aerial Cable is not available for 35kV distribution at this time.

20.3.50 Existing Conductors

Primary conductors smaller than #1/0 is not recommended to be operated on 25-35kV Distribution Systems. Consider replacement of conductors smaller than #1/0, if economically feasible, or the installation of step-down transformers

20.4 Separation of Conductors

20.4.10 General

Minimum recommended separations between supports and conductors on the same pole are shown on the construction drawings. These should be used on all poles for new lines. They are generally used for pole replacements.

20.4.20 Separation on New Poles

The separation between primary line conductors and neutrals or secondaries on poles for new lines shall generally not be less than 61 inch for 35 kV. These distances are predicated upon the NESC Phase to Ground Approach Distance, plus the dimension of “Reach” based upon the average distance from a line worker’s chest to their finger tips with the arms extended.
e.g. (NESC Phase to Ground Approach Distance for 35 kV = 31”) + (Reach =30”) = 61”

A. Tangent Poles (wires on pins and crossarms) – the vertical separation between the thru bolts for the primary crossarm and the secondary conductor shall be not less than 51 inches for 35 kV.
   e.g. 35 kV - The distance from the horizontal center of the crossarm to the top of the insulator holding the primary conductor is 10” + 51” = 61”.

B. Primary Deadend - the vertical separation between the thru bolts for the primary crossarm and the secondary conductor shall be not less than 61 inch for 35 kV.

20.4.30 Separation on Existing Poles

When pole tops are being rearranged to accommodate additional facilities or when circuits are cut over to a higher voltage level, the recommended separations between primary line conductors and neutrals or secondaries for work on **New Poles must** be used if possible. This will hold future work to a minimum and allow work on secondaries without covering the primaries (NESC Approach Distance). However, extensive work and pole change outs should not be undertaken solely to reduce work that might possible become necessary in the future. If the primary to secondary/neutral separation for **New Poles** cannot be obtained, reduce spacing can be utilized which may require transformers to be rotated to maintain proper NESC clearances. The minimum separations between conductors and supports on the same pole should be used only when values recommended for new poles are not practicable. See the following for guidelines:

Generally, the basic primary to secondary conductor separation may be reduced to 53 inches for 35 kV. This minimum separation may accommodate third party attachments without pole replacements.

20.4.40 Space Available on Jointly Owned Poles

Before replacing any jointly owned poles, be certain that communication company attachments cannot be moved to permit the desired construction (Ref.NESC rule 239 F.2 and Table 235 -5)

20.4.50 Separation on Replaced Poles

The separations on poles that are replaced should conform to the requirements for new poles. In some special cases, separation may be reduced, but shall not be less than permitted on existing poles.

20.4.60 Reduction of Separation on Poles

Reduced separations of conductors and facilities made to accommodate communication, CATV or other third party interest shall not be less than "Minimum Dimensions for Existing Poles".

20.5. Other

20.5.10 Surge Arresters

See Section 13

20.5.20 Insulators

A. Bare Conductor – One piece radio free, pin type, porcelain insulators of the appropriate ANSI class shall be used to support the phase conductors. A one piece polymer deadend insulator of proper voltage rating shall be used to deadend the conductor.

B. Tree Wire and Spacer Cable – A one piece, plain top, pin type, polyethylene insulator of the appropriate ANSI class shall be used to support the phase conductor. A one piece polymer deadend insulator of proper voltage rating shall be used to deadend the conductor.

Where severe environmental contamination exists, Line Post Insulators (I13D) with ¾" Studs (P1G) and Pole Top Pins (P12B) should be considered.

20.5.30 Neutral Brackets

An uninsulated metal bracket shall be used to support the common neutral conductor in the secondary position. See Section 10 for information on Secondary.

20.5.40 Conductor Ties

Follow these guidelines to ensure the reliability of primary circuits and to reduce or eliminate interruptions caused by inadequate conductor tie practices.

Line conductors are to be positioned on its insulators that will produce minimum strain on the tie wires. The function of the tie wire is only to hold the line conductor on its insulator. Conductor strain shall be taken by the insulator and pin.

Hand wrapped ties are to be used for all types of conductor on lines operating at higher voltages where they are worked dead and grounded. Ties are to be made by hand and without the use of pliers. A tie wire must be neatly and tightly wrapped around the insulator and conductor with free ends wrapped tightly around the conductor. The free ends shall be folded back on the conductor at a distance of 3 inches to facilitate the future removal of the tie with hot sticks.

Hot line ties are to be used when lines are being worked with hot sticks. These also need to be wrapped neatly and tightly around the insulator and conductor. Single loop ties are to be recommended for spans under 160 feet while double loop ties are recommended for conductors with spans of 160 feet and over.

Utilize preformed conductor ties (TT1) for 3000 lb construction.

Care shall be taken to use the proper length and size tie for each conductor specified in the tables on Page 20-120. Refer to Pages 20-118 thru 20-124 for diagrams and information on Hand Wrapped and Hot Line Ties.

Note:

1. Type Tie – Bridle tie shall be used for all bare and covered conductors larger than #4 AWG regardless of span length.
2. Looped Western Union and Cross Top Tie shall be used for all bare and covered conductors # 4 AWG or smaller (#4, #6, etc.).
2. Bare Conductor – Use bare tie wire. (W22A, W22BA, W22C)
3. Tree Wire – Use covered tie wire. **Note:** Do **not** use molded plastic ties. Do **not** remove tree wire covering at polyethylene pin type insulator. (W22D)
4. Existing Polyethylene and Neoprene Covered Line - Wire to be converted to the 35 kV Voltage class – Install 35 kV pin type polyethylene insulator and tie with covered tie wire (W22D) where existing covering on conductor has not been previously removed. Where covering has been removed, pin type porcelain insulator and tie with bare tie wire.
5. Double insulators shall use ties for single insulators with each tie occupying one-half the available space between insulators – same number of turns with closer spacing.

20.5.50 Splicing Conductors

A. Bare Conductors – Use automatic line splice or full tension compression splice per Section 5.

B. Tree and Covered Conductors – Remove covering with approved stripper for given conductor size and covering thickness. Completed splice should have 3 inches of bare conductor on both sides of the splice. DO NOT install splice at or near polyethylene pin insulator but keep the splice a minimum distance of 30 inches from pin insulator. Splices for additional phases should be staggered a minimum distance of 30 inches apart. **Warning: Always cover unused exposed bare conductors** outlined in Section 5. Use automatic line splice or full tension compression splice per Section 5. See Section 16 for more information on Tree Wire.

C. Spacer Cable – Follow procedures outlined in Section 16 when Tree Wire is installed in a spacer cable configuration. An automatic line splice **must not** be used because only the messenger is under tension and not the phase conductors.

20.5.60 Deadending Conductors

A. Bare Conductors – Use conventional strain clamps specified in Section 22 - Material Catalog of the Standards.

B. Tree and Covered Wire – Remove covering with approved stripper for given conductor size and covering thickness. Use conventional strain clamps chosen from the Material Section of the Standards Manual. Completed deadend shall allow 3 inches of covering removed on the line side of the strain clamp body to accommodate for grounds and jumpers. Do not use preformed deadend grips for tension applications.

C. Spacer Cable – Follow procedures outlined in Section 16 when Tree Wire is installed in a spacer cable configuration.
.

20.5.70 Tapping Conductor

A. Bare Conductors – Use connectors as specified per Section 5 of the Standards.

B. Tree and Covered Conductors – Remove covering with approved stripper for given conductor size and covering thickness. Use connectors as specified per Section 5 of the Standards. Installed connector shall allow 3 inches of bare conductor on both sides of connector ends to accommodate for grounds and jumpers. Do not tape completed connections.

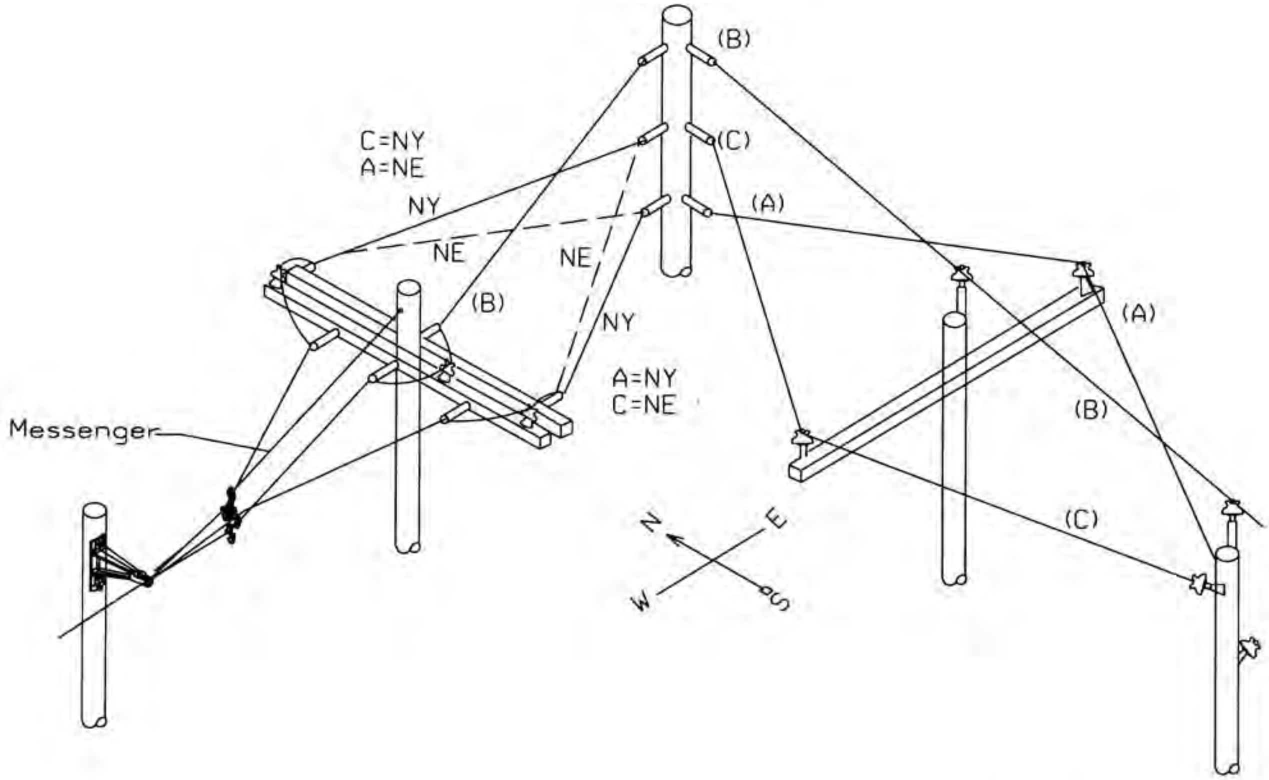
C. Spacer Cable – Follow procedures outlined in Section 16 when Tree Wire is installed in a spacer cable configuration.

20.5.80 Conductors Installed in Angle Suspension Clamps

A. Bare Conductors - Use appropriate angle suspension clamp. See Section 22 - Material Catalog.

B. Tree and Covered Conductors - Remove covering with approved stripper for given conductor size and covering thickness. Use appropriate angle suspension clamp specified in the Material section of the Standards. Complete clamp installation shall allow for 3 inches of bare conductor on both sides of clamp ends.

C. Spacer Cable – Follow procedures outlined in Section 16 when Tree Wire is installed in a spacer cable configuration.



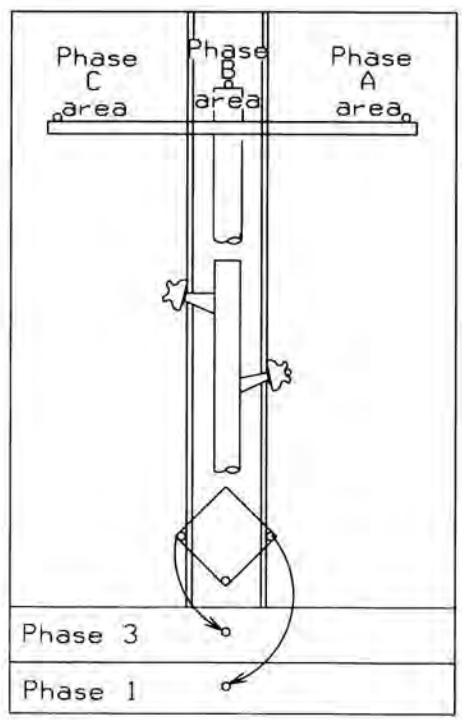
Notes:
If there are local rules that have been approved by the division superintendent, these should be followed where practicable. Otherwise use the rules below:

(1) New England - Put phase A on the northerly or easterly side for horizontal crossarm or spacer cable installations. Put phase A on the bottom for vertical construction.

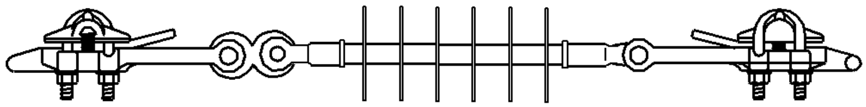
New York - Put phase A on the southerly or easterly side for horizontal corssarm or spacer cable installations. Put phase A on the bottom for vertical construction.

(2) Put phase B in the middle or top positoin for horizontal crossarm or for vertical construction. Phase B shall occupy the middle and bottom position for spacer cable in triangular arrangments.

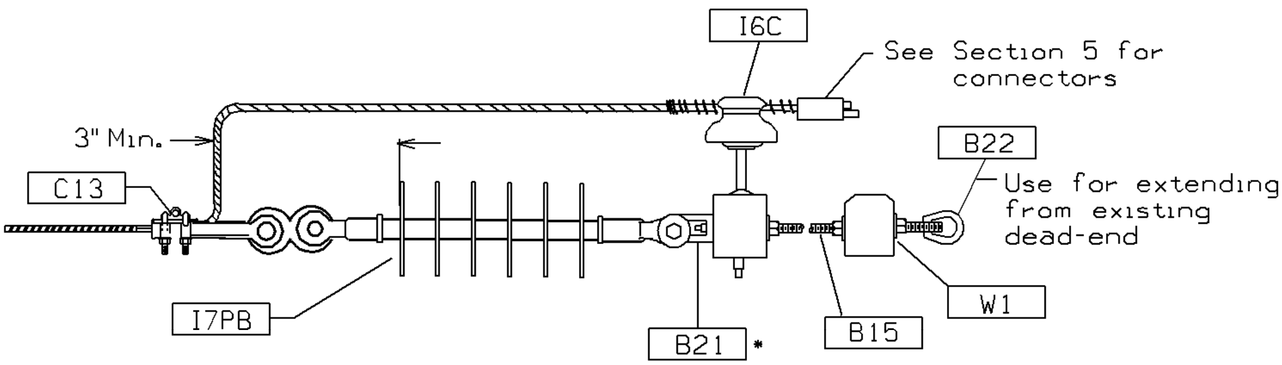
(3) Put phase C in the remaining position.



Look north = NE & NY
Look east = NY
Look west = NE

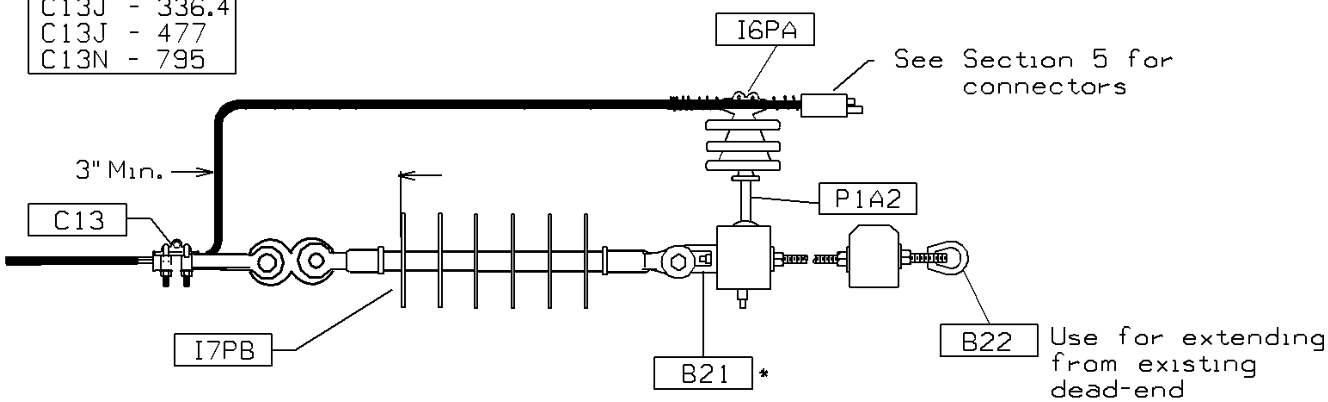


Inline Dead Ends

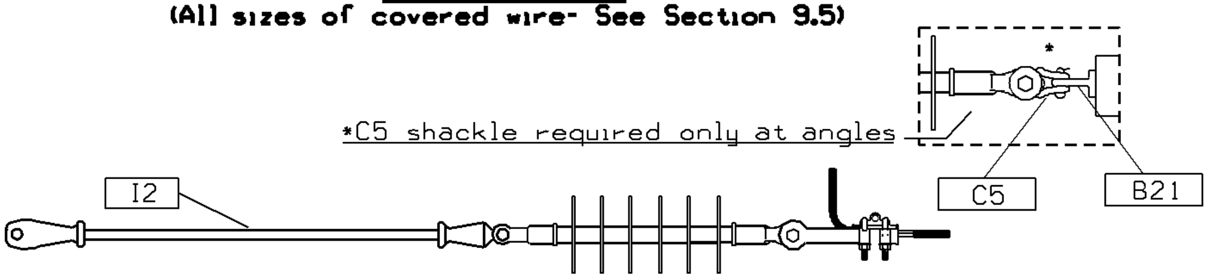


Dead-End Clamps
(All sizes of bare wire)

C13H	1/0
C13J	336.4
C13J	477
C13N	795



Dead-End Clamps
(All sizes of covered wire- See Section 9.5)



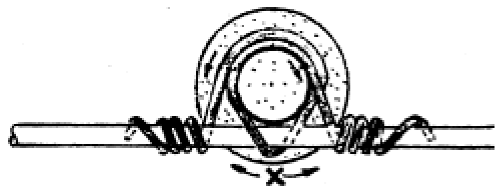
Inline Dead Ends

Notes:

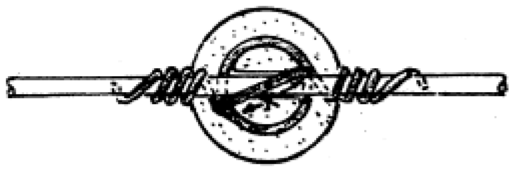
Maintain full impulse and flashover strength; see Section 7.
This drawing is for dead-ends on wood crossarms or wood poles.

See 2.8 for information on crossarm.
Use heavy duty crossarms(C31D) and braces(TB60) and gain plates(C37) for 3000 lb construction.

HAND WRAPPED TIES

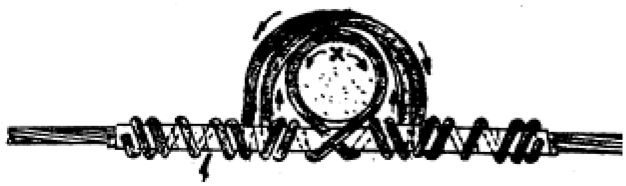


LOOPED WESTERN UNION (LWU) - SIDE GROOVE TIE
FIG I



CROSS TOP (CT) TOP GROOVE TIE
FIG II

FIG I & II TO BE USED FOR ALL BARE AND COVERED CONDUCTOR OF #4 AWG OR SMALLER.



BRIDLE TIE SIDE GROOVE
FIG III

BRIDLE TIE TOP GROOVE
FIG IV

FIG III & IV TO BE USED ON ALL COPPER & ALUMINUM CONDUCTORS LARGER THAN #4 AWG

TIE CONDUCTORS

TABLE I – LENGTH AND TYPE - FOR BARE LINE CONDUCTOR

Line Conductor Size AWG-kcmil	Tie Wire Size AWG	Std Item	Class 55-6 Insulator – 35kV			
			Side Groove		Top Groove	
			Length (Inches)	Type	Length (Inches)	Type
# 6 Cu	# 6 Cu	W22A	-	-	-	-
# 6A CW &CCW	# 6 Cu	W22A	-	-	-	-
# 4 Cu	# 6 Cu	W22A	-	-	-	-
# 3 Cu	# 6 Cu	W22A	58	Bridle	46	Bridle
# 2 Cu	# 4 Cu	W22BA	68	Bridle	55	Bridle
# 1/0 Cu	# 4 Cu	W22BA	73	Bridle	63	Bridle
# 4/0 Cu	# 4 Cu	W22BA	79	Bridle	67	Bridle
Larger Cu	# 4 Cu	W22BA	-	-	-	-
# 4 ACSR	#4 AL	W22C	62	Bridle	53	Bridle
# 2 ACSR	#4 AL	W22C	65	Bridle	56	Bridle
# 1/0 ACSR	#4 AL	W22C	69	Bridle	59	Bridle
# 4/0 AL (AAC)	#4 AL	W22C	81	Bridle	69	Bridle
336.4 AL (AAC)	#4 AL	W22C	89	Bridle	77	Bridle
336.4 ACSR3000#	#4 AL	TT1B	Preform	Bridle	Preform	Bridle
477.0 AL (AAC)	#4 AL	W22C	108	Bridle	96	Bridle
795 AAC	#4 AL	W22C	108	Bridle	96	Bridle

TABLE II – LENGTH AND TYPE - FOR COVERED AND TREE LINE CONDUCTOR

Note: If insulation is removed 30", use bare tie wire (see above)

Line Conductor Size AWG-kcmil	Tie Wire Size AWG	Std Item	Class 55-6 Insulator – 35kV			
			Side Groove		Top Groove	
			Length (Inches)	Type	Length (Inches)	Type
# 6 Cu	#4 AL TPR	W22D	-	-	-	-
# 6A CW &CCW	#4 AL TPR	W22D	-	-	-	-
# 4 Cu	#4 AL TPR	W22D	-	-	-	-
# 3 Cu	#4 AL TPR	W22D	58	Bridle	46	Bridle
# 2 Cu	#4 AL TPR	W22D	68	Bridle	55	Bridle
# 1/0 Cu	#4 AL TPR	W22D	73	Bridle	63	Bridle
# 4/0 Cu	#4 AL TPR	W22D	79	Bridle	67	Bridle
Larger Cu	#4 AL TPR	W22D	-	-	-	-
# 4 ACSR	#4 AL TPR	W22D	62	Bridle	53	Bridle
# 2 ACSR	#4 AL TPR	W22D	65	Bridle	56	Bridle
# 1/0 ACSR	#4 AL TPR	W22D	69	Bridle	59	Bridle
# 4/0 AL (AAC)	#4 AL TPR	W22D	81	Bridle	69	Bridle
336.4 AL (AAC)	#4 AL TPR	W22D	89	Bridle	77	Bridle
336.4 ACSR	#4 AL TPR	W22D	89	Bridle	77	Bridle
477.0 AL (AAC)	#4 AL TPR	W22D	108	Bridle	96	Bridle
795 AAC	#4 AL TPR	W22D	108	Bridle	96	Bridle

SINGLE LOOP HOT LINE TIES

1. **<u>USE SINGLE LOOP TIES FOR SPANS UNDER 160 FEET</u>**. where lines are to be worked hot. Use double ties for spans over 160 feet. and for all angle poles.

Approx. ¾" Diameter.

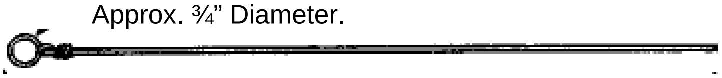


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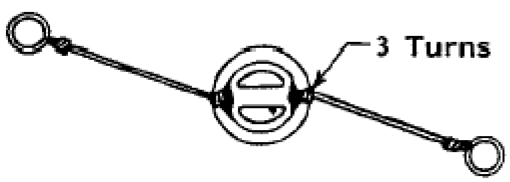
Figure A – Prepare Loop – Two Required



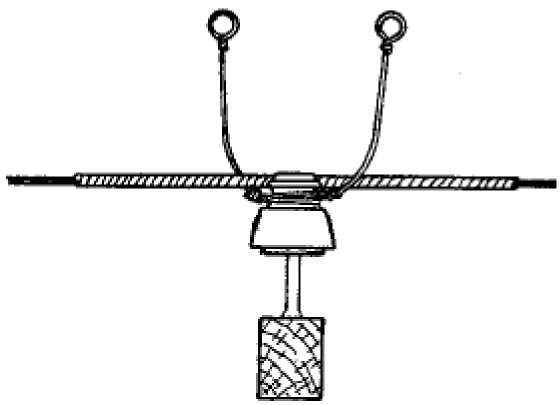


Figure B – Loops In Place On Insulator

Figure C – Conductor In Place

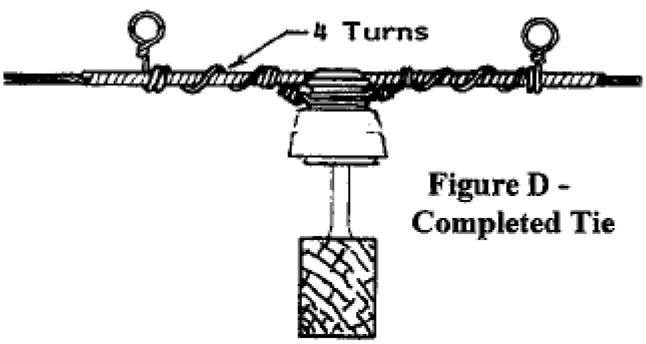


Figure D - Completed Tie

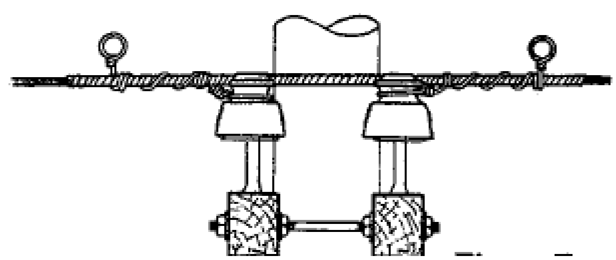


Figure E – On Double Arms

Line Wire Size AWG-kcmil	Tie Wire Size AWG-kcmil	Length "K" (Inches)			Line Wire Size AWG-kcmil	Tie Wire Size AWG-kcmil	Length "K" (Inches)
#3 Copper	#6 Copper	32			#1/0 6201 Al.	#4 Alum.	34
#1/0 Copper	#4 Copper	36			#4/0 6201 Al.	#4 Alum	40
#4/0 Copper	#4 Copper	40			336.4 ECA	#4 Alum	44
#4 ACSR	#4 Alum.	28			477.0 ECA	#4 Alum	46
#1/0 ACSR	#4 Alum.	34					

DOUBLE LOOP HOT LINE TIES

1. **USE DOUBLE LOOP TIES FOR SPANS OVER 160 FEET**. where lines are to be worked on hot and for all angle poles. Use single ties for spans under 160 feet.

Approx. ¾" Dia.
2 - Full Turns
Figure A- Prepare Loop – Two Required

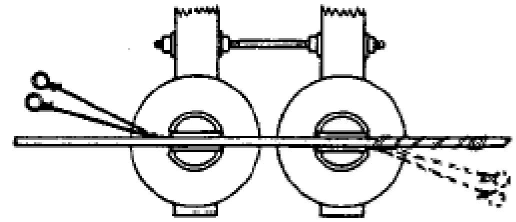


Figure E – Double Insulators Conductor In Place – Top Groove

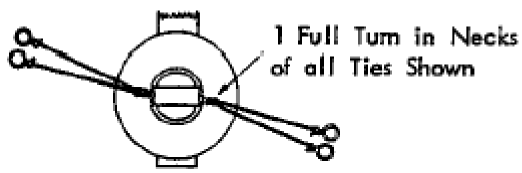


Figure B – Loops In Place On Insulator (Top View)

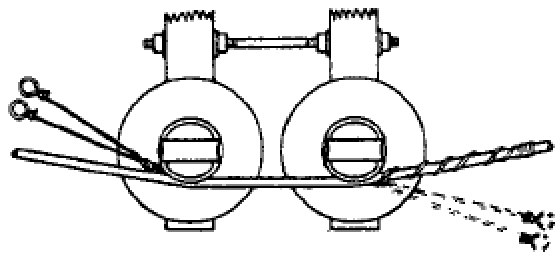


Figure F – Double Insulators Conductor In Place – Side Groove

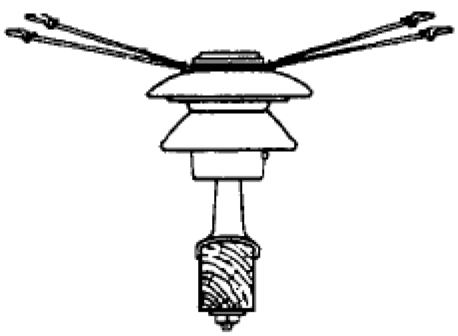


Figure C – Loops In Place On Insulator

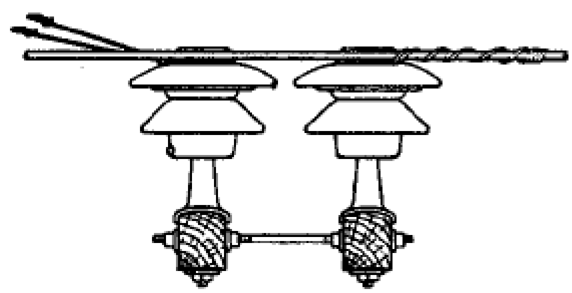


Figure G – Double Insulators Elevation

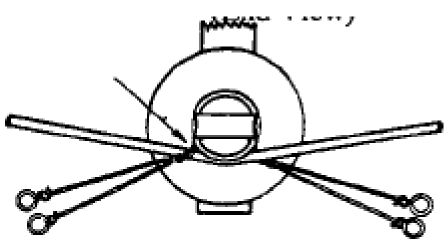


Figure D – Conductor In Place (In Side Groove For Angle In Line)

Pole spans are limited primarily by the sag characteristics of the primary conductor relative to the horizontal and vertical separations provided by the standard pole top arrangement. Increases in separations at the pole may permit longer spans. Transverse wind loadings may not allow use of extremely long spans

Maximum spans are determined by the following criteria:

Horizontal Clearance (Distance between Phase Conductors at the same level):
Maximum spans are based on the HORIZONTAL clearance of the primary conductors outlined in the NESC (National Electrical Safety Code) rule 235B.

The clearance at the supports of conductors of the same or different circuits of Grade B or C in no case shall be less than the values given by the following formulas, at a conductor temperature of 15°C (60°F), final unloaded sag, and no wind. The clearance shown in Table 235-1 (NESC) shall be used if they give a greater separation than below formulas.
See the formulas below for the appropriate applicable situation:
For conductors smaller than AWG #2: clearance (c) = 0.3 inches per kilovolt + 4.04 $\sqrt{s-24}$.
For conductors of AWG #2 and larger: clearance (c) = 0.3 inches per kilovolt + 8 $\sqrt{s/12}$.
c = Horizontal clearance between the primary conductors in inches.
s = Apparent Sag of the conductor in inches having the greater sag.

Clearances are between conductors located at the same level (i.e. the two outside phase conductors on standard crossarm/armless pole top construction or two nearest phases in crossarm deadend construction).

Vertical Clearance (Primary vs Secondary): Maximum operating temperature. See section 6
Maximum spans are based on the VERTICAL clearance between primary and 600 V secondary or neutral conductors outlined in the NESC (National Electrical Safety Code) rule 235C. The separation is given for the spacing shown on the pole top drawings in this section while maintaining 16 inch minimum mid-span clearance as shown in the Section 7. Clearances are taken between conductors that are directly above and below each other and are based on the sag of the primary conductor and either 600 V secondary or neutral conductors. Combinations of conductor sag verse span may be calculated using the sag data provided in Section 6-Conductors.

A comparison of sag between two different operating conditions need to be evaluated and the one requiring the greater separation at the structure needs to be used. They are to be compared as follows:

> The upper conductor is at final sag at the maximum operating temperature for which the line is designed to operate and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading– or
>
> The upper conductor is at final sag at 32° F with the radial thickness of ice, and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, and without ice loading.

Generally, the sag of primary conductor for both bare and tree wire at maximum operating temperature of 194° F (90° C) would be greater than conductor under “Heavy Loading” operating conditions. A comparison should be made.

If the operating temperature sag is greater, determine the upper primary conductor sag based on the 194°F (90°C) for bare or tree primary conductor and the lower secondary or neutral conductor at 32° F (0° C) of the same ambient temperature of 32° F for upper and lower conductor. See Section 6 for “Loading (Unloaded Conditions)” and “Loading (Loaded Conditions)” sag charts.

For span lengths in excess of 150’, a supply conductor above 750V but less than 50kV shall not sag lower in the span than a straight line joining the points of support of the highest communication cable or conductor. The conductor sag is based upon the sag data obtained from a conductor temperature of 60°F (15°C), no wind displacement and final unloaded sag conditions.

<u>Vertical Clearance (Secondary Vs Communications):</u>

New Plant - maximum spans are based on the vertical clearance between the 600V Secondary or Neutral conductor and the communication conductor's In-Line-Of-Site from adjoining structures. The conductor in the secondary position should not sag closer than 30" to the Communication Conductor's "In–Line-Of-Site" at mid-span utilizing the 32°F (0°C) Loading (Unloaded Conditions) sag data.

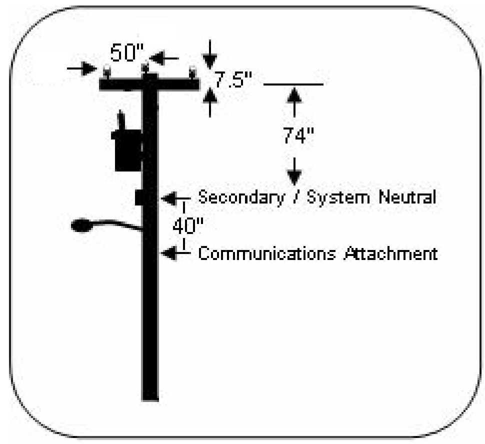
Existing Plant – may sag below Communication Conductor's "In-Line-Of-Site" but must maintain the NESC clearance of 30" mid-span between the communication and Secondary Conductors.

For either condition of New Plant or Existing Plant, longer spans can occur by either increasing the pole height, relocating conductor per the "Minimum Dimension" spacing, or consult the respective communication company for their cable sag requirements agreeing the sag of their cable will follow the sag of the conductor in the secondary position. This will allow the cable to have a 30" mid span clearance which is 75% of the separation at the adjoining structures of 40".

Communication conductor in line of site is defined as a straight line joining points of support of the highest communication cable or conductor. Consult the communications company for sag of their conductor.

Given:

35 kV class construction
Primary Voltage – 34.5kV effectively grounded
Pole Framed 20-411A
Grade C construction
1 – 40 ft., class 3 wood pole JT NE (84" Allocated)
3 – 477 kcmil AAC bare conductors (W21BA)
1/0 AAAC triplex secondary cable (W15C)
Ø to Ø Primary Horizontal Separation = 50" (20-206)
Vertical Pole Spacing (74"+10" = 84")
(10" = thru bolt of xarm to conductor on top of insulator)
40" of Neutral Spacing (Bottom Secondary Bracket to top of comm.
300' of 477 kcmil Bare AAC Sag @ final Unloaded Sag@60°F with no wind. =121.92 (6-114). (Design Ruling Span)
135' Span
*135' - 477kcm B AAC Sag @ 176°F (90°C) Final Unloaded = 53"
*135' - #1/0 AAAC Triplex Sag @ 30° = 12"
* = Calculated Values. (Steps 5-7)



Maximum Span Contingent on Horizontal Primary Conductors Separation: Steps 1-4

Step	Action	Use
1	Determine maximum Primary Conductor sag based on 50" of primary horizontal conductor separation Section 20-206.	NESC 235Bb2: #2 AWG and greater. $s = 12 * \left(\frac{(c - .3k)_v}{8} \right)^2$
2	Calculate maximum allowable primary sag	s= Apparent Sag in Inches = unknown c=Primary phase to phase separation based on 20-206 = 50" k=Kilovolt of circuit = 35kV $s = (12)x\left(\frac{50\,in. - .3x35\,kV}{8}\right)^2 = (12)x\left(\frac{50 - 10.5}{8}\right)^2$ $s = 292.5''$ (293")
3	Determine maximum span based on Primary conductor sag of 292.5" (293") for 477kcmil AAC Bare Primary Conductor.	$S_m = S_r * \sqrt{\frac{D_m}{D_r}}$ S_m = Maximum Allowable Span S_r= Design Ruling Span D_m= Defined Sag Limit D_r= Design Ruling Span Sag @ final Unloaded Sag@60°F with no wind.
4	Calculate Maximum Span (Maximum Span based solely on Horizontal Separation. Not influenced with Vertical Separation)	$S_m = 300 * \sqrt{293/121.92}$ $S_m = 300 * \sqrt{2.4}$ S_m = 300 * 1.55 S_m = 464.75'(465') .

Determine Sag of Actual Span versus Ruling Span: Steps 5-7

Step	Action	Use
5	Determine Sag of “Other Span”. (135’ section)	$S_a = \frac{L_a^2}{L_r^2} * S_r$ S_a = Sag of Actual Span S_r = Sag of Ruling Span L_a = Length of Actual Span L_r = Length of Ruling Span
6	Calculate 135’ - 477kcm B AAC Sag @ 194°F (90°C) Final Unloaded (See 6-114)	S_a = Sag of Actual Span = Unknown S_r = Sag of Ruling Span = 45.24” (125’ Ruling span) L_a = Length of Actual Span = 135’ L_r = Length of Ruling Span = 125’ $S_a = \frac{L_a^2}{L_r^2} * S_r$ $S_a = \frac{135^2}{125^2} * 45.24_k$ S_a = 52.77” **= 53”**
7	Calculate 135’ - #1/0 AAC Triplex Sag @ 30°F .(0°C) (See 10-6)	S_a = Sag of Actual Span = Unknown S_r = Sag of Ruling Span = 10” L_a = Length of Actual Span = 135’ L_r = Length of Ruling Span = 125’, $S_a = \frac{L_a^2}{L_r^2} * S_r$ $S_a = \frac{135^2}{125^2} * 10$ S_a = 11.64” **= 12”**

Determine 34.5kV Effectively Grounded Phase to Secondary/Neutral (Supply) NESC Clearance: Steps 8-9

Step	Action	Use
8	Determine NESC required phase to 0-750V secondary (Supply) clearance per NESC requirements at the **structure**. (See Table 9 – page 7-19 in the Overhead Construction Standards)	34.5kV/19.9kV effectively grounded distribution circuit Structure Clearance = 16” + .(4” per KV). See Table 9 page 7-19 Structure Clearance = 16” + (.4 X 19.9 – 8.7) Structure Clearance = 16” + 4.48 Structure Clearance = 20.48” (20.5”)
9	Determine NESC Mid-Span Clearances. (See Table 9 – page 7-19 in the Overhead Construction Standards)	Mid-Span clearance = 75% X Structure Clearance Mid-Span clearance = 75% X 20.5” Mid-Span clearance = 15.375” (16”)

Maximum Span Contingent on Vertical Conductor Separation between Primary – Secondary – Communication Conductors : Steps 10-12

•

Step	Action	Use
10	Calculate Sagged Primary Conductor Above or Below Secondary Line-Of-Site.	Vertical Pole Spacing = 82” Primary Conductor Sag = 53” Sagged Primary Conductor **ABOVE** Sec Line-of-Site = 29”
11	Calculate Mid Span Conductor Separation between Primary and Secondary	Sagged Primary Conductor Above Sec Line-Of-Site = 29” Secondary Conductor Sag = 12” Mid Span Vertical Separation between Pri & Sec = 41” (16” minimum required per Section 7)
12	Calculate Mid Span Conductor Separation between Secondary and Communication’s Conductor Line-Of-Site	Vertical Separation between Sec Conductor and Line-Of-Site for communications conductor (40” vertical +2” from Sec cond to bottom of Sec Bracket) = 42” Secondary Conductor Sag = 12” Mid Span Vertical Separation between Pri & Sec = 30” (30” minimum required per Section 7)

Determine Clearance between Sagged Primary Conductor and Communication’s In-Line-of-Site (>150’ & >750V NESC Rule 235C.2.b.3): Steps 13-14

Step	Action	Use
13	Determine maximum vertical separation between primary positions on pole to Communication’s Line-Of-Site.	Conductor Position On Insulator = 8.0” Framing Vertical Pole Spacing (Framing) = 74.0” Allocated Space = 2.5” Communication’s Neutral spacing (Line-of-Site) = 40.0” Total Space to Communication’s Line-of-Site 124.5”
14	Calculate sagged Primary Conductor position relative to Communication’s Line-Of-Site. (NESC 235.C.2b.3 - Supply Cable exceeding 750V and less than 50kV for spans exceeding 150’ shall not sag below communication’s In-Line-of-Site)	175’ - 477 B AAC sag @ 60°F (15°C) no wind displacement and final unloaded. = 45” Total Space to Communication’s Line-of-Site =124.5” Primary Conductor Sag = 45.0” Mid Span Vertical Clearance between sagged Primary = 79.5” And Communication’s Line-of-Site (Above Line-of-Site -0” Minimum)

Conclusion:

Horizontal – The horizontal clearance of 50" will allow a maximum span of 465' for 477 B AAC before mid span contact becomes an issue between primary conductors. This calculated value, per NESC guidelines, is well beyond the span of 135' in the above example. (Steps 1 - 4)

Vertical – There are several vertical clearances that need to be evaluated regarding maximum spans. They are as follows:

` Primary vs Secondary – The vertical mid span clearance between the primary and secondary conductor was calculated to be 29" for a span of 135' in the above example. The NESC minimum clearance shown in Section 7, Page 7-19 indicates 16" is the minimum required at mid span. Therefore, mid span contact between primary and the conductor in the secondary position is not an issue in the above example. (Step 10 & 11)

Secondary Vs Communications

750V Line –of –Site Rule: This calculation to determine the relative position of the sagged primary conductor to the highest Communication's Cable position for a straight line joining the points of support were not necessary because the span was under 150'. NESC Code requires this clearance to be calculated if the span is greater than 150' and the supply cable is greater than 750V but less than 50KV. The calculation was shown to demonstrate how this clearance should be determine if it falls within the NESC guidelines.

Span Requirements: The span of 135' will allow a vertical mid span clearance of 30" between the conductor in the Secondary position (#1/0 Triplex) and the Communication's cable "In-Line-of-Site" on adjoining structures. Spans can be increased by either installing a higher pole, raise the secondary bracket to the Minimum Dimensions as indicated in the construction drawing (9-411A), requests the communication company to lower their cable, or have Communication Company agree to sag their cable following the sag of the conductor in the secondary position maintaining 30" mid span clearance. .

Ice Loaded Conditions: Sag information for Conductors in the Secondary Position should be shared with the various Communication Companies to assist them in evaluating their cable sag requirements to meet NESC codes. Both Electric and Communication companies are allocated their attachment space on poles; however, a mid span clearance of 30" must be maintained when ice loading conditions occur (See Section 7).

Maximum spans are also contingent upon pole loading and crossarm/pin/insulator strengths. See Section 2.

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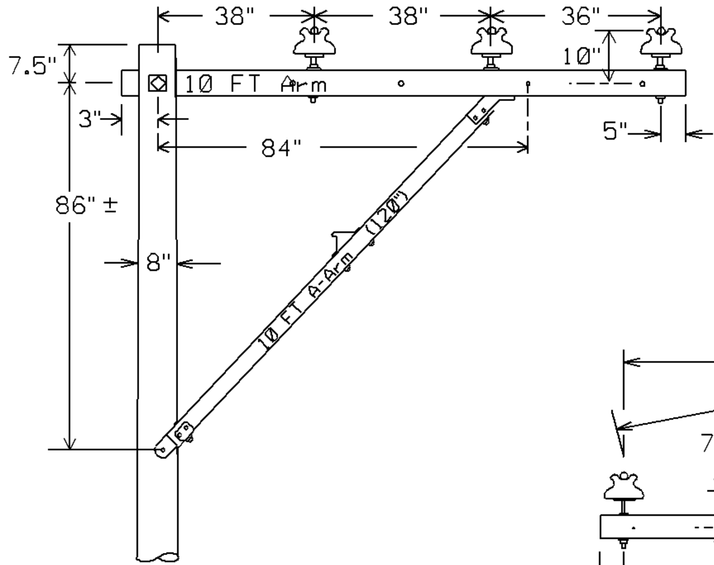
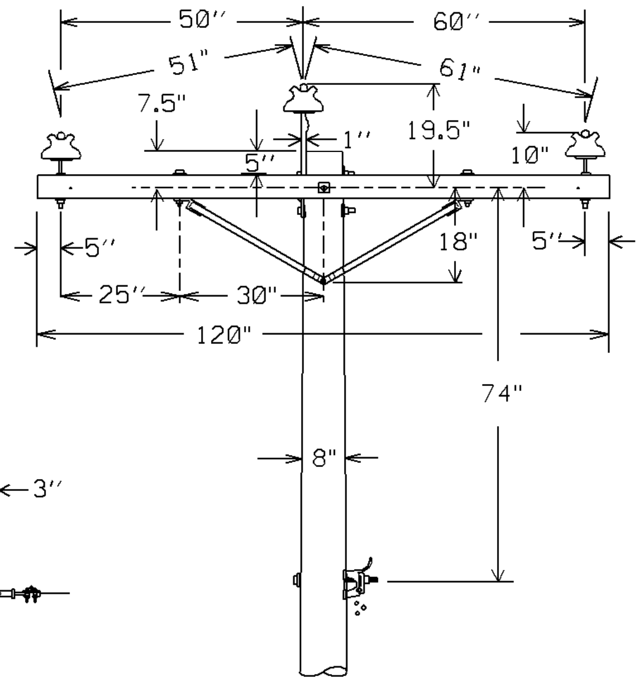
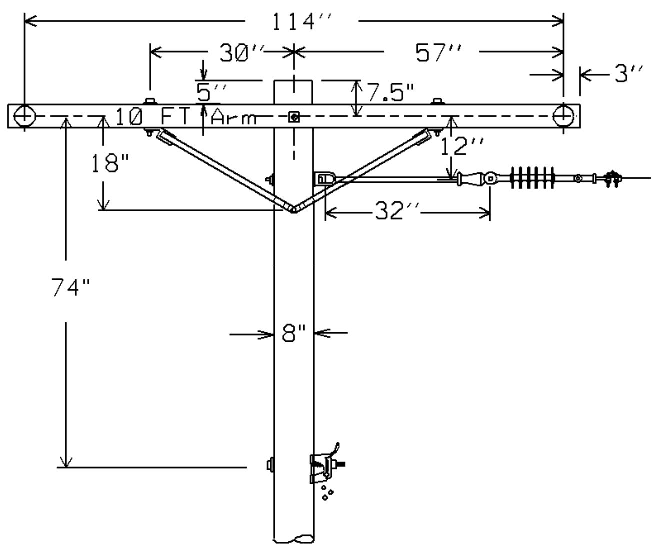


10' - Alley Arm (TC10)
(Dwg. 20-437)



10' - Crossarm (TC10)
Tangent
(Dwg. 20-411)

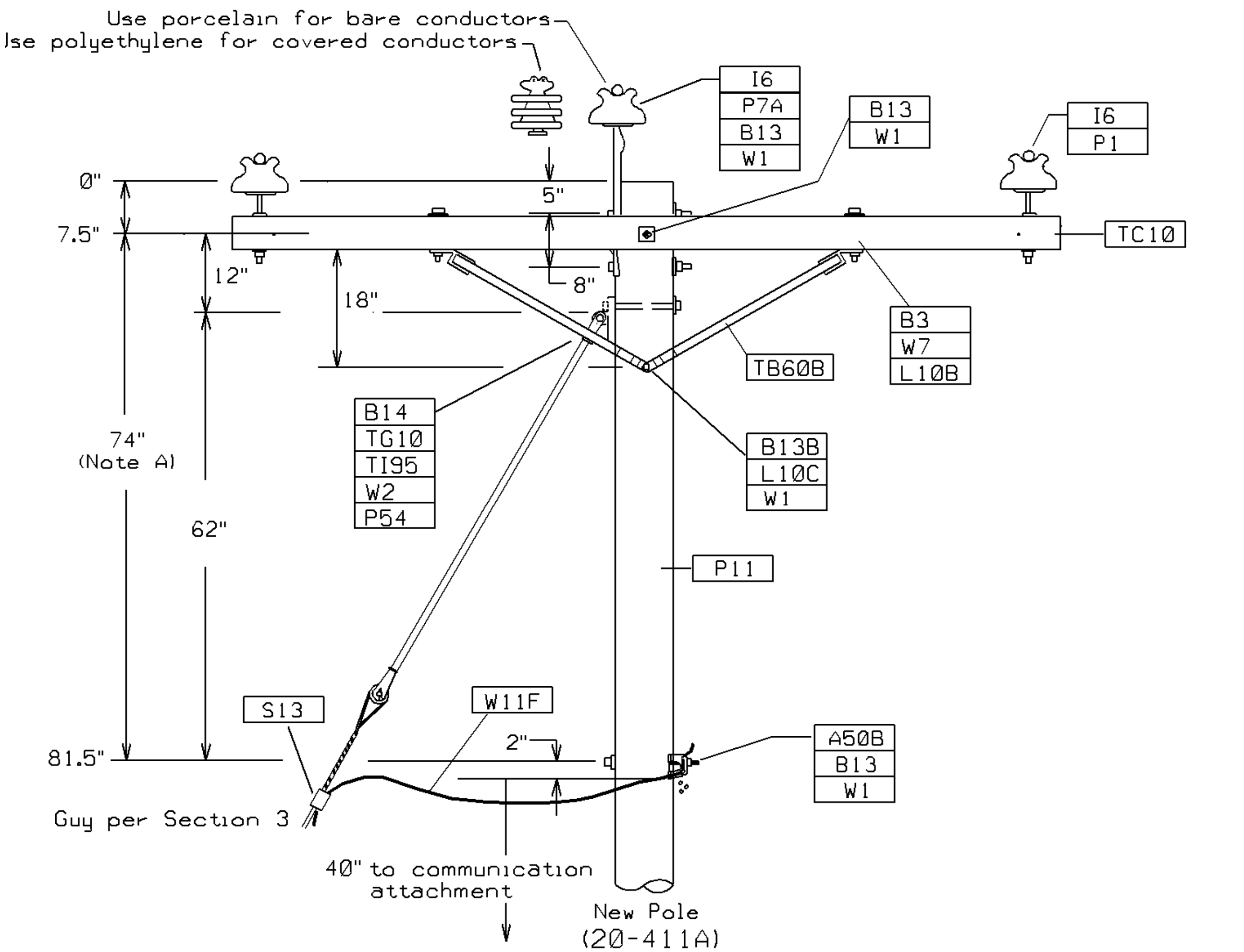


10' - Double (TC10)
Crossarm
Deadend with Tap
(Dwg. 20-419 F2)

Notes:

- These dimensions are shown as general information for standard pole tops using standard materals. Refer to Section 20 primary drawings for other arrangements.

MU = @20-411A	25-35KV 3Φ - Bare	MU = @20-411ACL	25-35KV 3Φ - Covered
MU = @20-411B	25-35KV 1Φ - Bare	MU = @20-411BCL	25-35KV 1Φ - Covered



Note A

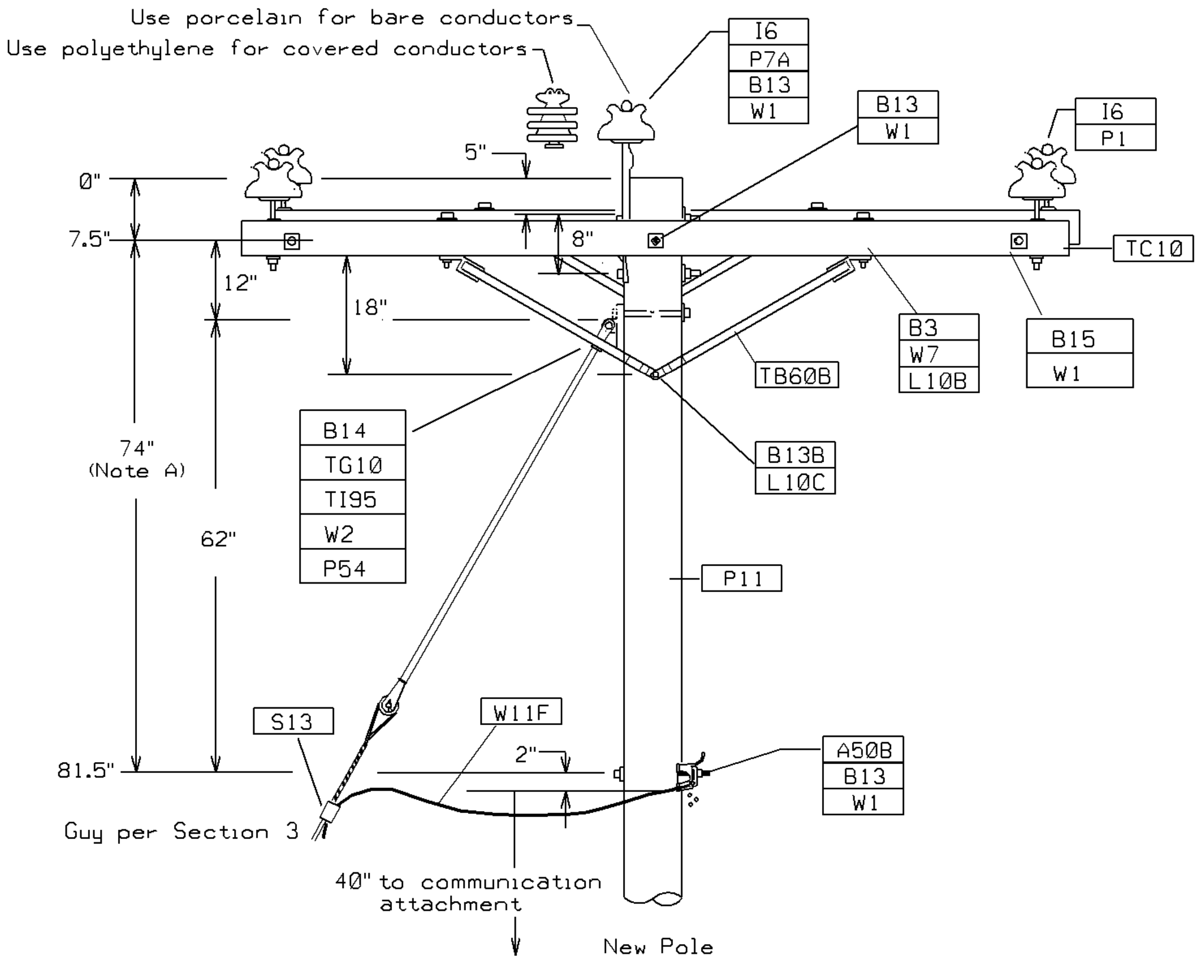
MINIMUM DIMENSIONS	
600V SECONDARY -35KV	53"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments.(20-411B)
- See Section Index for standard pole top construction selection.
- Use preformed conductor (TT1) for 3000 lb. construction.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ CROSSARM POLE TOP – 0-35 kV 0° - 10°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-411		

MU = @20-412A	25-35KV 3Φ - Bare	MU = @20-412ACL	25-35KV 3Φ - Covered
MU = @20-412B	25-35KV 1Φ - Bare	MU = @20-412BCL	25-35KV 1Φ - Covered



New Pole
(20-412A)

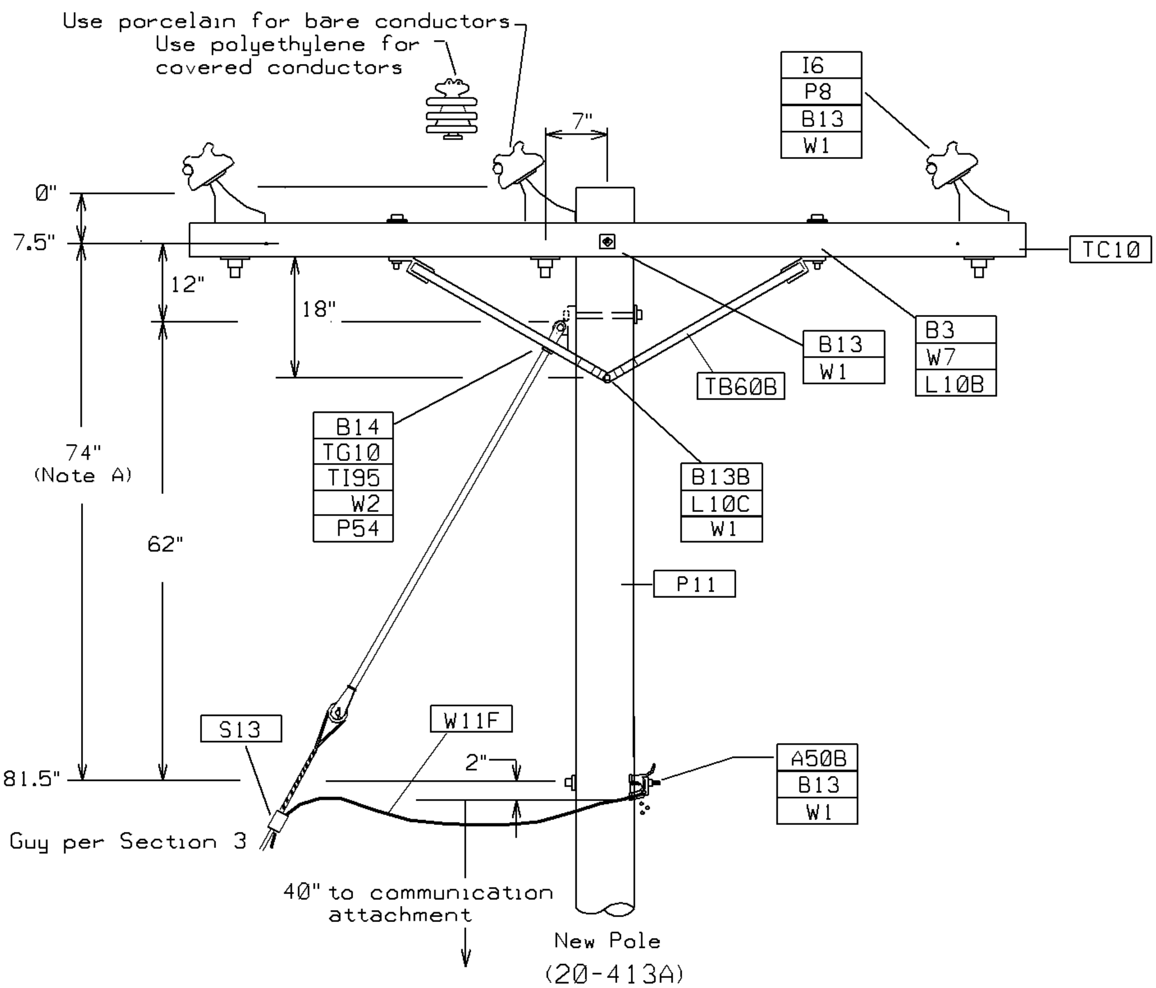
Note A

MINIMUM DIMENSIONS	
600V SECONDARY -35KV	53"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments.(20-412B)
- See Section Index for standard pole top construction selection.
- Use performed conductor ties (TT1) for 3000 lb construction & heavy duty crossarm.
- Double crossarms or equivalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

MU = @20-413A	25-35KV 3Φ - Bare	MU = @20-413ACL	25-35KV 3Φ - Covered
MU = @20-413B	25-35KV 1Φ - Bare	MU = @20-413BCL	25-35KV 1Φ - Covered



Note A

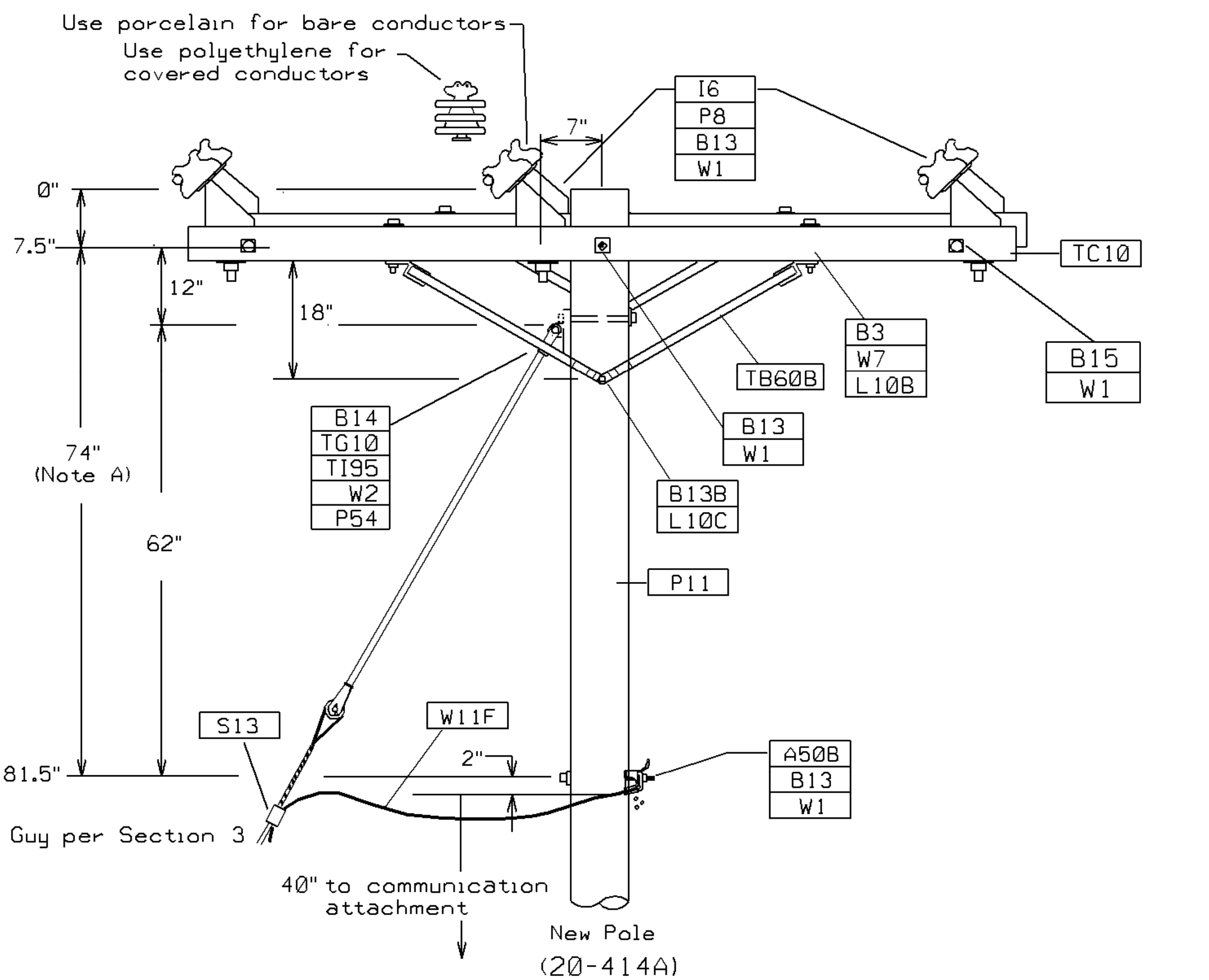
MINIMUM DIMENSIONS	
600V SECONDARY -35KV	53"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments.(20-413B)
- See Section Index for standard pole top construction selection.
- Use performed conductor ties (TT1) for 3000 lb construction.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ CROSSARM POLE TOP – 25-35 kV 11° - 20°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-413		

MU = @20-414A	25-35KV 3Φ - Bare	MU = @20-414ACL	25-35KV 3Φ - Covered
MU = @20-414B	25-35KV 1Φ - Bare	MU = @20-414BCL	25-35KV 1Φ - Covered



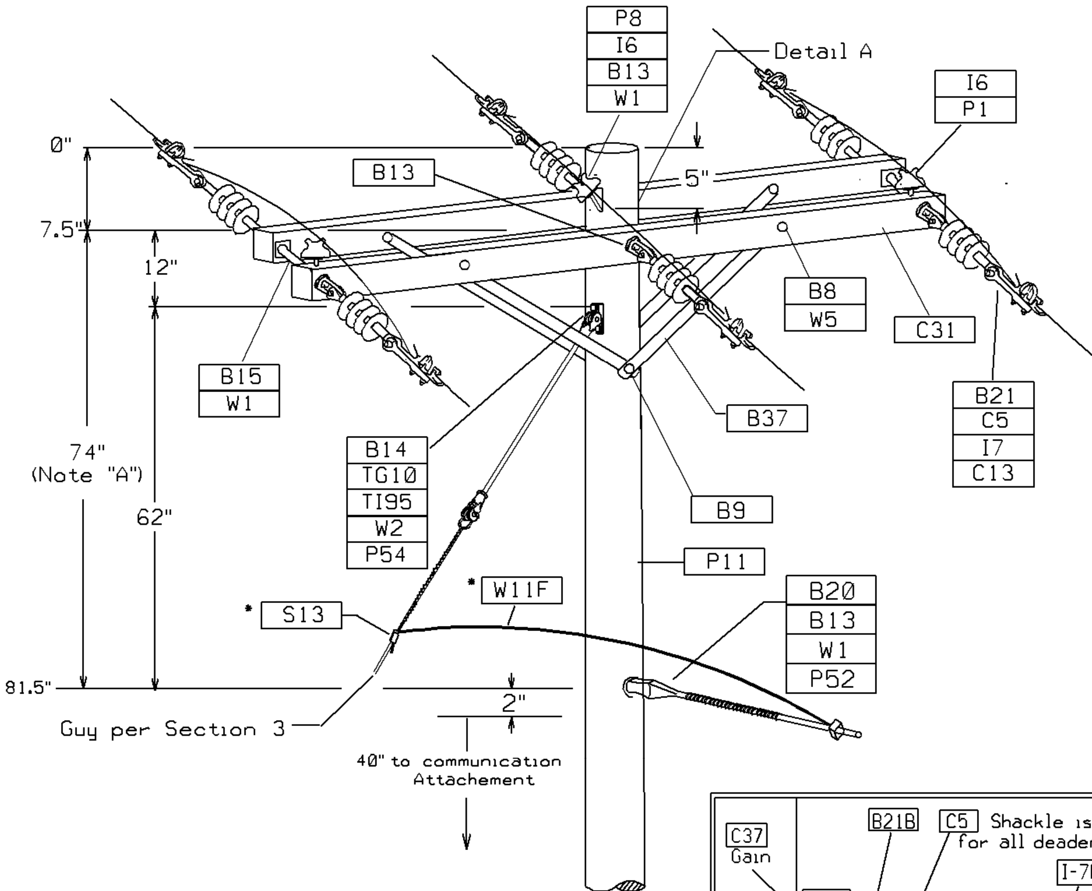
Note A

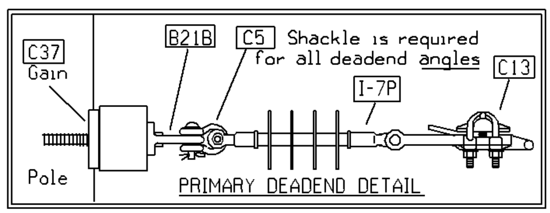
MINIMUM DIMENSIONS	
600V SECONDARY -35KV	53"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments. (20-414B)
- See Section Index for standard pole top construction selection.
- Use performed conductor ties (TT1) for 3000 lb construction.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

MU = @20-415A	25-35KV 3Φ - Bare	MU = @20-415ACL	25-35KV 3Φ - Covered
MU = @20-415B	25-35KV 1Φ - Bare	MU = @20-415BCL	25-35KV 1Φ - Covered





Note A

MINIMUM DIMENSIONS	
5KV OPERATION	20"
NEUTRAL ONLY-15KV OPERATION	20"
600V SECONDARY-15KV	48"

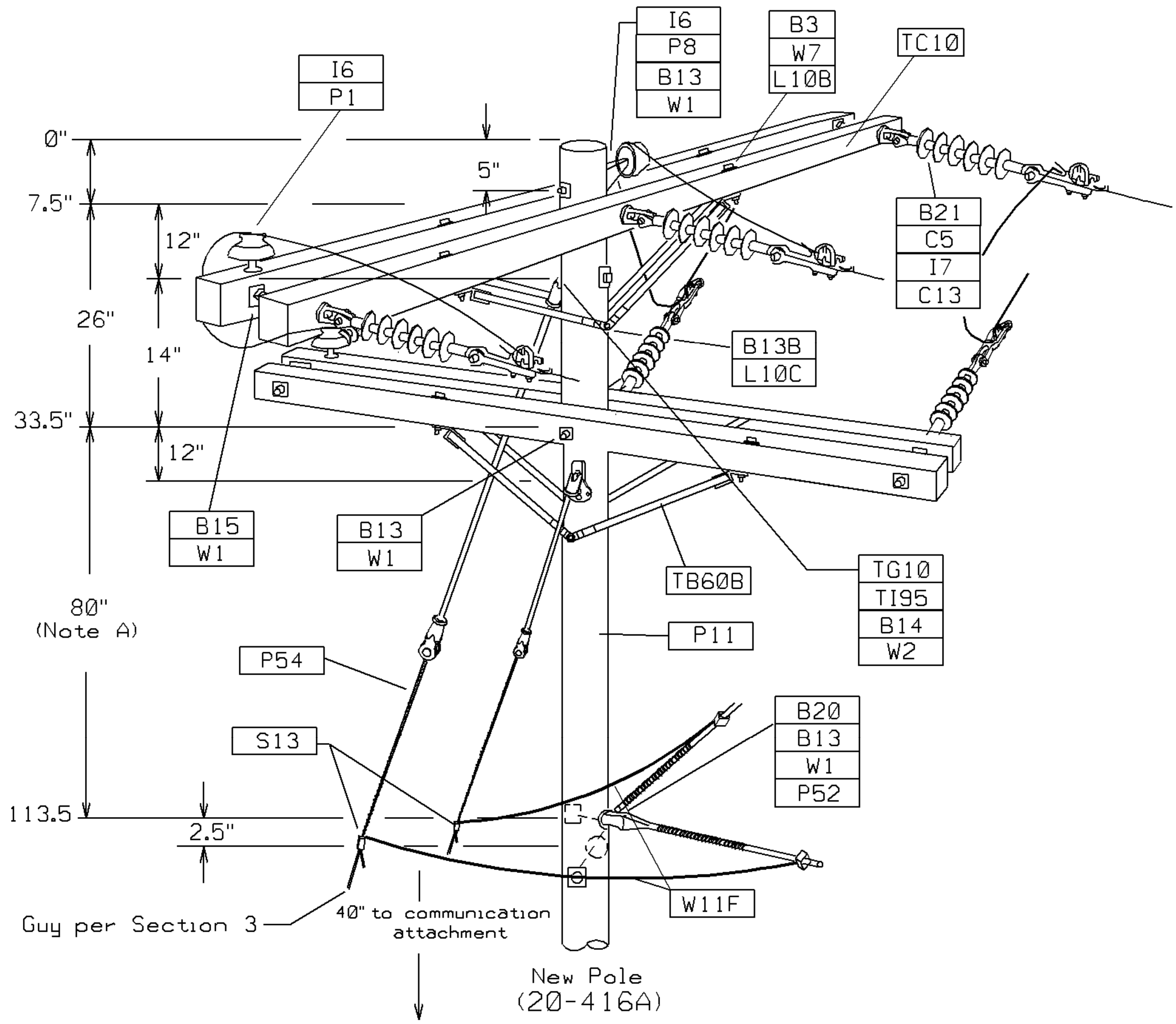
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	45 JT-111"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	45 JT-111"	255	185	175
86	45 JT-111"	300	--	--
106	45 JT-111"	--	240	--
107	45 JT-111"	--	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

- For Single Phase (phase-phase), omit center conductor and attachments. (9-415B)
- See Section Index for standard pole top construction selection.
- Use HD (Heavy Duty) crossarms (C31D) and (TB60) braces and gain plates (C37) for 3000# construction.
- Install Surge Arresters per Section 13.

* Omit bond from down guy to secondary on noneffectively grounded systems.

1Φ AND 3Φ DOUBLE CROSSARM POLE TOP – 25-35 kV 46° - 60°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-415		

MU = @20-416A	25-35KV 3Φ - Bare	MU = @20-416ACL	25-35KV 3Φ - Covered
MU = @20-416B	25-35KV 1Φ - Bare	MU = @20-416BCL	25-35KV 1Φ - Covered



Note A

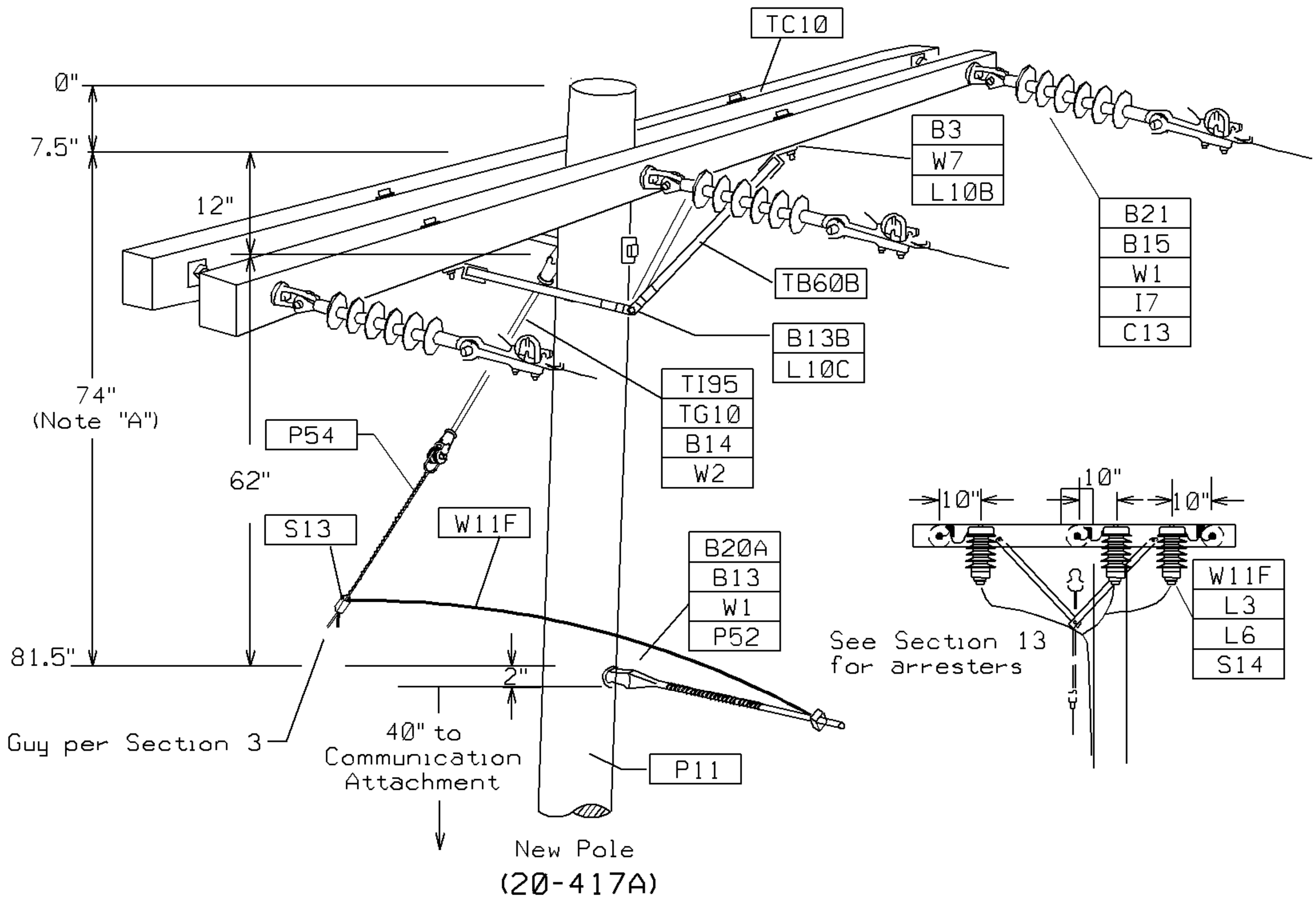
MINIMUM DIMENSIONS	
600V SECONDARY -35KV	59"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
92.5	45 JT-111"	185	--
98.5	45 JT-111"	--	175
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
106	45 JT-111"	250	--
109	45 JT-111"	--	160
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments. (20-416B)
- See Section Index for standard pole top construction selection.
- Use HD (Heavy Duty) crossarms (C31D) and (TB60) braces and gain plates (C37) for 3000# construction.
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ DOUBLE CROSSARM POLE TOP – 25-35 kV ANGLES 61° - 90° AND DEADENDS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		20-416	7/07

MU = @20-417A	25-35KV 3Φ - Bare	MU = @20-417ACL	25-35KV 3Φ - Covered
MU = @20-417B	25-35KV 1Φ - Bare	MU = @20-417BCL	25-35KV 1Φ - Covered



Note A

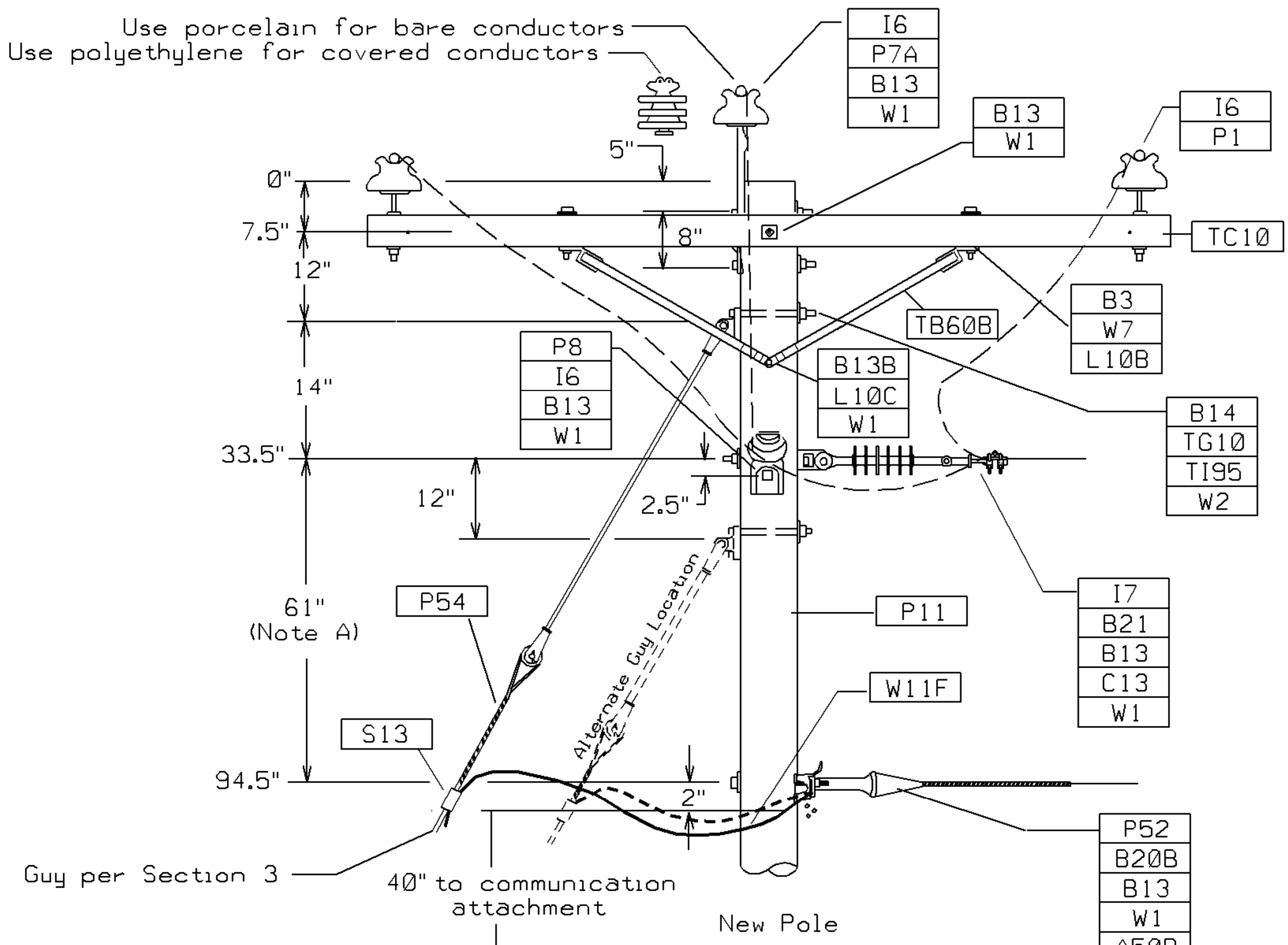
MINIMUM DIMENSIONS	
600V SECONDARY -35KV	55"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	160
89.5	45 JT-111"	300	--
106	45 JT-111"	--	210
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments. (20-417B)
- See Section Index for standard pole top construction selection.
- Use HD (Heavy Duty) crossarms (C31D) and (TB60) braces and gain plates (C37) for 3000# construction.
- Install Surge Arrester per Section 13.

1Φ AND 3Φ DOUBLE CROSSARM POLE TOP – 25-35 kV DEADEND			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-417		

MU = @20-419F1A	25-35KV 3Φ - Bare	MU = @20-419F1ACL	25-35KV 3Φ - Covered
MU = @20-419F1B	25-35KV 1Φ - Bare	MU = @20-419F1BCL	25-35KV 1Φ - Covered



(20-419F1A)

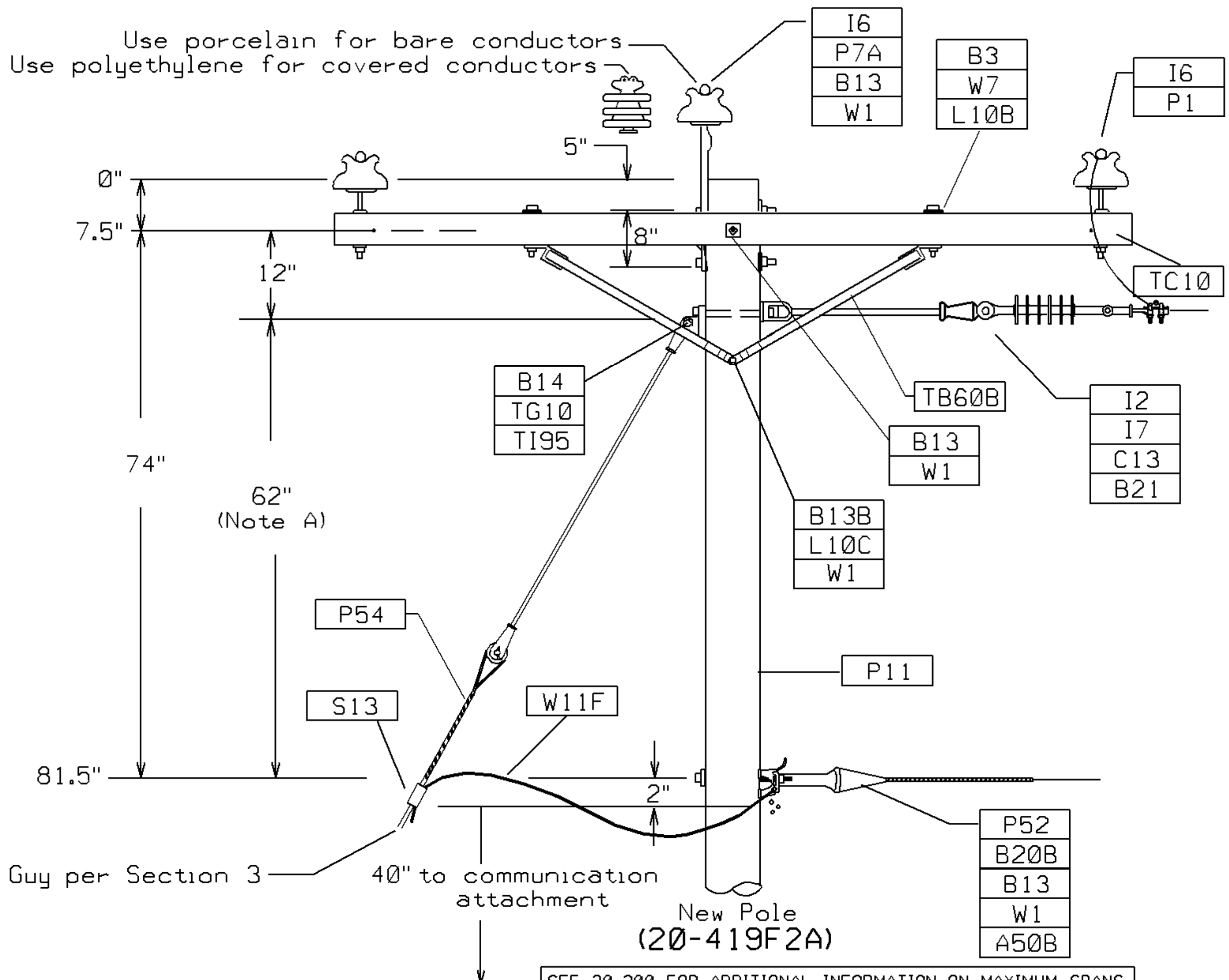
Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	177	177	177
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	--	--
107	45 JT-111"	--	230	--
94.5	45 JT-111"	--	--	184
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

- Omit center conductor and attachments. (20-419F1B)
- See Section Index for standard pole top construction selection.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

MU = @20-419F2A	25-35KV 3Φ - Bare	MU = @20-419F2ACL	25-35KV 3Φ - Covered
MU = @20-419F2B	25-35KV 1Φ - Bare	MU = @20-419F2BCL	25-35KV 1Φ - Covered



Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS

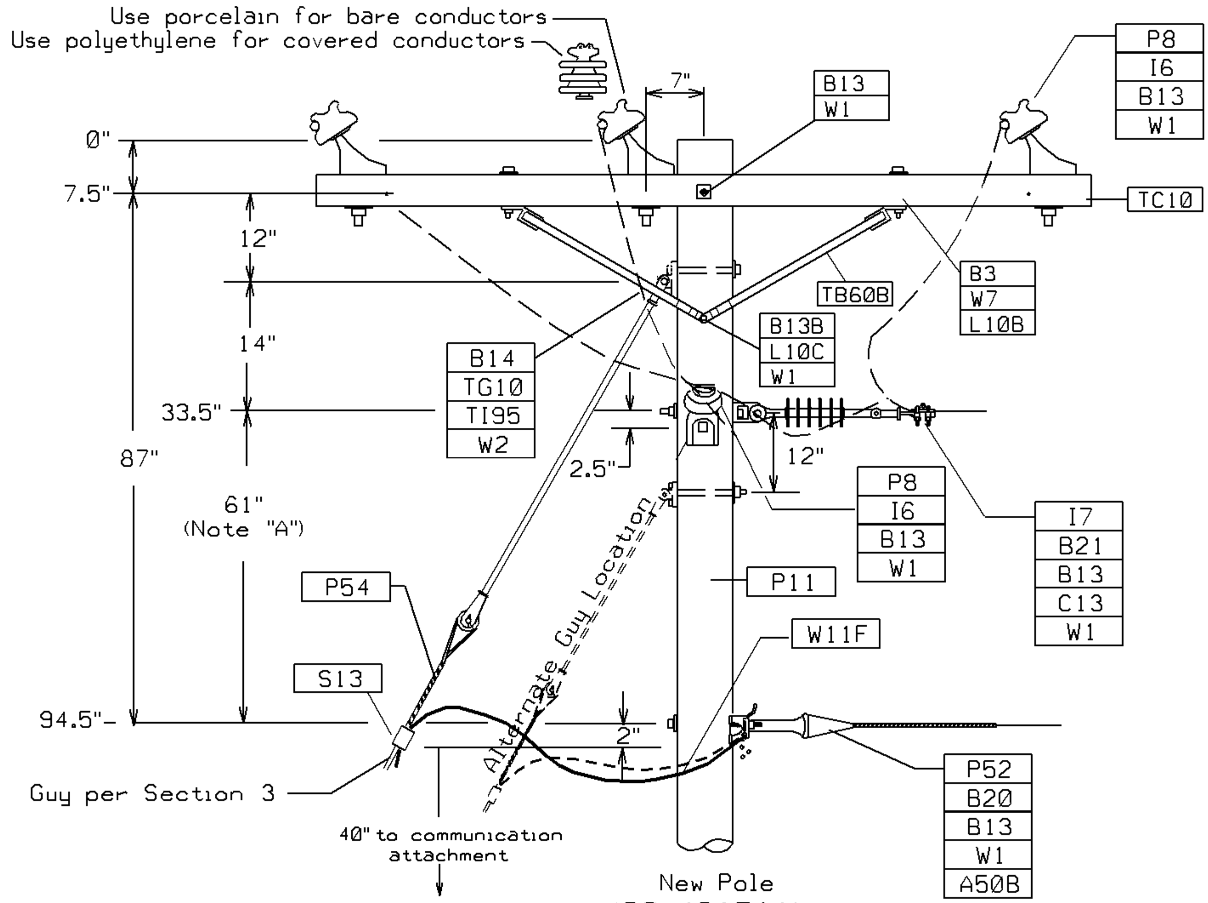
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC	TAP 1/0 AAAC
SPANS WITH 1/0 TRIPLEX SEC				
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
81.5	40 JT-84"	225	180	187
81.5	45 JT-111"	300	--	--
103	45 JT-111"	--	225	--
81.5	45 JT-111"	--	--	200

THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE

- Omit center conductor and attachments. (20-419F2B)
- See Section Index for standard pole top construction selection.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ CROSSARM POLE TOP – 25-35 kV (ALTERNATE) 0° - 10 ° – TAP TO 1Φ ARMLESS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-419 FIG 2		

MU = @20-421F1A	25-35KV 3Φ - Bare	MU = @20-421F1ACL	25-35KV 3Φ - Covered
MU = @20-421F1B	25-35KV 1Φ - Bare	MU = @20-421F1BCL	25-35KV 1Φ - Covered



New Pole
(20-421F1A)

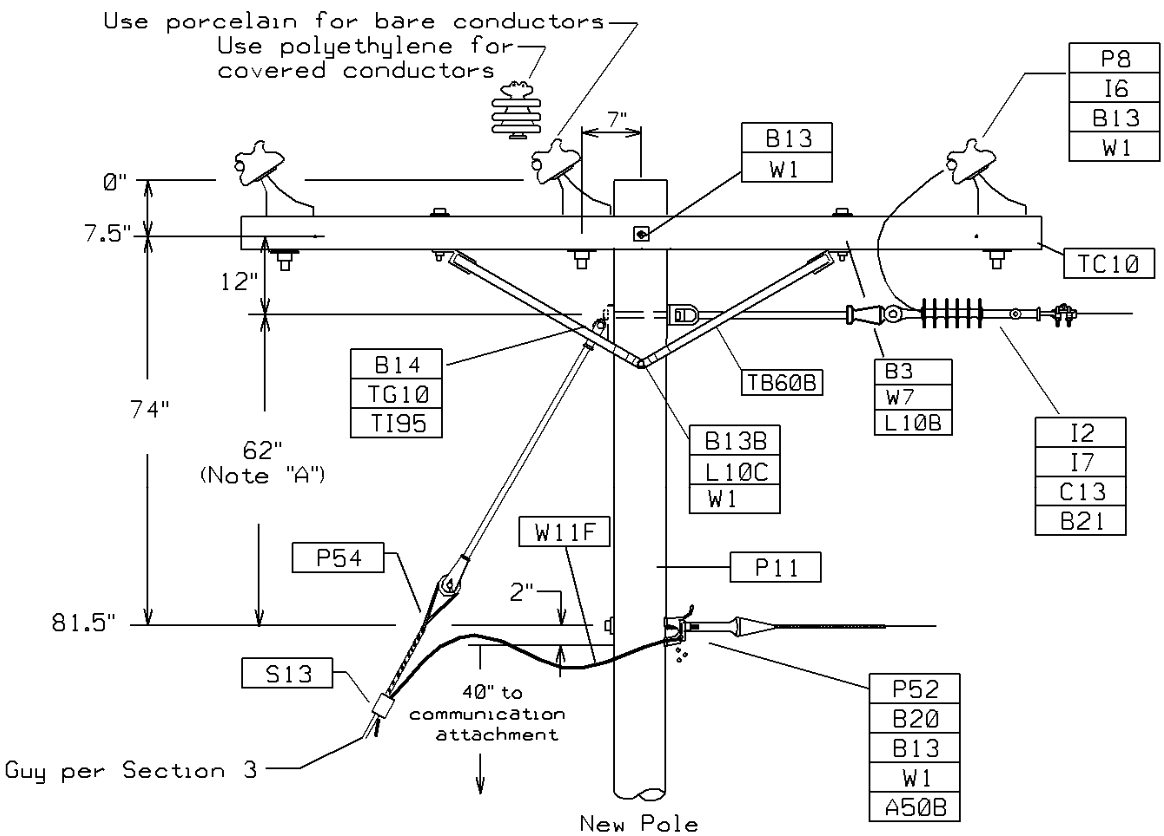
Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	177	177	177
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	--	--
107	45 JT-111"	--	230	--
94.5	45 JT-111"	--	--	184
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

- Omit center conductor and attachments. (20-421F1B)
- See Section Index for standard pole top construction selection.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

MU = @20-421F2A	25-35KV 3Φ - Bare	MU = @20-421F2ACL	25-35KV 3Φ - Covered
MU = @20-421F2B	25-35KV 1Φ - Bare	MU = @20-421F2BCL	25-35KV 1Φ - Covered



(20-421F2A)

Note A

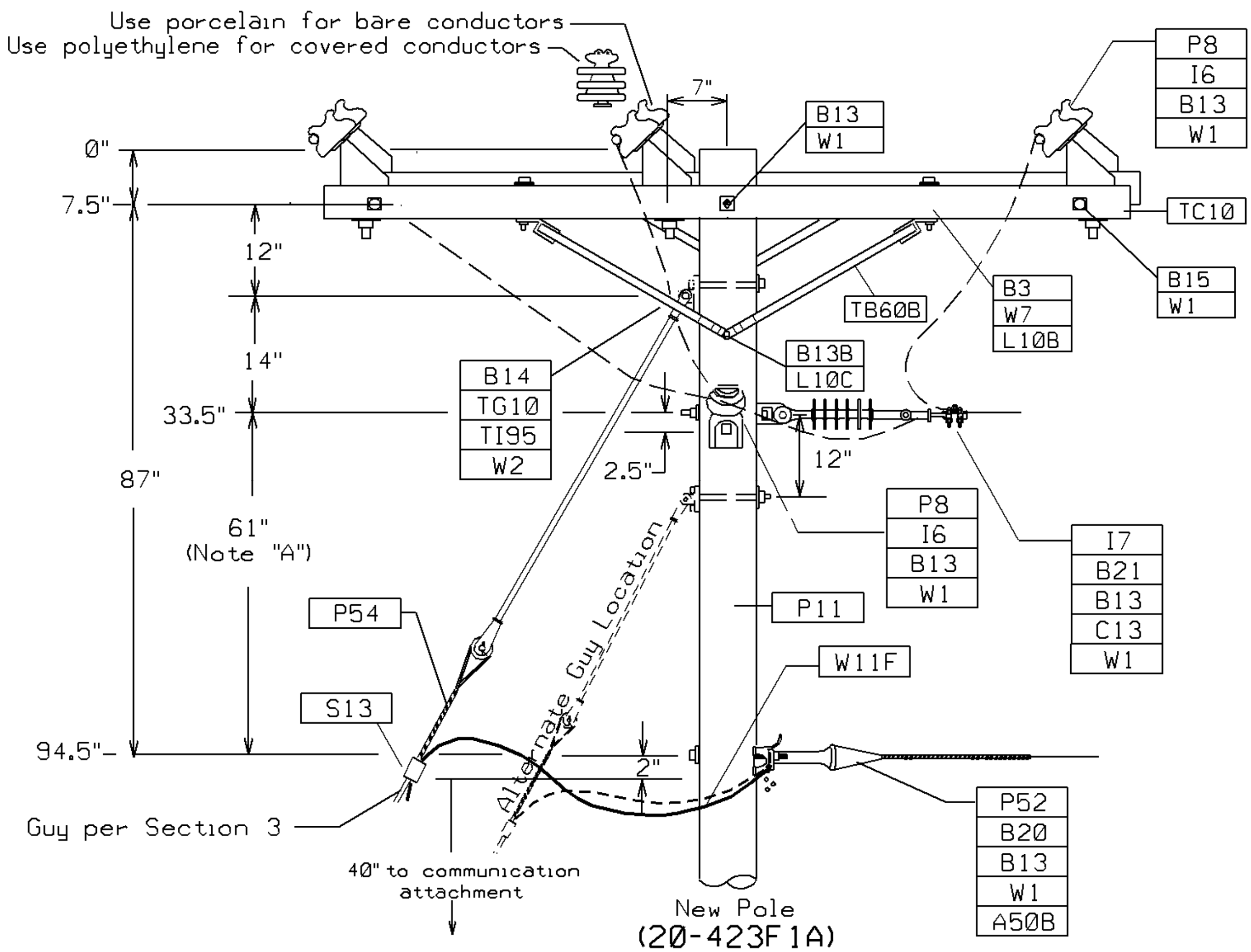
MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	180	187
81.5	45 JT-111"	300	--	--
103	45 JT-111"	--	225	--
81.5	45 JT-111"	--	--	200
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

- Omit center conductor and attachments. (20-421F2B)
- See Section Index for standard pole top construction selection.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ CROSSARM POLE TOP – 0-35 kV (ALTERNATE) 11° - 20° – TAP TO 1Φ ARMLESS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-421 FIG 2		

MU = @20-423F1A	25-35KV 3Φ - B	MU = @20-423F1ACL	25-35KV 3Φ - Covered
MU = @20-423F1B	25-35KV 1Φ - B	MU = @20-423F1BCL	25-35KV 1Φ - Covered



Note A

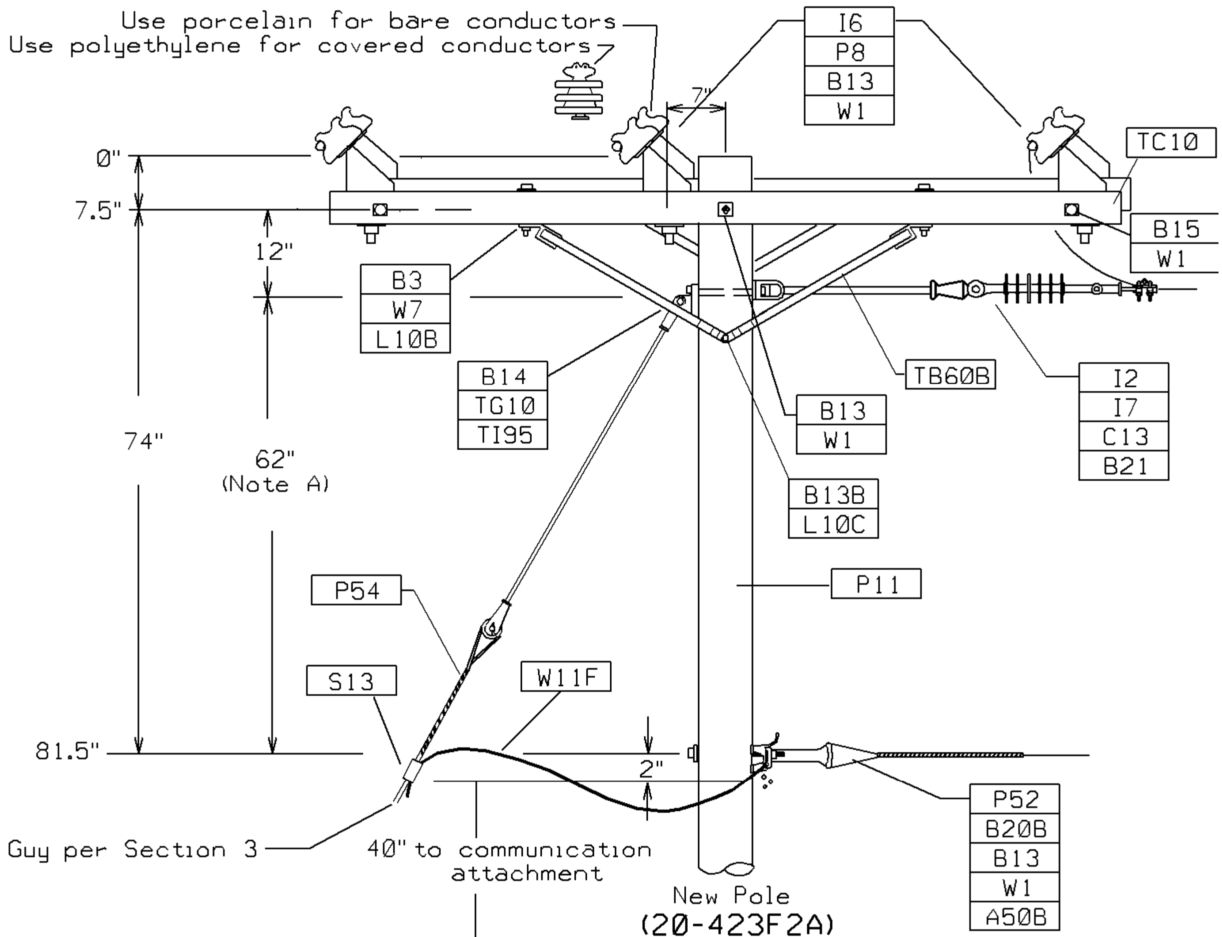
MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	177	177	177
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	--	--
107	45 JT-111"	--	230	--
94.5	45 JT-111"	--	--	184
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

- Omit center conductor and attachments. (20-423F1B)
- See Section Index for standard pole top construction selection.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ DOUBLE CROSSARM POLE TOP – 0-35 kV (PREFERRED) CROSSINGS 11° - 45° / ANGLES - 21° - 45° – TAP TO 1Φ ARMLESS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 20-423 FIG I	ISSUE: 7/07

MU = @20-423F2A	25-35KV 3Φ - Bare	MU = @20-423F2ACL	25-35KV 3Φ - Covered
MU = @20-423F2B	25-35KV 1Φ - Bare	MU = @20-423F2BCL	25-35KV 1Φ - Covered



SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	180	187
81.5	45 JT-111"	300	--	--
103	45 JT-111"	--	225	--
81.5	45 JT-111"	--	--	200
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

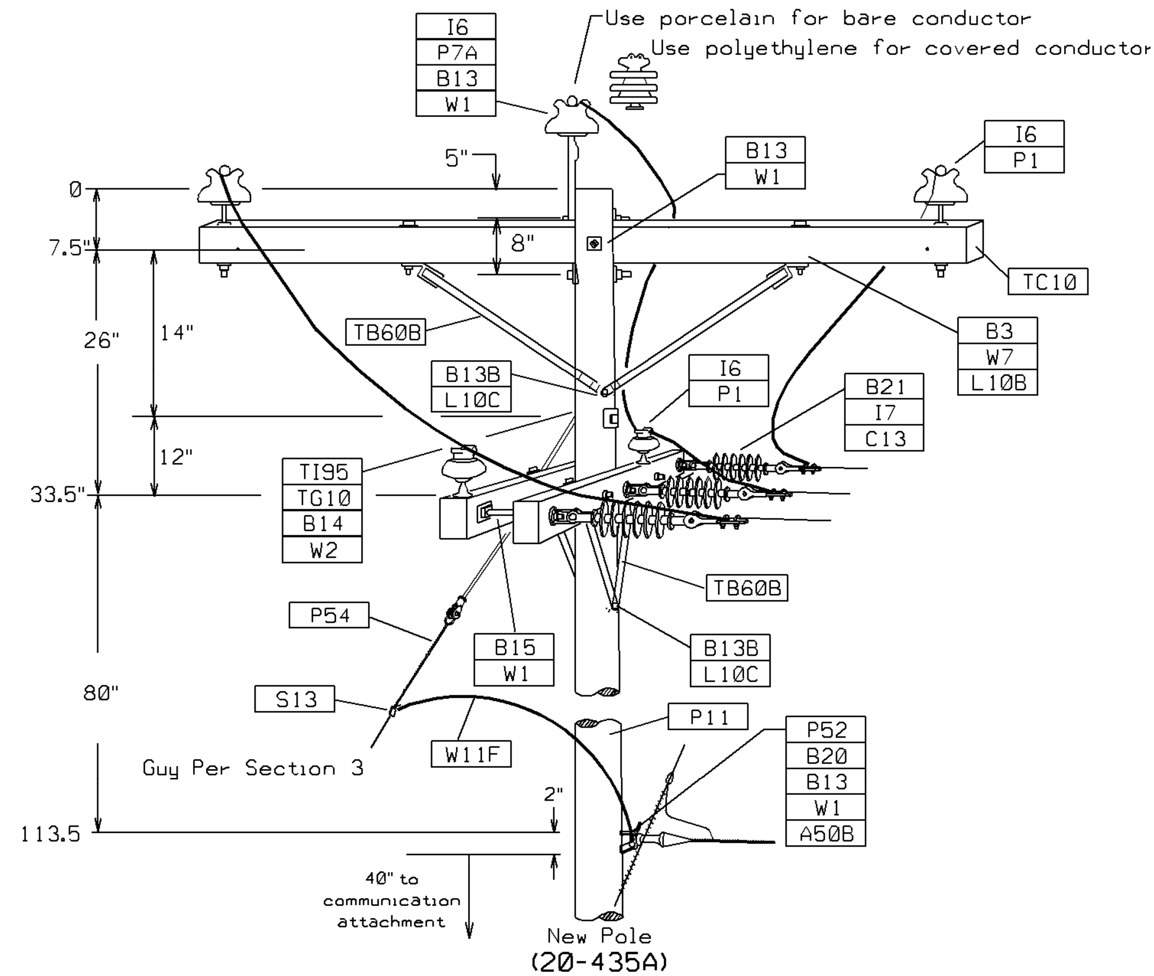
Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY OPERATION	28"

- Omit center conductor and attachments. (20-423F2B)
- See Section Index for standard pole top construction selection.
- Double crossarms or equvalent are required (NESC 261.D.5.c.) at each crossing structure, lines over railways, limited access highways, or navigable waterways requiring crossing permits (NESC 241C), and deadend or angles over 20 degrees.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ DOUBLE CROSSARM POLE TOP – 0-35 kV (ALTERNATE) CROSSINGS 11° - 45° / ANGLES - 21° - 45° – TAP TO 1Φ ARMLESS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-423 FIG 2		

MU = @20-435A	25-35KV 3Φ - Bare	MU = @20-435ACL	25-35KV 3Φ - Covered
MU = @20-435A(X)	25-35KV 3Φ - Bare, (X) = 11 or 21	MU = @20-435ACL(X)	25-35KV 3Φ - Covered, (X) = 11 or 21
MU = @20-435B	25-35KV 1Φ - Bare	MU = @20-435BCL	25-35KV 1Φ - Covered
MU = @20-435B(X)	25-35KV 1Φ - Bare, (X) = 11 or 21	MU = @20-435BCL(X)	25-35KV 1Φ - Covered, (X) = 11 or 21



Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV NEUTRAL ONLY OPERATION	59" 28"

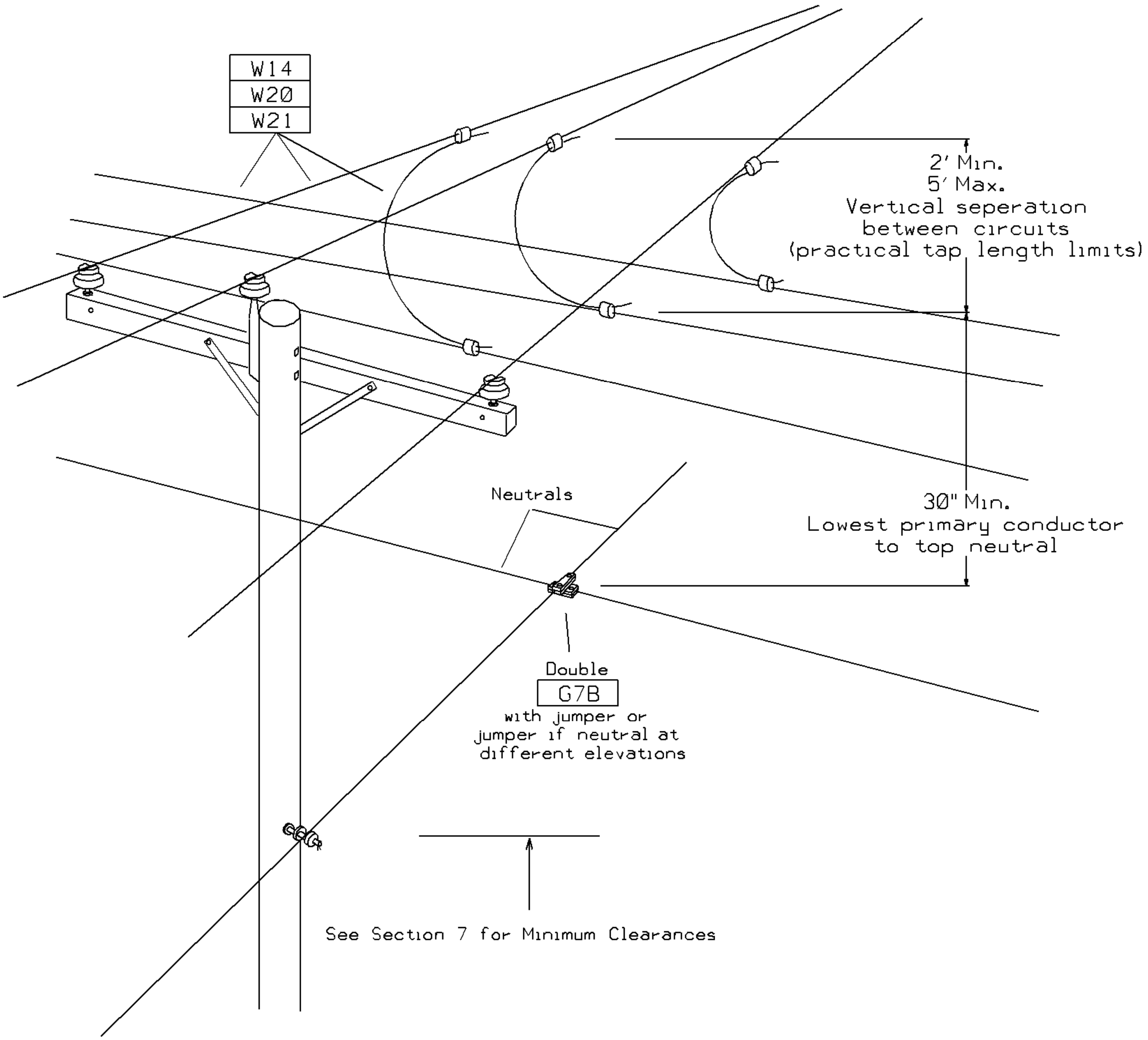
SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
92.5	45 JT-111"	185	--
98.5	45 JT-111"	--	175
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
106	45 JT-111"	250	--
109	45 JT-111"	--	160
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- Omit center conductor and attachments. (20-435B)
- See Section Index for standard pole top construction selection.
- Use HD (Heavy Duty) crossarms (C31D) and (TB60) braces and gain plates (C37) for 3000# construction.
- Install Surge Arresters per Section 13.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)

See 20-413 for Tangent Line Angles 11° - 20°.
See 20-414 for Tangent Line Angles 21° - 45°.
See 20-415 for Tangent Line Angles 46° - 60°.

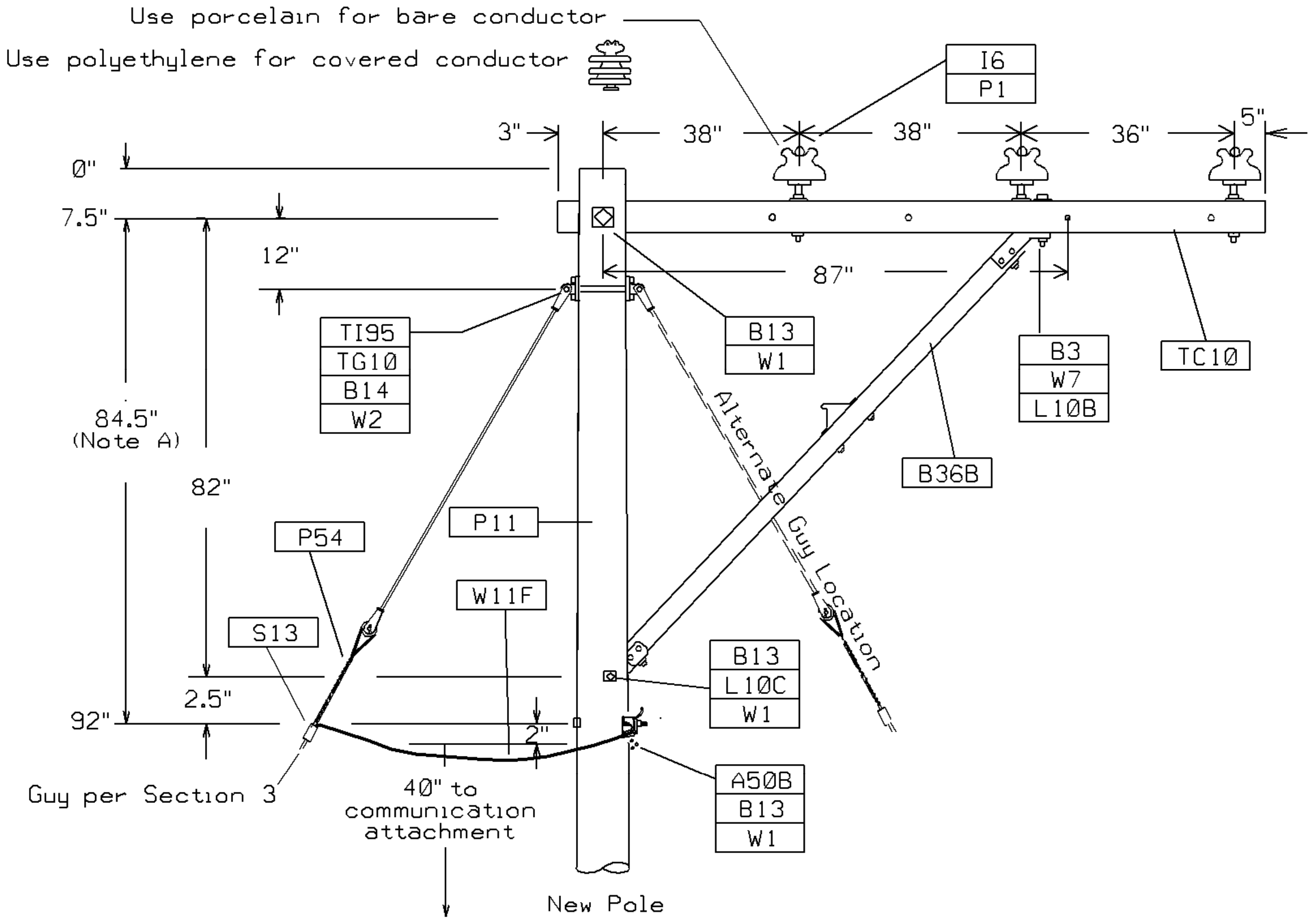
Notes:

1. Midspan taps may be required where poles are set back at heavy intersections.
2. See Page 20-435 for standard 3-phase tap - at the pole.
3. Refer to Page 20-105 for information on relative phase positioning.
4. Aluminum Oxide quickly forms on cleaned aluminum conductions and is non-conductive and non-visible. Always wire brush surface of conductors immediately before making electrical connections.
5. See Section 5 for connectors



PRIMARY MIDSPAN TAP			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-436		

MU = @20-437A	25-35KV 3Φ - Bare	MU = @20-437ACL	25-35KV 3Φ - Covered
MU = @20-437B	25-35KV 1Φ - Bare	MU = @20-437BCL	25-35KV 1Φ - Covered



(20-437A)

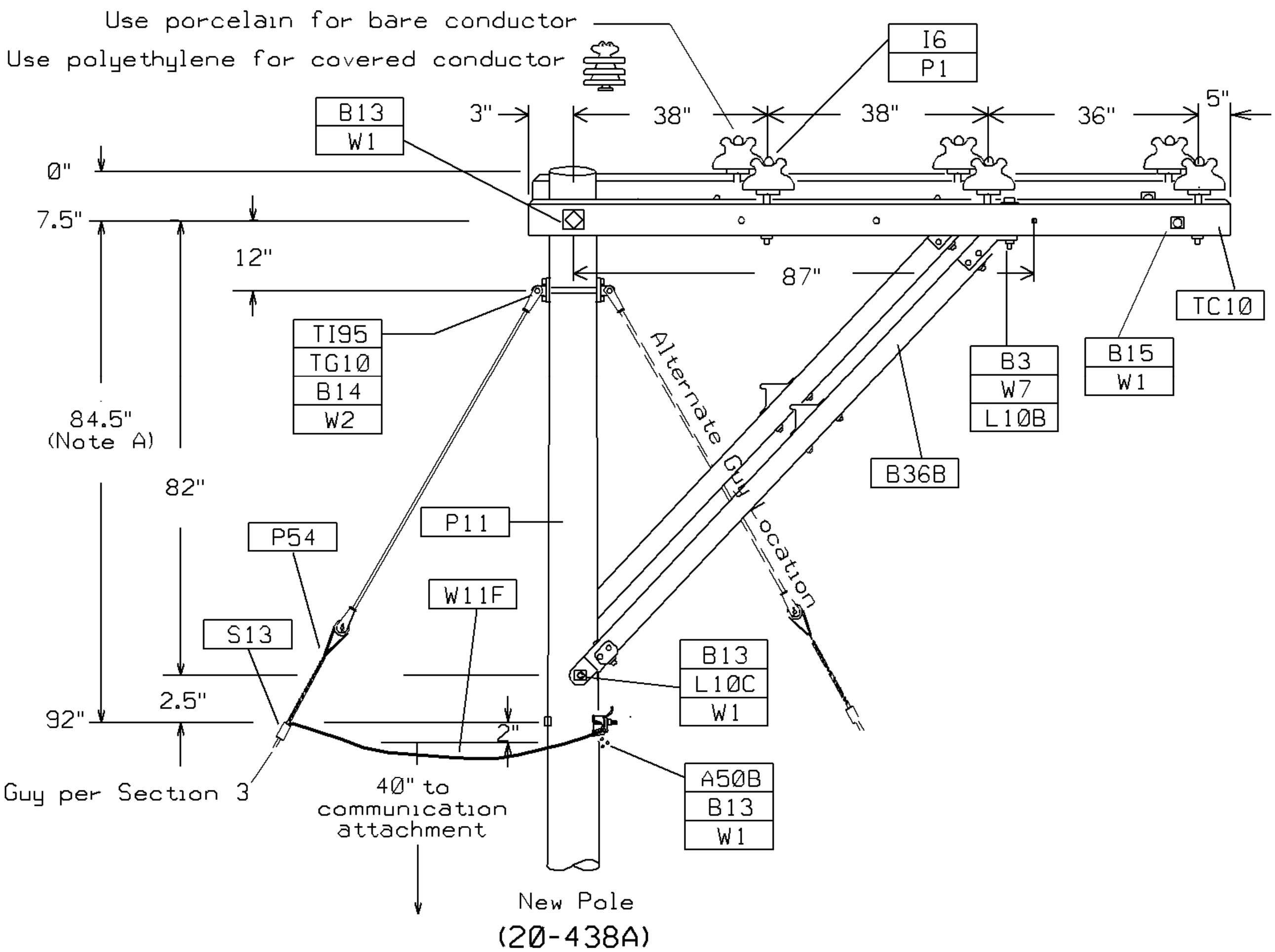
Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	45"
NEUTRAL ONLY-15KV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

Note:
- Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
- Omit center conductor and attachments. (20-437B)
- See Section Index for standard pole top construction selection.
- Use 2000 lb construction only.
- Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.
- Guying is not necessary for in line poles with offset arms unless forcess are being exerted per Section 3.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

MU = @20-438A	25-35KV 3Φ - Bare	MU = @20-438ACL	25-35KV 3Φ - Covered
MU = @20-438B	25-35KV 1Φ - Bare	MU = @20-438BCL	25-35KV 1Φ - Covered



Note A

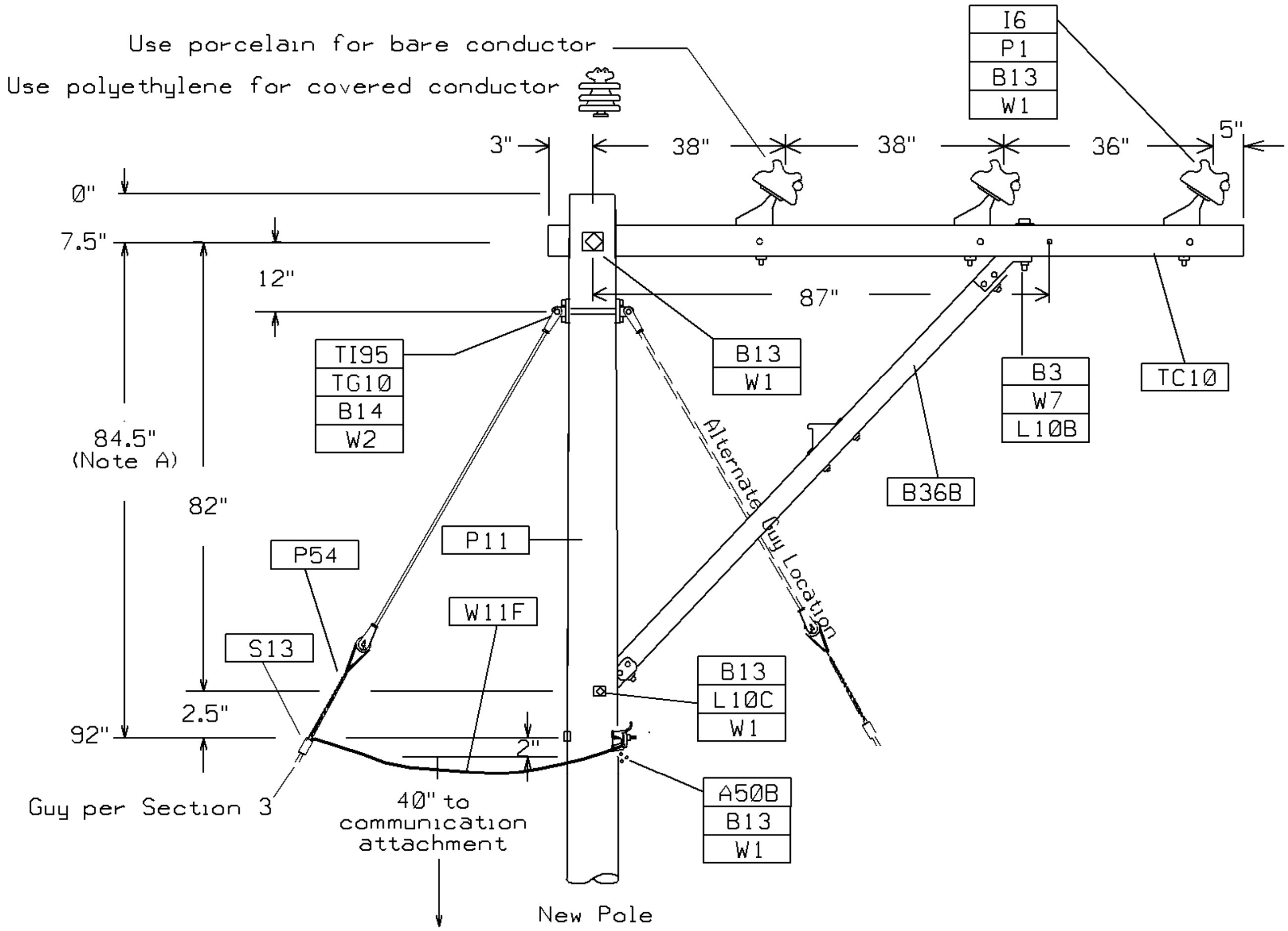
MINIMUM DIMENSIONS	
600V SECONDARY-35KV	45"
NEUTRAL ONLY-15KV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

Note:
- Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
- Omit center conductor and attachments. (20-438B)
- See Section Index for standard pole top construction selection.
- Use 2000 lb construction only.
- Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.
- Guying is not necessary for in line poles with offset arms unless forcess are being exerted per Section 3.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ DOUBLE ALLEY ARM POLE TOP – 25-35 kV – CROSSINGS AND ANGLES - 0° - 10°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-438		

MU = @20-439A	25-35KV 3Φ - Bare	MU = @20-439ACL	25-35KV 3Φ - Covered
MU = @20-439B	25-35KV 1Φ - Bare	MU = @20-439BCL	25-35KV 1Φ - Covered



(20-439A)

Note A

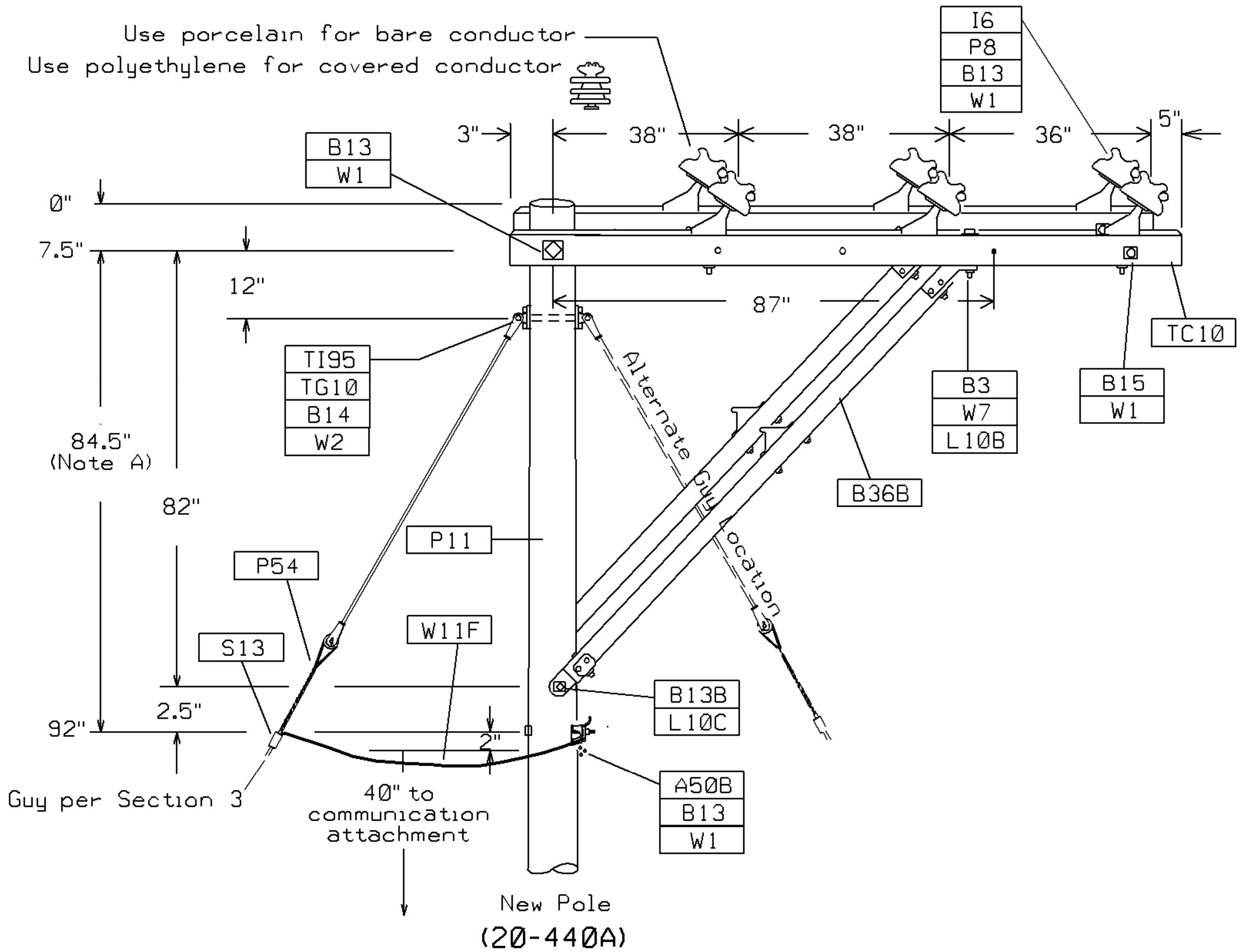
MINIMUM DIMENSIONS	
600V SECONDARY-35KV	45"
NEUTRAL ONLY-15KV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

Note:
- Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
- Omit center conductor and attachments. (20-439B)
- See Section Index for standard pole top construction selection.
- Use 2000 lb construction only.
- Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.
- Guying is not necessary for in line poles with offset arms unless forcess are being exerted per Section 3.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ SINGLE ALLEY ARM POLE TOP – 25-35 kV – 11° - 20°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 20-439	ISSUE: 7/07

MU = @20-440A	25-35KV 3Φ - Bare	MU = @20-440ACL	25-35KV 3Φ - Covered
MU = @20-440B	25-35KV 1Φ - Bare	MU = @20-440BCL	25-35KV 1Φ - Covered



Note A

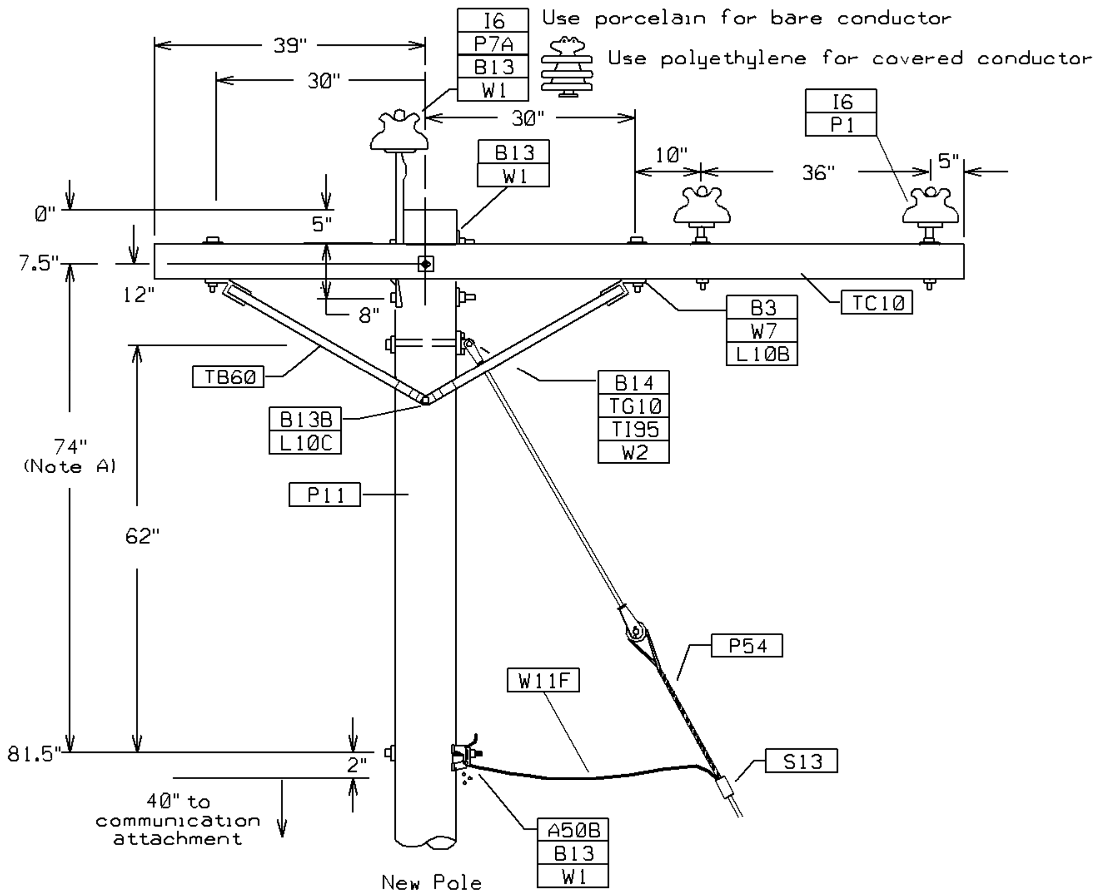
MINIMUM DIMENSIONS	
600V SECONDARY-35KV	45"
NEUTRAL ONLY-15KV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

Note:
- Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
- Omit center conductor and attachments. (20-440B)
- See Section Index for standard pole top construction selection.
- Use 2000 lb construction only.
- Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.
- Guying is not necessary for in line poles with offset arms unless forcess are being exerted per Section 3.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ AND 3Φ DOUBLE ALLEY ARM POLE TOP – 25-35 kV CROSSINGS 11° - 60° / ANGLES - 21° - 60°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/07	20-440		

MU = @20-441A	25-35KV 3Φ - Bare	MU = @20-441ACL	25-35KV 3Φ - Covered
MU = @20-441B	25-35KV 1Φ - Bare	MU = @20-441BCL	25-35KV 1Φ - Covered



(20-441A)

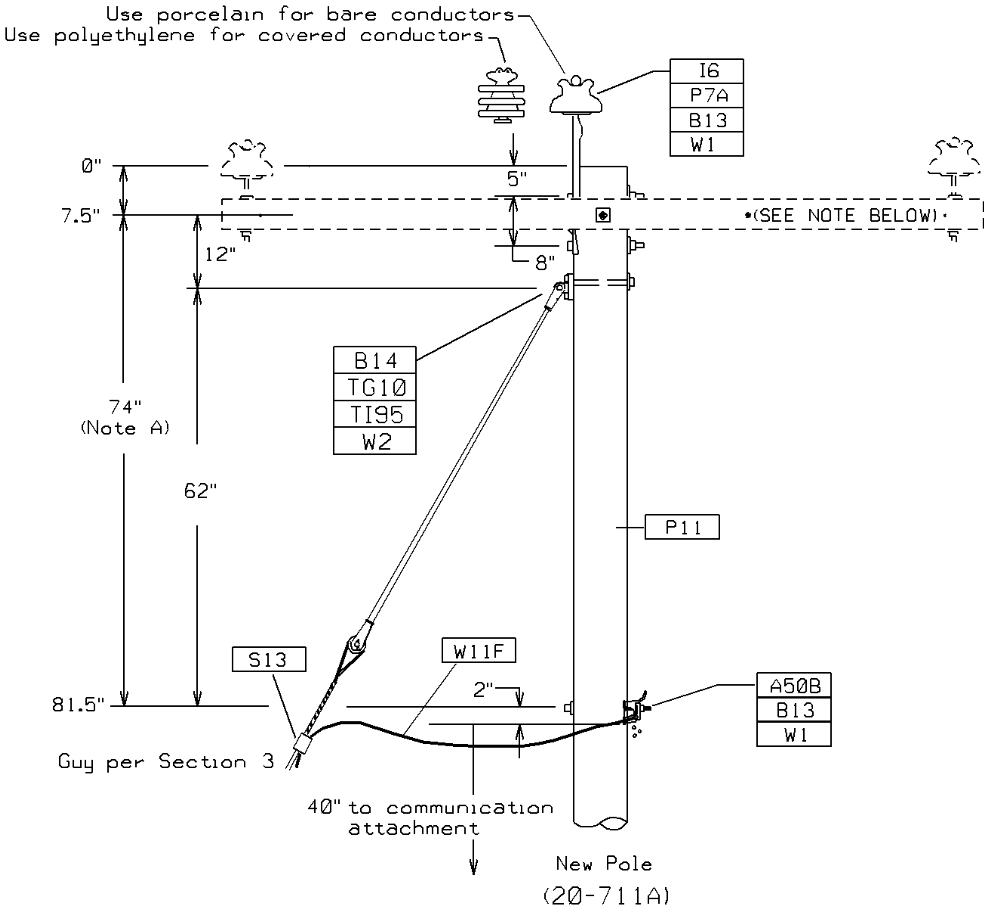
Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	52"
NEUTRAL ONLY-35kV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	180
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

Note:
- Offset Crossarm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
- Omit center conductor and attachments. (20-441B)
- See Section Index for standard pole top construction selection.
- Use 2000 lb construction only.
- Two or more adjacent poles with offset arms shall be used to reduce the excessive lateral stress.
- Guying is not necessary for in line poles with offset arms unless forcess are being exerted per Section 3.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

MU = @20-711	25-35KV 1Φ - Bare	MU = @20-711CL	25-35KV 1Φ - Covered



Note A

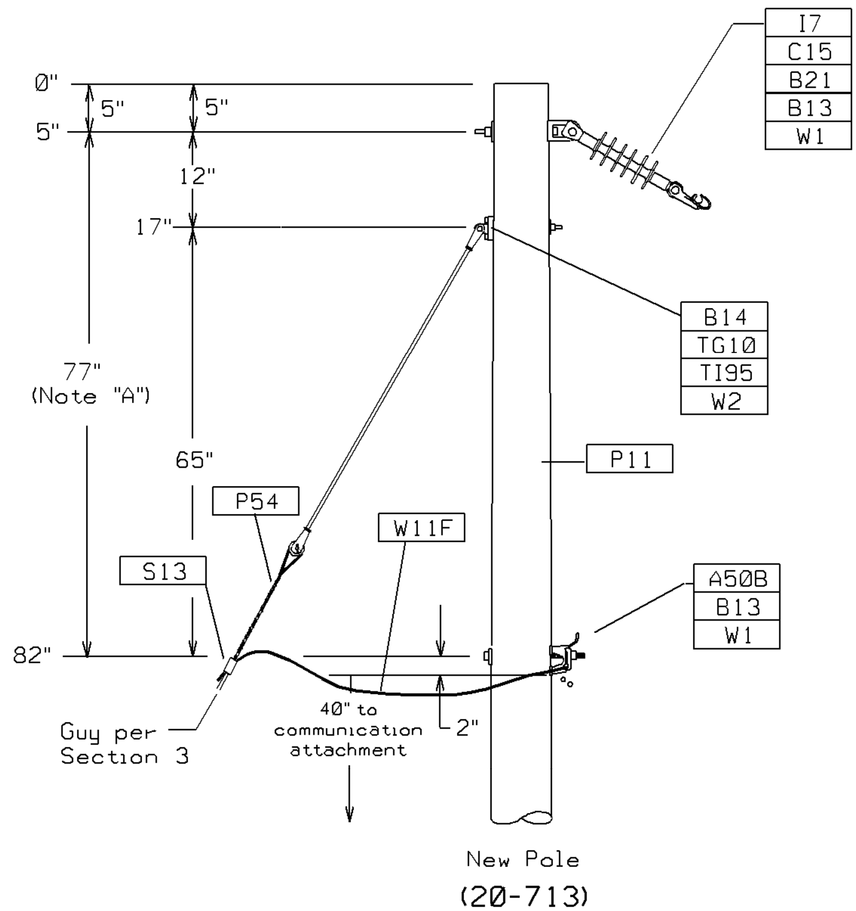
MINIMUM DIMENSIONS	
600V SECONDARY -35KV	38"
Neutral Only - 35 kV Operation	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	135	135
81.5	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
81.5	40 JT-84"	225	225
81.5	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- See Section Index for standard pole top construction selection.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

*- For Future 3ϕ, See 20-411.

MU = @20-713	25-35KV 1Φ - Bare	MU = @20-713CL	25-3KV 1Φ - Covered



Note A

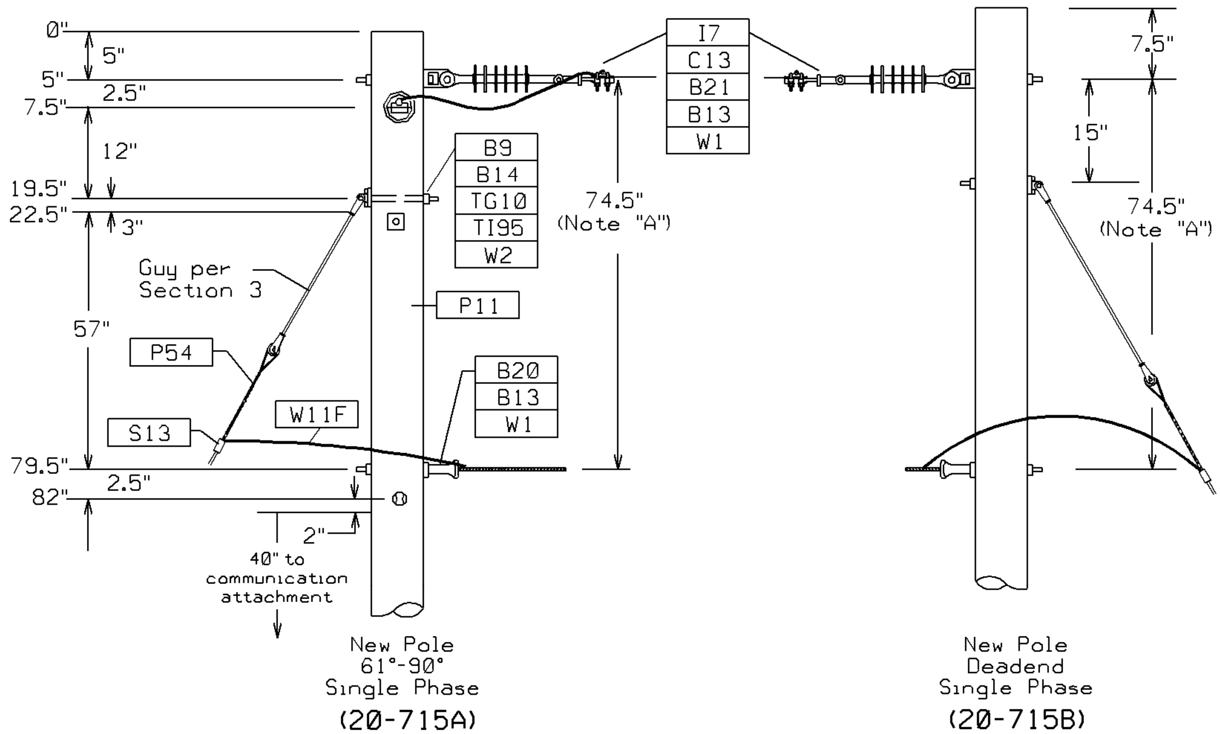
MINIMUM DIMENSIONS	
600V SECONDARY-35KV NEUTRAL ONLY-35KV OPERATION	48" 28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
82	40 JT-84"	135	135
82	45 JT-111"	220	220
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
82	40 JT-84"	221	163
87	45 JT-111"	300	--
103	45 JT-111"	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- See Section Index for standard pole top construction selection.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.

1Φ ARMLESS POLE TOP – 0-35 kV 21° - 60°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 20-713	ISSUE 7/07

MU = @20-715A	25-35KV 1Φ - Bare	MU = @20-715ACL	25-35KV 1Φ - Covered
MU = @20-715B	25-35KV 1Φ DE - Bare	MU = @20-715BCL	25-35KV 1Φ – DE - Covered



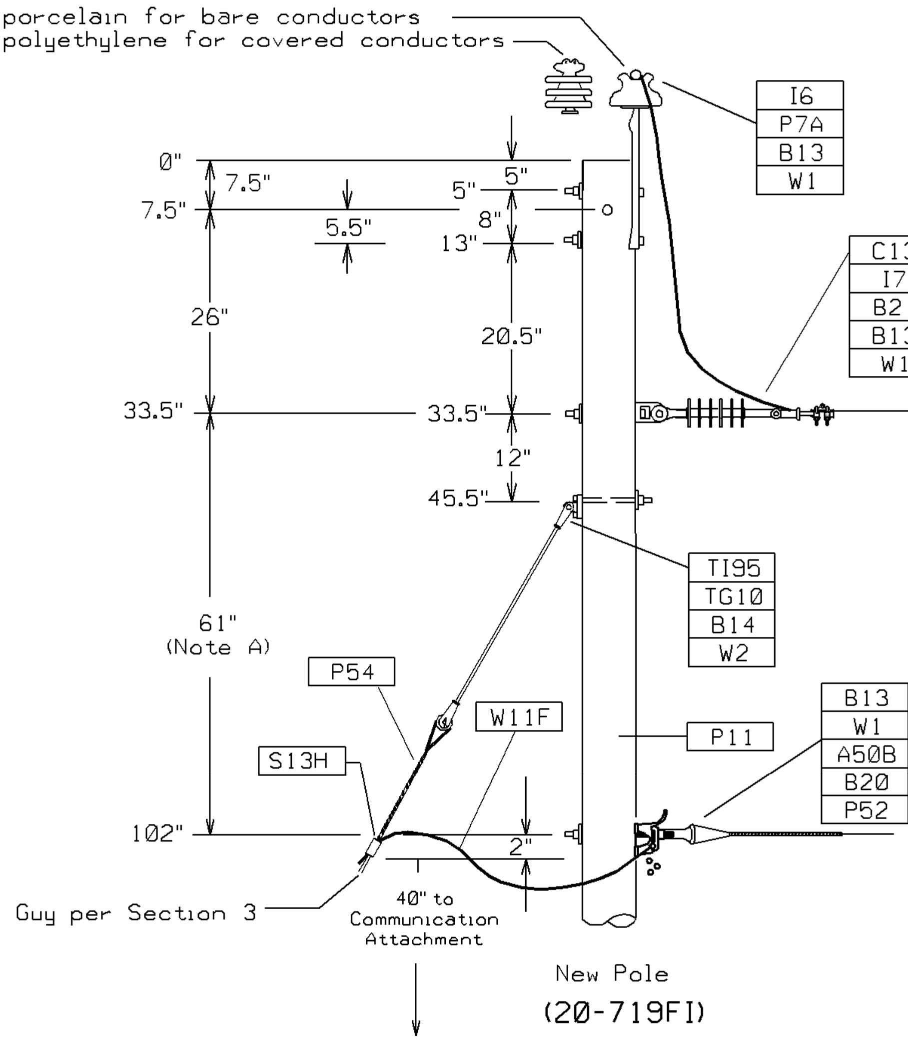
Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50.5"
NEUTRAL ONLY-35KV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS			
SPANS WITH 1/0 TRIPLEX SEC			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
82	40 JT-84"	135	135
82	45 JT-111"	220	214
SPANS WITH 1/0 AAAC NEUTRAL			
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE	
		1/0 AAAC	477 AAC
82	40 JT-84"	225	160
90	45 JT-111"	300	--
106	45 JT-111"	--	210
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE			

- See Section Index for standard pole top construction selection.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.
- Install Surge Arrester per Section 13.

MU = @20-719	25-35KV 1Φ - Bare	MU = @20-719CL	25-35KV 1Φ - Covered



Note A

MINIMUM DIMENSIONS	
600V SECONDARY-35KV	50"
NEUTRAL ONLY-35KV OPERATION	28"

SEE 20-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	177	177	177
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		TAP
		1/0 AAAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	207	184
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

- See Section Index for standard pole top construction selection.
- Where severe enviromental contamination exists, Line Post Insulators (I13D), ¾" Studs (P1G), and Pole Top Pins (P12B) should be used.
- Secondary deadend bracket may be relocated 4" minimum above or below existing secondary thru bracket on existing construction providing clearances can be maintained. (2.3)
- Install Surge Arrester per Section 13.

Supersedes 1/06 Issue – Section reorganized and expanded.

Supersedes 1/06 Issue – Section reorganized and expanded.

Supersedes 1/06 Issue – Revised Scope & Application. Added Grade of Construction.

21.0 GENERAL

21.0.10 Scope

This standard covers design and construction of new overhead sub-transmission lines on wood poles for 25kV, 35kV, 46kV and 69kV voltage classes. Sub-transmission lines are lines generally used to supply distribution substations, rather than supplying customers through transformers that step down directly to customer service voltages. Occasionally, a few large industrial customers are served directly from sub-transmission lines. Distribution lines are lines generally used to supply customers through transformers that step down directly to customer service voltages rather than supplying distribution substations. For standards applicable to overhead distribution lines at 25kV and 35kV, see Section 20. When planned future conversion of an overhead sub-transmission line requires that it be designed for an operating voltage above 69kV, see transmission standards for applicable construction standards.

21.0.20 Application

This standard contains three basic families of structure configurations: (i) a flat configuration using vertical post insulators on 10' crossarms for 25kV, 35 kV, 46kV and 69kV using conductors up to 477 ACSR, (ii) a 4' triangular configuration using vertical post insulators for 25kV and 35 kV using 795 and 1113 ACSR conductors and (iii) a vertical arrangement using horizontal post insulators for 46kV and 69kV using conductors up to 477 ACSR. Sub-transmission lines operated at 15kV must be built for the 25kV class (or higher if future conversion to a higher class is planned).

This standard is applicable for line angles from zero degrees to 90 degrees. Engineering tables and construction drawings are provided to facilitate selection of the proper structure type, and the correct class of pole to accommodate a coordinated line design. Application of structure types, span lengths, or line angles beyond the limits established herein shall be considered a special case requiring special engineering solutions and should be referred to Distribution Standards or Sub-Transmission Engineering for appropriate solutions.

21.1 GRADE OF CONSTRUCTION

New sub-transmission lines shall be built to NESC Grade B.

When modifying existing sub-transmission lines built on wood poles to allow distribution or communications to share the same poles, NESC Grade C may be used where allowed by the NESC. NESC Grade C is not allowed where the sub-transmission line crosses railroad tracks, limited-access highways or navigable waterways requiring waterway crossing permits. Where a communication line is below a sub-transmission line (at a crossing or on the same structures), NESC Grade C construction is allowed only if both of the following conditions are fulfilled: (a) the supply voltage will be promptly removed from the communications plant by de-energization or other means, both initially and following subsequent circuit-breaker operations in the event of a contact with the communications plant, and (b) the voltage and current impressed on the communications plant in the event of a contact with the supply conductors are not in excess of the safe operating limit of the communications-protective devices.

When modifying existing sub-transmission lines built on structures other than wood poles, NESC Grade B shall be used.

21.2 LOADING CONDITIONS

21.2.10 NESC Heavy District Loading Conditions (NESC Rule 250B Loads)

All poles, cross arms, guys, and insulators must be designed to withstand the load conditions in Table 1 multiplied by the load factors in Table 2 without exceeding the permitted stress levels of the material when multiplied by the strength factor in Table 3.

Table 1
NESC Heavy District Loading Conditions –
All Structures

Condition	Temp °F / °C	Ice (Inches)	Wind (mph / PSF)
NESC Heavy (NESC Rule 250B)	0 / -20	0.5	40 / 4.0

Table 2
Load Factors for Structures, Crossarms, Support Hardware, Guys, Foundations, and Anchors to be Used with the Strength Factors of Table 3

Load Factor	Grade B	Grade C	
		At Crossings	Elsewhere
Vertical Loads	1.50	1.90	1.90
Transverse Loads			
Wind	2.50	2.20	2.20
Wire Tension	1.65	1.30	1.30
Longitudinal Loads			
In General	1.10	No requirements	No requirements
At Deadends	1.65	1.30	1.30

Table 3
Strength Factors for Structures, Crossarms, Braces, Support Hardware, Guys, Foundations, and Anchors with the Load Factors of Table 2

Strength Factor	Grade B	Grade C
Metal Braces	1.0	1.0
Wood Poles, Crossarms and Braces	0.65	0.85
Fiberglass Crossarms	1.0	1.0
Support Hardware	1.0	1.0
Guy Wire	0.9	0.9
Guy Anchor	1.0	1.0

21.2.20 Extreme Wind Loading Conditions (NESC Rule 250C Loads)

For structures that extend more than 60 feet above ground, the poles, cross arms, guys, and insulators must be designed to withstand the load conditions in Table 4 multiplied by the load factors in Table 5 without exceeding the permitted stress levels of the material when multiplied by the strength factor in Table 6. In general, this will apply only for wood poles 70 feet long or greater.

For exact boundaries for the Extreme Wind (NESC Rule 250C) loads see NESC Figure 250-2(e).

Supersedes 1/06 Issue – Revised Loading Conditions, Separated Load Cases.

Table 4
Extreme Wind Loading Conditions –
Structures Exceeding 60 Feet Above Ground

NESC Extreme Wind (NESC Rule 250C)	Temp °F / °C	Ice (Inches)	Wind (mph / PSF)
Northern NH	60 /15	0	90 / 20.7
Southern NH	60 /15	0	100 / 25.6

Table 5
Load Factors for Structures, Crossarms, Support Hardware, Guys, Foundations, and Anchors to be Used with the Strength Factors of Table 6

Load Factor	Grade B	Grade C
Transverse Wind Loads	1.00	0.87
All Other Loads	1.00	1.00

Table 6
Strength Factors for Structures, Crossarms, Braces, Support Hardware, Guys, Foundations, and Anchors with the Load Factors of Table 5

Strength Factor	Grade B	Grade C
Metal Braces	1.0	1.0
Wood Poles, Crossarms and Braces	0.75	0.75
Fiberglass Crossarms	1.0	1.0
Support Hardware	1.0	1.0
Guy Wire	0.9	0.9
Guy Anchor	1.0	1.0

21.2.30 <u>Extreme Ice With Concurrent Wind Loading Conditions (NESC Rule 250D Loads)</u>

For structures that extend more than 60 feet above ground, the poles, cross arms, guys, and insulators must be designed to withstand the load conditions in Table 7 multiplied by the load factors in Table 8 without exceeding the permitted stress levels of the material when multiplied by the strength factor in Table 9. In general, this will apply only for wood poles 70 feet long or greater.

For exact boundaries for the Extreme Ice with Concurrent Wind (NESC Rule 250D) loads see NESC Figure 250-3(b).

Table 7
Extreme Ice With Concurrent Wind Loading Conditions –
Structures Exceeding 60 Feet Above Ground

NESC Extreme Ice With Wind (NESC Rule 250D)	Temp °F / °C	Ice (Inches)	Wind (mph / PSF)
Northern NH	30 / 0	1.25	40 / 4.0
Southern NH	30 / 0	1.00	40 / 4.0

Supersedes 1/06 Issue – Revised Loading Conditions, Separated Load Cases.

Table 8
Load Factors for Structures, Crossarms, Support Hardware, Guys, Foundations, and Anchors to be Used with the Strength Factors of Table 9

Load Factor	Grade B	Grade C
All Loads	1.00	1.00

Table 9
Strength Factors for Structures, Crossarms, Braces, Support Hardware, Guys, Foundations, and Anchors with the Load Factors of Table 8

Strength Factor	Grade B	Grade C
Metal Braces	1.0	1.0
Wood Poles, Crossarms and Braces	0.75	0.75
Fiberglass Crossarms	1.0	1.0
Support Hardware	1.0	1.0
Guy Wire	0.9	0.9
Guy Anchor	1.0	1.0

21.3 SPLICING AND DEADENDING

Splices shall use the one die system of compression fittings. Automatic splices are excluded from use.

Deadends for “Condor” or “Finch” shall use the one die system of compression fittings. Connection hardware for joining the jumper terminal to the deadend body shall be made using stainless steel hardware, Belleville washers, and #2 EJC Electrical Joint Compound (NG9D). Deadends for other wire types shall use bolted deadend clamps.

21.4 ANCHORS

The preferred anchor type for this standard is the screw anchor. See Section 3 for additional information.

21.5 CONDUCTORS

A number of conductors are preferred for use in the construction of new sub-transmission lines. These include:

- 1/0, 7 Strand, Bare 6201-T81 AAC, “Azuza”
- 336.4 Kcmil, 19 Strand, Bare AAC, “Tulip”
- 336.4 Kcmil, 18/1 Stranding, Bare ACSR, “Merlin”
- 477.0 Kcmil, 19 Strand, Bare AAC, “Cosmos”
- 477.0 Kcmil, 26/7 Stranding, Bare ACSR, “Hawk”
- 795.0 Kcmil, 37 Strand, Bare AAC, “Arbutus”
- 795.0 Kcmil, 54/7 Stranding, Bare ACSR, “Condor”
- 1113.0 Kcmil, 54/19 Stranding, Bare ACSR, “Finch”

While not preferred, some tree wires may be used in the construction of new sub-transmission lines at 15kV and below where required. These conductors are more suitable for use in 15kV distribution lines. Consult Standards, Sub-transmission Engineering, or Manufacturer (Hendrix) before using these conductors in a new sub-transmission line. These conductors include:

- 1/0, 7 Strand, 6201 Reg. Conc. Round Covered Tree Wire – 15kV
- 477.0 Kcmil, 19 Strand, Compact EC Covered Tree Wire – 15kV
- 795.0 Kcmil, 37 Strand, Compact EC Covered Tree Wire – 15kV

Pages 21-401 through 21-418 contain detailed information for these conductors, including sag and tension information for these conductors. Structure selection and loading limit information in Section 21.7 Structure

Supersedes 1/06 Issue – Revised Loading Conditions, Separated Load Cases. Revised Anchor Information. Added 21.5 Conductors.

Selection of this standard are based on use of this sag and tension information. Other sags and tensions may be used, but the structure selection and loading limit information in Section 21.7 Structure Selection of this standard may not apply. When sags and tensions other than those contained in this standard are used, appropriate structure selection and loading limits must be developed meeting the requirements of Section 21.2 Loading Conditions above.

21.5.10 Sags and Tensions

All overhead lines must meet minimum clearance requirements of the NESC at the time the line is constructed.

For more information about maximum conductor operating temperatures, see Section 21.6 - Clearances of these standards.

For more details on maximum conductor operating temperatures and conductor ratings see pages 21-400 through 21-418.

21.5.10.1 Limiting Tensions

In the design of overhead sub-transmission lines, three limiting values of tension shall be observed:

A. Initial Unloaded or Stringing Tension is that which will exist before the application of any external load or immediately after new conductors have been installed. The initial unloaded tension at 0˚F/-18˚C shall not exceed 35% of the rated breaking strength of the conductor.

B. Maximum Design Tension is that which will exist on the occurrence of the maximum loading conditions specified in the NESC for the Heavy Loading District. These loading conditions are: (i) conductor temperature of 0˚F/-18˚C, (ii) radial ice on the conductor of 0.5 inches/12.5 mm, and (iii) wind pressure on the conductor of 4 pound per square foot/190 Pa. The maximum conductor tension under NESC Heavy Loading conditions, either initial or final, shall not exceed 50% of the rated breaking strength of the conductor. To limit structure loading conductor maximum design tensions shown in this book are limited to:

- 4,000 lbs. for 1113 kcmil ACSR;
- 3,500 lbs. for 795 kcmil ACSR;
- 3,000 lbs. for 477 & 336 kcmil ACSR, and
- 2,000 lbs. for all other sub-transmission conductors.

C. Final Unloaded Tension is that which occurs on the conductor with no external loading but after the maximum design tension has been sustained for sufficient time to permit stretching to cease. The final unloaded tension at 0˚F/-18˚C shall not exceed 25% of the rated breaking strength of the conductor.

The sag tables show sags under various temperatures and loading conditions. New conductors strung to “Stringing” (Initial) values will have initial, maximum and final tensions as specified. The sag will increase under design loading, then change as shown in “Final” sags depending on temperature and loading.

The Initial Sag tables are based on the Ruling Span Method of calculation and the Final Sag tables are based on the Deadend Method, described below. If different Initial or Final Sags are required, contact Standards or Sub-transmission Engineering.

Supersedes 1/06 Issue – Added 21.5 Conductors.

21.5.10.2 Deadend or Uniform Spans

Sag tables based on deadend span methods assume that there is only one span or that all spans are the same length. This method is useful for short spans in urban areas where the spacing is reasonably uniform. If long spans in a section of line are sagged according to a deadend table, short spans in the same section will have a sag value that may or may not correspond with the table. For this reason, it is customary to sag a span of average length near the center of the line and to recognize that there may be slightly more or less sag in the longer and shorter spans than is indicated by the tables.

In order to determine the sag value for a specific span length, multiply the ruling span sag value by the ratio provided in Table 10 for the corresponding actual span length. In the event that the needed actual span length is not provided in this table, a method for determining the resultant ratio value is provided below.

Table 10
Ratio of Deadend Span Sag to Sags at Other Span Lengths with Same Tension

ACTUAL SPAN	DEADEND SPAN										
	50’	75’	100’	125’	150’	175’	200’	225’	250’	275’	300’
100’	4.00	1.78	1.00	0.64	0.44	0.33	0.25	0.20	0.16	0.13	0.11
110’	4.84	2.15	1.21	0.77	0.54	0.40	0.30	0.24	0.19	0.16	0.13
120’	5.76	2.56	1.44	0.92	0.64	0.47	0.36	0.28	0.23	0.19	0.16
130’	6.76	3.00	1.69	1.08	0.75	0.55	0.42	0.33	0.27	0.22	0.19
140’	7.84	3.48	1.96	1.25	0.87	0.64	0.49	0.39	0.31	0.26	0.22
150’	9.00	4.00	2.25	1.44	1.00	0.73	0.56	0.44	0.36	0.30	0.25
160’	10.24	4.55	2.56	1.64	1.14	0.84	0.64	0.51	0.41	0.34	0.28
170’	11.56	5.13	2.89	1.85	1.28	0.94	0.72	0.57	0.46	0.38	0.32
180’	12.96	5.76	3.24	2.07	1.44	1.06	0.81	0.64	0.52	0.43	0.36
190’	14.44	6.42	3.61	2.31	1.60	1.18	0.90	0.71	0.58	0.48	0.40
200’	16.00	7.11	4.00	2.56	1.78	1.31	1.00	0.79	0.64	0.53	0.44
210’	17.64	7.84	4.41	2.82	1.96	1.44	1.10	0.87	0.71	0.58	0.49
220’	19.36	8.60	4.84	3.10	2.15	1.58	1.21	0.96	0.77	0.64	0.54
230’	21.16	9.40	5.29	3.39	2.35	1.73	1.32	1.04	0.85	0.70	0.59
240’	23.04	10.24	5.76	3.69	2.56	1.88	1.44	1.14	0.92	0.76	0.64
250’	25.00	11.11	6.25	4.00	2.78	2.04	1.56	1.23	1.00	0.83	0.69

Supersedes 1/06 Issue – Added 21.5 Conductos.

Method for Determining Ratio:
1. Choose Deadend Span.
2. Find deadend span sag from sag table for temperature and deadend span desired.
3. Multiply deadend span sag by above ratio for actual spans as line is laid out to obtain actual span.
4. For deadend span to actual span ratio other than those listed above:

$$RATIO = \frac{(ACTUAL\ SPAN)^2}{(DEADEND\ SPAN)^2}$$

21.5.10.3 Ruling Spans

This is a calculated span length for which the conductor tension, under changes in temperature and loading, best represents the average tension in the conductor in a particular series of spans between deadends. Ideally, a line should be installed in such a way that all spans of the line have equal horizontal line tension. If this is done, longitudinal forces on pole tops between spans

Supersedes 1/06 Issue – Added 21.5 Conductors.

are theoretically zero. Deadend poles and poles located at bends in the line will typically require guying in order to counteract the line tension.

Sag tables based on the ruling span method recognize variations in span length. This method assumes that the line will be strung to uniform tension. If this is done, all spans will have initial sags that are very near the values in the table. After the conductors are tied into place, however, and after ice and wind loads stretch the wires, the tension may not be uniform and the sags may vary from the calculated values. If the actual spans are much longer or shorter than the ruling span, the tension and sags may be different than the calculations.

The ruling span can most accurately be determined through the following equation:

$$\text{Ruling Span} = \sqrt{\frac{\left(L_1^3 + L_2^3 + L_3^3 + \ldots L_N^3\right)}{\left(L_1 + L_2 + L_3 + \ldots L_N\right)}}$$

Where L1, L2, L3, etc. are the lengths of the first, second, third, etc., spans between deadends.

Spans that are longer than 150% of the average should be avoided or should be sagged independently and guyed to hold the unbalanced tension. All new standard construction for tension should conform to the Company's design which limits tension to 50% of the conductor rated breaking strength by following the above mentioned ruling span calculation.

21.5.10.4 Slack Spans

When guys cannot be installed on the end pole of a line, they may be placed on an adjacent pole. A slack span should then be installed to the end pole. Slack spans may also be necessary for other applications. They are not recommended if there is any way of avoiding them, but when used, calculations should be made as follows:

$$\text{String Sag in Feet} = \frac{W \times L^2}{8 \times T}$$

Where,

W = Total loaded weight lbs./ft.
L = Total length of span in ft.
T = Tension in pounds.
(See Section 2-Poles / Hardware for strength required in poles.)

Example:

50 foot span, 3-336.4 kcmil bare AAC to be deadended on an un-guyed Class 5 pole.
Use T = 200 lb. per conductor.

W = 1.48 lbs./foot (from Page 6-109)
L = 50 feet (span length)
T = 200 lbs.

$$S = \frac{W \times L^2}{8 \times T} = \frac{1.48 \times 50^2}{8 \times 200} = \frac{3700}{1600} = 2.3125\ Feet$$

Sag the conductor at 2.31 feet, at normal temperature. This approximation assumes that the conductors will have 2.31 feet of sag at 0˚F/-18˚C when subject to ice and wind.

21.5.20 Ampacity

Current in overhead line conductors should be limited so that conductors will not be severely annealed or damaged and that clearances are not exceeded. Any line that is desired to be operated at the elevated operating temperature permitted for emergency conditions shall be assessed to verify that available clearances are present to account for the resulting additional sag as outlined in each respective conductor data table. Minimum clearances, outlined in Section 21.6 – Clearances, shallnot be compromised.

To protect conductors from damage caused by excessive heating, the maximum conductor operating temperature (MCOT) for sub-transmission lines shall not exceed the following limits under the design conditions of Table 11:

- 284°F/140°C for bare ACSR conductor,
- 212°F/100°C for bare AAC or AAAC conductor,
- 167°F/75°C for covered conductors,

Table 11
Ampacity Design Parameters

SPECIFICATION	SUMMER	WINTER
Ambient Air Temperature (˚C)	100˚F/37.7˚C	50˚F/10˚C
Wind Speed (FT. / SEC.)	3 FEET/SEC.	3 FEET/SEC.
Angle between Wind and Conductor	90˚	90˚
Coefficient of Emissivity	0.75	0.75
Coefficient of Absorption	0.75	0.75
Climatic Data Record (CDR) elevation above sea level (FT.)	914.2125 FEET	914.2125 FEET
Conductor Direction	North – South	North – South
CDR Latitude in Degrees	42˚	42˚
Solar Heating	12:00 PM (noon)	12:00 PM (noon)
Atmosphere	CLEAR	CLEAR
Conductor Resistance in Ohm/mi. for the Low Temperature @ 77˚F/25˚C	Conductor Specific – In Accordance with Low Conductor Temperature	Conductor Specific – In Accordance with Low Conductor Temperature
Conductor Resistance in Ohm/mi. for the High Temperature @ 167˚F/75˚C	Conductor Specific – In Accordance with High Conductor Temperature	Conductor Specific – In Accordance with High Conductor Temperature

Supersedes 1/06 Issue – Added 21.5 Conductors.

21.6 CLEARANCES

21.6.10 Clearance Requirements for Sub-Transmission Lines

Each vertical and horizontal clearance shall be observed, but within the limits of each other only.

The uniform clearance system contained in the NESC is based on the dimensions of the expected activities in each area and the relative potential problem caused by each type of facility.

In general, vertical clearance requirements must be met during maximum sag conditions to provide for the expected activity beneath the line.

Horizontal clearance requirements must be met with the conductor at rest to provide for the expected activity alongside the line. Conductor "blowout" (wind displacement) is considered under certain conditions (refer to Sections 21.6.70, 21.6.100, 21.6.110 and 21.6.130 and page 21-33).

All clearances listed in this section are based on assumed criteria and should be used for general guidance only. If any actual clearances are found to be less than that given in the tables, they should be brought to the attention of the Distribution Engineering Services Department for further review.

21.6.20 General

21.6.20.1 Liberty Utilities Clearance Criteria for Sub-Transmission Lines

A. Overhead sub-transmission lines shall be designed to maintain adequate clearances under ice loaded conditions and the line's maximum conductor operating temperature (MCOT). In no case shall a sub-transmission line be designed for a MCOT below 120°F/48.9°C.

B. The required MCOT of the sub-transmission line shall be determined by the appropriate planning department.

C. To protect conductors from damage caused by excessive heating, the required MCOT for the sub-transmission line shall not exceed the following limits:

   i. 284°F/140°C for bare ACSR conductor,
   ii. 212°F/100°C for bare AAC or AAAC conductor,
   iii. 167°F/75°C for covered conductors,
   iv. 120°F/50°C for spacer cable messengers and 167°F/75°C for spacer cable phase conductors (Phase conductor temperatures higher than 120°F/50°C are taken to have no influence in elevating messenger temperatures.), and
   v. Shielded aerial cables 69 kV and below shall be designed to operate with the messenger at 120°F/50°C ambient (Phase conductor temperatures higher than 120°F/50°C are taken to have no influence in elevating messenger temperatures).

D. New Installations and Extensions Clearances for the installation of all new sub-transmission lines and extensions to existing lines shall be in accordance with the latest edition of the NESC and the requirements of any applicable state or local laws, rules or regulations.

E. Existing Installations Where an existing installation meets, or is altered to meet, the current NESC rules, such installation is considered to be in compliance with the current edition of the NESC and is not required to comply with any previous edition of the NESC.

F. Existing installations, including maintenance replacements, that currently comply with prior editions of the NESC, need not be modified to comply with these standards except as may be required for safety reasons by the administrative authority.

G. Where conductors or equipment are added, altered, or replaced on an existing structure, the structure or the facilities on the structure need not be modified or replaced if the resulting installation will be in compliance with either (a) the NESC rules that were in effect at the time of

Supersedes 1/06 Issue – Added 21.6 Clearances.

the original installation, (b) the rules in effect in a subsequent edition of the NESC to which the installation has been previously brought into compliance, or (c) the rules in the latest edition of the NESC.

H. Clearances listed in the following standards and tables are considered minimum requirements for new construction. In some instances clearances exceeding those given may be required (e.g. when mandated by local ordinances). Other design considerations applying to Company work and operating practices may result in clearances greater than NESC minimum clearances.

I. Voltage is the root-mean-square (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. Nominal voltage is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. Actual operating voltage of the system may vary above or below the nominal voltage.

J. Sub-transmission voltages in the following tables are, unless otherwise noted, given as the nominal phase to phase operating voltage of the sub-transmission line. Voltages for other circuits in the following tables are, unless otherwise noted, given as the highest nominal phase to ground voltage for effectively grounded circuits and for other circuits where all ground faults are cleared by promptly de energizing the faulted section, both initially and following subsequent breaker operations. “Effectively grounded” means intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to limit the buildup of voltages to levels below that which may result in undue hazard to persons or to connected equipment. The voltage of a circuit that is not effectively grounded is the highest nominal voltage available between any two conductors on the circuit.

K. Clearance is defined as the clear distance between two objects measured surface to surface.

L. Spacing is defined as the distance between two objects measured center to center.

M. Clearances for tree wire, covered conductor, and spacer cable conductor are taken as if they were bare conductors.

N. Open conductors are defined as electric supply or communication construction in which the conductors are bare, covered or insulated and without grounded shielding, or individually supported at a structure either directly or with insulators.

O. Electric supply lines are those conductors used to transmit electric energy and their necessary supporting or containing structures.

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21.6.20.2 NESC Vertical Clearance Requirements Illustration – Rules 232 & 235

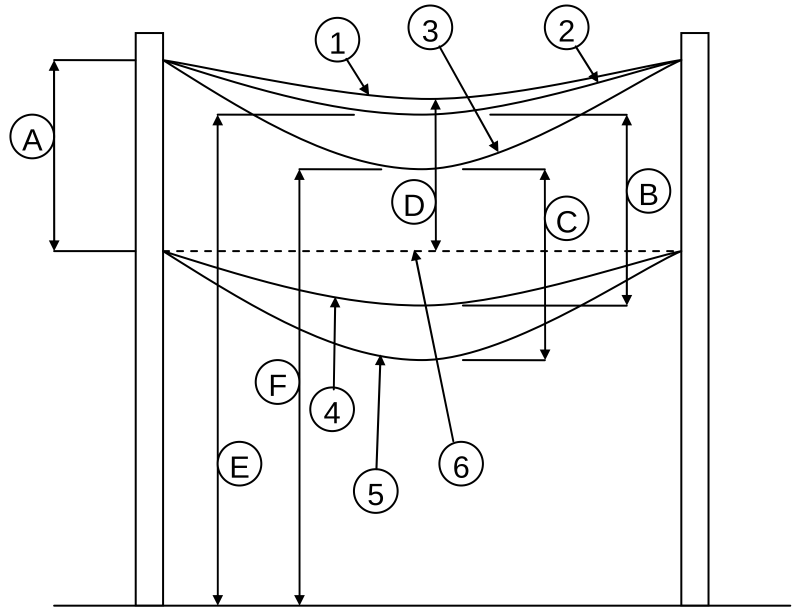

Figure 1

WIRES AND CABLES

1 – Lowest sub-transmission conductor at 60ºF/15.6ºC, final unloaded sag.
2 – Lowest sub-transmission conductor at the greater of its maximum conductor operating temperature (MCOT) or 120ºF/48.9ºC, final unloaded sag.
3 – Lowest sub-transmission conductor at 32ºF/0ºC, final loaded sag, with 1/2" radial ice and no wind.
4 – Next wire or cable (supply or communication space) below sub-transmission at 50ºF/10ºC, final unloaded sag.
5 – Next wire or cable (supply or communication space) below sub-transmission at 32ºF/0ºC, final unloaded sag.
6 – Straight line between attachment points of communications space wire or cable below sub-transmission.

CLEARANCES

A – Minimum vertical clearance required at pole between lowest sub-transmission conductor and next wire or cable (supply or communication space) below it.
B – Minimum vertical clearance required anywhere in span between lowest sub-transmission conductor at condition 2 above and next wire or cable (supply or communication space) below it at condition 4 above (ambient condition corresponding to winter rating).
C – Minimum vertical clearance required anywhere in span between lowest sub-transmission conductor at condition 3 above and next wire or cable (supply or communication space) below it at condition 5 above (ambient condition corresponding to NESC Heavy Loading condition).
D – For spans greater than 150 feet, minimum vertical clearance required anywhere in span between lowest sub-transmission conductor at condition 1 above and a straight line between attachment points of a communications space wire or cable.
E – Minimum vertical clearance above ground required anywhere in span below lowest sub-transmission conductor at condition 2 above.
F – Minimum vertical clearance above ground required anywhere in span below lowest sub-transmission conductor at condition 3 above.

21.6.30 Relative Levels

21.6.30.1 At Crossings or Conflicts

Where supply lines of different voltage classifications cross each other or structure conflict exists, the higher-voltage lines should, where practical, be carried at the higher level.

21.6.30.2 For Wires, Conductors, or Cables Carried On The Same Supporting Structure

Where supply lines, all owned by Liberty Utilities, of different voltage classifications are on the same structures, the conductors of higher voltage should, where practical, be placed above those of lower voltage.

21.6.40 Clearances Of Supporting Structures From Rail, Curb, Hydrant & Other Objects

Poles for overhead sub-transmission lines shall be located with adequate clearance to railroad and automobile traffic. The following table, Table 12, identifies NESC minimum requirements. These requirements should be exceeded if practicable. State and local authorities prefer that poles be set back as far as possible from the pavement edge, and behind guard rails, ditches, sidewalks, curbs, or other features that may help isolate poles from traffic. In any case, the approval of the authorities shall be obtained. To the extent practicable, avoid placing poles at exposed corners or similar locations where they are likely to be struck by motor vehicles or snow removal equipment.

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Table 12
Clearance of Supporting Structures from Rail, Curb or Hydrant
(Reference: NESC Rule 231)

Supporting structures [1], support arms, attached equipment, and braces shall have the following clearances measured between the nearest parts of the objects concerned:

Objects	**Minimum (Ft.)**	**Recommended (Ft.)**
A. Fire Hydrants	3 [2,3]	4 [2]
B. Streets, Roads, Highways [4]	***Horizontal Clearance for First 15 Feet Above Ground***	
1. With street curbs (measured from street side of the curb)		
a. Arterial Streets which are primarily for through traffic	0.5	2 [2,5]
b. Local Streets which are primarily for access to residences, businesses or other abutting properties	0.5	1 [2]
2. With no curbs		See Footnote 6
C. All Railroad Tracks	***Horizontal Clearance for First 22 Feet Above the Nearest Track Rail***	
	12 [7]	

FOOTNOTES:

1. Supporting structures are defined as the main supporting unit, usually a pole or tower.
2. This clearance also applies to anchor guys and push braces.
3. EXCEPTION: Clearance may be reduced by agreement with the local fire authority.

4. Where a governmental authority exercising jurisdiction over structure location has issued a permit for, or otherwise approved, specific locations for supporting structures, that permit or approval shall govern.
5. Place the supporting structures as far as practical behind the curb within the road right of way.
6. Place the supporting structures a sufficient distance from the roadway to avoid contact by ordinary vehicles using the traveled way.
7. This may be reduced to 7 feet where the supporting structure is not the controlling obstruction, provided sufficient space for a driveway is left where the cars are loaded and unloaded.

21.6.50 Vertical Clearances Of Wires, Conductors, and Cables Above Ground, Roadway, Rails, Etc.

21.6.5.1 Generally Applicable Clearances

Clearances, found in Table 13, apply under the following conductor temperature and loading conditions, whichever produces the largest final sag:

A. 120°F/50°C, no wind displacement,
B. The maximum conductor temperature for which the line is designed to operate, if greater than 120°F/50°C, with no wind displacement,
C. 32°F/0°C, no wind displacement, with 0.5 inch radial thickness of ice.

Table 13
Minimum Vertical Clearance of Wires, Conductors, and Cables Above Ground, Roadways, or Rails
(Reference: NESC Table 232-1)

Nature of Surface Underneath Wires, Conductors, or Cables	Grounded Guys [14,15]	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)
Where wires, conductors, or cables cross over or overhang					
1. Track rails of railroads (not using overhead electric supply conductors) [2, 16, 22]	23.5	26.7	27.0	27.4	28.2
2. Roads, streets, and other areas subject to truck traffic [23]	15.5	18.7	19.0	19.4	20.2
3. Driveways, parking lots, and alleys [23]	15.5 [13]	18. 7	19.0	19.4	20.2
4. Land traversed by vehicles, such as cultivated, grazing, forest, orchards, etc. [26]	15.5	18. 7	19.0	19.4	20.2
5. Spaces and ways subject to pedestrians or restricted traffic only [9]	9.5	14. 7	15.0	15.4	16.2
Where wires, conductors or cables run along highway or rights-of-way but do not overhang the roadway					
6. Roads, streets, or alleys	15.5	18. 7	19.0	19.4	20.2
7. Roads in rural districts where it is unlikely that vehicles will be crossing under the line	13.5 [10]	16. 7	17.0	17.4	18.2

NOTES:

For 69 kV, the clearance specified in Table 13 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

FOOTNOTES:

Note: Footnotes 1, 3-8, 11-12, 17-21, and 24-25 from NESC Table 232-1 are not used.

Supersedes 1/06 Issue – Added 21.6 Clearances.

2. For wires, conductors, or cables crossing over mine, logging, or similar railways that handle only cars lower than standard freight cars, the clearance may be reduced by an amount equal to the difference in height between the highest loaded car handled and 20 feet, but the clearance shall not be reduced below that required for street crossings.

9. Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles, or other mobile units exceeding a total height of 8 feet are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

10. Where a sub-transmission line along a road is located relative to fences, ditches, embankments, etc., so that ground under the line would not be expected to be traveled except by pedestrians, the clearances for guys may be reduced to 9.5 feet.

13. Where this construction crosses over or runs along alleys, driveways, or parking lots not subject to truck traffic, this clearance may be reduced to 15 feet.

14. Ungrounded guys and ungrounded portions of span guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to slack conductor or guy.

15. Insulated anchor guys may have the same clearance as grounded guys. Insulators shall be installed as follows: (a) all guy insulators or span-wire insulators shall be located at a position such that the bottom of the insulator shall be not less than 2.45 m (8 ft) above the ground if the guy or span wire is broken below the insulator, (b) insulators shall be so placed that, in case any guy or span-wire contacts, or is contacted by, an energized conductor or part, the voltage will not be transferred to other facilities on the structure(s), and (c) insulators shall be so placed that in case any guy or span wire sags down upon another, the insulators will not become ineffective.

16. Adjacent to tunnels and overhead bridges that restrict the height of loaded rail cars to less than 20 ft, these clearances may be reduced by the difference between the highest loaded rail car handled and 20 ft, if mutually agreed to by the parties at interest.

22. See Section 7.7 for the required horizontal and diagonal clearances to rail cars.

23. For the purpose of this Rule, trucks are defined as any vehicle exceeding 8 feet in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

26. When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 14 feet.

Supersedes 1/06 Issue – Added 21.6 Clearances.

21.6.5.2 Clearances required by local Administrative Authorities

The clearances shall not be less than required by the Administrative Authority (Table 14).

Table 14
Vertical Clearance of Wires, Conductors, and Cables Above Ground, Railroads or Water Surfaces - Compliance With Administrative Authority

Nature of surface underneath wires, conductors or cables	Grounded guy, span or surge protection wire (FT)	Open Supply Conductors 23 kV to 46 kV (FT)	Open Supply Conductors 69 kV (FT)
New York State Thruway Authority	Requirements not available	37	41
New York State Highways	Requirements not available	29	33
New York State Barge Canal	59	62	66
Corp of Engineers – Navigable Waters	Requirements not available	27	31
Railroad Tracks	27	33	39

For clearances near airports in New York refer to ESB # 803 – 808 'Permits'.

21.6.60 Vertical Clearance Of Wires, Conductors and Cables Above Water Surfaces

Vertical clearances of sub-transmission supply wires and conductors over waterways shall not be less than those shown on Table 15: Vertical Clearance Above Water Surfaces. For canals and waterways controlled by the New York State Department of Transportation, see Electric and Gas System Manual Bulletin #806.

Table 15
Vertical Clearance Above Water Surface
(Reference: NESC Table 232-1)

Nature of Surface Underneath Wires, Conductors, or Cables	Ref. Height (ft.)	Grounded Guys [14,15] (ft.)	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)
Where wires, conductors, or cables cross over or overhang						
1. Water areas not suitable for sailboating or where sailboating is prohibited [21]	12.5	14.0	17.2	17.5	17.9	18.7
2. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of: [17, 18, 19, 20, 21]						
a. Less than 20 acres	16	17.5	20.7	21.0	21.4	22.2
b. Over 20 to 200 acres	24	25.5	28.7	29.0	29.4	30.2
c. Over 200 to 2000 acres	30	31.5	34.7	35.0	35.4	36.2
d. Over 2000 acres	36	37.5	40.7	41.0	41.4	42.2
3. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sailboats		Clearance aboveground shall be 5 ft greater than in 2 above, for the type of water areas served by the launching site				

NOTES:

For 69 kV, the clearance specified in Table 15 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

FOOTNOTES:

NOTE: Footnotes 1-13, 16, and 22-25 from NESC Table 232-1 are not used.

14. Ungrounded guys and ungrounded portions of span guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
15. Insulated anchor guys may have the same clearance as grounded guys. Insulators shall be installed as follows: (a) all guy insulators or span-wire insulators shall be located at a position such that the bottom of the insulator shall be not less than 2.45 m (8 ft) above the ground if the guy or span wire is broken below the insulator, (b) insulators shall be so placed that, in case any guy or span-wire contacts, or is contacted by, an energized conductor or part, the voltage will not be transferred to other facilities on the structure(s), and (c) insulators shall be so placed that in case any guy or span wire sags down upon another, the insulators will not become ineffective.
17. For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level.
18. For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.

Supersedes 1/06 Issue – Added 21.6 Clearances.

19. The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1 mile long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.
20. Where an over-water obstruction restricts vessel height to less than the applicable reference height given in Table 15, the required clearance may be reduced by the difference between the reference height and the over-water obstruction height, except that the reduced clearance shall not be less than that required for the surface area on the line crossing side of the obstruction.
21. Where the US Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearances of that permit shall govern, if greater.

21.6.70 Clearances Over or Near Swimming Areas

Sub-transmission supply wires and conductors should not pass over a swimming pool or the surrounding land within 25 feet around the edge of the pool. If such crossings cannot be reasonable avoided, the clearances shown below in Table 16 shall be obtained. In New York, refer to Electric & Gas System Bulletin #304 for policy on relocation to obtain clearance.

For all spans, horizontal clearances must be increased to allow for conductor “blowout” as shown on Page 21-33.

21.6.70.1 Swimming Pools

Where sub-transmission lines cross over a swimming pool or the surrounding area, the clearances in any direction shall not be less than those shown in Table 5 below. This rule does not apply to a pool enclosed by a solid or screened permanent structure.

21.6.70.2 Beaches and Waterways Restricted to Swimming

Where sub-transmission lines cross over a supervised swimming beach, where rescue poles are used by lifeguards, the clearances in any direction shall not be less than those shown in Table 16 below. Where rescue poles are not used, the clearances shall be as specified in Section 21.6.50.

21.6.70.3 Waterways Subject to Water Skiing

Where sub-transmission lines cross over a waterway subject to water skiing, the clearances shall be as specified in Section 21.6.60.

Superseded 1/06 Issue – Added 21.6 Clearances.

Table 16
Clearance to Swimming Pools [1]
(Reference: NESC Table 234-3, Figure 234-3, Rules 232 and 234)

	Grounded Guys [2, 3]	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.) [1]
A. Clearance in any direction from the water level, edge of pool, base of diving platform, or anchored raft	22.0	25.2	25.5	25.9	26.7
B. Clearance in any direction to the diving platform, tower, water slide, or other fixed, pool-related structures	14.0	17.2	17.5	17.9	18.7
V. Vertical clearance to adjacent land	Clearances specified in Section 21.6.50 & 21.6.60				

NOTE: A, B, and V are shown in Figure 2, below.

Supersedes 1/06 Issue – Added 21.6 Clearances.

FOOTNOTES:

1. For 69 kV, the clearance specified in Table 5 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.
2. Ungrounded guys and ungrounded portions of guys between insulators shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
3. Insulated anchor guys may have the same clearance as grounded guys. Insulators shall be installed as follows: (a) all guy insulators or span-wire insulators shall be located at a position such that the bottom of the insulator shall be not less than 2.45 m (8 ft) above the ground if the guy or span wire is broken below the insulator, (b) insulators shall be so placed that, in case any guy or span-wire contacts, or is contacted by, an energized conductor or part, the voltage will not be transferred to other facilities on the structure(s), and (c) insulators shall be so placed that in case any guy or span wire sags down upon another, the insulators will not become ineffective.

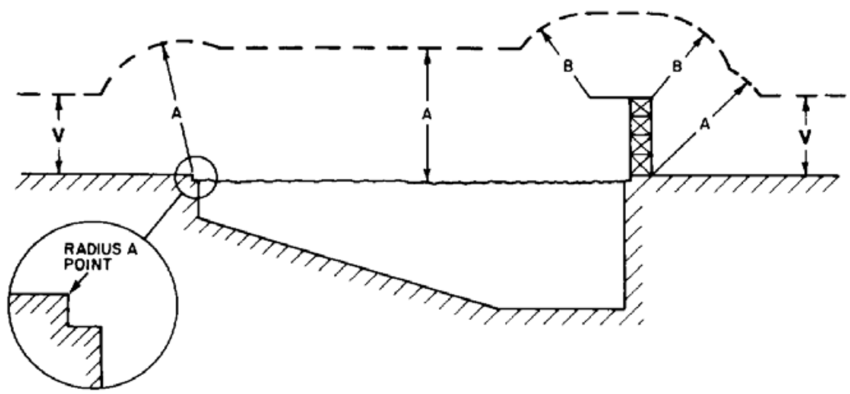


Figure 2

21.6.80 <u>Vertical & Horizontal Clearance Of Wires, Conductors And Cables To Rail Cars</u>

Where sub-transmission lines run along railroad tracks, the clearance in any direction shall not be less than that shown in Figure 3 and Table 17 below.

Table 17
Clearance to Rail Cars [1]
(Reference: NESC Figure 234-5 and Rule 234I)

	Grounded Guys [3]	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV [4] (ft.)
V	3.5	6.7	7.0	7.4	8.2
H	8.5	11.7	12.0	12.4	13.2

NOTE: V and H are shown in Figure 3, below.

FOOTNOTES:

1. If the Railroad crossed requires greater clearances than detailed in this Standard, the Railroad clearances shall apply.
3. Anchor guys shall not be located less than 12 feet from the nearest track rail. Insulated guys may have the same clearance as grounded guys. Insulators shall be installed as follows: (a) all guy

insulators or span-wire insulators shall be located at a position such that the bottom of the insulator shall be not less than 2.45 m (8 ft) above the ground if the guy or span wire is broken below the insulator, (b) insulators shall be so placed that, in case any guy or span-wire contacts, or is contacted by, an energized conductor or part, the voltage will not be transferred to other facilities on the structure(s), and (c) insulators shall be so placed that in case any guy or span wire sags down upon another, the insulators will not become ineffective. Ungrounded guys and ungrounded portions of span guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to slack conductor or guy.

4. For 69 kV, the clearance specified in Table 6 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

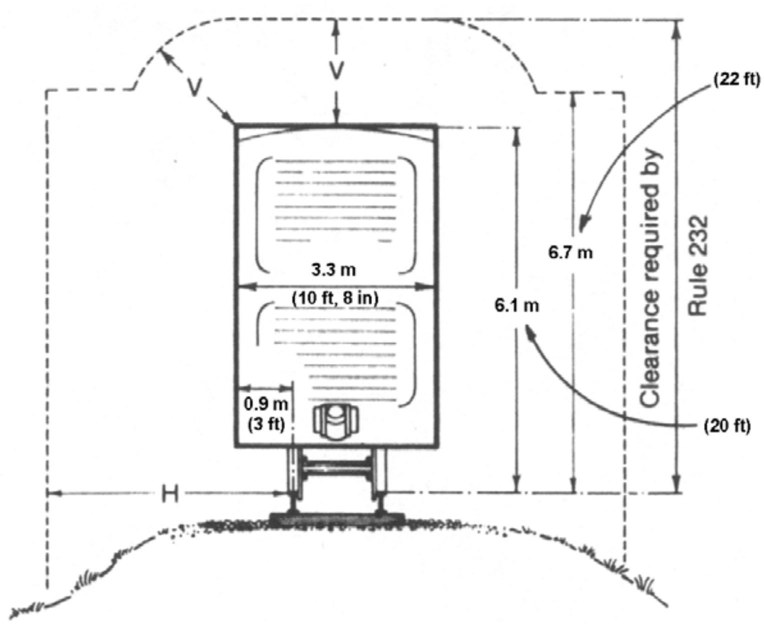


Figure 3

21.6.90 Vertical Clearance Of Equipment Cases and Rigid Live Parts Of Equipment Mounted On Structures

Where sub-transmission lines have equipment cases or rigid live parts, the clearance of such equipment cases or rigid live parts shall not be less than that shown in Table 18 below.

Supersedes 1/06 Issue – Added 21.6 Clearances.

Table 18
(Reference: NESC Rule 232B, Table 232-2)

Note These vertical clearances above ground or roadway surfaces are for unguarded rigid live parts such as potheads, transformer bushings, surge arresters, and short lengths of connecting supply conductors which are not subject to variations in sag.

Nature of Surface Below	Clearance Above Ground or Roadway				
	Effectively Grounded Equipment Cases (ft.)	Rigid Live Parts			
		25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)
1. Where rigid parts overhang:					
a. Roads, streets and other areas subject to truck traffic.[4]	15.0	18.2	18.5	18.9	19.7
b. Driveways, parking lots and alleys.	15.0	18.2	18.5	18.9	19.7
c. Other land traversed by vehicles such as cultivated land, grazing land, forest, orchard, etc.	15.0 [7]	18.2	18.5	18.9	19.7
d. Spaces and ways subject to pedestrians or restricted traffic only. [5]	11.0 [7]	14.2	14.5	14.9	15.7
2. Where rigid parts are along and within the limits of highways or other road rights-of-way but do not overhang the roadway.					
a. Roads, streets and alleys.	15.0 [7]	18.2	18.5	18.9	19.7
b. Roads in rural districts where it is unlikely that vehicles will be crossing under the line.	13.0 [7]	16.2	16.5	16.9	17.7
3. Water areas not suitable for sailboating or where sailboating in prohibited. [9]	14.0	15.25	15.5	15.9	16.7

Supersedes 1/06 Issue – Added 21.6 Clearances.

Note:

For 69 kV, the clearance specified in Table 18 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

FOOTNOTES:

Note: Footnotes 1, 2, 3, 6, and 8 will not be used.

4. For the purpose of this rule, trucks are defined as any vehicle exceeding 8 ft in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.
5. Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles or other mobile units exceeding 8 ft in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.
7. Effectively grounded switch handles and supply or communication equipment cases (such as fire alarm boxes, control boxes, communication terminals, meters, or similar equipment cases) may be mounted at a lower level for accessibility provided such cases do not unduly obstruct a walkway.

Such switch handles and equipment cases shall be located so as not to serve as a means of approach to unguarded rigid live parts by unqualified persons.

9. Where the US Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearance of that permit shall govern.

21.6.100 Clearance Of Wires, Conductors, Cables and Unguarded Live Parts To Buildings, Signs, Billboards, Chimneys, Radio and Television Antennas, Tanks and Other Installations Except Bridges

Sub-transmission conductors should not be installed over buildings. There are cases, however, especially for temporary work, where such construction cannot be avoided. The clearance of sub-transmission lines over or near buildings and appurtenances shall be as much as is practicable. In no case shall it be less than shown below.

For open supply conductors, the minimum vertical and horizontal clearances shown in Table 19 shall apply under whichever of the following conditions of conductor temperature and loading produces the closest approach:

(a) 120°F, no wind displacement, final sag.
(b) The maximum conductor temperature for which the line is designed to operate, no wind displacement, final sag.
(c) 32°F, no wind displacement, with ½" radial thickness of ice, final sag.
(d) The minimum conductor temperature for which the line is designed to operate, no wind displacement, initial sag.

For open supply conductors, the minimum horizontal clearances shown in Table 20 shall apply with the wires, conductors or cables displaced from rest by a 6 lb/ft2 wind at final sag at 60°F. The displacement of the wires, conductors or cables shall include the displacement of suspension insulators. If the highest wire, conductor or cable is installed 60 ft or more above grade, the displacement of the wires, conductors or cables shall include the deflection of a flexible structure.

The transition between vertical and horizontal clearance requirements shall be as shown in Figure 4 below.

Supersedes 1/06 Issue – Added 21.6 Clearances.

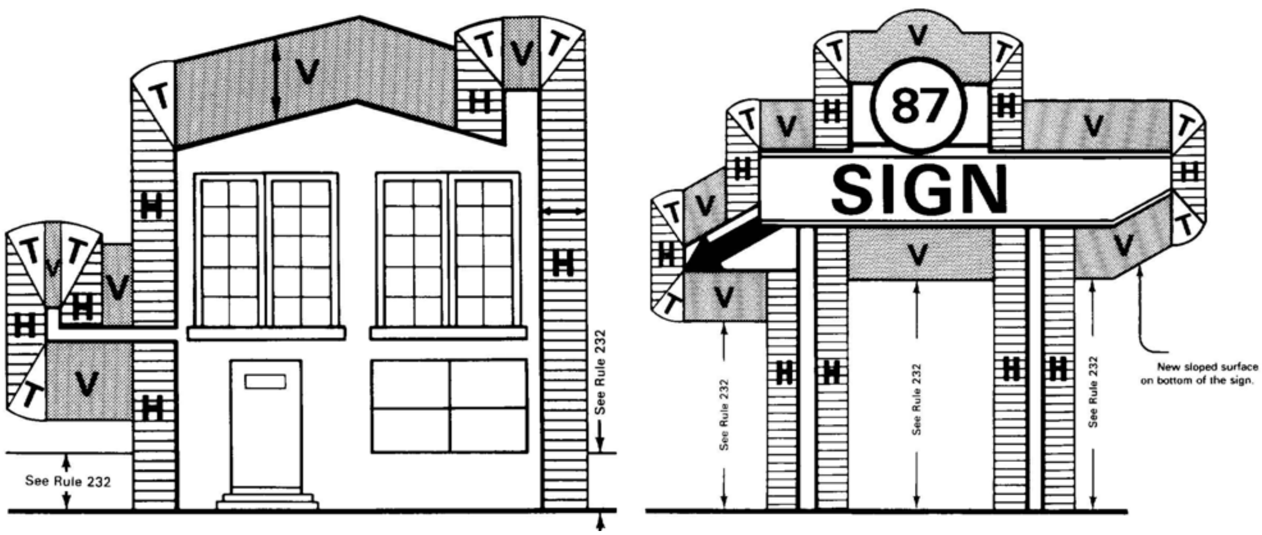


Figure 4
Regions Where Conductors Are Prohibited:
H = Horizontal; V = Vertical; T = Transitional = Vertical (Arc)

Table 19
Clearance of Wires, Conductors, Cables and Unguarded Rigid Live Parts Adjacent But Not Attached to Buildings And Other Installations Except Bridges
(Reference: NESC Tables 234-1 and Rules 232 and 234)

Clearance of:	Grounded Guys (ft.)	Unguarded rigid live parts, ungrounded equipment cases, ungrounded guys exposed to live parts				Open supply conductors			
		25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)
1. Buildings									
a. Horizontal									
(1) To walls, projections, and guarded windows	4.5 [1,2,7]	7.2 [1,2]	7.5 [1,2]	7.9 [1,2]	8.7 [1,2]	7.7[1,2,10,11]	8.0[1,2,10,11]	8.4[1,2,10,11]	9.2[1,2,10,11]
(2) To unguarded windows [8]	4.5	7.2	7.5	7.9	8.7	7.7 [10,11]	8.0 [10,11]	8.4 [10,11]	9.2 [10,11]
(3) To balconies and areas readily accessible to pedestrians [3]	4.5	7.2	7.5	7.9	8.7	7.7 [10,11]	8.0 [10,11]	8.4 [10,11]	9.2 [10,11]
b. Vertical [14]									
(1) Over or under roofs or projections not readily accessible to pedestrians [3]	3.0	12.2	12.5	12.9	13.7	12.7	13.0	13.4	14.2
(2) Over/under balconies and roofs readily accessible to pedestrians [3]	10.5	13.2	13.5	13.9	14.7	13.7	14.0	14.4	15.2
(3) Over roofs accessible to vehicles but not subject to truck traffic [6]	10.5	13.2	13.5	13.9	14.7	13.7	14.0	14.4	15.2
(4) Over roofs accessible to truck traffic [6]	15.5	18.2	18.5	18.9	19.7	18.7	19.0	19.4	20.2
2. Signs, chimneys, billboards, radio and TV antennas, tanks, and other installations not classified as buildings or bridges									
a. Horizontal [4]									
(1) To portions that are readily accessible to pedestrians [3]	4.5	7.2 [1,2]	7.5 [1,2]	7.9 [1,2]	8.7 [1,2]	7.7 [10,11]	8.0 [10,11]	8.4 [10,11]	9.2 [10,11]
(2) To portions that are not readily accessible to pedestrians [3]	3.0	7.2 [1,2]	7.5 [1,2]	7.9 [1,2]	8.7 [1,2]	7.7[1,2,10,11]	8.0[1,2,10,11]	8.4[1,2,10,11]	9.2[1,2,10,11]
b. Vertical									
(1) Over/under catwalks and other surfaces upon which personnel walk	10.5	13.2	13.5	13.9	14.7	13.7	14.0	14.4	15.2
(2) Over/under other portions of such installations [4]	3.0	7.7	8.0	8.4	9.2	8.2	8.5	8.9	9.7
3. Clearance from other supporting structures [15]									
a. Horizontal (no wind)	3.0	5.0	5.0	5.0	5.75	5.0	5.0	5.0	5.75
b. Vertical	2.0	5.5	5.5	5.5	6.25	5.5	5.5	5.5	6.25

Supersedes 1/06 Issue – Added 21.6 Clearances.

Note:

For 69 kV, the clearance specified in Table 19 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

FOOTNOTES:

1. Where building, sign, chimney, antenna, tank, or other installation does not require maintenance such as painting, washing, changing of sign letters, or other operations that would require persons to work or pass between wires, conductors, cables or unguarded live parts and structure, the clearance may be reduced by 2 feet.
2. Where available space may not permit this value, the clearance may be reduced by 2 feet provided the wires, conductors, or cables, including splices and taps, and unguarded live parts have a covering that provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact with a structure or building.
3. A roof, balcony, or area is considered readily accessible to pedestrians if it can be casually accessed through a doorway, ramp, window, stairway, or permanently mounted ladder by a person on foot who neither exerts extraordinary physical effort nor employs special tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its bottom rung is 8 feet or more from the ground or other permanently installed accessible surface.
4. The required clearances shall be to the closest approach of motorized signs or moving portions of the signs, billboards, chimneys, radio and television antennas, tanks, and other installations except bridges.
5. Ungrounded guys and ungrounded portion of guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed to a slack conductor or guy.
6. For purpose of this rule, trucks are defined as any vehicle exceeding 8 feet in height.
7. This clearance may be reduced to 3 inches for the grounded portions of guys.
8. Windows not designed to open may have the clearances permitted for walls and projections.
10. The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than the minimum clearances shown in Table 9, below.
11. Where available space will not permit this value, the clearance may be reduced to 7feet for conductors limited to 8.7 kV to ground.
13. The anchor end of insulated anchor guys may have the same clearance as grounded guys. Insulators shall be installed as follows: (a) all guy insulators or span-wire insulators shall be located at a position such that the bottom of the insulator shall be not less than 2.45 m (8 ft) above the ground if the guy or span wire is broken below the insulator, (b) insulators shall be so placed that, in case any guy or span-wire contacts, or is contacted by, an energized conductor or part, the voltage will not be transferred to other facilities on the structure(s), and (c) insulators shall be so placed that in case any guy or span wire sags down upon another, the insulators will not become ineffective.
14. For clearances above railings, walls, or parapets around balconies or roofs, use the clearances required for roofs not accessible to pedestrians.
15. Other supporting structures include those to which the conductor is not attached, such as lighting support, a traffic signal support, and a supporting structure of another line.

Supersedes 1/06 Issue – Added 21.6 Clearances.

Table 20
Horizontal Clearance of Wires, Conductors, Cables Under Wind Displacement Conditions

Conductor or Cable	Horizontal Clearance Required when Displaced by Wind			
	25 kV (ft.)	**35 kV (ft.)**	**46 kV (ft.)**	**69 kV (ft.)**
Open Supply Conductor	4.7	5.0	5.4	6.2

Note:

Sample calculations for accounting for wind displacement can be found on Page 21-33.

21.6.110 Clearance To Bridges

Sub-transmission conductors may be located adjacent to or within a bridge structure

The clearance over pedestrian walks or over roadways on bridges shall meet the requirements of Table 13 in Section 21.6.50.

For open supply conductors, the minimum vertical and horizontal clearances shown in Table 21 shall apply under whichever of the following conditions of conductor temperature and loading produces the closest approach:

(a) 120°F, no wind displacement, final sag.
(b) The maximum conductor temperature for which the line is designed to operate, no wind displacement, final sag.
(c) 32°F, no wind displacement, with ½" radial thickness of ice, final sag.
(d) The minimum conductor temperature for which the line is designed to operate, no wind displacement, initial sag.

For open supply conductors, the minimum horizontal clearances shown in Table 22 shall apply with the wires, conductors or cables displaced from rest by a 6 lb/ft2 wind at final sag at 60°F. The displacement of the wires, conductors or cables shall include the displacement of suspension insulators. If the highest wire, conductor or cable is installed 60 ft or more above grade, the displacement of the wires, conductors or cables shall include the deflection of a flexible structure.

The transition between vertical and horizontal clearance requirements shall be as shown in Figure 4 above.

Supersedes 1/06 Issue – Added 21.6 Clearances.

Table 21
Horizontal and Vertical Clearance of Wires, Conductors, Cables, and Unguarded Rigid Live Parts from Bridges
(Reference: NESC Tables 234 – 2 and Rules 234D1a and 234H4)

Clearance of:	Unguarded rigid live parts, ungrounded equipment cases, ungrounded guys exposed to live parts [4]				Open supply conductors			
	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)	25 kV (ft.)	35 kV (ft.)	46 kV (ft.)	69 kV (ft.)
1. Clearance over bridges [1]								
a. Attached [3]	5.2	5.5	5.9	6.7	5.7	6.0	6.4	7.2
b. Not Attached	12.2	12.5	12.9	13.7	12.7	13.0	13.4	14.2
2. Clearance beside, under, or within bridge structure [6]								
a. Readily accessible portions of any bridge including wing, walls, and bridge attachments [1]								
(1) Attached [3]	5.2	5.5	5.9	6.7	5.7 [9]	6.0 [9]	6.4 [9]	7.2 [9]
(2) Not Attached	7.2	7.5	7.9	8.7	7.7 [9]	8.0 [9]	8.4 [9]	9.2 [9]
b. Ordinarily inaccessible portions of bridges (other than brick, concrete, or masonry) and from abutments [2]								
(1) Attached [3,5]	5.2	5.5	5.9	6.7	5.7 [9]	6.0 [9]	6.4 [9]	7.2 [9]
(2) Not Attached [4,5]	6.2	6.5	6.9	7.7	6.7 [9]	7.0 [9]	7.4 [9]	8.2 [9]

Note:

For 69 kV, the clearance specified in Table 21 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

FOOTNOTES:

Note: Footnotes 7, 8 and 10 are not used.

1. Where over traveled ways on or near bridges, the clearances of Section 21.6.50 shall also apply.
2. Bridge seats of steel bridges carried on masonry, brick, or concrete abutments that require frequent access for inspection shall be considered as readily accessible portions.
3. Clearance from sub-transmission conductors to supporting arms and brackets owned, operated, or maintained by the Company and attached to bridges shall be the same as specified from Surfaces of Supports in Table 26 in Section 21.6.150.
4. Ungrounded guys and ungrounded portions of guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.
5. Where conductors passing under bridges are adequately guarded against contact by unauthorized persons and can be de-energized and grounded for maintenance of the bridge, clearances of the conductors from the bridge, at any point, may have the clearances specified from Surfaces of Supports in Table 26 in Section 21.6.150 plus one-half the final unloaded sag of the conductor at that point.
6. Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.
9. The clearance at rest shall be not less than the value shown in this Table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than shown in Table 22, below.

Supersedes 1/06 Issue – Added 21.6 Clearances.

Table 22
Horizontal Clearance of Wires, Conductors, Cables Under Wind Displacement Conditions

Conductor or Cable	Horizontal Clearance Required when Displaced by Wind			
	25 kV (ft.)	**35 kV (ft.)**	**46 kV (ft.)**	**69 kV (ft.)**
Open Supply Conductor	4.7	5.0	5.4	6.2

Note:

Sample calculations for accounting for wind displacement can be found on Page 21-33.

21.6.120 Separation Of Conductors and Supports On The Same Pole

21.6.120.1 General

Minimum vertical clearances between sub-transmission wires, conductors, or cables and other wires, conductors, or cables carried on the same supporting structures are shown in Table 23A for wires, conductors, or cables owned by the same utility and in Table 23B for wires, conductors, or cables owned by different utilities. These minimum vertical clearances shall be met or exceeded on all new poles. Where the recommended separations in other sections of these standards exceed these minimum vertical clearances, those separations should be used for poles in new lines. Where the recommended separations in other sections of these standards exceed these minimum vertical clearances, those separations should generally be used for pole replacements in existing lines except where such separations are not practicable in the existing line. These vertical clearances are suggested minimum clearances; separations should be increased to provide additional safety protection wherever possible.

"At Pole" clearances are the vertical clear space separation requirements, surface-to-surface, at the pole.

"In-Span" clearances are the vertical clear space separation requirements, surface-to-surface, at any location in the span. Vertical clearances at the supporting structures shall be adjusted so that the vertical clearance at any point in the span shall be not less than the required "In-Span" clearance under whichever of the following conditions produces the greater vertical clearance at the structure:

i. The upper conductor is at final sag at 120°F or the maximum operating temperature for which the line is designed to operate and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, or

ii. The upper conductor is at final sag at 32°F with ½" radial thickness of ice (NESC Heavy Loading District) and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, and without ice loading.

Supersedes 1/06 Issue – Added 21.6 Clearances.

Table 23A
Vertical Clearance Between Conductors Owned by the Same Utility
(Reference: NESC Rules 235A, C and Table 235-5)

Conductors and Cables Usually at Lower Levels	Open Supply Conductors and Cables Usually At Upper Levels							
	25 kV		35 kV		46 kV		69 kV	
	At Pole (in.)	In-Span (in.)	At Pole (in.)	In-Span (in.)	At Pole (in.)	In-Span (in.)	At Pole (in.)	In-Span (in.)
1. Communication Conductors and Cables								
a. Located in the communication space	40	30	40	30	40	30	49	39
b. Located in the supply space	40 [10]	30 [10]	40 [10]	30 [10]	40 [10]	30 [10]	49 [10]	39 [10]
2. Supply conductors and cables								
a. Open conductors 0-750 V; supply cables meeting Rule 230C1, 2, or 3; neutral conductors meeting Rule 230E1 [11]	24	18	28	21	32	24	42	34
b. Open conductors over 750 V-8.7 kV	24 [4a]	18 [4b]	28 [4a]	21 [4b]	35 [4a]	27 [4b]	45 [4a]	37 [4b]
c. Open conductors over 8.7-22 kV								
(1) If worked on alive with live-line tools and adjacent circuits are neither de-energized nor covered with shields or protectors	24	18	31	24	40	32	51	43
(2) If not worked on alive except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by use of live-line tools not requiring line workers to go between live wires	24 [3]	18 [3]	31 [3]	24 [3]	40 [3]	32 [3]	51 [3]	43 [3]
2. Open supply conductors and cables exceeding 22 kV	Contact Distribution Standards Department							

Table 23B
Vertical Clearance Between Conductors Owned by Different Utilities
(Reference: NESC Rules 235A, C and Table 235-5)

Conductors and Cables Usually at Lower Levels	Open Supply Conductors and Cables Usually At Upper Levels							
	25 kV		35 kV		46 kV		69 kV	
	At Pole (in.)	In-Span (in.)	At Pole (in.)	In-Span (in.)	At Pole (in.)	In-Span (in.)	At Pole (in.)	In-Span (in.)
1. Communication Conductors and Cables								
a. Located in the communication space	48	36	52	39	56	42	66	52
b. Located in the supply space	48 [10]	36 [10]	52 [10]	39 [10]	56 [10]	42 [10]	66 [10]	52 [10]
2. Supply conductors and cables								
a. Open conductors 0-750 V; supply cables meeting Rule 230C1, 2, or 3; neutral conductors meeting Rule 230E1 [11]	48	36	52	39	56	42	66	52
b. Open conductors over 750 V-8.7 kV	48	36	52	39	56	42	66	52
c. Open conductors over 8.7-22 kV								
(1) If worked on alive with live-line tools and adjacent circuits are neither de-energized nor covered with shields or protectors	48	36	55	42	64	50	75	61
(2) If not worked on alive except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by use of live-line tools not requiring line workers to go between live wires	24 [3]	18 [3]	31 [3]	24 [3]	40 [3]	32 [3]	51 [3]	43 [3]
2. Open supply conductors and cables exceeding 22 kV	Contact Distribution Standards Department							

Supersedes 1/06 Issue – Added 21.6 Clearances.

NOTES:

When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de energizing the faulted section, both initially and following subsequent breaker operations.

For span lengths in excess of 45 m (150 ft), vertical clearance at the structure between 25 kV, 35 kV and 46 kV open supply conductors and communication space cables or conductors shall be adjusted so that under conditions of conductor temperature of 15 °C (60 °F), no wind displacement and final unloaded sag, the open supply conductor shall not be lower in the span than a straight line joining the points of support of the highest communication cable or conductor. For span lengths in excess of 45 m (150 ft), vertical clearance at the structure between 69 kV open supply conductors and communication space cables or conductors shall be adjusted so that under conditions of conductor temperature of 15 °C (60 °F), no wind displacement and final unloaded sag, the open supply conductor shall not be lower in the span than 9” above a straight line joining the points of support of the highest communication cable or conductor.

FOOTNOTES:

3. These values do not apply to conductors of the same circuit or circuits being carried on adjacent conductor supports.
4. May be reduced where conductors are not worked on energized except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live line tools not requiring line workers to go between live wires:
   a. to 16 in at pole,
   b. to 12 in in-span.
10. No clearance is specified between fiber-optic supply cables meeting Rule 230F1b and supply cables and conductors.
11. Does not include neutral conductors meeting Rule 230E1.

21.6.120.2 Separation on Replaced Poles

In general, the separations on poles that are replaced shall conform to the requirements for new poles. In some special cases, separation may be reduced, but shall not be less than permitted on existing poles.

21.6.120.3 Reduction of Separation on Poles

Reduced separations of conductors and facilities made to accommodate communication, community antenna television (CATV), or other third party interest shall not be less than 15 kV minimum requirements.

21.6.120.4 Basic Impulse Level (BIL) & Air – Wood Spacing

BIL refers to the ability of the pole top design to resist flashovers caused by lightning or line surges.

Sub-transmission pole tops are generally designed to provide 150 kV minimum insulation withstand value. This impulse strength shall be based entirely on the impulse flashover of 20 inches or more of wood. Where lightning arresters are used, the “inches of wood” requirement does not apply for the particular conductor having the arrester. In locations where sufficient wood separation is not obtainable due to guy attachment, the use of a fiberglass guy strain insulator will meet this requirement. Additionally, insulated pole top pins (P6B and P6C), long strain insulators (I2), guy strain insulator (I24, TI95B, TI95C, TI95D), and wood braces (TB60 & B37B) may be used to provide the necessary separation if it cannot be met with standard hardware.

Supersedes 1/06 Issue – Added 21.6 Clearances.

In design and construction of pole tops, avoid shorting out the insulation provided by air and wood with steel crossarm braces, steel hardware, ground wires, guy wires, etc. The total distance measured over insulators, wood, and air should be as great as possible.

21.6.120.5 Climbing Space

Standard pole top designs shall meet or exceed code requirements for vertical or lateral clearance for line conductors at different levels attached to the same pole. When various designs are combined, however, or when work is done on an existing pole, care should be taken to provide good clearance and to maintain climbing and working space. Page 7-127 shows the NESC clearance required when workers must climb through energized conductors. This drawing should be used as a guide even when the conductors concerned are covered by protective equipment or otherwise guarded as an unvarying practice before personnel climb past them.

The climbing space needs to be provided on one side or a corner of the support only.

Vertical runs physically protected by conduit or other protective covering securely attached without spacers to the surface of the pole are not considered to obstruct climbing space.

The climbing space shall extend vertically in the same position 40 inches above and 40 inches below any wire attachment, but may otherwise be shifted to any other adjacent side or corner of the pole.

All voltages in Table 24 are between the two conductors bounding the climbing space, except for communications conductors, which are voltage to ground. Where two conductors are in different circuits, the voltage between conductors shall be the arithmetic sum of the voltages of each conductor to ground for a grounded circuit or phase to phase for an ungrounded circuit.

Table 24
Horizontal Climbing Space Between Conductors
(Reference: NESC Rule 236 and Table 236-1)

Character of Conductors Adjacent to Climbing Space	Voltage of Conductors	Horizontal Clearance Between Conductors Bounding the Climbing Space [3,4,5]		
		On S.O. Structures used Solely By Supply Conductors (Inches)	On J.O. Structures: Supply Conductors Above Communication Conductors (Inches)	On J.O. Structures: Communication Conductors Above Supply Conductors [1] (Inches)
Open Supply Line Conductors and Supply Cables Meeting Rule 230D	25 kV	36	36	36
	35 kV	40	40	
	46 kV	46	46	
	69 kV	54	54	

FOOTNOTES:

Footnotes 2 and 3 are not used.

1. This level relation is undesirable, in general, and should be avoided.
4. The climbing space specified in Table 13 above shall be provided above the top support arm to the ridge pin conductor but need not be carried past it.
5. All supply equipment such as transformers, capacitors, cable terminations, switches, etc. when located below conductors or other attachments, shall be mounted outside the climbing space.

Supersedes 1/06 Issue – Added 21.6 Clearances.

21.6.130 Clearance To Property Line

In general, conductors and supports shall not overhang property lines unless a right of way or easement has been obtained. In checking overhang, it should be assumed that conductors on rigid supports will be deflected by wind at the amount calculated on Page 21-33.

Plan for future buildings or structures along the property lines, or, if local ordinances specify, along the established building line. If it is probable that a structure will be erected in the foreseeable future, the right-of-way should be adequate to provide standard clearances to such a structure.

21.6.140 Clearance Between Wires, Conductors and Cables At Point Of Crossing On Different Supporting Structures

It is generally undesirable to build a sub-transmission line directly over or under another line. Where this cannot be avoided, clearance should be provided so that a man working on the top of a pole will be able to maintain adequate working clearances from conductors overhead.

The conductor movement envelope shall be developed from the locus of the most displaced conductor positions defined below and shown in Figure 5:

(1) 15 °C (60 °F), no wind displacement, at both initial unloaded and final unloaded sag (conductor positions A and C).

(2) With the wire, conductor, or cable displaced from rest by a 290 Pa (6 lb/ft2) wind at both initial and final sag at 15 °C (60 °F). The displacement of the wire, conductor, or cable shall include deflection of suspension insulators and flexible structures (conductor positions B and D).

EXCEPTION: Where the entire span is so close to a building, terrain feature, or other obstacle as to be sheltered from the wind flowing across the line in either direction, the wind pressure may be reduced to a 190 Pa (4 lb/ft2) wind. Trees are not considered to shelter a line.

(3) Final sag at one of the following loading conditions, whichever produces the largest sag (conductor position E):

(a) 50 °C (120 °F), no wind displacement,
(b) The maximum conductor temperature for which the line is designed to operate, if greater than 50 °C (120 °F), with no wind displacement, or
(c) 0 °C (32 °F), no wind displacement, with 0.5 inch radial thickness of ice.

Supersedes 1/06 Issue – Added 21.6 Clearances.

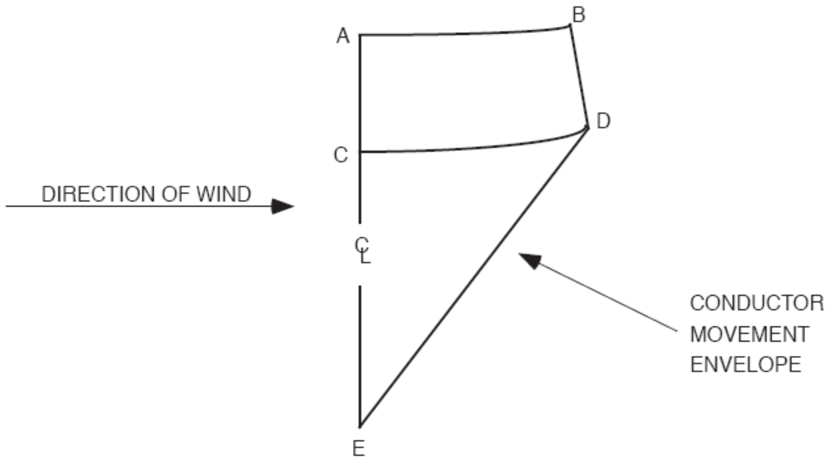


Figure 5

The horizontal clearance between crossing or adjacent wires, conductors, or cables carried on different supporting structures shall be not less than 5 ft.

Supersedes 1/06 Issue – Added 21.6 Clearances.

Table 25
Vertical Clearance Between Wires, Conductors, and Cables Carried on Different Supporting Structures
(Reference: NESC Rule 233, Table 233-1)

	Upper Level				
	Effectively grounded supply guys, span wires, neutral conductors meeting Rule 230E1, and overhead shield / surge-protection wires	Open supply conductors			
Lower Level	**(ft)**	**25 kV (ft)**	**35 kV (ft)**	**46 kV (ft)**	**69 kV (ft)**
1. Effectively grounded supply guys [7], span wires, neutral conductors meeting Rule 230E2, and overhead shield/surge-protection wires	2.0 [1,2]	2.2	2.5	2.9	3.7
2. Effectively grounded communication guys [7], conductors and cables, and messengers	2.0 [1,2]	5.2 [8]	5.5 [8]	5.9 [8]	6.7 [8]
3. Supply cables meeting Rule 230C1, and supply cables of 0-750 V meeting Rules 230C2 or 230C3	2.0	2.2	2.5	2.9	3.7
4. Open supply conductors, 0-750 V [6]; supply cables over 750 V meeting Rule 230C2 or 230C3	2.0 [9]	2.2	2.5	2.9	3.7
5. Open supply conductors, 750 V-22 kV	2.0 [9]	2.2	2.5	2.9	3.7

NOTES:

1. For lower-level conductors exceeding 22 kV, the clearance given in Table 25 shall be increased at the rate of 0.4 in per kV in excess of 22 kV.

2. For 69 kV, the clearance specified in Table 10 shall be increased 0.6 in for each 1000 ft in excess of 3300 ft above mean sea level.

FOOTNOTES:

Note: Footnotes 3, 4, 5, and 6 are not used.

1. No clearance is specified between guys or span wires that are electrically interconnected.
2. The clearance of communication conductors and their guy span, and messenger wires from each other in locations where no other classes of conductors are involved may be reduced by mutual consent of the parties concerned, except for fire-alarm conductors and conductors used in the operation of railroads.
6. Does not include neutrals that are effectively grounded throughout their length and are associated with circuits of 0 to 22 kV to ground.
7. These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the un-insulated portion of the guy.
8. This clearance may be reduced by 3 feet for supply service drops.
9. In general, this type of crossing is not recommended.

21.6.150 Clearances Of Vertical and Lateral Supply Conductors From Other Wires & Surfaces Of The Same Structure

Minimum clearances between vertical and lateral sub-transmission conductors from other wires and surfaces of the supporting structures are shown, in general, in Table 26. Table 27 shows minimum clearances between vertical and lateral sub-transmission conductors from other wires and surfaces of the supporting structures are shown for portions of a structure that workers ascend while the conductors in question are energized.

Table 26
Clearances of Open Lateral and Vertical Conductors
(Circuit Phase-to Phase Voltages, Reference: NESC Rule 239E, Table 239-1)

Clearances of Open Vertical & Lateral Conductors	Phase to Phase Voltage			
	25 kV (Inches)	35 kV (Inches)	46 kV (Inches)	69 kV [4] (Inches)
From Surfaces of Supports	7	9	11	16 [4a]
From Span, Guy and Messenger Wires [5]	14	18	22	32 [4b]
Anchor Guys	11	14	16	29 [4c]

FOOTNOTES:

4. The clearance for 69 kV specified in Table 26 shall be increased by the following amounts:
   a. For clearances from surfaces of supports: Increase by 0.15 in / 1000 ft in excess of 3300 ft above mean sea level,
   b. For clearances from span, guy, and messenger wires: Increase by 0.27 in / 1000 ft in excess of 3300 ft above mean sea level, and
   c. For clearances from anchor guy wires: Increase by 0.18 in / 1000 ft in excess of 3300 ft above mean sea level.

Supersedes 1/06 Issue – Added 21.6 Clearances.

5. These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the un-insulated portion of the guy.

Table 27 [5]
Clearance Between Open Vertical Conductors and Pole Surface (Figures 6 & 7)
(Circuit Phase-to Phase Voltages, Reference: NESC Rule 239E, Table 239-2)

Clearances of Open Vertical & Lateral Conductors	Phase to Phase Voltage			
	25 kV (Inches)	35 kV (Inches)	46 kV (Inches)	69 kV [4] (Inches)
From Surfaces of Supports	7	9	11	16 [4a]
From Span, Guy and Messenger Wires [5]	14	18	22	32 [4b]
Anchor Guys	11	14	16	29 [4c]

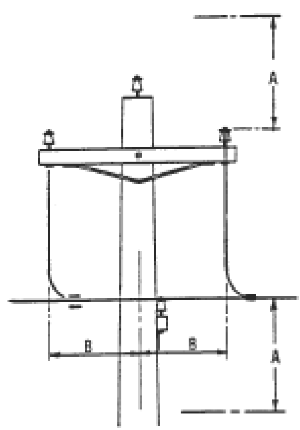


Figure 6

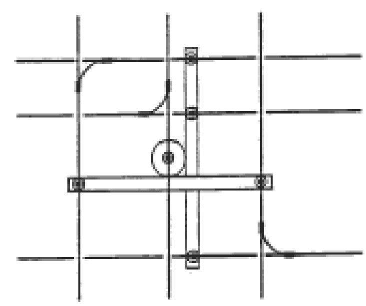


Figure 7

A = zone above and below conductor
B = distance between vertical wire and pole center

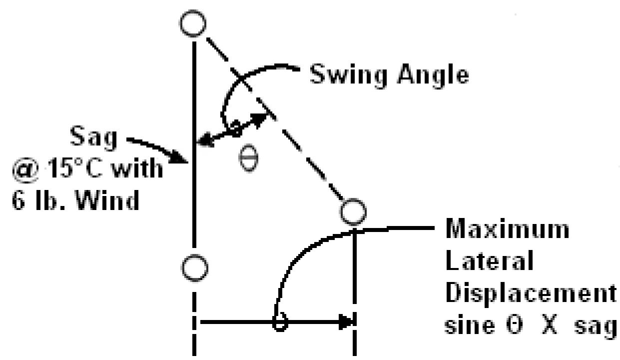
Supersedes 1/06 Issue – Added 21.6 Clearances.

Basic HORIZONTAL clearances shown in Section 21.6.110 must be increased as follows to allow for wind caused lateral conductor displacement. For horizontal adders between conductors carried on different poles (Table 22), apply adder for only one of the conductors.

The vertical sag at 60°F/15°C final with 6 lb. wind taken from conductor information on pages 21-401 through 21-418 for the subject conductor and span is multiplied by the sine of the conductor's swing angle to obtain maximum conductor horizontal movement.

The sine of the swing angle may be calculated or taken from the following table (rounding up to the next value shown).

Swing Angle (Θ)	Sine
25°	0.4226
30°	0.5000
35°	0.5736
40°	0.6428
45°	0.7071
50°	0.7660
55°	0.8192
60°	0.8660



Example:

For a 200 feet span of 336.4 kcm AAC 19 Strand Bare (Std. Item W20B)

1. Swing Angle = 46.5degrees (from Page 21-417)
2. Multiplier = 0.7660 (from table above for 50°)
3. Sag at 60°F/15°C, 6 lb. wind for 200 foot span = 48.36 inches (from Page 21-418)
4. Maximum Lateral Displacement = (48.36 inches) X (0.7660) = 37.04 inches

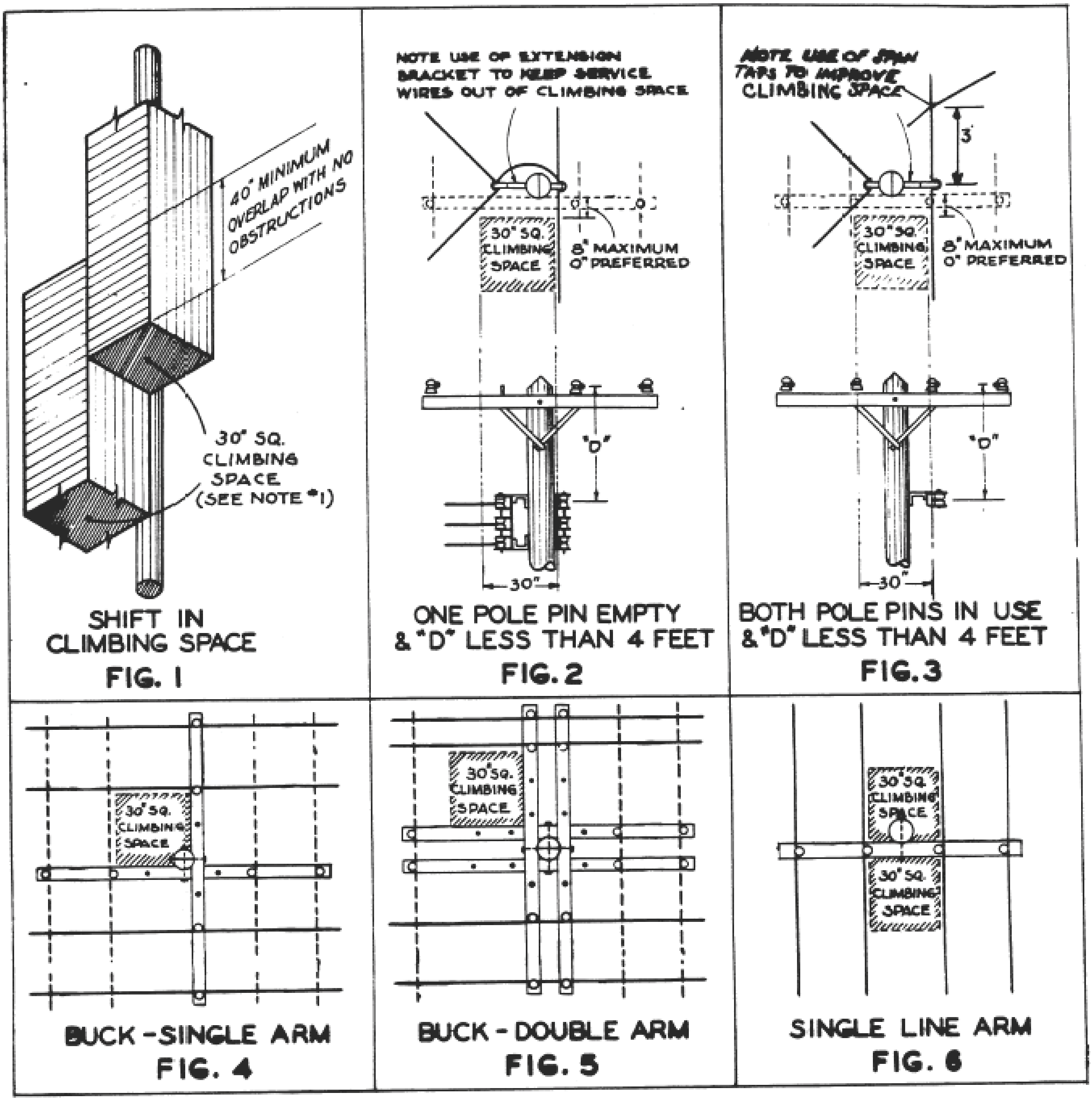
Note:

If point of conflict is not at point of maximum sag, the additional horizontal clearance may be reduced as follows:

If the distance between point of crossing or clearance and the nearest support is ___% of the total span, multiply additional clearance by the multiplier outlined below.

Percent of Span	Multiplier
5%	0.19
10%	0.36
15%	0.51
20%	0.64
25%	0.75
30%	0.84
35%	0.91
40%	0.96
45%	0.99
50%	1.00
*Interpolate for intermediate vales or use next higher multiplier.	

Supersedes 1/06 Issue – Added 21.6 Clearances.

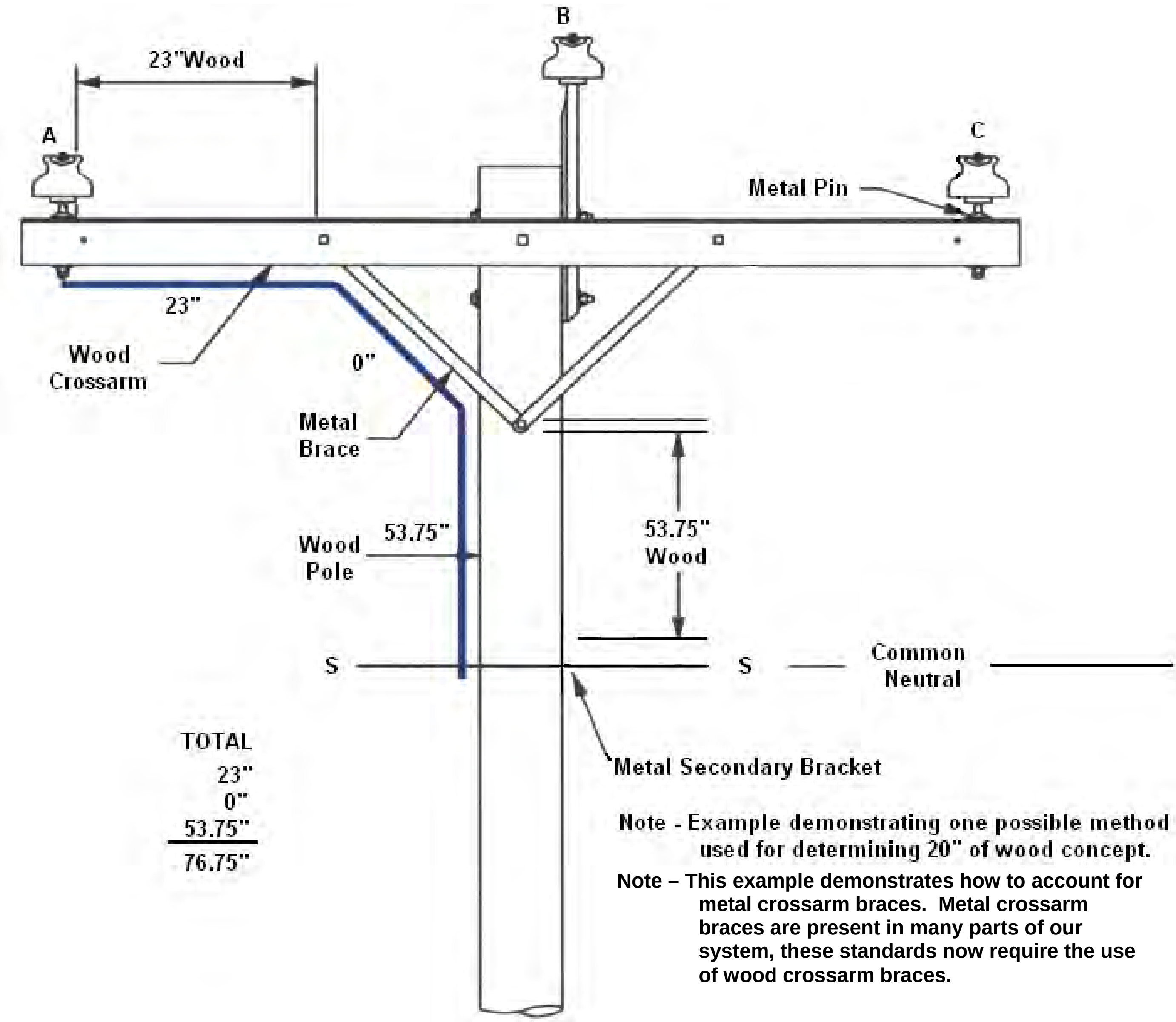


Supersedes 1/06 Issue – Added 21.6 Clearances.

Notes:

1. The climbing space should preferably be continuous from the ground to beyond the top of the pole; but when necessary, it may be shifted from one quarter of the pole to another provided the sections overlap at least 40 inches and there are no obstructions between the two climbing space columns. The climbing space column should extend 40 inches above and below the limiting conductors, but need not extend above a pole top pin.
2. Climbing space should be located in the quarter of the pole not occupied by risers.

Supersedes 1/06 Issue – Added 21.6 Clearances.



Note - Example demonstrating one possible method used for determining 20" of wood concept.

Note – This example demonstrates how to account for metal crossarm braces. Metal crossarm braces are present in many parts of our system, these standards now require the use of wood crossarm braces.

To resist current leakage or electrical flashover a minimum of 20” of wood, fiberglass and effective insulation is needed. Non-conducting material such as air, wood, porcelain, or fiberglass is taken together to determine the insulation level.

Keep as much air, wood, porcelain and fiberglass between phase and ground and between phases as is practicable. The above drawing illustrates the 20 inches of wood concept.

Spacing can be increased by:

1. Relocating hardware, pins, deadends, guy attachments, etc.
2. Using wood braces.
3. Using fiberglass pole top pin.
4. Using fiberglass guy insulator or extra insulators in deadends.

For applications where surge arresters are used, the 20 inches of wood requirement does not apply for the particular conductor protected by the arrester.

21.7 STRUCTURE TYPE SELECTION

This standard contains three basic families of structure configurations:

(i) Flat configuration using vertical post insulators on 10' crossarms for 25kV, 35 kV, 46kV and 69kV with conductors up to 477 ACSR (see Standards Pages 21-211 through 21-218 and 21-236),
(ii) 4' Triangular configuration using vertical post insulators for 25kV and 35 kV using 795 and 1113 ACSR conductors (see Standards Pages 21-101 through 21-109) and
(iii) Vertical configuration using horizontal post insulators for 25kV, 35kV, 46kV and 69kV with conductors up to 477 ACSR (see Standards Pages 21-224 through 21-230).

In general, the vertical configuration is preferred for new line construction. The flat configuration fits well into many existing line configurations throughout the system for new or replacement structures in existing lines, in short line extensions and where a lower line profile is desirable. The 4' triangular configuration should only be used when 795 or 1113 ACSR is required at 25kV or 35kV.

Within each family of structures, the structure type is selected based on the line angle. Each structure drawing title indicates the range of or maximum line angles for which the structure may be used.

Allowable span lengths are limited by a variety of considerations including: (i) loads from wires and the strengths of the supporting poles, crossarms, insulators and hardware, (ii) required clearances between conductors and (iii) where appropriate, conductor gallop.

Tables 28 through 34 contain span limits for each of the structure types considering (i) loads from wires and the strengths of the supporting crossarms, insulators and hardware, (ii) required clearances between conductors and (iii) where appropriate, conductor gallop. These tables are applicable only for standard conductors strung at standard tensions and sags included in pages 21-401 through 21-418 of these standards. These tables do not apply when other sags and tensions are used and appropriate limits for the tensions and sags actually used must be determined. These tables do not take pole strength into consideration and appropriate pole strength must be considered separately.

These tables contain span limits based on conductor gallop. Conductor gallop is not always a factor, but span lengths should be limited based on gallop clearances when the line is built in open, level terrain. When considering gallop, the gallop limit for span length applies to all structure types in the faily of structures. Conductor gallop is a large amplitude movement of conductors that occurs in open terrain. Gallop is generally associated with steady wind over entire spans of conductors with some ice on the conductors. Gallop does not normally occur in areas where the wind is not steady over an entire span because parts of the span are sheltered by trees or buildings or where uneven terrain makes the wind flow across a span turbulent. Gallop clearances do not need to considered when the line is built in an area with trees that are close to the height of the line or when the line is built through an area where terrain or buildings near the line will make winds across the line turbulent rather than steady across the entire span.

Supersedes 1/06 Issue – Added 217 Structure Type Selection.

Table 28
Maximum Allowable Spans
4'Triangular Configuration – 25kV

CONDUCTOR	**Double Arm / Single Insulator 21-101 (3 deg) (ft.)**	**Double Arm / Single Insulator 21-102 (6 deg) (ft.)**	**Double Arm / Double Insulator 21-103 (15 deg) (ft.)**	**Other Str. Types 21-104 --- 21-109 (ft.)**	**Gallop Limited (ft.)**
1113.0 KCMIL, 54/19 STRANDING, BARE ACSR, "FINCH"	408	289	460	502	200
795.0 KCMIL, 54/7 STRANDING, BARE ACSR, "CONDOR"	464	349	521	521	210

Table 29
Maximum Allowable Spans
4'Triangular Configuration – 35kV

CONDUCTOR	**Double Arm / Single Insulator 21-101 (3 deg) (ft.)**	**Double Arm / Single Insulator 21-102 (6 deg) (ft.)**	**Double Arm / Double Insulator 21-103 (15 deg) (ft.)**	**Other Str. Types 21-104 --- 21-109 (ft.)**	**Gallop Limited (ft.)**
1113.0 KCMIL, 54/19 STRANDING, BARE ACSR, "FINCH"	408	289	460	502	200
795.0 KCMIL, 54/7 STRANDING, BARE ACSR, "CONDOR"	464	349	482	521	210

Supersedes 1/06 Issue – Added 21.7 Structure Type Selection.

Table 30
Maximum Allowable Spans
Flat Configuration – 25kV

CONDUCTOR	Single Arm / Single Insulator 21-211 (2 deg) (ft.)	Double Arm / Single Insulator 21-217 (2 deg) (ft.)	Double Arm / Single Insulator 21-220 (8 deg) (ft.)	Double Arm / Double Insulator 21-236 (8 deg) (ft.)	Other Str. Types (ft.)	Gallop Limited (ft.)
477.0 KCMIL, 26/7 STRANDING, BARE ACSR, “HAWK”	324	577	357	629	643	310
477.0 KCMIL, 19 STRAND, BARE AAC, “COSMOS”	387	559	471	559	559	270
477.0 KCMIL, 19 STRAND, COMPACT AAC, 320 MIL COVERED TREE WIRE – 35 kV	242	464	358	464	464	***
336.4 KCMIL, 18/1 STRANDING, BARE ACSR, “MERLIN”	350	577	436	660	660	350
336.4 KCMIL, 19 STRAND, BARE AAC, “TULIP”	457	608	507	608	608	290
1/0, 7 STRAND, BARE 6201-T81 AAAC, “AZUZA”	660	660	604	660	660	360
1/0, 7 STRAND, CONCENTRIC ROUND 6201-T81 AAAC, 315 MIL COVERED TREE WIRE – 35 kV	351	539	417	539	539	***

*** If tree wire is required, the line should be in an area where it is sheltered by trees and gallop should not be a concern.

Supersedes 1/06 Issue – Added 217 Structure Type Selection.

Table 31
Maximum Allowable Spans
Flat Configuration – 35kV

CONDUCTOR	Single Arm / Single Insulator 21-211 (2 deg) (ft.)	Double Arm / Single Insulator 21-217 (2 deg) (ft.)	Double Arm / Single Insulator 21-220 (8 deg) (ft.)	Double Arm / Double Insulator 21-236 (8 deg) (ft.)	Other Str. Types (ft.)	Gallop Limited (ft.)
477.0 KCMIL, 26/7 STRANDING, BARE ACSR, “HAWK”	303	577	357	584	603	310
477.0 KCMIL, 19 STRAND, BARE AAC, “COSMOS”	361	523	471	523	523	270
477.0 KCMIL, 19 STRAND, COMPACT AAC, 320 MIL COVERED TREE WIRE – 35 kV	228	435	358	435	435	***
336.4 KCMIL, 18/1 STRANDING, BARE ACSR, “MERLIN”	326	577	436	643	660	350
336.4 KCMIL, 19 STRAND, BARE AAC, “TULIP”	425	570	507	570	570	290
1/0, 7 STRAND, BARE 6201-T81 AAAC, “AZUZA”	618	660	604	660	660	360
1/0, 7 STRAND, CONCENTRIC ROUND 6201-T81 AAAC, 315 MIL COVERED TREE WIRE – 35 kV	327	505	417	505	505	***

*** If tree wire is required, the line should be in an area where it is sheltered by trees and gallop should not be a concern.

Supersedes 1/06 Issue – Added 21.7 Structure Type Selection.

Table 32
Maximum Allowable Spans
Flat Configuration – 46kV

CONDUCTOR	Single Arm / Single Insulator 21-211 (2 deg) (ft.)	Double Arm / Single Insulator 21-217 (2 deg) (ft.)	Double Arm / Single Insulator 21-220 (8 deg) (ft.)	Double Arm / Double Insulator 21-236 (8 deg) (ft.)	Other Str. Types (ft.)	Gallop Limited (ft.)
477.0 KCMIL, 26/7 STRANDING, BARE ACSR, “HAWK”	290	558	357	556	558	310
477.0 KCMIL, 19 STRAND, BARE AAC, “COSMOS”	345	485	471	485	485	270
336.4 KCMIL, 18/1 STRANDING, BARE ACSR, “MERLIN”	313	577	436	616	659	350
336.4 KCMIL, 19 STRAND, BARE AAC, “TULIP”	504	527	507	527	527	290
1/0, 7 STRAND, BARE 6201-T81 AAAC, “AZUZA”	586	660	604	660	660	360

Table 33
Maximum Allowable Spans
Flat Configuration – 69kV

CONDUCTOR	Single Arm / Single Insulator 21-211 (2 deg) (ft.)	Double Arm / Single Insulator 21-217 (2 deg) (ft.)	Double Arm / Single Insulator 21-220 (8 deg) (ft.)	Double Arm / Double Insulator 21-236 (8 deg) (ft.)	Other Str. Types (ft.)	Gallop Limited (ft.)
477.0 KCMIL, 26/7 STRANDING, BARE ACSR, “HAWK”	261	465	357	465	465	310
477.0 KCMIL, 19 STRAND, BARE AAC, “COSMOS”	312	403	403	403	403	270
336.4 KCMIL, 18/1 STRANDING, BARE ACSR, “MERLIN”	292	546	436	548	548	350
336.4 KCMIL, 19 STRAND, BARE AAC, “TULIP”	364	439	439	439	439	290
1/0, 7 STRAND, BARE 6201-T81 AAAC, “AZUZA”	519	660	604	660	660	360

Supersedes 1/06 Issue – Added 217 Structure Type Selection.

Table 34
Maximum Allowable Spans
Vertical Configuration – 46kV & 69kV

CONDUCTOR	Single Arm / Single Insulator 21-211 (2 deg) (ft.)	Gallop Limited (ft.)
477.0 KCMIL, 26/7 STRANDING, BARE ACSR, "HAWK"	660	300
477.0 KCMIL, 19 STRAND, BARE AAC, "COSMOS"	660	260
477.0 KCMIL, 19 STRAND, COMPACT AAC, 320 MIL COVERED TREE WIRE – 35 kV	543	***
336.4 KCMIL, 18/1 STRANDING, BARE ACSR, "MERLIN"	660	340
336.4 KCMIL, 19 STRAND, BARE AAC, "TULIP"	660	280
1/0, 7 STRAND, BARE 6201-T81 AAAC, "AZUZA"	660	350
1/0, 7 STRAND, CONCENTRIC ROUND 6201-T81 AAAC, 315 MIL COVERED TREE WIRE – 35 kV	660	***

*** If tree wire is required, the line should be in an area where it is sheltered by trees and gallop should not be a concern.

Supersedes 1/06 Issue – Added 21.7 Structure Type Selection.

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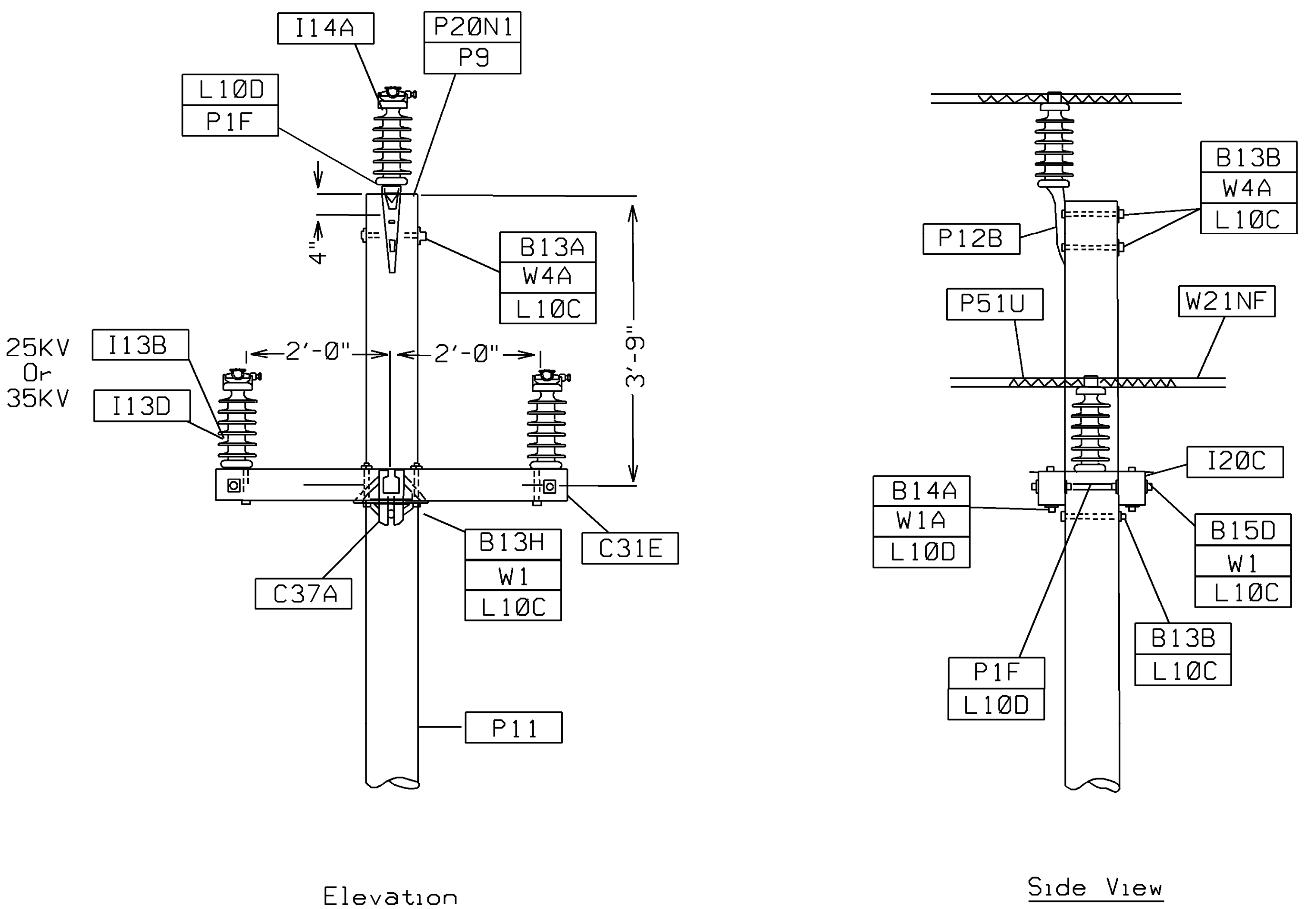
 Doc. # ST. 21.00.002

MU = @CS144027NE	4'Tri DA Sing-Ins 25kV 795 ACSR
MU = @CS144037NE	4'Tri DA Sing-Ins 35kV 795 ACSR
MU = @CS145021NE	4'Tri DA Sing-Ins 25kV 1113 ACSR
MU = @CS145031NE	4'Tri DA Sing-Ins 35kV 1113 ACSR



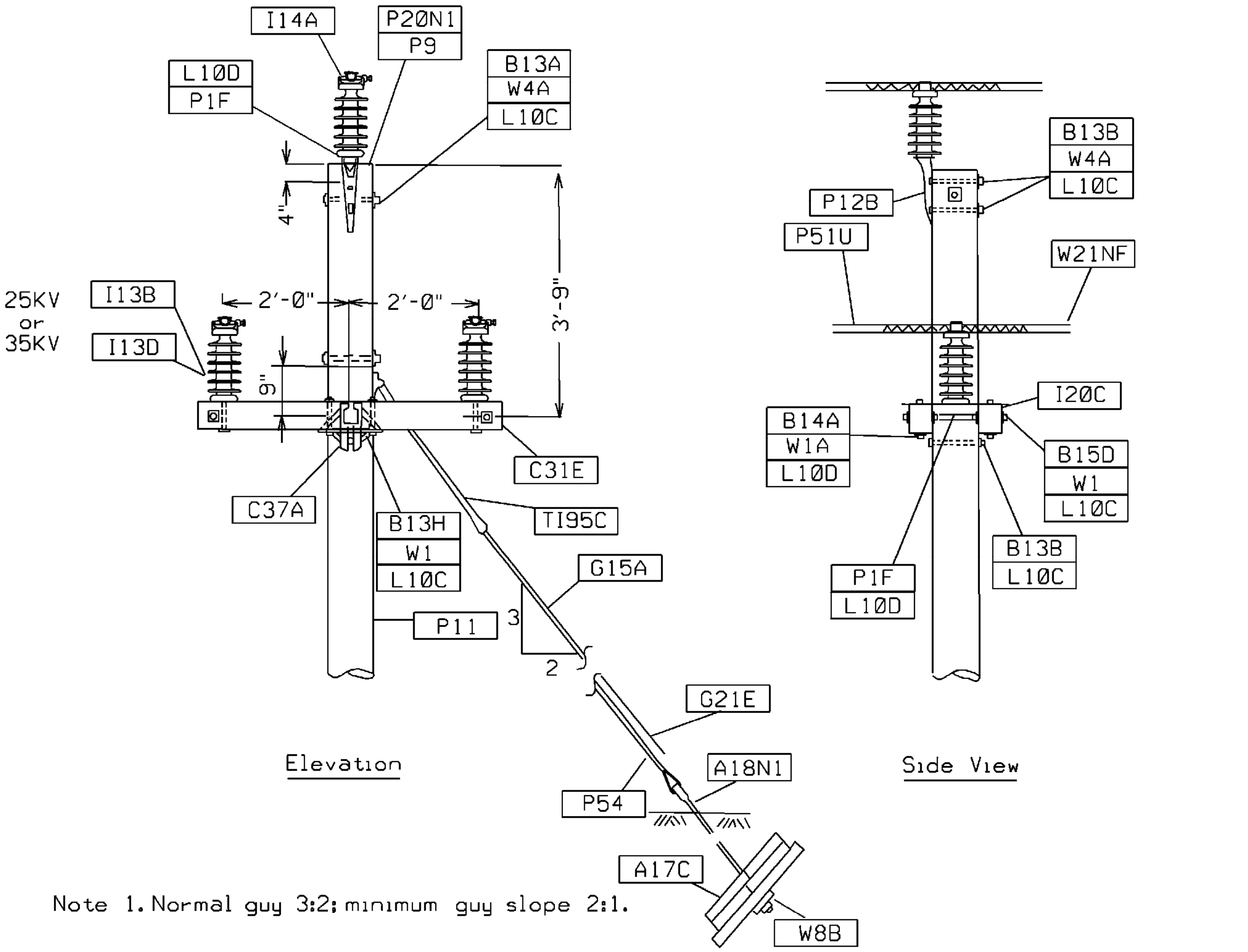
Note: This drawing is for 795 kcmil, however it can be used for 1113 kcmil with the following component changes:

P51V replaces P51U
I14B replaces I14A
W21NG replaces W21NF

4 FOOT TRIANGLE, DOUBLE ARM, SINGLE INSULATOR, DASI-3 FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 21-101	ISSUE 1/06

 Doc. # ST. 21.00.002

MU = @CS144027NE	4'Tri DA Sing-Ins 25kV 795 ACSR
MU = @CS144037NE	4'Tri DA Sing-Ins 35kV 795 ACSR
MU = @CS145021NE	4'Tri DA Sing-Ins 25kV 1113 ACSR
MU = @CS145031NE	4'Tri DA Sing-Ins 35kV 1113 ACSR
MU = @13MPA35K4TNE	Down Guy



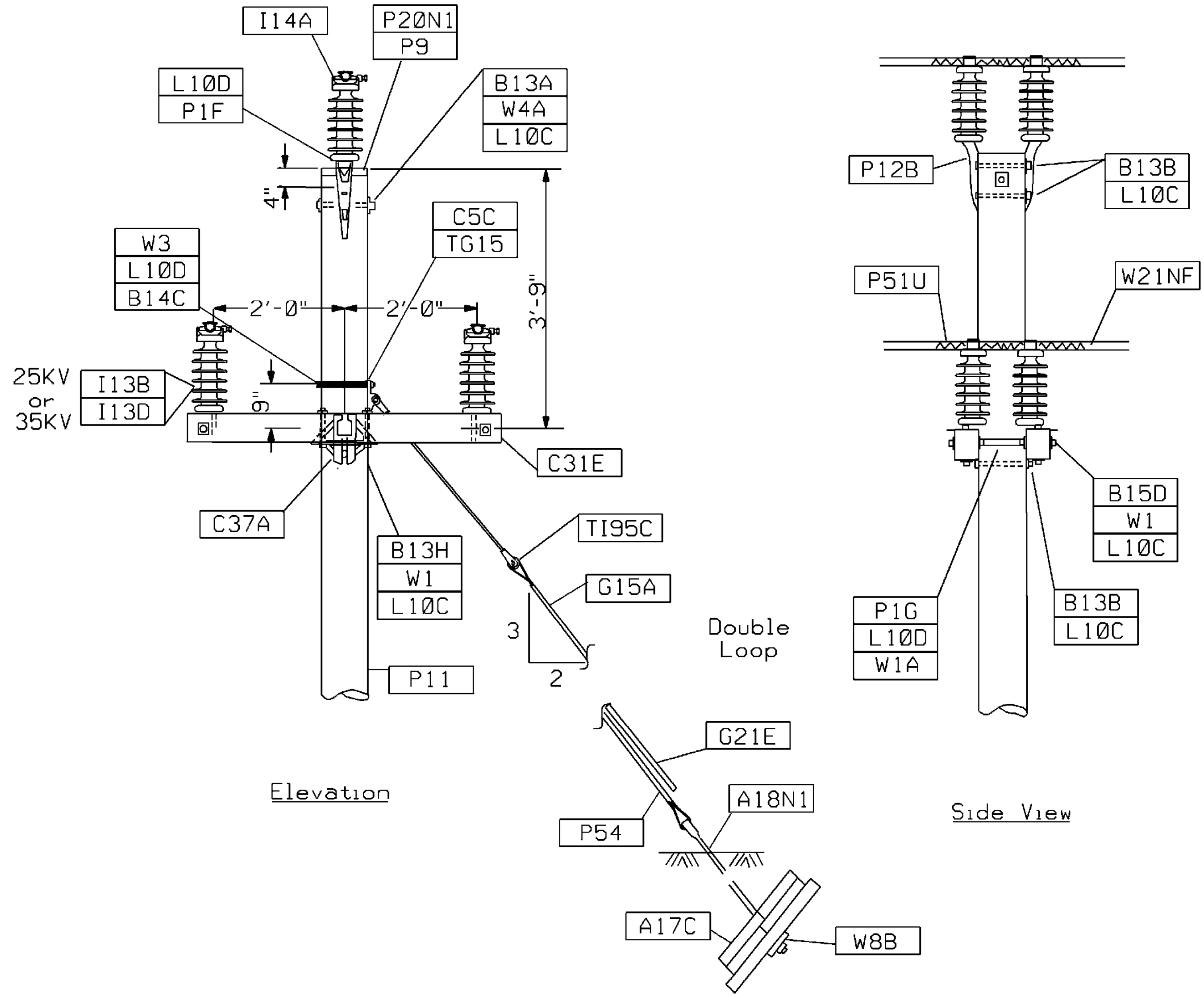
Note: This drawing is for 795 kcmil, however it can be used for 1113 kcmil with the following component changes:

P15V replaces P51U
I14B replaces I14A
W21NG replaces W21NF

4 FOOT TRIANGLE, DOUBLE ARM, SINGLE INSULATOR, DASI-6
FOR 795 KCMIL AND 1113 KCMIL 15-35 KV

ISSUE	PAGE NUMBER		
1/06	21-102	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @CS144227NE	4'Tri DA Doub-Ins 25kV 795 ACSR
MU = @CS144237NE	4'Tri DA Doub-Ins 35kV 795 ACSR
MU = @CS145221NE	4'Tri DA Doub-Ins 25kV 1113 ACSR
MU = @CS145231NE	4'Tri DA Doub-Ins 35kV 1113 ACSR
MU = @13MPA35K4TNE	Down Guy



Note 1. Normal guy 3:2; minimum guy slope 2:1

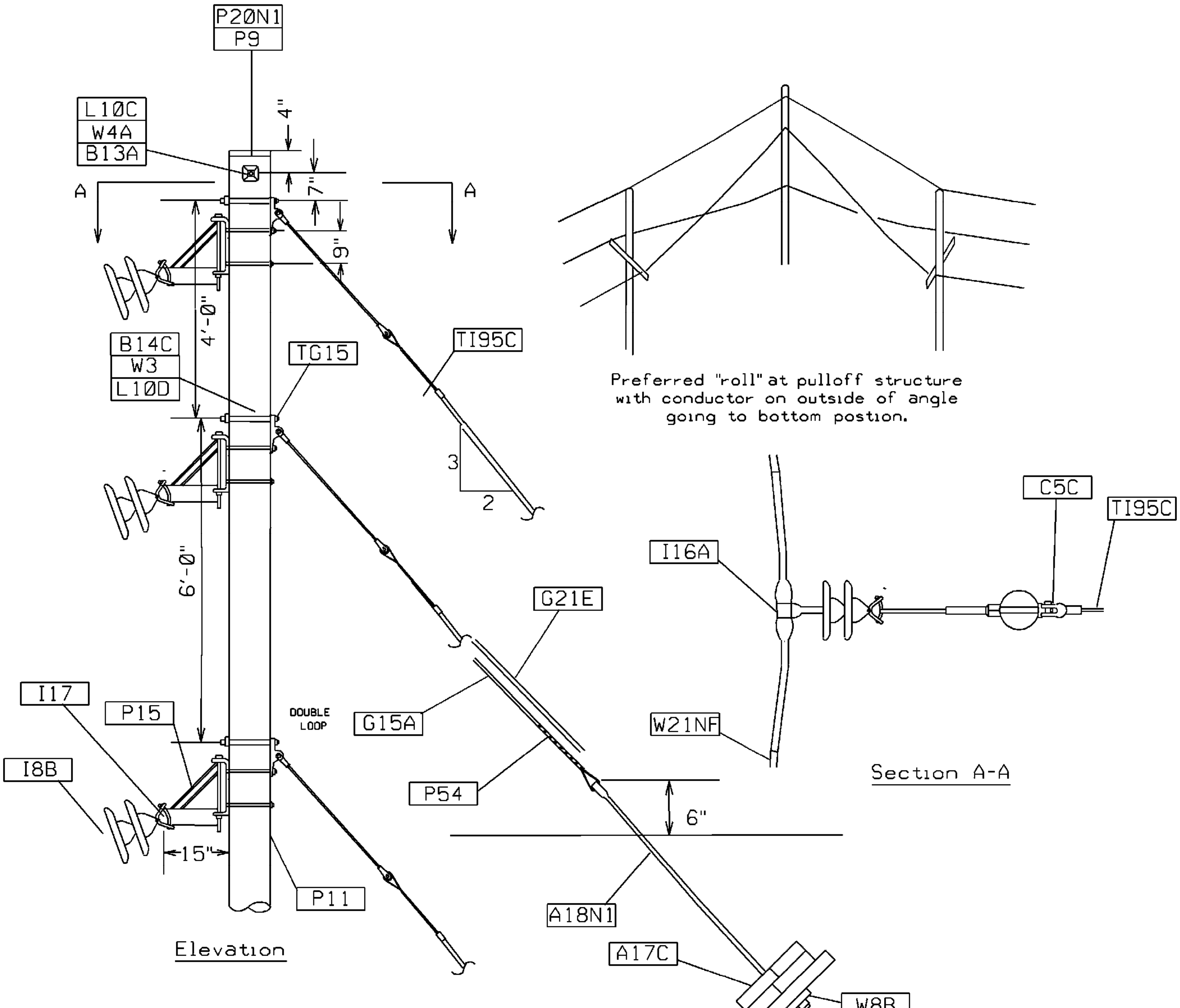
Note This drawing is for 795 kcmil, however it can be used for 1113 kcmil with the following component changes:

P15V replaces P51U
I14B replaces I14A
W21NG replaces W21NF

4 FOOT TRIANGLE, DOUBLE ARM, DOUBLE INSULATOR, DADI-15 FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 21-103	ISSUE 1/06

 Doc. # ST. 21.00.002

MU = @CS144327NE	Suspension Pulloff 1 Unit 25kV 795 ACSR
MU = @CS144337NE	Suspension Pulloff 1 Unit 35kV 795 ACSR
MU = @CS145321NE	Suspension Pulloff 1 Unit 25kV 1113 ACSR
MU = @CS145331NE	Suspension Pulloff 1 Unit 35kV 1113 ACSR
MU = @13MPA35KDETPNE	Down Guy - Top
MU = @13MPA35KDECPNE	Down Guy - Center
MU = @13MPA35KDELPNE	Down Guy - Lower



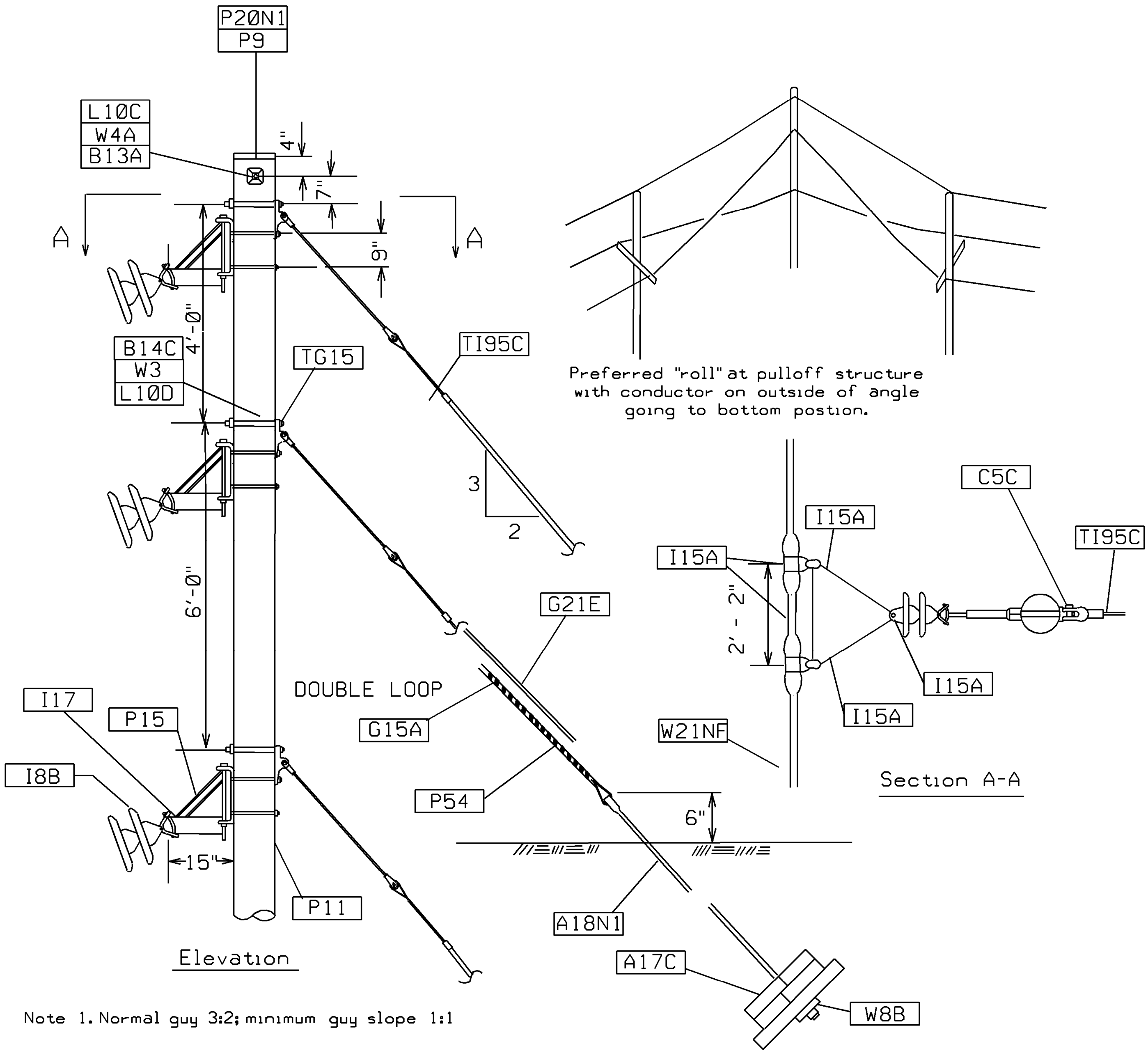
Note 1. Normal guy 3:2; minimum guy slope 2:1

Note: This drawing is for 795 kcmil, however it can be used for 113kcmil with the following component changes:

I16B replaces I16A
W21NG replaces W21NF

SUSPENSION PULLOFF, SINGLE AGS UNIT, SPO-30 FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
ISSUE	**PAGE NUMBER**	**OVERHEAD CONSTRUCTION STANDARD**	Liberty Utilities
1/06	**21-104**		

MU = @CS144427NE	Suspension Pulloff 2 Unit 25kV 795 ACSR
MU = @CS144437NE	Suspension Pulloff 2 Unit 35kV 795 ACSR
MU = @CS145421NE	Suspension Pulloff 2 Unit 25kV 1113 ACSR
MU = @CS145431NE	Suspension Pulloff 2 Unit 35kV 1113 ACSR
MU = @13MPA35KDETPNE	Down Guy - Top
MU = @13MPA35KDECPNE	Down Guy - Center
MU = @13MPA35KDELPNE	Down Guy - Lower



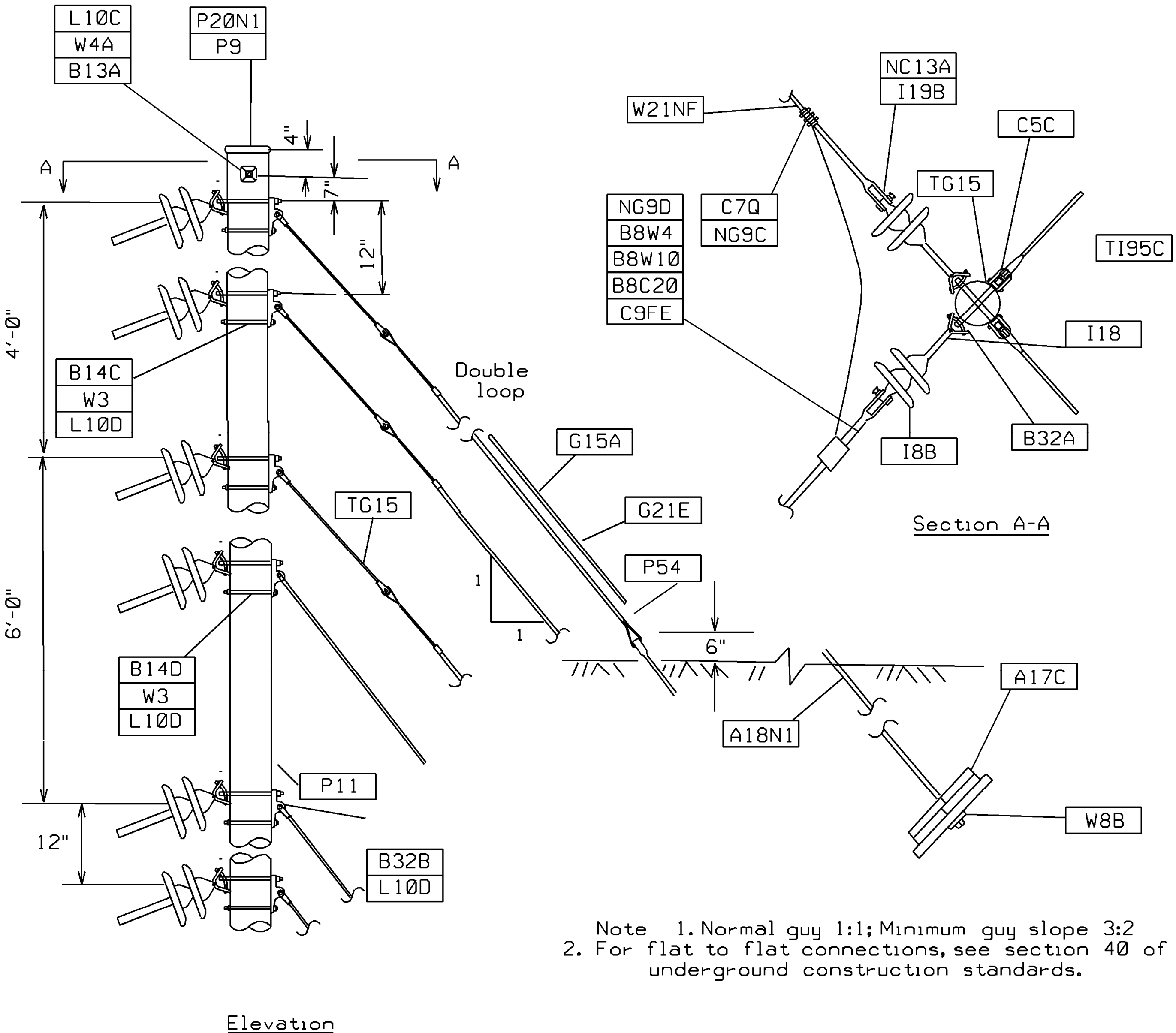
Note 1. Normal guy 3:2; minimum guy slope 1:1

Note: This drawing is for 795 kcmil, however it can be used for 113kcmil with the following component changes:

I16B replaces I16A
W21NG replaces W21NF

SUSPENSION PULLOFF, DOUBLE AGS UNIT, SPO-60 FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 21-105	ISSUE 1/06

MU = @CS144527NE	Deadend Pulloff 25kV 795 ACSR
MU = @CS144537NE	Deadend Pulloff 35kV 795 ACSR
MU = @CS145521NE	Deadend Pulloff 25kV 1113 ACSR
MU = @CS145531NE	Deadend Pulloff 35kV 1113 ACSR
MU = @13MPA35KDETPNE	Down Guy - Top
MU = @13MPA35KDECPNE	Down Guy - Center
MU = @13MPA35KDELPNE	Down Guy - Lower



Note 1. Normal guy 1:1; Minimum guy slope 3:2
2. For flat to flat connections, see section 40 of underground construction standards.

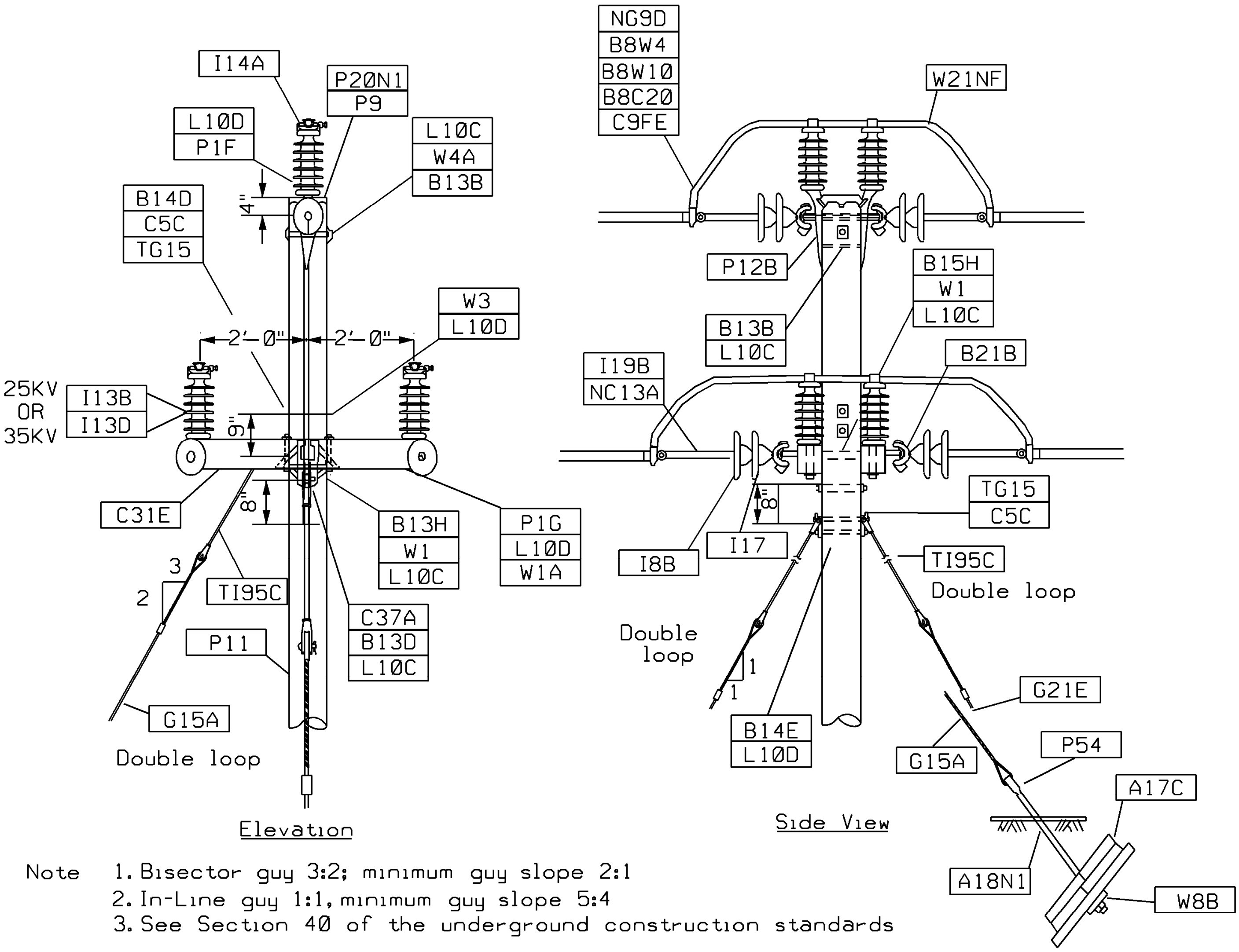
Note: This Drawing is for 795 kcmil, however it can be used for 1113 kcmil with the following component changes:

NC13C replaces NC13A
C9FF replaces C9FE
W21NG replaces W21NF

DEADEND PULLOFF, DEPO-90 FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
ISSUE	PAGE NUMBER		
1/06	21-106	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Doc. # ST. 21.00.002

MU = @CS144627NE	4 foot Tri Sin Pole DE Ten CH 25kV 795 ACSR
MU = @CS144637NE	4 foot Tri Sin Pole DE Ten CH 35kV 795 ACSR
MU = @CS144621NE	4 foot Tri Sin Pole DE Ten CH 25kV 1113 ACSR
MU = @CS144631NE	4 foot Tri Sin Pole DE Ten CH 35kV 1113 ACSR
MU = @213MPA35KBTBNE	Down Guy (2-13M Back to Back)
MU = @13MPA35K4TNE	Down Guy Angle (If Required)



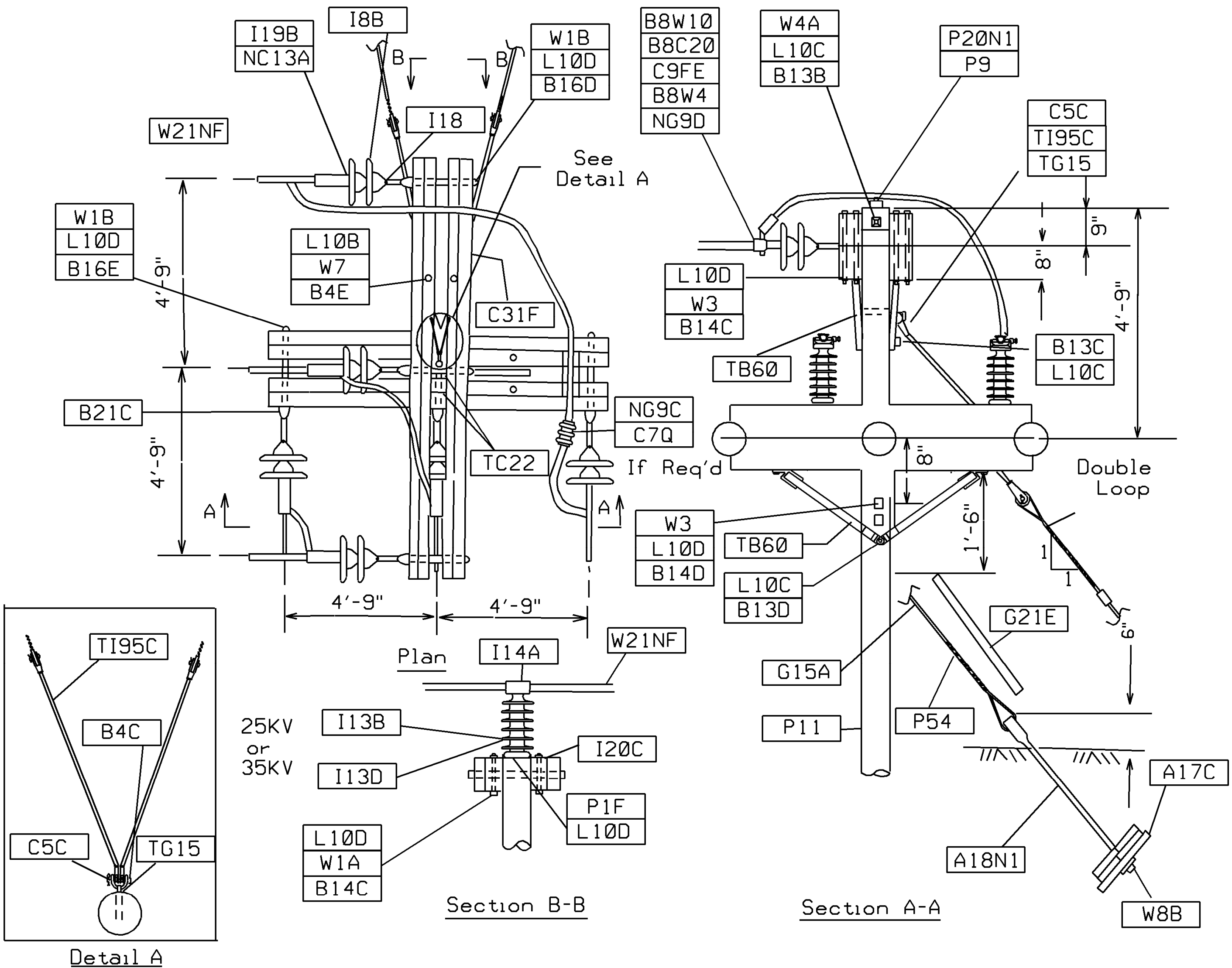
Note 1. Bisector guy 3:2; minimum guy slope 2:1
2. In-Line guy 1:1, minimum guy slope 5:4
3. See Section 40 of the underground construction standards

Note: This drawing is for 795 kcmil, however it can be used for 1113 kcmil with the following component changes

NC13C replaces NC13A
C9FF replaces C9FE
W21NG replaces W21NF

4 FOOT TRIANGLE, SINGLE POLE DEADEND, TENSION CHANGE, SPDE-22 FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 21-107	ISSUE: 1/06

MU = @CS144727NE	Buckarm DE Single Pole Ten RD 25kV 795 ACSR
MU = @CS144737NE	Buckarm DE Single Pole Ten RD 35kV 795 ACSR
MU = @CS145721NE	Buckarm DE Single Pole Ten RD 25kV 1113 ACSR
MU = @CS145731NE	Buckarm DE Single Pole Ten RD 35kV 1113 ACSR
MU = @D13MPA35KBADENE	Down Guy (Buckarm Deadend)
MU = @13MPA35K4TNE	Down Guy



Note: This Drawing is for 795 kcmil, however it can be used for 113 kcmil with the following component changes:

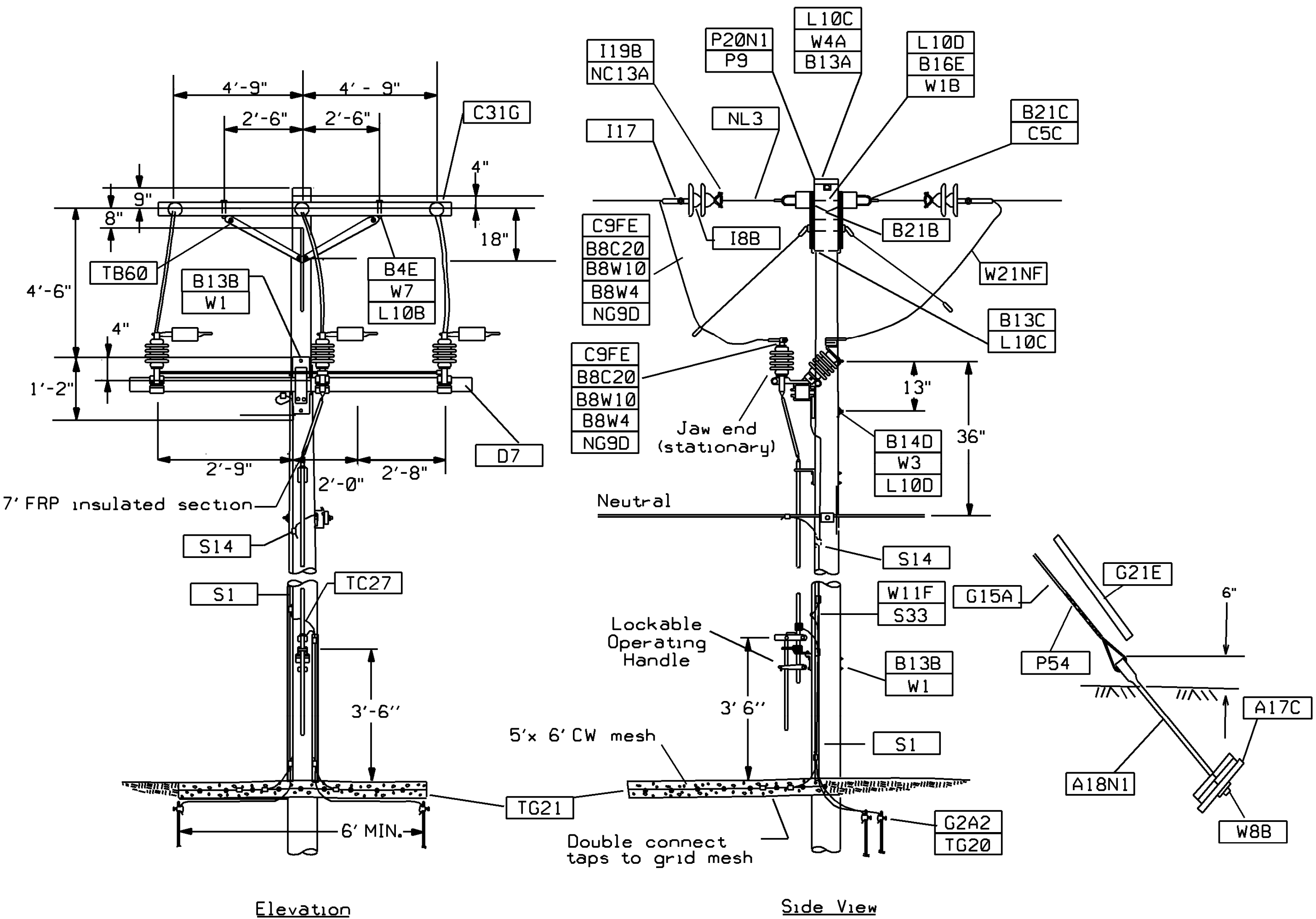
C7R replaces C7Q
C9FF replaces C9FE
W21NG replaces W21NF

BUCKARM DEADEND, SINGLE POLE, TENSION REDUCED – BADE
FOR 795 KCMIL AND 1113 KCMIL 15-35 KV

ISSUE	PAGE NUMBER		
1/06	21-108	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Doc. # ST. 21.00.002

MU = @CS1448237NE	Loadbreak Switch 795 ACSR
MU = @CS1448231NE	Loadbreak Switch 1113 ACSR
MU = @213MPA35KBTBNE	Down Guy (2-13M Back to Back)
MU = @13MPA35K4TNE	Down Guy Angle (If Required)

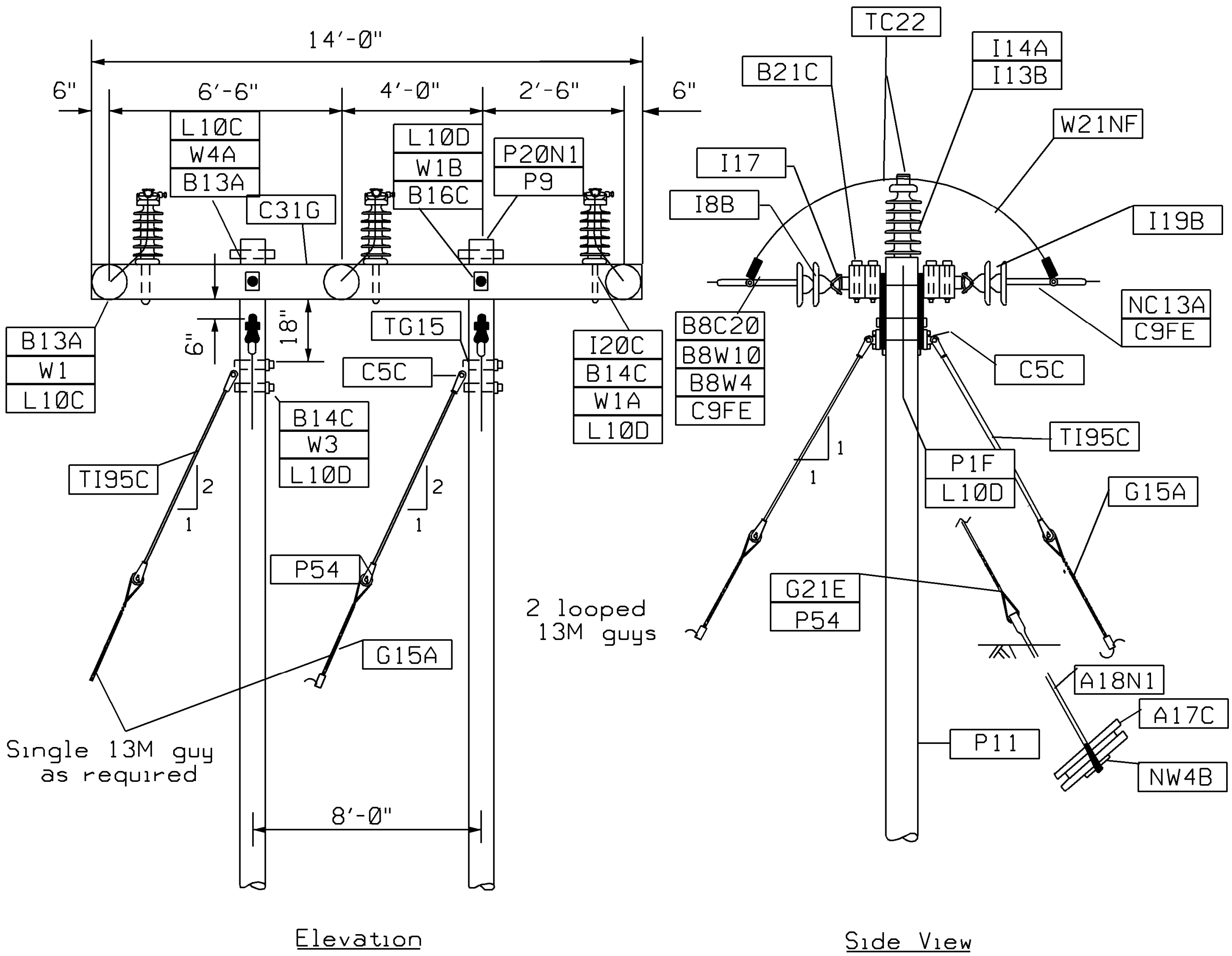


Note: This Drawing is for 795 kcmil, however it can be used for 1113 kcmil
with the following component changes:

NC13C replaces NC13A
C9FF replaces C9FE

LOADBREAK SWITCH FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		21-109	1/06

MU = @21-11325KVC795	2 Pole Highway Crossing 25kV 795 ACSR
MU = @21-11335KVC795	2 Pole Highway Crossing 35kV 795 ACSR
MU = @21-11325KVC1113	2 Pole Highway Crossing 25kV 1113 ACSR
MU = @21-11335KVC1113	2 Pole Highway Crossing 1113 ACSR
MU = @213MPA35KBTBNE	Down Guy (2-13M Back to Back) With 2 – Plank Anchors
MU = @13MPA35K4TNE	13M Down Guy Angle (If Required) With Plank Anchor



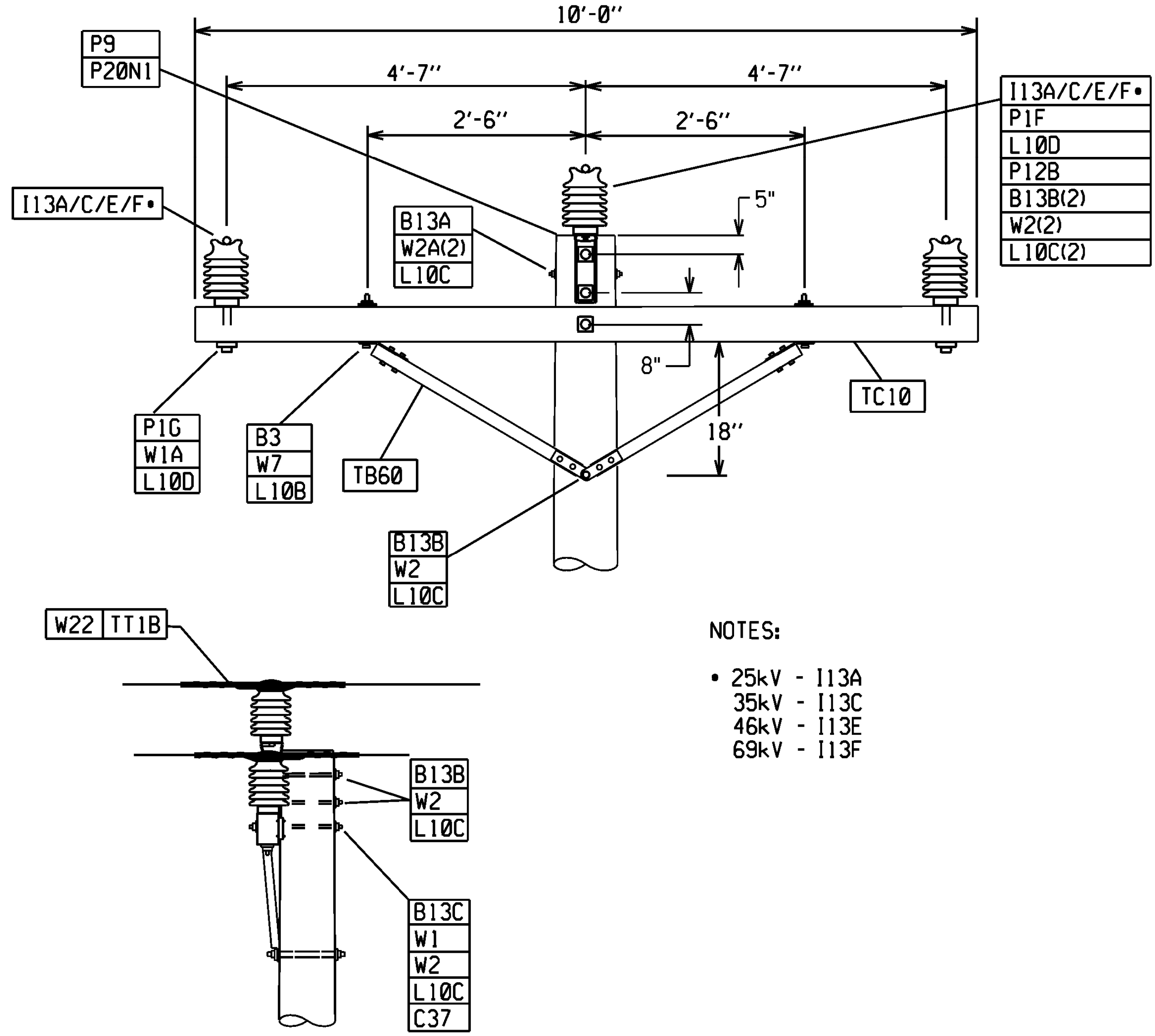
Elevation

Side View

Note: This drawing is for 795 kcmil, however it can be used for 1113 kcmil with the following component changes:

NC13C replaces NC13A
C9FF replaces C9FE
W21NG replaces W21NF

TWO POLE HIGHWAY CROSSING STRUCTURE FOR 795 KCMIL AND 1113 KCMIL 15-35 KV			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
1/06	21-113		

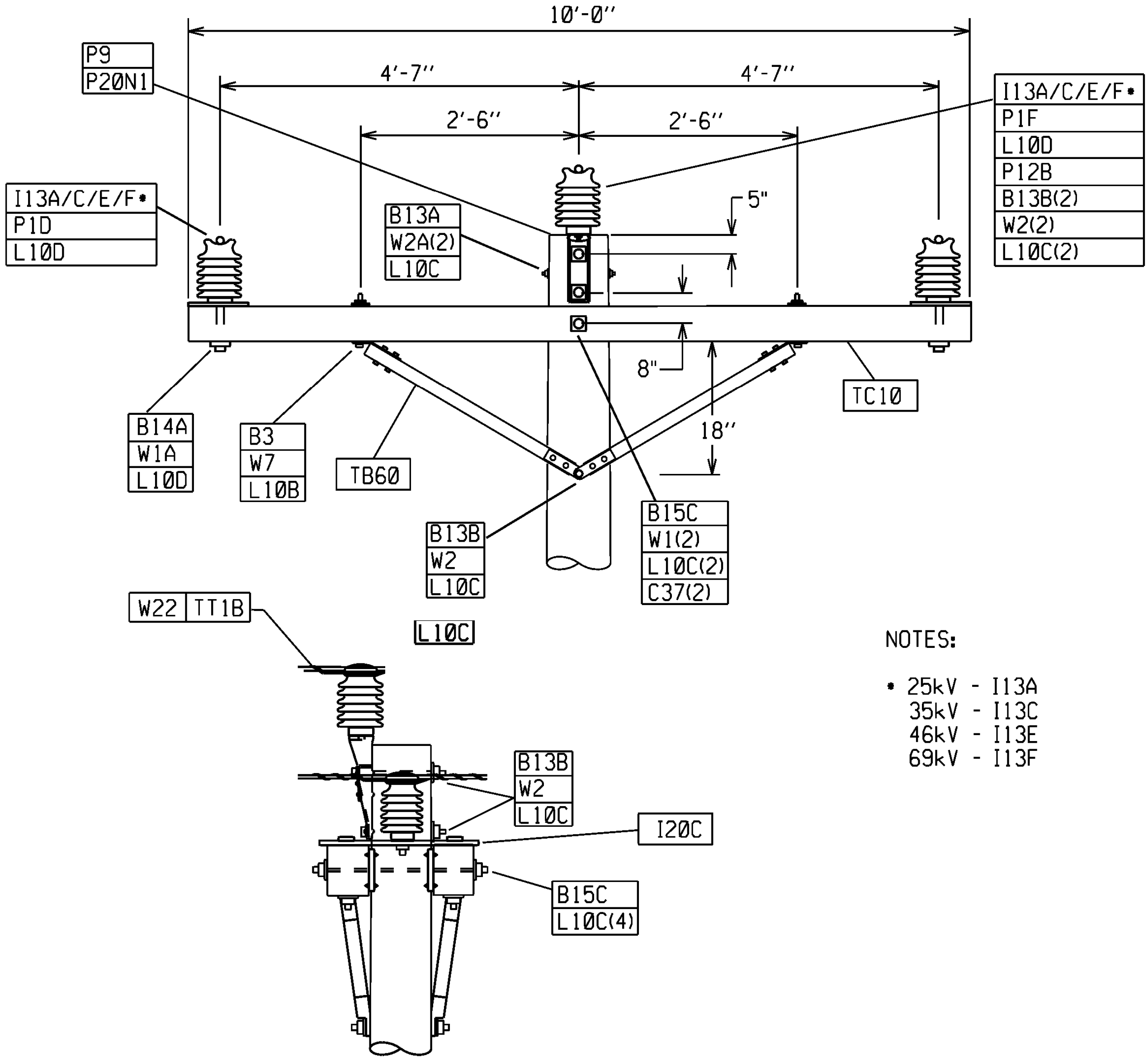


NOTES:

- 25kV - I13A
  35kV - I13C
  46kV - I13E
  69kV - I13F

25kV, 35kV, 46kV & 69kV --- 0 - 2 Degree Line Angle --- Flat			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 21 - 211	ISSUE: 7/12

 | Doc. # ST. 21.00.003

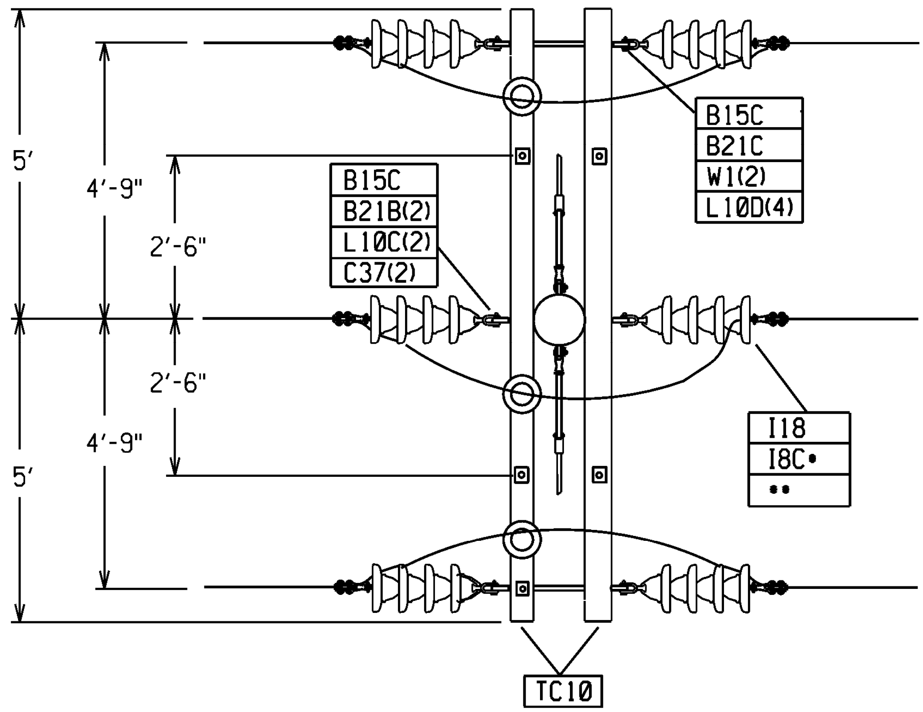


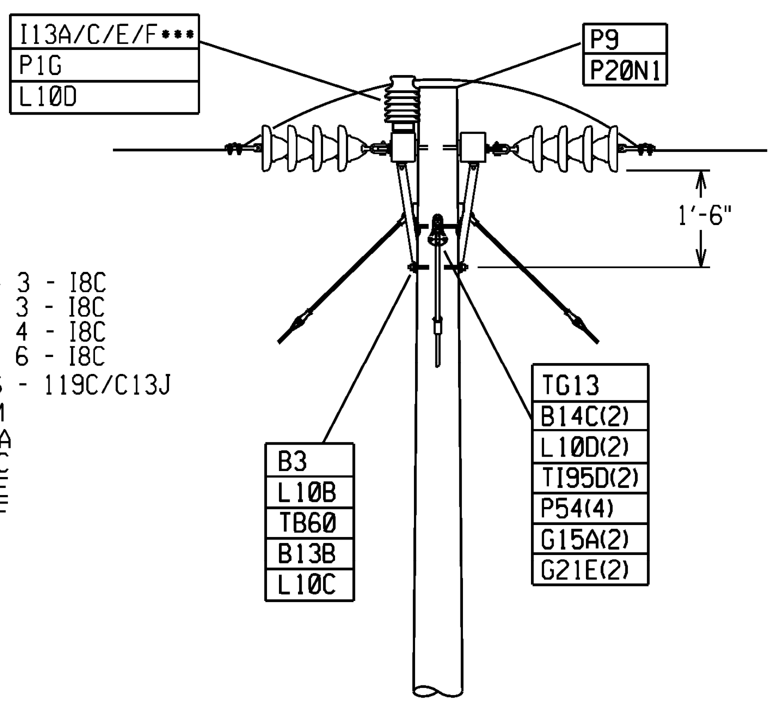
NOTES:

• 25kV - I13A
35kV - I13C
46kV - I13E
69kV - I13F

25kV, 35kV, 46kV & 69kV --- 0 - 2 Degree Line Angle --- Flat – Double Crossarm

ISSUE	PAGE NUMBER		
7/12	21-217	OVERHEAD SUB-TRANSMISSION CONSTRUCTION STANDARD	Liberty Utilities



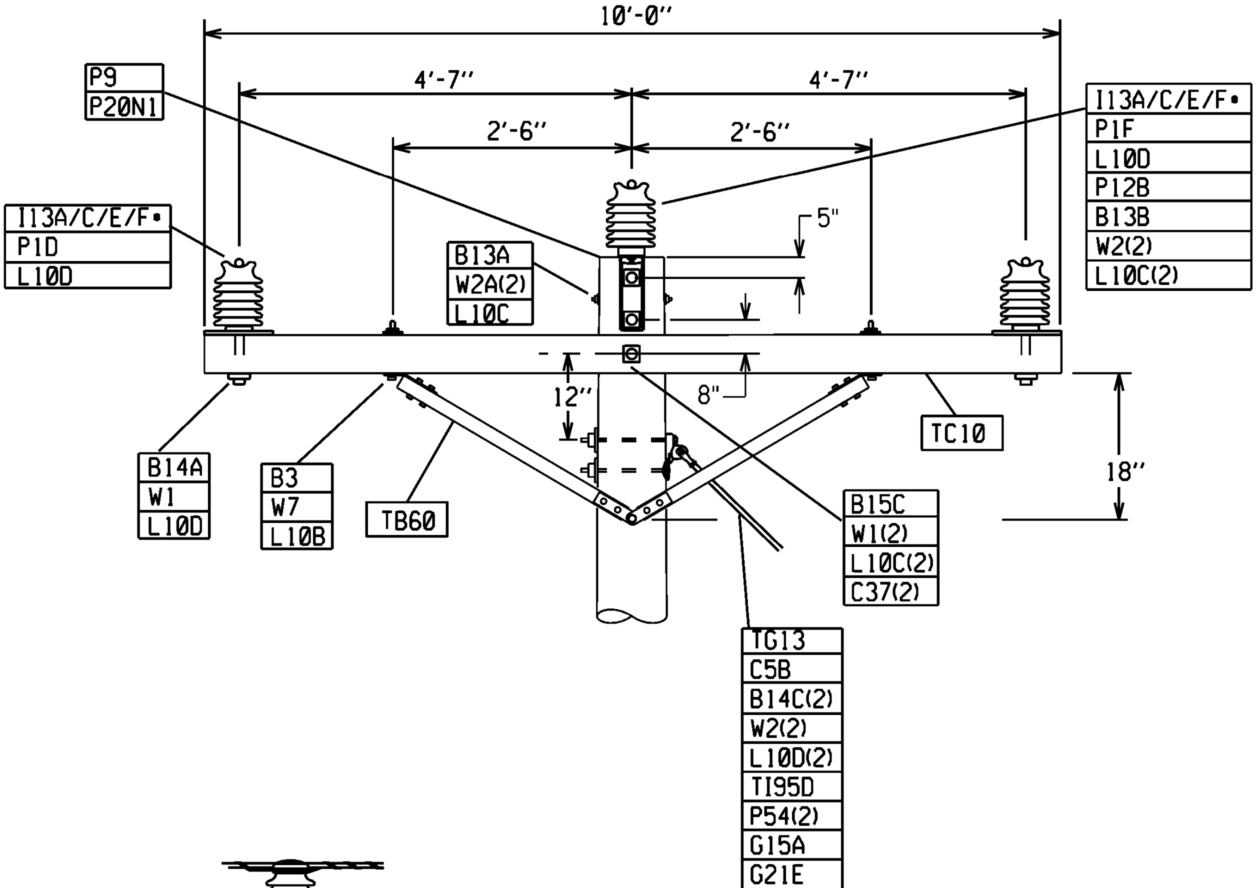


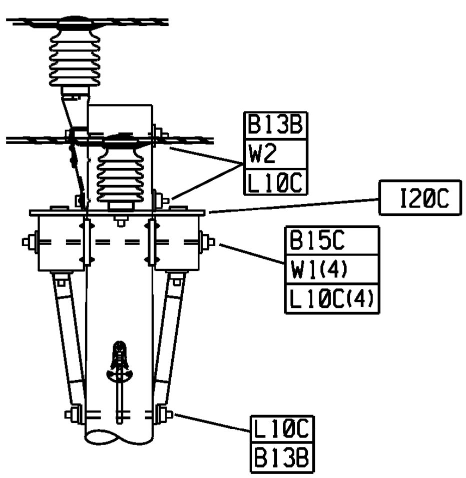
NOTES:

- • 25kV - Use 3 - I8C
  35kV - Use 3 - I8C
  46kV - Use 4 - I8C
  69kV - Use 6 - I8C
- ••1/0 or 336 - 119C/C13J
  477 - C13M
- ••• 25kV - I13A
  35kV - I13C
  46kV - I13E
  69kV - I13F

25kV, 35kV, 46kV & 69kV --- Tension / Wire Change --- Flat

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		21 - 218	7/12



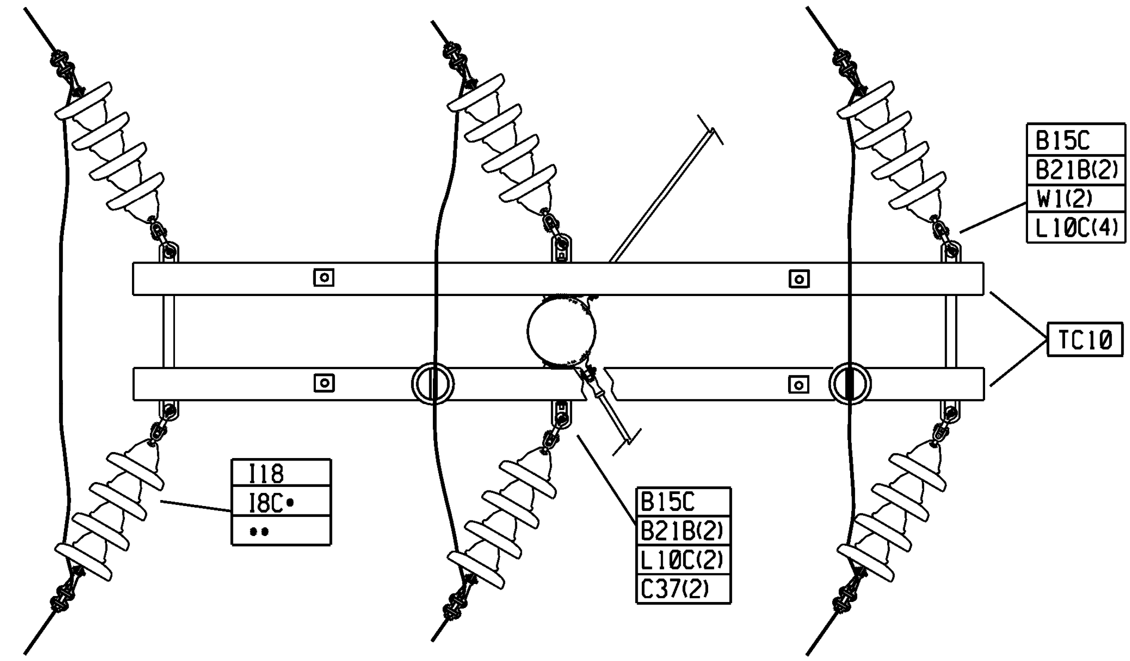


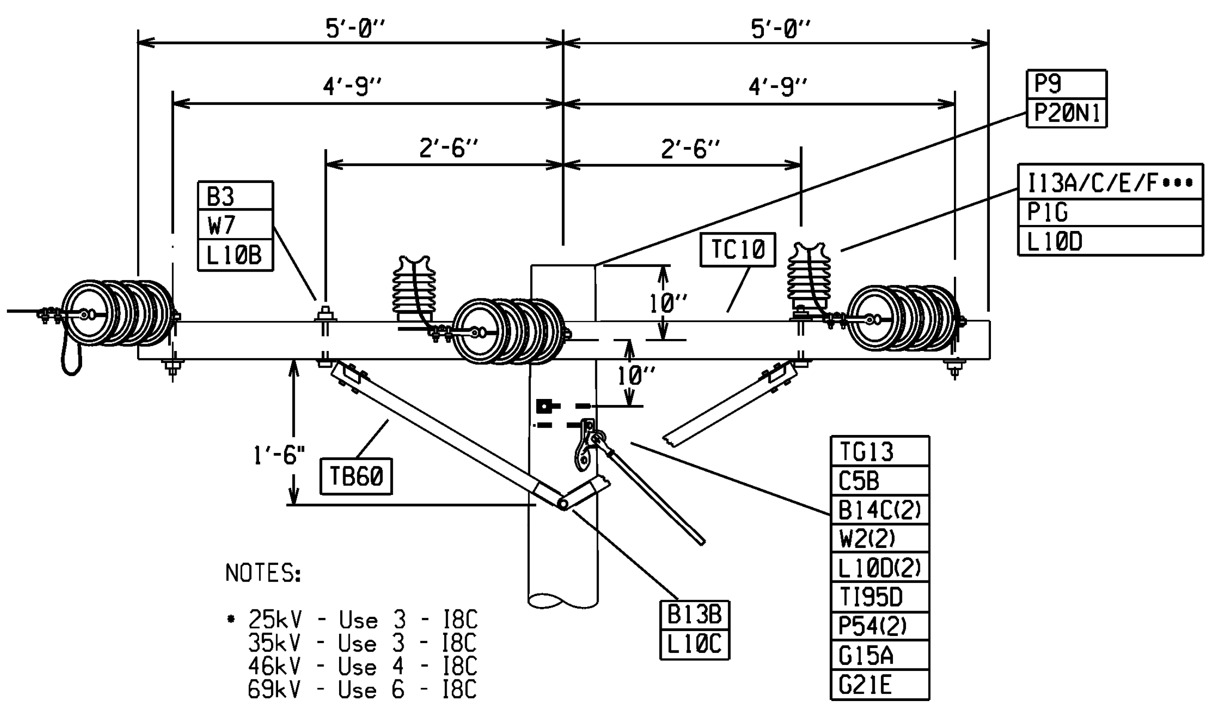
NOTES:

• 25kV - I13A
35kV - I13C
46kV - I13E
69kV - I13F

25kV, 35kV, 46kV & 69kV --- 3 - 8 Degree Line Angle --- Flat

ISSUE	PAGE NUMBER		
7/12	21-220	OVERHEAD SUB-TRANSMISSION CONSTRUCTION STANDARD	Liberty Utilities





NOTES:

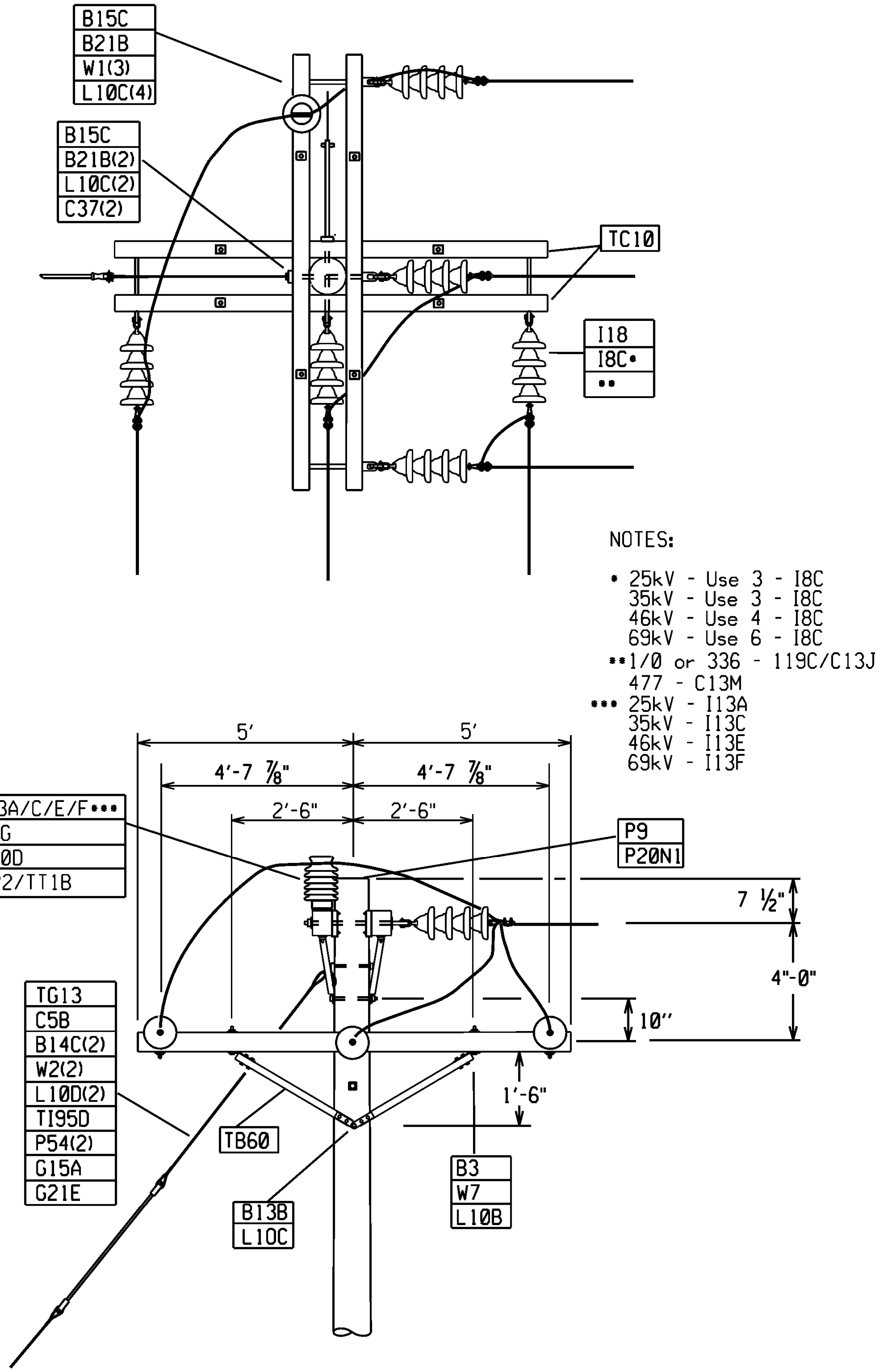
* 25kV - Use 3 - I8C
35kV - Use 3 - I8C
46kV - Use 4 - I8C
69kV - Use 6 - I8C

**1/0 or 336 - 119C/C13J
477 - C13M

*** 25kV - I13A
35kV - I13C
46kV - I13E
69kV - I13F

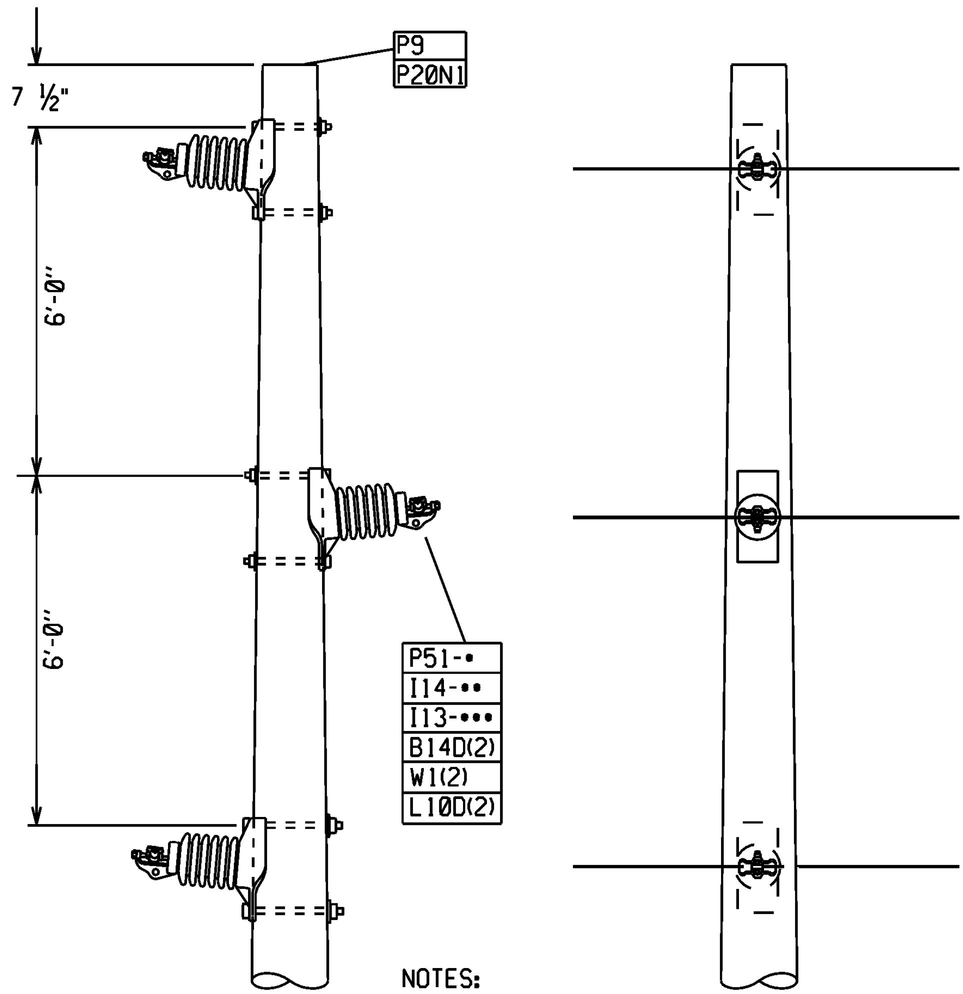
25kV, 35kV, 46kV & 69kV --- 1 - 60 Degree Line Angle --- Flat

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	21 - 222	7/12



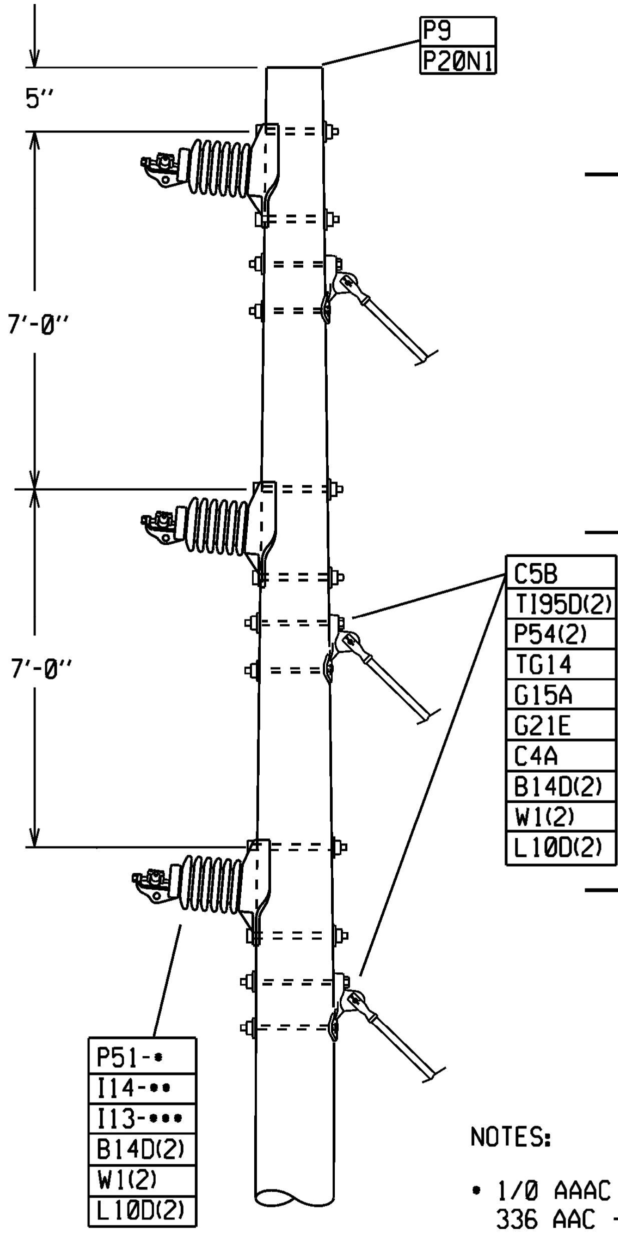
25kV, 35kV, 46kV & 69kV --- 61 – 90 Degree Line Angle --- Flat

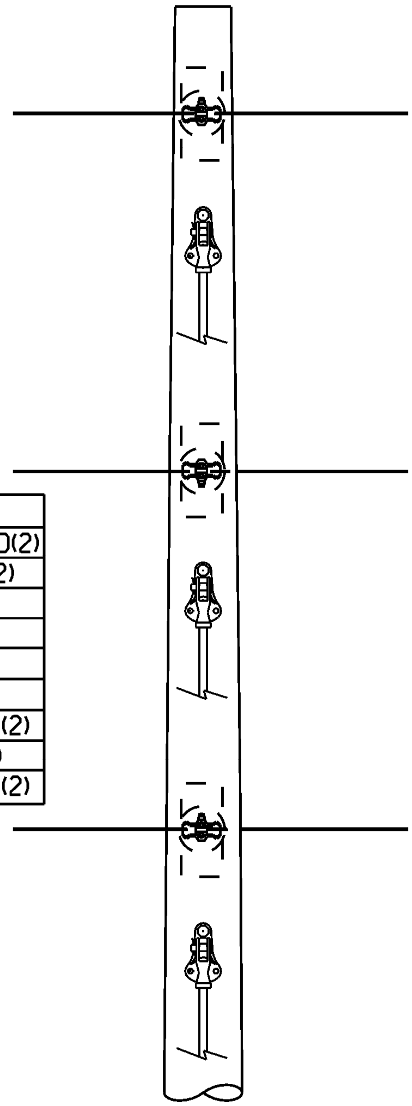
ISSUE	PAGE NUMBER	OVERHEAD SUB-TRANSMISSION CONSTRUCTION STANDARD	Liberty Utilities
7/12	21-223		



NOTES:

- • 1/0 AAAC - P51C
  336 AAC - P51E (3506741)
  336 ACSR -P51G
  477 AAC - P51H (5989461)
  477 ACSR - P51J (5989463)
  795 AAC - P51K
  795 ACSR - P51U
  1113 ACSR - P51V
- •• 1/0 AAAC - I14C
  336 AAC/ACSR - I14E
  477 AAC/ACSR - I14F
  795 AAC - I14F
  795 ACSR - I14H
  1113 - I14H
- •• 46kV - I13J (2021977)
  69kV - I13K (2021976)





NOTES:

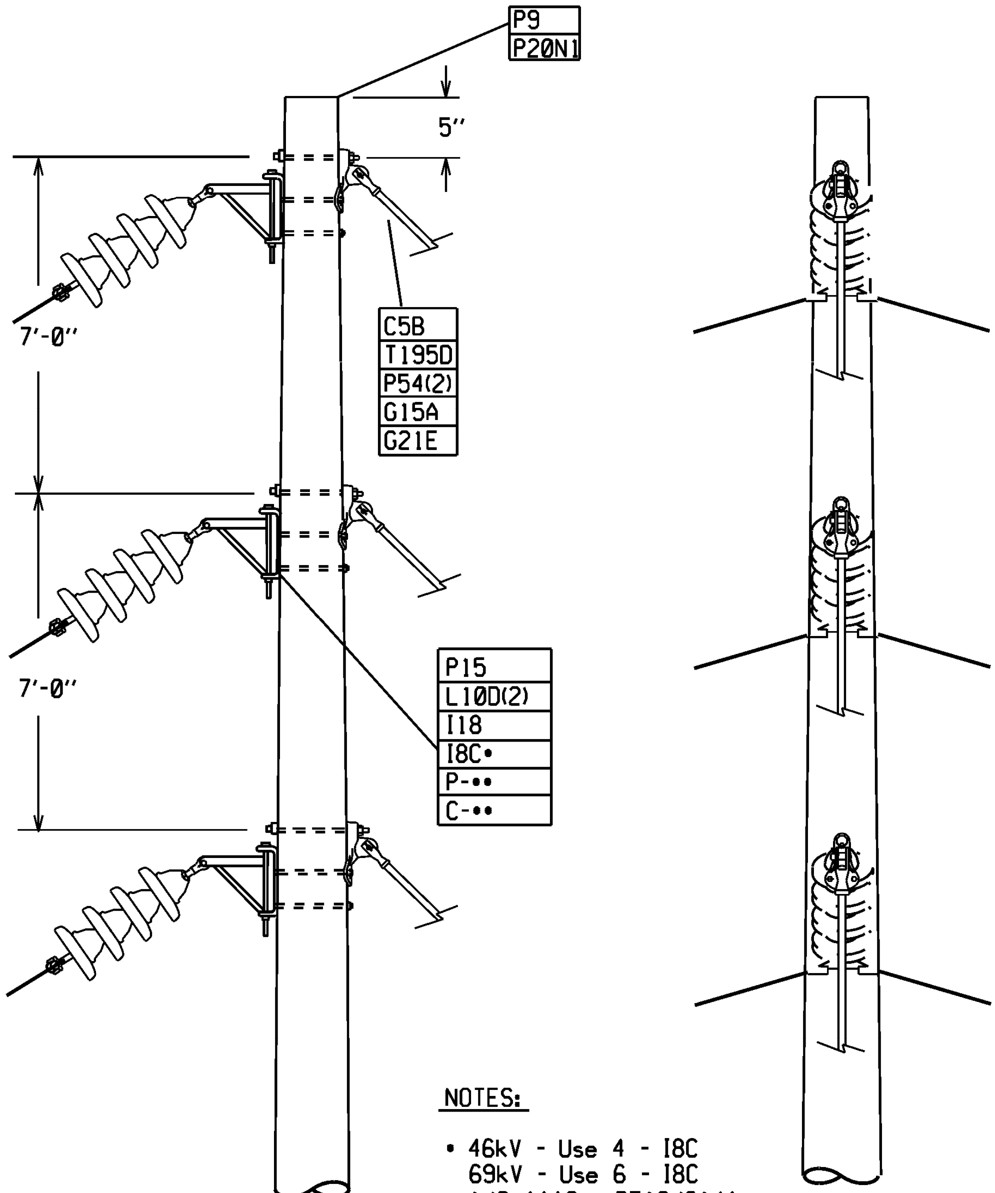
• 1/0 AAAC - P51C
336 AAC - P51E (3506741)
336 ACSR -P51G
477 AAC - P51H (5989461)
477 ACSR - P51J (5989463)
795 AAC - P51K
795 ACSR - P51U
1113 ACSR - P51V

•• 1/0 AAAC - I14C
336 AAC/ACSR - I14E
477 AAC/ACSR - I14F
795 AAC - I14F
795 ACSR - I14H
1113 - I14H

•• 46kV - I13J (2021977)
69kV - I13K (2021976)

46kV & 69kV --- 3 - 15 Degree Line Angle --- Vertical

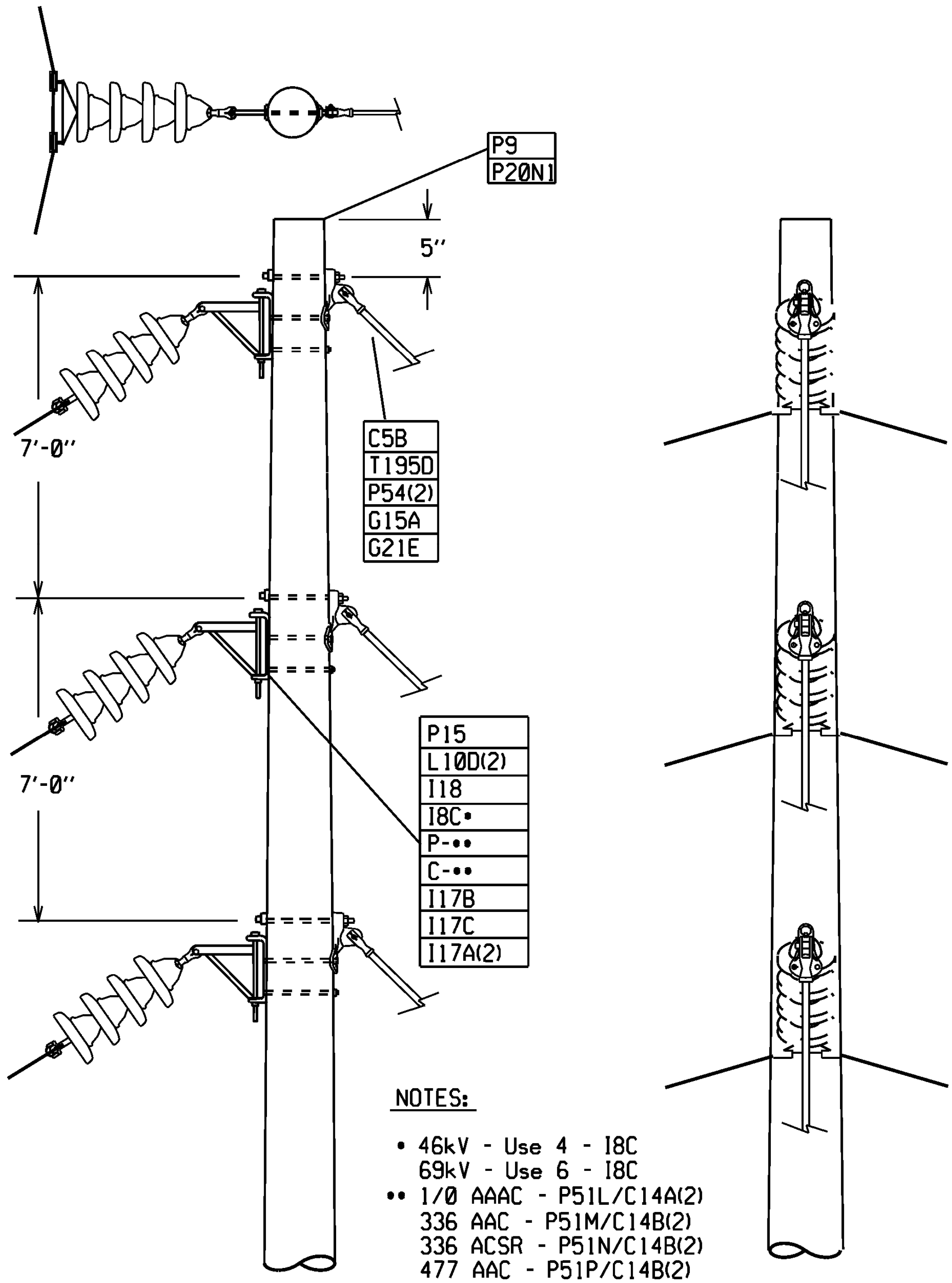
ISSUE	PAGE NUMBER		
7/12	21-226	OVERHEAD SUB-TRANSMISSION CONSTRUCTION STANDARD	Liberty Utilities



NOTES:

- • 46kV - Use 4 - I8C
  69kV - Use 6 - I8C
- •• 1/0 AAAC - P51C/C14A
  336 AAC - P51E/C14B
  336 ACSR - P51G/C14B
  477 AAC - P51H/C14B
  477 ACSR - P51J/C14B
  795 AAC - P51K/C14C
  795 ACSR - I16A
  1113 ACSR - I16B

46kV & 69kV --- 16 - 30 Degree Line Angle --- Vertical

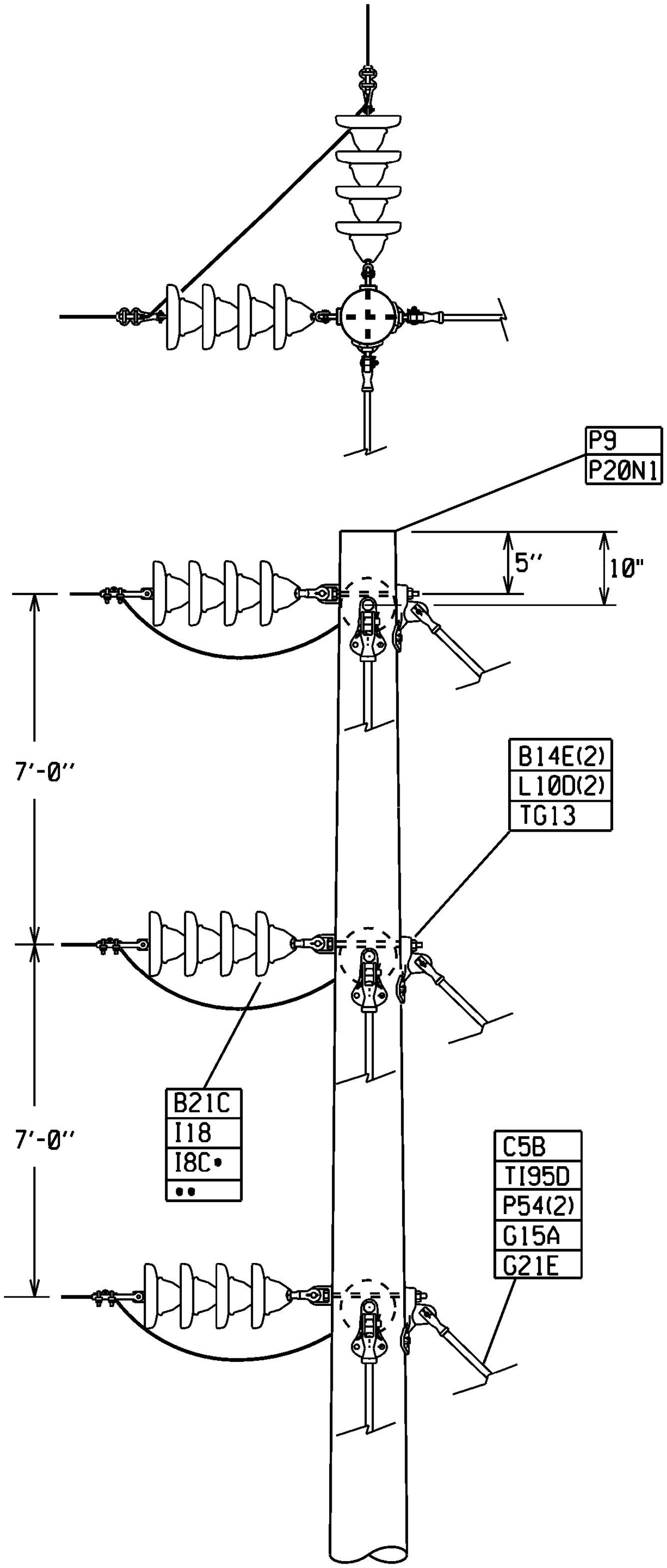


NOTES:

• 46kV - Use 4 - I8C
  69kV - Use 6 - I8C
•• 1/0 AAAC - P51L/C14A(2)
  336 AAC - P51M/C14B(2)
  336 ACSR - P51N/C14B(2)
  477 AAC - P51P/C14B(2)
  477 ACSR - P51Q/C14B(2)
  795 AAC - P51R/C14C(2)
  795 ACSR - I15A
  1113 ACSR - I15B

46kV & 69kV --- 31 - 60 Degree Line Angle --- Vertical

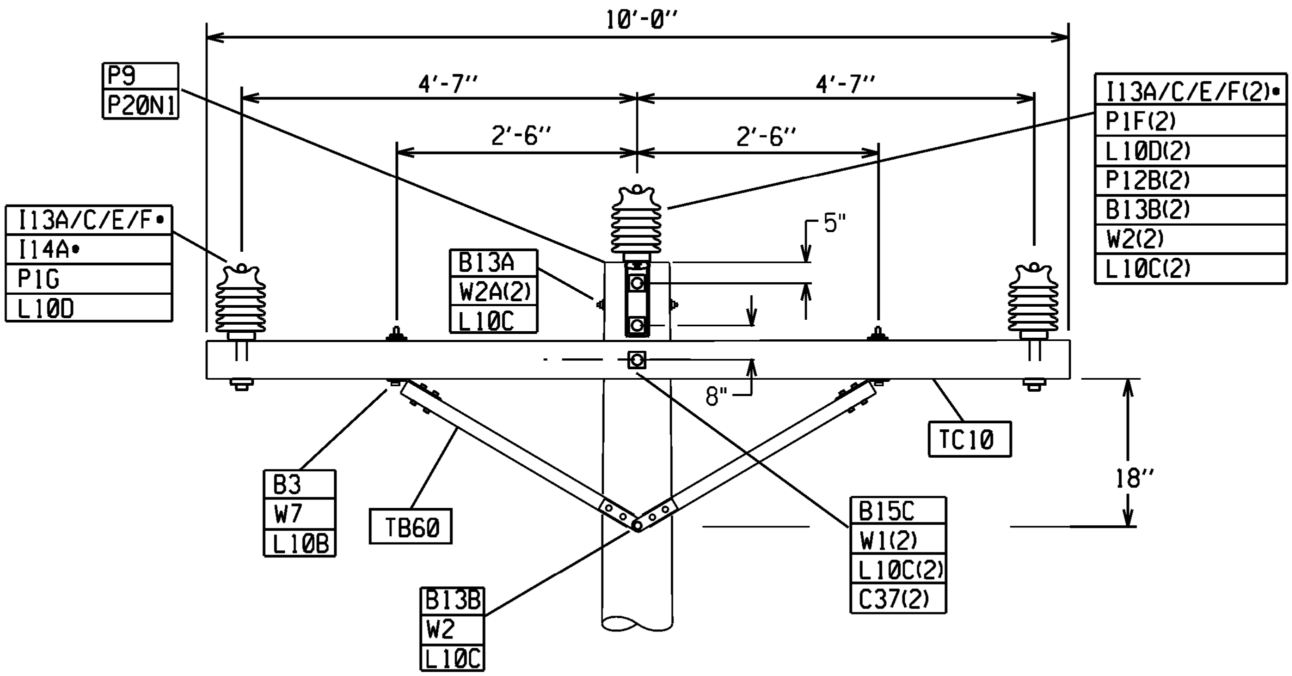
ISSUE	PAGE NUMBER		
7/12	21-229	OVERHEAD SUB-TRANSMISSION CONSTRUCTION STANDARD	Liberty Utilities

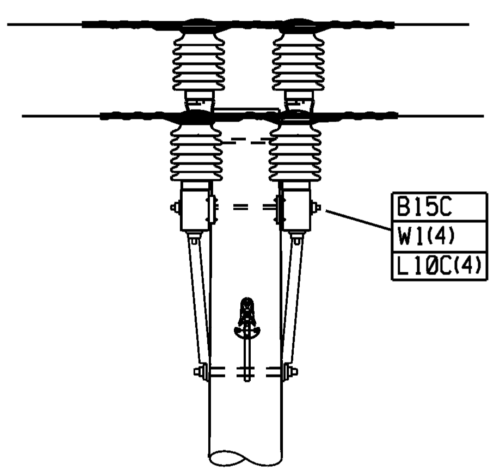


NOTES:

• 46kV - Use 4 - I8C
  69kV - Use 6 - I8C
•• 1/0 AAAC - I19C/C13J
  336 AAC - I19C/C13J
  336 ACSR - I19C/C13J
  477 AAC - C13M
  477 ACSR - C13M
  795 AAC - C13M
  795 ACSR - I19B/NC13A
  1113 ACSR - I19B/NC13C

46kV & 69kV --- 61 - 90 Degree Line Angle --- Vertical			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER: 21 - 230	ISSUE: 7/12





NOTES:

- 25kV - I13A
  35kV - I13C
  46kV - I13E
  69kV - I13F

25kV, 35kV, 46kV & 69kV --- 0 - 2 Degree Line Angle --- Flat			
ISSUE	PAGE NUMBER	OVERHEAD SUB-TRANSMISSION CONSTRUCTION STANDARD	Liberty Utilities
7/11	21-236		

Standard Overhead Sub-Transmission Conductors

 Doc. # ST. 21.00.004

Std. Item:	W21NG
Item ID:	5941814[E]
CU:	C1113ASSTBRNE

PHYSICAL PROPERTIES	
R.B.S.	39,100 lbs.
C.S.A.	0.9854 sq. in.
R. (@ 25˚C)	0.0161 Ω / 1000’
R. (@ 75˚C)	0.0191 Ω / 1000’
CONDUCTOR DIAMETER	1.293”
WEIGHT	1430 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.7634 Lb/Ft
VERTICAL	2.546 Lb/Ft
TOTAL	2.958 Lb/Ft
SWING	24.33˚

CURRENT CARRYING CAPACITIES		
SUMMER (37.7˚C)	CONDUCTOR TEMPERATURE	WINTER (10˚C)
276	122˚F/50˚C	1202
1111	176˚F/80˚C	1573
1393	212˚F/100˚C	1763
1803	284˚F/140˚C	2073

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2672	1772	1394	1162	2461	1810	1499	1287	2318	1837	1578	1389	2208	1857	1639	1471
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	3	4	2	3	3	4
60	3	4	6	7	3	4	5	6	3	4	5	6	3	4	5	5
70	4	6	8	9	4	6	7	8	5	6	7	8	5	6	6	7
80	5	8	10	12	6	8	9	11	6	7	9	10	6	7	8	9
90	7	10	12	15	7	10	12	14	8	9	11	13	8	9	11	12
100	8	12	15	18	9	12	14	17	9	12	14	15	10	12	13	15
110	10	15	19	22	11	14	17	20	11	14	16	19	12	14	16	18
120	12	17	22	27	13	17	21	24	13	17	20	22	14	17	19	21
130	14	20	26	31	15	20	24	28	16	20	23	26	16	20	22	25
140	16	24	30	36	17	23	28	33	18	23	27	30	19	23	26	29
150	18	27	35	42	20	27	32	38	21	26	31	35	22	26	29	33
160	21	31	39	47	22	30	37	43	24	30	35	40	25	30	34	37
170	23	35	45	53	25	34	41	48	27	34	39	45	28	33	38	42
180	26	39	50	60	28	38	46	54	30	38	44	50	32	37	42	47
190	29	44	56	67	31	43	52	60	33	42	49	56	35	42	47	53
200	32	48	62	74	35	47	57	67	37	47	54	62	39	46	52	58
210	35	53	68	82	38	52	63	74	41	52	60	68	43	51	58	64
220	39	59	75	90	42	57	69	81	45	57	66	75	47	56	63	71
230	43	64	82	98	46	63	76	88	49	62	72	82	51	61	69	77
240	46	70	89	107	50	68	83	96	53	67	78	89	56	67	75	84
250	50	76	96	116	55	74	90	104	58	73	85	97	61	72	82	91
260	54	82	104	125	59	80	97	113	63	79	92	105	66	78	89	99
270	59	88	112	135	64	87	105	122	68	85	99	113	71	84	96	107
280	63	95	121	145	68	93	112	131	73	92	107	121	76	91	103	115
290	68	102	130	156	73	100	121	141	78	98	115	130	82	97	110	123
300	72	109	139	167	79	107	129	150	83	105	123	139	88	104	118	132

****** Simulated with a maximum tension of 4000 lbs. ******

Std. Item:	W21NG
Item ID:	5941814[E]
CU:	C1113ASSTBRNE

FINAL SAG TABLE										
	LOADING (UNLOADED CONDITIONS)									
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**212**	**257**	**284**
TEMP. ˚C	**-20**	**0**	**15**	**32**	**50**	**70**	**80**	**100**	**125**	**140**
DEAD END SPAN (FEET)										
50	1	4	7	9	10	11	12	13	14	15
75	4	8	12	14	16	18	19	21	22	24
100	8	13	18	21	23	26	27	29	31	33
125	13	20	25	29	32	34	36	38	41	47
150	21	28	33	38	41	44	46	48	51	53
175	30	37	43	48	52	55	57	60	63	65
200	40	47	54	60	63	67	69	72	76	78
225	51	59	66	72	76	80	82	85	90	92
250	65	73	79	85	90	95	96	100	105	107
275	79	87	94	100	106	110	112	116	121	123
300	95	103	110	117	122	127	129	133	138	141

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3	5	7	*4000
75	6	10	12	*4000
100	11	15	18	*4000
125	17	22	25	*4000
150	25	30	33	*4000
175	34	39	43	*4000
200	44	50	54	*4000
225	56	62	66	*4000
250	70	76	79	*4000
275	84	90	94	*4000
300	100	106	110	*4000
** Note: Design Specification Constraint*				

****** Simulated with a maximum tension of 4000 lbs. ******

 Doc. # ST. 21.00.004

Std. Item:	W21NF
Item ID:	5941794[E]
CU:	C795ASSTBRNE

PHYSICAL PROPERTIES	
R.B.S.	28,200 lbs.
C.S.A.	0.7049 sq. in.
R. (@ 25˚C)	0.0222 Ω / 1000’
R. (@ 75˚C)	0.0265 Ω / 1000’
CONDUCTOR DIAMETER	1.093”
WEIGHT	1022 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.6966 Lb/Ft
VERTICAL	2.015 Lb/Ft
TOTAL	2.432 Lb/Ft
SWING	28.14˚

CURRENT CARRYING CAPACITIES		
SUMMER (37.7˚C)	CONDUCTOR TEMPERATURE	WINTER (10˚C)
258	122˚F/50˚C	973
902	176˚F/80˚C	1268
1124	212˚F/100˚C	1418
1447	284˚F/140˚C	1662

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2446	1557	1165	938	2192	1537	1228	1028	2004	1523	1274	1100	1874	1513	1310	1157
ACTUAL SPAN (FEET)																
50	2	2	3	4	2	2	3	4	2	3	3	3	2	3	3	3
60	2	4	5	6	3	4	5	5	3	4	4	5	3	4	4	5
70	3	5	6	8	3	5	6	7	4	5	6	7	4	5	6	7
80	4	6	8	10	4	6	8	10	5	6	8	9	5	6	8	8
90	5	8	11	13	6	8	10	12	6	8	10	11	7	8	10	11
100	6	10	13	16	7	10	13	15	8	10	12	14	8	10	12	13
110	8	12	16	20	8	12	15	18	9	12	15	17	10	12	14	16
120	9	14	19	24	10	14	18	22	11	15	17	20	12	15	17	19
130	11	17	22	28	12	17	21	25	13	17	20	24	14	17	20	22
140	12	19	26	32	14	20	25	29	15	20	24	27	16	20	23	26
150	14	22	30	37	16	22	28	34	17	23	27	31	18	23	26	30
160	16	25	34	42	18	26	32	38	20	26	31	36	21	26	30	34
170	18	29	38	47	20	29	36	43	22	29	35	40	24	29	34	38
180	20	32	43	53	23	32	41	48	25	33	39	45	27	33	38	43
190	23	36	48	59	25	36	45	54	28	36	44	50	30	37	42	48
200	25	39	53	66	28	40	50	60	31	40	48	56	33	41	47	53
210	28	44	58	72	31	44	55	66	34	45	53	62	36	45	52	59
220	30	48	64	79	34	48	61	72	37	49	58	68	40	49	57	64
230	33	52	70	87	37	53	66	79	41	53	64	74	43	54	62	70
240	36	57	76	94	40	58	72	86	44	58	69	81	47	59	68	77
250	39	62	82	103	44	62	78	94	48	63	75	87	51	63	73	83
260	42	67	89	111	47	68	85	101	52	68	82	95	55	69	79	90
270	46	71	96	120	51	73	91	109	56	74	88	102	60	74	59	97
280	49	77	103	129	55	78	98	117	60	79	95	110	64	80	92	104
290	53	83	111	138	59	84	105	126	64	85	101	118	69	85	99	112
300	57	89	119	148	63	90	113	135	69	91	109	126	74	91	106	120

****** Simulated with a maximum tension of 3500 lbs. ******

Std. Item:	W21NF
Item ID:	5941794E
CU:	C795ASSTBRNE

FINAL SAG TABLE										
	LOADING (UNLOADED CONDITIONS)									
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**212**	**257**	**284**
TEMP. ˚C	**-20**	**0**	**15**	**32**	**50**	**70**	**80**	**100**	**125**	**140**
DEAD END SPAN (FEET)										
50	1	3	6	8	9	10	11	12	14	15
75	3	6	10	13	15	17	18	20	21	23
100	6	11	16	20	22	24	25	27	30	31
125	11	17	22	27	30	32	34	36	39	41
150	17	24	30	36	38	42	43	46	49	51
175	25	33	39	45	48	52	53	57	60	63
200	35	43	49	55	59	63	65	68	72	75
225	45	54	60	67	71	75	77	81	85	88
250	58	66	73	80	85	89	91	95	99	102
275	71	80	87	94	100	104	106	110	115	117
300	87	95	102	110	115	120	122	126	131	134

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	3	4	6	*3500
75	6	8	11	*3500
100	10	14	16	*3500
125	16	20	23	*3500
150	23	28	30	*3500
175	32	37	39	*3500
200	42	47	50	*3500
225	53	58	61	*3500
250	65	71	74	*3500
275	79	84	87	*3500
300	94	100	102	*3500
* Note: Design Specification Constraint				

****** Simulated with a maximum tension of 3500 lbs. ******

Std. Item:	
Item ID:	5941551
CU:	477BACSR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	19,500 lbs.	TRANSVERSE	0.6174 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.4353 sq. in.	VERTICAL	1.501 Lb/Ft			
R. (@ 25˚C)	0.0366 Ω / 1000’	TOTAL	1.923 Lb/Ft	658	NORMAL	938
R. (@ 75˚C)	0.0438 Ω / 1000’			742	EMERGENCY	991
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	33.18˚			
CONDUCTOR DIAMETER	0.858” (Nominal)					
WEIGHT	656 lbs / 1000’					

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2200	1333	913	691	1936	1255	937	750	1707	1200	954	796	1533	1161	967	832
ACTUAL SPAN (FEET)																
50	1	2	3	4	1	2	3	3	1	2	3	3	2	2	3	3
60	2	3	4	5	2	3	4	5	2	3	4	4	2	3	4	4
70	2	4	5	7	2	4	5	6	3	4	5	6	3	4	5	6
80	3	5	7	9	3	5	7	8	4	5	7	8	4	5	7	8
90	4	6	9	12	4	6	9	11	5	7	8	10	5	7	8	10
100	4	7	11	14	5	8	11	13	6	8	10	12	6	8	10	12
110	5	9	13	17	6	9	13	16	7	10	12	15	8	10	12	14
120	6	11	16	21	7	11	15	19	8	12	15	18	9	12	15	17
130	8	12	18	24	9	13	18	22	10	14	17	21	11	14	17	20
140	9	14	21	28	10	15	21	26	11	16	20	24	13	17	20	23
150	10	17	24	32	11	18	24	30	13	18	23	28	14	19	23	27
160	11	19	28	36	13	20	27	34	15	21	26	32	16	22	26	30
170	13	21	31	41	15	23	30	38	17	24	30	36	19	25	29	34
180	14	24	35	46	16	25	34	43	19	27	33	40	21	27	33	38
190	16	27	39	51	18	28	38	47	21	30	37	45	23	31	37	43
200	18	30	43	57	20	31	42	53	23	33	41	50	26	34	41	47
210	20	33	48	63	22	35	46	58	25	36	45	55	28	37	45	52
220	22	36	52	69	25	38	51	64	28	40	50	60	31	41	49	57
230	24	39	57	75	27	41	56	69	31	43	55	65	34	45	54	63
240	26	43	62	82	29	45	61	76	33	47	59	71	37	49	59	68
250	28	46	67	89	32	49	66	82	36	51	64	77	40	53	64	74
260	30	50	73	96	34	53	71	89	39	55	70	84	43	57	69	80
270	33	54	79	104	37	57	77	96	42	60	75	90	47	62	74	86
280	35	58	85	112	40	61	82	103	45	64	81	97	50	66	80	93
290	38	62	91	120	43	66	88	111	48	69	87	104	54	71	86	100
300	40	66	97	128	46	71	95	118	52	74	93	111	58	76	92	107

****** Simulated with a maximum tension of 3000 lbs. ******

Std. Item:	
Item ID:	5941551
CU:	477BACSR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1	2	4	6	8	9	10	11
75	2	4	8	11	13	15	16	17
100	4	8	13	17	19	22	23	24
125	7	13	19	2	26	29	31	32
150	12	20	26	31	34	38	39	41
175	19	27	34	40	43	47	49	51
200	27	36	43	50	53	57	59	61
225	37	47	54	61	64	69	71	73
250	49	58	65	72	77	81	83	85
275	61	71	78	85	90	95	97	99
300	75	84	92	99	104	109	112	114

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	2	3	5	3000*
75	5	7	9	3000*
100	10	12	14	3000*
125	15	18	20	3000*
150	22	25	27	3000*
175	30	33	35	3000*
200	39	42	44	3000*
225	49	53	55	3000*
250	60	64	66	3000*
275	73	77	79	3000*
300	87	91	93	3000*
* Note: Design Specification Constraint				

****** Simulated with a maximum tension of 3000 lbs. ******

Std. Item:	W21BA
Item ID:	0811125
CU:	C477ALSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8,360 lbs.	TRANSVERSE	0.5992 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.3744 sq. in.	VERTICAL	1.252 Lb/Ft			
R. (@ 25˚C)	0.0373 Ω / 1000’	TOTAL	1.688 Lb/Ft	640	NORMAL	908
R. (@ 75˚C)	0.0445 Ω / 1000’			721	EMERGENCY	960
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	41.59˚			
CONDUCTOR DIAMETER	0.793”					
WEIGHT	446.8 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1086	616	451	363	885	590	470	394	765	574	482	419	695	564	492	438
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	3	4	2	3	3	4
60	2	4	5	7	3	4	5	6	3	4	5	6	3	4	5	6
70	3	5	7	9	4	6	7	8	4	6	7	8	5	6	7	8
80	4	7	10	12	5	7	9	11	6	7	9	10	6	8	9	10
90	5	9	12	15	6	9	12	14	7	9	11	13	8	10	11	12
100	6	11	15	19	8	11	14	17	9	12	14	16	10	12	14	15
110	7	13	18	22	9	14	17	21	11	14	17	19	12	14	17	19
120	9	16	21	27	11	16	21	25	13	17	20	23	14	17	20	22
130	10	18	25	31	13	19	24	29	15	20	24	27	16	20	23	26
140	12	21	29	36	15	22	28	33	17	23	27	31	19	23	27	30
150	14	25	34	42	17	26	32	38	20	26	31	36	22	27	31	35
160	16	28	38	47	19	29	37	44	22	30	36	41	25	31	35	39
170	18	32	43	54	22	33	41	49	25	34	40	46	28	34	40	44
180	20	35	48	60	25	37	46	55	28	38	45	52	31	39	44	50
190	22	39	54	67	27	41	52	62	32	42	50	58	35	43	49	55
200	25	44	60	74	30	46	57	68	35	47	56	64	39	48	55	61
210	27	48	66	82	33	50	63	75	39	52	61	71	43	53	60	68
220	30	53	72	90	37	55	69	83	43	57	67	78	47	58	66	74
230	33	58	79	98	40	60	76	90	46	62	74	85	51	63	72	81
240	36	63	86	107	44	66	83	98	51	67	80	93	56	69	79	89
250	39	68	93	116	47	71	90	107	55	73	87	100	60	75	86	96
260	42	74	101	126	51	77	97	115	59	79	94	109	65	81	93	104
270	45	80	109	135	55	83	104	124	64	85	102	117	70	87	100	112
280	49	86	117	146	60	89	112	134	69	92	109	126	76	94	107	121
290	52	92	125	156	64	96	121	144	74	98	117	135	81	100	115	129
300	56	98	134	167	68	103	129	154	79	105	126	145	87	107	123	139

477.0 KCMIL, 19 STRAND, BARE AAC, “COSMOS”

Std. Item:	W21BA
Item ID:	0811125
CU:	C477ALSTBR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1	3	7	10	12	14	15	16
75	3	7	12	15	19	22	24	25
100	6	12	18	23	27	31	33	35
125	11	19	25	31	36	41	43	45
150	19	28	34	40	45	51	54	57
175	30	38	45	51	57	63	66	69
200	42	50	57	64	67	77	80	83
225	55	64	71	78	84	92	95	98
250	71	79	86	94	100	108	111	115
275	87	96	103	111	117	125	129	133
300	106	115	122	129	136	144	148	152

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3	5	7	*2000
75	7	10	12	*2000
100	13	16	18	*2000
125	20	23	26	*2000
150	29	33	35	*2000
175	39	43	46	*1995
200	51	55	58	*1989
225	65	69	72	*1986
250	80	85	87	*1986
275	97	102	104	*1986
300	115	120	123	*1987
** Note: Design Specification Constraint*				

Std. Item:	W21NB
Item ID:	5942639[E]
CU:	C477ALTWHMP35KNE
CU:	C477ALSCHMP35KNE

PHYSICAL PROPERTIES		LOADING PROPERTIES	
R.B.S.	8,360 lbs.	TRANSVERSE	0.7866 Lb/Ft
C.S.A.	0.3746 sq. in.	VERTICAL	2.061 Lb/Ft
R. (@ 25˚C)	0.0373 Ω / 1000’	TOTAL	2.506 Lb/Ft
R. (@ 75˚C)	0.0447 Ω / 1000’		
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	37.02˚
CONDUCTOR DIAMETER	0.722”		
COMPLETE DIAMETER	1.362” (Nominal)		
WEIGHT	903 lbs / 1000’		

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
435	NORMAL	710
543	EMERGENCY	770

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	822	675	593	531	789	687	624	572	770	695	645	602	758	701	660	624
ACTUAL SPAN (FEET)																
50	4	5	6	6	4	5	5	6	4	5	5	6	4	5	5	5
60	6	7	8	9	6	7	8	9	6	7	8	8	6	7	7	8
70	8	10	11	12	8	10	11	12	9	10	10	11	9	9	10	11
80	11	13	15	16	11	13	14	15	11	12	13	14	11	12	13	14
90	13	16	19	21	14	16	18	19	14	16	17	18	14	16	17	18
100	16	20	23	26	17	20	22	24	18	19	21	23	18	19	21	22
110	20	24	28	31	21	24	26	29	21	24	25	27	22	23	25	26
120	24	29	33	37	25	28	31	34	25	28	30	32	26	28	30	31
130	28	34	39	43	29	33	37	40	30	33	36	38	30	33	35	37
140	32	39	45	50	34	39	43	46	35	38	41	44	35	38	40	43
150	37	45	51	57	39	44	49	53	40	44	47	51	40	44	46	49
160	42	51	59	65	44	51	56	61	45	50	54	58	46	50	53	56
170	48	58	66	74	50	57	63	69	51	56	61	65	52	56	59	63
180	53	65	74	83	56	64	70	77	57	63	68	73	58	63	67	70
190	60	73	83	92	62	71	78	86	64	70	76	81	65	70	74	79
200	66	80	92	102	69	79	87	95	70	78	84	90	72	77	82	87
210	73	89	101	113	76	87	96	105	78	86	93	99	79	85	91	96
220	80	97	111	124	83	96	105	115	85	94	102	109	87	94	99	105
230	87	106	121	135	91	104	115	126	93	103	111	119	95	102	109	115
240	95	116	132	147	99	114	125	137	102	112	121	130	103	112	118	125
250	103	126	143	160	108	123	136	149	110	122	132	141	112	121	128	136
260	112	136	155	173	116	134	147	161	119	132	142	153	121	131	139	147
270	120	147	167	187	125	144	159	173	129	142	153	165	131	141	150	159
280	129	158	180	201	135	155	171	186	138	153	165	177	141	152	161	171
290	139	169	193	215	145	166	183	200	148	164	177	190	151	163	173	183
300	149	181	206	231	155	178	196	214	159	176	190	203	161	174	185	196

Std. Item:	W21NB
Item ID:	5942639[E]
CU:	C477ALTWHMP35KNE
CU:	C477ALSCHMP35KNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	3	7	9	12	14	16	17	18
75	8	13	16	20	22	25	27	28
100	16	21	25	29	32	36	38	39
125	26	32	36	40	44	49	51	52
150	39	45	50	54	58	63	65	67
175	55	60	65	70	74	79	82	84
200	72	78	83	88	92	98	100	103
225	92	98	103	108	113	118	121	124
250	115	121	125	130	135	141	144	147
275	140	145	150	155	160	166	169	172
300	167	173	177	183	188	194	197	200

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	5	8	9	*2000
75	11	14	17	*2000
100	19	23	26	*2000
125	29	34	37	*2000
150	42	47	50	*2000
175	58	62	65	*2000
200	75	80	83	*2000
225	95	100	103	*2000
250	118	123	13	*2000
275	143	147	151	*2000
300	170	175	178	*2000
** Note: Design Specification Constraint*				

Std. Item:	TC52
Item ID:	4035236[Y]
CU:	C33ASSTBR

PHYSICAL PROPERTIES	
R.B.S.	8,700 lbs.
C.S.A.	0.2789 sq. in.
R. (@ 25˚C)	0.0523 Ω / 1000’
R. (@ 75˚C)	0.0625 Ω / 1000’
CONDUCTOR DIAMETER	0.684”
WEIGHT	365 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.5617 Lb/Ft
VERTICAL	1.101 Lb/Ft
TOTAL	1.536 Lb/Ft
SWING	43.14˚

CURRENT CARRYING CAPACITIES		
SUMMER (37.7˚C)	**CONDUCTOR TEMPERATURE**	**WINTER (10˚C)**
187	122˚F/50˚C	555
519	176˚F/80˚C	719
640	212˚F/100˚C	801
757	257˚F/125˚C	888

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2400	1624	972	552	2449	1690	1063	643	2398	1655	1072	693	2217	1503	1001	696
ACTUAL SPAN (FEET)																
50	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2
60	1	1	2	4	1	1	2	3	1	1	2	3	1	1	2	3
70	1	2	3	5	1	2	3	4	1	2	3	4	1	2	3	4
80	1	2	4	6	1	2	3	5	1	2	3	5	2	2	3	5
90	2	3	5	8	2	3	4	7	2	3	4	6	2	3	4	6
100	2	3	6	10	2	3	5	9	2	3	5	8	2	4	5	8
110	3	4	7	12	3	4	6	10	3	4	6	10	3	4	7	10
120	3	5	8	14	3	5	7	12	3	5	7	11	4	5	8	11
130	4	6	10	17	4	5	9	14	4	6	9	13	4	6	9	13
140	4	7	11	19	4	6	10	17	4	6	10	15	5	7	11	15
150	5	8	13	22	5	7	12	19	5	7	11	18	6	8	12	18
160	6	9	14	25	6	8	13	22	6	8	13	20	6	9	14	20
170	7	10	16	29	6	9	15	25	7	10	15	23	7	11	16	23
180	7	11	18	32	7	10	17	28	7	11	17	26	8	12	18	25
190	8	12	20	36	8	12	19	31	8	12	18	29	9	13	20	28
200	9	13	23	40	9	13	21	34	9	13	20	32	10	15	22	31
210	10	15	25	44	10	14	23	38	10	15	23	35	11	16	24	35
220	11	16	27	48	11	16	25	41	11	16	25	38	12	18	26	38
230	12	18	30	53	12	17	27	45	12	17	27	42	13	19	29	42
240	13	19	32	57	13	19	30	49	13	19	29	46	14	21	32	45
250	14	21	35	62	14	20	32	53	14	21	32	49	15	23	34	49
260	15	23	38	67	15	22	35	58	15	22	35	53	17	25	37	53
270	17	25	41	72	16	24	38	62	17	24	37	58	18	27	40	57
280	18	26	44	78	18	25	40	67	18	26	40	62	19	29	43	62
290	19	28	47	84	19	27	43	72	19	28	43	67	21	31	46	66
300	21	30	51	89	20	29	46	77	21	30	46	71	22	33	49	71

****** Simulated with a maximum tension of 3000 lbs. ******

336.4 KCMIL, 18/1 STRANDING, BARE ACSR, “MERLIN”

Std. Item:	TC52
Item ID:	4035236[Y]
CU:	C33ASSTBR

FINAL SAG TABLE										
	LOADING (UNLOADED CONDITIONS)									
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**212**	**257**	**284**
TEMP. ˚C	**-20**	**0**	**15**	**32**	**50**	**70**	**80**	**100**	**125**	**140**
DEAD END SPAN (FEET)										
50	1	1	3	7	8	10	10	12	13	14
75	1	3	6	11	14	16	17	18	20	21
100	3	5	9	15	20	22	23	25	28	29
125	4	7	13	20	26	29	31	33	36	38
150	6	10	16	24	31	37	38	41	44	46
175	8	14	21	30	38	45	47	50	54	56
200	12	19	28	38	46	55	57	60	64	66
225	17	26	36	46	55	65	68	71	75	78
250	23	35	45	56	65	75	79	83	87	90
275	31	44	55	66	75	86	91	95	100	103
300	41	55	66	77	87	98	103	109	114	117

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3	3	4	2291
75	5	6	7	2414
100	9	10	10	2553
125	13	15	14	2700
150	18	19	18	2849
175	24	25	24	*2936
200	31	33	31	*2948
225	39	41	39	*2958
250	49	50	48	*2965
275	59	61	58	*2971
300	70	72	69	*2976
** Note: Design Specification Constraint*				

****** Simulated with a maximum tension of 3000 lbs. ******

 Doc. # ST. 21.00.004

Std. Item:	W20B
Item ID:	4035204
CU:	C33ALSTBR

PHYSICAL PROPERTIES	
R.B.S.	6,150 lbs.
C.S.A.	0.2644 sq. in.
R. (@ 25˚C)	0.0527 Ω / 1000’
R. (@ 75˚C)	0.0629 Ω / 1000’
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	0.666”
WEIGHT	315.5 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.5556 Lb/Ft
VERTICAL	1.041 Lb/Ft
TOTAL	1.480 Lb/Ft
SWING	46.55˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
514	NORMAL	725
578	EMERGENCY	766

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1445	819	484	334	1221	701	469	353	1001	619	459	368	824	567	452	379
ACTUAL SPAN (FEET)																
50	1	1	2	4	1	2	3	3	1	2	3	3	1	2	3	3
60	1	2	4	5	1	2	4	5	2	3	4	5	2	3	4	5
70	2	3	5	7	2	3	5	7	2	4	5	6	3	4	5	6
80	2	4	6	9	2	4	6	9	3	5	7	8	4	5	7	8
90	3	5	8	11	3	5	8	11	4	6	8	10	5	7	9	10
100	3	6	10	14	4	7	10	13	5	8	10	13	6	8	10	13
110	4	7	12	17	5	8	12	16	6	9	13	16	7	10	13	15
120	5	8	14	20	6	10	15	19	7	11	15	19	8	12	15	18
130	6	10	17	24	7	11	17	23	8	13	17	22	10	14	18	21
140	6	11	19	28	8	13	20	26	9	15	20	25	11	16	21	25
150	7	13	22	32	9	15	23	30	11	17	23	29	13	19	24	28
160	8	15	25	36	10	17	26	34	12	20	26	33	15	21	27	32
170	9	17	28	41	11	20	29	39	14	22	30	37	17	24	30	36
180	11	19	32	46	13	22	33	43	15	25	34	42	19	27	34	41
190	12	21	35	51	14	24	37	48	17	28	37	47	21	30	38	45
200	13	23	39	57	16	27	40	54	19	31	41	52	23	33	42	50
210	14	26	43	63	17	30	45	59	21	34	46	57	25	37	46	55
220	16	28	47	69	19	33	49	65	23	37	50	62	28	40	51	61
230	17	31	52	75	21	36	54	71	25	41	55	68	30	44	56	66
240	19	33	56	82	22	39	58	77	27	44	60	74	33	48	60	72
250	21	36	61	89	24	42	63	84	30	48	65	81	36	52	66	78
260	22	39	66	96	26	46	68	91	32	52	70	87	39	57	71	85
270	24	42	71	104	28	49	74	98	35	56	75	94	42	61	77	91
280	26	45	77	111	30	53	79	105	37	60	81	101	45	66	82	98
290	28	49	82	120	33	57	85	113	40	64	87	109	48	70	88	105
300	30	52	88	128	35	61	91	121	43	69	93	116	52	75	95	113

336.4 KCMIL, 19 STRAND, BARE AAC, “TULIP”

Std. Item:	W20B
Item ID:	4035204
CU:	C33ALSTBR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1	2	5	9	11	14	15	16
75	2	4	9	13	17	21	22	24
100	3	7	13	19	23	28	30	32
125	6	12	19	26	31	37	40	42
150	11	19	27	34	40	47	49	52
175	18	28	36	44	50	57	60	63
200	28	39	47	55	61	69	73	76
225	40	50	59	67	74	82	86	89
250	53	64	72	80	88	96	100	104
275	68	78	87	95	103	112	116	120
300	84	94	103	111	119	128	133	137

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	3	4	6	1710
75	7	8	9	1862
100	11	13	14	*2000
125	17	19	21	*2000
150	25	27	28	*2000
175	34	37	38	*1996
200	45	47	48	*1993
225	56	60	60	*1992
250	70	73	74	*1992
275	84	88	88	*1992
300	100	104	105	*1992
** Note: Design Specification Constraint*				

Std. Item:	W14B
Item ID:	0811017
CU:	C10AAACBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4,415 lbs.	**TRANSVERSE**	0.4656 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0968 sq. in.	**VERTICAL**	0.675 Lb/Ft			
R. (@ 25˚C)	0.166 Ω / 1000’	**TOTAL**	1.120 Lb/Ft	256	**NORMAL**	354
R. (@ 75˚C)	0.195 Ω / 1000’			286	**EMERGENCY**	374
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	59.98˚			
CONDUCTOR DIAMETER	0.398”					
WEIGHT	115 lbs / 1000’					

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1229	940	698	459	1236	949	708	474	1243	957	718	489	1251	966	729	504
ACTUAL SPAN (FEET)																
50	0	0	0	1	0	0	1	1	0	0	1	1	0	0	1	1
60	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
70	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	2
80	1	1	1	2	1	1	2	2	1	1	2	2	1	1	2	2
90	1	1	1	2	1	1	2	3	1	1	2	3	1	1	2	3
100	1	2	2	2	1	2	2	4	1	2	2	4	1	2	2	3
110	2	2	2	3	2	2	3	4	2	2	3	4	2	2	3	4
120	2	3	3	4	2	3	4	5	2	3	3	5	2	3	3	5
130	2	3	3	4	2	3	4	6	2	3	4	6	2	3	4	6
140	3	4	4	5	3	4	5	7	3	4	5	7	3	4	5	7
150	3	4	4	6	3	4	6	8	3	4	5	8	3	4	5	8
160	4	5	5	6	4	5	6	9	4	5	6	9	4	5	6	9
170	4	5	5	7	4	5	7	11	4	5	7	10	4	5	7	10
180	5	6	6	8	5	6	8	12	5	6	8	12	5	6	8	11
190	5	7	7	9	5	7	9	13	5	7	9	13	5	7	9	12
200	6	7	7	10	6	7	10	15	6	7	10	14	6	7	10	14
210	6	8	8	11	6	8	11	16	6	8	11	16	6	8	11	15
220	7	9	9	12	7	9	12	18	7	9	12	17	7	9	12	17
230	7	10	10	13	7	10	13	19	7	10	13	19	7	10	13	18
240	8	11	10	14	8	11	14	21	8	10	14	21	8	10	14	20
250	9	12	11	16	9	11	15	23	9	11	15	22	9	11	15	22
260	10	13	12	17	10	12	17	25	9	12	16	24	9	12	16	23
270	10	13	13	18	10	13	18	27	10	13	18	26	10	13	17	25
280	11	15	14	20	11	14	19	29	11	14	19	28	11	14	19	27
290	12	16	15	21	12	15	21	31	12	15	20	30	12	15	20	29
300	13	17	16	22	13	17	22	33	13	16	22	32	13	16	21	31

Std. Item:	W14B
Item ID:	0811017
CU:	C10AAACBR

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1	1	1	3	7	10	12	13
75	1	1	2	5	11	16	18	20
100	2	2	4	8	15	21	24	27
125	2	4	6	12	19	27	30	33
150	3	5	8	15	24	33	37	40
175	5	7	11	19	29	39	44	48
200	6	9	14	23	34	45	50	55
225	8	11	17	27	39	52	57	62
250	10	14	21	32	44	58	64	69
275	12	17	24	37	50	65	71	77
300	15	23	33	46	60	75	82	88

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	4	3	2	1195
75	7	6	4	1273
100	12	11	7	1360
125	18	16	10	1451
150	24	21	14	1542
175	32	27	18	1632
200	39	34	22	1721
225	47	41	27	1808
250	55	48	32	1893
275	64	55	37	1976
300	76	66	46	*2000

** Note: Design Specification Constraint*

 Doc. # ST. 21.00.004

Std. Item:	W21NA
Item ID:	5942107[E]
CU:	C1/0ALHMPESTNE
CU:	C10ALSCHMPNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4,270 lbs.	TRANSVERSE	0.6776 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0968 sq. in.	VERTICAL	1.374 Lb/Ft			
R. (@ 25˚C)	0.166 Ω / 1000'	TOTAL	1.832 Lb/Ft	196	NORMAL	316
R. (@ 75˚C)	0.195 Ω / 1000'			243	EMERGENCY	343
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	50.48˚			
CONDUCTOR DIAMETER	0.398"					
COMPLETE DIAMETER	1.028" (Nominal)					
WEIGHT	424 lbs / 1000'					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	939	556	416	338	755	527	428	364	654	510	436	383	597	499	441	397
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	4	4	3	3	4	4
60	2	4	6	7	3	4	5	6	4	4	5	6	4	5	5	6
70	3	6	7	9	4	6	7	9	5	6	7	8	5	6	7	8
80	4	7	10	12	5	8	10	11	6	8	9	11	7	8	9	10
90	5	9	12	15	7	10	12	14	8	10	12	13	9	10	12	13
100	7	11	15	19	8	12	15	18	10	12	15	17	11	13	14	16
110	8	14	18	23	10	15	18	21	12	15	18	20	13	15	17	19
120	10	16	22	27	12	17	21	25	14	18	21	24	15	18	21	23
130	11	19	26	32	14	20	25	30	16	21	25	28	18	22	24	27
140	13	22	30	37	17	24	29	34	19	24	29	33	21	25	28	31
150	15	26	34	42	19	27	33	39	22	28	33	37	24	29	32	36
160	17	29	39	48	22	31	38	45	25	32	37	43	27	33	37	41
170	20	33	44	54	24	35	43	51	28	36	42	48	31	37	42	46
180	22	37	50	61	27	39	48	57	32	40	47	54	35	41	47	52
190	24	41	55	68	30	44	54	63	35	45	53	60	38	46	52	58
200	27	46	61	75	34	48	60	70	39	50	58	67	43	51	58	64
210	30	51	67	83	37	53	66	77	43	55	64	73	47	56	64	71
220	33	55	74	91	41	58	72	85	47	60	71	81	52	62	70	78
230	36	61	81	100	45	64	79	93	51	66	77	88	56	68	76	85
240	39	66	88	109	49	70	86	101	56	72	84	96	61	74	83	92
250	42	72	96	118	53	75	93	110	61	78	91	104	67	80	90	100
260	46	77	103	127	57	82	101	119	66	84	99	113	72	86	98	108
270	49	84	112	137	61	88	109	128	71	91	107	121	78	93	105	117
280	53	90	120	148	66	95	117	137	76	98	115	131	84	100	113	126
290	57	96	129	159	71	102	125	147	82	105	123	140	90	107	121	135
300	61	103	138	170	76	109	134	158	88	112	132	150	96	115	130	145

Std. Item:	W21NA
Item ID:	5942107[E]
CU:	C1/0ALHMPESTNE
CU:	C10ALSCHMPNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1	5	9	11	13	15	16	17
75	3	9	13	17	20	24	25	26
100	6	14	19	24	28	32	34	36
125	13	21	27	32	37	42	44	46
150	23	31	37	43	48	53	56	58
175	34	42	48	54	60	66	69	72
200	47	55	61	68	73	80	83	86
225	61	70	76	83	89	96	99	102
250	78	86	93	99	105	113	116	120
275	96	104	111	117	124	132	135	138
300	116	124	131	137	144	152	156	159

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	4	7	9	1549
75	9	11	14	1817
100	14	17	20	*2000
125	21	25	28	*2000
150	31	35	38	*2000
175	42	47	49	*2000
200	55	60	62	*2000
225	70	74	77	*2000
250	86	91	94	*2000
275	104	109	112	*2000
300	124	129	132	*2000
** Note: Design Specification Constraint*				

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1.1	11/13	• Convert to a Liberty Utilities Document from National Grid.	Robert Johnson	Robert Johnson
1	07/12	• Added Flat & Vertical Configuration Structure Drawings (pages 21-200 through 21-236). • Added Clearance Information (Section 21.6). • Added Conductor Information (Section 21.5 & pages 21-400 through 21-418).	G. Paul Anundson	Susan Fleck VP of Standards, Policies, and Codes

 Doc. # ST. 03.00.002

Supersedes 7/10 Issue - Added Section 3.4.60.

Supersedes 7/10 Issue - Added Drawing 3-120.

Supersedes 7/08 Issue - Revised Sections 3.0 and 3.1.

3.0 GENERAL

This section of the Standards is used to determine the appropriate guy/pole support necessary to support distribution poles and their equipment. The Standards in this section meet or exceed the requirements of the most recent publication of the National Electric Safety Code (NESC).

3.1 WHEN TO GUY

3.1.10 Deadend Poles

Poles at deadends, where an uneven number of wires terminate on each side of the pole, shall always be guyed. Where it is not practical to guy such a pole directly, the conductors may be deadended on the first or second pole from the end of that line. That pole shall be guyed and slack spans shall be strung to the terminal pole. The unbalanced force at the top of the unguyed pole shall in no case exceed 50% of the breaking strength of the pole.

3.1.20 Junction Poles

The junction pole with a lateral line deadend tap shall be guyed in the same manner as a deadend pole.

3.1.30 Transition Poles

Poles unbalanced more than 10% by a change in the number or size of conductors shall be longitudinally guyed (includes deadend in-line secondaries on tangent poles). Pole to pole guys to distribute the imbalance shall be considered.

3.1.40 Line Poles with Transverse (Lateral) Loading

Poles subject to excessive lateral loading shall be side guyed as required. These loadings include heavy unbalanced service pulls (e.g. when all services are taken off from one side of a line of poles); heavy transverse wind loading (e.g. long span north-south lines); and normally loaded pole lines set in soft soils. Transverse loading values for standard conductors are given in Section 6 (Primary Conductors). Transverse guying may also be required where poles are located in extremely hazardous locations.

3.1.50 Line Angle Poles

Poles at line angles where the steady unbalanced force due to conductor tension caused by the angle exceeds 300 lbs. (this includes 3 phase line poles at angles over 2 degrees and 1 phase line poles at angles over 4½ degrees) shall be guyed. Angles over 60 degrees require deadending the lines in both directions and guying both ways.

3.2 TYPES OF GUY WIRES/POLE SUPPORTS

3.2.10 Anchor/Down Guys

This is the most common type of guy wire used on distribution circuits. The lower end of the guy is anchored in the earth. This type of guy wire shall be installed in accordance with Drawing 3-105 or 3-106.

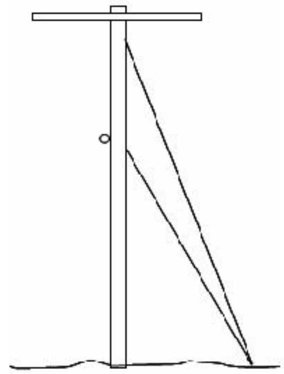


Figure 1 - Anchor/Down Guy

3.2.20 Stub Guys

When it is not feasible to guy directly to an anchor, a guy stub pole may be installed. When the guy stub pole is set where there is a possibility of a line being extended at a later date, the pole shall be of a length and class expected for such line extension. See Drawings 3-107D/3-107Y and 3-108D/3-108Y for installation details.

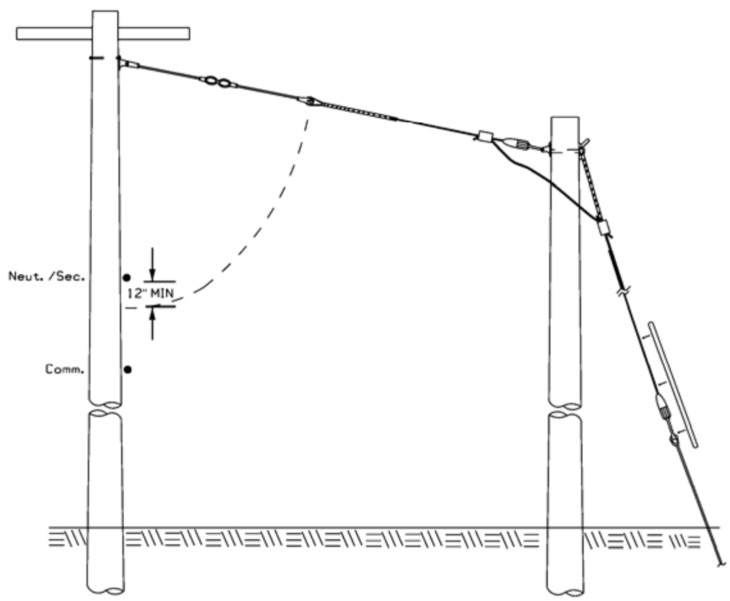


Figure 2 - Stub Guy

A. Steel Guy Stub Poles

If additional strength is required for the stub pole, steel guy stub poles are available for use. The pole is manufactured in accordance with Liberty Utilities MS2355 and is installed in accordance with Drawing 3-112.

3.2.30 Span Guys/Pole to Pole Guys

When it is not feasible to install an anchor guy directly on the pole, pole to pole guys may be installed to an adjacent pole. A minimum clearance of 15’ 6” is required at the lower attachment point if the guy wire is above driveways, parking lots, alleys, and other land possibly traversed by vehicles that are more than 8’ in height or by riders on horses or other large animals. If spaces and ways are subject to pedestrian or restricted traffic only (areas where riders on horses or other large animals, vehicles, or other mobile units exceeding a total height of 8’ are

Supersedes 1/06 Issue - Revised Section 3.2, added figures for each type of guy.

prohibited by regulation or permanent terrain configurations), a minimum height of 9’ 6” may be used (NESC Rule 232B, Table 232-1).. Refer to Drawing 3-115D/3-115Y for installation details.

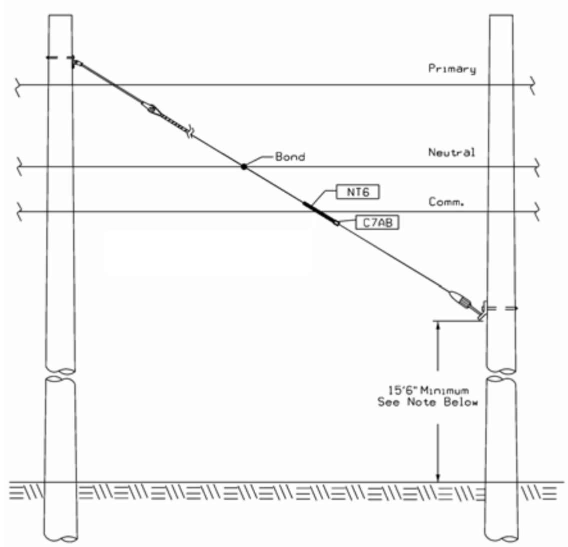


Figure 3 - Span Guy/Pole to Pole Guy

3.2.40 **Sidewalk/Strut Guy**

Where suitable land or access rights cannot be obtained for a sufficient guy lead length on an anchor guy, a sidewalk/strut guy shall be installed. Refer to Drawing 3-109D/3-109Y for installation details.

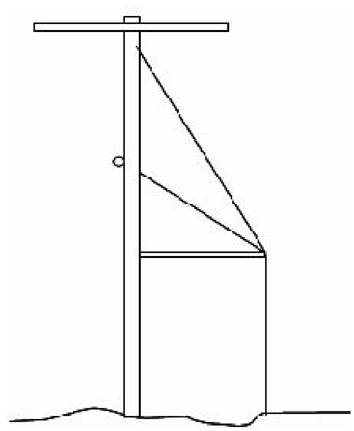


Figure 4 - Sidewalk/Strut Guy

3.2.50 **Push Brace**

Where the aforementioned means of guying a pole are not feasible, a push brace may be installed as shown on Drawing 3-111. For pole loading calculators, a push brace is treated as a regular down (anchor) guy installed on the opposite side of the pole. Refer to the table below for the minimum class pole that can be used for this installation.

Supersedes 7/08 Issue - Revised Section 3.2, added figures for each type of guy.

Equiv. Amount of Guying	35 Foot Pole	40 Foot Pole	45 Foot Pole	Line Pole Setting to Balance Up-Lift
6M	5	5	4	Normal
12M 18M	5 4	4 3	3 2	Normal depth but backfill with crushed stone and earth well-tamped.
24M 30M	3 2	2 1	1 X	Set an extra foot deep; bolt with two 24" x 12" planks with two 5/8" bolts; backfill with crushed stone and earth well-tamped.
36M	1	X	X	Requires special considerations.

Table 1 - Minimum Class of Push Brace Pole Allowed

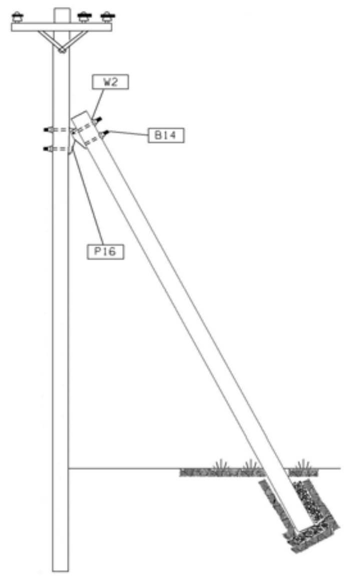


Figure 5 - Push Brace

3.2.60 <u>Storm Guys</u>

Pole lines located where topographical features may cause extreme winds (on ridgelines, for example) may require the installation of storm guys to offset the unbalanced condition created by these winds.

3.2.70 <u>Unguyed Poles</u>

Contact Distribution Standards Engineering or see Section 2 (Poles/Hardware) for requirements/alternatives for unguyed line angle poles. Slack span construction may be used where suitable land or guying rights cannot be obtained at line angle or deadend pole locations. Spans adjacent to the line angle should have approximately twice the normal sag. This added sag may limit span length in order to meet NESC midspan clearance requirements. Total pole loads shall be determined jointly with all telecommunication parties attached to the pole. Telecommunication conductors and equipment loading must also be considered when determining if guying may be omitted on angle poles.

Supersedes 1/06 Issue - Revised Section 3.2, added figures for each type of guy.

3.2.80 Steel Stub Pole

A steel guy stub pole is used when rights cannot be obtained or space is not available for conventional guying installations. The steel guy stub pole specification is in accordance with Material Specification MS 2355 and installed in accordance with Page 3-112. The maximum horizontal load per attachment point is 13,400 lbs. The maximum combined horizontal load on the pole stub on both attachment points is 24,000 lbs. (21,600 lbs. with .9 overload factor per NESC). For a guy at an angle (°) other than horizontal (See Page 3-112), the equivalent horizontal tension per attachment point is determined by the formula T Cosine Ø. This value shall not be greater than 13,400 lbs. T equals the tension on the guy and equals Ø equals the angle of the guy from horizontal. Example: For a guy with a tension of 15,000 lbs. at an angle of 30°, 15,000 x Cosine 30° = 15,000 x .866 = 12,990 lbs. Since this load does not exceed the maximum horizontal load of 13,400 lbs. for an attachment point, this load is acceptable. Note: Two guys with this load would exceed the maximum allowable horizontal load on this stub (13,400 lbs. x 2 = 26,800 lbs., which is greater than the allowed maximum combined horizontal load of 21,600 lbs.)

3.3 GUYING MATERIALS

3.3.10 Guy Wire

There are currently two sizes of guy wire available for new construction, but the table below also includes some of the common sizes that were previously used on the system in case there is equipment being added to an existing guyed pole.

Std Item #	Size	RBS (Rated Breaking Strength)	Use Strength (90% of the RBS)
G11 (old)	1/4" galvanized steel (3M)	3150 lbs	2800 lbs
G13A (old)	5/16" galvanized steel (6M)	6000 lbs	5400 lbs
G15A (old)	3/8" galvanized steel (10M)	11500 lbs	10350 lbs
G15A	**3/8" alumoweld (12.5M)**	**12630 lbs**	**11367 lbs**
(old)	11/32" (13M)	12630 lbs	11367 lbs
G17A	**7/16" galvanized steel (16M)**	**18000 lbs**	**16200 lbs**
G17B	7/16" copperweld (16M)	16890 lbs	15200 lbs

Table 2 - Guy Wire Sizes and Strengths

Items G15A and G17A are the two sizes of guy wire currently used for new construction on distribution circuits. Item G17B is commonly used for guy wire on sub-transmission/distribution supply circuits or it is used as a messenger wire in some situations. The other sizes listed are not available but are listed for reference purposes.

3.3.20 Anchor Rod and Helix

Anchor selection is based primarily upon actual field soil conditions. A standard 10 inch screw anchor (Std Item A16A) shall be used unless soil conditions are known to be unsuitable for the required holding capacity or the anchor location is inaccessible to a digger truck. Installation of or failure to install the standard 10 inch screw anchor will provide the best basis for determining whether a different anchor is needed. A 14 inch screw anchor (Std Item A16B) shall be used in lower class soil conditions (see the following table and Drawing 3-102). Maximum soil/anchor holding strength should be sought since this will likely be the weakest link of the guy-anchor assembly. If a screw anchor cannot be installed because it is inaccessible to a digger truck, a hand dug anchor can be used. See Drawing 3-104.

Usually knowledge of the soil types encountered on site will help promote proper anchor selection. Observation of the soil removed from the pole bore hole is the best practical methods for judging the site soil type. The following table should be used as a general guide for determining soil type and anchor selection.

Supersedes 1/12 Issue - Added 3.2.80 Steel Stub Pole design guide.

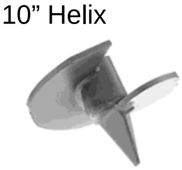
Soil Class	Soil Description	Recommended Anchor
0	Sound unweathered rock	A13A - Rock Anchor 
1	Very dense and/or cemented sands, coarse gravel and cobbles	A16C - Twin 4" Helix 
2	Dense sand, very hard silts & clay, coarse gravel	A16A - 10" Helix 
3	Dense sands & clay, hard silts & clay, gravel, shale, hardpan, broken rock	
4	Compacted sands, gravel, claypan, hard silts & clays	
5	Compacted coarse sand, sandy gravels, still silts & clay	
6	Loose coarse sand, firm clay loam, damp clay	A16B - 14" Helix 
7*	Loose fine sand, varied clays, silt loam, fill	
8*	Swamp, saturated loam, marshland, peat	

Table 3 - Soil Classes and Recommended Anchors

Notes:

*** -** Anchor should penetrate through saturated strata to class 5, 6, or 7 substrata for best results.

- Anchor selection as shown is for general use. Best judgement may be used to decide between Class 1 and 2 (twin 4" or single 10"), and Class 5 and 6 (single 10" or single 14").

- Actual anchor holding capacity will depend on the real holding capacity of the soil. General soil holding capacities, provided by the anchor manufacturers, are reduced to NESC required 90% and are shown in the following table.

STANDARD SCREW ANCHOR	APPROXIMATE EXPECTED SOIL HOLDING CAPACITY – IN LBS X 90% FOR STANDARD SCREW ANCHORS INSTALLED IN THESE SOIL CLASS TYPES						
	DENSE/ROCKY SOILS……………………………….LOOSE/SOFT SOILS						
	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7
Twin 4" HELIX (for Hard Soils) (A16C)	32,000	27,000	16,000				
Single 10" HELIX (all Normal Soils) (A16A)	32,000	25,200	21,600	18,000	14,000	10,000	8,000
Single 14" HELIX (for Soft Soils) (A16B)				28,000	22,000	19,000	15,000

Table 4 - Approximate Holding Capacity for Anchors

Note: Soil holding strength is an important component of the guy-anchor system. These holding capacity values were derived from field testing results obtained by the manufacturers. The installing torque required during installation is proportional to the resulting holding strength of the system. The skill and experience of the operator is generally the best or only indicator of a sound anchor installation.

Supersedes 1/06 Issue - Information on this page was previously found in Section 3.5.20.

3.3.30 Bolts

Two bolts sizes are used for guying – a 5/8" and a 3/4". The lengths will vary depending on the diameter of the pole, what all it is holding, etc. Refer to the table below for rated strength and use strength for each type of bolt used for guying.

Std Item	Description	Minimum Tensile Strength	Use Strength (90% of Min Tensile Strength) per NESC
B13_	5/8" square head machine bolt	12,400 lbs	11,000 lbs
B14_	3/4" square head machine bolt	18,350 lbs	16,500 lbs

Table 5 - Thru-Bolt Strengths

3.3.40 Guy Hooks

Guy hooks are selected based on strength needed and angle at which the guy will be installed. The B20A or B20B items are used for span, pole or the seldom used arm guys where the pull is very close to horizontal. TG17 is used on fiberglass poles. A detailed installation drawing can be found in Section 9 for TG17.

Guy Hooks			
Item	**Bolt Size**	**Use Strength**	**Remarks**
B20A	1-5/8"	11,000 lbs	Meets/ exceeds use rating of bolts
B20B	1-3/4"	16,500 lbs	
G33A	1-5/8"	11,000 lbs	
G33B[Y]	2-3/4"	16,500 lbs	
G33C[E]	1-3/4"	25,000 lbs	
G33D[E]	1-3/4"	25,000 lbs	
TG10	2-3/4"	15,000 lbs	
TG13	2-3/4"	20,000 lbs	
TG14	2-3/4"	28,000 lbs	
TG15[E]	2-3/4"	30,000 lbs	
TG17	3-5/8"		Use with 12.5M guy wire only

Table 6 - Guy Hooks and Rated Strengths

3.3.50 Guy Grips

Guy grips/connectors, both preformed (Std Item P54) and automatic (Std Item G5C), are full-tension devices, based on the heaviest strand for which they were designed and rated for over 95% of the conductor rated breaking strength. The preforms can be located at any attachment point – at the top by the guy hook, at the bottom by the anchor, or in the middle at insulators. The automatic guy grip is used at the anchor only (shall not be used at the top of the guy). For areas where automatics rust and break due to salt or other contaminants, refer to Section 8 - Coastline Construction.

3.3.60 Fiberglass Guy Strain Insulators

Guy strain insulators are to be installed in distribution guys to maintain the basic insulation impulse level (BIL) of the pole top, to provide and maintain the required clearances from equipment as specified by the NESC, and to provide additional worker safety. Refer to the following table for installation guidelines.

Supersedes 1/06 Issue - New information for guying components (previously not in section).

Std Item #	Size	Rated Breaking Strength	Use Strength (90% of the RBS) per NESC
I24	12” fiberglass rod	15,000 lbs	13,500 lbs
TI95B	54” fiberglass rod	15,000 lbs	13,500 lbs
TI95C	54” fiberglass rod	30,000 lbs	27,000 lbs
TI95D	72” fiberglass rod	30,000 lbs	27,000 lbs

Table 7 - Fiberglass Guy Strain Insulators

For more information on placement of fiberglass insulators in the guy wires, refer to Section 3.4 below.

Note: Ceramic guy insulators (“Johnny Balls”) are no longer approved for use on new guy wire construction.

3.4 BONDING AND ISOLATION/INSULATION

The NESC requires that all guy wire shall be effectively grounded or insulated.

3.4.10 Effectively Grounded or Multi-Grounded Wye Circuits

A. Primary Guy Wires

All primary guy wires shall have a fiberglass insulating rod (54” minimum length) at the top (pole end) of the guy. The guy wire shall also be bonded to the system neutral using a compression connector **except** where the bond wire will create a work method problem. If the exception is taken, the guy wire shall be insulated/isolated as described below for guy wires on delta circuits. See Drawings 3-105 and 3-106 for more details.

B. Secondary Guy Wires

All secondary guy wires shall be attached at the lowest secondary attachment point (usually the secondary cable). All secondary guy wires on an effectively grounded or multi-grounded wye circuit shall be bonded to the system neutral using a compression connector. See Drawing 3-118 for more details.

3.4.20 Delta or Uni-Grounded Circuits

A. Primary Guy Wires

All primary guy wires shall have a minimum of two 54” fiberglass insulating rods at the top (pole end) of the guy. There shall be a minimum of 12” of fiberglass from the bottom insulator that extends past the secondary connection to prevent the transfer of energy from electric conductors to any third party attachments if the guy were slack against the pole. It is acceptable to use a combination of fiberglass rods to obtain the 12” of fiberglass below the secondary connection. See Drawing 3-105 and 3-106 for more details.

B. Secondary Guy Wires

All secondary guy wires shall be attached at the lowest secondary attachment point (usually the secondary cable). All secondary guy wires on delta or uni-grounded circuits shall be insulated with a minimum of one fiberglass insulating rod (12” minimum length). See Drawing 3-119 for more details.

Supersedes 1/07 Issue - Info in Section 3.4 was previously found in Section 3.6. Insulating on Delta Primary guy wires was updated.

3.4.30 Stub Guy Poles

Refer to Drawings 3-107W and 3-107D for construction details when there is no secondary on the stub pole. Refer to Drawings 3-108W and 3-108D when there is secondary on the stub pole.

3.4.40 Ceramic/Porcelain Insulators (Johnny Balls)

This type of guy insulator is no longer accepted for use on new construction. Ceramic/porcelain insulators can either be removed from the guy wire or a jumper wire can be placed across the insulator when the guy wire is being brought up to current Standards (i.e. during a conversion, structure replacement, or when reconductoring a line).

3.4.50 Voltage Conversions

When performing circuit voltage conversions, if the guy wires are properly built to current Standards for the existing type of circuit (delta or wye), there is no requirement to change the guy wires after the conversion is complete.

A. **EXAMPLES**

1. Converting a 5kV class delta circuit to a 15kV class wye circuit:
   - Build guy wires to current Standards for guy wires on a 15kV class delta circuit.
   - This includes removing existing ceramic/porcelain guy insulators (commonly referred to as “Johnny balls”) or installing a jumper wire across it as these are no longer used for guy wire insulation and installing required fiberglass guy insulators.
   - It is not necessary to go back and bond the guy wires or jumper out the guy insulators as part of the conversion project.

2. Converting a 5kV class wye circuit to a 15kV class wye circuit:
   - Build guy wires to current Standards for guy wires on a 15kV class wye circuit.
   - This includes installing the 54” fiberglass at the top of primary guy wires where not already installed and/or removing existing ceramic/porcelain guy insulators (commonly referred to as “Johnny balls”) or installing a jumper wire across it as these are no longer used for guy wire insulation and installing required fiberglass guy insulators.
   - This includes bonding all guy wires to the system neutral where not already bonded.

3.4.60 Guying on Multi-Circuit Structures

On structures where at least one ungrounded/delta circuit is present, the guying standards in Section 3.4.20 (Delta or Uni-Grounded Circuits) shall be followed.

On structures where all circuits are multi-grounded wye, the guying standards in Section 3.4.10 (Effectively Grounded or Multi-Grounded Wye Circuits) shall be followed since all neutrals on these structures will be bonded together.

3.5 CLEARANCES

When installing guy wires, adequate clearance shall be maintained between all conductors and guy wires and guy strain insulators per NESC Table 235-6 and Note 11. Minimum clearance depends upon the type of guy wire installed and the normal operating voltage. Additional clearance may be required due to conductor movement as a result of wind. Refer to the following tables for required clearances.

Clearance between the primary conductor and fiberglass guy strain insulator may be reduced by no more than 25% of the clearance between the primary conductor and guy wire. This reduced clearance is shown in the following tables.

3.5.10 Down/Sidewalk Guys

Primary Voltage (Phase to Phase)	Clearance - Primary to Guy Wire	Clearance - Primary to Guy Insulator
Up to 8.7kV	6”	5”
>8.7kV to 15kV	8”	6”
>15kV to 25kV	11”	9”
>25kV to 35kV	13”	10”
>35kV to 50kV	17”	13”

Table 8 - Down/Sidewalk Guy Clearances

3.5.20 Span Guys

Primary Voltage (Phase to Phase)	Clearance - Primary to Guy Wire	Clearance - Primary to Guy Insulator
Up to 8.7kV	12”	9”
>8.7kV to 15kV	15”	11”
>15kV to 25kV	19”	15”
>25kV to 35kV	23”	17”
>35kV to 50kV	29”	22”

Table 9 - Span Guy Clearances

3.5.30 Other Guys

These guy wires are defined as a guy wire that is neither a down guy nor a span guy, but a guy wire that is attached to two distribution poles that do not have conductors parallel to the guy wire (a stub pole guy, for example).

Primary Voltage (Phase to Phase)	Clearance - Primary to Guy Wire	Clearance - Primary to Guy Insulator
Up to 8.7kV	6”	5”
>8.7kV to 15kV	7”	6”
>15kV to 25kV	13”	10”
>25kV to 35kV	17”	13”
>35kV to 50kV	23”	18”

Table 10 - Other Guy Wire Clearances

3.5.40 Other Clearance Considerations

The same clearances apply for double circuit construction; however additional fiberglass rods may be needed to prevent contact with the lower primary if the guy wire were to break (see Figure 6 below).

Supersedes 7/10 Issue - Text shifted.

Supersedes 7/10 Issue - Edited Figure 6 and Figure 7.

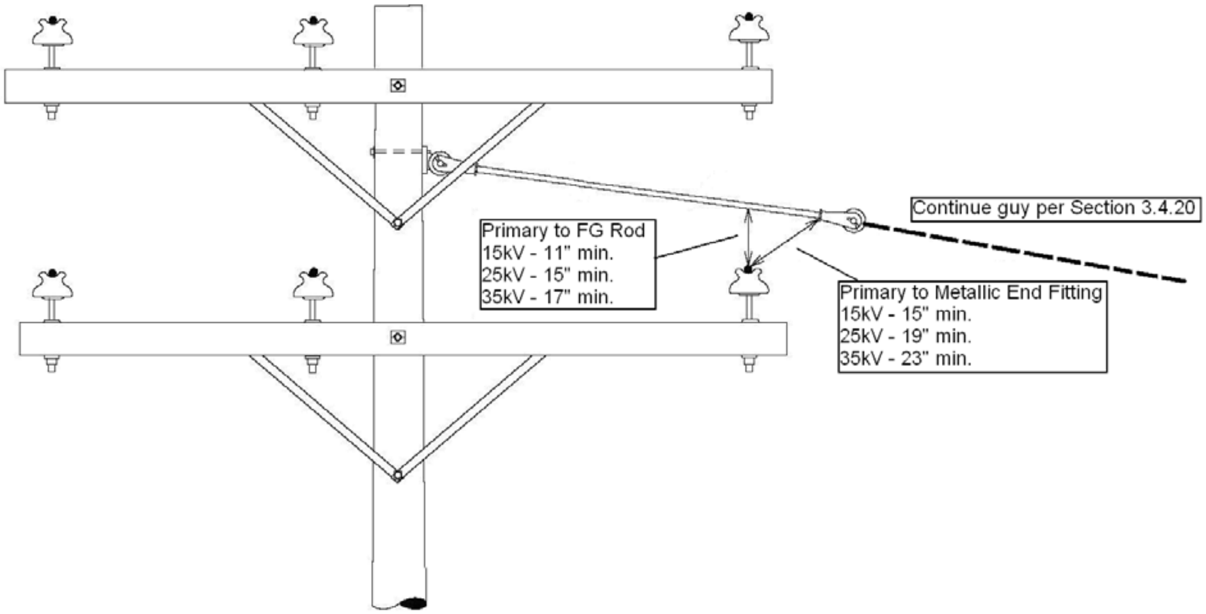


Figure 6 - Double Circuit Guy Wire (Using Table 9 Clearances)

For poles that also have a transformer on it, clearance needs to be maintained between the guy wire and bushings (see Figure 7 below).

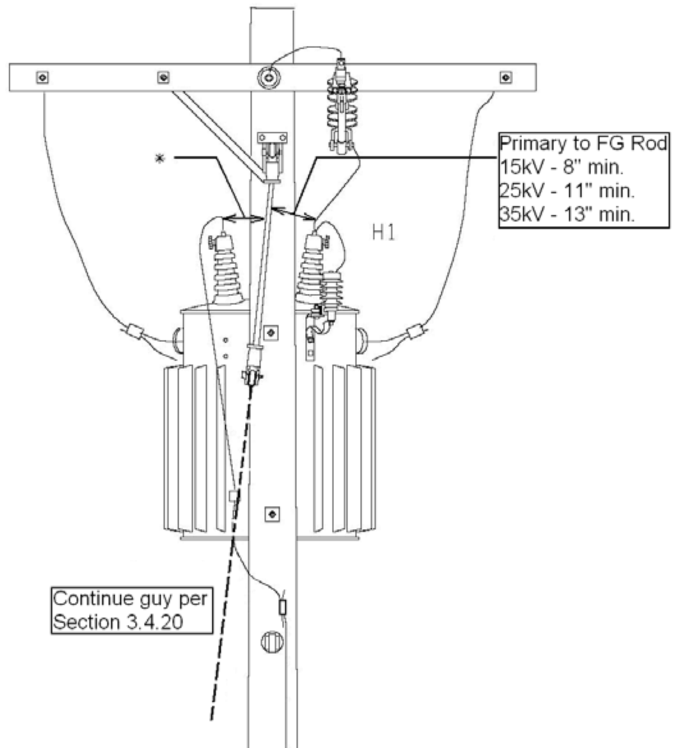


Figure 7 - Guy Wire Clearances (Using Table 8 Clearances)

If a pole-to-pole guy (span guy) is attached above the primary conductors, additional clearance may be needed towards the middle of the span where there can be conductor movement due to wind. In the example below in Figure 8, spacer cable messenger is deadended on one side of the pole at the top of the figure, and there is a guy wire attached on the other side of the pole above the primary conductors.

Where the guy wire passes by a conductor, adequate clearance must be maintained between the conductor and guy wire and/or guy insulator. If the conductor to guy wire/insulator clearance point is near the pole attachment, the clearances from Table 9 are required. If the clearance to the guy/insulator clearance point is further than a few feet from the guy attachment point to the pole, additional clearance is required to take into account conductor movement due to wind. Refer to Section 6 to calculate the maximum conductor horizontal movement using the conductor swing angle.

For this type of installation, do not install the middle phase of the primary conductors directly above the guy wire (do not use a pole top pin). Install the middle phase on the crossarms, as shown.

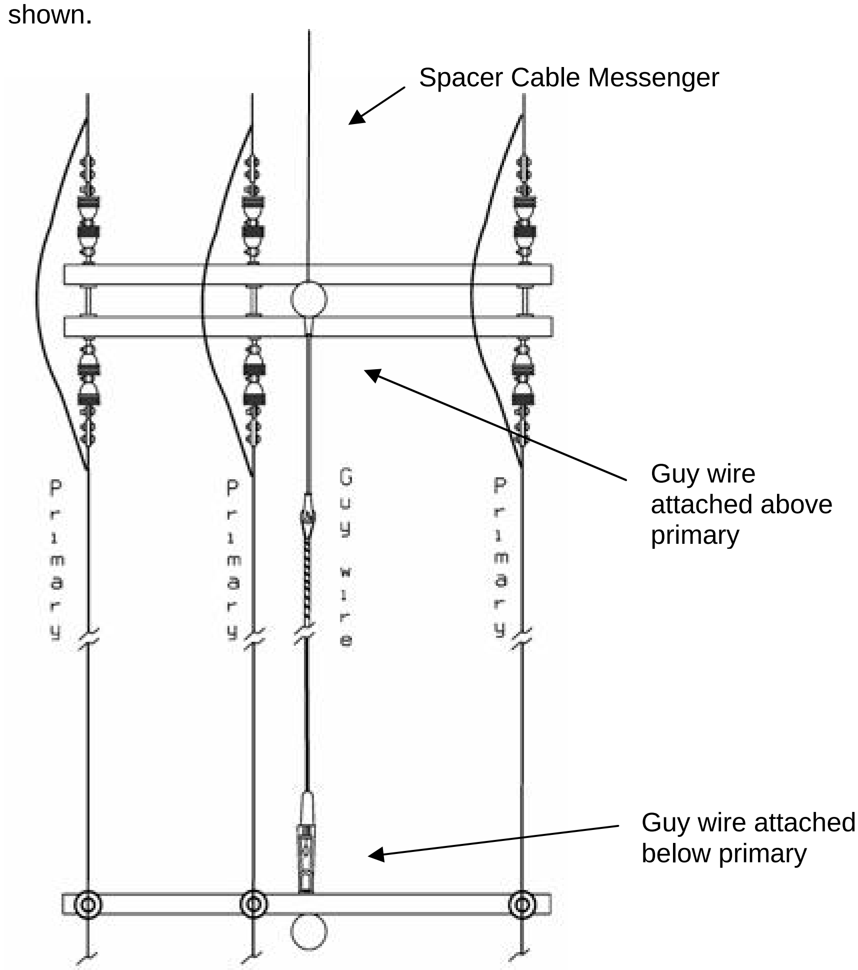


Figure 8 - Span Guy Clearance Considerations - Top View

3.5.50 Guy Wire Clearance to Neutrals

The NESC requires 6” of clearance between the guy wire and the neutral. By using a fiberglass rod the distance between the conductor (neutral) and the fiberglass rod can be reduced by 25%. Therefore, the clearance between the fiberglass rod and the neutral shall be no less than 5”.

3.5.60 Guy Wire Clearance to Third Party Conductors

Per NESC, 6” of clearance is required between the guy wire and communication cables. This clearance may be reduced to no less than 3” if abrasion protection (Std Item T15) is added to the guy wire. See Drawing 3-115D/3-115Y for installation details.

Supersedes 7/10 Issue - Text shifted.

3.6 DETERMINING THE STRENGTH REQUIRED TO SUPPORT THE POLE

3.6.10 General

The amount of guy strength required to prevent a pole from leaning or falling over depends on the storm loaded tension of the conductors, the line angle (pull or corner) on the pole, and the length of the lead away from the pole (lead/height ratio).

Wherever possible, guying layout should be preformed in the field before construction begins so that obstacles to the desired guying can be taken into consideration. All pole and guy locations should be staked or otherwise marked to assure adequate lead lengths and proper locations.

Guys should be installed as close to the unbalanced load as possible. Guy anchor assemblies shall be designed for the sum of all loads placed upon them. The unbalanced force above the top guy shall be less than 50% of the resisting moment of the pole at the point of guy attachment.

If there are other loads of similar magnitude below the top guy, they should be balanced with a second guy. Deadended secondaries limited to a 2,000 lb design may be installed without an additional guy unless the magnitude of the total loading (primary and secondary) dictates the use of more than one guy. All communication conductors and messengers shall be guyed by the Owner of the telecommunication facilities against their unbalanced loads where required.

Design of the guy assembly shall include the following NESC overload factors for Grade C and B construction.

TYPE OF LOAD	NESC TABLE 253-1 OVERLOAD CAPACITY FACTOR	
	Grade C	Grade B
Vertical Loads	1.90	1.50
Transverse Loads: Wind	1.75	2.50
Transverse Loads: Wire Tension	1.10	1.65
Longitudinal Loads: In General	None	1.10
Longitudinal Loads: At Deadends	1.10	1.65

Table 11 - NESC Overload Factors for Guy Wires

Construction Component	Grade C	Grade B
Poles	0.85	0.65
Guy Wire	0.9	0.9
Anchors and Foundations	1.0	1.0

Table 12 - Strength Factors for Poles, Guys and Anchors (per NESC)

3.6.20 Procedure

Determine the pull or corner on the pole if applicable. The following diagrams illustrate methods of determining pull on the pole (in feet) by direct measurement. When measuring pull, if D is 100 feet, then P is the pull (also in feet). If D is other than 100 feet, the pull would be (100/D)*P.

Supersedes 7/10 Issue - Changed material used for abrasion protection in 3.5.60.

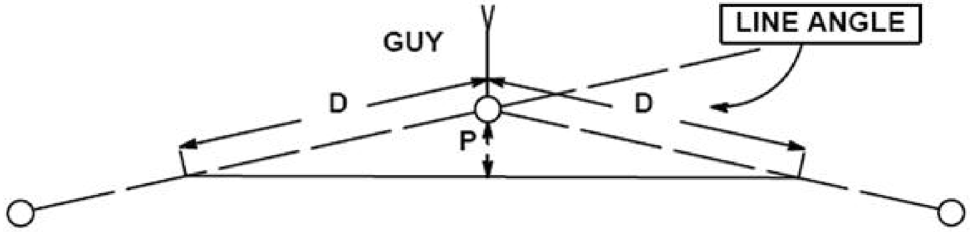


Figure 9 - Preferred Method of Finding Pull

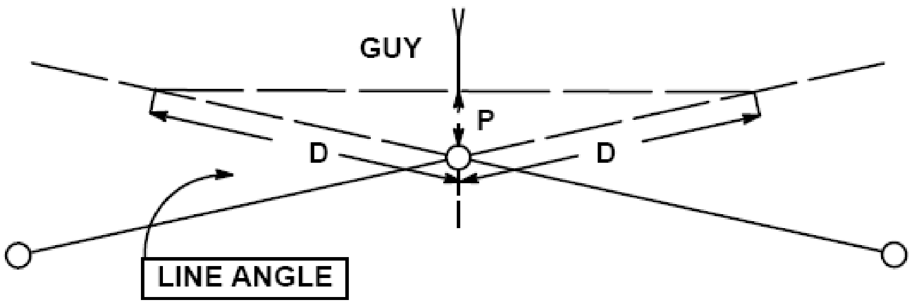


Figure 10 - Alternate Method #1 of Finding Pull

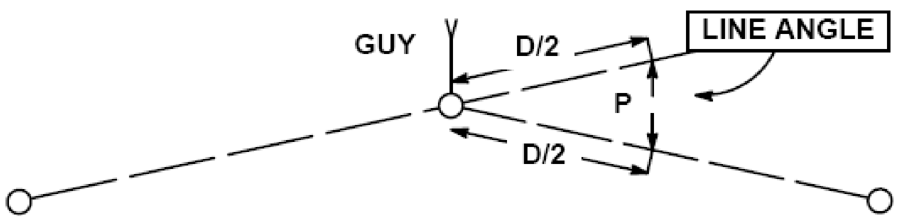


Figure 11 - Alternate Method #2 of Finding Pull

New page. This info was previously found on Page 3-101.

New page. Info was previously found on Page 3-75.

Line Angle (degrees)	**Pull** (feet)	**Line Angle Factor**	**Line Angle** (degrees)	**Pull** (feet)	**Line Angle Factor**
1	0.9	0.0175	31	26.7	0.5150
2	1.7	0.0349	32	27.6	0.5299
3	2.6	0.0524	33	28.4	0.5446
4	3.5	0.0698	34	29.2	0.5592
5	4.4	0.0872	35	30.1	0.5736
6	5.2	0.1045	36	30.9	0.5878
7	6.1	0.1219	37	31.7	0.6018
8	7.0	0.1392	38	32.6	0.6157
9	7.8	0.1564	39	33.4	0.6293
10	8.7	0.1736	40	34.2	0.6428
11	9.6	0.1908	41	35.0	0.6561
12	10.5	0.2079	42	35.8	0.6691
13	11.3	0.2250	43	36.7	0.6820
14	12.2	0.2419	44	37.5	0.6947
15	13.1	0.2588	45	38.3	0.7071
16	13.9	0.2756	46	39.1	0.7193
17	14.8	0.2924	47	39.9	0.7314
18	15.6	0.3090	48	40.7	0.7431
19	16.5	0.3256	49	41.5	0.7547
20	17.4	0.3420	50	42.3	0.7660
21	18.2	0.3584	51	43.1	0.7771
22	19.1	0.3746	52	43.8	0.7880
23	19.9	0.3907	53	44.6	0.7986
24	20.8	0.4067	54	45.4	0.8090
25	21.6	0.4226	55	46.2	0.8192
26	22.5	0.4384	56	46.9	0.8290
27	23.3	0.4540	57	47.7	0.8387
28	24.2	0.4695	58	48.5	0.8480
29	25.0	0.4848	59	49.2	0.8572
30	25.9	0.5000	60	50.0	0.8660

Line Angle Factor = Sine (Line Angle in Degrees)

Table 13 - Line Angle Factors

Refer to the following figure when measuring the lead to height ratio of a guy.

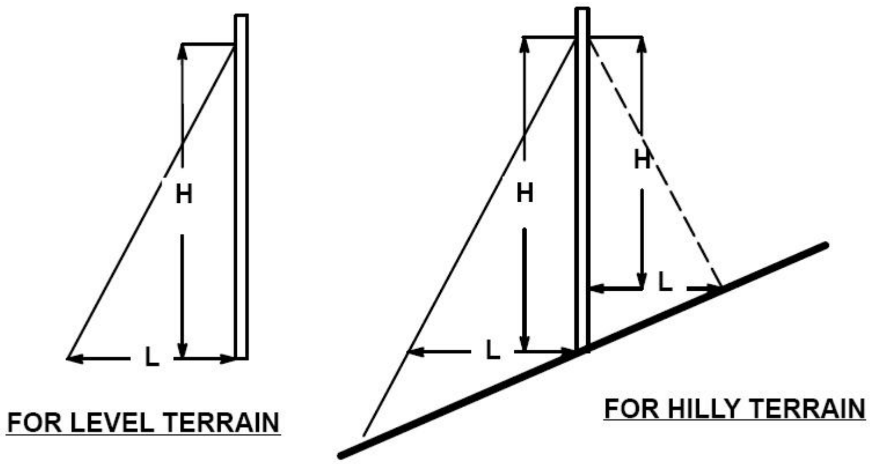


Figure 12 - Measuring Lead and Height

When the terrain slopes and the guy will be installed higher or lower than the base of the pole, adjustments must be made to the lead and height measurements. **Note: The Lead/Height ratio shall never be less than 0.3 because guy loading on the pole becomes excessive.**

The following "Quick Calculations" can be used for most guying calculations. For more detailed calculations and examples, refer to Section 3.7 (Worksheets and Examples).

A. <u>Quick Calculation - Line Angles</u>

1. Find the total conductor and equipment (if applicable) tension by multiplying the number of wires by the storm loaded tension of each wire and adding equipment loading information found in Table 15. Storm loaded tensions can be found in Section 6.
2. Multiply the total loaded tension by the NESC safety factor required (see Table 11).
3. Using Figure 13 on the following page, locate this total loaded tension on the "A" scale.
4. Follow the line diagonally up to where it intersects Line Angle.
5. Follow this point horizontally to the right of the "B" scale, which gives you the resultant horizontal loading.
6. Continue that point horizontally to the right where it intersects the L/H ratio line.
7. Follow the arc down from this point to the "C" scale - which is the guy tension.
8. Use the result to determine the proper materials needed.

B. <u>Quick Calculation - Deadends</u>

1. Find the total conductor and equipment (if applicable) tension by multiplying the number of wires by the storm loaded tension of each wire and adding equipment loading information found in Table 15. Storm loaded tensions can be found in Section 6.
2. Multiply the total loaded tension by the NESC safety factor required (see Table 11).
3. Using Figure 13 on the following page, locate this tension on the "B" scale.
4. Follow this point to the right where it intersects with the L/H ratio line.
5. Follow the arc down from this point to the "C" scale - which is the guy tension.
6. Use the result to determine the proper materials needed.

New page. Figure on this page was previously found on Page 3-101. Quick calculations added.

New page with new figure for quick calculations.

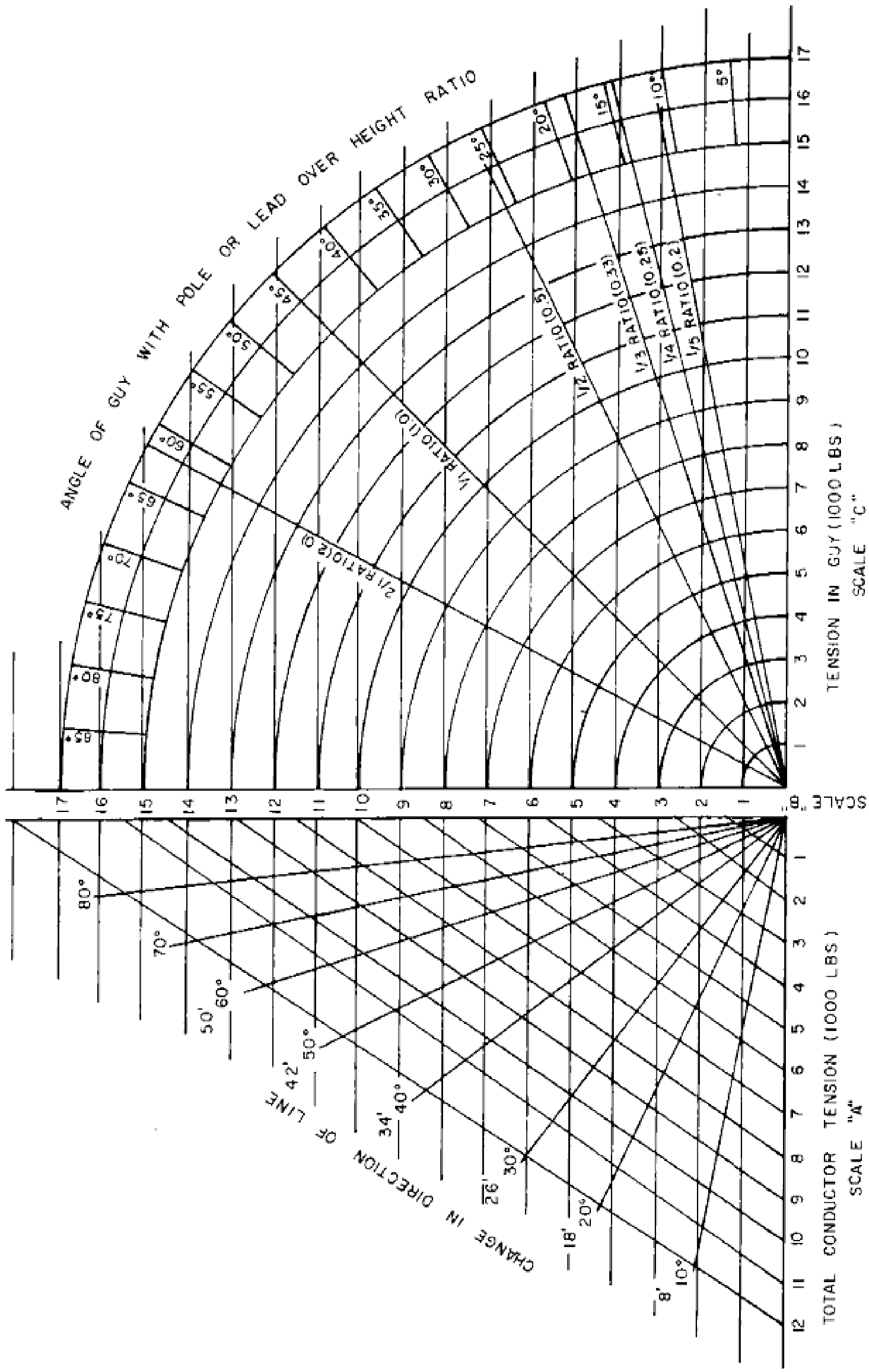


Figure 13 - Guy Wire Chart

3.6.30 Tables Needed for Calculations

Refer to the following tables for calculating guy wire loading.

Description		Conductor Size Diameter (in.)	Conductor Tension (lbs.)	Transverse Load Factor (lbs./ft.)
#22 AWG and 3/8" Messenger	25 Pair	1.000	6,600	0.667
	50 Pair	1.175	6,600	0.725
	100 Pair	1.445	6,600	0.815
	200 Pair	1.815	6,600	0.938
	300 Pair	2.115	6,600	1.038
	400 Pair	2.345	6,600	1.115
#24 AWG and 3/8" Messenger	600 Pair	2.295	6,600	1.098
	900 Pair	2.685	6,600	1.228
Fiber Optic and ¼" Messenger (non-armored)	3-36	.0640	2,850	0.547
	38-72	0.739	2,850	0.580
	74-84	0.781	2,850	0.594
	86-96	0.820	2,850	0.607
	98-108	0.850	2,850	0.617
	110-120	0.889	2,850	0.630
	122-132	0.931	2,850	0.644
	134-216	0.979	2,850	0.660
	218-264	1.045	2,850	0.682
Fiber Optic and 3/8" Messenger (non-armored)	144	1.159	6,000	0.720
Fiber Optic Self Supporting Figure "8" Cable (non-armored)	2-72 & 2-36	0.949	2,850	0.650
	74-84	0.991	2,850	0.664
	86-96	1.030	2,850	0.677
	98-108	1.060	2,850	0.687
	110-120	1.099	2,850	0.700
	122-132	1.141	2,850	0.714
	134-144	1.189	2,850	0.730
¼" Messenger (CATV)	0.750	1.069	2,850	0.690
	0.635	0.883	2,850	0.628
	0.500	0.751	2,850	0.584
	0.412	0.652	2,850	0.551

Table 14 - Common Telephone & CATV Cables - Maximum Allowed Conductor Tensions and Transverse Load Factor (Wind)

New page. Info on this page was previously found on Page 3-72.

EQUIPMENT	SQ. FT EPA	DISTANCE BELOW POLE TOP	LOAD REDUCTION FACTOR	SQ. FT. REDUCED EPA	4 LBS./ SQ. FT WIND LOAD
Capacitor Bank 9 x 50 kVAR	3	5’	90%	3	12 lbs
Capacitor Bank 6 x 200kVAR	7	5’	85%	6	24 lbs
Conductor – Primary	See Sect. 6	2’	100%		Lbs/ft x Span ft
Conductor - Secondary	See Sect. 6	8’	100%		Lbs/ft x Span ft
Conductor Comm. Allowance		11’	70%		75 lbs
Floodlight (All)	3	9’	90%	2	8 lbs
Gang Operated Switch	18	4’	90%	16	65 lbs
Primary Metering	7	6’	85%	6	24 lbs
Recloser 1- 3Ø	4	5’	90%	4	16 lbs
Regulators 3 X 100a	22	7’	85%	19	76 lbs
Regulators 3 x 219A	30	7’	85%	26	104 lbs
Streetlight (All)	4	10’	85%	3	13 lbs
Trans. 1Ø up to 75kVA	12	5’	90%	10	42 lbs
Trans. 1Ø 100kVA and up	17	5’	90%	15	61 lbs
Trans. 3 x 100 kVA	14	5’	90%	19	52 lbs
Trans. 2 x 250 kVA	21	5’	90%	19	76 lbs

Table 15 - Transverse Load Factors (Wind) for Overhead Equipment

Poles	Class 1 Factor (lbs.)	Class 2 Factor (lbs.)	Class 3 Factor (lbs.)	Class 4 Factor (lbs.)	Class 5 Factor (lbs.)
25 foot	66	62	58	53	49
30 foot	85	79	73	67	62
35 foot	104	97	90	82	75
40 foot	123	115	106	98	90
45 foot	143	133	123	114	100
50 foot	163	152	141	130	120
55 foot	184	171	159	147	--------
60 foot	205	191	177	164	--------

Table 16 - Transverse Load Factors (Wind) for Wood Poles

New page. Info found on this page was previously on Page 3-73.

All loads that are applied to poles that are guyed are transferred into vertical or axial loads. Therefore the limiting factor of the pole is at what point a pole will fail due to buckling.

The following tables list these maximum loading points (lbs) based on pole class and where the guy wire is attached to the pole.

Guy Attachment from top of pole (ft)	30 FOOT POLE				
	Class 1	Class 2	Class 3	Class 4	Class 5
1	102,090	75,852	56,512	38,820	27,870
2	117,289	84,971	63,433	43,549	31,374
3	131,792	95,546	71,470	49,037	35,451
4	148,707	107,885	80,859	55,447	40,222
5	172,864	122,379	91,900	62,982	45,842
6	196,923	139,529	104,979	71,905	52,511
7	225,611	159,990	120,601	82,559	60,489
8	266,602	184,625	139,431	95,397	70,120

Table 17 - Buckling Limits for 30ft Poles (lbs)

Guy Attachment from top of pole (ft)	35 FOOT POLE						
	Class H2	Class H1	Class 1	Class 2	Class 3	Class 4	Class 5
1	131,492	104,138	79,516	59,541	43,590	31,081	21,480
2	148,445	117,905	90,152	67,613	49,590	35,436	24,552
3	163,980	130,429	99,795	74,903	54,987	39,334	27,288
4	181,651	144,688	110,779	83,211	61,140	43,781	30,411
5	206,669	165,068	126,548	95,199	70,070	50,279	35,009
6	230,377	184,254	141,348	106,411	78,389	56,304	39,252
7	257,744	206,417	158,450	119,373	88,012	63,279	44,166
8	296,277	237,901	182,845	137,948	101,876	73,388	51,339

Table 18 - Buckling Limits for 35ft Poles (lbs)

Guy Attachment from top of pole (ft)	40 FOOT POLE								
	Class H4	Class H3	Class H2	Class H1	Class 1	Class 2	Class 3	Class 4	Class 5
1	166,225	133,382	105,664	82,508	63,385	47,796	35,276	25,393	17,749
2	180,906	145,240	115,128	89,960	69,163	52,199	38,566	27,795	19,456
3	197,242	158,440	125,667	98,261	75,603	57,110	42,237	30,477	21,363
4	220,419	177,245	140,747	110,199	84,916	64,256	47,617	34,440	24,207
5	241,266	194,109	154,228	120,833	93,179	70,568	52,346	37,903	26,678
6	264,680	213,056	169,379	132,789	102,474	77,672	57,671	41,806	29,464
7	297,604	239,799	190,855	149,815	115,779	87,901	65,389	47,506	33,569
8	328,098	264,502	210,631	165,442	127,946	97,217	72,386	52,647	37,249
9	362,746	292,576	233,116	183,215	141,790	107,821	80,356	58,505	41,447
10	411,120	331,912	264,742	208,323	161,441	122,956	91,801	66,978	47,566
11	457,418	369,465	294,851	232,153	180,029	137,219	102,539	74,890	53,250
12	510,799	412,776	329,587	259,655	201,491	153,693	114,950	84,039	59,826
13	585,009	473,180	378,207	298,303	231,783	177,063	132,656	97,177	69,341

Table 19 - Buckling Limits for 40ft Poles (lbs)

New page. Info on this page was previously found on Pages 3-60 and 3-61.

New page. Info on this page was previously found on Page 3-61.

Guy Attachment from top of pole (ft)	45 FOOT POLE								
	Class H4	Class H3	Class H2	Class H1	Class 1	Class 2	Class 3	Class 4	Class 5
1	129,446	104,125	82,714	63,617	48,984	37,033	26,802	19,325	13,753
2	139,856	112,569	89,485	68,834	53,047	40,145	29,064	20,982	14,964
3	151,309	121,863	96,940	74,580	57,524	43,575	31,558	22,812	16,301
4	167,734	135,257	107,741	82,914	64,058	48,617	35,234	25,532	18,317
5	181,992	146,843	117,049	90,090	69,659	52,917	38,364	27,832	20,007
6	197,789	159,683	127,368	98,046	75,872	57,690	41,838	30,389	21,886
7	220,210	177,992	142,157	109,461	84,840	64,626	46,898	34,144	24,683
8	240,172	194,239	155,232	119,545	92,727	70,697	51,320	37,406	27,090
9	262,475	212,396	169,850	130,820	101,551	77,492	56,271	41,061	29,791
10	293,836	238,039	190,593	146,835	114,156	87,261	63,403	46,367	33,761
11	322,539	261,435	209,454	161,386	125,562	96,061	69,818	51,114	37,281
12	354,942	287,855	230,760	177,826	138,454	106,012	77,074	56,487	41,270
13	400,149	324,864	260,738	200,978	156,705	120,184	87,429	64,210	47,071
14	471,721	383,762	308,719	238,078	186,151	143,220	104,305	76,915	56,750
15	523,529	426,124	342,988	264,538	206,979	159,368	116,096	85,694	63,326
16	595,235	484,969	390,783	301,470	236,191	182,135	132,753	98,178	72,774
17	665,420	542,416	437,310	337,403	264,516	204,129	148,824	110,167	81,784
18	747,031	609,236	491,444	379,213	297,486	229,741	167,541	124,138	92,293
19	859,784	701,857	566,756	437,423	343,589	265,729	193,885	143,922	107,314

Table 20 - Buckling Limits for 45ft Poles (lbs)

Guy Attachment from top of pole (ft)	50 FOOT POLE							
	Class H4	Class H3	Class H2	Class H1	Class 1	Class 2	Class 3	Class 4
1	111,481	90,157	72,049	55,732	43,241	32,257	23,511	17,118
2	122,126	98,890	79,140	61,251	47,604	35,540	25,928	18,924
3	130,992	106,136	84,997	65,801	51,184	38,228	27,902	20,389
4	140,652	114,033	91,384	70,764	55,091	41,161	30,056	21,989
5	154,487	125,401	100,630	77,964	60,796	45,458	33,223	24,363
6	166,248	135,028	108,427	84,026	65,576	49,050	35,864	26,330
7	179,132	145,578	116,975	90,673	70,821	52,992	38,763	28,490
8	197,393	160,604	129,215	100,210	78,393	58,701	42,974	31,656
9	213,259	173,612	139,769	108,422	84,882	63,582	46,567	34,340
10	230,752	187,959	151,414	117,483	92,047	68,973	50,536	37,307
11	255,303	208,188	167,916	130,349	102,280	76,694	56,238	41,604
12	277,143	226,121	182,490	141,696	111,266	83,460	61,223	45,339
13	301,408	246,052	198,695	154,313	121,262	90,988	66,772	49,499
14	335,159	273,895	221,441	172,056	135,399	101,663	74,662	55,459
15	365,964	299,226	242,061	188,119	148,145	111,268	81,747	60,783
16	400,511	327,643	265,202	206,149	162,457	122,057	89,706	66,766
17	448,196	367,027	297,417	231,290	182,521	137,217	100,921	75,258
18	492,966	403,893	327,473	254,718	201,145	151,265	111,293	83,071
19	543,763	445,734	361,597	281,320	222,300	167,226	123,080	91,955
20	613,473	503,370	408,798	318,175	251,754	189,496	139,568	104,466

Table 21 - Buckling Limits for 50ft Poles (lbs)

New page. Info on this page was previously found on Page 3-62.

Guy Attachment from top of pole (ft)	55 FOOT POLE							
	Class H4	Class H3	Class H2	Class H1	Class 1	Class 2	Class 3	Class 4
1	98,214	78,456	61,841	48,949	37,412	28,045	20,559	15,066
2	104,694	83,654	65,956	52,247	39,949	29,961	21,974	16,123
3	111,689	89,266	70,401	55,811	42,690	32,032	23,506	17,268
4	121,834	97,422	76,877	61,037	46,724	35,089	25,776	18,980
5	130,181	104,122	82,186	65,301	50,007	37,571	27,613	20,357
6	139,227	111,385	87,943	69,926	53,569	40,265	29,608	21,853
7	152,208	121,827	96,239	76,634	58,752	44,198	32,532	24,065
8	163,092	130,570	103,172	82,213	63,052	47,453	34,945	25,878
9	174,944	140,091	110,724	88,293	67,739	51,002	37,576	27,857
10	191,773	153,637	121,493	97,015	74,483	56,125	41,390	30,750
11	206,172	165,210	130,678	104,420	80,197	60,454	44,603	33,173
12	221,936	177,881	140,736	112,533	86,458	65,200	48,126	35,830
13	244,096	195,729	154,933	124,050	95,370	71,977	53,177	39,671
14	263,471	211,310	167,307	134,045	103,089	77,832	57,528	42,961
15	284,819	228,481	180,945	145,066	111,602	84,291	62,329	46,593
16	314,549	252,436	200,011	160,556	123,599	93,422	69,141	51,786
17	341,151	273,842	217,022	174,320	134,238	101,501	75,152	56,342
18	370,692	297,616	235,917	189,615	146,062	110,482	81,835	61,411
19	411,480	330,498	262,101	210,918	162,574	123,059	91,227	68,587
20	448,913	360,635	286,066	230,341	177,600	134,480	99,734	75,052

Table 22 - Buckling Limits for 55ft Poles (lbs)

New page. Info on this page was previously found on Page 3-63.

Strut Length (feet)	Strut Height Below Guy Attachment Height (feet)	Strut Factor	Strut Length (feet)	Strut Height Below Guy Attachment Height (feet)	Strut Factor
8	6	1.250	10	6	1.166
8	7	1.329	10	7	1.221
8	8	1.414	10	8	1.281
8	9	1.505	10	9	1.345
8	10	1.601	10	10	1.414
8	11	1.700	10	11	1.487
8	12	1.803	10	12	1.562
8	13	1.908	10	13	1.640
8	14	2.016	10	14	1.720
8	15	2.125	10	15	1.803
8	16	2.236	10	16	1.887
8	17	2.349	10	17	1.972
8	18	2.462	10	18	2.059
8	19	2.577	10	19	2.147
8	20	2.693	10	20	2.236
8	21	2.809	10	21	2.326
8	22	2.926	10	22	2.417
8	23	3.044	10	23	2.508
8	24	3.162	10	24	2.600

Table 23 - Strut Factors

New page. Info on this page was previously found on Page 3-76.

New page. Info on this page was previously found on Page 3-77.

Sidewalk/Strut Guy Pole Loading Factors
Allowable Pole Design Compression at Guy Attachment Point (Ca)

Guy attachment from top of pole	35 Foot Pole			
	Class 1	Class 2	Class 3	Class 4
2'	71,089	53,351	39,161	28,009
3'	77,851	58,500	43,002	30,809
4'	85,495	64,323	47,350	33,981
5'	94,172	70,938	52,294	37,591
6'	104,068	78,488	57,941	41,720

Guy attachment from top of pole	40 Foot Pole			
	Class 1	Class 2	Class 3	Class 4
2'	56,623	42,749	31,595	22,782
3'	61,337	46,364	34,315	24,782
4'	66,578	50,385	37,342	27,012
5'	72,423	54,873	40,723	29,505
6'	78,964	59,898	44,513	32,301

Guy attachment from top of pole	45 Foot Pole			
	Class 1	Class 2	Class 3	Class 4
2'	46,876	35,590	25,864	18,755
3'	50,363	38,281	27,860	20,233
4'	54,191	41,238	30,054	21,861
5'	58,404	44,495	32,473	23,657
6'	63,053	48,090	53,147	50,965

Guy attachment from top of pole	50 Foot Pole		
	Class 1	Class 2	Class 3
2'	39,963	29,868	21,818
3'	42,658	31,920	23,350
4'	45,589	34,154	25,433
5'	48,783	36,590	26,839
6'	52,270	39,251	28,830

Table 24 - Sidewalk/Strut Guy Pole Loading Factors (Ca)

These tables are for Grade C Construction. For Grade B Construction, multiply each value by .76.

Sidewalk/Strut Guy Pole Loading Factors
Allowable Pole Design Moment at the Strut location on the pole (Ma)

Strut attachment from top of pole	35 Foot Pole			
	Class 1	**Class 2**	**Class 3**	**Class 4**
20’	92,710	75,424	60,433	47,572
18’	86,337	70,105	56,046	44,006
16’	80,263	65,042	51,878	40,622
14’	74,480	60,228	47,921	37,417
12’	68,983	55,659	44,171	34,384
10’	63,762	51,326	40,622	31,521
6'	58,812	47,224	37,268	28,820

Strut attachment from top of pole	40 Foot Pole			
	Class 1	**Class 2**	**Class 3**	**Class 4**
24’	105,962	86,948	70,357	56,024
22’	99,021	81,086	65,459	51,981
20’	92,391	75,494	60,794	48,138
18’	86,063	70,165	56,356	44,489
16’	80,030	65,092	52,139	41,029
14’	74,287	60,270	48,138	37,754
12'	68,825	55,693	44,347	34,658

Strut attachment from top of pole	45 Foot Pole			
	Class 1	**Class 2**	**Class 3**	**Class 4**
30’	128,270	106,313	84,142	67,720
28’	120,404	99,594	78,765	63,231
26’	112,867	93,164	73,622	58,946
24’	105,650	87,017	68,708	54,859
22’	98,748	81,146	64,018	50,965
20’	92,153	75,546	59,546	47,260
18'	85,859	70,209	55,287	43,739

Strut attachment from top of pole	50 Foot Pole			
	Class 1	**Class 2**	**Class 3**	**Class 4**
34'	144,595	117,142	93,404	75,742
32'	136,092	110,164	87,759	70,991
30'	127,928	103,470	82,346	66,442
28'	120,098	97,052	77,160	62,092
26'	112,594	90,905	72,197	57,936
24'	105,410	85,024	67,452	53,970
22'	98,537	79,401	62,919	50,189

Table 25 - Sidewalk/Strut Guy Pole Loading Factors (Ma)

New page. Info on this page was previously found on Page 3-78.

Strut Length	Standard Weight Galvanized Pipe	
(Ft.)	2 Inches	2 ½ Inches
6	21,175	38,386
7	17,922	34,289
8	14,959	30,890
9	12,166	26,248
10	9,876	22,253
11	8,089	18,760
12	6,816	15,691

Table 26 - Pipe Strut Compression Capacity (lbs)

New page. Info on this page was previously found on Page 3-79.

Guy Attachment Height on Pole Above Ground (feet)	Guy Lead Length from Center of Pole to Anchor (feet)																		
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
20	3.027	2.693	2.437	2.236	2.075	1.944	1.835	1.744	1.667	1.601	1.544	1.495	1.452	1.414	1.381	1.351	1.325	1.302	1.281
21	3.162	2.809	2.539	2.326	2.155	2.016	1.900	1.803	1.720	1.650	1.589	1.537	1.491	1.450	1.414	1.382	1.354	1.329	1.306
22		2.926	2.641	2.417	2.236	2.088	1.966	1.863	1.775	1.700	1.635	1.579	1.530	1.487	1.448	1.414	1.384	1.357	1.332
23		3.044	2.744	2.508	2.318	2.162	2.032	1.923	1.831	1.751	1.682	1.623	1.570	1.524	1.483	1.447	1.414	1.385	1.359
24		3.162	2.848	2.600	2.400	2.236	2.100	1.985	1.887	1.803	1.730	1.667	1.611	1.562	1.519	1.480	1.445	1.414	1.386
25			2.952	2.693	2.483	2.311	2.168	2.047	1.944	1.855	1.778	1.711	1.653	1.601	1.555	1.514	1.477	1.444	1.414
26			3.057	2.786	2.566	2.386	2.236	2.109	2.001	1.908	1.827	1.757	1.695	1.640	1.592	1.548	1.509	1.474	1.443
27			3.162	2.879	2.650	2.462	2.305	2.172	2.059	1.962	1.877	1.803	1.738	1.680	1.629	1.583	1.542	1.505	1.472
28				2.973	2.735	2.539	2.375	2.236	2.118	2.016	1.927	1.849	1.781	1.720	1.667	1.619	1.575	1.537	1.501
29				3.068	2.820	2.615	2.445	2.300	2.177	2.070	1.977	1.896	1.825	1.761	1.705	1.655	1.609	1.568	1.532
30				3.162	2.905	2.693	2.515	2.365	2.236	2.125	2.028	1.944	1.869	1.803	1.744	1.691	1.644	1.601	1.562
31					2.990	2.770	2.586	2.430	2.296	2.180	2.080	1.991	1.914	1.845	1.783	1.728	1.678	1.634	1.593
32					3.076	2.848	2.657	2.495	2.356	2.236	2.131	2.040	1.959	1.887	1.823	1.765	1.713	1.667	1.624
33					3.162	2.926	2.728	2.560	2.417	2.292	2.184	2.088	2.004	1.929	1.863	1.803	1.749	1.700	1.656
34						3.005	2.800	2.626	2.477	2.349	2.236	2.137	2.050	1.972	1.903	1.841	1.785	1.734	1.688
35						3.083	2.872	2.693	2.539	2.405	2.289	2.187	2.096	2.016	1.944	1.879	1.821	1.768	1.720
36						3.162	2.944	2.759	2.600	2.462	2.342	2.236	2.142	2.059	1.985	1.918	1.857	1.803	1.753
37							3.017	2.826	2.662	2.519	2.395	2.286	2.189	2.103	2.026	1.957	1.894	1.838	1.786
38							3.089	2.893	2.724	2.577	2.449	2.336	2.236	2.147	2.067	1.996	1.931	1.873	1.819
39							3.162	2.960	2.786	2.635	2.503	2.386	2.283	2.191	2.109	2.035	1.969	1.908	1.853
40								3.027	2.848	2.693	2.557	2.437	2.331	2.236	2.151	2.075	2.006	1.944	1.887
41								3.095	2.911	2.751	2.611	2.488	2.378	2.281	2.194	2.115	2.044	1.979	1.921
42								3.162	2.973	2.809	2.665	2.539	2.426	2.326	2.236	2.155	2.082	2.016	1.955
43									3.036	2.868	2.720	2.590	2.474	2.371	2.279	2.196	2.120	2.052	1.990
44									3.099	2.926	2.775	2.641	2.522	2.417	2.322	2.236	2.159	2.088	2.024
45									3.162	2.985	2.830	2.693	2.571	2.462	2.365	2.277	2.197	2.125	2.059
46										3.044	2.885	2.744	2.619	2.508	2.408	2.318	2.236	2.162	2.094
47										3.103	2.940	2.796	2.668	2.554	2.451	2.359	2.275	2.199	2.129
48										3.162	2.995	2.848	2.717	2.600	2.495	2.400	2.314	2.236	2.165
49											3.051	2.900	2.766	2.646	2.539	2.441	2.353	2.273	2.200
50											3.107	2.952	2.815	2.693	2.582	2.483	2.393	2.311	2.236

Table 27 - Guy Factors

New page. Info on this page was previously found on Page 3-74.

New page. Info on this page was previously found on Page 3-59.

3.7 Worksheets and Examples

The following worksheets are provided to assist in determining the appropriate pole class for tangent distribution pole structures. The method followed by the worksheet is valid for span lengths with a ratio less than 3:1. For span lengths that have a ration of 3:1 or greater, apply the wind load perpendicular on the longest span. The wind applied to the shorter span shall be multiplied by the cosine of the line angle.

The worksheets are divided into three sections:
1. Axial load due to wind on conductors and equipment.
2. Weight of conductors and equipment on the pole.
3. Axial load due to conductor tension.

Step	Action
1	Fill in the appropriate information on the worksheet.
2	Subtotal the separate sections of the worksheet.
3	Calculate the total axial load that will be applied to the pole.
4	Select the appropriate pole. **3.4** Select the Axial Loading table for the pole height used. **3.5** Determine the lowest guy attachment point on the pole **3.6** Choose the lowest pole class that will support the axial load imposed upon the pole. **Note:** There are circumstances where if the communications utilities were to be removed that a greater pole class would be required to support the electric utilities facilities. Therefore, always select the highest pole class determined from the worksheet.

Table 28 - Worksheet Instructions

3.7.10 Angle Pole Worksheet - 0° to 60°

Transverse Load Due to Wind

Conductor Name/Size	Number of Cond.		Ave. Span Length of Conductor (ft)		Transverse Load of Conductor or Equipment (lbs)		Cosine of 1/2 the line angle		H/L of the guy supporting the conductors		Total Axial Load on the pole (lbs)
Primary Distribution Conductor(s)											
		X		X		X		X		=	
		X		X		X		X		=	
		X		X		X		X		=	
Neutral Conductors											
		X		X		X		X		=	
Secondary Conductors											
		X		X		X		X		=	
		X		X		X		X		=	
Communications Conductor(s)											
		X		X		X		X		=	
		X		X		X		X		=	
		X		X		X		X		=	
		X		X		X		X		=	
Service Conductor(s)											
		X		X		X		X		=	
		X		X		X		X		=	
Equipment											
								X		=	
								X		=	
								X		=	
Transverse Axial Loading Due to Wind										=	

Weight of Conductors and Equipment

Conductor Name/Size	Number of Conductors or Equipment		Average Span of Conductor		Wt. per ft w/ice of Cond. Or Wt of Equip. (lbs)		Total
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
Weight of Conductors and Equipment						=	

New page. Info on this page was previously found on Page 3-65.

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Transverse Load Due to Conductor Tension

Conductor Name/Size	Number of Cond.		Max. Cond. Tension (See Section 6)		Sine of 1/2 the line angle		H/L of the guy supporting the conductors		Axial Load on the pole (lbs)
Primary Distribution Conductor(s)									
		X		X		X		=	
		X		X		X		=	
		X		X		X		=	
Neutral Conductor									
		X		X		X		=	
Secondary Conductor(s)									
		X		X		X		=	
		X		X		X		=	
Communications Conductor(s)									
		X		X		X		=	
		X		X		X		=	
		X		X		X		=	
		X		X		X		=	
Transverse Axial Loading Due to Conductor Tension								=	

Transverse Axial Loading Due to Service Conductor Tension

Conductor Name/Size	Number of Cond.		Max. Cond. Tension (See Section 6)		Sine of 1/2 the line angle		H/L of the guy supporting the conductors		Axial Load on the pole (lbs)
Service Conductors									
		X		X		X		=	
		X		X		X		=	
Transverse Axial Loading Due to Service Conductor Tension								=	

	Transverse Axial Loading Due to Wind (lbs)		Wt of Cond. And Equipment (lbs)		Transverse Axial Loading Due to Cond. Tension (lbs)		Transverse Axial Loading Due to Service Cond. Tension (lbs)		Grade C & B Overload Capacity Factor	
Total Axial Load Applied to Pole =	(	+		+		+	)	X	**2.20**	

Refer to the appropriate pole buckling limit table (Tables 15-20) based on pole height to determine the correct class of pole to install.

3.7.20 Deadend Pole Worksheet

Transverse Load Due to Wind

Conductor Name/Size	Number of Cond.		1/2 of the span length (ft)		Transverse Load of Cond. (lbs)		H/L of the guy supporting the conductors		Axial Load on the pole (lbs)
Primary Distribution Conductor(s)									
		X		X		X		=	
		X		X		X		=	
		X		X		X		=	
Neutral Conductor									
		X		X		X		=	
Secondary Conductor									
		X		X		X		=	
Communications Conductor(s)									
		X		X		X		=	
		X		X		X		=	
		X		X		X		=	
		X		X		X		=	
Equipment									
						X		=	
						X		=	
Transverse Axial Loading Due to Wind								=	

Transverse Load Due to Wind on Service Conductors

Conductor Name/Size	Number of Cond.		Avg. span length of Cond. (ft)		Transverse load of Cond. (lbs)		Cosine of the line Angle		H/L of the guy supporting the conductors		Total Axial Load on Pole (lbs)
Service											
		X		X		X		X		=	
		X		X		X		X		=	
Transverse Axial Loading Due to Wind on Service Conductors										=	

New page. Info on this page was previously found on Page 3-67.

New page. Info on this page was previously found on Page 3-68.

Weight of Conductors and Equipment

Conductor or Equipment Name/Size	Number of Conductors or Equipment		Average Span of Conductors		Wt per ft w/ice of Cond. Or Wt of Equipment (lbs)		Total
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
Transverse Load Due to Conductor Tension						=	

Transverse Load Due to Conductor Tension

Conductor or Equipment Name/Size	Number of Conductors or Equipment		Average Span of Conductors		Wt per ft w/ice of Cond. Or Wt of Equipment (lbs)		Total
Primary Distribution Conductor(s)							
		X		X		=	
		X		X		=	
		X		X		=	
Neutral Conductor							
		X		X		=	
Secondary Conductors							
		X		X		=	
		X		X		=	
Communications Conductor(s)							
		X		X		=	
		X		X		=	
		X		X		=	
		X		X		=	
Transverse Axial Loading Due to Conductor Tension						=	

Transverse Loading Due to Service Conductor Tension

Conductor Name/Size	Number of Cond.		Max. cond. Tension (See Section 6)		Sine of 1/2 of the line angle		H/L of the guy supporting the conductors		Axial Load on Pole (lbs)
Service Conductor(s)									
		X		X		X		=	
		X		X		X		=	
Transverse Axial Loading Due to Service Conductor Tension								=	

	Trans. Axial Loading Due to Wind (lbs)		Trans. Axial Loading Due to Wind on Serv. Cond.		Wt of Equipment		Trans. Axial Loading Due to Cond. Tension (lbs)		Trans. Axial Loading Due to Serv. Cond. Tension (lbs)		Grade C & B Overload Capacity Factor		
Total Axial Load Applied to Pole =	(	+		+		+		+	)	**X**	**2.20**	**=**	

Refer to the appropriate pole buckling limit table (Tables 15-20) based on pole height to determine the correct class of pole to install.

RESULTS

Enter information below. Select the highest pole class from the results.

Participants of Pole	Guy Lead (ft)	Lowest Guy Attachment from top of pole (ft)	Pole Class
Electric and Communications Conductors			
Electric (one guy)			
Electric (two guys)			

EXAMPLE: Line design requires a 45 ft. pole with a calculated Total Axial Load of 19,000 lbs. determined by using the worksheet above. Look up 19,000 lbs in Table 19 for a 45 ft pole and start with the lowest guy attachment. For this example, assume a 15 ft. guy attachment (Communications guy), 1 ft. guy attachment (Electric primary guy) and 8 ft. guy attachment (Electric secondary guy if used) and record results in the table below. Select the highest class pole so if communications are removed from a pole, the pole is still strong enough for the remaining electric facilities.

Participants of Pole	Guy Lead	Lowest Guy Attachment from top of pole	Pole Class
Electric and Communications Conductors	**15 ft**	**15 ft**	**5**
Electric (one guy)	**15 ft**	**1 ft**	**4**
Electric (two guys)	**15 ft**	**8 ft**	**5**

In this example, the highest class pole is a Class 4 pole which would be the correct selection.

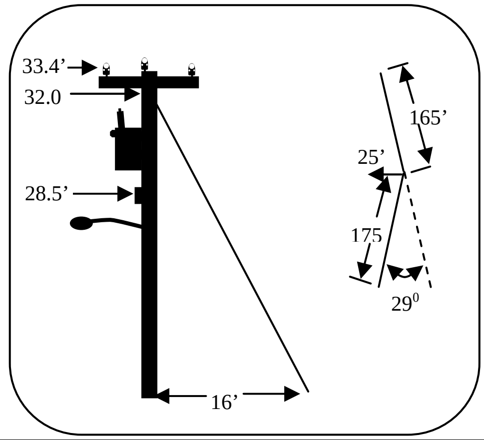
New page. Info on this page was previously found on Page 3-69.

New page. Info on this page was previously found on Page 3-51.

3.7.30 EXAMPLE #1: ANGLE GUYING

Given:

15 kV class construction
150 ft. ruling span
175 ft. actual front span
165 ft. actual back span
1 – 40 ft., class 3 wood pole
3 – 477 kcmil Al AAC bare conductors (W21BA)
1 – 3/c – 1/0 Al triplex secondary cable (W15C)
1 street light (attachment height = 27 ft.)
1 – 50 kVA transformer
(attachment height = 30 ft.)
Corner Pull – 25 ft. or 29 degrees
Grade B construction
Soil Classification = 4



Transverse Wind Loading: Steps 1-6

Step	Action	Use
1	Determine Conductor Wind Load Tensions (WLT) from Sections 6 and 10.	3 - 477 kcmil Al bare (W21BA) = 0.5992 lbs./ft. 1 - 3/c 1/0 Al triplex secondary cable (W15C) = 0.652 lbs./ft.
2	Calculate Total Conductor Wind Load Tension.	Total Conductor Wind Load Tension (WLT) = (No. of Conductors) x (Conductor WLT) x $\frac{\text{(Back Span + Front Span)}}{2}$ x (Conductor/Equipment Height /Guy Height) Total Conductor Wind Load Tension = $(3x0.5992\ lbs./\ ft.)x\left(\frac{175\ ft.+165\ ft.}{2}\right)x\ \frac{33.4}{32}+$ $(1x0.652\ lbs./\ ft.)x\left(\frac{175\ ft.+165\ ft.}{2}\right)x\ \frac{28.5}{32} = 418\ lbs.$
3	Determine and calculate Total Equipment Wind Load Tension from Table 15 and Table 16.	Equipment Wind Load = Wind load x (Attachment height/Guy height) 1 – 40 ft. Class 3 wood pole (Table 16) = 106 lbs x (17 ft./32 ft.) = **57 lbs.** 1 – 50 kVA transformer (Table 15) = 42 lbs x (30 ft./32 ft.) = **40 lbs.** 1 – streetlight (Table 15) = 13 lbs x (27 ft./32 ft.) = **11 lbs.** Total Equipment Transverse Wind Load = **108 lbs.**
4	Calculate Transverse Wind Loading.	Transverse Wind Loading = (Total Conductor Transverse Wind Loading) + (Total Equipment Transverse Wind Loading) Transverse Wind Loading – 418 lbs. + 108 lbs. = 526 lbs.
5	Determine Construction Grade Overload Factor from Table 11.	Grade B, Transverse Loads: Wind, Overload Factor = 2.50
6	Calculate Total Transverse Wind Loading.	Total Transverse Wind Loading = (Transverse Wind Loading) x (Overload Factor) Total Transverse Wind Loading = 526 lbs. x 2.50 = **1,315 lbs**.

EXAMPLE #1: ANGLE GUYING (continued)

Transverse Wire Tension Steps 7-11

Step	Action	Use
7	Determine Conductor Tensions from Section 6	3 - 477 kcmil Al AAC bare (W21BA) = 2,000 lbs. 1 - 3/c 1/0 Al triplex secondary cable (W15C) = 1,925 lbs.
8	Calculate Total Tension at the guy attachment height.	Total Conductor Tension = $(No.ofConductors)x\left(\frac{ConductorHeight}{GuyHeight}\right)x(ConductorTension)$ Total Conductor Tension = $\left(3x\frac{33.4\,ft.}{32.0\,ft}x2{,}000lbs.\right)+\left(1x\frac{28.5\,ft.}{32.0\,ft.}x1{,}925lbs.\right)=7{,}977lbs.$
9	Determine Line Angle Factor from Table 13.	Pull = 25 ft.; Line Angle = 29 degrees; Line Angle Factor = 0.5008
10	Determine Construction Grade Overload Factor from Table 11.	Grade B, Transverse loads: Wire Tension, Overload Factor = 1.65
11	Calculate Transverse Wire Tension.	Transverse Wire Tension = (Total Conductor Tension) x (Line Angle Factor) x (Overload Factor) Transverse Wire Tension = 7,977 lbs. x 0.5008 x 1.65 = 6,592 lbs.

Anchor Guy Requirements Steps 12-17

Step	Action	Use
12	Calculate Total Transverse Tension.	Total Transverse Tension = (Transverse Wind Loading) + (Transverse Wire Tension) Total Transverse Tension = 1,315 lbs. + 6,592 lbs. = 7,907 lbs.
13	Determine Guy Factor from Table 27	Guy Height = 32.0 ft.; Guy Lead = 16 ft.; Guy factor = 2.236
14	Calculate Total Tension in guy wire and anchor.	Tension (guy wire) = (Total Transverse Tension) x (Guy Factor) Tension (guy wire) = 7,907 lbs. x 2.236 = 17,682 lbs. Tension in guy wire – tension in anchor (except sidewalk guys)
15	Determine guy wire Strength Factor from Table 12.	Grade B, guy wire, Strength Factor = 0.9 Grade B, anchor, Strength Factor = 1.0
16	Determine Guy Wire and Anchor Requirements.	Guy Wire Req. = $\frac{Tension(GuyWire)}{StrengthFactor}=\frac{17{,}680}{.9}=19{,}645lbs.$ Anchor Req. = $\frac{Tension(Anchor)}{StrengthFactor}=\frac{17{,}645}{1.0}=17{,}645lbs.$
17	Determine Guy Components from Table 2, Table 4, Table 7, etc.	**Guy Wire Required = 19,645 lbs**. Use a 25M guy (looped 12.5M guy wire) (G15A) with one 54 in. strain insulator (30,000 lbs.) (TI95C) **Anchor Required = 17,645 lbs** Soil Class = 4 Use one 14 in. Helix (A16B) with one 1in. x 7 ft. rod (A18K)

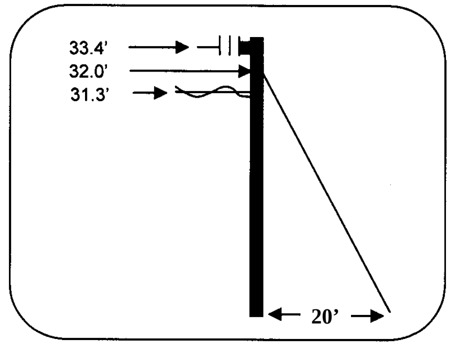
Note: In this example, the guying is adequate but the pole is overloaded. A higher class pole is needed.

New page. Info on this page was previously found on Page 3-52.

EXAMPLE #2: DEADEND GUYING

Given:

15 kV class construction
150 ft. ruling span
1 – 40 ft., class 3 wood pole
3 – 1/0, Al AAAC, bare conductors (W14B)
1 – 3/c – 1/0 Al. triplex secondary cable ((W15C)
Grade C construction
Soil Classification = 4



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Transverse Wire Tension: Steps 1-8

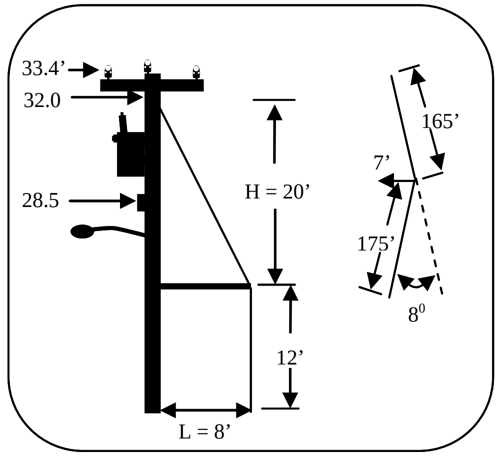
Step	Action	Use
1	Determine Conductor Tensions from Section 6	1 - 1/0 Al AAAC, bare (W14B) = 2,000 lbs. 1 - 3/c 1/0 Al secondary cable (W15C) = 1,925 lbs.
2	Calculate Total Conductor Tension at the guy attachment height	Total Conductor Tension = $(No.ofConductors)x\left(\frac{ConductorHeight}{GuyHeight}\right)x(ConductorTension)$ Total Conductor Wind Load Tension = $\left(3x\frac{33.4\ ft.}{32.0\ ft.}x2.000\ lbs.\right)+\left(1x\frac{31.3\ ft.}{32.0\ ft.}x1{,}925\ lbs.\right)=8{,}146\ lbs.$
3	Determine Guy Factor from Table 27	Guy Height = 32.0 ft.; Guy Lead = 20 ft.; Guy Factor = 1.887
4	Determine Construction grade Overload Factor from Table 11.	Grade C, Longitudinal loads: Deadends, Overload Factor = 1.10
5	Calculate Tension in guy wire and anchor	Tension (guy wire) = (Total Conductor Tension) x (Guy Factor) x (Overload Factor) Tension (guy wire) = 8,146 lbs. x 1.887 x 1.10 = 16,909 lbs. Tension in guy wire – tension in anchor (except sidewalk guys).
6	Determine guy wire and anchor Strength Factor from Table 12.	Grade C, guy wire, Strength Factor = 0.9 Grade C, anchor, Strength Factor = 1.0
7	Determine guy wire and anchor requirements	$GuyWire\ Req.=\frac{Tension(GuyWire)}{(StrengthFactor)}=\frac{16{,}909lbs.}{0.9}=18{,}788lbs.$ $Anchor\ Req.=\frac{Tension(anchor)}{(StrengthFactor)}=\frac{16{,}909lbs.}{1.0}=16{,}909lbs.$
8	Determine Guy Components from Table 2, Table 4, Table 7, etc.	**Guy wire required = 18,788 lbs**. Use a 25M guy (looped 12.5M guy wire) (G15A) with one 54 in. strain insulator (30,000 lbs.) (TI-95B) **Anchor required = 16,909 lbs** Soil class = 4 Use one 10 in. Helix (A16A) with one 1 in. x 7 ft. rod (A18K)

Note: Anchors and anchor rods installed for joint company use must be sized to hold both electric and telephone company conductors and equipment.

3.7.40 EXAMPLE #3: SIDEWALK/STRUT GUYING

Given:

15 kV class construction
150 ft. ruling span
175 ft. actual front span
165 ft. actual back span
1 – 40 ft., class 3 wood pole
3 – 1/0 AAAC, bare conductors (W14B)
1 – 3/c 1/0 Al triplex secondary cable (W15C)
1 – streetlight (attachment height = 27 ft.)
1 – 50 kVA transformer
(attachment height = 30 ft.)
Corner Pull – 7 ft. or 8 degrees
Grade B construction
Pole height above ground – 34 ft.
Soil Classification = 4
Strut attachment from top of pole = 22 ft.



Transverse Wind Loading: Steps 1-6

Step	Action	Use
1	Determine Conductor Wind Load Tensions from Sections 6 and 10.	3- -1/0 Al AAAC, bare (W14B) bare = 0.4656 lbs./ft. 1- 3/c 1/0 Al. triplex secondary cable (W15C) = 0.652 lbs./ft.
2	Calculate Total Conductor Wind Load Tension	Total Conductor Wind Load Tension = (No. of Conductors) x (Conductor WLT) x $\frac{\text{(Back Span + Front Span)}}{2}$ x (Conductor/Equipment Height /Guy Height) Total Conductor Wind Load Tension = $(3x0.4656\ lbs./\ ft.)x\left(\frac{175\ ft.+165\ ft.}{2}\right)x\ \frac{33.4}{32}+$ $(1x0.652\,lbs./\ ft.)x\left(\frac{175\ ft.+165\ ft.}{2}\right)x\ \frac{28.5}{32}=347\,lbs.$
3	Determine and calculate Total Equipment Wind Load Tension from Table 15 and Table 16.	Equipment Wind Load = Wind load x (Attachment height/Guy height) 1 – 40 ft. Class 3 wood pole (Table 16) = 125 lbs. x (17 ft./32 ft.) = **66 lbs**. 1 – 50 kVA transformer (Table 15) = 42 lbs. x (30 ft./32 ft.) = **38 lbs.** 1 – streetlight (Table 15) = 13 lbs. x (27 ft./32 ft. = **11 lbs.** Total Equipment Transverse Wind Load = **115 lbs.**
4	Calculate Transverse Wind Loading	Transverse Wind Loading = (Total Conductor Transverse Wind Loading) + (Total Equipment Transverse Wind Loading) Transverse Wind Loading – 347 lbs. + 115 lbs. = 462 lbs
5	Determine Construction Grade Overload Factor from Table 11.	Grade B, Transverse Loads: Wind, Overload Factor = 2.50
6	Calculate Total Transverse Wind Loading	Total Transverse Wind Loading = (Transverse Wind Loading) x (Overload Factor) Total Transverse Wind Loading = 462 lbs. x 2.50 = **1,155 lbs**.

New page. Info on this page was previously found on Page 3-54.

EXAMPLE #3: SIDEWALK GUYING (continued)

Transverse Wire Tension Steps 7-18

New page. Info on this page was previously found on Page 3-55.

Step	Action	Use
7	Determine Conductor Tensions from Section 6.	3 - 1/0 Al AAAC, bare (W14B) bare = 2,000 lbs. 1 - 3/c 1/0 Al triplex secondary cable (W15C) = 1,925 lbs.
8	Calculate Total Tension at the guy attachment height.	Total Conductor Tension = $(No.ofConducto\ rs)x\left(\frac{ConductorH\ eight}{GuyHeight}\right)x(ConductorT\ ension)$ Total Conductor Tension = $\left(3x\frac{33.4\ ft.}{32.0\ ft}x2{,}000\ lbs.\right)+\left(1x\frac{28.5\ ft.}{32.0\ ft.}x1{,}925\ lbs.\right)=7{,}977\ lbs.$
9	Determine Line Angle Factor from Table 13.	Pull = 7 ft.; Line Angle = 8 degrees; Line Angle Factor = 0.1395
10	Determine Construction Grade Overload Factor from Table 11.	Grade B, Transverse loads: Wire Tension, Overload Factor = 1.65
11	Calculate Transverse Wire Tension	Transverse Wire Tension = (Total Conductor Tension) x (Line Angle Factor) x (Overload Factor) Transverse Wire Tension = 7,977 lbs. x 0.1395 x 1.65 = 1,836 lbs.
12	Calculate Total Transverse Tension	Total Transverse Tension = (Transverse Wind Loading) + (Transverse Wire Tension) Total Transverse Tension = 1,155 lbs. + 1,836 lbs = 2,991 lbs.
13	Calculate Tension on the anchor	Tension (anchor) = (Total Transverse Tension) x <u>(Pole height above ground)</u> / (Strut Length) $Tension\ (anchor\ )=2{,}991 lbs.x\frac{34\ ft.}{8\ ft.}=12{,}712\ lbs.$
14	Calculate Compression on the strut	Compression (Strut) = Total Transverse Tension) x <u>(Pole height above ground)</u> / (Guy attach height – strut attach height) $Compression(Strut)=2{,}991 lbs.x\frac{(34\ ft.)}{(32\ ft.-12\ ft.)}=5{,}085 lbs.$
15	Determine the Strut Factor from Table 23.	Strut length = 8 ft., Guy attachment height less Strut attachment height = 20 ft. Strut Factor = 2.693
16	Calculate tension in guy wire	Tension (guy wire) = (Compression (strut) x Strut Factor) Tension (guy wire) = 5,085 lbs. x 2.693 = 13,694 lbs.
17	Determine guy wire and anchor Strength Factor from Table 12.	Grade C, guy wire, Strength Factor = 0.9 Grade C, anchor, Strength Factor = 1.0
18	Determine guy wire and anchor requirements	$GuyWire\ \mathrm{Re}\,q.=\frac{Tension\,(GuyWire)}{StrengthFa\,ctor}=\frac{13{,}694 lbs.}{0.9}=15{,}216 lbs.$ $Anchor\ \mathrm{Re}\,q.=\frac{Tension\,(Anchor\,)}{StrengthFa\ ctor}=\frac{12{,}712 lbs.}{1.0}=12{,}712 lbs.$ Tension (guy wire) will always be greater than tension (anchor) on all sidewalk guying installations.

EXAMPLE #3: SIDEWALK GUYING (continued)

Transverse Wire Tension (continued) Step 19

Step	Action	Use
19	Determine Guy Components from Table 2, Table 4, Table 7, etc.	**Guy required = 15,443 lbs.** Use a 25M guy (looped 12.5M guy wire) (G15A) with one 54 in. strain insulator (30,000 lbs.)(TI-95B) **Anchor required = 12,903 lbs.** Soil class = 4 Use one 10 in. Helix (A16A) with one 1 in. x 7 ft. rod (A18K)

Pole Moment & Compression Strength Steps 20-26

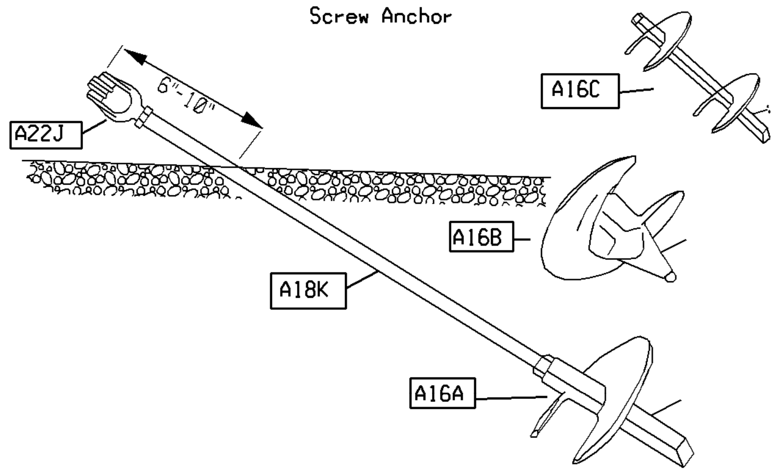
Step	Action	Use
20	Determine Pole Moment (M) and Compression (CC)	M equals (Pole height above ground minus distance between guy attachment and strut attachment (H) times horizontal load). CC equals anchor tension determined from Step 13.
21	Calculate Pole Moment (M)	M = (34 ft. – 20 ft.) x 2,991lbs. = **41,874 ft-lbs**.
22	Calculate Compression (CC)	From Step 13, CC = **12,712 lbs**.
23	Determine lowest guy attachment from top of pole	Lowest guy attachment is 2 ft. from top of pole
24	Determine allowable Pole Moment (Ma) and Compression (Ca) from Table 25 and Table 24.	A safely loaded pole is determined by the equation **CC/Ca + M/Ma<1**
25	Calculate if Pole Size and Class are adequate for attached load.	From Sidewalk/Strut guy Pole Loading Factor Tables for a 40 ft., Class 3 pole <u>Calculate if CC/Ca + M/Ma<1</u> Lowest guy attachment is 2 ft. from top of pole: **Ca** = **31,595** from Table 24 Strut attachment 22 ft. from top of pole: **Ma** = **65,459** from Table 25 **CC = 12,712** from Step 13 **M = 41,874** from Step 21 Therefore, (12,712/31,595) + (41,874/65,459) = **1.04**
26	Determine if pole is adequate	Since 1.04 is more than 1, a 40 ft. Class 3 pole is not adequate so a 40 ft. Class 2 pole is required.

New page. Info on this page was previously found on Page 3-56.

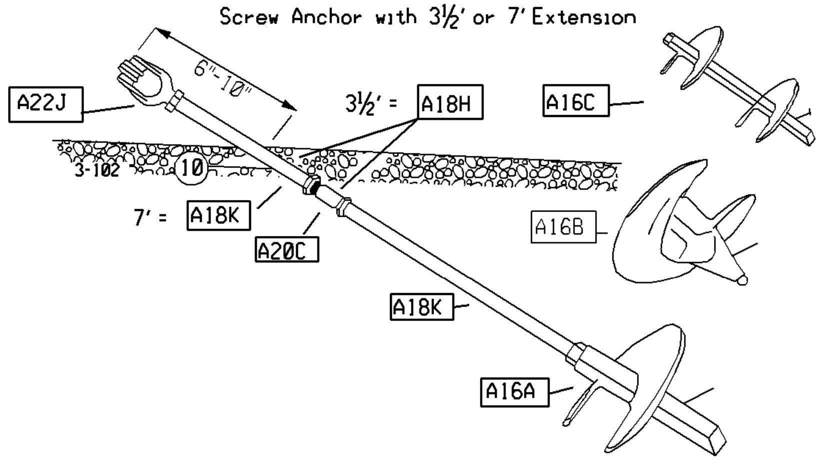
CU = ANC-3-102,T4HEL,84ROD	2-4" HEL W/84" ROD	CU = ANC-3-102-10HEL,84RD,84EX	1-10" HEL W84"ROD,84"EXT
CU = ANC-3-102,T4HEL,84RD,42EX	2-4" HEL W/84"ROD,42"EXT	CU = ANC-3-102,14HEL,84ROD	1-14" HEL W/84"ROD
CU = ANC-3-102-T4HEL,84RD,84EX	2-4" HEL W/84"ROD,84"EXT	CU = ANC-3-102,14HEL,84RD,42EX	1-14" HEL W/84"ROD,42"EXT
CU = ANC-3-102,10HEL,84ROD	1-10" HEL W/84"ROD	CU = ANC-3-102-14HEL,84RD,84EX	1-14" HEL W/84"ROD,84"EXT
CU = ANC-3-102,10HEL,84RD,42EX	1-10" HEL W/84"ROD,42"EXT		

Supersedes 7/07 Issue – Updated CUs.

Screw Anchor



Screw Anchor with 3½' or 7' Extension



To achieve maximum holding capacity, the torque applied should approach 5,500 foot-pounds. This can be translated to hydraulic auger gauge pressure (psi) per the following table.

Hydraulic Auger Gauge Pressure (psi)	Applied Torque Low Speed (ft.-lbs.)	Predicted Holding Capacity (lbs.)	
		10" Screw Anchor Helix	14" Screw Anchor Helix
750	1,600	11,200	16,000
1,000	3,250	22,750	25,000
1,250	5,000	34,000	37,000

Notes:
1. To assure an adequate screw anchor installation, use these values if the digger has a hydraulic auger pressure gauge. Contact Standards to confirm that your digger has the gauges necessary to utilize this information. The digger operator should notify the designer / engineer what anchor holding strength was achieved based on applied auger gauge pressure. If the desired holding strength is not achieved, continue installing the anchor rod deeper with a 3.5 ft. or 7 ft. extension rod. If the desired holding strength is still not achieved, consider installing a second anchor rod with additional guys.
2. Disturb the soil as little as possible.
3. Maintain alignment during installation.
4. Do not use more than one (1) extension rod per installation.

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CU = ANC-3-103,ROCK,1X30	1" X 30" ROCK ANCHOR
CU = ANC-3-103,ROCK,1X53	1" X 53" ROCK ANCHOR
CU = ANC-3-103,ROCK,1X72	1" X 72" ROCK ANCHOR

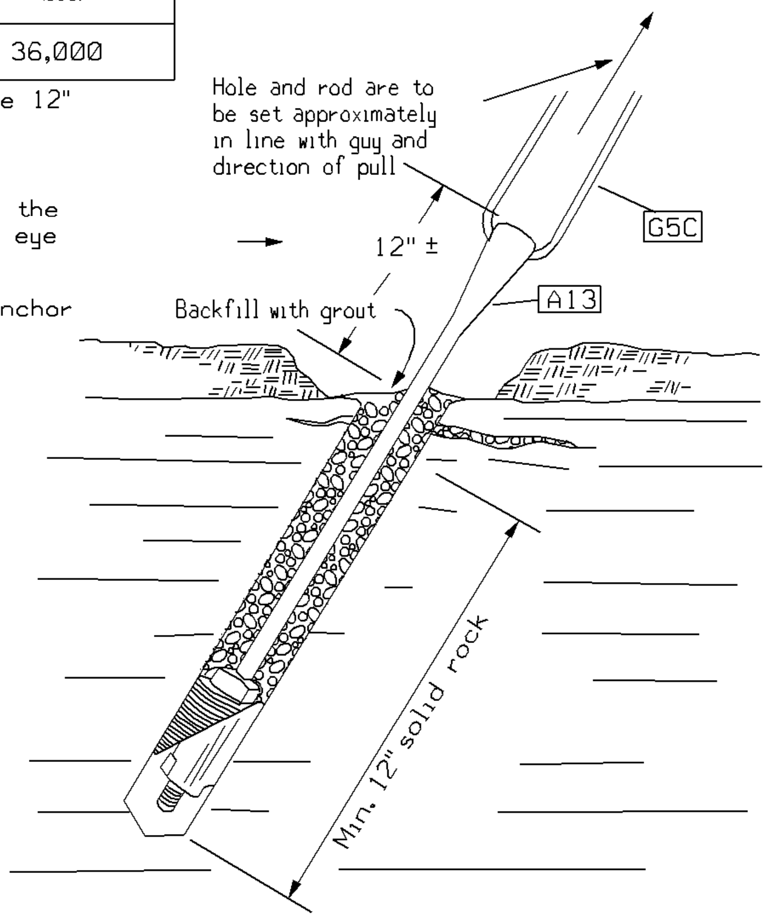
Guidelines for Installation of the expanding rock anchor are as follows:

1. Remove the soil to the top of the rock layer.

2. Drill the properly sized hole, in line with the final installed guy angle, into the solid rock. The drill hole must be clean and smooth and sized per the chart below.

Anchor Rod Diameter	Anchor Size	Required Hole Size	Holding Strength (lbs)
1"	2¼"	2⅜"	36,000

Minimum depth for the hole should be 12" into the solid rock.



3. Insert the unexpanded anchor into the hole and insert a bar through the eye of the anchor rod.

4. Turn the bar clockwise until the anchor is firmly expanded against the sides of the hole.

5. Test pull the anchor before backfilling by applying a load in the direction of the final guy angle. If the anchor is properly set, there should be no movement or creep of the anchor while applying the test load. If creep does occur (under load) corrective action is required, since this movement would indicate that the anchor is set in soft, weathered rock or possibly in a rock joint or fracture zone in the rock.

6. Where corrective action is necessary, additional drilling into sound rock and resetting of the anchor should be attempted. Where the rock is indicated to be soft or weathered, the installation of a twin 4" screw anchor should be attempted.

7. Rock anchors shall be backfilled with a sand-cement grout to keep out surface water that could result in deterioration of the rock through freezing and thawing.

Supersedes 7/07 Issue – Updated CUs.

CU = ANC-3-104,14HEL,84RD,HNDG	1-14" HEL W/84"ROD HAND DUG

Supersedes 1/07 Issue – Updated CU.

Use this hand-dug anchor when a screw anchor cannot be installed due to surrounding obsticles such as cable or pipes.

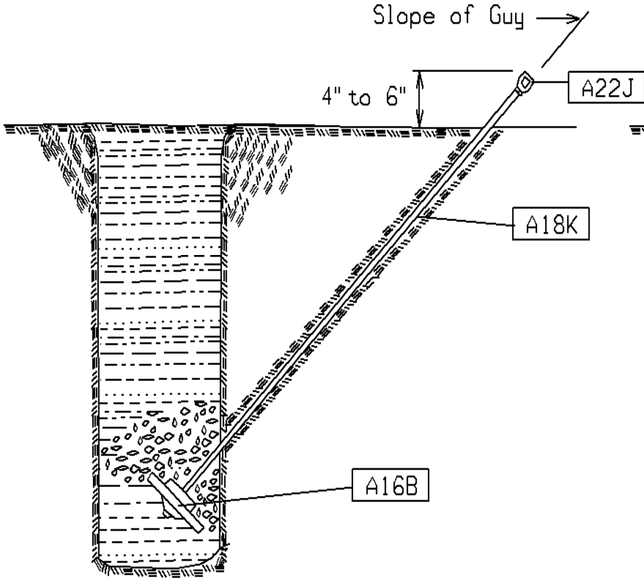


Figure 1

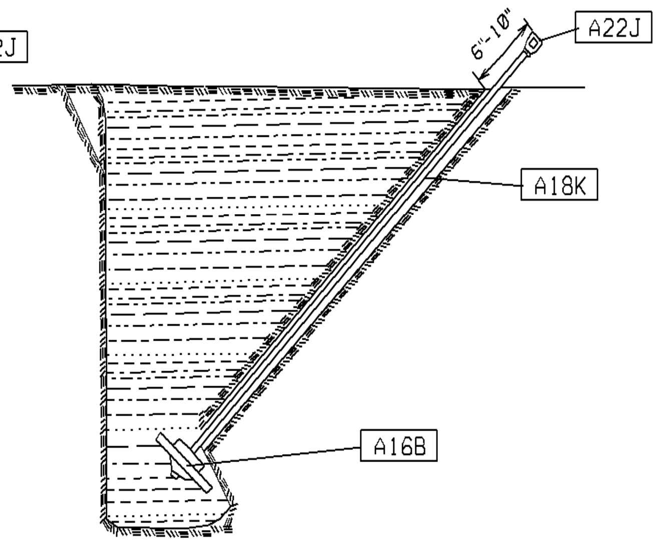


Figure 2

Installation Procedure

A. Dig hole a minimum 5½ feet deep.
B. Cut channel for rod to line up with guy.
C. Scrape loose earth to far corner of bottom of hole to square with bottom of anchor.
D. Attach 14" Helix (A16B) to 1" x 7' Rod (A18K).
E. Fit anchor assembly in hole.
F. Line up anchor rod with slope of guy (upper guy when two guys are attached).
G. Tamp crushed stone or coarse gravel between face of anchor and undisturbed earth. Fill void completely.
H. Backfill all earth removed - thoroughly tamping by layers.

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CU = GUY-3-105,12.5MDWNG/TI95B	GROUNDED 12.5M GUY - WYE PRIMARY (FIG #1)
CU = GUY-3-105,12.5MDWN2-TI95B	INSULATED 12.5M GUY - DELTA PRIMARY (FIG #2)

Figure 1 - **Primary Guy for WYE Circuits**

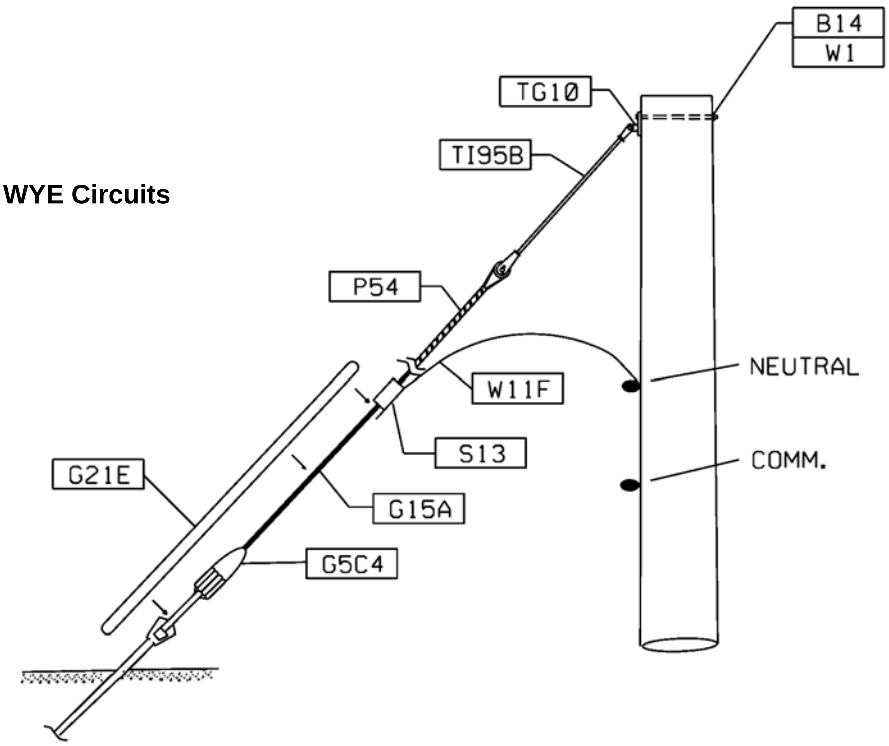
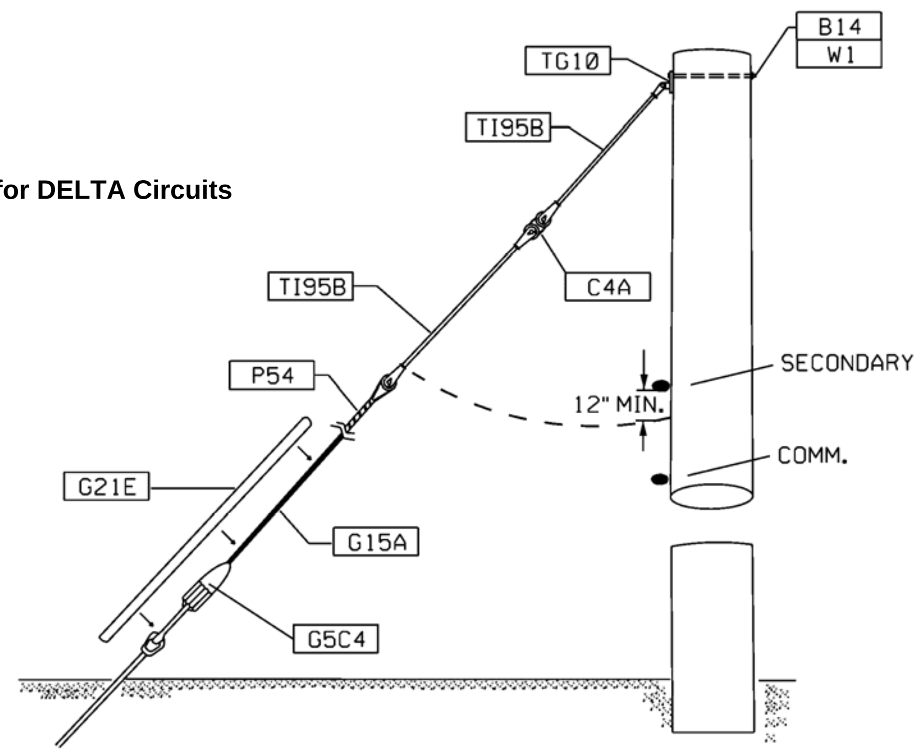


Figure 2 - **Primary Guy for DELTA Circuits**



Supersedes 7/09 Issue – Updated Fig 2 - Primary Guy for Delta Circuits.

NOTE: If the lower fiberglass rod does not extend a minimum of 12" below the secondary attachment if the guy were slack against the pole, additional fiberglass rods shall be used (applies to delta circuits).

CU = GUY-3-106,25MDOWN	GROUNDED 25M GUY - WYE PRIMARY (FIG #1)
CU = GUY-3-106,25MDWN2-TI95C	INSULATED 25M GUY - DELTA PRIMARY (FIG #2)

Supersedes 7/09 Issue – Updated Figure 2 - 25M Down Guy on Delta Circuits.

Figure 1 - **25M Down Guy on WYE Circuits**

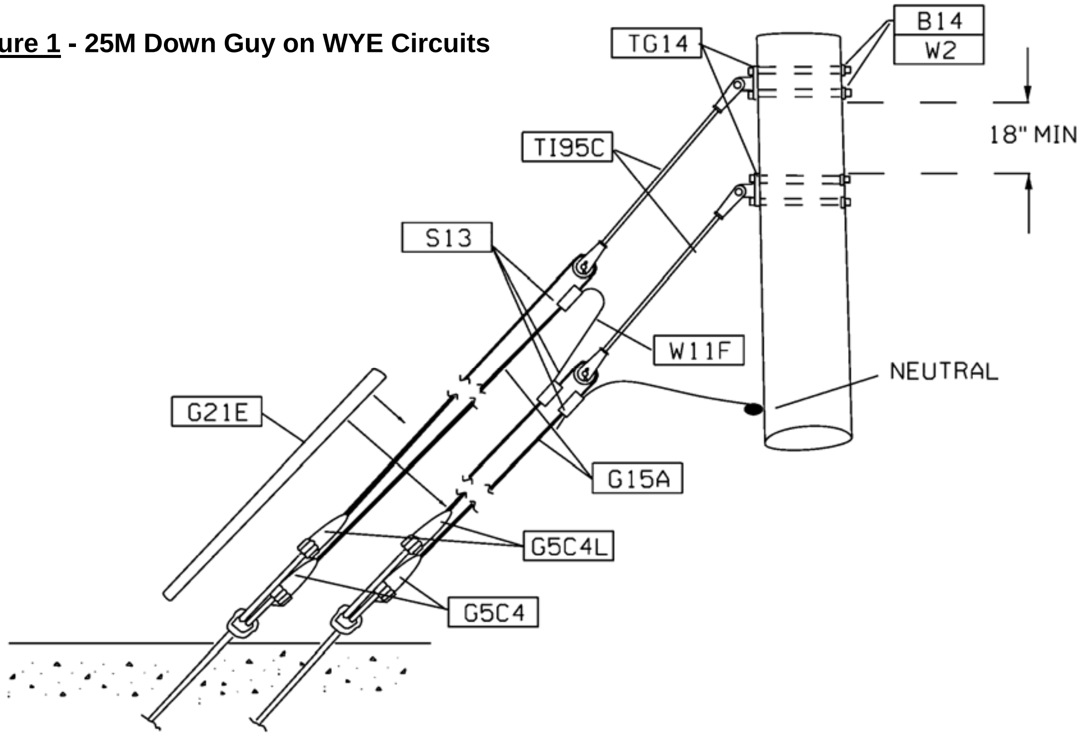
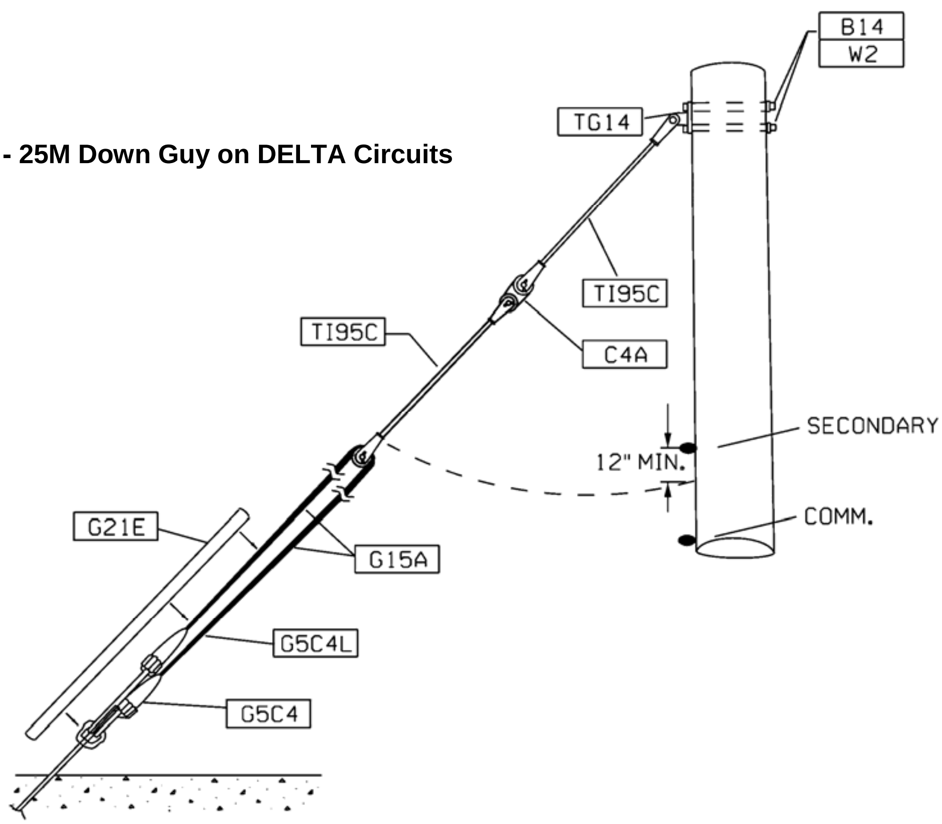


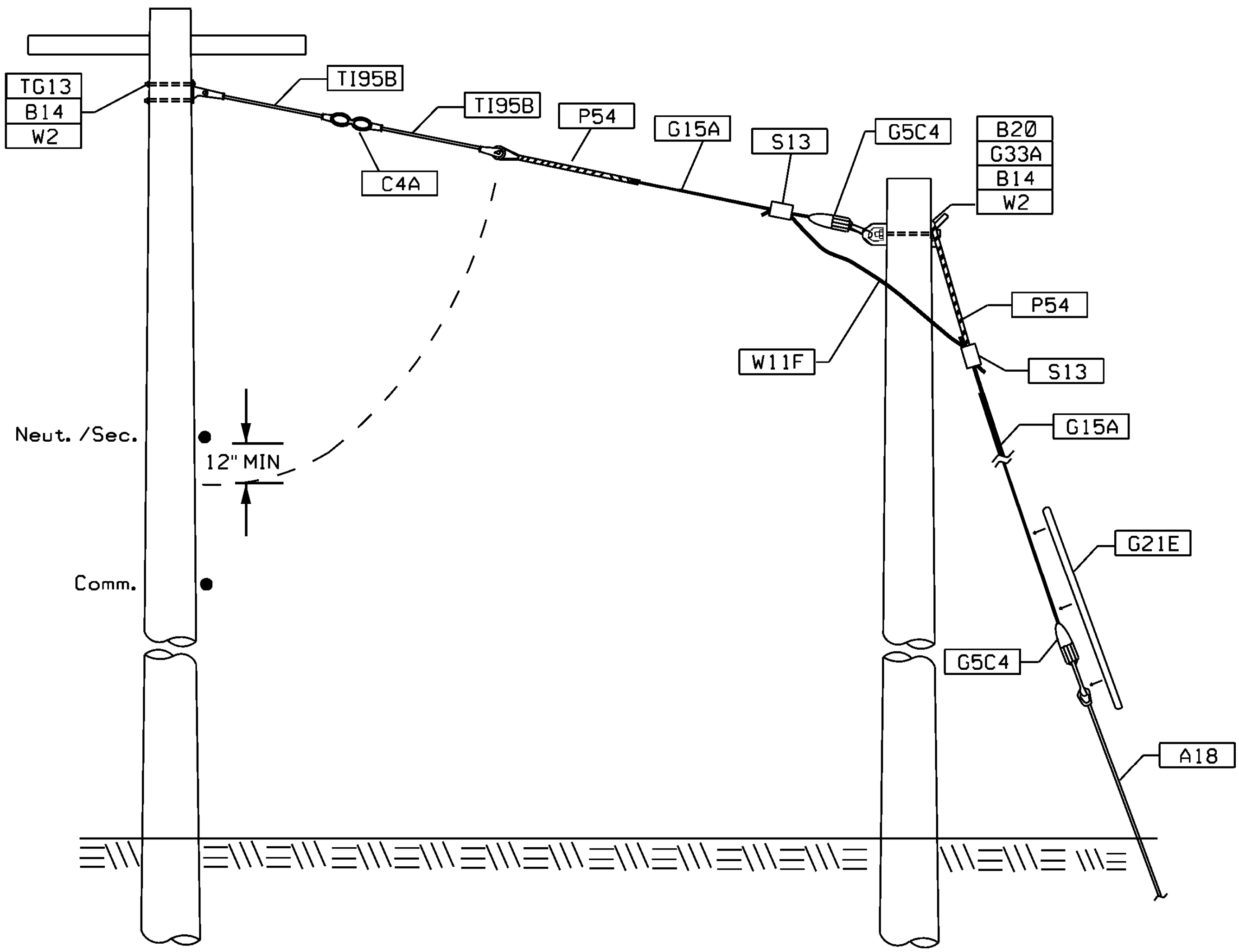
Figure 2 - **25M Down Guy on DELTA Circuits**



NOTE 1: If the lower fiberglass rod does not extend a minimum of 12" below the secondary attachment if the guy were slack against the pole, additional fiberglass rods shall be used (applies to delta circuits).
NOTE 2: Adjacent anchors to have a 4 foot minimum separation (for both wye and delta circuits).

CU = GUY-3-107D,12.5MSPANPRIDP	GUY,12.5M SPAN GUY- DELTA PRIMARY	(SPAN GUY COMPONENTS ONLY)
CU = GUY-3-107D,12.5MDWNNOINS	GUY,12.5M DOWN NO INSUL- STUB POLE	(ANCHORED DOWN GUY WIRE)

CU = GUY-G15A,WIRE12.5M	GUY, G15A, WIRE 12.5M ALUMO-WELD	(GUY WIRE ONLY)



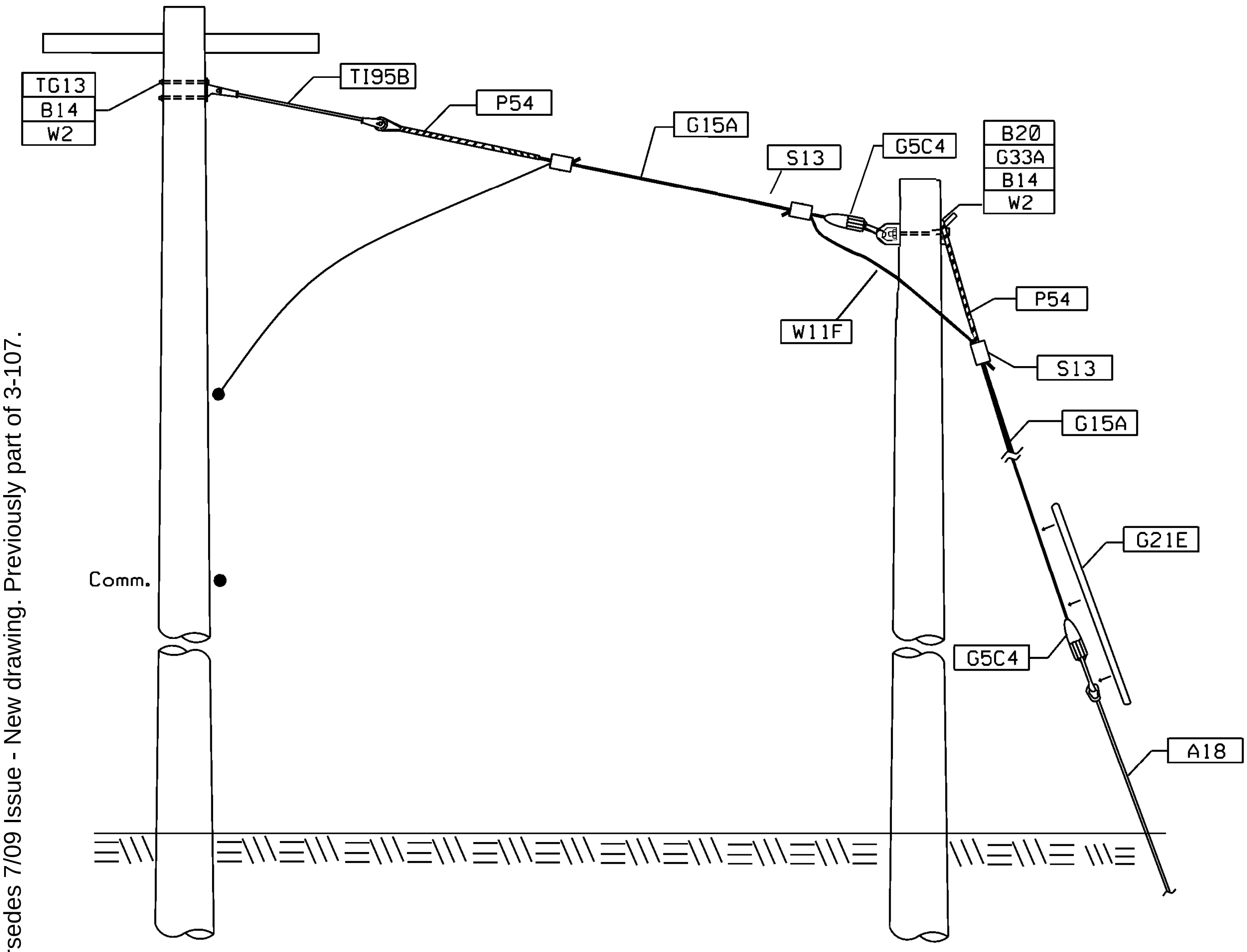
Supersedes 7/09 Issue – New drawing. Previously part of 3-107.

NOTE 1: If the lower fiberglass rod does not extend a minimum of 12” below the secondary attachment if the guy were slack against the pole, additional fiberglass rods shall be used.

NOTE 2: It is acceptable to use the tail of the stub pole guy wire as a bond to the pole-to-pole guy wire, or vice versa. Otherwise, a piece of #4 solid copper wire should be used as a bond wire as shown in the drawing above. DO NOT bond to the preform or the bail of the automatic. These connections must be wire to wire and a compression connector must be used.

CU = GUY-3-107Y,12.5MSPANPRIYP	GUY,12.5M SPAN GUY- WYE PRIMARY	(SPAN GUY COMPONENTS ONLY)
CU = GUY-3-107Y,12.5MDWNGNOINS	GUY,12.5M DOWN GROUNDED NO INSUL- STUB POLE	(ANCHORED DOWN GUY WIRE)

CU = GUY-G15A,WIRE12.5M	GUY, G15A, WIRE 12.5M ALUMO-WELD	(GUY WIRE ONLY)

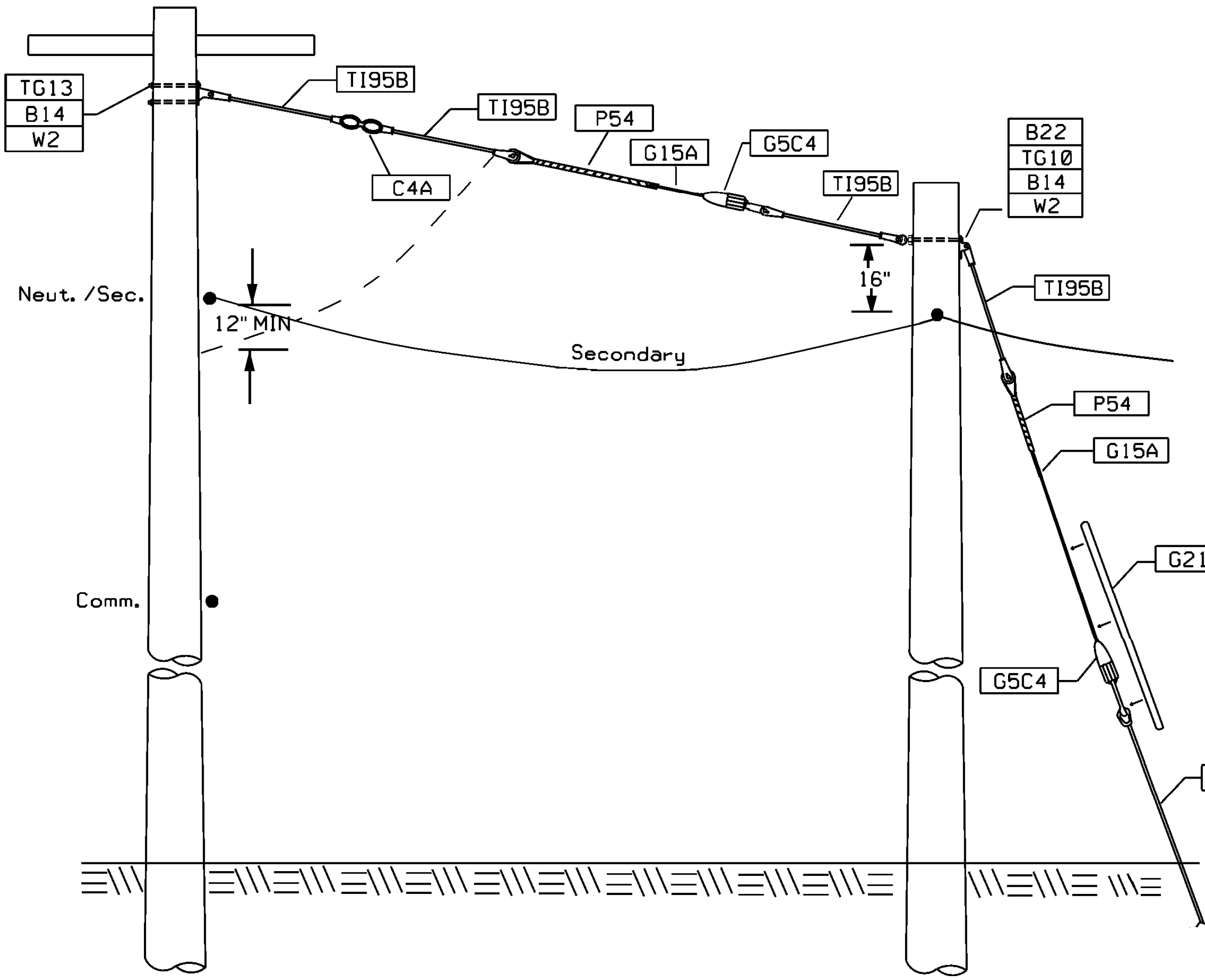


Supersedes 7/09 Issue - New drawing. Previously part of 3-107.

NOTE: It is acceptable to use the tail of the stub pole guy wire as a bond to the pole-to-pole guy wire, or vice versa. Otherwise, a piece of #4 solid copper wire should be used as a bond wire as shown in the drawing above. DO NOT bond to the preform or the bail of the automatic. These connections must be wire to wire and a compression connector must be used.

CU = GUY-3-108D,12.5MSPANSECDP	GUY,12.5M SPAN GUY, W/SEC - DELTA PRIMARY	(SPAN GUY COMPONENTS ONLY)
CU = GUY-3-108D,12.5MDWNW/INS	GUY,12.5M DOWN W /INSUL - STUB POLE	(ANCHORED DOWN GUY WIRE)

CU = GUY-G15A,WIRE12.5M	GUY, G15A, WIRE 12.5M ALUMO-WELD	(GUY WIRE ONLY)

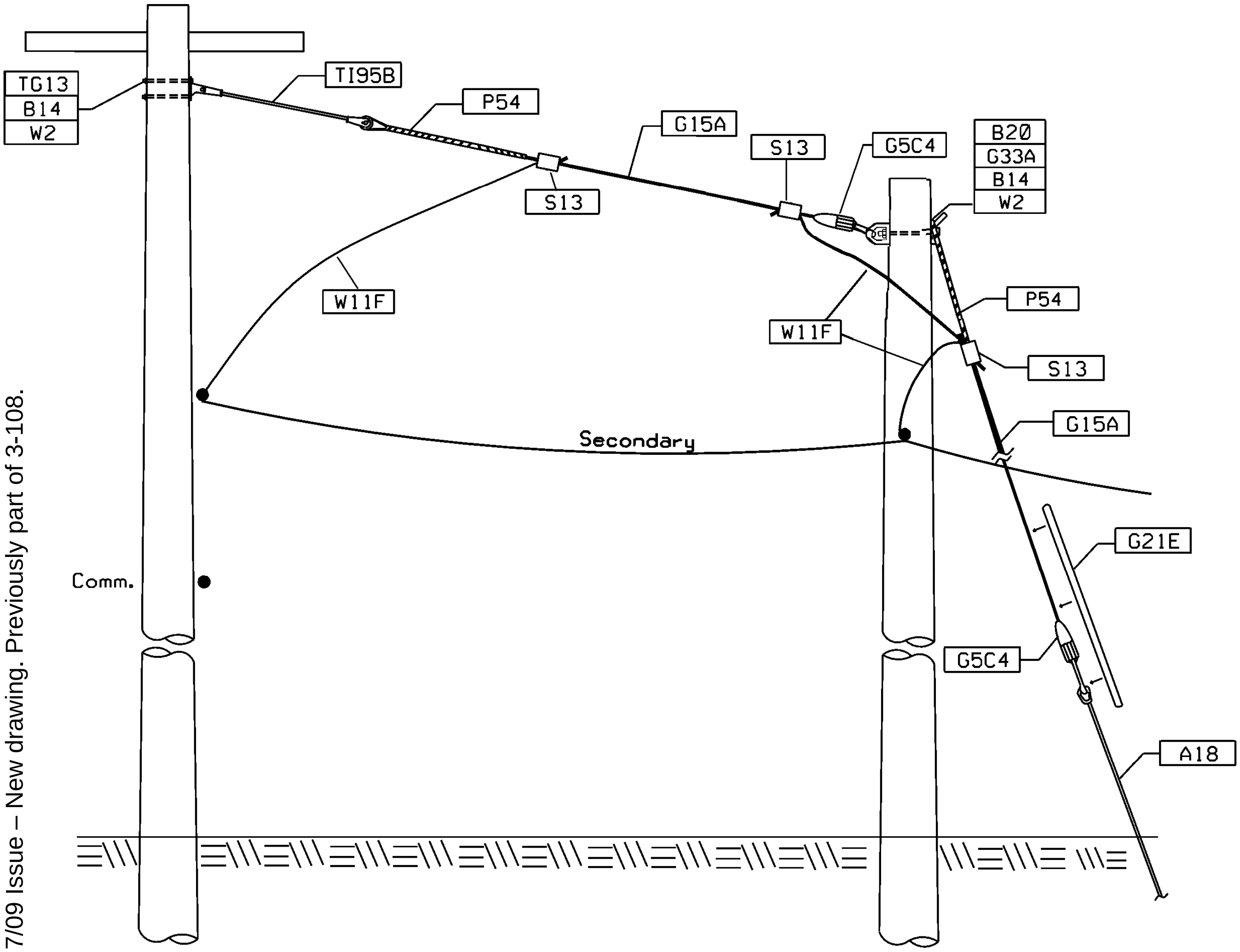


Supersedes 7/09 Issue – New drawing. Previously part of 3-108.

NOTE: If the lower fiberglass rod does not extend a minimum of 12” below the secondary attachment if the guy were slack against the pole, additional fiberglass rods shall be used.

CU = GUY-3-108Y,12.5MSPANSECYP	GUY, 12.5M SPAN GUY, W/SEC - WYE PRIMARY	(SPAN GUY COMPONENTS ONLY)
CU = GUY-3-108Y,12.5MDWNGNOINS	GUY, 12.5M DOWN GROUNDED NO INSUL- STUB POLE	(ANCHORED DOWN GUY WIRE)

CU = GUY-G15A,WIRE 12.5M	GUY, G15A, WIRE 12.5M ALUMO-WELD	(GUY WIRE ONLY)



Supersedes 7/09 Issue – New drawing. Previously part of 3-108.

NOTE: It is acceptable to use the tail of the stub pole guy wire as a bond to the pole-to-pole guy wire, or vice versa. Otherwise, a piece of #4 solid copper wire should be used as a bond wire as shown in the drawing above. DO NOT bond to the preform or the bail of the automatic. These connections must be wire to wire and a compression connector must be used.

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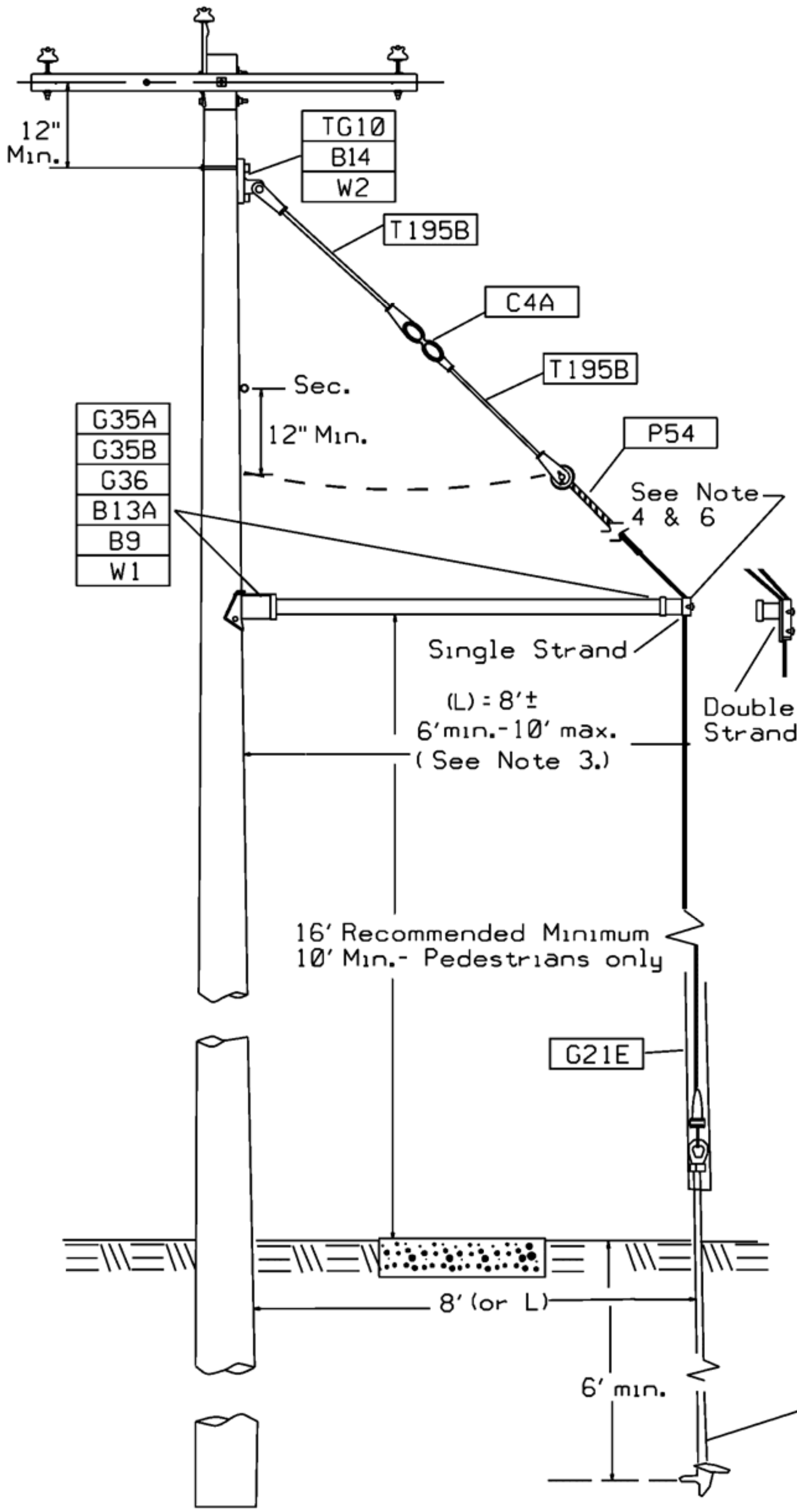
CU = GUY-3-109D,12.5MSTRUT	12.5M STRUT GUY - DELTA PRIMARY
CU = GUY-3-109D,25MSTRUT	25M STRUT GUY - DELTA PRIMARY

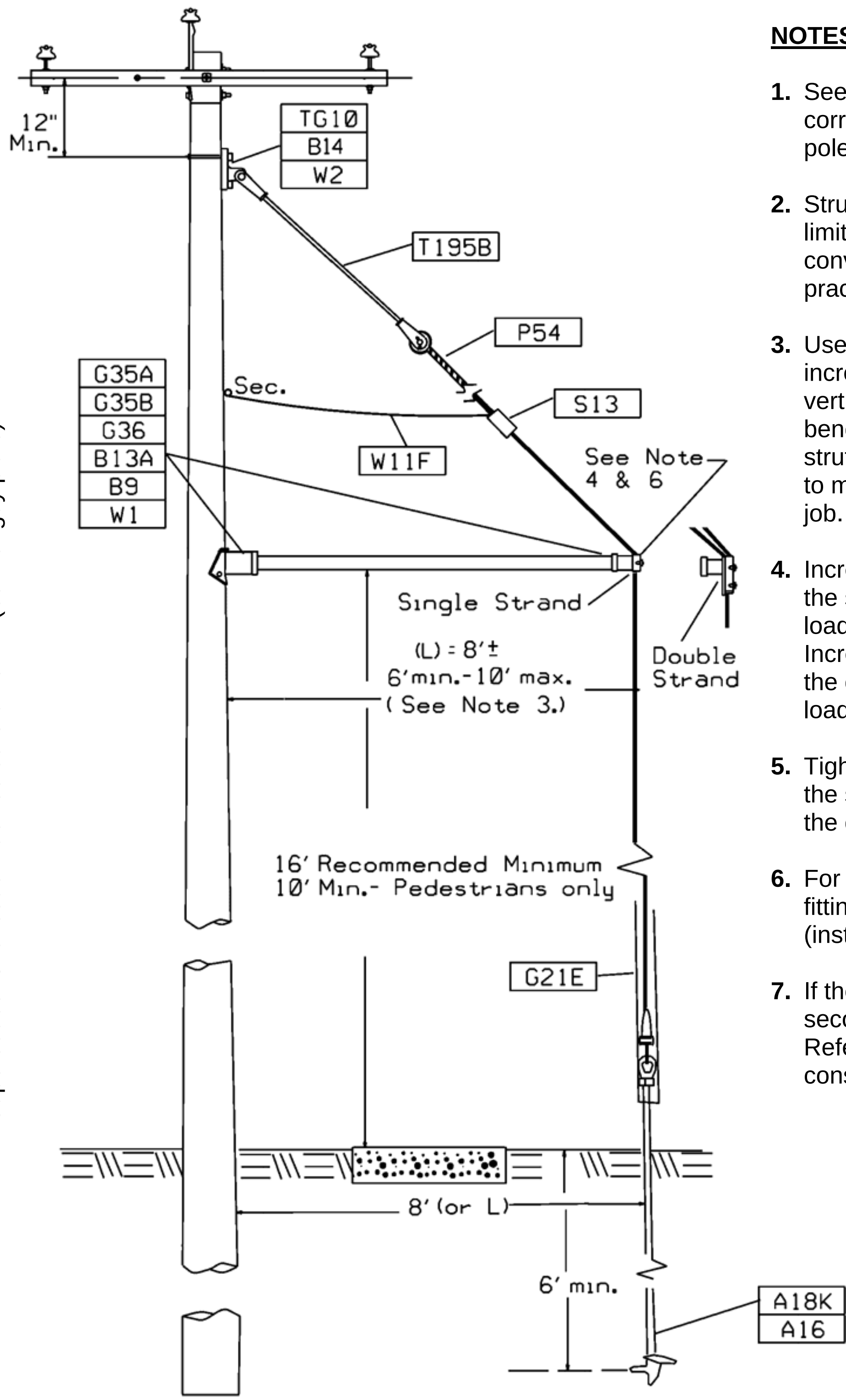


NOTES:

1. See Example #3 to determine the correct guy strand & strut size and pole class.
2. Strut guys shall be used only for limited pole loadings and where conventional guying methods are not practical.
3. Use of strut guys significantly increases guy strand tension and vertical pole load and introduces bending stress to the pole. If a 10' strut is needed, engineering will need to manually add item UK30D to the job.
4. Increasing the height above grade of the strut increases the lateral pole loading and increases guy tension. Increasing the strut length decreases the guy tension and vertical pole loading.
5. Tighten the end of the guy strand into the strut end-clamp before tensioning the guy.
6. For double guy strands, use sidewalk fitting G35C with guy clamp G7B (instead of G35B).
7. If the lower fiberglass rod does not extend a minimum of 12" below the secondary attachment if the guy were slack against the pole, additional fiberglass rods shall be used.

Supersedes 7/10 Issue - Corrected Std Item # (bolt for guy plate).

CU = GUY-3-109Y,12.5MSTRUT	12.5M STRUT GUY- WYE PRIMARY
CU = GUY-3-109Y,25MSTRUT	25M STRUT GUY - WYE PRIMARY

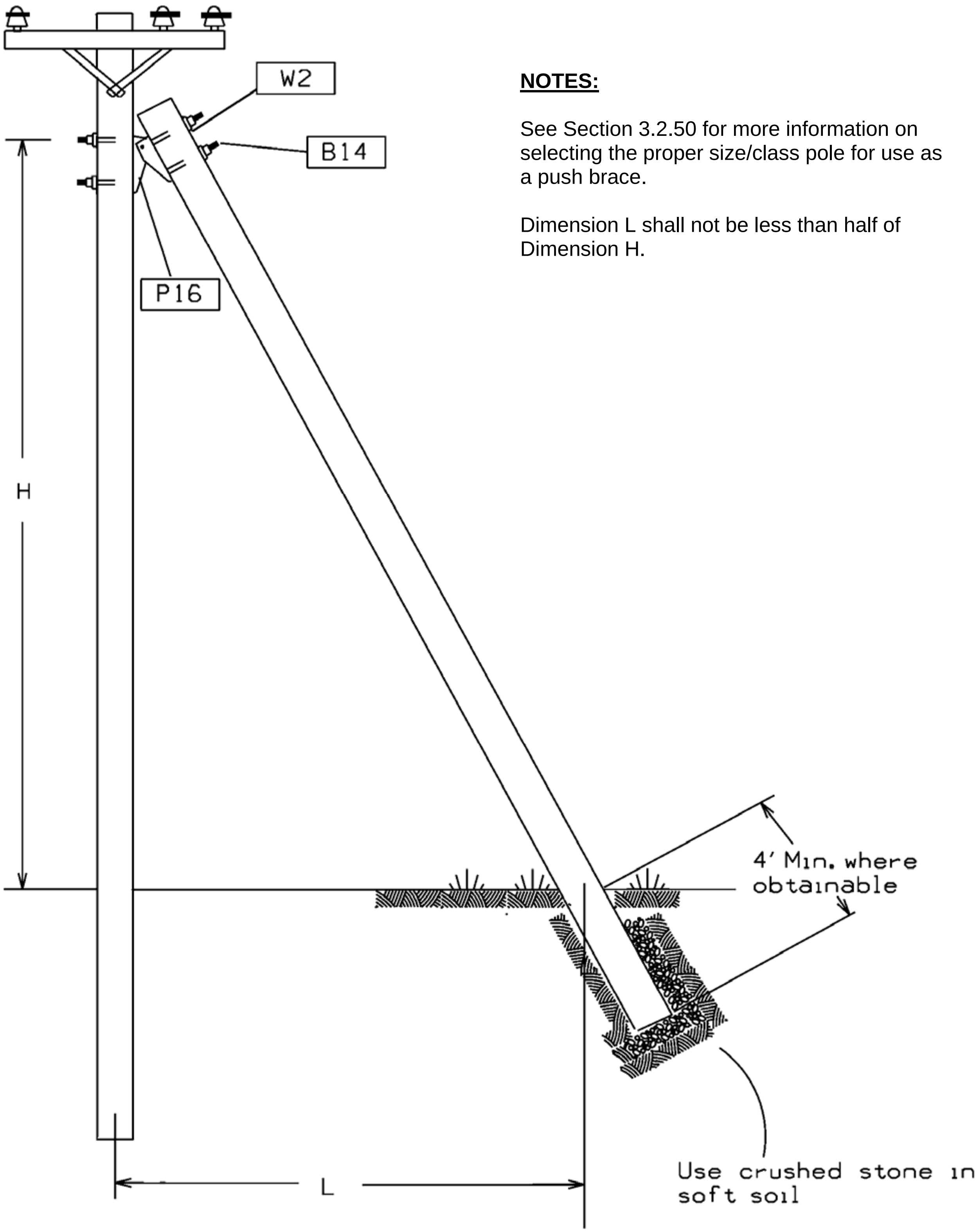


Supersedes 7/10 Issue - Corrected Std Item # (bolt for guy plate).

NOTES:

1. See Example #3 to determine the correct guy strand & strut size and pole class.
2. Strut guys shall be used only for limited pole loadings and where conventional guying methods are not practical.
3. Use of strut guys significantly increases guy strand tension and vertical pole load and introduces bending stress to the pole. If a 10' strut is needed, engineering will need to manually add item UK30D to the job.
4. Increasing the height above grade of the strut increases the lateral pole loading and increases guy tension. Increasing the strut length decreases the guy tension and vertical pole loading.
5. Tighten the end of the guy strand into the strut end-clamp before tensioning the guy.
6. For double guy strands, use sidewalk fitting G35C with guy clamp G7B (instead of G35B).
7. If the guy wire is not bonded, a second fiberglass rod is required. Refer to Drawing 3-109D for construction details.

CU = PBR-3-111,(XX)'CLASS(Y)	PUSH BRACE – (XX) = POLE SIZE, (Y) = POLE CLASS
CU = PBR-3-111,(XX)'CLASS(Y)JO	PUSH BRACE –(XX) = POLE SIZE, (Y) = POLE CLASS – TEL SET



NOTES:

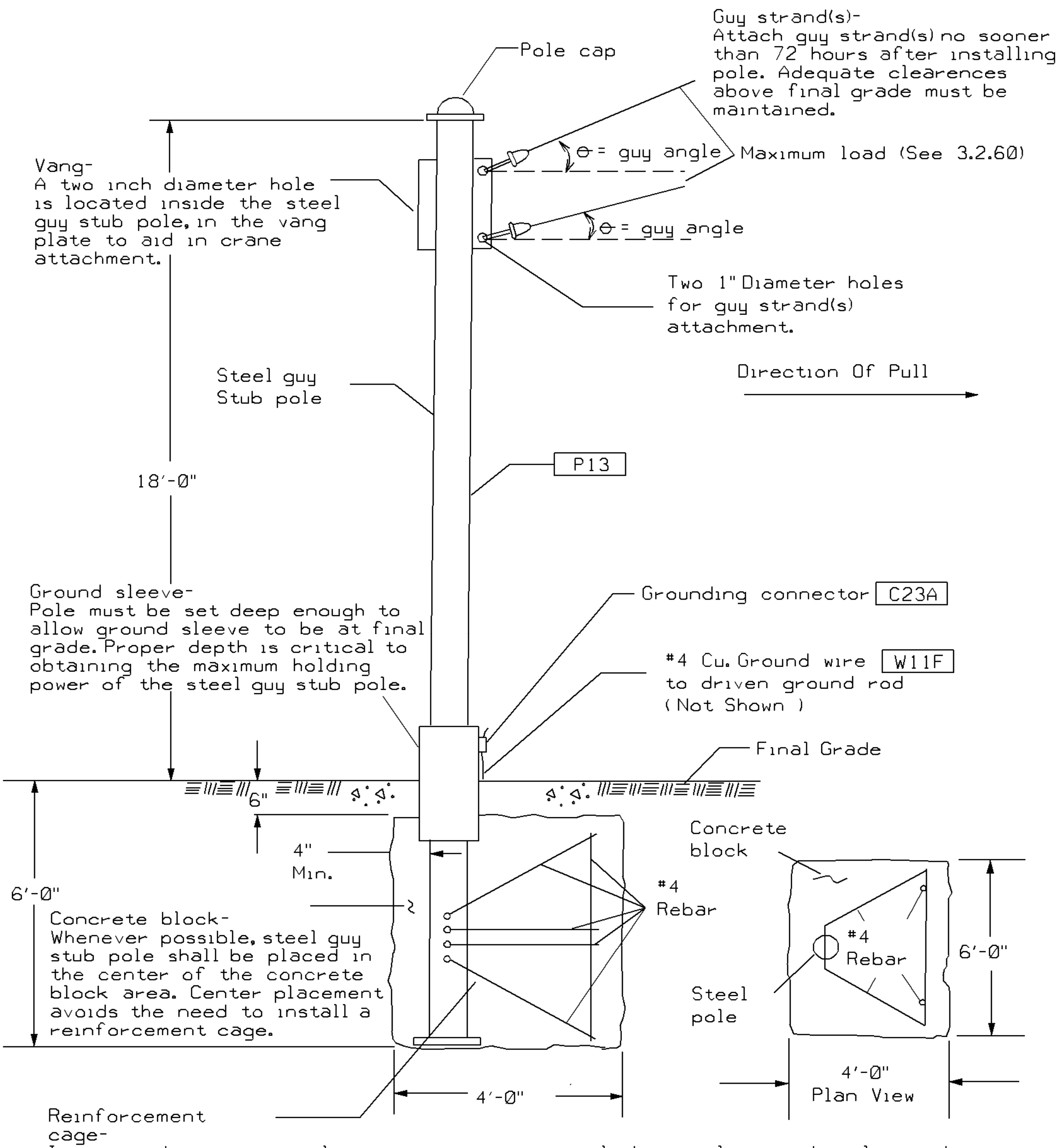
See Section 3.2.50 for more information on selecting the proper size/class pole for use as a push brace.

Dimension L shall not be less than half of Dimension H.

Supersedes 7/10 Issue – Updated notes, revised dimensions shown.

CU = ANC-3-112,STLGUYSTUBPOLE	STEEL GUY STUB

Supersedes 7/09 Issue – Page shift due to other updates.



In cases where center placement is not practical, the steel guy stub pole may be placed anywhere within the concrete block, but in no case closer than 4 inches from an outside edge. Off center placement requires the installation of a reinforcement cage, as shown Figure 1, in order to engage the mass of concrete in holding the steel guy stub pole. Reinforcement cage shall consist of four horizontal members, each one, #4 rebar formed into a triangle, held in place vertically by two # 4 rebars.

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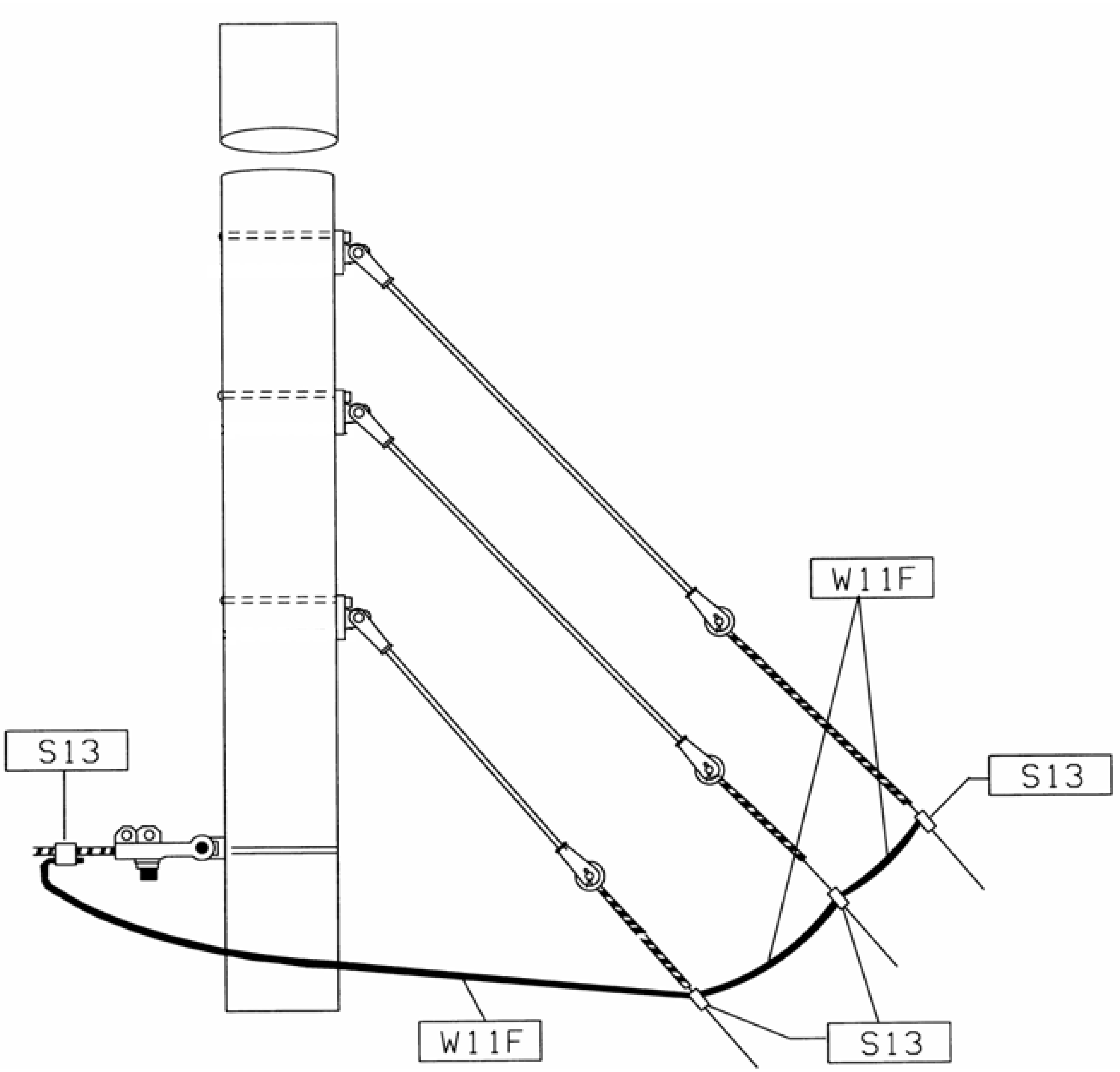
CU = GUY-3-114,BONDGUY	BONDING GUY



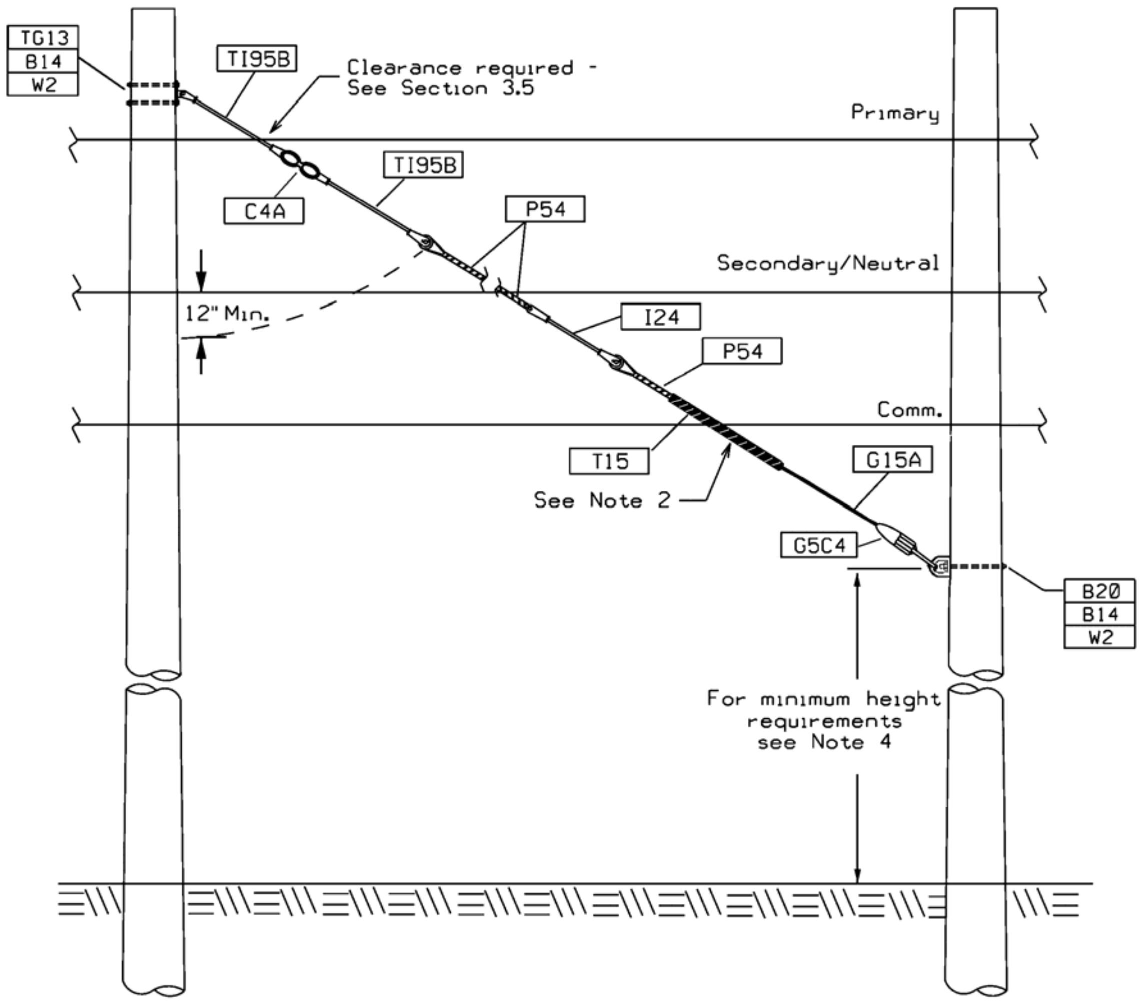
Supersedes 1/06 Issue – Updated CU.

BONDING GUYS

ISSUE	PAGE NUMBER		
7/09	3-114	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

CU = GUY-3-115D,12.5MPOLE-POLE	GUY,12.5M POLE TO POLE - DELTA PRIMARY	(SPAN GUY COMPONENTS ONLY)

CU = GUY-G15A,WIRE12.5M	GUY, G15A, WIRE 12.5M ALUMO-WELD	(GUY WIRE ONLY)



Supersedes 7/11 Issue – Added provisions for spans with no primary wires. Note #6.

NOTES:

1. Always use a minimum of two fiberglass rods (54” minimum length) at the top of the guy where it is attached near the primary wires. If the lower fiberglass rod does not extend a minimum of 12” past the secondary if the guy were slack against the pole, additional fiberglass rods shall be installed. Install one fiberglass rod (12” minimum length) placed in the guy wire so that it sits between the secondary and communication cables.
2. Per the NESC, 6” of clearance is required between the guy wire and any communication cables. This clearance may be reduced to no less than 3” if abrasion protection (Std Item T15) is added to the guy wire.
3. The pole to pole guy wire must be installed with the minimum clearances to primary conductors shown in the table in Section 3.5. For most installations, this will require off-setting the center phase from a pole top pin to a crossarm, even if the guy wire is attached to the pole below the primary conductor. Refer to Figure 8 in Section 3.5 for more information.
4. A minimum clearance of 15’ 6” is required if the guy wire is above driveways, parking lots, alleys, and other land possibly traversed by vehicles that are more than 8’ in height or by riders on horses or other large animals. If spaces and ways are subject to pedestrian or restricted traffic only (areas where riders on horses or other large animals, vehicles, or other mobile units exceeding a total height of 8’ are prohibited by regulation or permanent terrain configurations), a minimum height of 9’ 6” may be used (NESC Rule 232B, Table 232-1).
5. If the lower end of the guy wire is attached above all communication attachments, the 12” fiberglass rod (I24) is not needed.
6. For spans with no primary wires, all clearances, assembly hardware and bonding shown in the figure above are required.

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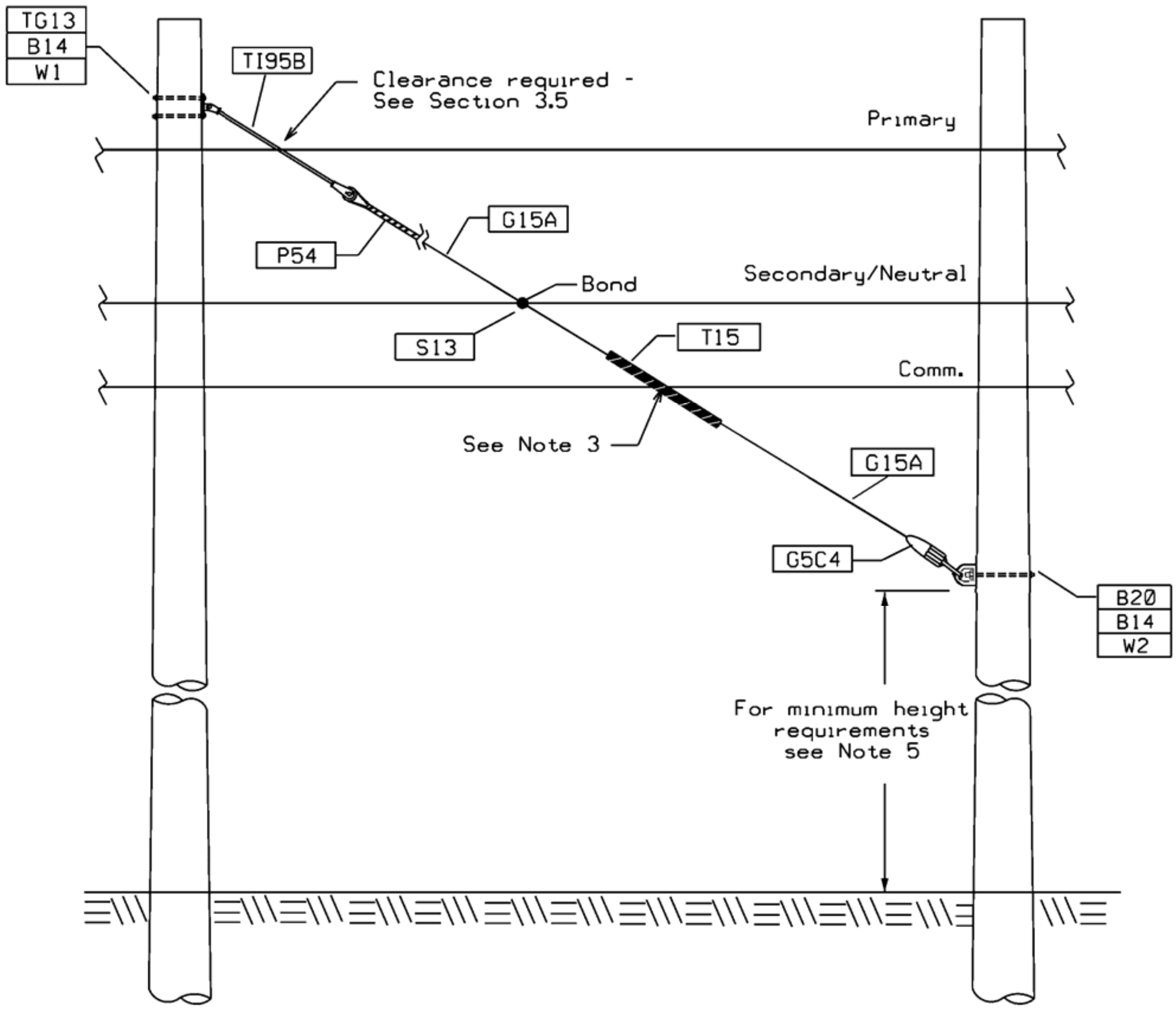
CU = GUY-3-115Y,12.5MPOLE-POLE	GUY,12.5M POLE TO POLE – WYE PRIMARY (SPAN GUY COMPONENTS ONLY)

CU = GUY-G15A,WIRE,12.5M	GUY, G15A, WIRE 12.5M ALUMO-WELD (GUY WIRE ONLY)



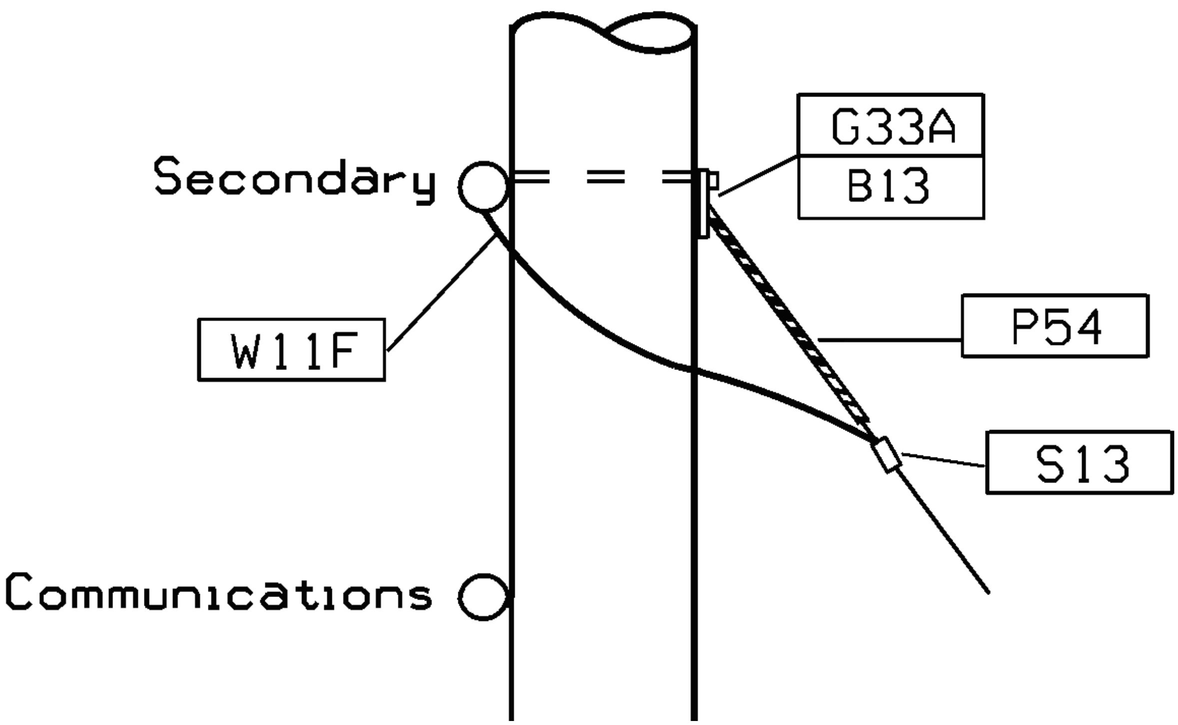
Supersedes 7/11 Issue - Added provisions for spans with no primary wires. Note #6.

NOTES:

1. Always use a minimum of one fiberglass rod (54” length minimum) at the top of the guy where it is attached near the primary wires.
2. Bond the guy wire to the neutral as the guy wire passes the secondary cable using a compression connector.
3. Per the NESC, 6” of clearance is required between the guy wire and any communication cables. This clearance may be reduced to no less than 3” if abrasion protection (Std Item T15) is added to the guy wire.
4. The pole to pole guy wire must be installed with the minimum clearances to primary conductors shown in the table in Section 3.5. For most installations, this will require off-setting the center phase from a pole top pin to a crossarm, even if the guy wire is attached to the pole below the primary conductor. Refer to Figure 8 in Section 3.5 for more information.
5. A minimum clearance of 15’ 6” is required if the guy wire is above driveways, parking lots, alleys, and other land possibly traversed by vehicles that are more than 8’ in height or by riders on horses or other large animals. If spaces and ways are subject to pedestrian or restricted traffic only (areas where riders on horses or other large animals, vehicles, or other mobile units exceeding a total height of 8’ are prohibited by regulation or permanent terrain configurations), a minimum height of 9’ 6” may be used (NESC Rule 232B, Table 232-1).
6. For spans with no primary wires, all clearances, assembly hardware and bonding shown in the figure above are required.

CU = GUY-3-118,12.5MDWNGSECYP	GUY, 12.5M DOWN GUY,SECONDARY - WYE PRIMARY

Wye - Secondary Triplex/Quadplex.

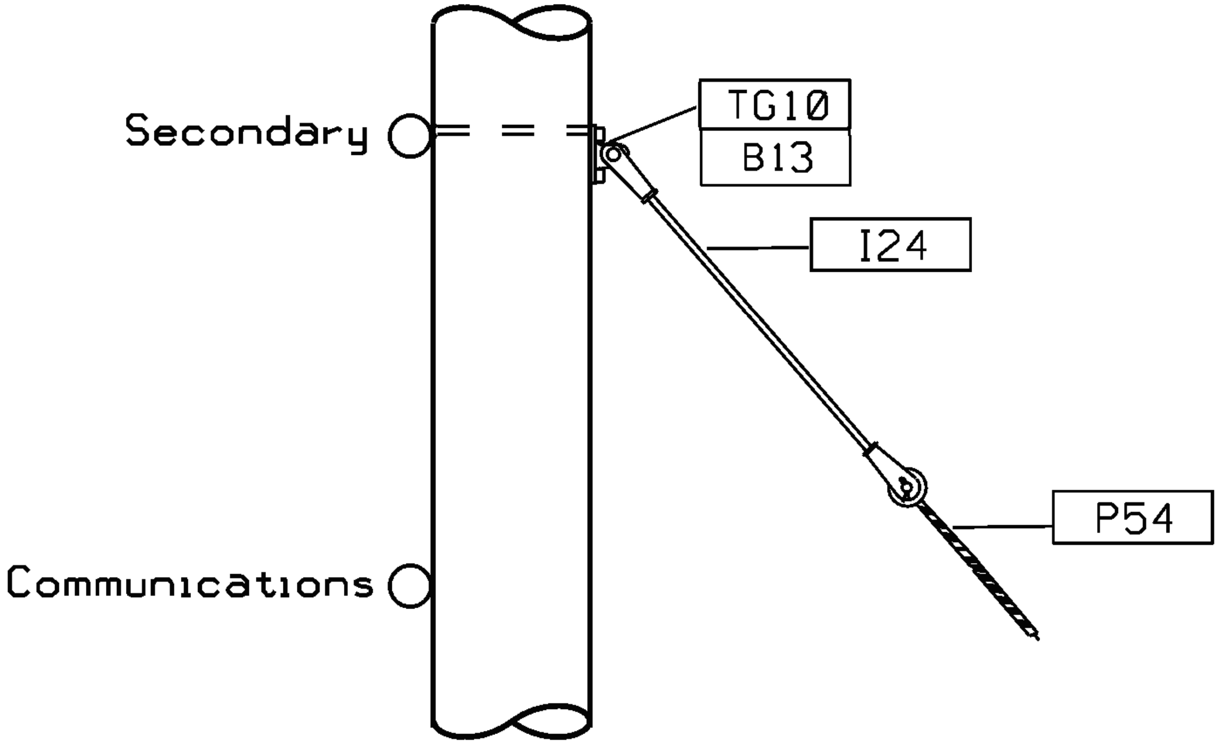


NOTE: For guy wire placement related to other secondary configurations on the pole, see Pages 10-100 and 10-101.

Supersedes 7/10 Issue - Removed open wire secondary guying (now on 3-120); added bolt Std Item #.

CU= GUY-3-119,12.5MDWNGSECD	GUY,12.5M DOWN GUY,SECONDARY- DELTA PRIMARY

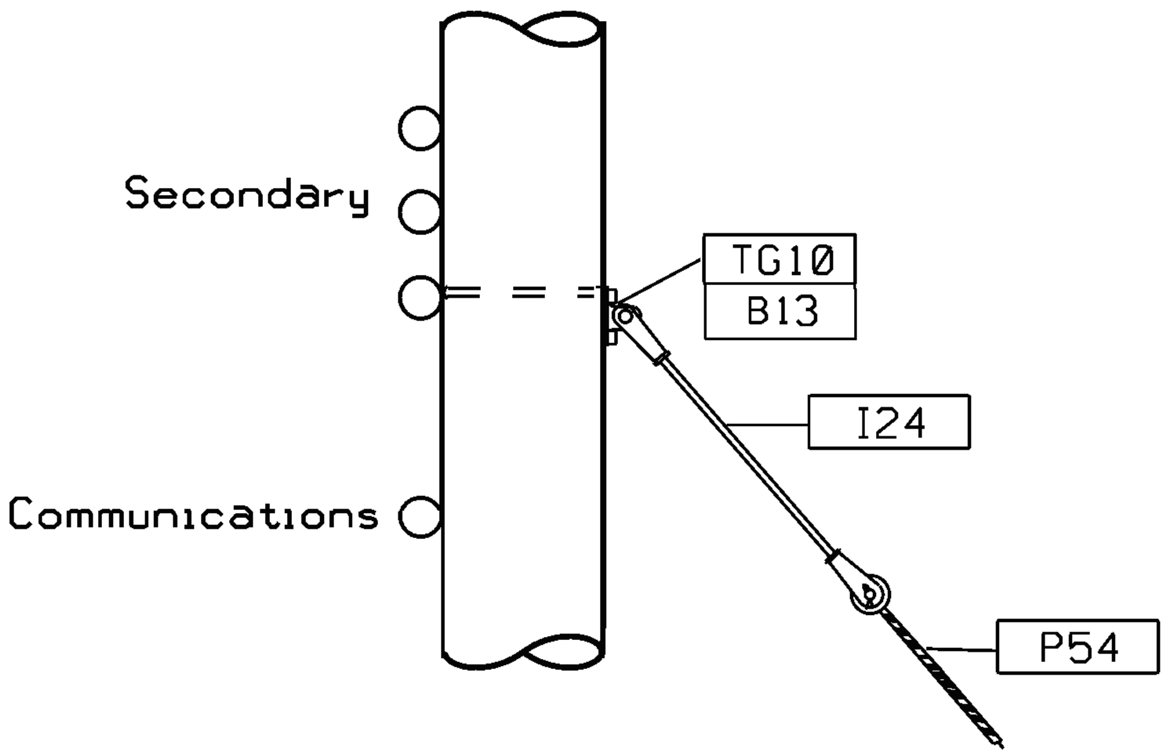
Delta - Secondary Triplex/Quadplex/Etc



Supersedes 7/10 Issue - Removed open wire secondary guying (now on 3-120); added bolt Std Item #..

NOTE: For guy wire placement related to other secondary configurations on the pole, see Pages 10-100 and 10-101.

CU = GUY-3-120,12.5MDWNGSECOW	GUY, 12.5M DOWN GUY SECONDARY OPEN WIRE



New drawing.

GUYING OPEN WIRE SECONDARY RACKS (WYE AND DELTA)			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		3-120	7/11

Version	Date	Modification	Author(s)	Approval by (Name/Title)
6	7/13	• Added steel stub pole design guide • Converted from National Grid to a Liberty Utilities document.	Robert Johnson	Robert Johnson Program Manager
5	7/12	• Added provisions for span guys with no primary wires (drawings 3-115D and 3-115Y).	Brian Reynolds	Susan Fleck, VP of Standards, Policies, & Codes
4	7/11	• Removed open wire secondary information from 3-118 and 3-119 and created new drawing 3-120 with the information. • Revised material used for abrasion protection on span guys (drawings 3-115D and 3-115Y). • Added Section 3.4.60 - Guying on multi-circuit structures.	Katie Croteau	Susan Fleck, VP of Standards, Policies, & Codes
3	7/10	• Revisions made to entire section - rearranged information in order to make information easier to locate and understand. • Removed Drawings 3-99, 3-101, 3-113, 3-116, and 3-117. All information from these pages is now in the text portion of the section. • Revised Drawings 3-105 and 3-106 - Updated Primary Guy Wires on Delta Systems. • Revised 3-107 - now split into two drawings to show differences between stub pole guys on delta and wye systems. • Revised 3-108 - now split into two drawings to show differences between sidewalk guys on delta and wye systems. • Revised 3-115 - now split into two drawings to show differences between pole to pole guys on delta and wye systems. • Added Drawing 3-118 to show secondary guy wires on a wye system. • Revised Drawing 3-119 to show only secondary wires on a delta system.	Katie Croteau	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/06 Issue – Added Standard Page 5-149 for Repair Sleeves

5.0 GENERAL

Automatic, bolted, and compression type connectors are used for all work on the overhead distribution system. All connectors shall be installed using the correct tools, dies, and connectors. Each connector has a specific location to be used (See Page 5-111). Some exceptions may be made for temporary work or for connections that may have to be removed. **Note: All conductors shall be thoroughly cleaned (wire brushed) prior to connector installation.**

5.1 SELECTION OF CONNECTORS

Connector items shall be selected from Pages 5-111 and 5-112. Details of the size range and die index numbers are shown on the material list. Corresponding conductor range and die information, the number of crimps required, and the crimp-limit lines are printed or embossed on the connectors as well. Unless a compression connector, or its packaging, is properly marked for the wire size and die information, a bolted connector shall be employed.

5.2 LOCATION OF CONNECTORS

Splices shall be located where they are needed, but they will not be used on conductors crossing over railroads or limited access highways, or in spans on either side of those crossings.

Automatic tension splices shall not be used on services or slack spans conductors.

When aluminum cables are joined to copper, efforts should be made to keep the aluminum above the copper, and oxide-inhibiting compound/grease (G9B) should be applied between the surfaces.

5.3 CONDUCTOR PREPARATION

Conductor surface preparation is essential to ensure proper contact between conductors and the connector. Surface oxidation and contaminants will greatly interfere with the establishment of a sound electrical connection. An insulating oxide naturally forms on all conductor surfaces exposed to air. The oxide formation is relatively quick and transparent to the eye. **Always** thoroughly wire brush the conductors (both new conductors and conductors in service) before making connections. **Never** use the same wire brush to clean both an aluminum and copper conductor. Copper contaminants transferred to the aluminum conductor will cause the aluminum conductor to corrode. The Standard Item for a wire brush is NTE1 in Section 22-Material Catalog.

5.4 INSULATION OF CONNECTORS

Splices and tap connectors on service/secondary conductors up to 600 V shall be covered with snap-on covers (C60) or taped. Bare messenger/neutral connectors shall not be covered.

Splices and tap connectors on bare primary conductors shall not be covered or taped.

Splices on tree wire/spacer cable conductors shall be covered or taped. Tree wire/spacer cable is considered a “covered” rather than “insulated” conductor. **Note**: **Always cover any unused, exposed bare conductor.** Splices on these conductors shall be taped or covered using one of the following methods:

- Gelwrap Cover (C62 & C63) – Use on all 15 kV splices for 1/0 thru 795kcmil. Installation instructions are included in the cover package.
- Cold Shrink Cover (S16) – Use on all 15 kV and 35 kV splices except 15 kV 1/0 because the cover is too large. See Section 16 for installation instructions.
- Taped Cover – Use on all 15 kV and 35 kV splices. See Section 16 for installation instructions.

Supersedes 1/07 Issue – Added Note to 5.4 Insulation of Connectors.

5.5 TYPES OF CONNECTORS

5.5.10 Splices

There are two types of Line splices: Automatic and Compression. Applications should be as specified in A and B below.

All splices must be located a minimum distance of 30 inches from pin insulators for all installations.

For tree wire and covered conductor splicing, remove covering with approved stripper for given conductor size and covering thickness. Always cover any unused, exposed bare conductor per section 5.4.

For Spacer Cable splicing, follow procedures outlined in Section 16. Stagger splices 30" inches from other phases. **Do not** use automatic line splices on spacer conductors.

A. Automatic Line Splices

An automatic line splice is a full tension splice for aluminum and copper conductors (Std. Items S19A thru S19V). They are to be used on full tension conductors only. They are not designed to be used on spacer cable phase conductors, slack spans, or secondary/service cable phase conductor. **Note:** Because service cable is a low tension conductor, an automatic splice shall not be used on a service cable messenger/neutral. See Page 5-141 for installation instructions.

B. Compression Line Splices

A compression splice can be a full tension, partial tension or non-tension splice for aluminum and copper conductors. Full tension splices are used on overhead bare wire and tree wire primary aluminum conductors (Std. Items S20B thru S20G and S20R1 thru S20R4) and copper conductors (Std. Items S23A thru S23N). **Note:** Although spacer cable phase conductors are a partial tension conductor, full tension compression splices shall be used. A partial tension splice is used for secondary/service messengers/neutrals (S22E thru S22H). A non-tension splice is used for non-tension conductors such as secondary/service phase conductors (Std. Items S26C and S26D). See Page 5-144 for installation instructions.

5.5.20 Taps

A. Bolted Connectors

There are several different types of bolted connectors presently used throughout the Company.

1. Parallel Groove Connector

The tap connector is the extruded aluminum parallel groove connector (Std. Items C7A thru C7J). This connector is used for overhead primary aluminum to aluminum or aluminum to copper tap connections. See Page 5-131 for connector sizes and range taking information. **Note:** Cast aluminum parallel groove connectors are not an approved connector and shall not be used for overhead tap connections.

2. Hot Line Clamp/Vice Connectors

Hot line clamp/vice connectors are used in very limited applications. Hot line clamps shall **NOT** be used for temporary jumpers as noted in Standards Bulletin 05-05. The limited applications for hotline clamps/vice connectors are as follows:

- Energized line installations on distribution class primary circuits above 15kV.

Supersedes 7/08 Issue – Added text to Splices – Min dist to insulator and TW /Spacer cable Reqmts.

- Energized line installations or maintenance on primary circuits below 15KV when rubber gloving is not allowed (such as off a pole), or crew make up does not allow gloving above 600 volts (such as OPC/Trouble man).
- Energized line installations of equipment (such as sectionalizers and reclosers) on primary circuits.
- Energized line installations of a line regulator.
- Energized line installation of a lightning arrester. (**Note:** Non-energized arrester connections **MUST** be done with parallel groove or fired on wedge).
- Installation and removal of Current Limiting Fuses used for Capacitor Banks on energized line installations.

There are both clamp and vice type hot line connectors and they are applied as follows:

- Aluminum clamp type hot line connectors (Std. Items ID C24A thru C24C) are used to tap aluminum primary conductors with an aluminum or copper tap for transformers, capacitors, and primary taps. Bronze clamp type hot line connector (Std. Item ID C24D) is used to tap copper primary conductors with a copper tap for transformers, capacitors, and primary taps.
- Aluminum vice type hot line connectors (Std. Items C16C thru C16G) are used for mainline connections such as switches, reclosers, and regulators.

Note: Stirrups shall <u>not</u> be used for future installations. See Page 5-147 for installation instructions

3. <u>Split Bolt Connector: Nantucket Use Only</u>

The split bolt connector is a bronze connector for primary and service/secondary copper conductors only (Std. Items C27A thru C27E). This connector is used in Nantucket on overhead primary and service/secondary that is exclusively copper.

4. <u>Vice Connector</u>

The vice connector is a single bolt bronze connector for copper conductors only (Std. Items ID C6N1 thru C6N7). This connector is used for overhead primary copper conductors, streetlighting, and some grounding applications.

B. <u>Compression Connectors</u>

1. <u>Secondary/Services Connections up to 600 Volts</u>

The H-Tap compression connector is used for secondary/service connections up to 4/0 AWG aluminum to aluminum or aluminum to copper and 600 V maximum (Std. Items S13B thru S13LI). See Page 5-121 for installation information. For secondary/service connections above 600 V, bolted or fired-on wedge connectors shall be used.

2. <u>Primary Connections</u>

Primary compression tap connectors are not a standard connection and therefore shall not be used.

3. <u>Grounding Connections</u>

A C-type compression connector shall be used for bonding copper grounding conductors (Std. Items S14A thru S14L). This connector can be installed with a hand or battery operated tool.

Supersedes 7/07 Issue – . Revised HLC usage for equipment and to include cap banks with CLF's .

C. Fired-on Wedge Connectors

The fired-on wedge connector is used by the Company for overhead primary aluminum to aluminum, or aluminum to copper tap connections (Std. Items S15G thru S15R7). See Page 5-133 for installation information.

5.5.30 Deadends

Deadend connectors are a mechanical connection. They are designed to have a holding strength greater than the maximum tension of the conductor attached to it. They are not designed to be electrical connectors.

A. Bolted Deadends – Strain Clamps (Straight and Quadrant)

Used on distribution primary and larger secondary and service cables for deadening AAC, AAAC, and ASCR conductors. Remove covering on covered conductor before installing the clamps. To select the correct deadend for the conductor desired, See Section 22-Material Catalog Standard Items C13A1 thru C13Q.

B. Formed Deadends

Used for deadending primary and secondary and service cable messengers – AAC, AAAC, AWAC and CW. Also, may be used to deadend primary spacer cable phase conductors. Do not remove covering for latter application. Use with proper thimble clevis or thimble eye. **WARNING:** Do not use with tree wire construction. See Section 22-Material Catalog Standard Items P52A1 thru P52P, and P54A thru P54J.

5.5.40 Terminations

Terminal connectors are used on airbreak/loadbreak switches, transformers, disconnect switches, or any application from aluminum cable to flat aluminum or copper pad or bus bar. **Note:** For applications where taps from copper flat pads to aluminum cables are made, preferred practice is to install copper taps with copper terminal connectors at the copper pads and aluminum tap connectors at the aluminum cables. See Section 22-Material Catalog Std. Item C9.

5.6 COMPRESSION TOOLS AND DIES

Burndy tools and dies, to compress connectors on standard conductors from #6 AWG through 500kcmil, are available. The battery-operated tool can be used for work on services and secondaries up to 4/0 AWG. The hand-operated tool is also available for conductors up to 4/0 AWG.

The HYPRESS Y35 hand-operated hydraulic tool is used primarily for work with larger connectors on conductors through 500kcmil. Although the Y35 will accommodate the same conductor range as the hand-operated tool, it is not generally used on the smaller range conductors (4/0 or less) unless a great number of crimps are required or connectors are used that do not easily yield to compression.

When new tools are to be selected, the Kearny hand-operated tool and the HYPRESS Y35 and dies are suggested. See illustrated tools and a list of standard dies on Page 5-121.

All compression tools shall be tested frequently to see that they are in adjustment. It is desirable that the test be made by the worker who will use the tool. See instructions furnished with the tool.

Supersedes 1/06 Issue – Revised Std. Item reference to C9

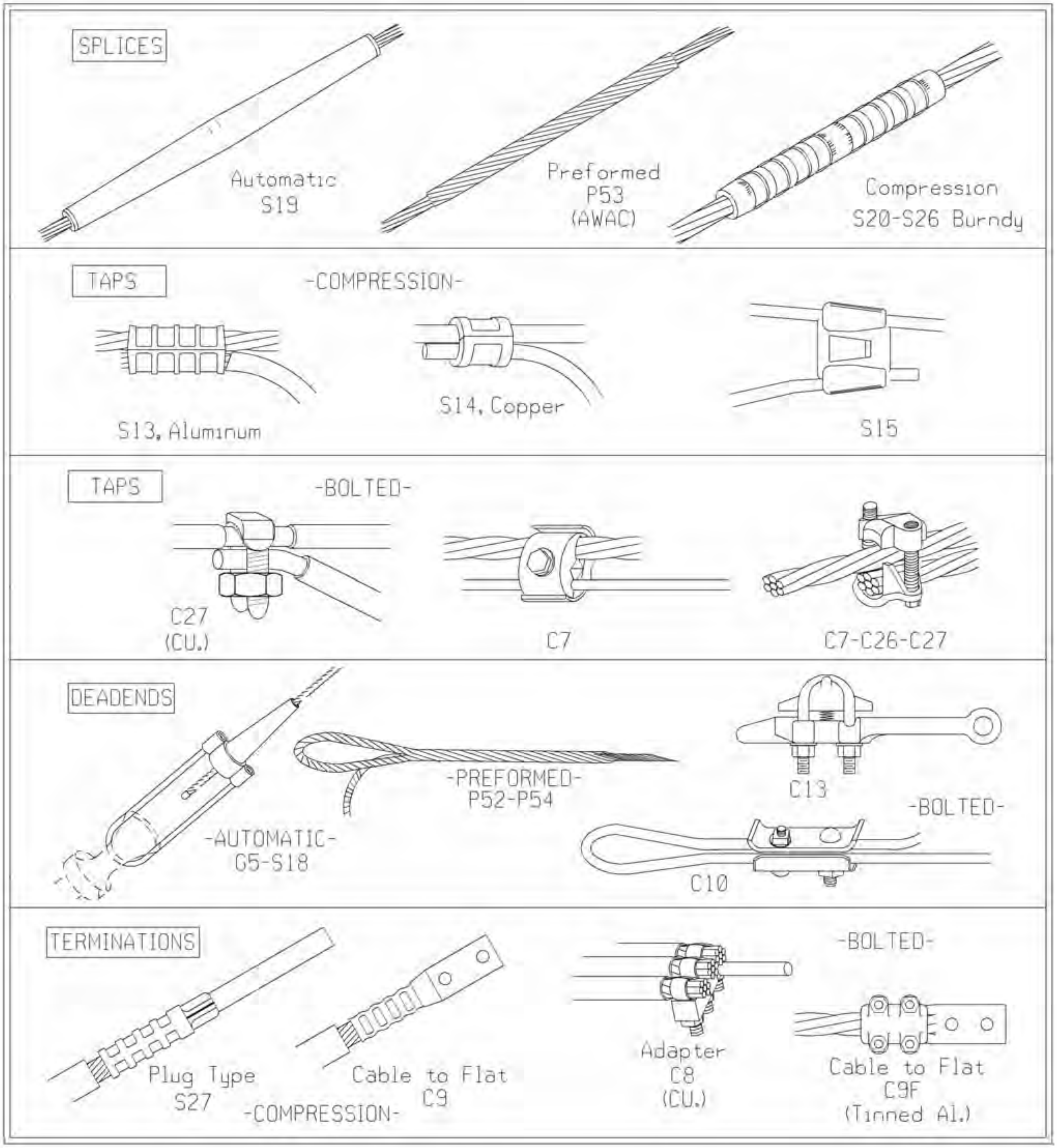
5.7 SELECTION OF CONNECTORS

The following table identifies the different types of connectors used for overhead distribution conductors. The connectors listed below are electrical connectors except for the deadend connectors, which are strictly a mechanical connection

APPLICATION	CONDUCTOR	RECOMMENDATED CONNECTOR (IDENTIFIED BY STD ITEM)				
		AUTOMATIC	PREFORMED	COMPRESSION	WEDGE	BOLTED
SPLICES Full Tension	AL. ACSR AWAC STEEL CU & CCW	S19 S19 S19 S19	 P53	S21 S20 S20 S23		
Partial Tension	AL & ACSR	S19		S22		
Non-Tension	AL. ACSR AL. & CU CU. CCW	DO NOT USE		S13, S26 S13 S13 S14,S24		C7,C26 C7,C26 C27 C27
TAPS	AL. & ACSR AL. & CU CU. & CCW CU. & G.S.			S13 S13 S14 S14	S15 S15	C7,C16, C26 C7,C26, S16 C27,S17 C27
DEADENDS Full Tension	AL. & ACSR AWAC STEEL CU. & CCW	S18 G5	P52 P54 P54			C10,C13 C10,C13
TERMINATIONS Non-tension	AL. CU.			C9,S27 C9,S27		C9 C8,C9
HOT LINE TAPS	AL. & ACSR CU.					C16,C24 C24
GROUNDING & BONDING	CU.			S14		C23,G2, G4

Notes:

1. See Section 22-Material Catalog for Item ID's of each connector using the Standard Items shown above.
2. <u>Full Tension (Class 1)</u> - Splice shall hold at least 95% of the strongest conductor's rated breaking strength.
3. <u>Partial Tension (Class 2)</u> - Splice shall hold a minimum 40% of the strongest conductor's rated breaking strength.
4. <u>Non-Tension (Class 3)</u> - Splice shall hold a minimum 5% of the strongest conductor's rated breaking strength and shall be used for applications such as loops, taps, multiplex cable phase conductors, etc.



Notes:

1. Remove PE or other covering. Avoid nicking conductor.
2. Clean all AL and CU. conductors of oxide scale by wire brushing and oxide inhibitor (G9) on conductor if the connector is not inhibitor loaded.
3. For compression connections, follow package instructions. Check wire size, insert conductor fully and start indents at the center for splices and taps and near the closed end on termination type connectors. On covered service and secondary conductors and primary spacer cable, re-cover connections as shown on Pages 5-151 and 5-152 or use PE covers (C60) where applicable.
4. For installation of automatic splices and deadends, refer to Pages 5141 and 5-142.

5.8 H-TAP CONNECTORS

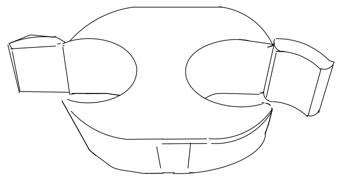


Figure 1

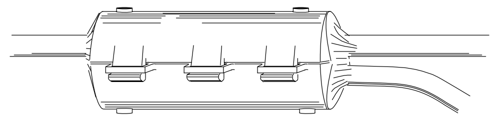


Figure 2

Table 1

CONNECTOR SERIES ON BOX	H-TAP CONNECTOR (FIGURE 1)	600 V INSULATED COVER (FIGURE 2)
	ITEM ID	ITEM ID
1	3507102	2005602
2	3507108	
4	3507110	2005603
5	3507113	
6	3507112	
7	3507117	

Table 2

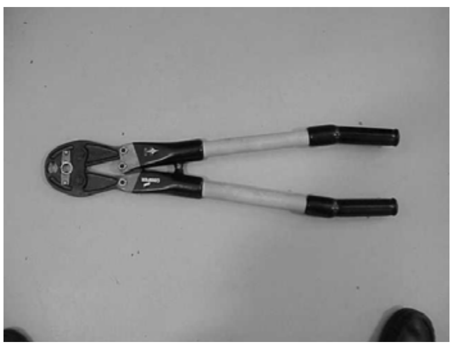
CONNECTOR SERIES ON BOX	RUN RANGE AL. to AL Or AL. to CU		RUN RANGE AL. to AL Or AL. to CU		DIE SIZE	# OF MECHANICAL OR BATTERY OPERATED TOOL CRIMPS	# OF HYDRAULIC TOOL CRIMPS
	Solid	Strand	Solid	Strand			
1	#6 to #1	#6 to #1	#6 to #1	#6 to #1	O	4	2
2	#1 to 2/0	#3 to 2/0	#6 to 1/0	#6 to #1	O	5	2
4	2/0 to 4/0	#1 to 3/0	2/0 to 3/0	#1 to 2/0	D	5	2
5	250 to 300	4/0	#6 to 1/0	#6 to #1	D	5	2
6	250 to 300	3/0 to 4/0	2/0 to 3/0	#1 to 2/0	D	7	3
7	250 to 300	3/0 to 4/0	250 to 300	3/0 to 4/0	D	7	3

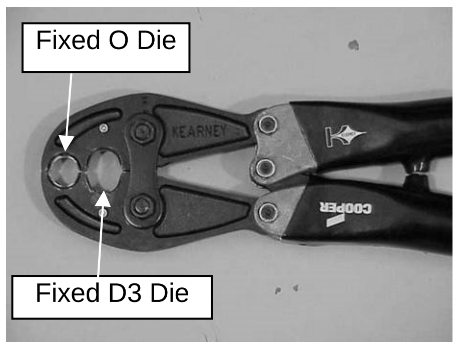
Installation Notes:

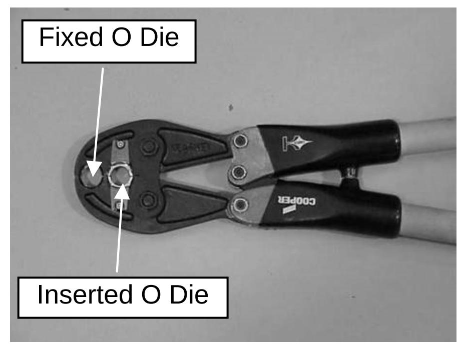
1. For services and secondary connections up to 600 V, H-Tap compression connectors (Figure 1) and insulated covers (Figure 2) shall be used. The H-Tap connectors are for connections of 4/0 aluminum to aluminum or aluminum to copper conductors. Each connector is pre-filled with an oxide inhibitor to maintain a reliable electrical connection. Use insulated covers to insulate the live leg connectors up to 600 V. See Table 1 above for the correct cover to use with a given connector.
2. Each H-Tap connector is shipped in its own box. Each box contains information about the range taking and die size to use. These connectors also have a Connector Series Number that identifies their size. All suppliers use this numbering series. The numbers range from 1 to 7 as indicated on Table 1 and 2. These numbers are also on each connector box to help in selecting the correct connector. Note: The number 3 connector is missing from Table 1 and 2 above because its conductor range is not required in National Grid territory.
3. Cables conductors where connections are required, use the Conductor Spreader Tool (Item ID 5487966).
4. All conductors shall be cleaned (wire brushed) prior to connector installation.

5. For aluminum to copper connections, be sure the copper conductor is installed under the aluminum conductor.
6. For a temporary service, bolted connectors may be used if the company's service drop conductors will be remaining at the location (temporary to permanent). If all the conductors are to be removed, use the H-Tap connectors.
7. H-Tap connectors are non-removable. When replacing an existing conductor, remove the insulating cover from the connector, if one is installed, and cut the conductor as close as possible from the connector and recover the connector with a new plastic cover to re-insulate. Then, install a new connector with the new or existing conductor and cover the connector with the plastic insulating cover. Note: There is no need to insulate a neutral connection. Leaving the old H-Tap connectors on the conductor creates no electrical problem with the installation. If available space on the secondary conductor becomes a problem, cut out a section of old secondary conductor and splice in a new piece of conductor.
8. **Warning:** Do not use these connectors for copper to copper conductor connections.
9. H-Tap compression connectors can be installed with a mechanical, hydraulic or battery operated compression tool using an "O" or "D" die as indicated on Table 1. The tools have a build in "D" die. The "O" die (Item ID 467615) is installed into the "D" die of the tool. To simplify the separation of multiplex

MECHANICAL COMPRESSION TOOL







HYDRAULIC COMPRESSION TOOL

BATTERY OPERATED COMPRESSION TOOL

5.9 INSULATING CONNECTIONS (600 VOLTS)

Connections on insulated Secondary/Service conductors shall be covered or taped, for nominal 600V insulation class. Polyethylene (or PVC) material provides approximately 200-300V per mil thickness. Unstretched Vinyl tape (T2W) is 8.2 mils thickness and rubber insulating tape (T5B) is 30 mils ("..ordinary writing paper is 4 mils thick"). 1 mil = .001 "

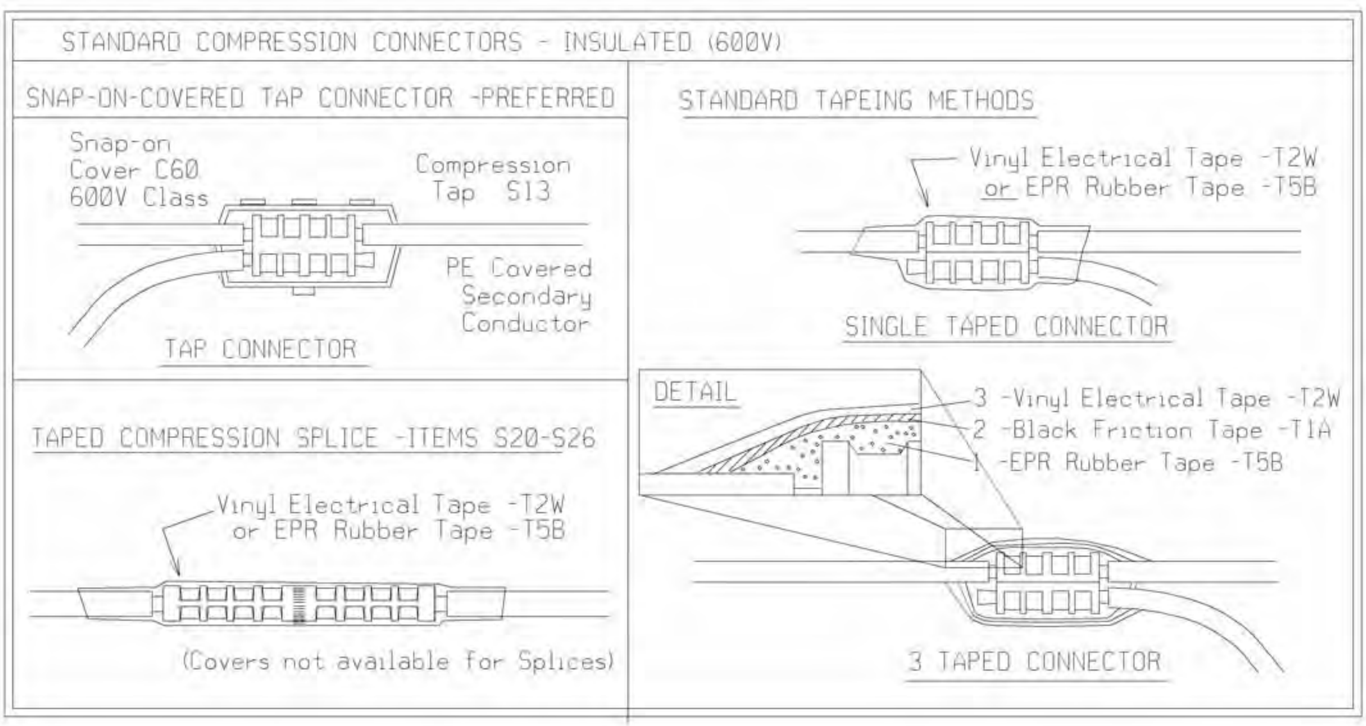
Use snap-on covers (C60) to provide low-voltage protection over compression connectors on covered secondary and service wires. Two or more half-lapped layers of vinyl electrical tape (T2W) or rubber insulating tape (T5B) may be substituted if needed. Do not overstretch the tape and the last two turns should be applied without tension.

Installation Notes:

1. Always clean conductors, wire brushing, (including newly stripped covered conductors) before connector installations. General notes for connector installation can be found on 5-112.

2. Train the conductors so that connections will not be subjected to unnecessary tensions. For large irregular connections or connectors depressions, fill the space with plastic sealer (T5D4).

3. If better insulation or mechanical protection is needed or to buffer sharp edges (i.e. around crimps, etc.) use first a few half-lapped layers of rubber insulating tape (T5B). Apply the rubber insulating tape (as recommended by the manufacturer) so that the sticky side (toward the spool) faces outward as it is applied. This rubber insulating tape is self amalgamating, U.V. and weather resistant but is usually covered using a couple of layers of black friction tape (T1A) and a few outside layers of vinyl tape (T2W). Always use the friction tape between the rubber and vinyl tapes to prevent possible adverse inter-reaction of the materials.



5.10 PARALLEL GROOVE CONNECTORS

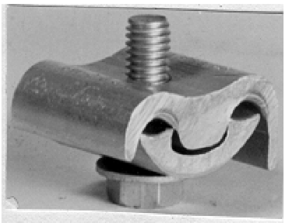


Figure 1

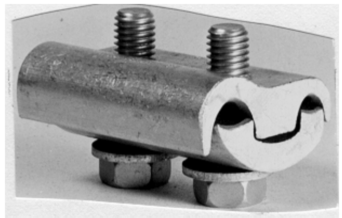


Figure 2

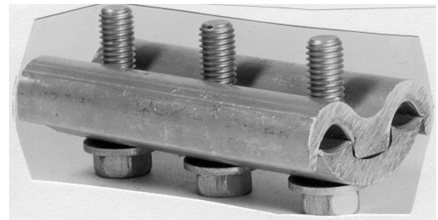


Figure 3

GROOVE A			GROOVE B					
AAC AL or CU	ACSR, AWAC, AAAC	WIRE DIA. RANGE (INCHES)	AAC AL or CU	ACSR, AWAC, AAAC	WIRE DIA. RANGE (INCHES	ITEM ID	FIGURE NUMBER	BOLT SIZE (INCH)
8 – 2	6 – 2	0.128 – 0.325	8 – 2	6 – 2	0.128 – 0.325	5962820	1	5/16
1/0	1/0	0.338 – 0.398	Str. 12	N/A	0.080 – 0.092	5962810	1	3/8
6 – 2/0	6 – 2/0	0.162 – 0.447	6 – 2/0	6 – 2/0	0.162 – 0.447	3506863	1	3/8
1/0 – 3/0	2 – 3/0	0.292 – 0.502	1/0 – 3/0	2 – 3/0	0.292 – 0.502	5962850	2	3/8
4/0 – 400.0	3/0 – 336.4	0.464 – 0.743	6 – 2/0	6 – 2/0	0.162 – 0.447	3506864	1	1/2
4/0 – 400.0	3/0 – 336.4	0.464 – 0.743	1/0 – 3/0	2 – 3/0	0.292 – 0.502	5962860	2	1/2
4/0 – 400.0	3/0 – 336.4	0.464 – 0.743	4/0 – 400.0	3/0 – 336.4	0.464 – 0.743	5962870	3	1/2
450.0 – 1000.0 AL & 450.0 – 500.0 CU	477.0 – 795.0	0.743 – 1.152	6 – 3/0	6 – 2/0	0.162 – 0.447	5962841	1	5/8
450.0 – 1000.0 AL & 450.0 – 500.0 CU	477.0 – 795.0	0.743 – 1.152	4/0 – 400.0	3/0 – 336.4	0.464 – 0.743	5962875	2	5/8
450.0 – 1000.0 AL & 450.0 – 500.0 CU	477.0 – 795.0	0.743 – 1.152	450.0 – 1000.0 AL & 450.0 – 500.0 CU	477.0 – 795.0	0.743 – 1.152	5962880	3	5/8

Supersedes 1/07 Issue – Corrected connector cover Item ID

600 Volt Insulated Covers for these parallel groove connectors only	
Connector - Item ID	Cover - Item ID
3506863	9201346
5962850	9201347
3506864	

Installation Notes:

1. Locate larger parallel plate above when possible.
   This provides an "Umbrella Effect" (see Figure 4 on right)

2. Position so rain will not wash from copper wire onto aluminum wire. Use lower position only when necessary.

3. Locate connector in jumper section when possible and not on span wire.

4. The connection is "non-tension" so there should be no pull or tension on the wires in the connector.

5. Clean conductor surfaces with wire brush. Remove all pieces of insulation/covering in case of insulated/covered wire.

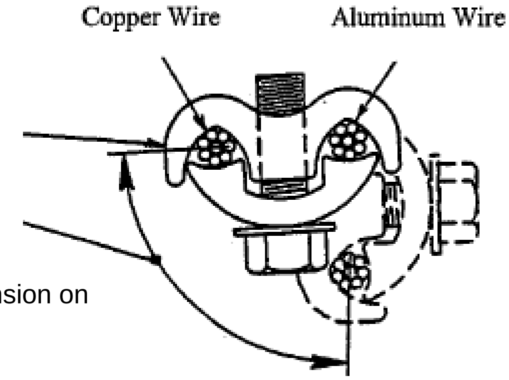


Figure 4

6. Connector groove must be clean. Approved connectors are individually packaged in plastic and protected by a covering of inhibitor compound. Wire brushing a new connector is not necessary.

7. In all cases, apply an inhibitor compound (NG9) on the entire aluminum and copper conductor surfaces that will be located within the connector. All voids shall be filled.

8. Free ends shall extend 1/2 inch beyond end of connector.

9. Tighten bolts properly. It is important to use care to tighten bolts uniformly and to recommended torques (see Table 1 below), particularly since aluminum bolts are covered with a grease. **Note: without a torque wrench, bolts should be tightened approximately 3/4 to 1-1/2 turns beyond the point where the bolt is snug in place. WARNING: Do not over-tighten and deform the connector.**

Table 1

REQURIED BOLT TORQUE			
5/16" – 8 lb. ft.	3/8" – 15 lb. ft.	1/2" - 25 lb. ft	5/8" – 40 lb. ft.

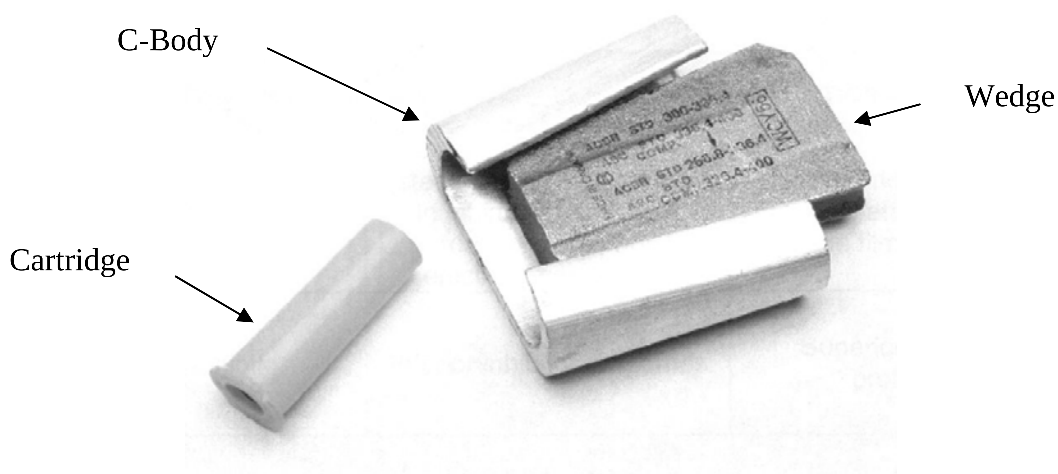
10. Do Not Reuse Connectors – Body and bolts may be distorted; also, it is difficult to clean properly and cover all surfaces with compound.

5.11 FIRED-ON WEDGE CONNECTORS

Installation Notes:

1. For complete information about fired-on wedge connector installation/removal and tool use/maintenance, refer to the manufacturer's "Customer Manual".
2. Position so rain will not wash from copper wire onto aluminum wire.
3. Locate connector in jumper section when possible and not on span wire.
4. The connection is "non-tension", and there should be "no-pull" on wires in the connector.
5. Clean conductor surfaces with wire brush. Remove all pieces of insulation/covering in case of insulated/covered wire.
6. Free ends shall extend 1/2 inch beyond end of connector.
7. Select the connector and charge Table 1 below.
8. **WARNING:** Do not reuse connectors as the body and wedge may be distorted; also, it is difficult to clean properly and cover all surfaces with compound.

SELECTION CHART			
RUN	**TAP**	**ITEM ID**	**CHARGE COLOR**
1/0 AL. & ACSR	1/0 AL & ACSR	3507245	Blue
1/0 AL. & ACSR	#2 AL	3507246	White
1/0 AL. & ACSR	#4 AL & ACSR	3507247	Red
336.4 AL. & ACSR	336.4 AL. & ACSR	0810220	Blue
336.4 AL. & ACSR	4/0 CU.	0810219	Blue
336.4 AL. & ACSR	2/0 AWAC	0810218	Blue
336.4 AL. & ACSR	1/0 AL. & ACSR	0810217	Blue
336.4 AL. & ACSR	#2 AL., ACSR, & CU	0810216	Blue
336.4 AL. & ACSR	500 AL. & CU.	3507250	Yellow
336.4 AL. & ACSR	750 AL. & CU.	0801961	Yellow



Supersedes Issue 1/06 – Changed Charge color for Item ID 3507246 from Red to White

Supersedes 1/06 Issue – Added "3. Important Note" about wire brushing and adding corrosion inhibitor to conductors

5.12 AUTOMATIC SPLICES

Automatic splices are stamped with the intended conductor range and are color identified at the ends with a band colored pilot-cup.

Approved automatic splices are full-tension, full-current rated devices for application on primary distribution lines.

Installation Notes:

1. Mark the full insertion depth on the conductor by placing the cut-end of the conductor to the connector center-line. See Figure 1 below.
2. Make sure the conductor is cut squarely, cleanly, straight, and free of burrs before insertion. Improper installation is the cause of most premature failures. Separated strands may not enter the internal pilot-cup and become wedged between the gripping jaws, preventing function of these essential components. A temporary tape wrap at the cut location will help reduce strand unwrapping during cutting.
3. **Important Note: All conductors must be cleaned (wire-brushed) immediately prior to making the connection. A non-conductive, thin, and invisible oxide layer begins formation within one minute on aluminum conductors and copper conductors. After wire brushing, immediately add corrosion inhibitor to the cleaned surfaces (Corrosive inhibitor Item ID 8010034)**
4. Insert the conductor fully into the connector in one complete motion. Do not pull back on the conductor or twist the conductor before insertion is complete. Conductor will move out slightly during final pull-set as the internal jaws "set". Internal pilot-cup must reach full insertion to clear jaws.
5. Automatic full-tension splices are not to be used on spans other that full-tension (i.e. slack spans and services). Wind-caused negative-tension episodes may release the holding jaws.
6. In repairing a burndown, the conductor should be cut back sufficiently to remove stretched, burned, or annealed strands.
7. The following Standard "Automatic" splices and Deadend Connectors can be found in Section 22-Materials Catalog:

- Standard Item G5C – Strand-vice Guy Grips (See Section 3 for application)
- Standard Item S18K & M – Aluminum Conductor Deadends
- Standard Item S19A-I – Copper & Copperweld Conductor Splices
- Standard Item S19J-M – Aluminum Conductor Splices
- Standard Item S19P-R – Steel Strand Splices

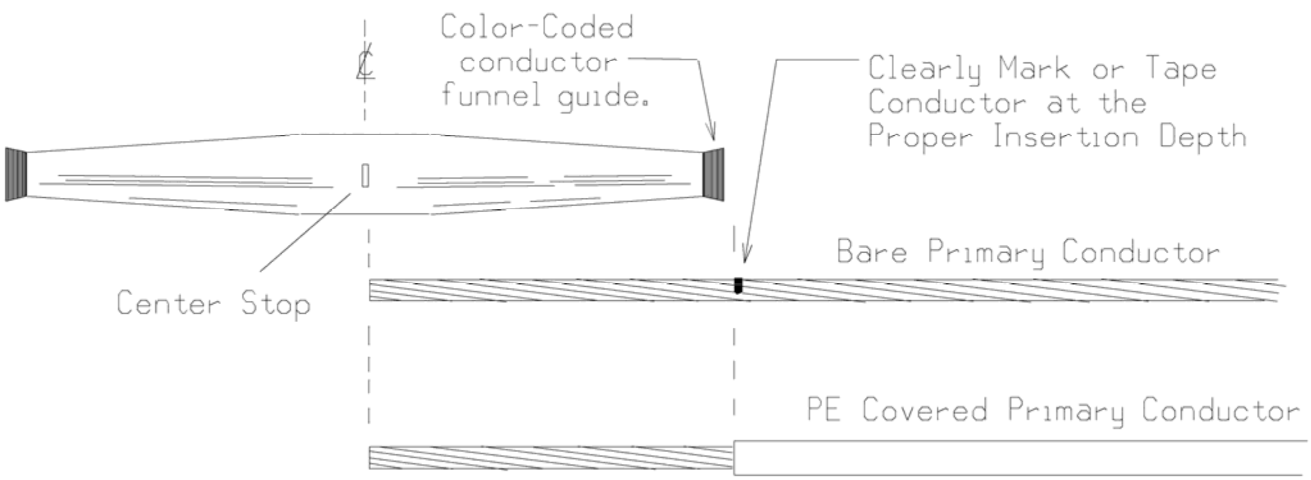


Table 1 Automatic Splices for Bare Aluminum Conductors

SPLICE ITEM ID	CONDUCTOR				
	SIZE AWG-KCMIL	CODE NAME	STRANDS	O.D. IN INCHES	CONDUCTOR ITEM ID
3506321	1/0, AAAC	AZUSA	7	0.398	0811017
3506323	336.4 AAC	TULIP	19	0.666	4035204
5968606	477 AAC	COSMOS	19	0.793	0811125

Table 2 - Automatic Splices for Tree Wire Aluminum Conductors

(**Note:** All other sizes of tree wire/spacer cable shall be spliced with a compression splice. See Section 16 – Aerial/Spacer Cable for splicing details)

SPLICE ITEM ID	CONDUCTOR				
	KV	SIZE AWG-KCMIL	STRANDS	O.D. IN INCHES	CONDUCTOR ITEM ID
3506321	15	1/0 6201	7	0.728	5942105
3506321	35	1/0 6201	7	1.028	5942107

Table 3 - Automatic Splices for Non-Standard Bare Aluminum Conductors

SPLICE ITEM ID	CONDUCTOR				
	SIZE AWG-KCMIL	CODE NAME	STRANDS	O.D. IN INCHES	CONDUCTOR ITEM ID
0810500	#4 ACSR				
3507324	2/0 – 3/0 ⬅				
3506323	394.5 AAC	CANTON	19	0.721	5941537
	636 AAC	ORCHID	37		

Table 4 - Automatic Splices for Non-Standard Covered Aluminum Conductors

SPLICE ITEM ID	CONDUCTOR					
	SIZE AWG-KCMIL	CODE NAME	STRANDS	BARE COND O.D. INCHES	TOTAL O.D. INCHES	CONDUCTOR ITEM ID
3506321	1/0 ACSR	ALMOND	6/1	0.398	0.313	4024029
3506321	1/0 AAAC	OILNUT	7	0.398	0.523	0811018
3506323	336.4 AAC	ANONA	19	0.666	0.791	4024050

Table 5 - Automatic Splice for AWAC Messenger for Spacer Cable

SPLICE ITEM ID	CONDUCTOR			
	SIZE AWG-KCMIL	STRANDS	O.D. IN INCHES	CONDUCTOR ITEM ID
5969624	1/0 – 3/4 AWAC	7	0.487	5998117

Table 6 - Automatic Reducing Splice for Aluminum Conductor

SPLICE ITEM ID	CONDUCTOR					
	SIZE AWG-KCMIL	STRANDS	CONDUCTOR ITEM ID	SIZE AWG-KCMIL	STRANDS	CONDUCTOR ITEM ID
5968608	477 AAC	19	5968606	336.4 AAC	19	4035204

Table 7 - Automatic Splice for Non-Standard Bare Copper Conductor

Supersedes 1/06 Issue – Changed Item ID 0806400 to 0806404 and added reducing splice Item ID 9201781

SPLICE ITEM ID	CONDUCTOR SIZE AWG-KCMIL	STRANDS	O.D. IN INCHES	CONDUCTOR ITEM ID
3506305	#6 SOL			
3506333	#6A CW & CCW, #4 STR			
5968405	#3 HD	7	0.260	5943080
5968405	#3A CW	3	0.326	5940335
3506307	#2 HD	7	0.292	4015074
5968405	#1 HD	7	0.328	5943097
3506319	#1 HD	3	0.360	5943093
3506319	1/0 HD	7	0.368	4035253
3506306	2/0 HD	7	0.414	5943207
3506308	2/0 CW & CCW	7		
3506309	4/0 HD	7	0.522	0806404

Table 8 - Automatic Splice for Non-Standard Covered Copper Conductor

SPLICE ITEM ID	CONDUCTOR SIZE AWG-KCMIL	STRANDS	BARE COND O.D. INCHES	TOTAL O.D. INCHES	CONDUCTOR ITEM ID
5968403	#3 HD	7	0.260	0.354	5944080
3506319	1/0 HD	7	0.369	0.494	5944107
3506309	4/0 SD	19	0.528	0.690	4001044

Table 9 - Automatic Splice for Non-Standard Copper Messenger for Spacer Cable

SPLICE ITEM ID	CONDUCTOR SIZE AWG-KCMIL	STRANDS	O.D. IN INCHES	CONDUCTOR ITEM ID
5968510	3/8 CW	7	0.385	5998230

Table 10 - Automatic Reducing Splice for Copper Conductor

SPLICE ITEM ID	CONDUCTOR LARGE END	SMALL END
5968415	4 SOL, 6 STR	6 SOL, 8 STR
9201781	1 SOL, 2 STR	2 SOL, 3 STR
5968420	2-3SOL, 3 STR	6 SOL, 8 STR
5968425	2-3 SOL, 3 STR	4 SOL, 6 STR
5968440	1/0 SOL, 1 STR	2-3 SOL, 3 STR
5968460	2/0 SOL, 1/0 STR	1/0 SOL, 1 STR
5968465	3/0 SOL, 2/0 STR	2 SOL, 3 STR
5968475	3/0 SOL, 2/0 STR	1/0 SOL, 1 STR
5968480	3/0 SOL, 2/0 STR	2/0 SOL, 1/0 STR
5968490	4/0 STR	3/0 SOL, 2/0 STR

5.13 COMPRESSION SPLICES

Installation Notes:

1. A compression splice installation shall confirm to specific manufacturer's instructions supplied with the splice and as noted below. **Note importance of installation details such as wire brushing and cleaning conductors, measurements and marking, adding oxidizing inhibitor compound when not already included in the connector, conductor straightening, cutting of aluminum strands, installation of steel splice, use of proper die, location of compression, etc.**

2. Compression splices are stamped with the intended conductor range, manufacturer's name, die information, and crimp indicator markings. Crimping inline splice connectors should begin near the center (to allow for connector growth) and successive crimps should be rotated to reduce a "banana" effect.

3. To locate a compression splice, find the type conductor in Table 1 (Aluminum) or Table 2 (Copper) below and look under the associated Standard Item in Section 22-Material Catalog. **Note:** For spacer cable and messenger splice selection and installation information; see Section 16-Aerial/Spacer Cable.

Supersedes 1/06 Issue – Highlighted Importance of installation details, Note 1

Table 1

CONDUCTOR TYPE - ALUMINUM	STD ITEM
Non-Tension One Piece – Service/Secondary Phase Conductors	
#2 and 1/0 AAC Aluminum	S26C & S26D
Partial Tension One-Piece - Service Phase Conductors & Messenger	
#4 AL – 336.4kcmil AL	S22E THRU S22H
Full Tension One-Piece – Primary Conductors	
ACSR Aluminum Conductor	S20B THRU S20G
AAC AND AAAC Aluminum Conductor	S21C1 THRU S21L
Full Tension Two-Piece – Primary Conductors	
ACSR Aluminum Conductor	S20R1 THRU S20R4

Table 2

CONDUCTOR TYPE - COPPER	STD ITEM
Non-Tension One-Piece -	
2/0 & 4/0 CU STR	S24E & S24G
Full Tension One-Piece – Primary Conductors	
CU, CW & CCW	S23A THRU S23N
ACSR Aluminum Conductor	

Supersedes 1/06 Issue – Deleted reference to 25kV and 35kV and added Item ID's to Tables 1,2 & 3

5.14 HOT LINE CONNECTORS

Hot line clamp/vice type connectors shall be used **only** when Hot Stick work is required. **Note:** Clean conductor surfaces by wire brushing until conductor surface is bright and shiny. **Warning:** Do not damage conductor. New connectors are packaged in plastic and pre-filled with oxidizing inhibitor. **Note:** Do not use stirrups or bails. Do not reuse connectors after use.

Bronze hot line clamp connectors shall be used for copper mainline to copper taps (See Table 1 below).

Aluminum hot line clamp connectors shall be used to connect aluminum mainline to aluminum or copper taps (See Table 2 below).

Aluminum hot line vice connectors shall be used to connect aluminum mainline to aluminum or copper mainline. (See Table 3 below).

Table 1

BRONZE CLAMP TYPE (Figure 1)					
RUN SIZE RANGE		TAP SIZE RANGE		STD ITEM	ITEM ID
#6 Solid	400kcmil	4/0	#6 Solid	C24D	5960240

Table 2

ALUMINUM CLAMP TYPE (Figure 1)									
RUN SIZE RANGE				TAP SIZE RANGE					
MAX.		MIN.		MAX.		MIN.			
ACSR	AL	ACSR	AL	ACSR	AL & CU	ACSR	AL & CU	STD ITEM	ITEM ID
1/0	1/0	#8	#8	1/0	1/0	#8	#8	C24A	5960210[E]
336kcmil	394kcmil	#6	#6	3/0	4/0	#6	#6 Sol	C24B	3504025
336kcmil	394kcmil	#4	#4	336kcmil	394kcmil	#4	#4	C24C	3504026
336kcmil	477kcmil	#6	#6	336kcmil	477kcmil	#6	#6	C24A1	5960215[E]

Table 3

ALUMINUM VICE TYPE (Figure 2)					
RUN SIZE RANGE		TAP SIZE RANGE			
MAX.	MIN.	MAX.	MIN.		
AL & ACSR	AL & ACSR	CU & AL & ACSR	CU & AL & ACSR	STD ITEM	ITEM ID
336.4kcmil	4/0	336.4kcmil	4/0	C16C	3504027
795kcmil	336.4kcmil	1/0	#4	C16D	5960228[E]
477kcmil	336.4kcmil	336.4kcmil	#3	C16E	5960226
477kcmil	4/0	477kcmil	4/0	C16F	5960235[E]
795kcmil	336.4kcmil	795kcmil	336.4kcmil	C16G	5960270

Figure 1

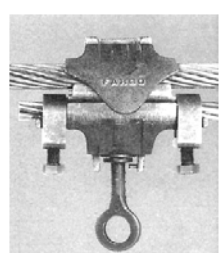


Figure 2

5.15 TERMINAL CONNECTORS

Installation Notes:

1. Install terminal connectors so that water drains from the aluminum to the copper surfaces, i.e., aluminum over copper connection.

2. Clean conductor surfaces thoroughly with wire brush and apply connector inhibiting compound (NG9D) liberally on the conductor and the surface of the terminal.

3. Bolted terminal to conductor using alloy bolts and nuts furnished with connector.

4. Clean pad on equipment with wire brush and apply connector compound (NG9D) on entire contact surface. Bolt surfaces together, using stainless steel bolts (B8B15 thru B8C30), nuts (B8C40) flat washers (B8W3) and Belleville washers (B8W10). See Figure 1.below.

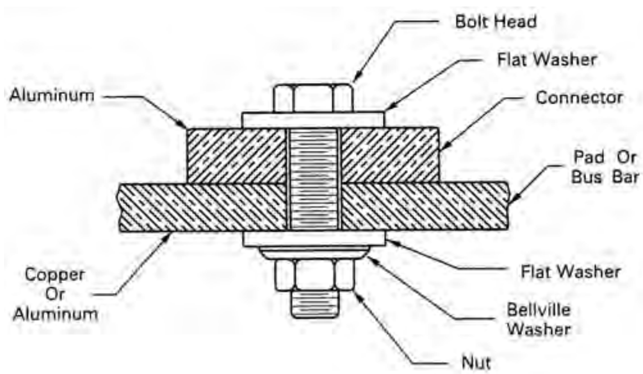


Figure 1

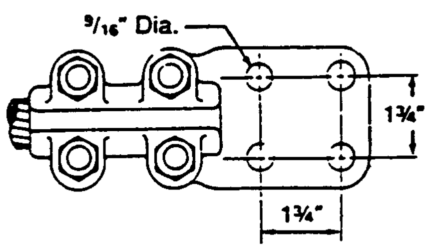


Figure 2

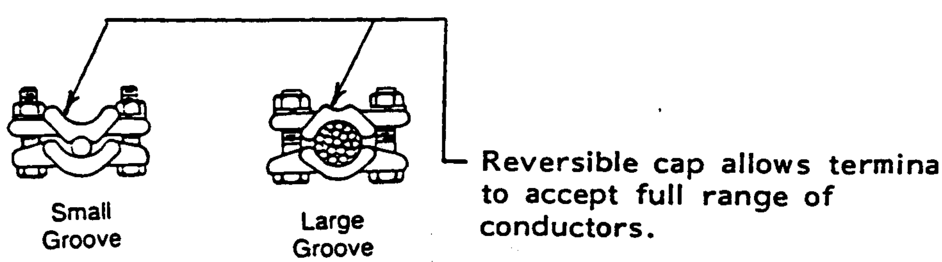


Figure 3

5.16 REPAIR SLEEVES

Table 1 below shows material to repair damaged bare overhead aluminum conductors. The materials include line guard, armor rod and compression sleeves. The repair material to choose depends upon the number of broken conductor strands as shown in Table 1. Table 2 shows tools and dies for installing compression sleeves.

Table 1

Wire Size			Line Guard			Armor Rod			Compression Sleeve	
All Aluminum AAC, All Aluminum Alloy (AAAC) and Spacer Cable (Compact)	**Cond. Dia. in.**		**Max. Broken Strands**	**Item ID**		**Max. Broken Strands**	**Item ID**		**Max. Broken Strands**	**Item ID**
1/0 AAAC 7 str. concentric	0.396		1	3506727		2	5995175			
4/0 AAC 7 str. concentric	0.522		1	5989458					3	5968205
4/0 AAAC 7 str. concentric	0.563		1	5989458					3	
336.4 AAC 19 str. - concentric	0.666		3	3506741		5	5995135		9	3504369
477 AAC 19 str. - concentric	0.793		3	5989461						
636 AAC 37 str. - concentric	0.918		4	5989462						
795 AAC 37 str. - concentric	1.026		4	5989465						
ACSR Conductors										
1/0 ACSR 6/1	0.398		1	3506727					3	3506579
3/0 ACSR 6/1	0.502		1	3506729						
336.4 ACSR 18/1	0.684		4	3506731						
477 ACSR 18/1 Pelican	0.814								9	5968230

Table 2

Wire Size	Cond. Dia. in.	Compression Sleeve Tools and Dies: Item ID	Splice Cat.#	Tool 6 Ton MD6 BCT500 PATMD6	Tool 12 Ton Y35 Y750 PAT5018V	Tool 15 Ton Y46 PAT4618V	Tool 60 Ton Y60BHU
4/0 AAC 7 strand	0.522	5968205	YCU28A	W249 (28)	U249 (14)		
4/0 AAAC 7 strand	0.563						
336.4 AAC 19 strand	0.666	3504369	YCU301A		U321 (20)		
1/0 ACSR 6/1	0.398	3506579	YCU25R	W243 (20)	U243 (10)		
477 ACSR 18/1	0.814	5968230	YOU321R		U327 (21)	U327 (21) with PT-6515 adapter	L327 (7)

New Standard Page

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1.1	7/12	• Added use of hot line clamps for CLF's on capacitors in section 5.5.20 • Added Min dist to insulator and TW/Spacer requirements in Section 5.5.10. Added note to 5.4	John Vartanain Dave Allen	Susan Fleck, VP of Standards, Policies & Codes
1	07/08	• Revised hot line clamp usage rewording, added note of lightning arresters in 5.5.20. • Revised Std. Item reference to C9 in 5.5.40. • Corrected connector cover Item ID in 5-10. • Changed charge color for Item ID 3507246 from red to white in 5.11. • Added Note 3 in 5.12. • Changed Item ID 0806400 to 0806404 and added reducing splice Item ID 9201781 on page 5-143. • Highlighted Importance of installation details in Note 1 in section 5.13. • Deleted reference to 25kV and 35kV and added Item IDs to Tables 1, 2, and 3 in section 5.14.	Joe Tumidajski	Al Chieco, Director of Distribution Standards and Work Methods

6.0 GENERAL

This Section covers the physical and electrical data on standard primary conductors and those that have been commonly used on overhead distribution systems.

Detailed design data for primaries, aerial and spacer cable, street lighting, and other specific conductor applications are covered in their respective sections of the text.

6.1 BASIC DATA

Basic conductor data is shown on drawings and tables indicated in the index. This data may differ in minor detail from those shown in other handbooks. The information shown here, however, should be used for all Company records and correspondence unless otherwise approved. If there are any questions concerning accuracy, please consult Standards Engineering.

6.1.10 Definitions & Notes:

PE = Regular Polyethylene Covering
AAC = All Aluminum Conductor (Type ECA or EC)
AAAC = All Aluminum Alloy Conductor, 5005 or 6201 aluminum alloy
1/0 AAAC (123.3 kcmil) is the electrical equivalent of 1/0 ECA
4/0 AAAC (246.9 kcmil) is the electrical equivalent of 4/0 ECA
394.5 kcmil AAAC is the electrical equivalent of 336.4 kcmil ECA
XLPE = Cross-Link Polyethylene Covering
HDPE = High Density Polyethylene Covering
ACSR = Aluminum Cable Steel Reinforced
CCW = Copper – Copperweld
ECA = Electrical Conductivity Aluminum, also known as “All Aluminum” or “AAC”
HD = Hard Drawn Copper
SD = Soft Drawn Copper

Note 1 – The outer layer on aluminum cable shall be right-hand twist (on copper, left-hand twist).
Note 2 – A Mylar separator shall not be included between the conductor and the insulation.
Note 3 – Manufacturer’s identification shall be printed on the outside of the covered conductor covering.
*Note 4 – Although tree wire /spacer cable and other covered line conductors offer some electrical protection, it is **NOT INSULATED CONDUCTOR** and shall not be depended upon in this respect.*

Loading Definitions

Deadend - Maximum tensions that will exist under conditions of “Heavy Loading” in conductors strung to standard sags. Values for NESC Grades B & C are based on 60% rated breaking strength; however, a 50% rated breaking strength value shall be employed for all new work. Values for Grade N are based on 70% rated breaking strength. These are furnished for use when maintaining existing Grade N lines. Use these values for guy and pole strength calculations and for calculation of crossarm strength at deadends.

Transverse - Loads resulting from a 4 lb./sq.foot wind blowing at right angles to the line with conductors covered by ½ inch ice (Heavy Loading). Use these values for transverse guy and pole strength calculations.

Vertical - Weight of conductors plus ½ inch radial ice. Use these values for calculations of vertical crossarm strength.

Total - Total resultant of vertical and transverse loads on conductors under "Heavy Loading" plus an adder of 0.30 lbs./foot (Total Load = $\sqrt{(T^2 + V^2)}$ + 0.3 lbs./foot). Use for slack span calculations and for other sag and tension problems.

Swing Angle - Angle at which the conductor will be displaced from the vertical by a 6 lbs./sq. foot wind blowing at right angles to the line at 60˚F/15˚C. Use these values for horizontal clearance calculations. Calculate horizontal displacement by R sine α where R = max. sag and α = swing angle.

Swing Angle = $\alpha = \tan^{-1}\left(\frac{W_h}{W_v}\right)$

$W_h = \frac{P}{12} \times d$ $\qquad P$ = 6 (6 lbs./sq. foot), 12 Inch Conductor Length

d = Conductor Diameter

W_v = Unloaded Weight of Conductor (lbs./foot)

6.2 SAGS AND TENSIONS

All overhead lines must meet minimum clearance requirements of the NESC in force at the time the line is constructed. Prior to the 1977 issue of the NESC, minimum basic clearances allowed for increased sag due to ice loading or operation at a 120˚F/50˚C maximum conductor temperature.

The 1977 revision to the NESC, under Rule 232B2, permits the owner to establish a conductor maximum operating temperature while maintaining minimum clearance requirements. The Company has established a 176˚F/80˚C maximum allowable conductor operating temperature under normal conditions and a 194˚F/90˚C maximum allowable conductor operating temperature under emergency conditions for a specific period of time.

6.2.10 Limiting Tensions

In the design of overhead lines, three limiting values of tension shall be observed:

A. Initial Unloaded or Stringing Tension is that which will exist before the application of any external load or immediately after new conductors have been installed. The initial unloaded tension at 0˚F/-18˚C shall not exceed 35% of rated breaking strength. The temperature of 0˚F/-18˚C is used instead of 60˚F/15˚C required by the NESC because the aluminum manufacturers have indicated that 0˚F/-18˚C is more critical for aluminum than 60˚F/15˚C. Although it is not necessary, the 0˚F/-18˚C tension is used for conductors other than aluminum to be consistent.

B. Maximum Design Tension is that to which the conductor is subjected upon occurrence of the maximum climatic loading specified for design work in the NESC Heavy Loading area. The maximum conductor tension, either initial or final, shall not exceed 50% of rated breaking strength. This limit is less than the 60% required by the NESC to allow for higher tensions due to spans longer than the ruling span and to allow for slight tolerances in sagging. A 2,000 lb. tension limitation is common for most distribution conductors, especially those that deadend on crossarms. All conductors except spacer cable messengers and specially noted conductors shall be limited to an approximate maximum tension of 2000 lbs. A 3,000 lb. tension limitation is acceptable, with appropriate hardware, in situations where the resulting line has a clear advantage over standard 2,000 lb. design because of lower costs due to longer spans or improved appearance of the line.

C. Final Unloaded Tension is that which the conductor assumes under no external loading but after the maximum design tension has been sustained for sufficient time to permit stretching to cease. The final unloaded tension at 0˚F/-18˚C shall not exceed 25% of rated breaking strength. The 0˚F/-18˚C tension is used for the same reason as in the above criteria A.

The sag tables demonstrate sags under various temperatures and loading conditions. New conductors strung to “Stringing” (Initial) values will have initial, maximum and final tensions as specified. The sag will increase under design loading, then change as shown in “Final” sags depending on temperature and loading.

The Initial Sag tables are based on the Ruling Span Method of calculation and the Final Sag tables are based on the Deadend Method, as discussed below. In the event that Initial or Final Sags that are not shown are required, contact Standards Engineering.

6.2.20 Deadend or Uniform Spans

Sag tables based on deadend span methods assume that there is only one span or that all spans are the same length. This method is useful for short spans in urban areas where the spacing is reasonably uniform. If long spans in a section of line are sagged according to a deadend table, short spans in the same section will have a sag value that may or may not correspond with the table. For this reason, it is customary to sag a span of average length near the center of the line and to recognize that there may be slightly more or less sag in the longer and shorter spans than is indicated by the tables.

In order to determine the sag value for a specific span length, multiply the ruling span sag value by the ratio provided in Table 1 for the corresponding actual span length. In the event that the needed actual span length is not provided in this table, a method for determining the resultant ratio value is provided below.

Table 1
Ratio of Deadend Span Sag to Sags at Other Span Lengths with Same Tension

ACTUAL SPAN	DEADEND SPAN										
	50’	75’	100’	125’	150’	175’	200’	225’	250’	275’	300’
100’	4.00	1.78	1.00	0.64	0.44	0.33	0.25	0.20	0.16	0.13	0.11
110’	4.84	2.15	1.21	0.77	0.54	0.40	0.30	0.24	0.19	0.16	0.13
120’	5.76	2.56	1.44	0.92	0.64	0.47	0.36	0.28	0.23	0.19	0.16
130’	6.76	3.00	1.69	1.08	0.75	0.55	0.42	0.33	0.27	0.22	0.19
140’	7.84	3.48	1.96	1.25	0.87	0.64	0.49	0.39	0.31	0.26	0.22
150’	9.00	4.00	2.25	1.44	1.00	0.73	0.56	0.44	0.36	0.30	0.25
160’	10.24	4.55	2.56	1.64	1.14	0.84	0.64	0.51	0.41	0.34	0.28
170’	11.56	5.13	2.89	1.85	1.28	0.94	0.72	0.57	0.46	0.38	0.32
180’	12.96	5.76	3.24	2.07	1.44	1.06	0.81	0.64	0.52	0.43	0.36
190’	14.44	6.42	3.61	2.31	1.60	1.18	0.90	0.71	0.58	0.48	0.40
200’	16.00	7.11	4.00	2.56	1.78	1.31	1.00	0.79	0.64	0.53	0.44
210’	17.64	7.84	4.41	2.82	1.96	1.44	1.10	0.87	0.71	0.58	0.49
220’	19.36	8.60	4.84	3.10	2.15	1.58	1.21	0.96	0.77	0.64	0.54
230’	21.16	9.40	5.29	3.39	2.35	1.73	1.32	1.04	0.85	0.70	0.59
240’	23.04	10.24	5.76	3.69	2.56	1.88	1.44	1.14	0.92	0.76	0.64
250’	25.00	11.11	6.25	4.00	2.78	2.04	1.56	1.23	1.00	0.83	0.69

Method for Determining Ratio:

1. Choose Deadend Span.
2. Find deadend span sag from sag table for temperature and deadend span desired.
3. Multiply deadend span sag by above ratio for actual spans as line is laid out to obtain actual span.
4. For deadend span to actual span ratio other than those listed above:

$$RATIO = \frac{(ACTUAL\ SPAN)^2}{(DEADEND\ SPAN)^2}$$

6.2.30 Ruling Spans

This is a calculated span length for which the conductor tension, under changes in temperature and loading, best represents the average tension in the conductor in a particular series of spans between deadends. Ideally, a line should be installed in such a way that all spans of the line have equal horizontal line tension. If this is done, longitudinal forces on pole tops between spans are theoretically zero. Deadend poles and poles located at bends in the line will typically require guying in order to counteract the line tension.

Sag tables based on the ruling span method recognize variations in span length. This method assumes that the line will be strung to uniform tension. If this is done, all spans will have initial sags that are very near the values in the table. After the conductors are tied into place, however, and after ice and wind loads stretch the wires, the tension may not be uniform and the sags may vary from the calculated values. If the actual spans are much longer or shorter than the ruling span, the tension and sags may be different than the calculations.

The ruling span can most accurately be determined through the following equation:

$$\text{Ruling Span} = \sqrt{\frac{(L_1^3 + L_2^3 + L_3^3 + \ldots L_N^3)}{(L_1 + L_2 + L_3 + \ldots L_N)}}$$

Where L_1, L_2, L_3, etc. are the lengths of the first, second, third, etc., spans between deadends.

Spans that are longer than 150% of the average should be avoided or should be sagged independently and guyed to hold the unbalanced tension. All new standard construction for tension should conform to the Company's design which limits tension to 50% of the conductor rated breaking strength by following the above mentioned ruling span calculation.

6.2.40 Slack Spans

When guys cannot be installed on the end pole of a line, they may be placed on an adjacent pole. A slack span should then be installed to the end pole. Slack spans may also be necessary for other applications. They are not recommended if there is any way of avoiding them, but when used, calculations should be made as follows:

$$\text{String Sag in Feet} = \frac{W \times L^2}{8 \times T}$$

W = Total loaded weight lbs./ft.
L = Total length of span in ft.
T = Tension in pounds. See Section 2-Poles / Hardware for strength required in poles.

Example:

50 foot span, 3-336.4 kcmil bare AAC to be deadended on an un-guyed Class 5 pole.
Use T = 200 lb. per conductor.

W = 1.48 lbs./foot (from Page 6-109)
L = 50 feet (span length)
T = 200 lbs.

$$S = \frac{W \times L^2}{8 \times T} = \frac{1.48 \times 50^2}{8 \times 200} = \frac{3700}{1600} = 2.3125\,Feet$$

Sag the conductor at 2.31 feet, at normal temperature. This approximation *assumes* that the conductors will have 2.31 feet of sag at 0˚F/-18˚C when subject to ice and wind.

6.3 MAXIMUM SPANS

Maximum spans, as shown in the table or on the pole top drawings, are based on many factors including: sag vs. pole height, transverse load vs. pole strength, vertical weight vs. strength of crossarms, and ratio of sag to separation of conductors. Spans are limited so that standard poles of reasonable height and class may be used for most work. They also are limited to reduce probability of wires coming together due to wind effects.

Span length should be limited to recommended values for all normal work. Longer spans may be used, except at railroad or major crossings, if clearances are adjusted accordingly. If longer spans are still essential, separate deadend spans should be designed by Standards Engineering to meet the field conditions.

6.4 AMPACITY

Current in overhead line conductors should be limited so that voltage drops will be held to reasonable values; so that conductors will not be severely annealed or damaged; so that switches, connectors, etc. will not be overloaded and that clearances are not exceeded. Any feeder that is desired to be operated at the elevated operating temperature permitted for emergency conditions should be assessed to verify that available clearances are present to account for the resulting additional sag as outlined in each respective conductor data table. Minimum clearances, outlined in Section 7 – Clearances, should not be compromised.

Table 2
Ampacity Design Parameters

SPECIFICATION	BARE CONDUCTOR	TREE WIRE
	SUMMER / WINTER	SUMMER / WINTER
Maximum Allowable Steady State Conductor Temperature (˚C) For Normal Operating Conditions	176˚F/80˚C	167˚F/75˚C
Maximum Allowable Steady State Conductor Temperature (˚C) For Emergency Contingencies	194˚F/90˚C	194˚F/90˚C
Ambient Air Temperature (˚C)	100˚F/37.7˚C / 50˚F/10˚C	100˚F/37.7˚C / 50˚F/10˚C
Wind Speed (FT. / SEC.)	3 FEET/SEC.	3 FEET/SEC.
Angle between Wind and Conductor	90˚	90˚
Coefficient of Emissivity	0.75	0.91
Coefficient of Absorption	0.75	0.91
Climatic Data Record (CDR) elevation above sea level (FT.)	914.2125 FEET	914.2125 FEET
Conductor Direction (North – South, East – West)	North – South	North – South
CDR Latitude in Degrees	42˚	42˚
Solar Heating	12:00 PM (noon)/NONE	12:00 PM (noon)/NONE
Atmosphere	CLEAR	CLEAR
Conductor Resistance in Ohm/mi. for the Low Temperature @ 77˚F/25˚C	Conductor Specific – In Accordance with Low Conductor Temperature	Conductor Specific – In Accordance with Low Conductor Temperature
Conductor Resistance in Ohm/mi. for the High Temperature @ 167˚F/75˚C	Conductor Specific – In Accordance with High Conductor Temperature	Conductor Specific – In Accordance with High Conductor Temperature

The "Normal" rating is the maximum rating for daily operation without encountering excessive loss of life, etc. and accounting for load cycles as well as ambient temperature cycles. Limits are based on allowable sags, clearance issues, and avoiding damage. The "Emergency" rating is the ultimate or maximum rating for a specific period of time, accounting for peak load cycle and ambient temperature cycles, without enduring excessive loss of life. Emergency ratings are applicable to short-term relief and should not exceed a 24 hour load cycle. For design purposes, emergency ratings exceeding a full load cycle were assumed resulting in a conductor rating that does not promote excessive loss of conductor life during such contingencies. This more conservative view was used for overhead conductors because of the concern for a permanent annealing of the conductor. For overhead conductors, such annealing could result in excess sag, and ultimately create clearance issues. In any case, the "Emergency" ampacity rating should not be exceeded nor allowed for prolonged duration in excess of 24 hours.

Primary overhead conductors have two (2) ampacity ratings for summer conditions and two (2) ampacity ratings for winter conditions as defined below:

Normal: The Normal rating shall be interpreted as the maximum value for normal peak loads on all new and rebuilt feeders. This is done to accommodate emergency conditions where ampacity may be increased for a period of time no greater than 24 hours. Existing feeders may be loaded to these levels if a review indicates that appropriate clearances can be maintained. (100% ampacity for normal operating conductor temperature limit; 176˚F/80˚C for bare conductors, 167˚F/75˚C for spacer cable / tree wire / covered conductors)

Emergency: The Emergency rating shall be interpreted as the absolute maximum ampacity allowed for a given conductor. This ampacity should not be exceeded under any condition unless an appropriate engineering review has been conducted. (100% ampacity for operating conductor at an elevated temperature during emergency conditions limited to a 24 hour period; 194˚F/90˚C for both bare and spacer cable / tree wire / covered conductors)

6.5 PLANNING CONDUCTOR INSTALLATIONS

6.5.10 General

Background knowledge of conductor sag and tensions, and ampacity are essential for all phases of planning, as well as determining the appropriate conductor, pole class and height, guy designs, etc. Designs will also be influenced by features that are discussed in specific Sections of these standards, including: Primaries, Street Lighting, and Secondaries.

The size for conductor should follow planning criteria or reviewed by a distribution system planning engineer. The distribution designer who selects the materials should furnish guidance to the field whenever it is required. For example, the distribution designer should furnish stringing sags at 32˚F/0˚C, 60˚F/15˚C, and 90˚F/32˚C and should indicate the spans that should be checked for sag whenever ruling span or slack span sag is needed.

For normal urban work refer to the standard tables, or curves, with variations discussed in Section 22-Materials Catalog.

6.5.20 Employment of 3,000 lb. Maximum Design Tension

Advantages of using design tensions greater than 2,000 lbs. may be substantial under certain circumstances. The advantages include reduced costs, avoiding need for intermediate poles when converting from single phase to three phase, and improved appearance resulting from fewer poles. If advantages like this are clearly evident, 3,000 lb. span construction may be used for three phase lines in rural areas where the presence of secondaries and telephone is minimal and future urbanization is not anticipated. Isolated situations where conventional construction results in excessive sag may also be justification for 3,000 lb. construction. Crossarm tangents, vertical construction, deadends, and 336.4 kcmil or 477 kcmil 18/1 bare ACSR conductors should be employed for 3000 lb construction. Heavy duty arms with gain plates should be used where vertical construction for line angle poles and double deadends are not practical. The 3,000 lb. section of line shall be isolated from 2,000 lb. line sections by proper longitudinal guys at each end.

6.5.30 Deadending Different Conductors

When different conductors are deadended from the opposite directions on the same pole, the load may be balanced under heavy load conditions but not under normal temperatures. Normal conditions must exist when the foreman installs the cable. Three 336.4 kcmil and one 1/0 ACSR conductors, for example, create an unbalanced load of about 8,000 lbs. under heavy loading conditions. One spacer cable messenger will almost balance this with a tension of 7,700 lbs. Under pre-stressed conditions, the spacer cable will be stressed to 5,000 lbs. The open wires, however, will have tensions not over 400 or 500 lbs. each or less than 2,000 lbs. total. For this reason, the spacer cable must be deadended and guyed against the stress. Similar conditions will be met when two small conductors are balanced against one large one. A head guy to the next pole will often be sufficient to take up small unbalanced loads.

6.6 INSTALLING CONDUCTORS

6.6.10 General

In order to obtain the desired tensions it is essential that the conductor be sagged correctly. This Standard has been prepared to guide the installation of conductors.

6.6.20 Sagging Open Wire Primaries – Long Span

For long span work or for special construction, the planner will usually select a ruling span, pick the span that should be sagged, choose the stringing sags, and show them on the construction drawing. If conditions in the field make it impractical to sag this span, the planner should be consulted and the new stringing sags provided.

6.6.30 Sagging Other Open Conductors

Where special conditions warrant, the planner may select the span to be sagged and choose the stringing sags. In many cases, however, the sags will not be specified. In these cases proceed as follows:

A. Choose a span of average length near the center of the section to be pulled.

B. Check the stringing sag tables for a span of that length at the temperature that can be expected during the sagging operations. If the exact span is not shown on the table, use the corresponding ratio multiplier found in Table 1 on Page 6-3 to determine the required value.

   If the actual ruling span is not specified, choose a ruling span that is equal to, or slightly more than, the actual span.

   If existing conductors are to be re-sagged or re-strung, see Part E below.

C. Pull up the entire section, equalizing tension in each span. Check the sag in the key span using a sagging stick or scale. Spans of other lengths will not necessarily have sags that match the stringing tables.

D. When different conductors are strung in parallel (e.g. on the same arm) string them to the value of the conductor with the greatest sag. It may be necessary to provide extra clearance for the wires so sagged.

E. When re-sagging or re-stringing old conductors, they should first be pulled tightly to sags somewhat less than final values, and then backed off to meet the final sag curves.

6.6.40 <u>Line of Sight Method of Sagging Conductors</u>

Select the longest span near the center of the line being sagged. Determine the proper stringing sag from the appropriate sag table. Measure down this distance “X” on both poles of the span from the height of the conductor attachment to the pole (see Figure 1 on Page 6-8). Attach a marker at this point that can be seen from the other pole. The conductor should be sagged to the line of sight between the two markers. The sag should be as close as practical to the stringing sag shown in the sag tables. Decreased sags cause tensions greater than design tensions and may overstress conductors, poles, crossarms and guys. Increased sags cause clearances smaller than design clearance.

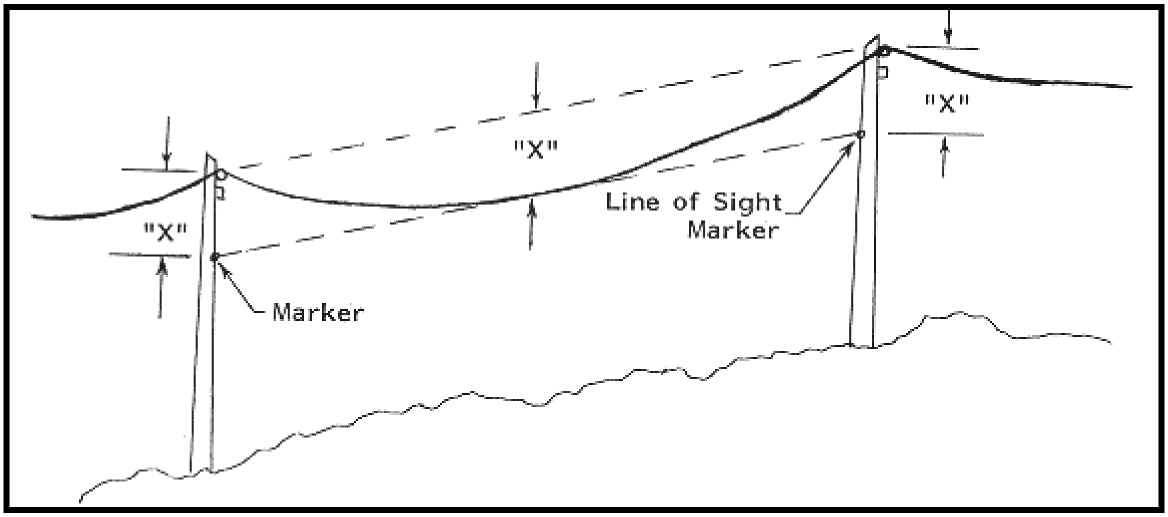


Figure 1 – Line of Sight Method of Sagging Conductors

Standard Overhead Distribution Conductors

 Doc. # ST.06.00.003

Std. Item:	W21NG
Item ID:	5941814[E]
CU:	C1113ASSTBRNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	39,100 lbs.	TRANSVERSE	0.7634 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.9854 sq. in.	VERTICAL	2.546 Lb/Ft			
R. (@ 25˚C)	0.0161 Ω / 1000’	TOTAL	2.958 Lb/Ft	1111	NORMAL	1614
R. (@ 75˚C)	0.0191 Ω / 1000’			1262	EMERGENCY	1709
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	24.33˚			
CONDUCTOR DIAMETER	1.293”					
WEIGHT	1430 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2672	1772	1394	1162	2461	1810	1499	1287	2318	1837	1578	1389	2208	1857	1639	1471
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	3	4	2	3	3	4
60	3	4	6	7	3	4	5	6	3	4	5	6	3	4	5	5
70	4	6	8	9	4	6	7	8	5	6	7	8	5	6	6	7
80	5	8	10	12	6	8	9	11	6	7	9	10	6	7	8	9
90	7	10	12	15	7	10	12	14	8	9	11	13	8	9	11	12
100	8	12	15	18	9	12	14	17	9	12	14	15	10	12	13	15
110	10	15	19	22	11	14	17	20	11	14	16	19	12	14	16	18
120	12	17	22	27	13	17	21	24	13	17	20	22	14	17	19	21
130	14	20	26	31	15	20	24	28	16	20	23	26	16	20	22	25
140	16	24	30	36	17	23	28	33	18	23	27	30	19	23	26	29
150	18	27	35	42	20	27	32	38	21	26	31	35	22	26	29	33
160	21	31	39	47	22	30	37	43	24	30	35	40	25	30	34	37
170	23	35	45	53	25	34	41	48	27	34	39	45	28	33	38	42
180	26	39	50	60	28	38	46	54	30	38	44	50	32	37	42	47
190	29	44	56	67	31	43	52	60	33	42	49	56	35	42	47	53
200	32	48	62	74	35	47	57	67	37	47	54	62	39	46	52	58
210	35	53	68	82	38	52	63	74	41	52	60	68	43	51	58	64
220	39	59	75	90	42	57	69	81	45	57	66	75	47	56	63	71
230	43	64	82	98	46	63	76	88	49	62	72	82	51	61	69	77
240	46	70	89	107	50	68	83	96	53	67	78	89	56	67	75	84
250	50	76	96	116	55	74	90	104	58	73	85	97	61	72	82	91
260	54	82	104	125	59	80	97	113	63	79	92	105	66	78	89	99
270	59	88	112	135	64	87	105	122	68	85	99	113	71	84	96	107
280	63	95	121	145	68	93	112	131	73	92	107	121	76	91	103	115
290	68	102	130	156	73	100	121	141	78	98	115	130	82	97	110	123
300	72	109	139	167	79	107	129	150	83	105	123	139	88	104	118	132

***** Simulated with a maximum tension of 4000 lbs. *****

Std. Item:	W21NG
Item ID:	5941814[E]
CU:	C1113ASSTBRNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.44	4.20	7.20	8.64	9.84	11.28	11.88	12.48
75	3.84	8.28	12.12	14.40	16.08	18.00	18.84	19.68
100	7.68	13.44	18.00	21.36	23.40	25.68	26.76	27.84
125	13.32	20.04	25.08	29.28	31.68	34.44	35.64	36.84
150	20.64	27.84	33.24	38.40	41.16	44.16	45.60	46.92
175	29.40	36.96	42.72	48.36	51.72	55.08	56.64	58.08
200	39.72	47.40	53.52	59.52	63.48	67.08	68.76	70.32
225	51.48	59.28	65.64	71.76	76.44	80.28	81.96	83.76
250	64.56	72.60	79.08	85.44	90.48	94.68	96.48	98.28
275	79.08	87.24	93.84	100.44	105.60	110.28	112.20	114.12
300	95.04	103.20	109.92	116.64	122.04	127.08	129.12	131.16

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	2.76	5.16	7.32	*4000
75	6.24	9.60	12.24	*4000
100	11.04	15.24	18.12	*4000
125	17.28	22.08	25.20	*4000
150	24.96	30.12	33.48	*4000
175	33.96	39.48	43.08	*4000
200	44.40	50.16	53.88	*4000
225	56.16	62.16	65.88	*4000
250	69.36	75.60	79.32	*4000
275	84.00	90.24	94.08	*4000
300	99.96	106.32	110.28	*4000
* Note: Design Specification Constraint				

****** Simulated with a maximum tension of 4000 lbs. ******

 Doc. # ST.06.00.003

Std. Item:	W21NF
Item ID:	5941794[E]
CU:	C795ASSTBRNE

PHYSICAL PROPERTIES	
R.B.S.	28,200 lbs.
C.S.A.	0.7049 sq. in.
R. (@ 25˚C)	0.0222 Ω / 1000'
R. (@ 75˚C)	0.0265 Ω / 1000'
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	1.093"
WEIGHT	1022 lbs / 1000'

LOADING PROPERTIES	
TRANSVERSE	0.6966 Lb/Ft
VERTICAL	2.015 Lb/Ft
TOTAL	2.432 Lb/Ft
SWING	28.14˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
902	**NORMAL**	1299
1021	**EMERGENCY**	1375

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2446	1557	1165	938	2192	1537	1228	1028	2004	1523	1274	1100	1874	1513	1310	1157
ACTUAL SPAN (FEET)																
50	2	2	3	4	2	2	3	4	2	3	3	3	2	3	3	3
60	2	4	5	6	3	4	5	5	3	4	4	5	3	4	4	5
70	3	5	6	8	3	5	6	7	4	5	6	7	4	5	6	7
80	4	6	8	10	4	6	8	10	5	6	8	9	5	6	8	8
90	5	8	11	13	6	8	10	12	6	8	10	11	7	8	10	11
100	6	10	13	16	7	10	13	15	8	10	12	14	8	10	12	13
110	8	12	16	20	8	12	15	18	9	12	15	17	10	12	14	16
120	9	14	19	24	10	14	18	22	11	15	17	20	12	15	17	19
130	11	17	22	28	12	17	21	25	13	17	20	24	14	17	20	22
140	12	19	26	32	14	20	25	29	15	20	24	27	16	20	23	26
150	14	22	30	37	16	22	28	34	17	23	27	31	18	23	26	30
160	16	25	34	42	18	26	32	38	20	26	31	36	21	26	30	34
170	18	29	38	47	20	29	36	43	22	29	35	40	24	29	34	38
180	20	32	43	53	23	32	41	48	25	333	39	45	27	33	38	43
190	23	36	48	59	25	36	45	54	28	36	44	50	30	37	42	48
200	25	39	53	66	28	40	50	60	31	40	48	56	33	41	47	53
210	28	44	58	72	31	44	55	66	34	45	53	62	36	45	52	59
220	30	48	64	79	34	48	61	72	37	49	58	68	40	49	57	64
230	33	52	70	87	37	53	66	79	41	53	64	74	43	54	62	70
240	36	57	76	94	40	58	72	86	44	58	69	81	47	59	68	77
250	39	62	82	103	44	62	78	94	48	63	75	87	51	63	73	83
260	42	67	89	111	47	68	85	101	52	68	82	95	55	69	79	90
270	46	71	96	120	51	73	91	109	56	74	88	102	60	74	59	97
280	49	77	103	129	55	78	98	117	60	79	95	110	64	80	92	104
290	53	83	111	138	59	84	105	126	64	85	101	118	69	85	99	112
300	57	89	119	148	63	90	113	135	69	91	109	126	74	91	106	120

****** Simulated with a maximum tension of 3500 lbs. ******

Std. Item:	W21NF
Item ID:	5941794[E]
CU:	C795ASSTBRNE

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.20	3.00	6.00	7.68	9.00	10.44	11.16	11.76
75	3.00	6.36	10.44	13.20	14.88	16.92	17.76	18.72
100	5.88	11.16	15.84	19.68	21.72	24.24	25.32	26.40
125	10.56	17.04	22.44	27.12	29.52	32.40	33.72	35.04
150	16.92	24.36	30.12	35.52	38.40	41.64	43.08	44.52
175	24.96	32.88	39.00	44.88	48.36	51.84	53.40	55.08
200	34.44	42.60	49.08	55.20	59.28	63.12	64.92	66.60
225	45.36	53.76	60.36	66.84	71.40	75.48	77.40	79.20
250	57.72	66.12	72.96	79.68	84.72	89.04	90.96	93.00
275	71.28	79.92	86.76	93.72	99.24	103.80	105.84	107.76
300	86.28	94.92	101.88	109.08	114.84	119.64	121.80	123.84

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	2.64	4.32	6.12	*3500
75	5.88	8.40	10.68	*3500
100	10.44	13.80	16.20	*3500
125	16.32	20.16	22.80	*3500
150	23.40	27.84	30.48	*3500
175	31.92	36.72	39.36	*3500
200	41.76	46.80	49.56	*3500
225	52.80	58.08	60.84	*3500
250	65.16	70.68	73.56	*3500
275	78.84	84.48	87.36	*3500
300	93.84	99.60	102.48	*3500

** Note: Design Specification Constraint*

****** Simulated with a maximum tension of 3500 lbs. ******

Std. Item:	W21BF
Item ID:	5941790[E]
CU:	C795ALSTBRNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	13,900 lbs.	**TRANSVERSE**	0.6765 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.6245 sq. in.	**VERTICAL**	1.695 Lb/Ft			
R. (@ 25˚C)	0.0227 Ω / 1000’	**TOTAL**	2.125 Lb/Ft	880	**NORMAL**	1265
R. (@ 75˚C)	0.0269 Ω / 1000’			997	**EMERGENCY**	1339
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	34.54˚			
CONDUCTOR DIAMETER	1.026”					
WEIGHT	745.3 lbs / 1000’					

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	869	656	554	484	812	668	588	527	780	676	612	559	761	682	629	584
ACTUAL SPAN (FEET)																
50	3	4	5	6	3	4	5	5	4	4	5	5	4	4	4	5
60	5	6	7	8	5	6	7	8	5	6	7	7	5	6	6	7
70	6	8	10	11	7	8	9	10	7	8	9	10	7	8	9	9
80	8	11	13	15	9	11	12	14	9	11	12	13	9	11	11	12
90	10	14	16	19	11	14	15	17	12	13	15	16	12	13	14	16
100	13	17	20	23	14	17	19	21	14	17	18	20	15	16	18	19
110	16	21	24	28	17	20	23	26	17	20	22	24	18	20	22	23
120	19	25	29	33	20	24	27	31	21	24	26	29	21	24	26	28
130	22	29	34	39	23	28	32	36	24	28	31	34	25	28	30	32
140	25	33	40	45	27	33	37	42	28	32	36	39	29	32	35	38
150	29	38	45	52	31	38	43	48	32	37	41	45	33	37	40	43
160	33	44	52	59	35	43	49	54	37	42	47	51	38	42	46	49
170	37	49	58	67	40	48	55	61	41	48	53	58	43	47	51	55
180	42	55	66	75	45	54	62	69	46	54	59	65	48	53	58	62
190	47	62	73	84	50	61	69	77	52	60	66	72	53	59	64	69
200	52	68	81	93	55	67	76	85	57	66	73	80	59	66	71	77
210	57	75	89	102	61	74	84	94	63	73	81	88	65	72	79	85
220	62	83	98	112	67	81	92	103	69	80	89	97	71	80	86	93
230	68	90	107	123	73	89	101	113	76	88	97	106	78	87	94	101
240	74	98	117	134	79	97	110	123	83	95	106	115	85	95	103	110
250	81	107	126	145	86	105	119	133	90	104	115	125	92	103	111	120
260	87	116	137	157	93	113	129	144	97	112	124	136	100	111	120	130
270	94	125	148	169	101	122	139	155	105	121	134	146	107	120	130	140
280	101	134	159	182	108	132	150	167	113	130	144	157	115	129	140	150
290	108	144	170	195	116	141	161	179	121	139	154	169	124	138	150	161
300	116	154	182	209	124	151	172	192	129	149	165	181	133	148	160	173

795.0 KCMIL, 37 STRAND, BARE AAC, “ARBUTUS” – 15 kV

ISSUE	PAGE NUMBER		
1/07	6-105	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Std. Item:	W21BF
Item ID:	5941790[E]
CU:	C795ALSTBRNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.92	5.88	8.88	11.28	13.44	15.60	16.56	17.52
75	6.00	11.52	15.24	18.60	21.48	24.60	26.04	27.24
100	12.84	18.96	23.28	27.24	30.72	34.68	36.48	38.04
125	21.96	28.20	33.00	37.44	41.40	46.08	48.12	50.04
150	33.00	39.48	44.40	49.32	53.76	58.92	61.20	63.48
175	45.96	52.56	57.84	63.00	67.68	73.32	75.96	78.36
200	61.08	67.68	73.08	78.48	83.52	89.52	92.28	94.92
225	78.00	84.72	90.24	95.88	101.04	107.40	110.28	113.16
250	97.08	103.80	109.44	115.08	120.60	127.20	130.20	133.08
275	118.08	124.80	130.56	136.32	141.96	148.80	151.92	154.92
300	141.12	147.96	153.60	159.60	165.24	172.32	175.56	178.68

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.08	6.84	9.00	*1948
75	9.36	12.84	15.48	*1921
100	16.56	20.64	23.52	*1924
125	25.80	30.12	33.24	*1934
150	36.84	41.52	44.76	*1945
175	50.04	54.84	58.20	*1954
200	65.04	70.08	73.44	*1961
225	82.08	87.24	90.60	*1968
250	101.16	106.32	109.80	*1972
275	122.16	127.44	130.92	*1976
300	145.20	150.60	154.08	*1979
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.003

Std. Item:	W21ND
Item ID:	5942647
CU:	C795ALTWHMP35KNE
CU:	C795ALSCHMP35KNE

PHYSICAL PROPERTIES	
R.B.S.	13,900 lbs.
C.S.A.	0.6245 sq. in.
R. (@ 25˚C)	0.0227 Ω / 1000’
R. (@ 75˚C)	0.0271 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	0.932”
COMPLETE DIAMETER	1.572” (Nominal)
WEIGHT	1,315 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.8557 Lb/Ft
VERTICAL	2.604 Lb/Ft
TOTAL	3.041 Lb/Ft
SWING	30.87˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
669	NORMAL	952
828	EMERGENCY	1058

Supersedes 1/07 Issue – Updated ampacities.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	914	804	734	676	898	821	767	719	889	832	789	750	884	839	805	773
ACTUAL SPAN (FEET)																
50	5	6	7	7	5	6	6	7	6	6	6	7	6	6	6	6
60	8	9	10	11	8	9	9	10	8	9	9	9	8	8	9	9
70	11	12	13	14	11	12	13	13	11	12	12	13	11	12	12	13
80	14	16	17	19	14	15	16	18	14	15	16	17	14	15	16	16
90	17	20	22	24	18	19	21	22	18	19	20	21	18	19	20	21
100	22	25	27	29	22	24	26	27	22	24	25	26	22	24	25	26
110	26	30	33	35	27	29	31	33	27	29	30	32	27	28	30	31
120	31	35	39	42	32	35	37	40	32	34	36	38	32	34	35	37
130	37	42	45	49	37	41	44	46	38	40	42	44	38	40	41	43
140	42	48	53	57	43	47	50	54	44	47	49	52	44	46	48	50
150	49	55	61	66	49	54	58	62	50	53	56	59	50	53	55	58
160	55	63	69	75	56	62	66	70	57	61	64	67	57	60	63	65
170	62	71	78	85	64	70	74	79	64	69	72	76	65	68	71	74
180	70	80	87	95	71	78	84	89	72	77	81	85	72	76	80	83
190	78	89	97	106	79	87	93	99	80	86	90	95	81	85	89	92
200	86	98	108	117	88	96	103	110	89	95	100	105	89	94	98	102
210	95	108	119	129	97	106	114	121	98	105	110	116	99	104	108	113
220	105	119	131	142	106	117	125	133	108	115	121	128	108	114	119	124
230	114	130	143	155	116	127	137	146	118	126	133	140	118	125	130	135
240	125	142	155	169	127	139	149	159	128	137	144	152	129	136	142	148
250	135	154	169	183	138	151	161	172	139	149	157	165	140	147	154	160
260	146	166	183	198	149	163	175	186	150	161	170	178	151	159	166	173
270	158	180	197	214	161	176	188	201	162	174	183	193	163	172	179	187
280	170	193	212	230	173	189	203	216	175	187	197	207	176	185	193	201
290	182	207	227	247	185	203	217	232	187	200	211	222	188	199	207	216
300	195	222	243	265	198	217	233	248	200	214	226	238	202	213	222	231

795.0 KCMIL, 19 STRAND, COMPACT AAC, 320 MIL COVERED TREE WIRE – 35 kV

ISSUE	PAGE NUMBER		
7/09	6-107	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

Std. Item:	W21ND
Item ID:	5942647
CU:	C795ALTWHMP35KNE
CU:	C795ALSCHMP35KNE

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	4.68	8.28	10.80	12.84	14.76	16.80	17.64	18.60
75	11.88	15.96	18.96	21.84	24.24	27.12	28.44	29.64
100	21.96	26.40	29.76	33.00	35.88	39.36	40.92	42.36
125	34.92	39.36	42.96	46.56	49.92	53.88	55.56	57.36
150	50.64	55.32	59.04	62.76	66.36	70.68	72.60	74.52
175	69.24	73.92	77.76	81.72	85.56	90.12	92.16	94.20
200	90.72	95.52	99.48	103.44	107.40	112.20	114.36	116.52
225	115.08	119.88	123.84	128.04	132.12	137.04	139.32	141.60
250	142.32	147.12	151.20	155.40	159.60	164.64	167.04	169.32
275	172.56	177.36	181.44	185.76	189.96	195.12	197.52	199.92
300	205.56	210.36	214.56	218.88	223.08	228.36	230.88	233.28

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	6.00	8.88	10.80	*1899
75	13.32	16.80	19.08	*1919
100	23.52	27.24	29.88	*1940
125	36.48	40.44	43.20	*1955
150	52.32	56.28	59.16	*1965
175	70.92	75.00	78.00	*1973
200	92.40	96.60	99.60	*1978
225	116.76	121.08	124.08	*1982
250	144.00	148.32	151.44	*1985
275	174.24	178.56	181.56	*1988
300	207.24	211.56	214.68	*1989

** Note: Design Specification Constraint*

 | Doc. # ST.06.00.003

Std. Item:	W21BG
Item ID:	5942646
CU:	C795ALTWHMPNE
CU:	C795ALSCHMPNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	13,900 lbs.	TRANSVERSE	0.7643 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.6245 sq. in.	VERTICAL	2.164 Lb/Ft			
R. (@ 25˚C)	0.0227 Ω / 1000’	TOTAL	2.595 Lb/Ft	714	NORMAL	1005
R. (@ 75˚C)	0.0271 Ω / 1000’			881	EMERGENCY	1118
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	31.63˚			
CONDUCTOR DIAMETER	0.932”					
COMPLETE DIAMETER	1.292” (Nominal)					
WEIGHT	1,049 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	900	752	667	601	871	767	701	646	853	777	725	679	843	784	742	703
ACTUAL SPAN (FEET)																
50	4	5	6	7	5	5	6	6	5	5	5	6	5	5	5	6
60	6	8	8	9	7	7	8	9	7	7	8	8	7	7	8	8
70	9	10	12	13	9	10	11	12	9	10	11	11	9	10	10	11
80	11	13	15	17	12	13	14	16	12	13	14	15	12	13	14	14
90	14	17	19	21	15	17	18	20	15	16	18	19	15	16	17	18
100	17	21	24	26	18	21	22	24	18	20	22	23	19	20	21	22
110	21	25	29	32	22	25	27	29	22	24	26	28	23	24	26	27
120	25	30	34	38	26	30	32	35	27	29	31	33	27	29	31	32
130	30	35	40	44	31	35	38	41	31	34	37	39	32	34	36	38
140	34	41	46	51	35	40	44	48	36	40	43	45	37	39	42	44
150	39	47	53	59	41	46	51	55	42	46	49	52	42	45	48	50
160	45	54	60	67	46	53	58	62	47	52	56	59	48	51	54	57
170	51	61	68	76	52	59	65	70	53	59	63	67	54	58	61	65
180	57	68	77	85	59	67	73	79	60	66	70	75	61	65	69	73
190	63	76	85	95	65	74	81	88	67	73	78	84	67	73	77	81
200	70	84	95	105	72	82	90	98	74	81	87	93	75	80	85	90
210	77	92	104	116	80	91	99	108	81	89	96	102	82	89	94	99
220	85	101	114	127	88	99	109	118	89	98	105	112	91	97	103	109
230	93	111	125	139	96	109	119	129	98	107	115	123	99	106	112	119
240	101	121	136	151	104	118	130	141	106	117	125	134	108	116	122	129
250	109	131	148	164	113	128	141	153	115	127	136	145	117	126	133	140
260	118	142	160	178	122	139	152	165	125	137	147	157	127	136	144	152
270	128	153	173	192	132	150	164	178	135	148	159	170	136	147	155	164
280	137	165	186	206	142	161	177	192	145	159	171	182	147	158	167	176
290	147	177	199	221	152	173	189	206	155	171	183	196	157	169	179	189
300	158	189	213	237	163	185	203	220	166	183	196	210	169	181	192	202

Supersedes 1/07 Issue – Updated ampacities.

795.0 KCMIL,19 STRAND, COMPACT AAC, 180 MIL COVERED TREE WIRE – 15 kV

Std. Item:	W21BG
Item ID:	5942646
CU:	C795ALTWHMPNE
CU:	C795ALSCHMPNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	3.24	7.20	9.84	12.12	14.04	16.20	17.16	18.00
75	9.24	13.92	17.16	20.28	142.92	25.92	27.12	28.44
100	17.88	22.80	26.64	30.12	33.36	37.08	38.64	40.20
125	28.92	34.08	38.16	42.12	45.72	49.92	51.84	53.64
150	42.36	47.64	51.96	56.16	60.12	64.80	66.96	69.00
175	58.20	63.72	68.04	72.48	76.68	81.72	84.12	86.28
200	76.56	82.08	86.64	91.20	95.64	100.92	103.32	105.72
225	97.32	102.84	107.52	112.20	116.76	122.28	124.92	127.32
250	120.60	126.12	130.80	135.60	140.40	146.04	148.68	151.32
275	146.28	151.80	156.60	161.52	166.32	172.20	174.84	177.60
300	174.36	180.00	184.80	189.84	194.64	200.64	203.40	206.16

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	5.16	7.92	9.96	*1904
75	11.52	14.88	17.28	*1906
100	20.28	24.12	26.76	*1923
125	31.32	35.52	38.28	*1939
150	44.88	49.20	52.20	*1952
175	60.84	65.28	68.28	*1961
200	79.20	83.76	86.88	*1968
225	99.96	104.64	107.76	*1974
250	123.24	127.92	131.04	*1978
275	148.92	153.72	156.84	*1981
300	177.12	181.92	185.04	*1984
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.003

Std. Item:	
Item ID:	5941551
CU:	C477BACSR

PHYSICAL PROPERTIES	
R.B.S.	19,500 lbs.
C.S.A.	0.4353 sq. in.
R. (@ 25˚C)	0.0366 Ω / 1000’
R. (@ 75˚C)	0.0438 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	0.858” (Nominal)
WEIGHT	656 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.6174 Lb/Ft
VERTICAL	1.501 Lb/Ft
TOTAL	1.923 Lb/Ft
SWING	33.18˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
658	NORMAL	938
742	EMERGENCY	991

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2200	1333	913	691	1936	1255	937	750	1707	1200	954	796	1533	1161	967	832
ACTUAL SPAN (FEET)																
50	1	2	3	4	1	2	3	3	1	2	3	3	2	2	3	3
60	2	3	4	5	2	3	4	5	2	3	4	4	2	3	4	4
70	2	4	5	7	2	4	5	6	3	4	5	6	3	4	5	6
80	3	5	7	9	3	5	7	8	4	5	7	8	4	5	7	8
90	4	6	9	12	4	6	9	11	5	7	8	10	5	7	8	10
100	4	7	11	14	5	8	11	13	6	8	10	12	6	8	10	12
110	5	9	13	17	6	9	13	16	7	10	12	15	8	10	12	14
120	6	11	16	21	7	11	15	19	8	12	15	18	9	12	15	17
130	8	12	18	24	9	13	18	22	10	14	17	21	11	14	17	20
140	9	14	21	28	10	15	21	26	11	16	20	24	13	17	20	23
150	10	17	24	32	11	18	24	30	13	18	23	28	14	19	23	27
160	11	19	28	36	13	20	27	34	15	21	26	32	16	22	26	30
170	13	21	31	41	15	23	30	38	17	24	30	36	19	25	29	34
180	14	24	35	46	16	25	34	43	19	27	33	40	21	27	33	38
190	16	27	39	51	18	28	38	47	21	30	37	45	23	31	37	43
200	18	30	43	57	20	31	42	53	23	33	41	50	26	34	41	47
210	20	33	48	63	22	35	46	58	25	36	45	55	28	37	45	52
220	22	36	52	69	25	38	51	64	28	40	50	60	31	41	49	57
230	24	39	57	75	27	41	56	69	31	43	55	65	34	45	54	63
240	26	43	62	82	29	45	61	76	33	47	59	71	37	49	59	68
250	28	46	67	89	32	49	66	82	36	51	64	77	40	53	64	74
260	30	50	73	96	34	53	71	89	39	55	70	84	43	57	69	80
270	33	54	79	104	37	57	77	96	42	60	75	90	47	62	74	86
280	35	58	85	112	40	61	82	103	45	64	81	97	50	66	80	93
290	38	62	91	120	43	66	88	111	48	69	87	104	54	71	86	100
300	40	66	97	128	46	71	95	118	52	74	93	111	58	76	92	107

****** Simulated with a maximum tension of 3000 lbs. ******

Std. Item:	
Item ID:	5941551
CU:	C477BACSR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.84	1.8	4.44	6.12	7.68	9.36	10.08	10.68
75	2.16	4.32	8.28	10.92	12.84	15.12	16.08	17.04
100	4.2	8.16	13.2	16.68	19.08	21.72	23.04	24.12
125	7.44	13.32	19.08	23.4	26.16	29.28	30.72	32.04
150	12.36	19.68	26.04	31.20	34.20	37.68	39.24	40.92
175	19.08	27.48	34.08	39.96	43.20	47.04	48.84	50.52
200	27.48	36.36	43.32	49.80	53.28	57.36	59.28	61.20
225	37.44	46.56	53.64	60.72	64.32	68.76	70.80	72.84
250	48.72	57.96	65.28	72.48	76.56	81.24	83.40	85.44
275	61.20	70.56	78.00	85.44	89.76	94.68	96.96	99.12
300	75.00	84.36	91.92	99.48	104.28	109.32	111.60	113.88

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	2.40	3.48	4.68	3000*
75	5.40	7.20	8.64	3000*
100	9.60	12.00	13.68	3000*
125	15.00	18.00	19.68	3000*
150	21.60	24.96	26.64	3000*
175	29.52	33.12	34.80	3000*
200	38.52	42.48	44.16	3000*
225	48.72	52.92	54.60	3000*
250	60.12	64.44	66.12	3000*
275	72.72	77.28	78.96	3000*
300	86.64	91.20	92.88	3000*
** Note: Design Specification Constraint*				

****** Simulated with a maximum tension of 3000 lbs. ******

 Doc. # ST.06.00.003

Std. Item:	W21BA
Item ID:	0811125
CU:	C477ALSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8,360 lbs.	**TRANSVERSE**	0.5992 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.3744 sq. in.	**VERTICAL**	1.252 Lb/Ft			
R. (@ 25˚C)	0.0373 Ω / 1000’	**TOTAL**	1.688 Lb/Ft	640	**NORMAL**	908
R. (@ 75˚C)	0.0445 Ω / 1000’			721	**EMERGENCY**	960
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	41.59˚			
CONDUCTOR DIAMETER	0.793”					
WEIGHT	446.8 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1086	616	451	363	885	590	470	394	765	574	482	419	695	564	492	438
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	3	4	2	3	3	4
60	2	4	5	7	3	4	5	6	3	4	5	6	3	4	5	6
70	3	5	7	9	4	6	7	8	4	6	7	8	5	6	7	8
80	4	7	10	12	5	7	9	11	6	7	9	10	6	8	9	10
90	5	9	12	15	6	9	12	14	7	9	11	13	8	10	11	12
100	6	11	15	19	8	11	14	17	9	12	14	16	10	12	14	15
110	7	13	18	22	9	14	17	21	11	14	17	19	12	14	17	19
120	9	16	21	27	11	16	21	25	13	17	20	23	14	17	20	22
130	10	18	25	31	13	19	24	29	15	20	24	27	16	20	23	26
140	12	21	29	36	15	22	28	33	17	23	27	31	19	23	27	30
150	14	25	34	42	17	26	32	38	20	26	31	36	22	27	31	35
160	16	28	38	47	19	29	37	44	22	30	36	41	25	31	35	39
170	18	32	43	54	22	33	41	49	25	34	40	46	28	34	40	44
180	20	35	48	60	25	37	46	55	28	38	45	52	31	39	44	50
190	22	39	54	67	27	41	52	62	32	42	50	58	35	43	49	55
200	25	44	60	74	30	46	57	68	35	47	56	64	39	48	55	61
210	27	48	66	82	33	50	63	75	39	52	61	71	43	53	60	68
220	30	53	72	90	37	55	69	83	43	57	67	78	47	58	66	74
230	33	58	79	98	40	60	76	90	46	62	74	85	51	63	72	81
240	36	63	86	107	44	66	83	98	51	67	80	93	56	69	79	89
250	39	68	93	116	47	71	90	107	55	73	87	100	60	75	86	96
260	42	74	101	126	51	77	97	115	59	79	94	109	65	81	93	104
270	45	80	109	135	55	83	104	124	64	85	102	117	70	87	100	112
280	49	86	117	146	60	89	112	134	69	92	109	126	76	94	107	121
290	52	92	125	156	64	96	121	144	74	98	117	135	81	100	115	129
300	56	98	134	167	68	103	129	154	79	105	126	145	87	107	123	139

 Doc. # ST.06.00.003

Std. Item:	W21BA
Item ID:	0811125
CU:	C477ALSTBR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.96	2.88	6.60	9.60	11.88	14.40	15.48	16.44
75	2.52	6.72	11.52	15.48	18.84	22.32	23.88	25.20
100	5.64	12.12	17.64	22.56	26.64	31.08	33.00	34.80
125	11.16	19.20	25.32	30.72	35.52	40.68	43.08	45.24
150	19.20	27.96	34.32	40.32	45.48	51.48	54.12	56.64
175	29.52	38.28	45.00	51.24	57.00	63.48	66.48	69.24
200	41.64	50.40	57.24	63.84	69.96	76.92	80.04	83.04
225	55.32	64.08	71.04	77.88	84.24	91.68	95.04	98.28
250	70.56	79.44	86.40	93.48	100.08	107.88	111.36	114.72
275	87.48	96.24	103.44	110.52	117.36	125.40	129.12	132.60
300	105.96	114.72	121.92	129.24	136.20	144.48	148.32	152.04

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	3.12	4.80	6.84	*2000
75	7.08	9.60	11.88	*2000
100	12.72	15.84	18.24	*2000
125	19.80	23.40	25.92	*2000
150	28.56	32.52	35.04	*2000
175	38.88	43.20	45.72	*1995
200	51.00	55.44	58.08	*1989
225	64.68	69.36	72.00	*1986
250	79.92	84.72	87.36	*1986
275	96.84	101.64	104.28	*1986
300	115.32	120.24	122.88	*1987
* Note: Design Specification Constraint				

Doc. # ST.06.00.003

Std. Item:	W21NB
Item ID:	5942639[E]
CU:	C477ALTWHMP35KNE
CU:	C477ALSCHMP35KNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8,360 lbs.	**TRANSVERSE**	0.7866 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.3746 sq. in.	**VERTICAL**	2.061 Lb/Ft			
R. (@ 25˚C)	0.0373 Ω / 1000'	**TOTAL**	2.506 Lb/Ft	489	**NORMAL**	692
R. (@ 75˚C)	0.0447 Ω / 1000'			603	**EMERGENCY**	768
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	37.02˚			
CONDUCTOR DIAMETER	0.722"					
COMPLETE DIAMETER	1.362" (Nominal)					
WEIGHT	903 lbs / 1000'					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	822	675	593	531	789	687	624	572	770	695	645	602	758	701	660	624
ACTUAL SPAN (FEET)																
50	4	5	6	6	4	5	5	6	4	5	5	6	4	5	5	5
60	6	7	8	9	6	7	8	9	6	7	8	8	6	7	7	8
70	8	10	11	12	8	10	11	12	9	10	10	11	9	9	10	11
80	11	13	15	16	11	13	14	15	11	12	13	14	11	12	13	14
90	13	16	19	21	14	16	18	19	14	16	17	18	14	16	17	18
100	16	20	23	26	17	20	22	24	18	19	21	23	18	19	21	22
110	20	24	28	31	21	24	26	29	21	24	25	27	22	23	25	26
120	24	29	33	37	25	28	31	34	25	28	30	32	26	28	30	31
130	28	34	39	43	29	33	37	40	30	33	36	38	30	33	35	37
140	32	39	45	50	34	39	43	46	35	38	41	44	35	38	40	43
150	37	45	51	57	39	44	49	53	40	44	47	51	40	44	46	49
160	42	51	59	65	44	51	56	61	45	50	54	58	46	50	53	56
170	48	58	66	74	50	57	63	69	51	56	61	65	52	56	59	63
180	53	65	74	83	56	64	70	77	57	63	68	73	58	63	67	70
190	60	73	83	92	62	71	78	86	64	70	76	81	65	70	74	79
200	66	80	92	102	69	79	87	95	70	78	84	90	72	77	82	87
210	73	89	101	113	76	87	96	105	78	86	93	99	79	85	91	96
220	80	97	111	124	83	96	105	115	85	94	102	109	87	94	99	105
230	87	106	121	135	91	104	115	126	93	103	111	119	95	102	109	115
240	95	116	132	147	99	114	125	137	102	112	121	130	103	112	118	125
250	103	126	143	160	108	123	136	149	110	122	132	141	112	121	128	136
260	112	136	155	173	116	134	147	161	119	132	142	153	121	131	139	147
270	120	147	167	187	125	144	159	173	129	142	153	165	131	141	150	159
280	129	158	180	201	135	155	171	186	138	153	165	177	141	152	161	171
290	139	169	193	215	145	166	183	200	148	164	177	190	151	163	173	183
300	149	181	206	231	155	178	196	214	159	176	190	203	161	174	185	196

Supersedes 1/07 Issue – Updated ampacities.

477.0 KCMIL, 19 STRAND, COMPACT AAC, 320 MIL COVERED TREE WIRE – 35 kV

ISSUE	PAGE NUMBER		
7/09	**6-115**	**OVERHEAD CONSTRUCTION STANDARD**	Liberty Utilities

 Doc. # ST.06.00.003

Std. Item:	W21NB
Item ID:	5942639[E]
CU:	C477ALTWHMP35KNE
CU:	C477ALSCHMP35KNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	2.64	6.72	9.48	11.88	13.80	15.96	16.92	17.88
75	7.80	12.96	16.44	19.56	22.32	25.32	26.76	27.96
100	15.96	21.36	25.32	29.04	32.40	36.12	37.80	39.36
125	26.40	32.04	36.36	40.44	44.16	48.60	50.52	52.44
150	39.36	45.00	49.56	54.00	58.08	62.88	65.04	67.20
175	54.72	60.36	65.04	69.72	74.04	79.32	81.60	83.88
200	72.36	78.12	82.80	87.60	92.28	97.68	100.20	102.72
225	92.40	98.16	102.96	107.88	112.68	118.44	120.96	123.60
250	114.72	120.60	125.40	130.44	135.36	141.24	144.00	146.64
275	139.56	145.32	15024.00	155.40	160.44	166.44	169.32	172.08
300	166.68	172.56	177.48	182.64	187.80	193.92	196.80	199.68

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.68	7.56	9.60	*2000
75	10.56	14.04	16.56	*2000
100	18.84	22.80	25.56	*2000
125	29.40	33.60	36.60	*2000
150	42.36	46.80	49.80	*2000
175	57.60	62.28	65.40	*2000
200	75.24	80.04	83.16	*2000
225	95.28	100.08	103.32	*2000
250	117.72	122.52	125.88	*2000
275	142.56	147.36	150.72	*2000
300	169.68	174.60	177.84	*2000
* Note: Design Specification Constraint				

 Doc. # ST.06.00.003

Std. Item:	W21BD
Item ID:	5942638
CU:	C477ALTWHMPNE
CU:	C477ALSCHMPNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8,360 lbs.	TRANSVERSE	0.680 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.3746 sq. in.	VERTICAL	1.596 Lb/Ft			
R. (@ 25˚C)	0.0373 Ω / 1000’	TOTAL	2.035 Lb/Ft	528	NORMAL	739
R. (@ 75˚C)	0.0447 Ω / 1000’			647	EMERGENCY	819
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	39.28˚			
CONDUCTOR DIAMETER	0.722”					
COMPLETE DIAMETER	1.042” (Nominal)					
WEIGHT	637 lbs / 1000’					

Supersedes 1/07 Issue – Updated ampacities, Item ID no longer limited to New England.

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	896	634	519	444	799	631	544	480	746	630	562	508	715	629	574	529
ACTUAL SPAN (FEET)																
50	3	4	5	5	3	4	4	5	3	4	4	5	3	4	4	5
60	4	5	7	8	4	5	6	7	5	5	6	7	5	5	6	7
70	5	7	9	11	6	7	9	10	6	7	8	9	7	7	8	9
80	7	10	12	14	8	10	11	13	8	10	11	12	9	10	11	12
90	9	12	15	17	10	12	14	16	10	12	14	15	11	12	13	15
100	11	15	18	22	12	15	18	20	13	15	17	19	13	15	17	18
110	13	18	22	26	14	18	21	24	15	18	21	23	16	18	20	22
120	15	22	27	31	17	22	25	29	18	22	25	27	19	22	24	26
130	18	25	31	36	20	26	30	34	22	26	29	32	23	26	28	31
140	21	30	36	42	23	30	34	39	25	30	33	37	26	30	33	35
150	24	34	41	49	27	34	40	45	29	34	38	42	30	34	37	41
160	27	39	47	55	31	39	45	51	33	39	44	48	34	39	43	46
170	31	44	53	62	35	44	51	58	37	44	49	54	39	44	48	52
180	35	49	60	70	39	49	57	65	42	49	55	61	43	49	54	59
190	39	54	67	78	43	55	63	72	46	55	61	68	48	55	60	65
200	43	60	74	86	48	61	70	80	51	61	68	75	54	61	67	72
210	47	67	81	95	53	68	78	88	57	67	75	83	59	67	73	80
220	52	73	89	104	58	73	85	96	62	73	82	91	65	74	81	88
230	56	80	98	114	63	80	93	105	68	80	90	100	71	80	88	96
240	61	87	106	124	69	87	101	115	74	87	98	109	77	88	96	104
250	67	94	115	135	75	95	110	125	80	95	107	118	84	95	104	113
260	72	102	125	146	81	102	119	135	87	103	115	127	90	103	113	122
270	78	110	135	158	87	110	128	145	93	111	124	138	98	111	121	132
280	84	118	145	169	94	119	138	156	101	119	134	148	105	119	131	142
290	90	127	155	182	101	127	148	168	108	128	143	159	113	128	140	152
300	96	136	166	195	108	136	158	180	115	137	153	170	121	137	150	163

477.0 KCMIL, 19 STRAND, COMPACT AAC, 160 MIL COVERED TREE WIRE – 15 kV

ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/09	6-117		

Std. Item:	W21BD
Item ID:	5942638
CU:	C477ALTWHMPNE
CU:	C477ALSCHMPNE

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.44	4.56	7.80	10.56	12.72	15.00	16.08	16.92
75	4.32	9.48	13.68	17.28	20.28	23.52	24.96	26.40
100	9.84	16.32	21.00	25.32	29.04	33.12	34.92	36.72
125	18.00	24.96	30.12	34.80	39.12	43.92	46.08	48.12
150	28.68	35.76	41.04	46.20	50.88	56.28	58.68	61.08
175	41.28	48.36	54.00	59.40	64.44	70.32	72.96	75.48
200	55.80	62.88	68.64	74.28	79.56	85.80	88.68	91.44
225	72.24	79.32	85.20	90.96	96.48	103.08	106.08	108.96
250	90.48	97.68	103.56	109.56	115.20	122.04	125.16	128.28
275	110.64	117.84	123.84	129.96	135.72	142.80	146.04	149.28
300	132.72	139.92	145.92	152.16	158.16	165.36	168.72	172.08

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-18	0	15	-18
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	3.84	6.00	8.04	*2000
75	8.64	11.64	13.92	*2000
100	15.24	18.84	21.36	*2000
125	23.88	27.84	30.48	*2000
150	34.56	38.88	41.64	*1989
175	47.16	51.72	54.48	*1982
200	61.68	66.36	69.24	*1980
225	78.12	82.92	85.80	*1980
250	96.36	101.28	104.16	*1982
275	116.64	121.56	124.44	*1983
300	138.72	143.76	146.64	*1985
* Note: Design Specification Constraint				

Supersedes 1/07 Issue –Item ID no longer limited to New England.

Std. Item:	TC52
Item ID:	4035236
CU:	C33ASSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8,700 lbs.	TRANSVERSE	0.5617 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.2789 sq. in.	VERTICAL	1.101 Lb/Ft			
R. (@ 25˚C)	0.0523 Ω / 1000’	TOTAL	1.536 Lb/Ft	519	NORMAL	733
R. (@ 75˚C)	0.0625 Ω / 1000’			584	EMERGENCY	775
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	43.14˚			
CONDUCTOR DIAMETER	0.684”					
WEIGHT	365 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	2400	1624	972	552	2449	1690	1063	643	2398	1655	1072	693	2217	1503	1001	696
ACTUAL SPAN (FEET)																
50	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2
60	1	1	2	4	1	1	2	3	1	1	2	3	1	1	2	3
70	1	2	3	5	1	2	3	4	1	2	3	4	1	2	3	4
80	1	2	4	6	1	2	3	5	1	2	3	5	2	2	3	5
90	2	3	5	8	2	3	4	7	2	3	4	6	2	3	4	6
100	2	3	6	10	2	3	5	9	2	3	5	8	2	4	5	8
110	3	4	7	12	3	4	6	10	3	4	6	10	3	4	7	10
120	3	5	8	14	3	5	7	12	3	5	7	11	4	5	8	11
130	4	6	10	17	4	5	9	14	4	6	9	13	4	6	9	13
140	4	7	11	19	4	6	10	17	4	6	10	15	5	7	11	15
150	5	8	13	22	5	7	12	19	5	7	11	18	6	8	12	18
160	6	9	14	25	6	8	13	22	6	8	13	20	6	9	14	20
170	7	10	16	29	6	9	15	25	7	10	15	23	7	11	16	23
180	7	11	18	32	7	10	17	28	7	11	17	26	8	12	18	25
190	8	12	20	36	8	12	19	31	8	12	18	29	9	13	20	28
200	9	13	23	40	9	13	21	34	9	13	20	32	10	15	22	31
210	10	15	25	44	10	14	23	38	10	15	23	35	11	16	24	35
220	11	16	27	48	11	16	25	41	11	16	25	38	12	18	26	38
230	12	18	30	53	12	17	27	45	12	17	27	42	13	19	29	42
240	13	19	32	57	13	19	30	49	13	19	29	46	14	21	32	45
250	14	21	35	62	14	20	32	53	14	21	32	49	15	23	34	49
260	15	23	38	67	15	22	35	58	15	22	35	53	17	25	37	53
270	17	25	41	72	16	24	38	62	17	24	37	58	18	27	40	57
280	18	26	44	78	18	25	40	67	18	26	40	62	19	29	43	62
290	19	28	47	84	19	27	43	72	19	28	43	67	21	31	46	66
300	21	30	51	89	20	29	46	77	21	30	46	71	22	33	49	71

Supersedes 1/07 Issue – Item ID no longer limited to New York.

****** Simulated with a maximum tension of 3000 lbs. ******

336.4 KCMIL, 18/1 STRANDING, BARE ACSR, “MERLIN” – 15 kV

Std. Item:	TC52
Item ID:	4035236
CU:	C33ASSTBR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.60	1.20	3.24	6.96	8.40	9.84	10.44	11.04
75	1.44	2.64	6.00	10.92	13.92	15.84	16.68	17.52
100	2.52	4.56	9.12	15.12	20.04	22.32	23.40	24.48
125	3.96	6.96	12.60	19.68	25.56	29.40	30.60	31.80
150	5.64	9.72	16.44	24.36	31.32	36.84	38.16	39.60
175	8.04	13.56	21.48	30.24	37.92	45.24	46.80	48.24
200	11.64	19.32	28.44	37.80	45.96	54.96	56.76	58.44
225	16.68	26.40	36.36	46.20	54.84	64.56	67.56	69.36
250	23.16	34.80	45.36	55.56	64.68	74.88	79.08	81.00
275	31.44	44.40	55.32	65.76	75.24	86.04	90.84	93.36
300	41.40	55.08	66.24	77.04	86.76	98.04	102.96	106.68

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	2.52	3.12	3.84	2291
75	5.40	6.36	6.84	2414
100	9.00	10.20	10.32	2553
125	13.32	14.64	14.28	2700
150	18.24	19.44	18.48	2849
175	24.00	25.32	23.88	*2936
200	31.32	32.76	31.08	*2948
225	39.48	41.04	39.12	*2958
250	48.60	50.28	48.24	*2965
275	58.68	60.48	58.20	*2971
300	69.72	71.52	69.24	*2976
** Note: Design Specification Constraint*				

****** Simulated with a maximum tension of 3000 lbs. ******

Supersedes 1/07 Issue –Item ID no longer limited to New York.

Std. Item:	W20B
Item ID:	4035204
CU:	C33ALSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES	
R.B.S.	6,150 lbs.	TRANSVERSE	0.5556 Lb/Ft
C.S.A.	0.2644 sq. in.	VERTICAL	1.041 Lb/Ft
R. (@ 25˚C)	0.0527 Ω / 1000’	TOTAL	1.480 Lb/Ft
R. (@ 75˚C)	0.0629 Ω / 1000’		
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	46.55˚
CONDUCTOR DIAMETER	0.666”		
WEIGHT	315.5 lbs / 1000’		

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
514	NORMAL	725
578	EMERGENCY	766

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1445	819	484	334	1221	701	469	353	1001	619	459	368	824	567	452	379
ACTUAL SPAN (FEET)																
50	1	1	2	4	1	2	3	3	1	2	3	3	1	2	3	3
60	1	2	4	5	1	2	4	5	2	3	4	5	2	3	4	5
70	2	3	5	7	2	3	5	7	2	4	5	6	3	4	5	6
80	2	4	6	9	2	4	6	9	3	5	7	8	4	5	7	8
90	3	5	8	11	3	5	8	11	4	6	8	10	5	7	9	10
100	3	6	10	14	4	7	10	13	5	8	10	13	6	8	10	13
110	4	7	12	17	5	8	12	16	6	9	13	16	7	10	13	15
120	5	8	14	20	6	10	15	19	7	11	15	19	8	12	15	18
130	6	10	17	24	7	11	17	23	8	13	17	22	10	14	18	21
140	6	11	19	28	8	13	20	26	9	15	20	25	11	16	21	25
150	7	13	22	32	9	15	23	30	11	17	23	29	13	19	24	28
160	8	15	25	36	10	17	26	34	12	20	26	33	15	21	27	32
170	9	17	28	41	11	20	29	39	14	22	30	37	17	24	30	36
180	11	19	32	46	13	22	33	43	15	25	34	42	19	27	34	41
190	12	21	35	51	14	24	37	48	17	28	37	47	21	30	38	45
200	13	23	39	57	16	27	40	54	19	31	41	52	23	33	42	50
210	14	26	43	63	17	30	45	59	21	34	46	57	25	37	46	55
220	16	28	47	69	19	33	49	65	23	37	50	62	28	40	51	61
230	17	31	52	75	21	36	54	71	25	41	55	68	30	44	56	66
240	19	33	56	82	22	39	58	77	27	44	60	74	33	48	60	72
250	21	36	61	89	24	42	63	84	30	48	65	81	36	52	66	78
260	22	39	66	96	26	46	68	91	32	52	70	87	39	57	71	85
270	24	42	71	104	28	49	74	98	35	56	75	94	42	61	77	91
280	26	45	77	111	30	53	79	105	37	60	81	101	45	66	82	98
290	28	49	82	120	33	57	85	113	40	64	87	109	48	70	88	105
300	30	52	88	128	35	61	91	121	43	69	93	116	52	75	95	113

 Doc. # ST.06.00.003

Std. Item:	W20B
Item ID:	4035204
CU:	C33ALSTBR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.72	1.92	5.40	8.76	11.28	13.80	14.88	15.84
75	1.68	3.96	8.76	13.44	17.04	20.88	22.44	24.00
100	3.12	6.72	12.84	18.60	23.28	28.20	30.24	32.28
125	5.88	12.12	19.20	25.68	31.08	36.96	39.36	41.76
150	10.56	19.32	27.00	33.96	39.96	46.56	49.44	52.08
175	18.00	28.20	36.24	43.56	50.04	57.36	60.48	63.48
200	27.84	38.64	46.80	54.48	61.32	69.12	72.60	75.84
225	39.60	50.40	58.68	66.60	73.80	82.20	85.80	89.40
250	52.92	63.60	72.00	80.16	87.60	96.36	100.20	103.92
275	67.56	78.24	86.64	94.92	102.72	111.72	115.80	119.76
300	83.64	94.20	102.72	111.12	119.04	128.40	132.72	136.80

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	3.24	4.32	5.76	1710
75	6.72	8.16	9.48	1862
100	11.16	12.84	13.92	*2000
125	17.40	19.44	20.52	*2000
150	24.96	27.36	28.44	*2000
175	34.08	36.72	37.68	*1996
200	44.52	47.40	48.36	*1993
225	56.40	59.52	60.36	*1992
250	69.72	72.84	73.68	*1992
275	84.36	87.60	88.44	*1992
300	100.44	103.68	104.52	*1992
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.003

PHYSICAL PROPERTIES	
R.B.S.	6,150 lbs.
C.S.A.	0.2644 sq. in.
R. (@ 25˚C)	0.0527 Ω / 1000’
R. (@ 75˚C)	0.0629 Ω / 1000’
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	0.607”
COMPLETE DIAMETER	0.937” (Nominal)
WEIGHT	497 lbs / 1000’

LOADING PROPERTIES	
TRANSVERSE	0.644 Lb/Ft
VERTICAL	1.391 Lb/Ft
TOTAL	1.833 Lb/Ft
SWING	43.31˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
425	NORMAL	593
519	EMERGENCY	657

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1042	638	482	393	858	609	497	423	753	591	507	446	692	580	514	463
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	4	4	3	3	4	4
60	3	4	6	7	3	4	5	6	4	5	5	6	4	5	5	6
70	4	6	8	9	4	6	7	9	5	6	7	8	5	6	7	8
80	5	7	10	12	6	8	10	11	6	8	9	11	7	8	9	10
90	6	9	13	15	7	10	12	14	8	10	12	14	9	10	12	13
100	7	12	15	19	9	12	15	18	10	13	15	17	11	13	15	16
110	9	14	19	23	11	15	18	21	12	15	18	20	13	16	18	19
120	10	17	22	27	13	18	22	25	14	18	21	24	16	19	21	23
130	12	20	26	32	15	21	25	30	17	21	25	28	18	22	25	27
140	14	23	30	37	17	24	29	35	19	25	29	33	21	25	28	32
150	16	26	35	43	20	28	34	40	22	28	33	38	24	29	33	36
160	18	30	40	49	22	31	38	45	25	32	38	43	28	33	37	41
170	21	34	45	55	25	35	43	51	29	36	43	48	31	37	42	47
180	23	38	50	62	28	40	49	57	32	41	48	54	35	42	47	52
190	26	42	56	69	31	44	54	64	36	46	53	60	39	46	52	58
200	29	47	62	76	35	49	60	71	40	50	59	67	43	51	58	64
210	32	52	68	84	38	54	66	78	44	56	65	74	48	57	64	71
220	35	57	75	92	42	59	73	85	48	61	71	81	52	62	70	78
230	38	62	82	101	46	65	79	93	52	67	78	89	57	68	77	85
240	41	67	89	109	50	71	87	102	57	73	85	96	62	74	84	93
250	45	73	97	119	54	77	94	110	62	79	92	105	67	80	91	101
260	48	79	105	129	59	83	102	119	67	85	100	113	73	87	98	109
270	52	85	113	139	63	89	110	129	72	92	107	122	79	94	106	118
280	56	92	121	149	68	96	118	138	78	99	115	131	85	101	114	126
290	60	98	130	160	73	103	126	149	83	106	124	141	91	108	122	136
300	64	105	139	171	78	110	135	159	89	114	133	151	97	116	131	145

Supersedes 1/07 Issue – Updated ampacities.

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.20	3.60	7.08	9.96	12.24	14.64	15.60	16.56
75	2.88	6.96	11.52	15.48	18.84	22.32	23.76	25.20
100	6.48	12.84	18.12	22.80	26.88	31.20	33.12	34.92
125	12.96	20.52	26.28	31.56	36.12	41.40	43.56	45.72
150	22.32	30.36	36.36	42.00	47.04	52.80	55.32	57.84
175	33.60	41.76	47.88	53.88	59.40	65.64	68.40	71.16
200	46.68	54.84	61.20	67.44	73.08	79.92	82.92	85.80
225	61.44	69.60	76.08	82.44	88.44	95.64	98.76	101.88
250	78.00	86.04	92.64	99.24	105.36	112.80	116.16	119.40
275	96.12	104.28	110.88	117.60	123.96	131.64	135.12	138.60
300	116.04	124.08	130.80	137.64	144.24	152.04	155.76	159.24

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	3.72	5.52	7.32	1829
75	7.68	10.08	12.00	*2000
100	13.80	16.68	18.72	*2000
125	21.60	24.96	27.12	*1994
150	31.32	35.04	37.20	*1979
175	42.72	46.68	48.84	*1974
200	55.80	60.00	62.16	*1973
225	70.56	74.88	77.04	*1974
250	87.12	91.44	93.72	*1976
275	105.24	109.80	111.96	*1978
300	125.16	129.72	131.88	*1980
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.003

Std. Item:	W20A
Item ID:	0811017
CU:	C10AAACBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4,415 lbs.	**TRANSVERSE**	0.4656 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0968 sq. in.	**VERTICAL**	0.675 Lb/Ft			
R. (@ 25˚C)	0.166 Ω / 1000’	**TOTAL**	1.120 Lb/Ft	256	**NORMAL**	354
R. (@ 75˚C)	0.195 Ω / 1000’			286	**EMERGENCY**	374
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	59.98˚			
CONDUCTOR DIAMETER	0.398”					
WEIGHT	115 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1229	940	698	459	1236	949	708	474	1243	957	718	489	1251	966	729	504
ACTUAL SPAN (FEET)																
50	0	0	0	1	0	0	1	1	0	0	1	1	0	0	1	1
60	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
70	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	2
80	1	1	1	2	1	1	2	2	1	1	2	2	1	1	2	2
90	1	1	1	2	1	1	2	3	1	1	2	3	1	1	2	3
100	1	2	2	2	1	2	2	4	1	2	2	4	1	2	2	3
110	2	2	2	3	2	2	3	4	2	2	3	4	2	2	3	4
120	2	3	3	4	2	3	4	5	2	3	3	5	2	3	3	5
130	2	3	3	4	2	3	4	6	2	3	4	6	2	3	4	6
140	3	4	4	5	3	4	5	7	3	4	5	7	3	4	5	7
150	3	4	4	6	3	4	6	8	3	4	5	8	3	4	5	8
160	4	5	5	6	4	5	6	9	4	5	6	9	4	5	6	9
170	4	5	5	7	4	5	7	11	4	5	7	10	4	5	7	10
180	5	6	6	8	5	6	8	12	5	6	8	12	5	6	8	11
190	5	7	7	9	5	7	9	13	5	7	9	13	5	7	9	12
200	6	7	7	10	6	7	10	15	6	7	10	14	6	7	10	14
210	6	8	8	11	6	8	11	16	6	8	11	16	6	8	11	15
220	7	9	9	12	7	9	12	18	7	9	12	17	7	9	12	17
230	7	10	10	13	7	10	13	19	7	10	13	19	7	10	13	18
240	8	11	10	14	8	11	14	21	8	10	14	21	8	10	14	20
250	9	12	11	16	9	11	15	23	9	11	15	22	9	11	15	22
260	10	13	12	17	10	12	17	25	9	12	16	24	9	12	16	23
270	10	13	13	18	10	13	18	27	10	13	18	26	10	13	17	25
280	11	15	14	20	11	14	19	29	11	14	19	28	11	14	19	27
290	12	16	15	21	12	15	21	31	12	15	20	30	12	15	20	29
300	13	17	16	22	13	17	22	33	13	16	22	32	13	16	21	31

Supersedes 1/07 Issue – Standard Item number revised.

Std. Item:	W20A
Item ID:	0811017
CU:	C10AAACBR

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.36	0.60	0.96	2.88	6.84	10.44	11.76	13.08
75	0.84	1.32	2.16	5.40	10.80	15.96	17.88	19.68
100	1.56	2.28	3.84	8.40	14.88	21.48	24.12	26.52
125	2.40	3.60	5.88	11.64	19.32	27.24	30.48	33.36
150	3.48	5.16	8.16	15.24	23.88	33.12	36.96	40.44
175	4.80	6.96	10.92	19.08	28.68	39.24	43.56	47.52
200	6.24	9.00	13.92	23.16	33.72	45.36	50.16	54.72
225	7.92	11.40	17.16	27.48	38.88	51.72	57.00	62.04
250	9.72	13.92	20.76	32.04	44.28	58.20	63.96	69.48
275	11.76	16.80	24.48	36.72	49.80	64.68	71.04	76.92
300	15.48	22.56	32.64	46.44	60.00	75.36	81.96	88.08

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3.48	3.12	1.92	1195
75	7.44	6.48	4.08	1273
100	12.36	10.80	6.84	1360
125	18.12	15.72	10.08	1451
150	24.48	21.24	13.80	1542
175	31.56	27.24	17.88	1632
200	39.00	33.72	22.20	1721
225	47.04	40.56	26.88	1808
250	55.44	47.76	31.92	1893
275	64.32	55.32	37.08	1976
300	75.60	65.76	46.20	*2000
** Note: Design Specification Constraint*				

Supersedes 1/07 Issue – Standard Item number revised.

Std. Item:	W21NA
Item ID:	5942107[E]
CU:	C1/0ALPESCNE
CU:	C10ALSCHMPNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4,270 lbs.	TRANSVERSE	0.6776 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0968 sq. in.	VERTICAL	1.374 Lb/Ft			
R. (@ 25˚C)	0.166 Ω / 1000’	TOTAL	1.832 Lb/Ft	200	NORMAL	280
R. (@ 75˚C)	0.195 Ω / 1000’			244	EMERGENCY	310
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	50.48˚			
CONDUCTOR DIAMETER	0.398”					
COMPLETE DIAMETER	1.028” (Nominal)					
WEIGHT	424 lbs / 1000’					

INITIAL SAG TABLE

	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	939	556	416	338	755	527	428	364	654	510	436	383	597	499	441	397
ACTUAL SPAN (FEET)																
50	2	3	4	5	2	3	4	4	2	3	4	4	3	3	4	4
60	2	4	6	7	3	4	5	6	4	4	5	6	4	5	5	6
70	3	6	7	9	4	6	7	9	5	6	7	8	5	6	7	8
80	4	7	10	12	5	8	10	11	6	8	9	11	7	8	9	10
90	5	9	12	15	7	10	12	14	8	10	12	13	9	10	12	13
100	7	11	15	19	8	12	15	18	10	12	15	17	11	13	14	16
110	8	14	18	23	10	15	18	21	12	15	18	20	13	15	17	19
120	10	16	22	27	12	17	21	25	14	18	21	24	15	18	21	23
130	11	19	26	32	14	20	25	30	16	21	25	28	18	22	24	27
140	13	22	30	37	17	24	29	34	19	24	29	33	21	25	28	31
150	15	26	34	42	19	27	33	39	22	28	33	37	24	29	32	36
160	17	29	39	48	22	31	38	45	25	32	37	43	27	33	37	41
170	20	33	44	54	24	35	43	51	28	36	42	48	31	37	42	46
180	22	37	50	61	27	39	48	57	32	40	47	54	35	41	47	52
190	24	41	55	68	30	44	54	63	35	45	53	60	38	46	52	58
200	27	46	61	75	34	48	60	70	39	50	58	67	43	51	58	64
210	30	51	67	83	37	53	66	77	43	55	64	73	47	56	64	71
220	33	55	74	91	41	58	72	85	47	60	71	81	52	62	70	78
230	36	61	81	100	45	64	79	93	51	66	77	88	56	68	76	85
240	39	66	88	109	49	70	86	101	56	72	84	96	61	74	83	92
250	42	72	96	118	53	75	93	110	61	78	91	104	67	80	90	100
260	46	77	103	127	57	82	101	119	66	84	99	113	72	86	98	108
270	49	84	112	137	61	88	109	128	71	91	107	121	78	93	105	117
280	53	90	120	148	66	95	117	137	76	98	115	131	84	100	113	126
290	57	96	129	159	71	102	125	147	82	105	123	140	90	107	121	135
300	61	103	138	170	76	109	134	158	88	112	132	150	96	115	130	145

Supersedes 1/07 Issue – Updated ampacities, revised CU.

1/0, 7 STRAND, CONCENTRIC ROUND 6201-T81 AAAC,
315 MIL COVERED TREE WIRE – 35 kV

Std. Item:	W21NA
Item ID:	5942107[E]
CU:	C1/0ALPESCNE
CU:	C10ALSCHMPNE

Supersedes 1/07 Issue – Revised CU.

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.44	5.40	8.64	11.16	13.20	15.48	16.44	17.40
75	3.36	9.00	13.44	17.04	20.16	23.52	24.96	26.28
100	6.48	13.68	19.08	23.64	27.60	31.92	33.84	35.64
125	13.32	21.48	27.24	32.40	36.96	42.12	44.28	46.44
150	22.56	30.84	36.96	42.60	47.64	53.40	55.92	58.32
175	33.72	42.00	48.36	54.36	59.76	66.12	68.88	71.52
200	46.68	54.96	61.32	67.68	73.44	80.16	83.16	86.16
225	61.32	69.48	76.08	82.56	88.56	95.76	99.00	102.12
250	77.64	85.92	92.52	99.12	105.48	112.92	116.28	119.52
275	95.76	103.92	110.64	117.48	123.84	131.64	135.12	138.48
300	115.56	123.72	130.56	137.40	144.00	151.92	155.52	159.12

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	4.44	6.84	8.76	1549
75	8.52	11.40	13.80	1817
100	13.68	17.16	19.68	*2000
125	21.48	25.32	27.96	*2000
150	30.96	35.16	37.80	*2000
175	42.12	46.56	49.32	*2000
200	54.96	59.64	62.40	*2000
225	69.60	74.40	77.16	*2000
250	85.92	90.84	93.72	*2000
275	104.04	108.96	111.84	*2000
300	123.84	128.88	131.76	*2000
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.003

Std. Item:	W20CA
Item ID:	5942105
CU:	C1/0ALHMPESTNE
CU:	C10ALSCPE1NE

PHYSICAL PROPERTIES		LOADING PROPERTIES	
R.B.S.	4,270 lbs.	TRANSVERSE	0.5749 Lb/Ft
C.S.A.	0.0968 sq. in.	VERTICAL	1.019 Lb/Ft
R. (@ 25˚C)	0.166 Ω / 1000’	TOTAL	1.470 Lb/Ft
R. (@ 75˚C)	0.195 Ω / 1000’		
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	54.99˚
CONDUCTOR DIAMETER	0.398”		
COMPLETE DIAMETER	0.728” (Nominal)		
WEIGHT	255 lbs / 1000’		

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
214	NORMAL	296
259	EMERGENCY	327

INITIAL SAG TABLE																
	RULING SPAN (FEET)															
	125				150				175				200			
TEMP. ˚F	0	32	60	90	0	32	60	90	0	32	60	90	0	32	60	90
TEMP. ˚C	-18	0	15	32	-18	0	15	32	-18	0	15	32	-18	0	15	32
TENSION (LBS.)	1209	762	480	318	1231	796	526	365	1178	774	535	391	982	658	487	382
ACTUAL SPAN (FEET)																
50	1	1	2	3	1	1	2	3	1	1	2	2	1	1	2	3
60	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
70	2	2	4	6	2	2	4	5	2	2	4	5	2	3	4	5
80	2	3	5	8	2	3	5	7	2	3	5	6	2	4	5	6
90	3	4	6	10	3	4	6	8	3	4	6	8	3	5	6	8
100	3	5	8	12	3	5	7	10	3	5	7	10	4	6	8	10
110	4	6	10	15	4	6	9	13	4	6	9	12	5	7	10	12
120	5	7	11	17	4	7	10	15	5	7	10	14	6	8	11	14
130	5	8	13	20	5	8	12	18	5	8	12	17	7	10	13	17
140	6	10	16	24	6	9	14	21	6	10	14	19	8	11	15	20
150	7	11	18	27	7	11	16	24	7	11	16	22	9	13	18	23
160	8	13	20	31	8	12	19	27	8	13	18	25	10	15	20	26
170	9	15	23	35	9	14	21	30	9	14	21	28	11	17	23	29
180	10	16	26	39	10	16	24	34	11	16	23	32	13	19	25	32
190	11	18	29	43	11	17	26	38	12	18	26	35	14	21	28	36
200	13	20	32	48	12	19	29	42	13	20	29	39	16	23	31	40
210	14	22	35	53	14	21	32	46	14	22	32	43	17	26	35	44
220	15	24	39	58	15	23	35	51	16	24	35	47	19	28	38	49
230	17	27	42	64	16	25	38	55	17	26	38	52	21	31	42	53
240	18	29	46	69	18	28	42	60	19	28	41	56	22	33	45	58
250	20	31	50	75	19	30	45	65	20	31	45	61	24	36	49	63
260	21	34	54	81	21	32	49	71	22	33	48	66	26	39	53	68
270	23	37	58	88	23	35	53	76	24	36	52	71	28	42	57	73
280	25	39	63	94	24	38	57	82	25	39	56	77	31	46	62	79
290	27	42	67	101	26	40	61	88	27	42	60	82	33	49	66	84
300	28	45	72	108	28	43	65	94	29	45	64	88	35	52	71	90

Supersedes 1/07 Issue – Updated ampacities.

1/0, 7 STRAND, CONCENTRIC ROUND 6201-T81 AAAC,
165 MIL COVERED TREE WIRE – 15 kV

Std. Item:	W20CA
Item ID:	5942105
CU:	C1/0ALHMPESTNE
CU:	C10ALSCPE1NE

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.84	2.16	5.64	8.88	11.28	13.92	15.00	15.96
75	2.04	4.56	9.24	13.68	17.28	21.00	22.56	24.12
100	3.60	7.44	13.20	18.84	23.40	28.32	30.36	32.40
125	5.64	10.80	17.64	24.24	29.76	35.76	38.40	40.80
150	8.04	14.64	22.32	29.88	36.36	43.44	46.44	49.32
175	11.76	20.16	28.80	37.08	44.28	52.20	55.56	58.80
200	19.32	29.88	39.00	47.52	55.08	63.48	67.20	70.68
225	29.88	41.40	50.64	59.28	67.08	76.08	79.92	83.76
250	42.72	54.48	63.60	72.48	80.52	89.88	93.96	97.92
275	57.24	68.88	78.12	87.00	95.28	104.88	109.20	113.28
300	73.32	84.72	93.84	102.96	111.36	121.20	125.64	129.96

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-18**	**0**	**15**	**-18**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	4.32	5.28	6.24	1285
75	8.52	9.72	10.44	1447
100	13.68	14.88	15.00	1607
125	19.56	20.64	20.04	1761
150	26.04	26.88	25.44	1906
175	33.84	34.44	32.40	*2000
200	44.16	44.76	42.60	*2000
225	55.80	56.52	54.36	*2000
250	69.00	69.72	67.44	*2000
275	83.52	84.24	81.84	*2000
300	99.36	100.20	97.68	*2000

** Note: Design Specification Constraint*

Non-Standard Overhead Distribution Conductors

Maintenance Only

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	11400 lbs.	**TRANSVERSE**	0.6387 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.4995 sq. in.	**VERTICAL**	1.479 Lb/Ft			
R. (@ 25˚C)	0.0282 Ω / 1000’	**TOTAL**	1.911 Lb/Ft	766	**NORMAL**	1095
R. (@ 75˚C)	0.0335 Ω / 1000’			866	**EMERGENCY**	1159
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	37.55˚			
CONDUCTOR DIAMETER	0.918”					
WEIGHT	597 lbs / 1000’					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.32	4.44	7.80	10.56	12.72	15.12	16.08	17.04
75	4.08	9.48	13.68	17.28	20.28	23.64	25.08	26.40
100	9.48	16.20	21.00	25.32	29.04	33.12	34.92	36.72
125	17.52	24.60	29.76	34.68	38.88	43.80	45.96	48.00
150	27.36	34.68	40.20	45.48	50.28	55.68	58.20	60.48
175	39.12	46.56	52.32	57.84	63.00	69.00	71.64	74.28
200	52.68	60.12	66.00	71.88	77.40	83.76	86.64	89.52
225	67.92	75.48	81.60	87.60	93.36	100.08	103.20	106.20
250	85.08	92.64	98.76	105.00	111.00	118.08	121.32	124.44
275	103.92	111.48	117.84	124.20	130.32	137.64	141.00	144.36
300	124.68	132.24	138.60	145.08	151.32	158.88	162.36	165.84

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3.60	5.88	8.04	*1994
75	8.28	11.40	13.92	*1947
100	14.76	18.60	21.24	*1936
125	23.16	27.36	30.12	*1939
150	33.12	37.68	40.68	*1945
175	45.00	49.68	52.80	*1953
200	58.56	63.48	66.60	*1959
225	73.92	78.96	82.08	*1965
250	91.08	96.24	99.36	*1970
275	110.04	115.20	118.44	*1974
300	130.68	135.96	139.20	*1977
** Note: Design Specification Constraint*				

636.0 KCMIL, 37 STRAND, BARE AAC, “ORCHID”
MAINTENANCE ONLY

 Doc. # ST.06.00.004

Std. Item:	
Item ID:	5941609[E]
CU:	C636ALSTPENE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	11,400 lbs.	**TRANSVERSE**	0.7022 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.5278 sq. in.	**VERTICAL**	1.745 Lb/Ft			
R. (@ 25˚C)	0.0282 Ω / 1000’	**TOTAL**	2.181 Lb/Ft	627	**NORMAL**	985
R. (@ 75˚C)	0.0335 Ω / 1000’			777	**EMERGENCY**	1072
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	36.64˚			
CONDUCTOR DIAMETER	0.918”					
COMPLETE DIAMETER	1.108”					
WEIGHT	745 lbs / 1000’					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.92	5.40	8.52	11.04	13.08	15.36	16.32	17.28
75	5.76	11.04	14.88	18.24	21.12	24.36	25.68	27.00
100	12.72	18.72	23.04	27.00	30.48	34.44	36.24	37.92
125	21.96	28.20	32.88	37.32	41.40	45.96	48.00	49.92
150	33.24	39.72	44.64	49.44	53.88	59.04	61.32	63.48
175	46.68	53.16	58.32	63.36	68.16	73.68	76.20	78.72
200	62.16	68.64	73.92	79.20	84.24	90.24	92.88	95.52
225	79.56	86.16	91.56	97.08	102.24	108.48	111.36	114.12
250	99.12	105.72	111.24	116.76	122.16	128.64	131.64	134.52
275	120.60	127.32	132.84	138.60	144.12	150.84	153.84	156.96
300	144.24	150.96	156.60	162.36	168.00	174.84	178.08	181.20

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	4.20	6.60	8.64	*1955
75	9.60	12.72	15.12	*1924
100	17.04	20.76	23.28	*1924
125	26.40	30.48	33.24	*1934
150	37.92	42.24	45.00	*1944
175	51.36	55.92	58.68	*1953
200	66.84	71.52	74.40	*1961
225	84.36	89.16	92.04	*1967
250	103.92	108.72	111.72	*1972
275	125.52	130.44	133.44	*1976
300	149.16	154.08	157.08	*1979

** Note: Design Specification Constraint*

636.0 KCMIL, 37 STRAND, AAC, 95 MIL HDPE COVERING, “TANGERINE”
MAINTENANCE ONLY

 Doc. # ST.06.00.000

Std. Item:	W20C
Item ID:	4010136Y
CU:	C33ALSTPE1R/T

Supersedes 7/09 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	5535 lbs.	TRANSVERSE	0.6693 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.3552 sq. in.	VERTICAL	1.450 Lb/Ft			
R. (@ 25˚C)	0.0528 Ω / 1000'	TOTAL	1.897 Lb/Ft	396	NORMAL	626
R. (@ 75˚C)	0.0630 Ω / 1000'			490	EMERGENCY	680
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	44.44˚			
CONDUCTOR DIAMETER	0.666"					
COMPLETE DIAMETER	1.006"					
WEIGHT	513 lbs / 1000'					

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.44	4.20	7.56	10.32	12.48	14.88	15.84	16.80
75	3.12	7.56	12.00	15.96	19.08	22.56	24.12	25.44
100	6.96	13.44	18.60	23.28	27.24	31.56	33.48	35.28
125	13.92	21.48	27.00	32.16	36.72	41.88	44.04	46.20
150	23.76	31.44	37.32	42.84	47.88	53.52	56.04	58.44
175	35.40	43.32	49.32	55.20	60.48	66.72	69.48	72.12
200	48.96	56.76	63.00	69.00	74.64	81.24	84.24	87.12
225	64.20	72.12	78.36	84.60	90.48	97.44	100.56	103.68
250	81.24	89.04	95.52	101.88	108.00	115.20	118.56	121.68
275	100.08	107.88	114.36	120.84	127.08	134.64	138.00	141.36
300	120.60	128.52	135.00	141.60	147.96	155.76	159.24	162.72

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.08	6.00	7.80	1733
75	8.16	10.56	12.48	1969
100	14.28	17.28	19.32	*2000
125	22.32	25.68	27.84	*1995
150	32.28	36.12	38.16	*1981
175	44.16	48.12	50.28	*1976
200	57.60	61.80	63.96	*1976
225	72.96	77.28	79.44	*1977
250	90.00	94.32	96.60	*1978
275	108.84	113.28	115.44	*1980
300	129.36	133.92	136.08	*1982

** Note: Design Specification Constraint*

336.4 KCMIL, 19 STRAND, AAC, 170 MIL HDPE COVERING, "ANONA"
MAINTENANCE ONLY

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	5790 lbs.	**TRANSVERSE**	0.6084 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.2845 sq. in.	**VERTICAL**	1.242 Lb/Ft			
R. (@ 25˚C)	0.0528 Ω / 1000’	**TOTAL**	1.683 Lb/Ft	432	**NORMAL**	665
R. (@ 75˚C)	0.0630 Ω / 1000’			530	**EMERGENCY**	723
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	44.72˚			
CONDUCTOR DIAMETER	0.666”					
COMPLETE DIAMETER	0.826”					
WEIGHT	417 lbs / 1000’					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.08	2.88	6.36	9.36	11.76	14.28	15.24	16.32
75	2.40	5.64	10.32	14.52	18.00	21.60	23.16	24.60
100	4.68	9.72	15.36	20.52	24.84	29.52	31.56	33.48
125	9.36	16.80	23.04	28.80	33.72	39.12	41.52	43.80
150	16.92	25.56	32.16	38.28	43.68	49.80	52.56	55.08
175	27.00	35.88	42.72	49.20	55.08	61.80	64.68	67.56
200	38.88	47.88	54.84	61.68	67.80	75.00	78.12	81.24
225	52.32	61.32	68.52	75.48	81.96	89.52	92.88	96.24
250	67.44	76.44	83.64	90.84	97.56	105.48	109.08	112.44
275	84.12	93.12	100.44	107.76	114.60	122.88	126.60	130.20
300	102.36	111.36	118.68	126.12	133.20	141.72	145.56	149.28

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3.72	5.16	6.72	1688
75	7.56	9.48	10.92	1876
100	12.60	14.88	16.32	*1995
125	19.92	22.68	24.12	*1975
150	28.92	31.92	33.24	*1967
175	39.36	42.60	44.04	*1965
200	51.36	54.84	56.16	*1966
225	64.92	68.52	69.84	*1969
250	80.16	83.76	85.08	*1971
275	96.84	100.56	101.88	*1974
300	115.08	118.92	120.24	*1977
** Note: Design Specification Constraint*				

336.4 KCMIL, 19 STRAND, AAC, 80 MIL HDPE COVERING, “CRABAPPLE”
MAINTENANCE ONLY

Std. Item:	W20A
Item ID:	4024050
CU:	C33ALSTPER/T

Supersedes 7/09 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	5535 lbs.	**TRANSVERSE**	0.5949 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.2757 sq. in.	**VERTICAL**	1.194 Lb/Ft			
R. (@ 25˚C)	0.0528 Ω / 1000'	**TOTAL**	1.634 Lb/Ft	441	**NORMAL**	675
R. (@ 75˚C)	0.0630 Ω / 1000'			541	**EMERGENCY**	735
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	44.93˚			
CONDUCTOR DIAMETER	0.666"					
COMPLETE DIAMETER	0.786"					
WEIGHT	394 lbs / 1000'					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.08	2.88	6.48	9.48	11.76	14.28	15.36	16.32
75	2.40	5.64	10.32	14.64	18.00	21.60	23.16	24.60
100	4.32	9.00	14.76	20.04	24.48	29.16	31.20	33.12
125	8.40	15.60	22.08	27.96	33.00	38.52	40.92	43.20
150	15.36	24.12	30.84	37.20	42.72	48.96	51.72	54.36
175	24.84	34.08	41.16	47.88	53.88	60.60	63.60	66.48
200	36.36	45.72	52.92	59.88	66.24	73.56	76.80	79.92
225	49.44	58.80	66.12	73.32	79.92	87.72	91.20	94.44
250	64.08	73.44	80.88	88.20	95.16	103.20	106.92	110.40
275	80.28	89.64	97.08	104.64	111.72	120.12	123.96	127.56
300	98.04	107.28	114.84	122.52	129.72	138.48	142.32	146.16

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	3.72	5.28	6.72	1622
75	7.68	9.48	11.04	1807
100	12.36	14.40	15.72	1990
125	19.32	21.96	23.16	*1978
150	27.96	30.84	32.16	*1970
175	38.16	41.28	42.48	*1968
200	49.80	53.16	54.36	*1969
225	63.00	66.48	67.56	*1971
250	77.76	81.24	82.44	*1973
275	93.96	97.56	98.64	*1976
300	111.72	115.44	116.40	*1978
** Note: Design Specification Constraint*				

336.4 KCMIL, 19 STRAND, AAC, 60 MIL HDPE COVERING, "ANONA"
MAINTENANCE ONLY

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8350 lbs.	TRANSVERSE	0.5205 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.1939 sq. in.	VERTICAL	0.952 Lb/Ft			
R. (@ 25˚C)	0.0822 Ω / 1000'	TOTAL	1.385 Lb/Ft	360	NORMAL	504
R. (@ 75˚C)	0.1160 Ω / 1000'			399	EMERGENCY	527
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	44.05˚			
CONDUCTOR DIAMETER	0.563"					
WEIGHT	291 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.96	1.92	3.96	5.40	7.20	8.04	8.88
75	1.44	2.28	4.68	8.04	9.96	12.48	13.56	14.64
100	2.76	4.80	8.88	13.32	15.72	18.60	20.04	21.24
125	4.92	8.76	14.52	19.80	22.56	25.92	27.48	28.92
150	8.64	14.76	21.48	27.36	30.48	34.20	35.88	37.56
175	14.40	22.56	29.88	36.24	39.60	43.56	45.48	47.28
200	22.68	32.04	39.48	46.32	49.80	54.12	56.16	58.08
225	33.24	42.96	50.52	57.60	61.32	65.88	67.92	69.96
250	45.48	55.20	62.88	70.20	74.04	78.84	81.00	83.16
275	59.16	68.76	76.44	84.00	87.96	92.88	95.16	97.44
300	74.16	83.64	91.44	99.00	103.20	108.24	110.64	112.92

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	2.64	2.76	2.52	*2000
75	5.88	6.24	5.76	*2000
100	10.44	10.92	10.20	*2000
125	16.20	16.92	16.08	*2000
150	23.40	24.24	23.16	*2000
175	31.80	32.76	31.56	*2000
200	41.52	42.60	41.28	*2000
225	52.68	53.64	52.32	*2000
250	65.04	66.12	64.68	*2000
275	78.60	79.80	78.36	*2000
300	93.60	94.80	93.24	*2000
** Note: Design Specification Constraint*				

Supersedes 1/07 Issue - Corrected unloaded sags for 200' and 225' spans.

Supersedes 1/07 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8560 lbs.	**TRANSVERSE**	0.5213 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.1939 sq. in.	**VERTICAL**	0.893 Lb/Ft			
R. (@ 25˚C)	0.0831 Ω / 1000'	**TOTAL**	1.334 Lb/Ft	396	**NORMAL**	555
R. (@ 75˚C)	0.0973 Ω / 1000'			445	**EMERGENCY**	587
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	50.53˚			
CONDUCTOR DIAMETER	0.563"					
WEIGHT	232 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.48	0.72	1.44	4.80	8.28	11.52	12.72	13.92
75	1.08	1.80	3.72	8.76	13.44	17.88	19.80	21.48
100	2.04	3.48	7.20	13.80	19.32	24.96	27.36	29.52
125	3.60	6.36	12.24	19.80	26.16	32.88	35.64	38.16
150	6.00	10.92	18.84	27.00	34.08	41.52	44.64	47.64
175	9.72	17.64	26.64	35.40	42.96	51.12	54.60	57.96
200	15.60	26.28	35.88	45.00	52.92	61.68	65.52	69.12
225	24.36	36.60	46.44	55.80	64.08	73.32	77.40	81.24
250	35.52	48.36	58.32	67.80	76.32	86.04	90.36	94.56
275	48.60	61.44	71.40	81.00	89.76	99.96	104.40	108.72
300	63.00	75.72	85.80	95.52	104.52	114.96	119.64	124.08

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	2.52	2.64	2.16	*2000
75	5.64	5.88	5.04	*2000
100	9.96	10.32	9.24	*2000
125	15.60	16.08	14.76	*2000
150	22.56	23.04	21.48	*2000
175	30.60	31.20	29.52	*2000
200	40.08	40.68	38.88	*2000
225	50.64	51.36	49.44	*2000
250	62.52	63.24	61.32	*2000
275	75.72	76.44	74.40	*2000
300	90.12	90.84	88.80	*2000
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.004

Std. Item:	W18B
Item ID:	4035219[Y]
CU:	C40ALSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	3830 lbs.	TRANSVERSE	0.5073 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.1663 sq. in.	VERTICAL	0.835 Lb/Ft			
R. (@ 25˚C)	0.0835 Ω / 1000’	TOTAL	1.277 Lb/Ft	383	NORMAL	535
R. (@ 75˚C)	0.0999 Ω / 1000’			429	EMERGENCY	565
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	52.73˚			
CONDUCTOR DIAMETER	0.522”					
WEIGHT	199 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.72	2.04	5.64	8.88	11.40	13.92	15.00	16.08
75	1.80	4.20	9.12	13.80	17.40	21.12	22.68	24.12
100	3.12	6.96	13.08	18.84	23.40	28.32	30.48	32.40
125	4.92	10.08	17.28	24.12	29.76	35.76	38.40	40.80
150	6.96	13.56	21.72	29.64	36.24	43.32	46.32	49.20
175	9.60	17.40	26.52	35.40	42.84	51.00	54.60	57.84
200	13.32	23.04	33.00	42.48	50.76	59.76	63.72	67.44
225	21.00	33.12	43.44	53.16	61.68	71.28	75.48	79.44
250	31.68	44.88	55.32	65.16	73.92	83.88	88.32	92.52
275	44.64	57.96	68.28	78.24	87.36	97.68	102.24	106.68
300	59.16	72.36	82.68	92.76	101.88	112.56	117.36	121.92

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	4.20	5.04	6.12	1149
75	8.28	9.36	10.08	1294
100	13.32	14.28	14.52	1437
125	18.96	19.68	19.20	1575
150	25.32	25.68	24.24	1706
175	32.04	32.04	29.64	1831
200	3.33	3.31	3.05	*1915
225	4.22	4.19	3.92	*1915
250	5.21	5.18	4.90	*1915
275	6.31	6.27	5.99	*1915
300	7.51	7.47	7.18	*1915
** Note: Design Specification Constraint*				

Supersedes 7/09 Issue - Corrected unloaded sags for 200’ and 225’ spans.

4/0, 7 STRAND, BARE AAC, “OXLIP”
MAINTENANCE ONLY

Supersedes 1/07 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	3445 lbs.	TRANSVERSE	0.5475 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.1776 sq. in.	VERTICAL	0.961 Lb/Ft			
R. (@ 25˚C)	0.0835 Ω / 1000'	TOTAL	1.406 Lb/Ft	331	NORMAL	501
R. (@ 75˚C)	0.1000 Ω / 1000'			404	EMERGENCY	545
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	51.98˚			
CONDUCTOR DIAMETER	0.522"					
COMPLETE DIAMETER	0.642"					
WEIGHT	251 lbs / 1000'					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.08	3.24	6.72	9.72	12.00	14.52	15.48	16.44
75	2.40	6.00	10.80	15.00	18.36	21.96	23.40	24.84
100	4.32	9.48	15.24	20.52	24.84	29.52	31.56	33.48
125	6.84	13.32	20.16	26.28	31.56	37.32	39.84	42.12
150	10.56	18.84	26.28	33.36	39.36	46.08	48.96	51.60
175	18.48	28.32	36.24	43.56	49.92	57.24	60.36	63.36
200	29.40	39.72	47.64	55.20	61.92	69.60	73.08	76.32
225	42.36	52.56	60.60	68.28	75.36	83.52	87.12	90.60
250	57.00	67.08	75.12	82.92	90.24	98.64	102.48	106.08
275	73.20	83.16	91.20	99.12	106.56	115.32	119.28	123.12
300	90.96	100.80	108.72	116.76	124.32	133.32	137.40	141.36

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.68	6.00	7.20	1118
75	9.24	10.56	11.64	1289
100	14.52	15.96	16.56	1450
125	20.64	21.84	21.84	1600
150	27.84	29.04	28.44	*1703
175	37.80	39.12	38.40	*1707
200	49.32	50.64	49.92	*1711
225	62.40	63.84	63.00	*1713
250	76.92	78.36	77.52	*1715
275	93.00	94.56	93.60	*1716
300	110.64	112.20	111.24	*1717
* *Note: Design Specification Constraint*				

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	8560 lbs.	**TRANSVERSE**	0.5604 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.1939 sq. in.	**VERTICAL**	1.043 Lb/Ft			
R. (@ 25˚C)	0.0831 Ω / 1000'	**TOTAL**	1.484 Lb/Ft	337	**NORMAL**	512
R. (@ 75˚C)	0.0973 Ω / 1000'			412	**EMERGENCY**	557
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	48.05˚			
CONDUCTOR DIAMETER	0.563"					
COMPLETE DIAMETER	0.683"					
WEIGHT	307 lbs / 1000'					

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.60	0.96	1.92	5.28	8.52	11.64	12.96	14.04
75	1.44	2.40	4.80	9.60	13.92	18.24	20.04	21.72
100	2.88	4.92	9.12	15.12	20.28	25.68	27.96	30.00
125	5.04	8.88	15.00	21.84	27.72	34.08	36.72	39.12
150	8.64	15.00	22.44	29.88	36.24	43.32	46.32	49.20
175	14.40	23.16	31.32	39.12	46.08	53.76	57.00	60.24
200	22.92	33.24	41.76	49.80	57.00	65.28	68.88	72.24
225	33.84	44.76	53.52	61.80	69.36	78.00	81.84	85.44
250	46.80	57.96	66.60	75.12	82.92	92.04	96.00	99.84
275	61.44	72.48	81.24	89.88	97.92	107.28	111.48	115.44
300	77.52	88.44	97.20	105.96	114.12	123.84	128.16	132.36

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	2.76	3.00	2.76	*1999
75	6.24	6.72	6.12	*2000
100	11.16	11.76	10.92	*2000
125	17.40	18.24	17.16	*2000
150	25.08	26.04	24.84	*2000
175	34.08	35.28	33.84	*2000
200	44.52	45.84	44.28	*2000
225	56.40	57.72	56.04	*2000
250	69.60	71.04	69.36	*2000
275	84.24	85.68	83.88	*2000
300	100.32	101.76	99.96	*2000

** Note: Design Specification Constraint*

Supersedes 1/07 Issue - Corrected unloaded sags for 200' and 225' spans.

4/0, 7 STRAND, AAC, 60 MIL PE COVERING, "PLANETREE"
MAINTENANCE ONLY

Supersedes 1/07 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	3620 lbs.	TRANSVERSE	0.5451 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.1678 sq. in.	VERTICAL	0.952 Lb/Ft			
R. (@ 25˚C)	0.0838 Ω / 1000'	TOTAL	1.397 Lb/Ft	330	NORMAL	499
R. (@ 75˚C)	0.1000 Ω / 1000'			402	EMERGENCY	543
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	51.87˚			
CONDUCTOR DIAMETER	0.512"					
COMPLETE DIAMETER	0.632"					
WEIGHT	248 lbs / 1000'					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.08	2.52	6.00	9.12	11.52	14.04	15.12	16.08
75	2.28	5.16	9.84	14.16	17.64	21.36	22.92	24.36
100	4.08	8.40	14.04	19.44	23.88	28.80	30.84	32.76
125	6.48	12.12	18.72	25.08	30.48	36.36	38.88	41.28
150	9.24	16.20	23.76	31.08	37.32	44.28	47.16	50.04
175	13.44	22.08	30.36	38.28	45.36	53.04	56.40	59.64
200	21.96	32.40	41.04	49.32	56.64	64.80	68.52	71.88
225	33.48	44.52	53.28	61.68	69.24	77.88	81.72	85.44
250	47.16	58.20	66.96	75.48	83.28	92.28	96.24	100.08
275	62.40	73.44	82.08	90.72	98.64	108.00	112.08	116.16
300	79.32	90.12	98.76	107.40	115.44	125.04	129.36	133.56

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.68	5.64	6.60	1129
75	9.12	10.20	10.80	1287
100	14.52	15.60	15.60	1439
125	20.64	21.48	20.76	1582
150	27.48	27.96	26.40	1717
175	35.40	35.76	33.48	*1810
200	46.32	46.68	44.16	*1810
225	58.68	58.92	56.40	*1810
250	72.36	72.72	70.08	*1810
275	87.60	87.96	85.32	*1810
300	104.28	104.64	101.88	*1810
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.004

Std. Item:	
Item ID:	4035221
CU:	C10ASSTBRRLR/T

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4380 lbs.	**TRANSVERSE**	0.4655 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0968 sq. in.	**VERTICAL**	0.704 Lb/Ft			
R. (@ 25˚C)	0.1630 Ω / 1000’	**TOTAL**	1.144 Lb/Ft	242	**NORMAL**	335
R. (@ 75˚C)	0.2160 Ω / 1000’			268	**EMERGENCY**	351
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	53.88˚			
CONDUCTOR DIAMETER	0.398”					
WEIGHT	145 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.48	0.72	1.32	2.88	3.96	5.76	6.60	7.56
75	1.08	1.68	2.88	5.52	7.20	9.60	10.80	11.88
100	2.04	3.00	4.92	8.76	10.80	13.68	15.12	16.56
125	3.12	4.56	7.44	12.36	14.76	18.12	19.80	21.48
150	4.44	6.60	10.20	16.20	18.84	22.68	24.60	26.52
175	6.12	8.88	13.44	20.16	23.28	27.48	29.64	31.68
200	7.92	11.40	16.92	24.48	27.84	32.52	34.80	37.08
225	10.08	14.40	20.64	28.92	32.64	37.56	40.08	42.48
250	12.36	17.52	24.72	33.60	37.56	42.84	45.48	48.12
275	17.28	24.72	33.96	42.48	46.92	52.80	55.68	58.44
300	24.72	34.92	45.60	53.40	58.20	64.56	67.56	70.56

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	3.60	3.24	2.16	1197
75	7.44	6.72	4.44	1292
100	12.36	10.92	7.32	1394
125	17.88	15.84	10.68	1498
150	24.12	21.24	14.52	1601
175	30.84	27.12	18.60	1702
200	38.16	33.48	23.04	1800
225	45.84	40.20	27.84	1896
250	54.00	47.16	32.88	1989
275	64.92	57.48	42.36	*2000
300	77.28	69.36	53.88	*2000
** Note: Design Specification Constraint*				

Supersedes 7/09 Issue - Corrected unloaded sags for 200' and 225' spans.

1/0, 6/1 STRANDING, BARE ACSR, “RAVEN”
MAINTENANCE ONLY

 Doc. # ST.06.00.004

Std. Item:	
Item ID:	
CU:	C10ASSTLTRT

Supersedes 7/09 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4160 lbs.	**TRANSVERSE**	0.5407 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.1348 sq. in.	**VERTICAL**	0.921 Lb/Ft			
R. (@ 25˚C)	0.1633 Ω / 1000'	**TOTAL**	1.368 Lb/Ft	210	**NORMAL**	320
R. (@ 75˚C)	0.2160 Ω / 1000'			256	**EMERGENCY**	348
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	53.82˚			
CONDUCTOR DIAMETER	0.398"					
COMPLETE DIAMETER	0.6518"					
WEIGHT	226 lbs / 1000'					

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.84	1.56	3.72	5.76	7.20	8.88	9.60	10.32
75	1.80	3.36	6.72	9.72	11.64	13.92	15.00	15.96
100	3.24	576.00	10.08	14.16	16.44	19.32	20.64	21.84
125	5.04	8.64	13.92	18.96	21.60	24.96	26.52	27.96
150	7.32	12.00	18.12	24.12	27.12	30.84	32.64	34.32
175	9.96	15.72	22.68	29.52	32.88	37.08	39.00	40.92
200	14.28	21.60	29.52	36.84	40.56	45.12	47.16	49.32
225	22.32	31.68	40.08	47.52	51.36	56.28	58.44	60.72
250	33.24	43.56	52.20	59.40	63.60	68.64	70.92	73.20
275	46.32	57.00	65.52	72.72	77.04	82.20	84.72	87.00
300	61.20	71.76	80.28	87.36	91.68	97.08	99.60	102.12

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	4.20	4.56	4.68	1229
75	8.40	8.76	8.16	1377
100	13.44	13.56	12.24	1523
125	19.32	19.08	16.80	1664
150	25.68	24.96	21.72	1800
175	32.64	31.44	27.00	1928
200	41.04	39.48	34.20	*2000
225	51.96	50.28	44.76	*2000
250	64.20	62.40	56.76	*2000
275	77.64	75.84	70.08	*2000
300	92.40	90.48	84.72	*2000

** Note: Design Specification Constraint*

1/0, 6/1 STRANDING, ACSR, 110 MIL PE COVERING, "ALMOND"
MAINTENANCE ONLY

 Doc. # ST.06.00.004

Std. Item:	
Item ID:	4024029
CU:	C10ASSTPER/T

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4160 lbs.	TRANSVERSE	0.5069 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.1081 sq. in.	VERTICAL	0.827 Lb/Ft			
R. (@ 25˚C)	0.1633 Ω / 1000’	TOTAL	1.270 Lb/Ft	220	NORMAL	330
R. (@ 75˚C)	0.2160 Ω / 1000’			267	EMERGENCY	359
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	53.17˚			
CONDUCTOR DIAMETER	0.398”					
COMPLETE DIAMETER	0.518”					
WEIGHT	194 lbs / 1000’					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.72	1.20	2.40	4.32	5.76	7.44	8.28	9.00
75	1.56	2.52	4.68	7.92	9.72	12.00	13.08	14.16
100	2.76	4.44	7.68	11.88	14.04	16.92	18.24	19.56
125	4.32	6.84	11.04	16.32	18.84	22.08	23.64	25.20
150	6.24	9.60	14.76	21.00	23.88	27.60	29.28	31.08
175	8.52	12.84	18.84	25.92	29.16	33.24	35.16	37.20
200	11.16	16.44	23.28	31.20	34.68	39.12	41.28	43.44
225	14.16	20.40	27.96	36.60	40.32	45.24	47.64	49.92
250	20.88	29.52	38.40	46.80	50.88	56.16	58.68	61.08
275	30.48	41.04	50.52	58.56	63.00	68.52	71.16	73.68
300	42.84	54.36	64.08	71.64	76.32	82.08	84.72	87.48

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	4.08	4.08	3.36	1183
75	8.28	8.04	6.48	1303
100	13.32	12.72	10.08	1427
125	19.20	18.12	14.28	1548
150	25.68	24.00	18.84	1666
175	32.76	30.36	23.76	1780
200	40.32	37.08	28.92	1890
225	48.36	44.40	34.56	1996
250	59.52	55.20	45.00	*2000
275	72.12	67.44	57.00	*2000
300	85.80	80.88	70.32	*2000

* *Note: Design Specification Constraint*

Supersedes 7/09 Issue - Corrected unloaded sags for 200' and 225' spans.

1/0 ACSR, 6/1 STANDING, 60 MIL PE COVERING, “ALMOND”
MAINTENANCE ONLY

Std. Item:	W14C
Item ID:	0811018
CU:	C10AAACPER/T

Supersedes 7/09 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES	
R.B.S.	4194 lbs.
C.S.A.	0.1081 sq. in.
R. (@ 25˚C)	0.1660 Ω / 1000'
R. (@ 75˚C)	0.1950 Ω / 1000'
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	0.468"
COMPLETE DIAMETER	0.588"
WEIGHT	166 lbs / 1000'

LOADING PROPERTIES	
TRANSVERSE	0.5286 Lb/Ft
VERTICAL	0.843 Lb/Ft
TOTAL	1.295 Lb/Ft
SWING	60.55˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
228	NORMAL	344
278	EMERGENCY	374

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.96	1.56	4.20	7.68	11.04	12.36	13.56
75	1.32	2.04	3.48	7.44	12.12	16.92	18.72	20.52
100	2.40	3.60	6.00	11.16	16.92	22.92	25.32	27.60
125	3.72	5.52	8.88	15.12	21.84	29.16	32.16	34.92
150	5.40	7.92	12.24	19.56	27.12	35.52	39.00	42.24
175	7.32	10.56	15.96	24.24	32.64	42.12	46.08	49.92
200	9.48	13.68	20.04	29.16	38.52	48.96	53.40	57.60
225	12.00	17.16	24.48	34.44	44.52	55.92	60.84	65.52
250	14.88	20.88	29.16	39.96	50.76	63.12	68.52	73.56
275	20.40	28.80	38.88	50.64	61.80	74.64	80.16	85.44
300	29.16	40.56	52.20	64.32	75.72	88.68	94.32	99.72

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	4.20	3.96	3.00	1161
75	8.64	8.16	6.00	1261
100	14.16	13.20	9.84	1368
125	20.52	18.84	14.04	1476
150	27.60	25.20	18.84	1582
175	35.28	32.04	24.00	1685
200	43.56	39.36	29.52	1785
225	52.32	47.16	35.28	1882
250	61.44	55.32	41.52	1976
275	73.56	66.72	51.84	*2000
300	87.48	80.28	64.92	*2000
** Note: Design Specification Constraint*				

Doc. # ST.06.00.004

Std. Item:	W12B
Item ID:	9200816[Y]
CU:	C02ASSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2850 lbs.	**TRANSVERSE**	0.4379 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0608 sq. in.	**VERTICAL**	0.599 Lb/Ft			
R. (@ 25˚C)	0.2591 Ω / 1000’	**TOTAL**	1.042 Lb/Ft	183	**NORMAL**	251
R. (@ 75˚C)	0.3360 Ω / 1000’			203	**EMERGENCY**	264
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	60.01˚			
CONDUCTOR DIAMETER	0.316”					
WEIGHT	91 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.48	0.72	1.20	3.12	4.32	6.24	7.08	7.92
75	1.08	1.56	2.76	5.88	7.56	10.08	11.16	12.36
100	1.92	2.88	4.68	8.88	11.04	14.04	15.48	16.80
125	3.00	4.44	7.08	12.24	14.64	18.00	19.68	21.36
150	4.32	6.36	9.84	15.60	18.36	22.20	24.12	25.92
175	5.88	8.52	12.96	19.20	22.20	26.40	28.44	30.48
200	7.68	11.04	16.32	22.80	26.04	30.48	32.76	35.04
225	10.44	15.24	22.08	28.32	31.92	36.96	39.36	41.88
250	16.80	25.08	34.32	39.12	43.32	48.96	51.60	54.24
275	27.60	38.88	47.40	52.08	56.76	62.76	65.52	68.28
300	43.08	55.32	62.04	66.96	72.00	78.12	80.88	83.76

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	4.68	4.08	2.28	827
75	9.60	8.04	4.80	921
100	15.36	12.96	7.92	1016
125	22.08	18.60	11.52	1109
150	29.40	24.72	15.48	1199
175	37.20	31.32	19.92	1286
200	45.60	38.40	24.60	1370
225	55.56	47.04	31.44	*1425
250	68.64	59.40	43.44	*1425
275	83.04	73.32	57.24	*1425
300	98.88	88.56	72.84	*1425

** Note: Design Specification Constraint*

Supersedes 7/09 Issue - Corrected unloaded sags for 200’ and 225’ spans.

Std. Item:	W12C
Item ID:	4001054
CU:	C02ASSTPER/T

Supersedes 7/09 Issue – Corrected unloaded sags for 200' and 225' spans.

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2710 lbs.	**TRANSVERSE**	0.4978 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0672 sq. in.	**VERTICAL**	0.739 Lb/Ft			
R. (@ 25˚C)	0.2591 Ω / 1000'	**TOTAL**	1.191 Lb/Ft	178	**NORMAL**	266
R. (@ 75˚C)	0.3360 Ω / 1000'			216	**EMERGENCY**	289
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	64.37˚			
CONDUCTOR DIAMETER	0.406"					
COMPLETE DIAMETER	0.496"					
WEIGHT	119 lbs / 1000'					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	0.60	0.96	1.80	4.08	5.40	7.08	7.92	8.64
75	1.44	2.28	3.84	7.32	9.00	11.28	12.36	13.44
100	2.64	3.96	6.48	10.92	12.96	15.72	17.04	18.36
125	4.08	6.12	9.48	14.76	17.16	20.28	21.84	23.40
150	5.88	8.64	12.96	18.84	21.48	24.96	26.76	28.44
175	8.04	11.64	16.80	22.92	25.80	29.76	31.68	33.60
200	13.92	20.40	27.84	33.00	36.48	40.92	42.96	45.00
225	24.60	33.84	41.88	45.84	49.68	54.36	56.64	58.80
250	40.20	49.92	56.76	60.84	64.80	69.72	72.00	74.16
275	58.32	67.80	73.56	77.76	81.84	86.76	89.04	91.32
300	78.24	87.36	92.28	96.48	100.56	105.60	107.88	110.16

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	5.40	4.92	3.48	827
75	10.68	9.60	6.84	938
100	17.04	15.12	10.92	1047
125	24.24	21.48	15.48	1152
150	32.16	28.32	20.40	1253
175	40.56	35.64	25.80	1349
200	52.80	47.28	36.84	*1355
225	66.84	60.84	50.28	*1355
250	82.44	76.20	65.64	*1355
275	99.84	93.24	82.80	*1355
300	118.80	111.96	101.64	*1355
** Note: Design Specification Constraint*				

#2, 6/1 STRANDING, ACSR, 45 MIL PE COVERING, "PIGNUT"
MAINTENANCE ONLY

Std. Item:	
Item ID:	4015207
CU:	C04ASBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2360 lbs.	TRANSVERSE	0.4191 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0411 sq. in.	VERTICAL	0.538 Lb/Ft			
R. (@ 25˚C)	0.4070 Ω / 1000’	TOTAL	0.982 Lb/Ft	140	NORMAL	191
R. (@ 75˚C)	0.5160 Ω / 1000’			155	EMERGENCY	201
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	62.46˚			
CONDUCTOR DIAMETER	0.257”					
WEIGHT	67 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.48	0.60	0.84	1.80	3.00	4.92	5.88	6.84
75	0.96	1.32	1.92	3.72	5.52	8.04	9.36	10.68
100	1.68	2.28	3.48	6.12	8.40	11.40	12.96	14.52
125	2.64	3.60	5.28	8.88	11.28	14.76	16.68	18.48
150	3.84	5.28	7.44	11.88	14.28	18.24	20.28	22.32
175	5.16	7.08	9.96	14.64	17.40	21.60	23.88	26.16
200	7.08	9.72	13.68	18.36	21.60	26.28	28.68	31.20
225	11.40	16.32	23.16	27.00	31.08	36.72	39.48	42.24
250	20.28	29.16	35.28	40.08	44.88	51.00	53.88	56.64
275	35.76	45.96	50.76	55.92	61.08	67.32	70.20	72.96
300	55.44	63.72	68.64	73.92	79.08	85.20	88.08	90.84

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	5.28	4.08	1.80	697
75	10.56	8.28	3.96	781
100	17.04	13.44	6.72	865
125	24.24	19.32	9.96	948
150	32.28	25.80	13.68	1027
175	40.92	32.76	17.76	1104
200	50.52	40.80	23.16	1166
225	63.24	52.32	33.36	*1180
250	78.12	66.36	47.40	*1180
275	94.44	82.20	63.60	*1180
300	112.44	99.60	81.60	*1180
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.004

Std. Item:	
Item ID:	4001053
CU:	C04ASPE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2240 lbs.	TRANSVERSE	0.4589 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0439 sq. in.	VERTICAL	0.627 Lb/Ft			
R. (@ 25˚C)	0.4072 Ω / 1000’	TOTAL	1.077 Lb/Ft	136	NORMAL	200
R. (@ 75˚C)	0.5160 Ω / 1000’			164	EMERGENCY	217
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	66.49˚			
CONDUCTOR DIAMETER	0.317”					
COMPLETE DIAMETER	0.377”					
WEIGHT	82 lbs / 1000’					

Supersedes 1/07 Issue - Updated CU.

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.84	1.32	2.88	4.44	6.36	7.32	8.16
75	1.20	1.80	2.76	5.52	7.56	10.20	11.40	12.60
100	2.16	3.12	4.80	8.64	10.92	14.04	15.60	17.04
125	3.48	4.92	7.32	11.88	14.40	18.00	19.80	21.48
150	4.92	6.96	10.20	15.12	18.00	22.08	24.00	26.04
175	7.68	11.28	16.32	21.24	24.72	29.40	31.56	33.72
200	15.12	22.32	29.52	33.48	37.44	42.48	44.76	47.04
225	29.16	38.28	44.16	48.36	52.56	57.60	59.88	62.16
250	47.76	56.52	61.20	65.52	69.60	74.64	76.92	79.20
275	68.16	76.20	80.28	84.48	88.56	93.60	95.88	98.16
300	90.00	97.20	101.16	105.36	109.44	114.36	116.64	118.80

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	5.76	4.92	2.88	697
75	11.40	9.60	5.88	795
100	18.12	15.24	9.60	892
125	25.68	21.60	13.80	984
150	33.96	28.44	18.36	1072
175	44.16	37.68	25.92	*1120
200	57.72	50.52	38.52	*1120
225	73.08	65.40	53.40	*1120
250	90.24	82.08	70.44	*1120
275	109.32	100.80	89.28	*1120
300	130.08	121.32	110.04	*1120
** Note: Design Specification Constraint*				

#4, 7/1 STRANDING, ACSR, 30 MIL PE COVERING, “HICKORY”
MAINTENANCE ONLY

 | Doc. # ST.06.00.004

Std. Item:	
Item ID:	
CU:	C04ASPE6NE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	1770 lbs.	TRANSVERSE	0.4577 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0411 sq. in.	VERTICAL	0.613 Lb/Ft			
R. (@ 25˚C)	0.4120 Ω / 1000’	TOTAL	1.065 Lb/Ft	135	NORMAL	199
R. (@ 75˚C)	0.5220 Ω / 1000’			163	EMERGENCY	216
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	68.73˚			
CONDUCTOR DIAMETER	0.310”					
COMPLETE DIAMETER	0.370”					
WEIGHT	72 lbs / 1000’					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.96	1.56	3.48	4.56	6.36	7.20	7.92
75	1.32	2.04	3.48	6.12	7.68	9.84	11.04	12.12
100	2.40	3.60	5.76	9.00	10.80	13.44	14.76	16.08
125	3.84	5.64	8.76	12.00	14.04	17.04	18.60	20.16
150	7.92	12.48	17.76	20.40	23.16	26.88	28.56	30.36
175	19.32	27.36	30.60	33.84	37.08	41.04	42.84	44.64
200	37.92	43.80	47.04	50.40	53.76	57.72	59.64	61.44
225	58.68	63.00	66.24	69.60	72.84	76.92	78.72	80.52
250	81.00	84.72	87.84	91.08	94.32	98.28	100.08	102.00
275	105.00	108.60	111.72	114.96	118.08	122.04	123.84	125.64
300	131.28	134.76	137.76	141.00	144.12	147.96	149.88	151.56

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	6.72	5.76	3.60	591
75	13.08	11.04	7.20	688
100	20.52	17.28	11.28	780
125	28.80	24.24	16.08	866
150	40.68	35.28	26.16	*885
175	55.32	49.32	40.32	*885
200	72.24	65.88	57.12	*885
225	91.44	84.84	76.32	*885
250	112.92	106.08	97.80	*885
275	136.80	129.72	121.44	*885
300	162.84	155.64	147.48	*885

** Note: Design Specification Constraint*

Supersedes 1/07 Issue - Updated CU.

#4, 6/1 STRANDING, ACSR, 30 MIL PE COVERING, “BUTTERNUT”
MAINTENANCE ONLY

Non-Standard Copper Overhead Distribution Conductors

Maintenance Only

 Doc. # ST.06.00.005

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	9160 lbs.	TRANSVERSE	0.5068 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.1663 sq. in.	VERTICAL	1.290 Lb/Ft			
R. (@ 25˚C)	0.0527 Ω / 1000’	TOTAL	1.686 Lb/Ft	486	NORMAL	679
R. (@ 50˚C)	0.0574 Ω / 1000’			545	EMERGENCY	718
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	21.76˚			
CONDUCTOR DIAMETER	0.522”					
WEIGHT	654 lbs.					

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	1.32	2.28	4.20	6.72	8.88	11.16	12.12	12.96
75	3.36	5.64	8.64	11.88	14.76	17.88	19.20	20.40
100	6.96	10.68	14.40	18.24	21.72	25.44	27.12	28.68
125	12.48	17.52	21.84	26.04	29.88	34.32	36.24	38.04
150	20.28	25.92	30.60	35.28	39.48	44.28	46.44	48.60
175	30.12	36.12	41.04	45.84	50.40	55.68	57.96	60.24
200	41.76	47.88	52.92	57.96	62.76	68.40	70.92	73.32
225	54.96	61.32	66.48	71.64	76.56	82.44	85.08	87.72
250	69.96	76.32	81.60	86.88	91.92	98.04	100.80	103.56
275	86.52	92.88	98.16	103.68	108.84	115.20	118.08	120.84
300	104.64	111.12	116.40	121.92	127.32	133.80	136.68	139.56

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	3.12	3.84	4.32	*2000
75	7.08	8.28	8.76	*2000
100	12.60	14.16	14.76	*2000
125	19.80	21.60	22.08	*2000
150	28.44	30.48	30.96	*2000
175	38.76	40.92	41.40	*2000
200	50.64	52.92	53.28	*2000
225	64.08	66.48	66.84	*2000
250	79.08	81.48	81.96	*2000
275	95.76	98.28	98.64	*2000
300	114.00	116.52	116.88	*2000

** Note: Design Specification Constraint*

 Doc. # ST.06.00.005

Std. Item:	W13K
Item ID:	4035253
CU:	C10BSTC

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4752 lbs.	**TRANSVERSE**	0.4566 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0829 sq. in.	**VERTICAL**	0.866 Lb/Ft			
R. (@ 25˚C)	0.1051 Ω / 1000'	**TOTAL**	1.279 Lb/Ft	313	**NORMAL**	432
R. (@ 50˚C)	0.1150 Ω / 1000'			350	**EMERGENCY**	457
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	**SWING**	29.44˚			
CONDUCTOR DIAMETER	0.368"					
WEIGHT	326 lbs.					

Supersedes 1/07 Issue - Updated CU.

FINAL SAG TABLE

	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.08	1.56	2.64	4.92	7.32	9.96	10.92	11.88
75	2.28	3.48	5.40	8.52	11.88	15.36	16.92	18.24
100	4.08	6.00	8.76	12.72	16.68	21.12	23.04	24.84
125	6.48	9.12	12.72	17.40	21.96	27.24	29.52	31.68
150	9.24	12.84	17.16	22.44	27.72	33.72	36.36	38.88
175	12.60	17.04	22.08	27.96	33.84	40.56	43.56	46.32
200	16.44	21.72	27.48	33.96	40.20	47.64	51.00	54.12
225	23.04	29.76	36.24	43.20	49.92	57.72	61.20	64.56
250	32.28	40.08	47.04	54.36	61.32	69.48	73.08	76.68
275	43.44	51.96	59.40	66.84	73.92	82.32	86.16	89.76
300	56.40	65.40	72.84	80.52	87.72	96.36	100.20	104.04

FINAL SAG TABLE

	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	3.60	3.60	2.88	1314
75	7.56	7.32	5.88	1426
100	12.48	11.88	9.48	1542
125	18.12	17.16	13.68	1658
150	24.36	22.92	18.36	1770
175	31.32	29.28	23.52	1877
200	38.76	36.12	29.04	1980
225	48.60	45.60	37.92	*2000
250	60.00	56.76	48.84	*2000
275	72.60	69.24	61.08	*2000
300	86.40	82.80	74.64	*2000

** Note: Design Specification Constraint*

1/0, 7 STRAND, HARD DRAWN COPPER, BARE
MAINTENANCE ONLY

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	4752 lbs.	**TRANSVERSE**	0.4947 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0942 sq. in.	**VERTICAL**	0.978 Lb/Ft			
R. (@ 25˚C)	0.1051 Ω / 1000'	**TOTAL**	1.396 Lb/Ft	278	**NORMAL**	415
R. (@ 50˚C)	0.1150 Ω / 1000'			337	**EMERGENCY**	452
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	33.91˚			
CONDUCTOR DIAMETER	0.368"					
COMPLETE DIAMETER	0.488"					
WEIGHT	363 lbs / 1000'					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.20	1.80	3.36	5.88	8.16	10.56	11.52	12.48
75	2.52	4.08	6.48	9.84	12.96	16.32	17.76	19.08
100	4.56	6.84	10.20	14.28	18.12	22.44	24.24	25.92
125	7.20	10.44	14.40	19.20	23.64	28.80	30.96	33.12
150	10.32	14.52	19.20	24.60	29.76	35.52	38.16	40.56
175	14.04	19.08	24.48	30.48	36.12	42.72	45.60	48.36
200	21.00	27.48	33.60	39.96	45.96	52.92	55.92	58.92
225	30.36	37.80	44.40	51.00	57.24	64.44	67.68	70.80
250	41.88	49.80	56.64	63.36	69.72	77.28	80.64	83.88
275	55.08	63.36	70.20	77.04	83.64	91.32	94.80	98.28
300	69.96	78.24	85.20	92.16	98.76	106.68	110.28	113.76

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	3.84	4.08	3.72	1349
75	7.92	8.04	7.08	1482
100	12.96	12.84	11.04	1617
125	18.72	18.36	15.60	1748
150	25.20	24.48	20.64	1873
175	32.28	31.08	26.28	1991
200	41.88	40.56	35.40	*2000
225	53.04	51.60	46.20	*2000
250	65.52	63.96	58.44	*2000
275	79.20	77.64	72.00	*2000
300	94.32	92.64	87.00	*2000
** Note: Design Specification Constraint*				

Std. Item:	W13D
Item ID:	4015065[Y]
CU:	C02CUSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	5876 lbs.	TRANSVERSE	0.4553 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0680 sq. in.	VERTICAL	0.796 Lb/Ft			
R. (@ 25˚C)	0.1653 Ω / 1000'	TOTAL	1.217 Lb/Ft	249	NORMAL	344
R. (@ 50˚C)	0.1809 Ω / 1000'			279	EMERGENCY	363
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	35.45˚			
CONDUCTOR DIAMETER	0.366"					
WEIGHT	257 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.84	1.20	1.92	3.60	6.60	7.80	9.00
75	1.44	1.92	2.64	3.96	6.60	10.68	12.36	13.92
100	2.64	3.36	4.56	6.72	10.08	15.00	17.16	19.20
125	4.08	5.28	6.96	9.96	14.04	19.80	22.32	24.72
150	5.88	7.56	9.84	13.56	18.36	24.84	27.72	30.48
175	8.16	10.44	13.56	18.00	23.52	30.60	33.84	36.84
200	12.00	15.48	19.80	25.44	31.68	39.24	42.72	45.96
225	17.16	22.32	27.84	34.44	41.16	49.08	52.68	56.04
250	24.48	31.08	37.68	44.88	51.84	60.12	63.72	67.32
275	33.96	41.76	48.96	56.52	63.60	72.12	75.96	79.56
300	45.60	54.24	61.68	69.36	76.68	85.32	89.16	93.00

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	3.00	2.52	1.44	1548
75	6.36	5.40	3.12	1628
100	10.56	9.12	5.52	1721
125	15.72	13.56	8.28	1819
150	21.36	18.60	11.64	1918
175	27.96	24.36	15.72	*2000
200	36.48	32.28	22.44	*2000
225	46.20	41.52	30.72	*2000
250	57.12	51.96	40.56	*2000
275	69.00	63.60	51.96	*2000
300	82.20	76.44	64.56	*2000
** Note: Design Specification Constraint*				

Supersedes 1/07 Issue - Updated CU.

#2, 3 STRAND, TYPE A COPPER – COPPERWELD, BARE
MAINTENANCE ONLY

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		6-304	7/09

 Doc. # ST.06.00.005

Std. Item:	W13B
Item ID:	4015074
CU:	C02CHSTBR

PHYSICAL PROPERTIES	
R.B.S.	3050 lbs.
C.S.A.	0.0522 sq. in.
R. (@ 25˚C)	0.1670 Ω / 1000’
R. (@ 50˚C)	0.1826 Ω / 1000’
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)
CONDUCTOR DIAMETER	0.292”
WEIGHT	205 lbs.

LOADING PROPERTIES	
TRANSVERSE	0.4303 Lb/Ft
VERTICAL	0.698 Lb/Ft
TOTAL	1.1207 Lb/Ft
SWING	35.46˚

ELECTRICAL PROPERTIES		
SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
234	NORMAL	321
261	EMERGENCY	339

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.96	1.56	2.52	4.80	7.20	9.84	10.92	11.88
75	2.28	3.36	5.16	8.40	11.64	15.24	16.68	18.12
100	4.08	5.88	8.52	12.48	16.44	21.00	22.92	24.72
125	6.36	8.88	12.48	17.04	57.72	27.00	29.28	31.56
150	9.12	12.48	16.80	22.08	27.36	33.48	36.12	38.64
175	12.36	16.68	21.60	27.60	33.36	40.20	43.20	46.08
200	16.08	21.36	26.88	33.48	39.72	47.28	50.52	53.76
225	22.44	29.04	35.52	42.48	49.20	57.12	60.60	63.96
250	33.12	41.04	48.00	55.32	62.16	70.20	73.80	77.40
275	46.44	54.96	62.28	69.60	76.56	84.72	88.44	92.04
300	61.92	70.68	78.00	85.32	92.28	100.56	104.40	108.00

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	4.68	4.32	3.00	898
75	9.36	8.52	6.00	1003
100	15.12	13.56	9.60	1108
125	21.72	19.32	13.80	1210
150	28.92	25.68	18.60	1306
175	36.84	32.64	23.76	1398
200	45.24	40.08	29.40	1486
225	55.80	49.92	38.16	*1525
250	68.88	62.52	50.64	*1525
275	83.40	76.68	64.68	*1525
300	99.24	92.28	80.28	*1525
* *Note: Design Specification Constraint*				

Supersedes 1/07 Issue - Updated CU.

#2, 7 STRAND, HARD DRAWN COPPER, BARE
MAINTENANCE ONLY

Std. Item:	W13E
Item ID:	4001042
CU:	C02CHSTPE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	3050 lbs.	**TRANSVERSE**	0.4601 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0585 sq. in.	**VERTICAL**	0.777 Lb/Ft			
R. (@ 25˚C)	0.1670 Ω / 1000’	**TOTAL**	1.203 Lb/Ft	213	**NORMAL**	314
R. (@ 50˚C)	0.1826 Ω / 1000’			257	**EMERGENCY**	342
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	39.95˚			
CONDUCTOR DIAMETER	0.292”					
COMPLETE DIAMETER	0.382”					
WEIGHT	228 lbs / 1000’					

Supersedes 1/07 Issue - Updated CU.

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.08	1.80	3.12	5.64	7.92	10.44	11.40	12.36
75	2.52	3.84	6.24	9.48	12.72	16.08	17.52	18.84
100	4.44	6.72	9.84	13.92	17.76	22.08	24.00	25.68
125	6.96	10.08	14.04	18.84	23.28	28.44	30.72	32.76
150	10.08	14.16	18.72	24.12	29.28	35.16	37.68	40.20
175	13.68	18.60	24.00	29.88	35.64	42.24	45.12	47.88
200	19.92	26.16	32.16	38.64	44.64	51.72	54.84	57.84
225	30.36	37.92	44.40	51.00	57.24	64.44	67.68	70.80
250	43.68	51.60	58.20	64.92	71.16	78.60	81.96	85.20
275	59.04	67.08	73.68	80.40	86.64	94.20	97.68	100.92
300	76.08	84.00	90.60	97.32	103.68	111.36	114.84	118.20

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	4.92	4.68	3.72	926
75	9.72	9.12	7.08	1046
100	15.48	14.40	11.16	1163
125	22.08	20.40	15.84	1274
150	29.40	27.00	20.88	1380
175	37.44	34.08	26.52	1479
200	47.40	43.56	35.04	*1525
225	60.00	55.80	47.16	*1525
250	74.04	69.60	60.84	*1525
275	89.52	84.96	76.20	*1525
300	106.56	101.88	93.12	*1525
** Note: Design Specification Constraint*				

#2, 7 STRAND, HARD DRAWN COPPER, 45 MIL PE COVERING
MAINTENANCE ONLY

 Doc. # ST.06.00.005

Std. Item:	W11G
Item ID:	5943080[E]
CU:	C03CHSTBRNE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2433 lbs.	TRANSVERSE	0.4197 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0416 sq. in.	VERTICAL	0.636 Lb/Ft			
R. (@ 25˚C)	0.2106 Ω / 1000’	TOTAL	1.062 Lb/Ft	202	NORMAL	277
R. (@ 50˚C)	0.2303 Ω / 1000’			226	EMERGENCY	292
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	38.57˚			
CONDUCTOR DIAMETER	0.260”					
WEIGHT	163 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.96	1.56	2.52	4.80	7.20	9.84	10.80	11.88
75	2.28	3.36	5.16	8.28	11.64	15.24	16.68	18.12
100	3.96	5.76	8.52	12.48	16.44	21.00	22.92	24.72
125	6.24	8.88	12.36	17.04	21.72	27.00	29.28	31.44
150	9.00	12.48	16.80	22.08	27.36	33.36	36.12	38.64
175	12.36	16.80	21.72	27.72	33.48	40.32	43.32	46.08
200	20.76	27.24	33.24	39.60	45.60	52.56	55.68	58.68
225	33.00	40.56	46.92	53.40	59.40	66.48	69.72	72.72
250	48.36	56.04	62.40	68.88	74.88	82.08	85.32	88.44
275	65.76	73.44	79.68	86.04	92.04	99.24	102.48	105.72
300	84.96	92.40	98.52	104.88	110.88	118.08	121.44	124.68

Supersedes 1/07 Issue - Updated CU.

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	5.28	4.68	3.00	749
75	10.56	9.24	6.12	851
100	16.80	14.64	9.84	950
125	23.88	20.76	14.16	1045
150	31.56	27.48	18.96	1134
175	40.08	34.80	24.36	*1216
200	52.44	46.56	35.76	*1217
225	66.36	60.00	49.32	*1217
250	81.96	75.24	64.68	*1216
275	99.12	92.28	81.72	*1217
300	117.96	110.88	100.56	*1217
** Note: Design Specification Constraint*				

 Doc. # ST.06.00.00

Std. Item:	W11H
Item ID:	5944080[E]
CU:	C03CHSTPENE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2433 lbs.	**TRANSVERSE**	0.4490 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0480 sq. in.	**VERTICAL**	0.704 Lb/Ft			
R. (@ 25˚C)	0.2106 Ω / 1000'	**TOTAL**	1.135 Lb/Ft	185	**NORMAL**	272
R. (@ 50˚C)	0.2303 Ω / 1000'			223	**EMERGENCY**	296
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	45.00˚			
CONDUCTOR DIAMETER	0.260"					
COMPLETE DIAMETER	0.350"					
WEIGHT	175 lbs / 1000'					

FINAL SAG TABLE							
	LOADING (UNLOADED CONDITIONS)						
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**
TEMP. ˚C	**-20**	**0**	**15**	**32**	**50**	**70**	**80**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)							
50	1.20	1.80	3.00	5.40	7.68	10.20	11.16
75	2.76	3.96	6.12	9.24	12.36	15.84	17.28
100	4.80	6.96	9.84	13.68	17.52	21.84	23.64
125	7.56	10.44	14.16	18.72	23.16	28.20	30.36
150	10.80	14.64	19.08	24.24	29.16	34.92	37.56
175	19.20	24.96	30.24	35.76	40.92	46.92	49.56
200	31.80	38.40	43.92	49.56	54.72	60.84	63.60
225	47.52	54.12	59.64	65.28	70.44	76.68	79.44
250	65.40	71.88	77.28	82.80	88.08	94.32	97.20
275	85.20	91.56	96.84	102.36	107.52	113.88	116.76
300	106.80	113.04	118.32	123.72	128.88	135.24	138.24

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½" ICE	**½" ICE**	**6 LB. WIND**	**4 LB. WIND, ½" ICE**
DEAD END SPAN (FEET)				
50	5.52	5.16	3.96	779
75	10.68	9.84	7.44	896
100	16.92	15.36	11.52	1007
125	24.00	21.60	16.20	1112
150	31.68	28.44	21.36	1210
175	42.84	39.12	31.80	*1217
200	56.04	51.96	44.52	*1216
225	70.92	66.60	59.28	*1217
250	87.60	83.16	75.84	*1217
275	105.96	101.40	94.20	*1217
300	126.24	121.44	114.24	*1217
** Note: Design Specification Constraint*				

Supersedes 1/07 Issue - Updated CU.

#3, 7 STRAND, HARD DRAWN COPPER, 45 MIL PE COVERING
MAINTENANCE ONLY

Std. Item:	W11D
Item ID:	4015066[Y]
CU:	C04CUSTBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	3938 lbs.	TRANSVERSE	0.4302 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0428 sq. in.	VERTICAL	0.653 Lb/Ft			
R. (@ 25˚C)	0.2629 Ω / 1000’	TOTAL	1.082 Lb/Ft	186	NORMAL	255
R. (@ 50˚C)	0.2875 Ω / 1000’			208	EMERGENCY	270
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	41.83˚			
CONDUCTOR DIAMETER	0.290”					
WEIGHT	162 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.84	1.08	1.56	3.00	5.88	7.32	8.40
75	1.44	1.80	2.40	3.48	5.76	9.72	11.52	13.20
100	2.52	3.12	4.20	6.00	9.00	13.92	16.08	18.24
125	3.84	4.92	6.36	8.88	12.72	18.48	21.00	23.52
150	5.52	7.08	9.00	12.36	16.80	23.28	26.28	29.04
175	7.56	9.60	12.12	16.08	21.24	28.44	31.68	34.92
200	9.84	12.36	15.60	20.28	26.04	33.84	37.44	40.92
225	12.48	15.60	19.32	24.72	31.08	39.60	43.44	47.28
250	15.48	19.08	23.52	29.52	36.48	45.48	49.68	53.76
275	18.72	23.04	27.96	34.56	42.00	51.72	56.16	60.60
300	22.20	27.24	32.76	39.96	47.88	58.20	63.00	67.56

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	3.84	3.00	1.44	1069
75	7.92	6.36	3.12	1148
100	13.20	10.56	5.40	1235
125	19.20	15.60	8.16	1323
150	25.92	21.12	11.52	1411
175	33.24	27.24	15.24	1497
200	41.04	33.84	19.32	1581
225	49.44	40.92	23.88	1663
250	58.32	48.36	28.68	1742
275	67.56	56.16	33.84	1819
300	77.16	64.32	39.36	1894
* Note: *Design Specification Constraint*				

Supersedes 1/07 Issue - Updated CU.

Std. Item:	W11B
Item ID:	4015073Y
CU:	C04CHSOBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	1970 lbs.	TRANSVERSE	0.4010 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0328 sq. in.	VERTICAL	0.564 Lb/Ft			
R. (@ 25˚C)	0.2602 Ω / 1000’	TOTAL	0.992 Lb/Ft	171	NORMAL	232
R. (@ 50˚C)	0.2847 Ω / 1000’			190	EMERGENCY	245
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	38.97˚			
CONDUCTOR DIAMETER	0.204”					
WEIGHT	126 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.96	1.44	2.40	4.56	7.08	9.72	10.80	11.76
75	2.16	3.12	4.92	8.04	11.40	15.00	16.56	18.00
100	3.84	5.52	8.16	12.12	16.08	20.76	22.68	24.48
125	6.00	8.52	11.88	16.56	21.24	26.64	29.04	31.20
150	8.64	12.00	16.20	21.60	26.88	33.00	35.76	38.28
175	16.32	22.08	27.72	33.60	39.00	45.36	48.12	50.76
200	29.04	36.00	41.88	47.64	53.16	59.40	62.28	65.04
225	45.24	52.32	57.96	63.72	69.12	75.48	78.36	81.12
250	63.72	70.56	76.08	81.72	87.12	93.48	96.36	99.24
275	84.12	90.60	96.12	101.64	106.92	113.28	116.28	119.16
300	106.32	112.68	117.96	123.36	128.64	135.12	138.00	140.88

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	5.88	5.04	2.88	635
75	11.52	9.72	5.88	733
100	18.24	15.36	9.48	826
125	25.68	21.60	13.68	913
150	33.96	28.68	18.48	*985
175	46.32	40.32	29.76	*985
200	60.48	54.00	43.68	*985
225	76.56	69.72	59.76	*985
250	94.56	87.36	77.76	*985
275	114.48	107.04	97.56	*985
300	136.20	128.76	119.40	*985
* Note: Design Specification Constraint				

#4, SOLID, HARD DRAWN COPPER, BARE
MAINTENANCE ONLY

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		6-310	1/07

Std. Item:	W11E
Item ID:	4001041Y
CU:	C04CHSOPE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	1970 lbs.	**TRANSVERSE**	0.4210 Lb/Ft	**SUMMER (37.7˚C)**	**MAXIMUM AMPACITY**	**WINTER (10˚C)**
C.S.A.	0.0356 sq. in.	**VERTICAL**	0.611 Lb/Ft			
R. (@ 25˚C)	0.2602 Ω / 1000’	**TOTAL**	1.042 Lb/Ft	159	**NORMAL**	230
R. (@ 50˚C)	0.2847 Ω / 1000’			191	**EMERGENCY**	250
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	**SWING**	44.33˚			
CONDUCTOR DIAMETER	0.204”					
COMPLETE DIAMETER	0.264”					
WEIGHT	135 lbs / 1000’					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	**0**	**32**	**60**	**90**	**120**	**158**	**176**	**194**
TEMP. ˚C	**-18**	**0**	**15**	**32**	**50**	**70**	**80**	**90**
	Unloaded	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**	**Unloaded**
DEAD END SPAN (FEET)								
50	1.08	1.56	2.52	4.68	7.20	9.72	10.80	11.76
75	2.28	3.36	5.28	8.28	11.52	15.12	16.68	18.00
100	4.08	5.88	8.64	12.48	16.44	20.88	22.80	24.60
125	6.48	9.00	12.48	17.04	21.72	27.00	29.28	31.44
150	10.20	14.04	18.60	23.88	28.92	34.92	37.44	39.96
175	19.44	25.56	30.96	36.60	41.76	47.76	50.40	52.92
200	33.72	40.44	45.96	51.48	56.52	62.64	65.28	67.92
225	51.00	57.60	62.88	68.28	73.44	79.44	82.20	84.84
250	70.32	76.68	81.84	87.24	92.28	98.28	101.16	103.80
275	91.68	97.80	102.84	108.12	113.16	119.16	122.04	124.68
300	114.84	120.84	125.76	130.92	135.96	142.08	144.84	147.60

Supersedes 1/07 Issue - Updated CU.

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			**TENSION (LBS.)**
TEMP. ˚F	**0**	**32**	**60**	**0**
TEMP. ˚C	**-20**	**0**	**15**	**-20**
	4 LB. WIND, ½” ICE	**½” ICE**	**6 LB. WIND**	**4 LB. WIND, ½” ICE**
DEAD END SPAN (FEET)				
50	6.12	5.28	3.24	641
75	11.88	10.20	6.48	741
100	18.72	16.08	10.44	835
125	26.40	22.56	14.88	925
150	35.76	30.84	21.48	*985
175	48.60	43.20	33.72	*985
200	63.48	57.72	48.36	*985
225	80.40	74.28	65.16	*985
250	99.24	92.88	84.00	*985
275	120.24	113.64	104.88	*985
300	143.04	136.32	127.68	*985

** Note: Design Specification Constraint*

#4, SOLID, HARD DRAWN COPPER, 30 MIL PE COVERING
MAINTENANCE ONLY

 Doc. # ST.06.00.002

Std. Item:	W9F
Item ID:	4015064[Y]
CU:	C6ABCCW

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	2585 lbs.	TRANSVERSE	0.4103 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0269 sq. in.	VERTICAL	0.556 Lb/Ft			
R. (@ 25˚C)	0.4186 Ω / 1000'	TOTAL	0.991 Lb/Ft	140	NORMAL	190
R. (@ 50˚C)	0.4564 Ω / 1000'			155	EMERGENCY	201
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	48.43˚			
CONDUCTOR DIAMETER	0.230"					
WEIGHT	102 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.60	0.72	0.96	1.44	2.52	5.40	6.84	8.04
75	1.32	1.68	2.16	3.24	5.16	9.12	10.92	12.60
100	2.40	3.00	3.84	5.52	8.28	13.08	15.36	17.52
125	3.72	4.68	6.00	8.28	11.88	17.52	20.16	22.68
150	5.28	6.72	8.52	11.52	15.84	22.20	25.20	28.08
175	7.20	9.12	11.40	15.12	20.04	27.24	30.60	33.72
200	9.48	11.76	14.76	19.08	24.72	32.52	36.12	39.72
225	12.00	14.88	18.36	23.40	29.64	38.04	42.00	45.84
250	17.16	21.48	26.64	33.12	40.32	49.32	53.40	57.36
275	26.52	33.24	40.08	47.76	55.32	64.32	68.40	72.36
300	40.44	48.84	56.52	64.44	71.88	80.88	84.96	88.80

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	5.04	3.72	1.44	740
75	10.20	7.80	3.24	818
100	16.56	12.72	5.64	899
125	23.76	18.48	8.52	978
150	31.68	24.84	12.00	1055
175	40.32	31.80	15.84	1130
200	49.44	39.24	20.04	1202
225	59.16	47.16	24.72	1272
250	71.88	58.56	33.84	*1292
275	87.00	72.72	47.28	*1293
300	103.56	88.44	63.24	*1293
** Note: Design Specification Constraint*				

#6, 3 STRAND, TYPE A COPPER – COPPERWELD, BARE
MAINTENANCE ONLY

 Doc. # ST.06.00.005

Std. Item:	
Item ID:	4015075
CU:	C06CHSOBR

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	1280 lbs.	TRANSVERSE	0.3867 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0234 sq. in.	VERTICAL	0.491 Lb/Ft			
R. (@ 25˚C)	0.4129 Ω / 1000’	TOTAL	0.925 Lb/Ft	128	NORMAL	173
R. (@ 50˚C)	0.4527 Ω / 1000’			142	EMERGENCY	182
TEMP. LIMIT	176˚F (80˚C) / 194˚F (90˚C)	SWING	45.72˚			
CONDUCTOR DIAMETER	0.162”					
WEIGHT	79 lbs.					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.96	1.32	2.28	4.32	6.84	9.48	10.56	11.52
75	2.04	3.00	4.68	7.68	11.04	14.76	16.32	17.76
100	3.72	5.28	7.80	11.64	15.72	20.28	22.32	24.12
125	9.24	13.56	18.12	22.68	26.88	31.56	33.72	35.64
150	23.40	29.04	33.48	37.80	41.88	46.44	48.60	50.52
175	42.24	47.40	51.48	55.56	59.52	64.08	66.24	68.28
200	63.48	68.16	72.12	76.08	79.92	84.48	86.52	88.68
225	87.12	91.56	95.40	99.24	102.96	107.52	109.68	111.72
250	113.40	117.72	121.32	125.16	128.88	133.44	135.48	137.64
275	142.20	146.40	150.00	153.72	157.44	162.00	164.16	166.20
300	173.76	177.84	181.44	185.16	188.76	193.32	195.48	197.52

Supersedes 1/07 Issue - Updated CU.

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½” ICE	½” ICE	6 LB. WIND	4 LB. WIND, ½” ICE
DEAD END SPAN (FEET)				
50	7.44	6.00	3.00	463
75	14.28	11.52	6.00	548
100	22.08	17.88	9.72	628
125	33.96	28.68	20.04	*640
150	48.84	43.08	34.92	*640
175	66.48	60.48	52.80	*640
200	86.88	80.64	73.20	*640
225	110.04	103.56	96.48	*640
250	135.84	129.24	122.40	*640
275	164.52	157.80	150.96	*640
300	195.96	189.12	182.40	*640
** Note: Design Specification Constraint*				

#6, SOLID, HARD DRAWN COPPER, BARE
MAINTENANCE ONLY

Std. Item:	W9E
Item ID:	4001038
CU:	C06CHSOPE

PHYSICAL PROPERTIES		LOADING PROPERTIES		ELECTRICAL PROPERTIES		
R.B.S.	1280 lbs.	TRANSVERSE	0.4070 Lb/Ft	SUMMER (37.7˚C)	MAXIMUM AMPACITY	WINTER (10˚C)
C.S.A.	0.0234 sq. in.	VERTICAL	0.536 Lb/Ft			
R. (@ 25˚C)	0.4129 Ω / 1000'	TOTAL	0.973 Lb/Ft	120	NORMAL	173
R. (@ 50˚C)	0.4527 Ω / 1000'			144	EMERGENCY	189
TEMP. LIMIT	167˚F (75˚C) / 194˚F (90˚C)	SWING	51.91˚			
CONDUCTOR DIAMETER	0.162"					
COMPLETE DIAMETER	0.222"					
WEIGHT	87 lbs / 1000'					

FINAL SAG TABLE								
	LOADING (UNLOADED CONDITIONS)							
TEMP. ˚F	0	32	60	90	120	158	176	194
TEMP. ˚C	-18	0	15	32	50	70	80	90
	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded	Unloaded
DEAD END SPAN (FEET)								
50	0.96	1.56	2.76	5.28	7.68	10.20	11.16	12.12
75	2.28	3.48	5.64	9.00	12.24	15.72	17.16	18.60
100	4.80	7.32	10.92	15.00	18.84	23.04	24.84	26.52
125	14.52	19.68	23.88	27.96	31.68	35.88	37.68	39.48
150	31.08	35.88	39.84	43.68	47.28	51.60	53.52	55.32
175	50.40	54.96	58.56	62.28	65.88	70.08	72.00	73.92
200	72.36	76.68	80.16	83.76	87.36	91.56	93.48	95.40
225	97.08	101.16	104.52	108.12	111.60	115.92	117.84	119.76
250	124.44	128.40	131.88	135.36	138.84	143.04	145.08	147.00
275	154.68	158.64	162.00	165.48	168.96	173.16	175.20	177.12
300	187.80	191.76	195.00	198.48	201.96	206.16	208.20	210.12

FINAL SAG TABLE				
	LOADING (LOADED CONDITIONS)			TENSION (LBS.)
TEMP. ˚F	0	32	60	0
TEMP. ˚C	-20	0	15	-20
	4 LB. WIND, ½" ICE	½" ICE	6 LB. WIND	4 LB. WIND, ½" ICE
DEAD END SPAN (FEET)				
50	7.56	6.36	3.84	484
75	14.28	11.88	7.44	577
100	22.80	19.44	13.20	*640
125	35.64	31.68	25.68	*640
150	51.36	47.16	41.40	*640
175	69.96	65.52	60.00	*640
200	91.44	86.76	81.48	*640
225	115.80	111.00	105.84	*640
250	143.04	138.24	133.08	*640
275	173.16	168.24	163.20	*640
300	206.16	201.24	196.20	*640
* *Note: Design Specification Constraint*				

#6, SOLID, HARD DRAWN COPPER, 30 MIL PE COVERING
MAINTENANCE ONLY

 | Doc. # ST.06.00.005

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2	7/10	• Corrected final unloaded sags for 200' and 225' spans on pages 6-203, and 6-205 through 6-217.	Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods
1	7/09	• Updated CUs on pages 6-127, 6-128, 6-203, 6-205, 6-208, 6-212, 6-213, 6-214, 6-215, 6-216, 6-217, 6-218, 6-219, 6-220, 6-302, 6-304, 6-305, 6-306, 6-307, 6-308, 6-309, 6-311, 6-313. • Updated conductor ampacities on pages 6-107, 6-109, 6-115, 6-117, 6-123, 6-127, 6-129.	Paul Anundson	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/06 Issue - Updated page numbers.

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Supersedes 1/06 Issue – Intro: Modified description of role of NESC & standard. General: Modified description of MCOT.

7.0 INTRODUCTION

7.0.10 Role of the National Electrical Safety Code

The National Electrical Safety Code (NESC) provides basic guidance for minimum clearances to protect the public and employees during the installation, maintenance and operation of electric supply and communication lines, and associated equipment. The NESC is not intended as a design specification or an instruction manual.

7.0.20 Role of this Standard

This standard is intended as a design specification to provide for compliance with the NESC, safe installation, operation and maintenance of lines, an adequate level of service reliability, and space for future equipment or conductors. New poles shall be selected to meet or exceed the clearances shown, which shall be considered as minimum requirements.

7.0.30 Clearance Requirements for Distribution Lines

The uniform clearance system contained in the 2011 Edition NESC reflects the dimensions of the expected activities in each electric distribution area, as well as the relative potential problem caused by each type of facility.

Each vertical and horizontal clearance shall be observed, but within the limits of each other only.

The uniform clearance system contained in the NESC is based on the dimensions of the expected activities in each area, as well as the relative potential problem caused by each type of facility.

Conductor clearance is stated in terms of the "closest approach." This is the clear distance between surfaces that **must** be maintained under specified conditions.

In general, vertical clearance requirements must be met during maximum sag conditions to provide for the expected activity beneath the line.

In general, horizontal clearance requirements must be met with the conductor at rest to provide for the expected activity alongside the line. Conductor "blowout" (wind displacement) is considered under certain conditions (refer to Sections 7.9, 7.10 and 7.13).

7.1 GENERAL

7.11.10 Liberty Utilities Clearance Criteria for Distribution Lines

A. Overhead distribution lines shall be designed to maintain adequate clearances under ice loaded conditions and the line's maximum conductor operating temperature (MCOT). In no case should a distribution line be designed for a MCOT below 120°F/48.9°C.

B. The required MCOT of the distribution line shall be determined by the appropriate planning department.

C. To protect conductors from damage caused by excessive heating, the required MCOT for the distribution shall not exceed the following limits:

i. 176°F/80°C for primary bare conductors 35 kV and below,
ii. 167°F/75°C primary covered conductors 35 kV and below,
iii. 120°F/48.9°C for spacer cable messengers and 167°F/75°C for spacer cable phase

conductors (Phase conductor temperatures higher than 120°F/50°C are taken to have no influence in elevating messenger temperatures),

iv. Primary shielded and non-shielded aerial cables 35 kV and below shall be designed to operate with the messenger at 120°F/48.9°C ambient (Phase conductor temperatures higher than 120°F/48.9°C are taken to have no influence in elevating messenger temperatures), and

v. Secondary non shielded cables 0 to 750 V shall be designed to operate with the messenger at 120°F/48.9°C ambient (Temperatures of the insulated conductors, lashed or twisted about the messenger, above 120°F/48.9°C, are taken to have no influence in elevating messenger temperatures).

D. New Installations and Extensions - Clearances for the installation of all new electric supply lines and extensions to existing lines shall be in accordance with the latest edition of the NESC and the requirements of any applicable state or local laws, rules or regulations.

E. Existing Installations - Where an existing installation meets, or is altered to meet, the current NESC Rules, such installation is considered to be in compliance with the current edition of the NESC and is not required to comply with any previous edition of the NESC.

F. Existing installations, including maintenance replacements, that currently comply with prior editions of the NESC, need not be modified to comply with these rules except as may be required for safety reasons by the administrative authority.

G. Where conductors or equipment are added, altered, or replaced on an existing structure, the structure or the facilities on the structure need not be modified or replaced if the resulting installation will be in compliance with either (a) the NESC rules that were in effect at the time of the original installation, (b) the rules in effect in a subsequent edition of the NESC to which the installation has been previously brought into compliance, or (c) rules in the latest edition of the NESC.

H. Clearances listed in the following STANDARDS and tables are considered minimum requirements for new construction. In some instances clearances exceeding those given may be required (e.g. when mandated by local ordinances). Other design considerations applying to Company work and operating practices may result in clearances greater than NESC minimum clearances. For example, vertical clearances for 34.5 kV grounded wye construction are based on pre-1987 codes, which called for 40 inch phase to neutral clearance at the pole and 30 inch phase to neutral clearance mid-span for spans up to 175 feet. These added clearances are deemed more prudent for hot-stick operation and maintenance of 25 kV and 35 kV constructions.

I. Effectively grounded circuits are defined as those circuits originating from a grounded-wye connected transformer or system, or from a system provided with a grounding transformer of sufficient size to stabilize the phase to ground voltage at approximately its normal value, regardless of whether the neutral conductor is present with the circuit. Circuits having a maximum X_0/X_1 ratio of 3.0 at the substation bus are considered effectively grounded circuits.

J. Voltage is the root-mean-square (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. Nominal voltage is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. Operating voltage of the system may vary above or below the nominal voltage.

Supersedes 1/06 Issue – Editorial and paging revisions.

K. Voltages in the following tables are phase to ground, unless otherwise noted, for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations. "Effectively grounded" means intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to limit the buildup of voltages to levels below that which may result in undue hazard to persons or to connected equipment. The voltage of a circuit not effectively grounded is the highest nominal voltage available between any two conductors on the circuit.

L. Clearance is defined as the clear distance between two objects measured surface to surface.

M. Spacing is defined as the distance between two objects measured center to center.

N. Clearances for tree wire, covered conductor, and spacer cable conductor are taken as if they were bare conductors.

O. Open conductors are defined as electric supply or communication construction in which the conductors are bare, covered or insulated and without grounded shielding, or individually supported at a structure either directly or with insulators.

P. Electric supply lines are those conductors used to transmit electric energy and their necessary supporting or containing equipment.

Q. Communication conductors include fire alarm, telephone, cable television, police alarm, data, telegraph, clock, and other systems used for communication service.

R. Fiber-Optic Cables in the supply space:

There are two general categories:

1. Fiber optic cables supported by an effectively ground metallic messenger.
2. All dielectric fiber optic (ADFO) cable.

Clearance requirements:

1. ADFO cables (i.e. meeting NESC Rule 230F1b) installed in the supply space have no specified clearances from supply conductors and other cables in the supply space.
2. Fiber optic cables supported by an effectively ground metallic messenger (i.e. meeting NESC Rule 230F1a) and ADFO cables (i.e. meeting NESC Rule 230F1b) are prohibited from being installed in the Communication Worker Safety Zone between the supply space and the communication space, but may be treated the same as effectively grounded neutrals for clearance purposes.

Supersedes 1/06 Issue – Fiber-optic cable information updated.

7.1.20 NESC Vertical Clearance Requirements Illustration – Rules 232 & 235

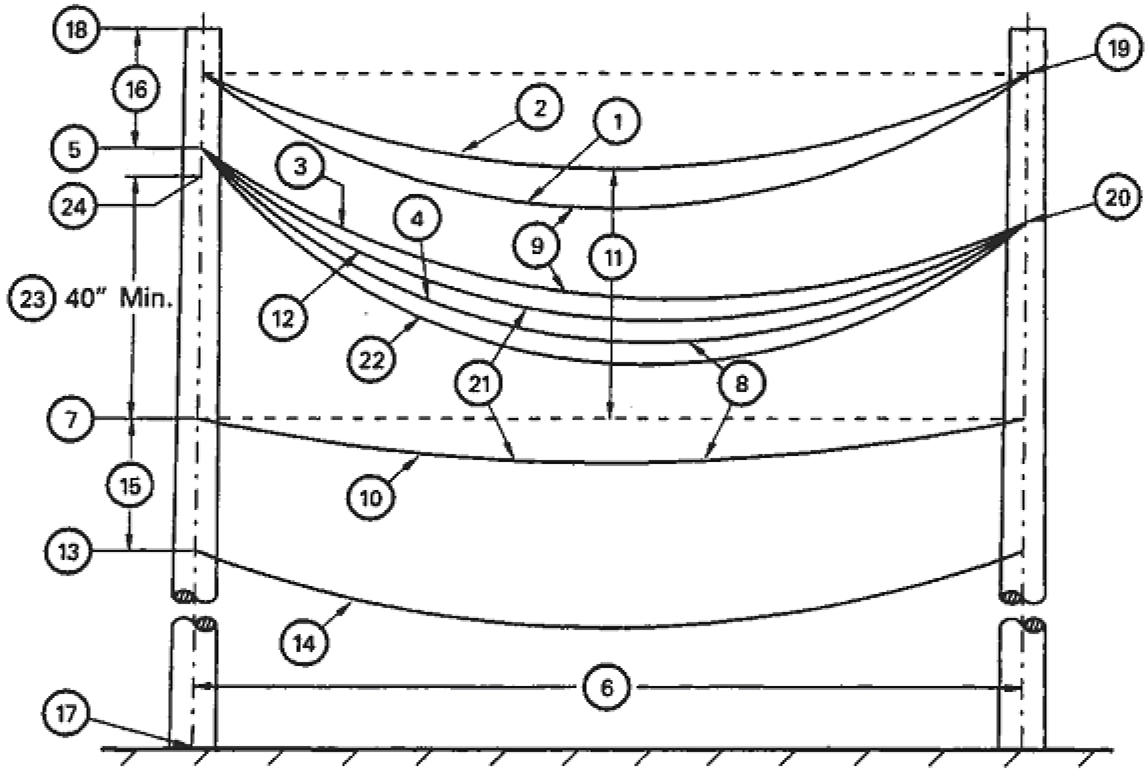


Figure 1

1 - Lowest upper supply conductor at position which produces maximum final sag; effectively grounded circuits 0-22 kV phase to ground.

2 - Lowest upper supply conductor at 60°F/15°C, final, unloaded sag; effectively grounded circuits 0-22 kV phase to ground

3 - Secondary cable, 0-750 V, supported by effectively grounded messenger; messenger at same operating ambient as 1 above.

4 - Effectively grounded neutral associated with 1 above.

5 - Lowest electrical point of attachment.

6 - Actual span length.

7 - Highest communication conductor attachment.

8 - May be reduced to 12 inches for effectively grounded neutral conductors, associated with circuits 0-22 kV phase to ground.

9 - Clearance in-span primary to secondary; must be 75% of that required at support, all span lengths.

10 - Highest communication conductor, Company design based on fire alarm pair or single telephone loop with midspan sag; 4 inches for 0 to 150 feet; 6 inches for 150 to 200 feet; 8 inches for 200 to 250 feet; and 12 inches for 250 to 300 feet; all ambients.

Supersedes 1/06 Issue – Editorial and paging revisions.

11 - For spans exceeding 150 feet, vertical clearances at the pole between the open supply conductors of over 750 V, but less than 50 kV, and the highest communication conductor, shall be adjusted, so that under conditions of both conductors at 60°F/15°C, no wind, and final unloaded sag, no point in the top supply conductor span shall be below a straight line joining the support points of the highest communication conductor.

12 - Secondary cable, 0-750 V, supported by effectively grounded messenger; at position which produces maximum final sag.

13 - Lowest communication conductor attachment.

14 - Lowest communication conductor.

15 - Communication conductor allocated space.

16 - Electric conductor allocated space.

17 - Final grade.

18 - Top of pole structure.

19 - Primary conductor attachment.

20 - Secondary cable or neutral attachment.

21 - Clearance in-span, secondary to top communication conductor; must be 75% of that required at support; all span lengths.

22 - Effectively grounded neutral conductor associated with top primary conductor; neutral at maximum sag condition.

23 - At pole clearance may be reduced to 30 inches from bottom of grounded non-current carrying equipment, such as transformers, capacitors and voltage regulators.

24 - Lowest electrical ownership.

Supersedes 1/06 Issue – Editorial and paging revisions.

7.2 RELATIVE LEVELS

Where supply lines of different voltages are attached to the same pole or cross one another, the higher voltage conductors should, where practical, be placed above those of lower voltage.

7.3 CLEARANCES OF SUPPORTING STRUCTURES FROM RAIL, CURB, HYDRANT & OTHER OBJECTS

Poles for overhead distribution lines shall be located with adequate clearance to railroad and automobile traffic. The following table demonstrates NESC minimum requirements. These requirements should be exceeded if practicable. State authorities prefer that poles be set back as far as possible from the pavement edge, behind guard rails, back of the ditch, behind sidewalks, curbs, etc. In any case, the approval of the authorities shall be obtained. Avoid poles at exposed corners and similar locations where they are likely to be struck by motor vehicles or snow removal equipment.

Table 1
Clearance of Supporting Structures from Rail, Curb or Hydrant
(Reference: NESC Rule 231)

Supporting structures[1], support arms, attached equipment, and braces shall have the following clearances (in feet) measured between the nearest parts of the objects concerned:

Objects	**Minimum (Ft.)**	**Recommended (Ft.)**
A. Fire Hydrants	3[2]	4[2]
B. Streets, Roads, Highways[3]	***Horizontal Clearance for First 15 Feet Above Ground***	
1. With street curbs (clearance measured from street side of the curb)		
a. Arterial Streets which are primarily for through traffic	0.5	2[4]
b. Local Streets which are primarily for access to residences, business or other abutting property	0.5	1[2]
2. With no curbs		See Note 5
C. All Railroad Tracks	***Horizontal Clearance for First 22 Feet Above the Nearest Track Rail***	
	12[6]	

FOOTNOTES:

1. Supporting structures are defined as the main supporting unit, usually a pole or tower.
2. This clearance also applies to anchor guys and push braces.
3. Where a governmental authority exercising jurisdiction over structure location has issued a permit for, or otherwise approved, specific locations for supporting structures, that permit or approval shall govern.
4. Place the supporting structures as far as practical behind the curb within the road right-of-way.
5. Place the supporting structures a sufficient distance from the roadway to avoid contact by ordinary vehicles using the traveled way.
6. This may be reduced to 7 feet where the supporting structure is not the controlling obstruction, provided sufficient space for a driveway is left where the cars are loaded and unloaded.

7.4 <u>VERTICAL CLEARANCES OF WIRES, CONDUCTORS, CABLES, AND EQUIPMENT ABOVE GROUND, ROADWAY, RAILS, ETC.</u>

Clearances for distribution conductors, found in Table 2, above ground, rails, etc., are based on a conductor temperature of 60°F/15°C, no wind.

Supersedes 1/06 Issue – Editorial and paging revisions.

Table 2
Minimum Vertical Clearance of Wires, Conductors, and Cables Above Ground, Roadways, or Rails
(Reference: NESC Table 232-1)

Column	Section Heading
1	Grounded guys; messengers, surge protection wires; grounded neutrals; shielded supply cables supported by grounded messenger; ungrounded guys exposed to 0- to 300 V[11,15;] and insulated communication cables and conductors
2A	Non-shielded supply cables, 0 to 750 V, supported by grounded messenger
2B	Non-insulated communication conductors
3	Open supply conductors 0 to 750 V; non-shielded supply cables supported by grounded messenger under 5 $kV_{Ø–Ø}$ or 2.9 $kV_{Ø–G}$; ungrounded guys exposed to over 300 V to 750 V[14]
4	Open supply conductors over 750 V-22 kV; ungrounded guys exposed to 750 V to 22 kV[14]

Nature of Surface Underneath Wires, Conductors, or Cables	1 (ft.)	2A / 2B (ft.)	3 (ft.)	4 (ft.)
Where wires, conductors, or cables cross over or overhang				
1. Track rails of railroads (not using overhead electric supply conductors)[2,16]	23.5	24.0	24.5	26.5
2. Roads, streets, and other areas subject to truck traffic [3]	15.5	16.0	16.5	18.5
3. Driveways, parking lots, and alleys[23]	15.5[7,13]	16.0[7,13]	16.5 [7]	18.5
4. Land traversed by vehicles, such as cultivated, grazing, forest, orchards, etc.[26]	15.5	16.0	16.5	18.5
5. Spaces and ways subject to pedestrians or restricted traffic only[9]	9.5	12.0[8]	12.5[8]	14.5
Where Wires, Conductors Or Cables Run Along Highway Or Rights-Of-Way But Do Not Overhang The Roadway				
Nature of Surface Underneath Wires, Conductors, or Cables	**1 (ft.)**	**2A / 2B (ft.)**	**3 (ft.)**	**4 (ft.)**
6. Roads, streets, or alleys	15.5[24]	16.0	16.5	18.5
7. Roads in rural districts where it is unlikely that vehicles will be crossing under the line	13.5[10,12]	14.0[10]	14.5[10]	16.5

Supersedes 1/06 Issue – Editorial and paging revisions.

Note:

For voltages exceeding 22 kV, increase clearances specified above at a rate of 0.4 inches per kV in excess of 22 kV (reference NESC Rule 232C2a).

FOOTNOTES:

Note: Footnotes 1, 4-6, 17-22, and 25, are not used.

2. For wires, conductors, or cables crossing over mine, logging, or similar railways that handle only cars lower than standard freight cars, the clearance may be reduced by an amount equal to the difference in height between the highest loaded car handled and 20 feet, but the clearance shall not be reduced below that required for street crossings

3. Does not include neutral conductors effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1).

7. Where the height of a residential building does not permit service drops to meet these values, the clearance over residential driveways only may be reduced to the following:

	Feet
Insulated supply service drops limited to 300 V to ground	12.5
Insulated drip loops of supply service drops limited to 300 V to ground	10.5
Supply service drops limited to 150 V to ground that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C2 or 230C3)	12.0
Drip loops only of service drops limited to 150 V to ground that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C2 or 230C3)	10.0
Insulated communication service drops	11.5

8. Where the height of a residential building does not permit service drops to meet these values, the clearances may be reduced to the following:

	Feet
Insulated supply service drops limited to 300 V to ground	10.5
Insulated drip loops of supply service drops limited to 300 V to ground	10.5
Supply service drops limited to 150 V to ground that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1 or 230C3)	10.0
Drip loops only of service drops limited to 150 V to ground that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1 or 230C3)	10.0

9. Spaces and ways subject to pedestrians or restricted traffic only are those where riders on horseback or other large animals, vehicles, or other mobile units exceeding 8 feet in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

10. Where a supply or communication line along a road is located relative to fences, ditches, embankments, etc., so that ground under the line would not be expected to be traveled except by pedestrians, the clearances may be reduced to the following values:

	Feet
Insulated communication conductor and communication cables	9.5
Conductors of other communication circuits	9.5
Lashed aerial cables (insulated and fully metallic shielded) installed according to these standards and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1), supply cables limited to 150 V to ground that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C2 or 230C3), and neutral conductors that are effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1)	9.5
Insulated supply conductors limited to 300 V to ground	12.5
Guys	9.5

11. No clearance from ground is required for anchor guys not crossing tracks, rails, streets, driveways, roads, or pathways.

12. This clearance may be reduced to 13 feet for communication conductors and guys.

13. Where this construction crosses over or runs along alleys, driveways, or parking lots not subject to truck traffic, this clearance may be reduced to 15 feet.

Supersedes 1/06 Issue – Clarified conductor type descriptions.

14. Ungrounded guys and ungrounded portions of span guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to slack conductor or guy.

15. Anchor guys insulated in accordance with these standards may have the same clearance as grounded guys.

16. Adjacent to tunnels and overhead bridges that restrict the height of loaded rail cats to less than 20 feet, if mutually agreed to by the parties at interest.

23. For the purpose of this Rule, trucks are defined as any vehicle exceeding 8 feet in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

24. Communication cables and conductors may have a clearance of 15 feet where poles are in back of curbs or other deterrents to vehicular traffic.

26. When designing a line to accommodate oversized vehicles, these clearance values shall be increased by the difference between the known height of the oversized vehicle and 14 feet.

Supersedes 1/06 Issue – Editorial and paging revisions.

7.5 VERTICAL CLEARANCE OF WIRES, CONDUCTORS AND CABLES ABOVE WATER SURFACES

Vertical clearances of distribution supply wires and conductors over waterways shall not be less than those shown on Table 3: Vertical Clearance Above Water Surfaces. Where the U.S. Army Corps of Engineers has issued a crossing permit, clearances of that permit shall govern, if greater.

Table 3
Vertical Clearance Above Water Surface (Reference: NESC Table 232-1)

Column	Section Heading
1	Insulated communication conductors and cable; messengers; surge-protection wires; grounded guys; ungrounded guys exposed to 0 to 300 V[11,15]
2	Non-insulated communication conductors; and non-shielded supply cables 0 to 750 V supported by grounded messenger
3	Open supply conductors 0 to 750 V; non-shielded supply cables supported by grounded messenger under 5 $kV_{\Phi-\Phi}$ or 2.9 $kV_{\Phi-G}$; ungrounded guys exposed to over 300 V to 750 V[14]
4	Open supply conductors over 750 V to 22 kV; ungrounded guys exposed to 750 V to 22 kV[14]

Nature of Surface Underneath Wires, Conductors, or Cables	1 (ft.)	2 (ft.)	3 (ft.)	4 (ft.)
Where wires, conductors, or cables cross over or overhang				
1. Water areas not suitable for sailboating or where sailboating is prohibited[21]	14.0	14.5	15.0	17.0
2. Water areas suitable for sailboating including lakes, ponds, reservoirs, tidal waters, rivers, streams, and canals with an unobstructed surface area of: [17,18,19,20,21]				
a. Less than 20 acres	17.5	18.0	18.5	20.5
b. Over 20 to 200 acres	25.5	26.0	26.5	28.5
c. Over 200 to 2000 acres	31.5	32.0	32.5	34.5
d. Over 2000 acres	37.5	38.0	38.5	40.5

Notes:

(a) Clearances may be reduced under certain conditions. See NESC Rule 232.

FOOTNOTES:

Note: Footnotes 1-10, 12, 13, and 16 will not be used.

11. No clearance from ground is required for anchor guys not crossing tracks, rails, streets, driveways, roads, or pathways.

14. Ungrounded guys and ungrounded portions of span guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

15. Anchor guys insulated in accordance with these standards may have the same clearance as grounded guys.

17. For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high-water level.

18. For uncontrolled water flow areas, the surface area shall be that enclosed by its annual high-water mark. Clearances shall be based on the normal flood level; if available, the 10-year flood level may be assumed as the normal flood level.

19. The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1 mile long segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water.

20. Where an over-water obstruction restricts vessel height to less than the applicable reference height given in NESC Table 232-3, the required clearance may be reduced by the difference between the reference height and the over-water obstruction height, except that the reduced clearance shall not be less than that required for the surface area on the line crossing side of the obstruction.

7.6 CLEARANCE TO SWIMMING POOLS

Service drops or other supply wires and conductors should not pass over a swimming pool or the surrounding land within 25 feet around the edge of the pool. If such crossings cannot be avoided, the clearances shown below shall be obtained. For all spans, horizontal clearances must be increased as shown on Page 7-124. For information on other requirements and relocation policy refer to Specifications for Electrical Installations (ESB 750).

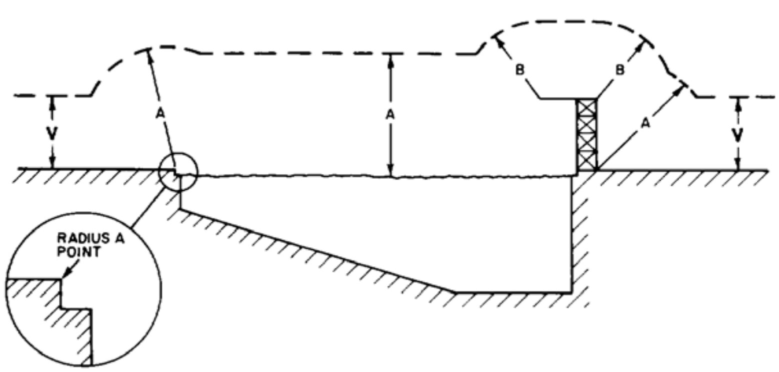


Figure 3

Table 4
Clearance to Swimming Pools
(Reference: NESC Table 234-3, Figure 234-3, Rules 232 and 234)

Column	Section Heading
1	Insulated communication conductors and cables; messengers; surge-protection wires; grounded guys; ungrounded guys exposed to 0-300 V[3]; neutral conductors that are effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1); lashed aerial cables (insulated and fully metallic shielded) installed according to these standards and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1)
2	Unguarded rigid live parts, 0 to 750 V; non-insulated communication conductors; supply cables of 0 to 750 V that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C2 or 230C3); ungrounded guys exposed to open supply conductors of over 300 V to 750 V[2]
3	Supply cables over 750 V and under 5 kV phase-to-phase or 2.9 kV phase-to-ground that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C2 or 230C3); open supply conductors, 0 to 750 V
4	Unguarded rigid live parts over 750 V to 22 kV; ungrounded guys exposed to over 750 V to 22 kV[2]
5	Open supply conductors, over 750 V to 22 kV

	Column 1 (ft)	Column 2 (ft)	Column 3 (ft)	Column 4 (ft)	Column 5 (ft)
A. Clearance in any direction from the water level, edge of pool, base of diving platform, or anchored raft	22.0	22.5	23.0	24.5	25.0
B. Clearance in any direction to the diving platform, tower, water slide or other fixed pool-related structures	14.0	14.5	15.0	16.5	17.0
V. Vertical clearance to adjacent land	*Clearances specified in Section 7.4*				

FOOTNOTES:

1. For voltages over 22 kV and up to 50 kV increase specified clearance at a rate of 0.4 inches per kV over 22 kV.

2. Ungrounded guys and ungrounded portions of guys between insulators shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

3. Anchor guys insulated in accordance with these standards may have the same clearance as grounded guys.

4. Where wires, conductors, cables, or unguarded rigid live parts are over a swimming pool or the surrounding area, clearances in any direction shall be as shown in the Figure 3 and Table 4 on Page 7-10. This rule does not apply to a pool enclosed by a solid or screened permanent structure.

5. If rescue poles are not used by lifeguards on supervised beaches and waterways, the clearances in Table 3 on Page 7-8 for appropriate land/water body shall be used.

6. Use clearances in Table 3 on Page 7-8 for waterways subject to waterskiing.

7. Direct buried primary and secondary supply cables shall not be installed under the pool or within 10 feet of a swimming pool or its auxiliary equipment.

Supersedes 1/06 Issue – Editorial and paging revisions.

7.7 VERTICAL & HORIZONTAL CLEARANCE OF WIRES, CONDUCTORS AND CABLES TO RAIL CARS

(Reference: NESC Rules 232, 234-1, 234I, Table 232-1, and Figure 234-5)

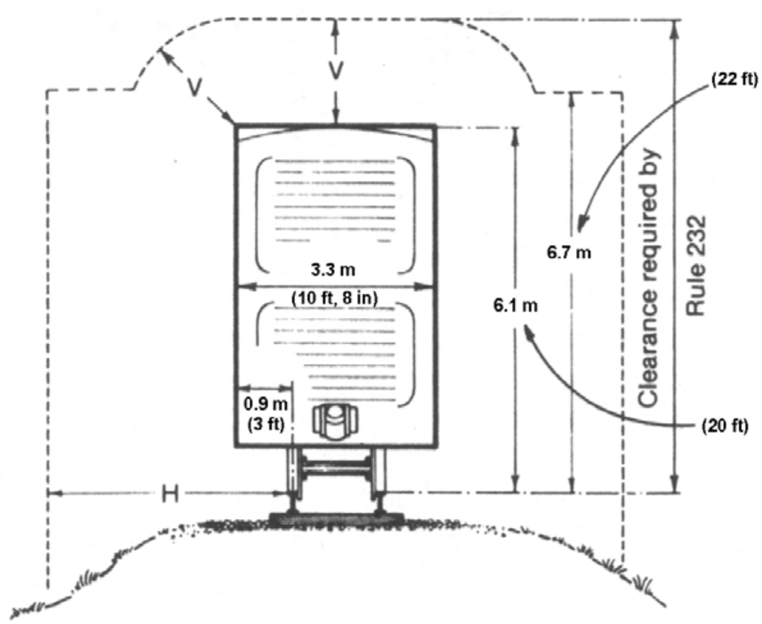


Figure 4

V = Vertical clearance above rails specified by Section 7.4 of these standards, minus 20 feet (height of rail car)
H = Horizontal clearance to nearest rail.

Overhead Wires, Conductors Or Cables	Clearance In Feet	
	V	H
Grounded Guys, Messengers, Surge Protection Wires, Grounded Neutrals, Shielded Supply Cables Supported By Grounded Messenger, Ungrounded Guys exposed to 0 to 300 V[(e)] And Insulated Communication Cables And Conductors	3.5	8.5
Non-shielded Supply Cables, 0 to 750 V, Supported By Grounded Messenger, Non-insulated Communication Conductors	4.0	9.0
Open Supply Conductors, 0 to 750 V, Non-shielded Supply Cables Supported By Grounded Messenger, Under 5 $kV_{\Phi-\Phi}$, or 2.9 $kV_{\Phi-g}$, Ungrounded Guys Exposed To Over 300 V to 750 V[(f)]	4.5	9.5
Open Supply Conductors Over 750 V to 22 kV; Ungrounded Guys Exposed To 750 V to 22 kV[(f)]	6.5	11.5

Notes:

(a) If the Railroad crossed requires greater clearances than detailed in this Standard, the Railroad clearances shall apply.

(b) Voltages are phase to ground for grounded circuits and those circuits where ground faults are cleared promptly by de-energizing the faulted section. For systems that are not effectively grounded, voltages are phase-to-phase.

(c) Anchor guys shall not be located less than 12 feet from the nearest track rail.

Supersedes 1/06 Issue – Editorial and paging revisions.

(d) Anchor guys insulated in accordance with these standards may have the same clearance as grounded guys.

(e) Ungrounded guys and ungrounded portions of span guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to slack conductor or guy.

7.8 VERTICAL CLEARANCE OF EQUIPMENT CASES AND RIGID LIVE PARTS OF EQUIPMENT MOUNTED ON STRUCTURES

Table 5
(Reference: NESC Rule 232B, Table 232-2)

Note - These vertical clearances above ground or roadway surfaces are for unguarded rigid live parts such as potheads, transformer bushings, surge arresters, and short lengths of connecting supply conductors which are not subject to variations in sag.

Column	Section Heading
1	Nonmetallic or effectively grounded support arms, switch handles, platforms, braces, and equipment cases
2	Unguarded rigid live parts of 0 to 750 V and ungrounded cases that contain equipment connected to circuits of not more than 750 V
3	Unguarded rigid live parts of over 750 V to 22 kV and ungrounded cases that contain equipment connected to circuits of over 750 V to 22 kV

Nature of Surface Below	Clearance Above Ground or Roadway		
	Column 1 (ft.)	Column 2 (ft.)	Column 3 (ft.)
1. Where rigid parts overhang:			
a. Roads, streets and other areas subject to truck traffic[4]	15.0	16.0	18.0
b. Driveways, parking lots and alleys	15.0	16.0[6]	18.0
c. Other land traversed by vehicles such as cultivated land, grazing land, forest, orchard, etc.	15.0[7]	16.0	18.0
d. Spaces and ways subject to pedestrians or restricted traffic only[5]	11.0[7]	12.0[1(b)]	14.0
2. Where rigid parts are along and within the limits of highways or other road rights-of-way but do not overhang the roadway			
a. Roads, streets and alleys	15.0[7]	16.0	18.0
b. Roads in rural districts where it is unlikely that vehicles will be crossing under the line	13.0[7]	14.0[2]	16.0
3. Water areas not suitable for sailboating or where sailboating in prohibited[9]	14.0	14.5	15.0

FOOTNOTES:

<u>**Note:**</u> **Footnotes 3, 6, and 8 will not be used.**

1. For insulated live parts limited to 150 V, this clearance may be reduced to 10 ft.

2. Where a supply line along a road is limited to 300 V to ground and is located relative to fences, ditches, embankments, etc., so that the ground under the line would not be expected to be traveled except by pedestrians, this clearance may be reduced to 12 feet.

Supersedes 1/06 Issue – Added FN 6, added switch handles in FN 7.

4. For the purpose of this rule, trucks are defined as any vehicle exceeding 8 feet in height. Areas not subject to truck traffic are areas where truck traffic is not normally encountered nor reasonably anticipated.

5. Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horseback or other large animals, vehicles or other mobile units exceeding 8 feet in height, are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered nor reasonably anticipated.

6. This clearance may be reduced to the following values for driveways, parking lots, and alleys not subject to truck traffic:

	(ft)
a. Insulated live parts limited to 300 V to ground	12
b. Insulated live parts limited to 150 V to ground	10

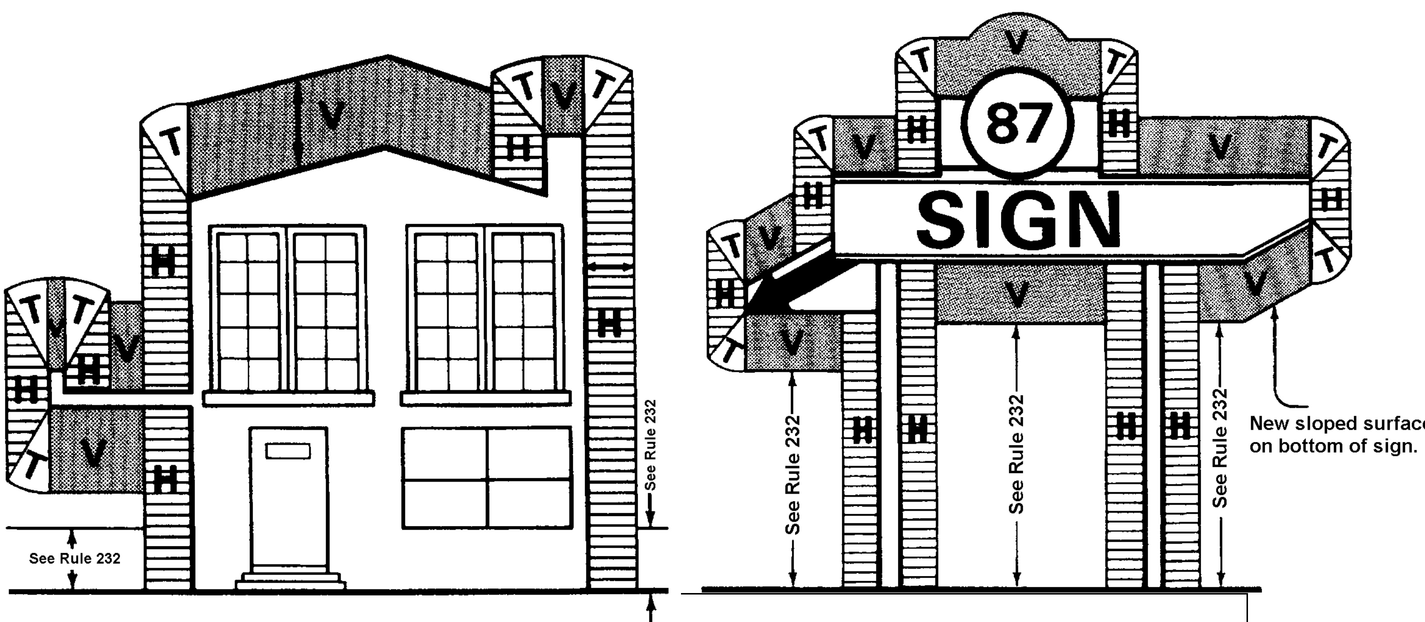
7. Effectively grounded switch handles and supply or communication equipment cases (such as fire alarm boxes, control boxes, communication terminals, meters, or similar equipment cases) may be mounted at a lower level for accessibility provided such cases do not unduly obstruct a walkway. Switch handles and supply or communications shall be located so as not to serve as a means of approach to unguarded live parts by unqualified persons.

9. Where the US Army Corps of Engineers, the state, or surrogate thereof has issued a crossing permit, clearance of that permit shall govern.

7.9 CLEARANCE OF WIRES, CONDUCTORS, CABLES AND UNGUARDED LIVE PARTS TO BUILDINGS & OTHER INSTALLATIONS EXCEPT BRIDGES

Primary wires should not be installed over buildings. There are cases, however, especially for temporary work, where such construction cannot be avoided. The clearance of 300 V to 15,000 volt lines over or near buildings and appurtenances shall be as much as is practicable. In no case should it be less than shown below. Services may however, be attached to or run along, or over the building in accordance with accepted practices.

Minimum clearances for multiplex conductors attached to buildings are shown below as well.



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Supersedes 1/06 Issue – Editorial and paging revisions.

Figure 5

Regions Where Conductors Are Prohibited:
H = Horizontal; V = Vertical; T = Transitional = Vertical (Arc)

Table 6
Clearance of Wires, Conductors, Cables and Unguarded Live Parts to Buildings & Other Installations Except Bridges

(Reference: NESC Tables 234-1 and Rules 232 and 234)

Column	Section Heading
1	Grounded guys, messengers; surge protection wires; grounded neutrals; shielded supply cables supported by grounded messenger; ungrounded guys exposed to 0 to 300 V[13]; and insulated communication cables and conductors
2	Non-shielded supply cables 0 to 750 V, supported by grounded messenger
3	Unguarded rigid live parts 0 to 750 V; ungrounded equipment cases, 0-750 V; ungrounded guys exposed to open supply conductors of over 300 to 750 V[5], and non-insulated communication conductors
4	Open supply conductors 0-750 V; non-shielded supply cables supported by a grounded messenger, over 750 V and under 5 $kV_{\Phi-\Phi}$ or 2.9 $kV_{\Phi-G}$[18]
5	Unguarded rigid live parts, over 750 V-22 kV; ungrounded equipment cases, 750 V–22 kV; ungrounded guys exposed to over 750 V to 22 kV[5]
6	Open supply conductors, over 750 V to 22 kV

Clearance of:	1 (Feet)	2 (Feet)	3 (Feet)	4 (Feet)	5 (Feet)	6 (Feet)
1. Buildings						
a. Horizontal						
(1) To walls, projections, and guarded windows	4.5[1,2,7]	5.0[1,2]	5.0[1,2]	5.5[1,2,9]	7.0[1,2]	7.5[1,2,10,11]
(2) To unguarded windows[8]	4.5	5.0	5.0	5.5[9]	7.0	7.5[10,11]
(3) To balconies and areas readily accessible to peedestrieans[3]	4.5	5.0	5.0	5.5[9]	7.0	7.5[10,11]
b. Vertical						
(1) Over/under roofs or projections not readily accessible to pedestrians	3.0	3.5	10.0	10.5	12.0	12.5
(2) Over/under balconies and roofs readily accessible to pedestrians[3]	10.5	11.0	11.0	11.5	13.0	13.5
(3) Over roofs accessible to vehicles but not subject to truck traffic[6]	10.5	11.0	11.0	11.5	13.0	13.5
(4) Over roofs accessible to truck traffic[6]	15.5	16.0	16.0	16.5	18.0	18.5
2. Signs, chimneys, billboards, radio and TV antennas, tanks, and other installations not classified as buildings or bridges						
a. Horizontal[4]						
(1) To portions that are readily accessible to pedestrians[3]	4.5	5.0	5.0[1,2]	5.5[9]	7.0[1,2]	7.5[10,11]
(2) To portions that are not readily accessible to pedestrians[3]	3.0	3.5	5.0[1,2]	5.5[1,2,9]	7.0[1,2]	7.5[1,2,10,11]
b. Vertical						
(1) Over/under catwalks and other surfaces upon which personnel walk	10.5	11.0	11.0	11.5	13.0	13.5
(2) Over/under other portions of such installations[4]	3.0	3.5	5.5	6.0[1]	7.5	8.0
3. Clearance from other supporting structures[15]						
a. Horizontal (no wind)	5.0[16]	5.0[16]	5.0[16]	5.0[16]		5.0[16]
b. Vertical	4.5[17]	4.5[17]	4.5[17]	4.5[17]		4.5[17]

Supersedes 1/06 Issue – Editorial and paging revisions.

FOOTNOTES:

Footnote 12 is not used

1. Where building, sign, chimney, antenna, tank, or other installation does not require maintenance such as painting, washing, changing of sign letters, or other operations that would require persons to work or pass between wires, conductors, cables or unguarded live parts and structure, the clearance may be reduced by 2 feet.

2. Where available space may not permit this value, the clearance may be reduced by 2 feet provided the wires, conductors, or cables, including splices and taps, and unguarded live parts have a covering that provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact with a structure or building.

3. A roof, balcony, or area is considered readily accessible to pedestrians if it can be casually accessed through a doorway, ramp, window, stairway, or permanently mounted ladder by a person on foot who neither exerts extraordinary physical effort nor employs tools or devices to gain entry. A permanently mounted ladder is not considered a means of access if its bottom rung is 8 feet or more from the ground or other permanently installed accessible surface.

Supersedes 1/06 Issue – Revised FNs 16 through 18.

4. The required clearances shall be to the closest approach of motorized signs or moving portions of installations (reference NESC rule 234C).

5. Ungrounded guys and ungrounded portion of guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed to a slack conductor or guy.

6. For purpose of this rule, trucks are defined as any vehicle exceeding 8 feet in height.

7. This clearance may be reduced to 3 inches for the grounded portions of guys.

8. Windows not designed to open may have the clearances permitted for walls and projections.

9. The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 4.5 feet (reference NESC Rule 234C1b).

10. The clearance at rest shall be not less than the value shown in this table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 4.5 feet (reference NESC Rule 234C1b).

11. Where available space will not permit this value, the clearance may be reduced to 7 feet for conductors limited to 8.7 kV to ground.

13. The anchor end of guys insulated in accordance with these standards may have the same clearance as grounded guys.

14. For clearances above railings, walls, or parapets around balconies or roofs, use the clearances required for roofs not accessible to pedestrians.

15. Support structures include those to which the conductor is not attached, such as lighting support, a traffic signal support, and a supporting structure of another line.

16. This may be reduced to 3 feet for effectively grounded guys and messengers, insulated communication conductors and cables, neutral conductors that are effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1), and supply cables of 300 V or less that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1, 230C2 or 230C3).

17. This may be reduced to 2 feet for effectively grounded guys and messengers, insulated communication conductors and cables, neutral conductors that are effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1), and supply cables of 300 V or less that are insulated and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1, 230C2 or 230C3).

18. Does not include neutral conductors effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1).

Note:

For horizontal clearances under wind displacement conditions, reference the table found in 7.10 corresponding to minimal clearance values. Sample calculations for accounting for wind displacement can be referenced on Page 7-124.

7.10 CLEARANCE TO BRIDGES

The clearance of distribution conductors and cables to bridges shall not be less than those shown in Table 7 below. These are minimum values that should be increased wherever practicable. The clearance over pedestrian walks or over roadways on bridges shall meet the requirements of Table 2 on Page 7-6.

For all spans, horizontal clearances must be increased as shown on Page 7-124.

Under wind displacement conditions, the following conductors and cables shall be in accordance with the below specified horizontal clearances to bridges. Sample calculations for increased clearances due to wind displacement can be referenced on Page 7-124.

Table 7
Horizontal Clearances Under Wind Displacement Conditions[2]
(Reference: NESC Rule 234D1b)

Conductor of Cable	**Horizontal Clearance Required when Displaced by Wind (Feet)**
Open Supply Conductor, 0 to 750 V[1]	3.5
230C2 Cable, Above 750 V	3.5
230C3 Cable, Above 750 V	3.5
Open Supply Conductor, over 750 V to 22 kV	4.5

FOOTNOTES:

1. Does not include neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1).
2. See Table 8 for clearances for conductors and cables at rest (not displaced by wind).

Table 8
Clearance of Wires, Conductors, Cables, and Unguarded Rigid Live Parts from Bridges
(Reference: NESC Table 234–2 and Rule 234D1a)

Column	**Section Heading**
1	Unguarded rigid live parts, 0 to 750 V; non-insulated communication conductors; supply cables of 0 to 750 V meeting Rules 230C2 or 230C3[7]; ungrounded equipment cases; 0 to 750 V; ungrounded guys exposed to open supply conductors over 300 V to 750 V[4]
2	Supply cables over 750 V meeting Rules 230C2 or 230C3[7]; open supply conductors, 0 to 750 V[10]
3	Open supply conductors, over 750 V to 22 kV
4	Unguarded rigid live parts, over 750 V to 22 kV; ungrounded equipment cases, 750 V to 22 kV; ungrounded guys exposed to open supply conductors of over 750 V to 22 kV[4]

	Column 1 (Feet)	**Column 2 (Feet)**	**Column 3 (Feet)**	**Column 4 (Feet)**
1. Clearance over bridges[1]				
a. Attached[3]	3.0	3.5	5.5	5.0
b. Not Attached	10.0	10.5	12.5	12.0
2. Clearance beside, under, or within bridge structure[6]				
a. Readily accessible portions of any bridge including wing, walls, and bridge attachments[1]				
(1) Attached[3]	3.0	3.5[8]	5.5[9]	5.0
(2) Not Attached	5.0	5.5[8]	7.5[9]	7.0
b. Ordinarily inaccessible portions of bridges (other than brick, concrete, or masonry) and from abutments[2]				
(1) Attached[3,5]	3.0	3.5[8]	5.5[9]	5.0
(2) Not Attached[4,5]	4.0	4.5[8]	6.5[9]	6.0

Supersedes 1/06 Issue – Added FNs 1 and 2.

Supersedes 1/06 Issue – Added FN 10.

FOOTNOTES:

1. Where over traveled ways on or near bridges, the clearances of Section 7.4 also apply.

2. Bridge seats of steel bridges carried on masonry, brick, or concrete abutments that require frequent access for inspection shall be considered as readily accessible portions.

3. Clearance from supply conductors to supporting arms and brackets attached to bridges shall be the same as specified in Section 7.14 if the supporting arms and brackets are owned, operated, or maintained by the same utility.

4. Ungrounded guys and ungrounded portions of guys between guy insulators shall have clearances based on the highest voltage to which they may be exposed due to a slack conductor or guy.

5. Where conductors passing under bridges are adequately guarded against contact by unauthorized persons and can be de-energized and appropriately grounded on each side of the work location for maintenance of the bridge, clearances of the conductors from the bridge, at any point, may have the clearances specified in Section 7.14 for clearance from surfaces of support arms plus one-half the final unloaded sag of the conductor at that point.

6. Where the bridge has moving parts, such as a lift bridge, the required clearances shall be maintained throughout the full range of movement of the bridge or any attachment thereto.

7. Where permitted by the bridge owner, supply cables may be run in rigid conduit attached directly to the bridge.

8. The clearance at rest shall not be less than the value shown in this Table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 3.5 feet (reference NESC Rule 234D1b).

9. The clearance at rest shall be not less than the value shown in this Table. Also, when the conductor or cable is displaced by wind, the clearance shall be not less than 4.5 feet (reference NESC Rule 234D1b).

10. Does not include neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1).

7.11 SEPARATION OF CONDUCTORS AND SUPPORTS ON THE SAME POLE

7.11.10 General

Minimum recommended separations between supports and conductors on the same pole are shown in Table 9 on Page 7-19. These should be used on all poles for new lines. They shall generally be used for pole replacements. These should be used only when values recommended for new poles per the Drawings demonstrated in Section 9 - Primaries, are not practicable. As these values are suggesting minimum guidelines, clearances shall be increased to provide additional safety protection wherever possible.

Table 9
Vertical Clearance Between Conductors at Supports
(Reference: NESC Rules 235A, C and Table 235-5)

Column	Section Heading
1	Lashed aerial cables (insulated and fully metallic shielded) installed according to these standards and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C1); insulated, nonshielded cable operated at not over 5 kV phase to phase, or 2.9 kV phase to ground, supported on and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C3); neutral conductors that are effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1); and insulated communication cables, located in the supply space, supported by an effectively grounded messenger (i.e. meeting NESC Rule 224A2)
2	Open supply conductors, 0 to 8.7 kV[12]
3	Open supply conductors, over 8.7 kV to 50 kV, same utility[8]
4	Open supply conductors, over 8.7 kV to 50 kV, different utilities[8]

Conductors and Cables Usually at Lower Levels	Conductors and Cables Usually At Upper Levels							
	Column 1		Column 2[12]		Column 3[8]		Column 4[8]	
	(Inches)		(Inches)		(Inches)		(Inches)	
	At Pole	Mid-Span	At Pole	Mid-Span	At Pole	Mid-Span	At Pole	Mid-Span
1. Communication Conductors and Cables								
a. Located in the communication space	40[1,5,6]	30[12]	40	30[13]	40	30	40+A[7]	See Note 15
b. Located in the supply space	16[9,10]	12	16[10]	12	40[10]	30	40+A[7]	See Note 15
2. Supply conductors and cables								
a. Open conductors 0 to 750 V; lashed aerial cables (insulated and fully metallic shielded) installed according to these standards and cabled together with an effectively grounded bare messenger or neutral; insulated, nonshielded cable operated at not over 5 kV phase to phase, or 2.9 kV phase to ground, supported on and cabled together with an effectively grounded bare messenger or neutral; and neutral conductors that are effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1)	16[9]	12	16[2]	12[14]	16+A[4,7]	See Note 15	40+A[7]	See Note 15
b. Open conductors over 750 V to 8.7 kV			16[2]	12	16+A[4,7]	See Note 15	40+A[7]	See Note 15
c. Open conductors over 8.7 to 22 kV								
(1) If worked on alive with live-line tools and adjacent circuits are neither de-energized nor covered with shields or protectors					16+A[7]	See Note 15	40+A[7]	See Note 15
(2) If not worked on alive except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by use of live-line tools not requiring line workers to go between live wires					16+A[3,7]	See Note 15	40+A[3,7]	See Note 15
d. Open conductors exceeding 22 kV , but not exceeding 50 kV					16+A[3,7]	See Note 15	40+A[3,7]	See Note 15

A = 0.4 inches per kV in excess of 8.7 kV

When using column and row headings, voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptly de-energizing the faulted section, both initially and following subsequent breaker operations.

Supersedes 7/08 Issue – Added new FN 6 & renumbered FNs 6 & 7.

Supersedes 7/08 Issue – Revised FN 5, added new FN 6 & renumbered FNs 6 & 7.

FOOTNOTES:

1. Where supply circuits of 600 V or less, with transmitted power of 5,000 W or less, are run below communication circuits, the clearance may be reduced to 16 inches. This type of installation must be built following special requirements of NESC Rule 220B2. Distribution Standards Engineering should be consulted prior to making an installation of this type.

2. Where conductors are operated by different utilities, a vertical clearance of not less than 40 inches is recommended.

3. These values do not apply to conductors of the same circuit or circuits being carried on adjacent conductor supports.

4. May be reduced to 16 inches where conductors are not worked on live except when adjacent circuits (either above or below) are de-energized or covered by shields or protectors, or by the use of live line tools not requiring line workers to go between live wires.

5. May be reduced to 30 inches for neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1); fiber-optic cables installed in the supply space supported on a messenger that is effectively grounded throughout its length (i.e. meeting NESC Rule 230F1a); and entirely dielectric fiber-optic cables or fiber-optic cables supported on a messenger that is entirely dielectric and installed in the supply space (i.e. meeting NESC Rule 230F1b). Bonding is not required for entirely dielectric fiber-optic cables or fiber-optic cables supported on a messenger that is entirely dielectric and installed in the supply space (i.e. meeting NESC Rule 230F1b).

6. May be reduced to 30 inches for lashed aerial cables that are insulated, shielded and installed according to these standards where the supply neutral or messenger is bonded to the communication messenger (i.e. meeting NESC Rule 230C1), except that in accordance with the Liberty Utilities settlement agreement with Fairpoint, Fairpoint requires Liberty Utilities to maintain 40" clearance at the pole between lashed aerial cables and Fairpoint owned communication cables. Application of this exception for lashed aerial cables shall require approval from Overhead Distribution Standards.

7. The greater of phaser difference or phase-to-ground voltage (for more information see NESC Rule 235A3).

8. Example: For a 50 kV-to-ground conductor above a 22 kV-to-ground conductor, when the conductors are 180 degrees out of phase: A = (50 + 22 - 8.7) * 0.4 = 25.4 inches, then round A up to 26 inches.

9. No clearance is specified between neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1) and insulated communication cables located in the supply space and supported by an effectively grounded messenger (i.e. meeting NESC Rule 230F1a).

10. No clearance is specified between entirely dielectric fiber-optic cables or fiber-optic cables supported on a messenger that is entirely dielectric and installed in the supply space (i.e. meeting NESC Rule 230F1a) and supply cables and conductors.

11. Does not include neutral conductors effectively ground throughout their length and associated with circuits of 0 to 22 kV phase to ground.

12. May be reduced to 12 inches for neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1); fiber-optic cables installed in the supply space supported on a messenger that is effectively grounded throughout its length (i.e. meeting NESC Rule 230F1a); entirely dielectric fiber-optic cables or fiber-optic cables supported on a messenger that is entirely dielectric and installed in the supply space (i.e. meeting NESC Rule 230F1b); and lashed aerial cables installed according to these standards where the supply neutral or messenger is bonded to the communication messenger (i.e. meeting NESC Rule 230C1). Bonding is not required for entirely dielectric fiber-optic cables or fiber-optic cables supported on a messenger that is entirely dielectric and installed in the supply space (i.e. meeting NESC Rule 230F1b).

13. Supply service drops of 0 to 750 volts, running above and parallel to communication service drops, may have a spacing of not less than 12 inches at any point in the span, including the point of their attachment to the building or structure being served provided the non-grounded conductors are insulated and that clearance as otherwise required by these standards is maintained between the two service drops at the pole.

14. Where conductors are operated by different utilities, a vertical clearance of not less than 30 inches is recommended.

15. 75% of clearance required at the pole.

7.11.20 <u>Separation on Replaced Poles</u>

In general, the separations on poles that are replaced shall conform to the requirements for new poles. In some special cases, separation may be reduced, but shall not be less than permitted on existing poles.

7.11.30 <u>Reduction of Separation on Poles</u>

Reduced separations of conductors and facilities may be used to accommodate other pole users but shall not be less than clearances required for 15 kV primary circuits.

7.11.40 <u>Basic Impulse Level (BIL) & Air – Wood Spacing</u>

BIL refers to the ability of the pole top design to resist flashovers caused by lightning or line surges.

Distribution pole tops are generally designed to provide 150 kV minimum BIL. This impulse strength shall be based entirely on the impulse flashover of 20 inches or more of wood. Where lightning arresters are used, the "inches of wood" requirement does not apply for the particular conductor having the arrester. In locations where sufficient wood separation is not obtainable due to guy attachment, the use of a fiberglass guy strain insulator will meet this requirement. Additionally, insulated pole top pins (P6B and P6C), long strain insulators (I2), guy strain insulator (TI95B, TI95C, TI95D), and wood braces (TB60 & B37B) may be used to provide the necessary separation if it cannot be met with standard hardware.

In design and construction of pole tops, avoid shorting out the insulation provided by air and wood with steel crossarm braces, steel hardware, ground wires, guy wires, etc. The total distance measured over insulators, wood, and air should be as great as possible.

Supersedes 7/08 Issue – Paging revisions.

7.11.50 **Climbing Space**

Standard pole top designs shall meet or exceed code requirements for vertical or lateral clearance for line conductors at different levels attached to the same pole. When various designs are combined, however, or when work is done on an existing pole, care should be taken to provide good clearance and to maintain climbing and working space. Page 7-127 shows the NESC clearance required when workers must climb through energized conductors. This drawing should be used as a guide even when the conductors concerned are covered by protective equipment or otherwise guarded as an unvarying practice before personnel climb past them.

Those who install services and secondaries should provide enough space for the personnel who may have to climb through these services to work on the primaries above. Multiplex service taps made 3 feet or more away from the pole will help improve the climbing and working space (Reference Section 10-Secondaries, Construction Drawings).

The climbing space needs to be provided on one side or a corner of the support only.

Vertical runs physically protected by conduit or other protective covering securely attached without spacers to the surface of the pole are not considered to obstruct climbing space.

The climbing space shall extend vertically in the same position - 40 inches above and 40 inches below any wire attachment, but may otherwise be shifted to any other adjacent side or corner of the pole.

All voltages in Table 10 on Page 7-22 are between the two conductors bounding the climbing space, except for communications conductors, which are voltage to ground. Where two conductors are in different circuits, the voltage between conductors shall be the arithmetic sum of the voltages of each conductor to ground for a grounded circuit or phase to phase for an ungrounded circuit.

Supersedes 7/08 Issue – Paging revisions.

Table 10
Horizontal Climbing Space Between Conductors
(Reference: NESC Rule 236 and Table 236-1)

Character of Conductors Adjacent to Climbing Space	Voltage of Conductors	Horizontal Clearance Between Conductors Bounding the Climbing Space[2]			
		On S.O. Structures used Solely By:		On J.O. Structures	
		Communication Conductors (Inches)	Supply Conductors (Inches)	Supply Conductors Above Communications Conductors (Inches)	Communication Conductors Above Supply Conductors[3] (Inches)
1. Communication conductors	0 to 150 V	No Requirements	--	See Footnote 1	No Requirements
	Over 150 V	24 Recommended	--	See Footnote 1	24 Recommended
2. Lashed aerial cables (insulated and shielded) installed according to these standards (i.e. meeting NESC Rule 230C1)	All	--	--	See Footnote 1	No Requirements
3. Insulated, nonshielded cable operated at not over 5 kV phase to phase, or 2.9 kV phase to ground, supported on and cabled together with an effectively grounded bare messenger or neutral (i.e. meeting NESC Rule 230C3).	All	--	24	24	30
4. Open supply line conductors and covered supply cables, including spacer cable and tree wire (i.e. meeting NESC Rule 230D)	0-750 V	--	24	24	30
	750 V-15 kV	--	30	30	30
	15 kV-28 kV	--	36	36	36
	28 kV-38 kV	--	40	40	
	38 kV-50 kV	--	46	46	
	50 kV-73 kV	--	54	54	
	Over 73 kV	--	>54		

Supersedes 7/08 Issue – Paging revisions.

FOOTNOTES:

1. Climbing space shall be the same as required for the supply conductors immediately above, with a maximum of 30 inches except that a climbing space of 16 inches across the line may be used for communication cables or conductors where the only supply conductors at a higher level are 0 to 750 V secondaries supplying airport or airway marker lights or crossing over the communication line and attached to the pole top or a pole-top extension fixture.

2. Attention is called to the operating requirements of NESC Rules 441A and 446C.

3. This relation of levels in general is not desirable and should be avoided.

4. The climbing space specified in Table 10 above shall be provided above the top support arm to the ridge pin conductor but need not be carried past it.

5. All supply equipment such as transformers, capacitors, cable terminations, switches, etc. when located below conductors or other attachments, shall be mounted outside the climbing space.

7.12 CLEARANCE TO PROPERTY LINE

In general, conductors and supports shall not overhang property lines unless a right of way or easement has been obtained. In checking overhang, it should be assumed that conductors on rigid supports will be deflected by wind at the amount calculated on Page 7-124.

Plan for future buildings or structures along the property lines, or, if local ordinances specify, along the established building line. If it is probable that a structure will be erected in the foreseeable future, the right-of-way should be adequate to provide standard clearances to such a structure.

7.13 VERTICAL CLEARANCE BETWEEN WIRES, CONDUCTORS & CABLES AT POINT OF CROSSING DIFFERENT SUPPORTING STRUCTURES

It is generally undesirable to build a distribution line directly over or under another line. Where this cannot be avoided, clearance should be provided so that a worker on the top of a pole will be able to maintain adequate working clearances from conductors overhead. Six feet of clearance from the pole top to overhead distribution conductors at 60°F/15°C final sag is suggested as a minimum. See Sub-Transmission or Transmission Standards for voltages over 22 kV.

Supersedes 7/08 Issue – Paging revisions.

Table 11
Vertical Clearance Between Wires, Conductors, and Cables Carried on Different Supporting Structures
(Reference: NESC Rule 233, Table 233-1)

Column	Section Heading
1	Effectively grounded supply guys,[7] span wires and messengers, neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1), and overhead shield/surge-protection wires
2	Effectively grounded communication guys,[7] span wires and communication conductors and cables
3	Lashed aerial cables (insulated and shielded) installed according to these standards (i.e. meeting NESC Rule 230C1), and insulated supply cables of 0 to 750 V (i.e. meeting NESC Rule 230C2 or 230C3)
4	Open supply conductors 0 to 750 V,[6] and insulated supply cables over 750 V other than lashed aerial cables (i.e. meeting NESC Rule 230C2 or 230C3)
5	Open supply conductors over 750 V to 22 kV

	Upper Level				
Lower Level	1 (ft)	2 (ft)	3 (ft)	4 (ft)	5 (ft)
1. Effectively grounded supply guys,[7] span wires and messengers, neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground, and overhead shield/surge-protection wires	2[1,2]	2[1,2]	2[2]	2	2
2. Effectively grounded communication guys,[7] span wires and communication conductors and cables	2[1]	2[1,2]	2	4[8]	5[7]
3. Lashed aerial cables (insulated and shielded) installed according to these standards, and insulated supply cables of 0 to 750 V	2	2	2	2	2
4. Open supply conductors 0 to 750 V,[6] and insulated supply cables over 750 V other than lashed aerial cables	2	4[9]	2	2	2
5. Open supply conductors, 750 V to 22 kV	2	5[5,9]	2[9]	2[9]	2

FOOTNOTES:

Note: Footnotes 3, 4, 6, are not used.

1. No clearance is specified between guys or span wires that are electrically interconnected.

2. The clearance of communication conductors and their guy span, and messenger wires from each other in locations where no other classes of conductors are involved may be reduced by mutual consent of the parties concerned, subject to the approval of the regulatory body having jurisdiction, except for fire-alarm conductors and conductors used in the operation of railroads.

5. This clearance may be reduced to 4 feet where supply conductors of 750 V to 8.7 kV cross a communication line more than 6 feet horizontally from the communications structure.

6. Does not include neutral conductors effectively grounded throughout their length and associated with circuits of 0 to 22 kV phase to ground (i.e. meeting NESC Rule 230E1).

7. These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.

8. This clearance may be reduced to 2 feet for supply service drops.

9. In general, this type of crossing is not recommended.

7.14 CLEARANCES OF VERTICAL & LATERAL SUPPLY CONDUCTORS FROM OTHER WIRES & SURFACES OF THE SAME STRUCTURE

Table 12[1]
Clearance of Open Lateral[2] and Vertical Conductors (Inches)
(Reference: NESC Rule 239E, Tables 239-1)

	Phase to Phase Voltage				
Clearances of Open Vertical & Lateral Conductors	**0-8.7 kV (Inches)**	**8.7-15 kV (Inches)**	**15-25 kV (Inches**	**25-35 kV (Inches)**	**35-50 kV (Inches)**
From Surfaces of Supports	3[3]	5	7	9	12
From Span Guys and Messenger Wires[6]	6[4]	9	13	17	23
Anchor Guys	6	8	11	13	17

Table 13[5]
Clearances Between Open Vertical Conductors and Pole Surface (Figures 6 & 7)
(Reference: NESC Rule 239E, Tables 239-2)

Clearances of Open Vertical & Lateral Conductors	**Effectively Grounded Circuits (Φ-G) Voltage**	**Not Effectively Grounded Circuits (Φ-Φ) Voltage**	**A. Zones Above & Below Conductor Where Clearances May Apply**	**B. Minimum Clearance Between Vertical Conductor & Pole Center**
	(kV)	**(kV)**	**(Feet)**	**(Inches)**
From Surfaces of Supports	0 to 22	0 to 22	6	19
From Span, Guy and Messenger Wires[6]	22 to 30	22 to 30	6	22
Anchor Guys	30 to 50	30 to 50	6	30

Supersedes 7/08 Issue – Paging revisions.

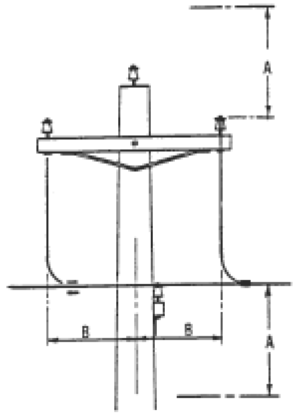


Figure 6

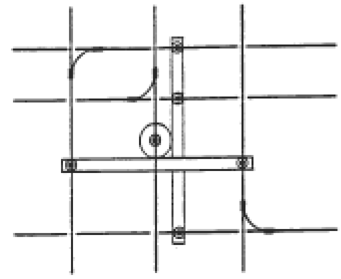


Figure 7

A = zone above and below conductor
B = distance between vertical wire and pole center

FOOTNOTES:

1. Table 12 applies to supply conductors on supply line structures or within the supply space of jointly used poles.

2. Lateral - A wire or cable extending in a general horizontal direction at an angle to the general direction of the line conductors.

3. Clearance may be reduced to 1 inch for supply circuits 0 to 750 volts. A neutral conductor may be attached directly to the structure surface.

4. Clearance may be reduced to 2 inches for insulated non-shielded cable operated at 0 to 750 volts and supported on and cabled together with an effectively grounded bare messenger.

5. If open wire conductors are within 4 feet of the pole, vertical conductors shall be run in one of the following ways:

   a. Open vertical conductors shall have the clearances given in Table 13 within the zone specified in the table.
   b. Within the zone above and below open supply conductors, as given in Table 13, vertical and lateral conductors may be enclosed in nonmetallic conduit or in cable protected by an insulated covering and may be run on the pole surface.
   c. Grounding conductors may be run on the pole surface without molding.

6. These clearances may be reduced by not more than 25% to a guy insulator, provided that full clearance is maintained to its metallic end fittings and the guy wires. The clearance to an insulated section of a guy between two insulators may be reduced by not more than 25% provided that full clearance is maintained to the uninsulated portion of the guy.

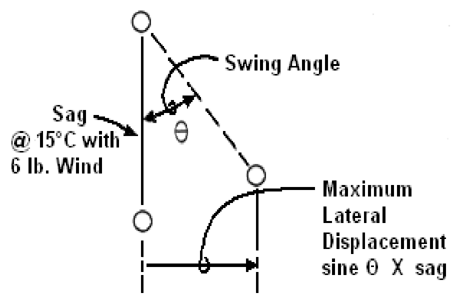
Supersedes 7/08 Issue – Paging revisions.

Basic HORIZONTAL clearances shown in Tables 2, 4, 6, 7, 8, and 11 must be increased as follows to allow for wind caused lateral conductor displacement. For horizontal adders between conductors carried on different poles (Table 11), apply adder for only one of the conductors.

The vertical sag at 60°F/15°C final with 6 lb. wind taken from Section 6-Primary Conductors for the subject conductor and span is multiplied by the sine of the conductor's swing angle to obtain maximum conductor horizontal movement.

The sine of the swing angle may be calculated or taken from the following table (rounding up to the next value shown).

Swing Angle (Θ)	Sine
25°	0.4226
30°	0.5000
35°	0.5736
40°	0.6428
45°	0.7071
50°	0.7660
55°	0.8192
60°	0.8660



Example:

For a 200 feet span of 336.4 kcm AAC 19 Strand Bare (Std. Item W20B)

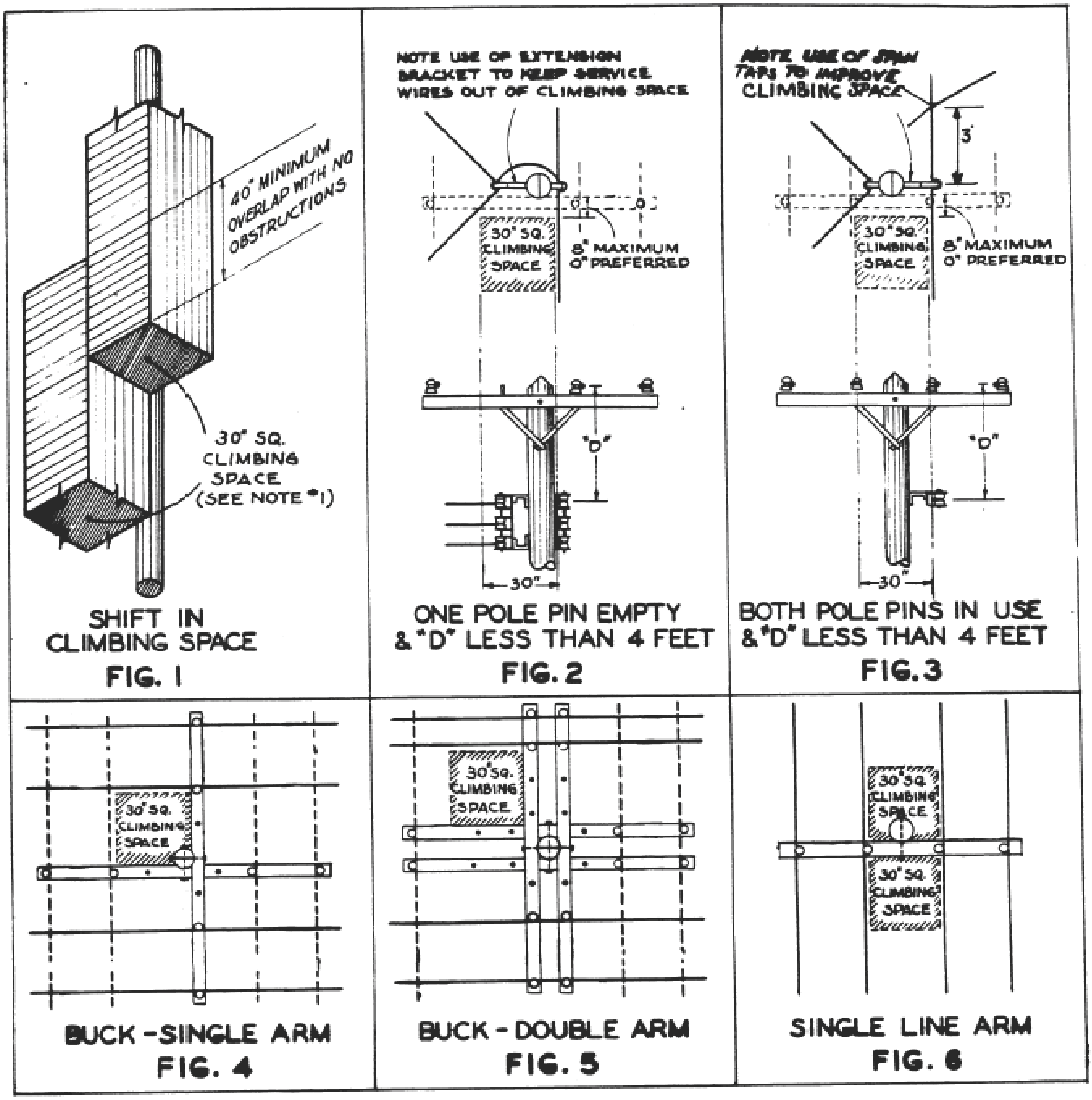
1. Swing Angle = 46.5degrees (from Page 6-109)
2. Multiplier = 0.7660 (from table above for 50°)
3. Sag at 60°F/15°C, 6 lb. wind for 200 foot span = 48.36 inches (from Page 6-110)
4. Maximum Lateral Displacement = (48.36 inches) X (0.7660) = 37.04 inches

<u>**Note:**</u>

If point of conflict is not at point of maximum sag, the additional horizontal clearance may be reduced as follows:

If the distance between point of crossing or clearance and the nearest support is ___% of the total span, multiply additional clearance by the multiplier outlined below.

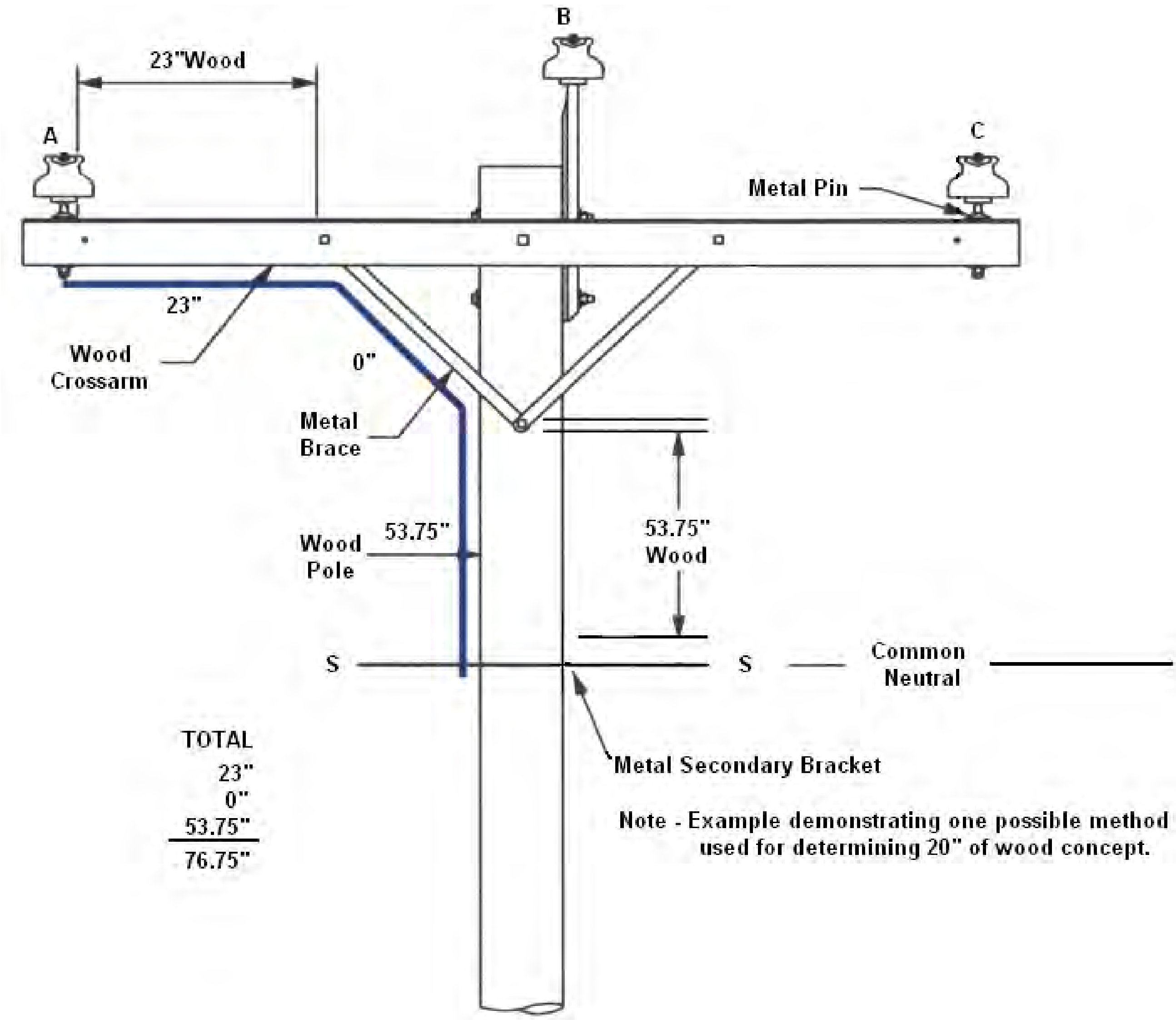
Percent of Span	Multiplier
5%	0.19
10%	0.36
15%	0.51
20%	0.64
25%	0.75
30%	0.84
35%	0.91
40%	0.96
45%	0.99
50%	1.00
*Interpolate for intermediate vales or use next higher multiplier.	



Notes:

1. The climbing space should preferably be continuous from the ground to beyond the top of the pole; but when necessary, it may be shifted from one quarter of the pole to another provided the sections overlap at least 40 inches and there are no obstructions between the two climbing space columns. The climbing space column should extend 40 inches above and below the limiting conductors, but need not extend above a pole top pin.

2. Climbing space should be located in the quarter of the pole not occupied by risers.



To resist current leakage or electrical flashover a minimum amount of 20" of wood and effective insulation is needed. Non-conducting material such as air, wood, porcelain, or fiberglass is taken together to determine the insulation level.

Keep as much air, wood, porcelain and fiberglass between phase and ground and between phases as is practicable. The above drawing illustrates the 20 inches of wood concept.

Spacing can be increased by
:

1. Relocating hardware, pins, deadends, guy attachments, etc.
2. Using wood braces.
3. Using fiberglass pole top pin.
4. Using fiberglass guy insulator or extra insulators in deadends.

For applications where surge arresters are used, this 20 inches of wood requirement does not apply for the particular conductor having the arrester.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
3	07/13	• Section 7.6 – Clearances to Swimming Pools: Revised text, modified FN 7 and added FN 8.	Robert Johnson	Robert Johnson Program Manager
2	07/10	• Table 9: Revised FN 5, added new FN 6 and renumbered FNs 6 and 7 for Verizon clearances to PLAC at pole, per Verizon settlement agreement.	Paul Anundson	Al Chieco, Director of Distribution Standards and Work Methods
1	07/08	• Under 7.0.10, modified description of role of NESC & standard. • Under 7.11.10, modified description of MCOT. • Under 7.11.10.R, fiber-optic cable information updated • Clarified conductor type descriptions on page 7-8. • Modified wire type descriptions and added water slides in Table 4. • Added FN 6, added switch handles in FN 7 on page 7-14. • Revised FNs 16 through 18 on page 7-17. • Added FNs 1 and 2 under Table 7. • Added FN 10 under Table 8. • Modified column descriptions in Table 9. • Revised FNs 1, 5, 7, 9, 10, 11 and 12 under Table 9. • Revised Conductor Descriptions for Rows in Table 10. • Modified conductor descriptions in Table 11. • Added FN 6 under Table 11.	Paul Anundson	Al Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/08 Issue – Updated page numbers; added Section 9.6; updated drawing titles.

Supersedes 7/11 Issue – Updated drawing.

Supersedes 7/07 Issue – Editorial changes.

9.0 GENERAL

This section includes the design and construction requirements necessary for overhead distribution lines in a crossarm or armless configuration and for single or multiple phases at 15kV primary distribution voltage levels and below. The following Standards shall be used for the design and construction of all new lines, line reconductoring projects, voltage conversion projects, and for pole replacements. Existing facilities should be modified to the current Standards when it is economically feasible to do so. For 25kV and 35kV class circuits, refer to Section 20 or Section 21 of the Overhead Standards book.

9.0.10 Voltage Classes

For the purpose of simplifying the terminology to be used in various descriptions of the following drawings, the voltage class designations are as follows:

5 kV - This designation is generally referred to primary circuit voltages of 5 kV and below regardless if the system is effectively grounded or non-effectively grounded.

15 kV - This designation is generally referred to primary circuit voltages of 15kV and below regardless if the system is effectively grounded or non-effectively grounded.

Refer to Pages 1-1 and 1-2 in the Overhead Standards book for specific voltages within the voltage classes used on the Liberty Utilities system.

9.0.20 Coordination With Other Parties

Contact shall occur with all necessary communication companies and municipalities during the initial planning stages so that all parties may properly coordinate their required activities. Construction shall be coordinated to allow for maximum system reliability and efficiency.

9.1 DESIGN OF PRIMARY FEEDERS

The standard 3 phase distribution feeder shall be 4 wire (three conductors, one neutral) multi-grounded wye. The objective is to design and safely construct distribution lines that will provide maximum service reliability at a reasonable cost. This can be attained by routing feeders through minimum tree and traffic exposure, employing the proper type of conductors for the conditions along the route, and providing circuit capacity for normal and reasonably probable contingency conditions, including anticipated load growth.

9.1.10 Routing

The route of the feeder should be such that normally only one distribution circuit is placed on a pole line. Where this is not possible, an effort should be made such that one feeder shall serve the local load while additional express feeders utilizing spacer cable or Preassembled Lashed Aerial Cable (PLAC) are carried through the area.

When feeder construction is necessary along the route of an existing subtransmission circuit, consider underbuilding the subtransmission circuit verses installing a duplicate pole line or major undergrounding. Underbuild of subtransmission can be used if the subtransmission is accessible by bucket truck for normal maintenance and can be taken out of service if required. Seven (7) foot minimum vertical clearance between upper and lower circuits is recommended for worker safety. Approval from the Transmission or Subtransmission Engineering Department is required.

9.1.20 Basic Impulse Insulation Level (BIL)

BIL refers to the ability of the pole top design to resist flashovers caused by lightning or line surges. Surge arresters, coordinated to the BIL of the equipment, are installed to limit the overvoltages on equipment by discharging surge current to ground.

Pole tops are designed to provide a minimum of 150 kV insulation impulse withstand. This impulse level is based on the assumed impulse flashover strength of 20 inches or more of wood.

Where lightning arresters are used and where grounding conductors are installed, the 20 inches of wood requirement does not apply for the particular conductor having the arrester. In locations where sufficient wood separation is not obtainable, the use of fiberglass strain insulators shall be installed. Fiberglass guy strain insulators shall be installed onto all new primary guy installations maintaining BIL requirements - refer to Section 3 for guying requirements.

See Section 7 for additional BIL information and drawings.

9.1.30 Size and Loading of Conductors

The initial load on the conductors of the feeder main and taps/branches shall be limited to allow reasonable load growth before the maximum normal peak load limit is reached. This initial load value should allow for a minimum of 10 years of additional expected load growth. The current values for normal and emergency loads are based on consideration of economy with respect to losses and the thermal limits of the conductor. See Section 6 - Primary Conductors for more information on specific primary conductors.

A. Size of Main Line Conductors

15 kV new main line feeders shall utilize 477 kcmil All Aluminum Conductors (AAC) primary conductors however, upon Engineering approval, 795 kcmil AAC is available. Existing conductors of adequate size may serve for part of any feeder main (see Section 9.3.50) and use of any other conductor size for this purpose will be considered on a case-by-case basis. See Section 6 - Primary Conductors for additional information.

B. Size of Tap (Branch Line) Conductors

Three phase taps shall utilize 1/0 All Aluminum Alloy Conductor (AAAC), or 477 kcmil AAC primary conductors.

Generally single phase taps shall utilize 1/0 AAAC conductor for expected loading up to 100A. Loadings above this value require the addition of one or more phases.

In existing taps that have a conductor smaller than #2 where it is not economically feasible to reconductor the line or convert it to a higher voltage, step down transformers should be installed.

C. Size of Grounded Neutral Conductors

Maintain a common neutral with minimum splices for effectively grounded circuits. Note: See Sections 13.4 and 13.5 for information on the bonding of circuit neutrals.

All neutral conductors shall be 1/0 aluminum except when a larger size is either existing or necessary as part of a secondary system. Example: 4/0 AAAC is used with 336.4 kcmil multiplex. Use of a larger neutral conductor, or use of any other secondary cable configuration or size, requires that National Electric Safety Code (NESC) clearances for that particular construction be met.

Supersedes 7/07 Issue – Editorial changes; text shift.

Generally if existing primary conductors are **smaller** than 1/0 aluminum or equivalent and a neutral conductor exists, it should be used if it is equal size or larger than the primary conductor.

If existing primary conductors are equal to or **larger** than 1/0 aluminum or equivalent and a neutral conductor exists, it should be used if it is at least equivalent to 1/0 aluminum or #3 copper. #2 ACSR (aluminum cable, steel reinforced) is also acceptable.

Existing 7/16 inch CW (copperweld) or #1 AWAC 2/5 messenger may also be used as an effectively grounded neutral, but separate secondary neutrals shall be used with this type of construction.

9.1.40 Voltage Regulation and Flicker

It is suggested that a voltage profile be run for each feeder so that regulation can be reviewed.

Voltage regulation on the primary feeder shall be such that voltage to customers can be maintain to the following acceptable levels on a 120 V base:

Range	Service Voltage	
	Minimum	Maximum
A	114	126
B	110	127

Table 1

Electric distribution systems should be design and operated to meet the voltage level requirements of Range A in Table 1. Users' electrical equipment of all types will generally be designed to give satisfactory performance in this range.

Maintaining voltages levels within Range A on all parts of the system at all times cannot be assured. As a result of the economics of operations, there may be some system voltages that fall in the extremes of Range B and even beyond. When voltages extend into Range B during normal conditions or for an extended period of time they should be corrected immediately to conform to Range A requirements by using interim measures, and plans for a permanent solution should be developed.

Voltages on lines serving loads such as motors, welders, etc., should be checked to see that any flicker does not exceed the limits given in Section 10. Loads that may cause excessive flicker should be referred to the Distribution Engineering Department.

9.1.50 Radio and Television Interference

Radio and television interference can be caused by loosely connected equipment and materials, which could cause arcing between parts. The higher the primary voltage, the greater the possibility of creating radio and television interference. This interference can be controlled by taking reasonable care to minimize the creation of sharp projections of energized parts by properly applying insulator ties, by making certain all bolted connections on structures are properly tightened, and by maintaining suitable clearances of pole hardware.

9.2 POLE TOPS

The following can be used for pole top constructions and pole considerations.

9.2.10 Selection of Sole Owned and Jointly Owned Poles

There is no standard pole height or class that can positively meet all construction conditions without causing unnecessary expense. Selection of pole height and class requires the coordination of all pole users. Once the correct pole height and class is determined for the most common pole in the project, the remaining pole heights and classes should be easily determined with small changes made to the original calculations. See Section 2 for pole selection information.

Existing poles in sound condition and in the proper locations should be used if pole loading and minimum clearance requirements can be met for the facilities that are being installed.

Prior to changing a jointly owned pole, it should be determined that the communications company is not occupying the Company's space. If the pole must be replaced, or if new poles are to be installed, they shall be selected to provide clearances specified for present and future needs following the Joint Use Contractual Agreements. The Company may be entitled to reimbursement of transfer costs.

Whenever present and future construction requires more pole space, pole top extensions should be considered before a new, larger pole is installed.

9.2.20 Crossarm Construction

The standard primary 3 phase construction is bare wire on a crossarm, which, for a tangent pole, consists of a 6-pin-8 foot wood crossarm with wood braces, a 24 inch steel pole top pin, steel crossarm pins, and porcelain pin-type insulators for 15kV and below. This type of construction is also recommended for long span rural lines and for lines in heavy industrial areas. It may also be necessary to continue this type of construction on existing lines that are rebuilt to maintain consistency of existing crossarm construction.

At line angles over 20 degrees, primary deadends, railroad crossings, and limited access highway crossings at each crossing structure, double crossarms are required per NESC 261.D.5.c. Double crossarms are also required at navigable waterways requiring waterway crossing permits per NESC Table 242-1.

Other crossarm sizes and arrangements may be used as field conditions require. They are:

A. Two-Pin Crossarm (10 foot) – Use when specifically called for on individual standards or additional clearances are required.
B. Six -Pin Heavy Duty Crossarm (10 foot) – Use for 3000 lbs Deadend construction.
C. Extension Arms (Alley Arms) – Use when this is the only practical method of obtaining clearance from trees, buildings, etc., or for reducing or eliminating an angle in the line. In general, two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress, which may be caused by one extension arm in a straight line. Side guys or equivalent may be required to support the unbalanced load of a series of extension arms. (9-440 series)
D. Offset Arms – Use 6 pin with wood braces when the full offset of an extension arm (Alley Arm) is not required. Refer to Section 7 for adequate BIL separation. See 9-441 for Offset Arm construction drawings.
E. Fiberglass Crossarms - Use when lifting weight of the arm is an issue or when strength is required without the use of crossarm braces.

9.2.30 Armless Construction

Three phase armless construction is available for distribution lines in urban and suburban residential districts for 15 kV and below if span limitations permit. It may also be considered in situations where tree trimming permission is restricted and spacer cable construction will be too costly. See drawings in the 9-800 series for armless construction details.

Supersedes 7/07 Issue - Editorial changes; added fiberglass crossarm info; text shift.

Single phase armless (vertical) construction, utilizing steel pole top pin, can be used for all voltages. The drawings in the 9-700 series have various diagrams pertaining to effectively grounded and noneffectively grounded circuits.

9.2.40 Spacer Cable Construction

Spacer Cable construction is preferred for distribution lines when NESC Clearances, Tree Trimming Clearances, and Right of Way Issues can not be resolved with the recommended crossarm or armless types of construction. It may also be selected for an additional express feeder purpose similar to preassembled lashed aerial cable (PLAC).

9.2.50 Phase Position

Circuits should hold the same relative phase position throughout their entire length as far as practicable following the guidelines shown on Page 9-105. Where there is an established policy on phase position in an operating area, it may be continued.

9.3 TYPES OF CONDUCTORS

The type of conductor shall be selected as follows:

9.3.10 Bare Conductors

Bare conductors are preferred over covered conductors due to the cost and construction/maintenance requirements. They shall be used in areas where there are no restrictions on tree trimming (local, state, or otherwise).

9.3.20 Covered Conductors

PE covered conductor is not approved for new installations but for maintenance purposes only. This conductor is designed to withstand a limited amount of incidental contact.

9.3.30 Tree Wire (Spacer Cable Installed in Crossarm Configuration)

Tree wire is an approved conductor for new installations on crossarms. This conductor is designed to withstand incidental tree contact but is not intended to be installed to permanently eliminate tree trimming. Tree wire may also be installed when local municipal ordinances mandate that covered primary conductors be installed.

Although tree wire offers some electrical protection, **it is not an insulated conductor**. It must be treated as a bare conductor during installation and maintenance.

Tree Wire contains a layer of semi-conducting material at the aluminum conductor surface. **WARNING: When skinning these conductor coverings, do not allow the removed covering to contact equipment grounds or adjacent live phase conductors as an electrical flash may result.**

9.3.40 Spacer Cable

Tree wire is the only wire to be used in a spacer cable configuration. Spacer cable configuration provides maximum reliability and is to be used in heavy tree areas but is not intended to be installed to permanently eliminate tree trimming. See Section 16-Aerial/Spacer Cable for more information and construction details. Tree wire in a spacer cable configuration is also approved for express or multiple feeder installations on existing poles.

9.3.50 Preassembled Lashed Aerial Cable (PLAC)

Preassembled lashed aerial cable is approved for expressed or multiple feeder installations on existing poles. This eliminates the need for the installation of a second pole line. It can also be used to achieve NESC Clearance or Right of Way Issues. See Section 16 for more information on this conductor and construction details.

9.3.60 Existing Conductors

A. 5 kV - Existing conductors in good condition, may remain in place for 5 kV operations. They may be repaired and maintained using the same or similar conductors. Non-standard conductors should not, however, be used for replacement of several spans, nor for adding a third phase to an existing line. When it is necessary to perform extensive repair work on an existing non-standard line, replacing it with standard conductors is required.

B. 15 kV - Do not use existing #4 or smaller conductors for 15 kV effectively grounded systems. Refer to Section 14 regarding the installation of step-up/step-down transformers. Triple Braid Weatherproof (TBWP) insulated conductors should normally be replaced if it will be operating at 15 kV or above in the foreseeable future.

Supersedes 7/07 Issue - Editorial changes; text shift.

9.4 SEPARATION OF CONDUCTORS

9.4.10 General

Minimum recommended separations between supports and conductors on the same pole are shown on the construction drawings. These should be used on all poles for new lines. They are generally used for pole replacements.

9.4.20 Separation on New Poles

The vertical clearance between primary line conductors and neutral or secondary conductors at poles for new lines shall generally not be less than 56” for 0-15 kV. This distance allows work on the neutral or secondary while maintaining the NESC Phase to Ground Minimum Approach Distance (MAD), including a 30” dimension for “Reach” (based upon the average line worker’s extended reach from chest to finger tips of 30”).

Note: NESC Phase to Ground MAD for 15 kV = 26” + Reach of 30” = 56”

A. Primary Tangent Poles (where wires are on pin insulators and crossarms) – the vertical separation between the bolt for the primary crossarm and the secondary bracket shall be not less than 48” for 15 kV. This will allow 56” clearance between primary line conductors and the neutral or secondary conductors. The distance between the crossarm bolt and the top of the 15kV insulator holding the primary conductor is 8”. This distance plus the distance from the crossarm bolt to the secondary bracket (48”) will total a minimum of 56”.

B. Primary Deadend Poles - the vertical separation between the bolts for the primary crossarm and the secondary bracket shall be not less than 56” for 0-15 kV lines.

9.4.30 Separation on Existing Poles

When pole tops are being rearranged to accommodate additional facilities or when circuits are cut over to a higher voltage level, the recommended separations between primary line conductors and neutrals or secondaries for work on new poles **must** be used if possible. This will hold future work to a minimum and allow work on secondaries without covering the primaries (NESC Minimum Approach Distance). However, extensive work and pole change outs should not be undertaken solely to reduce work that might become necessary in the future.

When pole tops are rearranged to accommodate additional facilities on the pole, without regard to the owner of the new facilities:

A. If the vertical separation between the primary and the secondary/neutral is 56” or more at the pole, a minimum vertical separation of 56” shall be maintained. This allows qualified electrical line workers to maintain MAD from the primary wires while working on the secondary/neutral at the pole.

B. If the vertical separation between the primary and the secondary/neutral is less than 56”, NESC minimum vertical separations at the pole and in the span shall be maintained. See Section 7.11 (Separation of Conductors and Supports on the Same Pole) for information on these minimum clearance requirements.

9.4.40 Space Available on Jointly Owned Poles

Before replacing any jointly owned poles, be certain that communication company and other attachments cannot be rearranged to permit the desired construction.

9.4.50 Separation on Replaced Poles

The separations on poles that are replaced should conform to the requirements for new poles. In some special cases, separation may be reduced, but shall not be less than that permitted on existing poles.

9.4.60 Reduction of Separation on Poles

Reduced separations of conductors and facilities made to accommodate communication, CATV or other third party interest shall not be less than 15kV minimum requirements.

9.5 OTHER

9.5.10 Surge Arresters

See Section 13.6 (Lightning Protection) and Section 13.7 (Surge Arrester Application Table) for more information on when arresters are required and what type should be used.

9.5.20 Insulators

A. Bare Conductor – One piece radio free, pin type, porcelain insulators of the appropriate ANSI class shall be used to support the phase conductors. A one piece polymer deadend insulator of proper voltage rating shall be used to deadend the conductor.

B. Tree wire/spacer cable – A one piece, plain top, pin type, polyethylene insulator of the appropriate ANSI class shall be used to support the phase conductor. A one piece polymer deadend insulator of proper voltage rating shall be used to deadend the conductor. **Note:** do not remove conductor covering at insulator location. To maintain the integrity of the covering, it must remain intact.

9.5.30 Neutral Brackets

An uninsulated metal bracket shall be used to support the common neutral conductor in the secondary position. See Section 10 for information on Secondaries.

Supersedes 7/07 Issue - Editorial changes; text shift.

9.5.40 Conductor Ties

Follow these guidelines to ensure the reliability of primary circuits and to reduce or eliminate interruptions caused by inadequate conductor tie practices. Line conductors are to be positioned on its insulators that will produce minimum strain on the tie wires. The function of the tie wire is only to hold the line conductor on its insulator. Conductor strain shall be taken by the insulator and pin.

Hand wrapped ties are to be used for all types of conductor within the 15 kV class. Ties are to be made by hand and without the use of pliers. A tie wire must be neatly and tightly wrapped around the insulator and conductor with free ends wrapped tightly around the conductor. On lines that may eventually be operated above 15 kV, the free ends shall be folded back on the conductor at a distance of 3 inches to facilitate the future removal of the tie with hot sticks.

Hot line ties are to be used when lines are being worked with hot sticks. These also need to be wrapped neatly and tightly around the insulator and conductor. Single loop ties are to be recommended for spans under 160 feet while double loop ties are recommended for conductors with spans of 160 feet and over.

Utilize preformed conductor ties (TT1) for 3000 lb construction.

Care shall be taken to use the proper length and size tie for each conductor specified in the tables on Page 9-120. Refer to Pages 9-118 thru 9-124 for diagrams and information on Hand Wrapped and Hot Line Ties.

9.5.50 Types of Ties –

A. Bridle tie shall be used for all bare and covered conductors larger than #4 AWG regardless of span length.

B. Looped Western Union and Cross Top Tie shall be used for all bare and covered conductors # 4 AWG or smaller (#4, #6,etc.).

C. Bare Conductor – Use bare tie wire. (W22A,W22BA,W22C)

D. Tree Wire – Use covered tie wire (W22D). **Note:** Do **not** use molded plastic ties. Do **not** remove tree wire covering at polyethylene pin type insulator.

E. Existing Polyethylene and Neoprene Covered Line - Wire to be converted to the 15 kV Voltage class – Install 15 kV pin type polyethylene insulator and tie with covered tie wire (W22D) where existing covering on conductor has not been previously removed. Where covering has been removed, use a pin type porcelain insulator and tie conductor to insulator with bare tie wire.

F. Existing Braid Covered (rubber) Line Wire (Maintenance Only) – Remove the covering at the insulators (30 inches on both sides of the insulator) and tie with bare tie wire of the same metal as the line conductor for all voltages.

G. Double insulators shall use ties for single insulators with each tie occupying one-half the available space between insulators – same number of turns with closer spacing.

9.5.60 Splices, Connectors, Taps, Etc.

See Section 5 (Connectors) for all information regarding choosing and installing splices, connectors, taps, deadend clamps, etc for bare or covered wire.

Supersedes 7/07 Issue - Removed splice/connector information (refer to Section 5); text shift.

9.6 VOLTAGE CONVERSIONS

All voltage conversions done on the Liberty Utilities distribution system must be done in accordance with EOP D010 - Primary Circuit/Transformer Voltage Conversion.

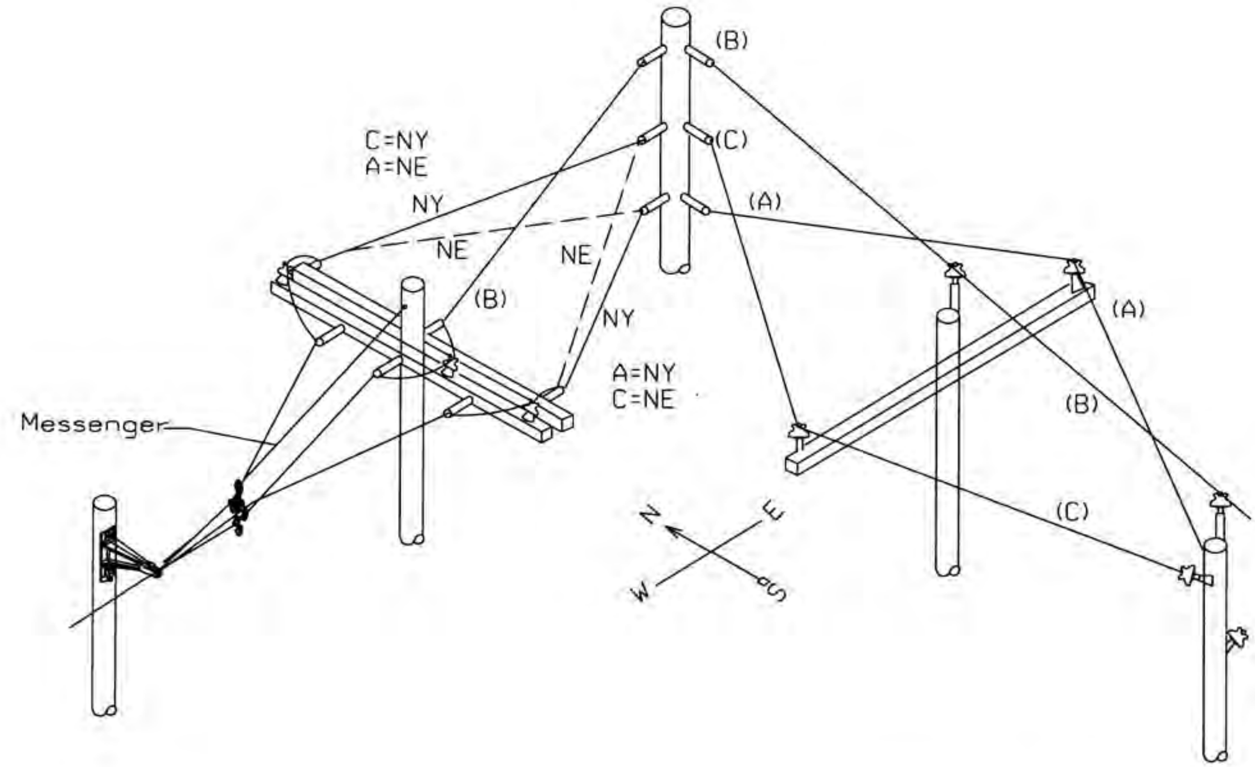
9.6.10 Material Requirements

Certain material items shall be replaced/added during a conversion. These include but are not limited to the following:

A. Wood insulator pins must be replaced with steel pins.
B. Guy wires must be built to current standards - see Section 3.4.50 (Voltage Conversions) for details.
C. Primary taps shall be fused.
D. Arresters shall be installed per Section 13.6 (Lightning Protection).

Supersedes 7/07 Issue - New section (9.6); text shift.

Supersedes 1/06 Issue – 25-35 kV Construction Information is Relocated to New Section 20



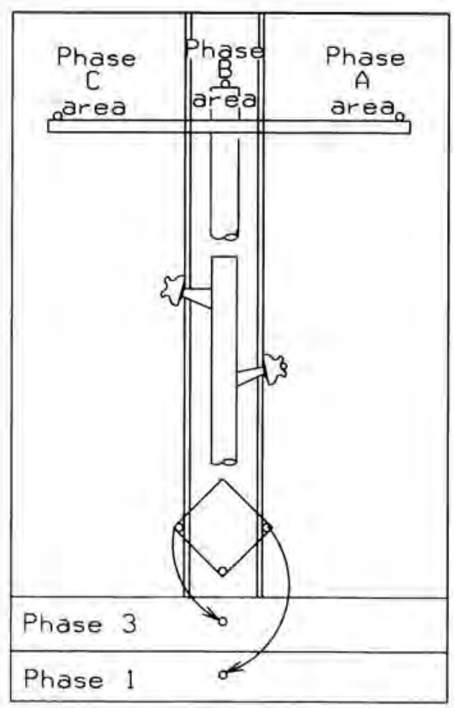
Notes:
If there are local rules that have been approved by the division superintendent, these should be followed where practicable. Otherwise use the rules below:

(1) New England - Put phase A on the northerly or easterly side for horizontal crossarm or spacer cable installations. Put phase A on the bottom for vertical construction.

New York - Put phase A on the southerly or easterly side for horizontal corssarm or spacer cable installations. Put phase A on the bottom for vertical construction.

(2) Put phase B in the middle or top positoin for horizontal crossarm or for vertical construction. Phase B shall occupy the middle and bottom position for spacer cable in triangular arrangments.

(3) Put phase C in the remaining position.

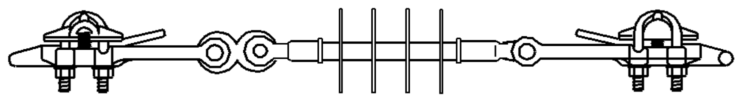


Look north = NE & NY
Look east = NY
Look west = NE

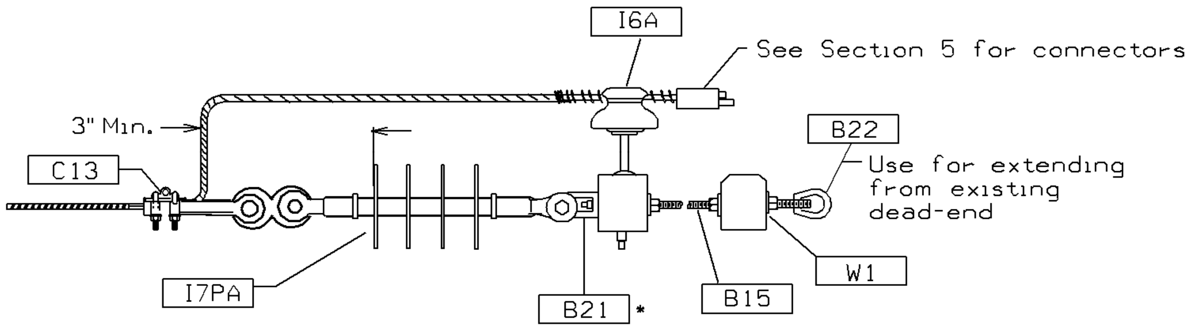
PHASE POSITIONS
15 kV DISTRIBUTION PRIMARY

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		9-105	7/07

 Doc. # ST. 09.00.003

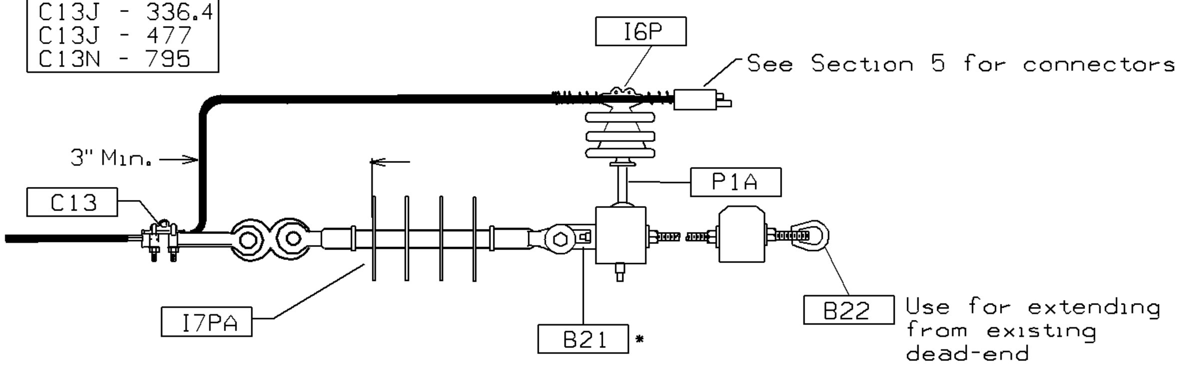


Inline Dead Ends

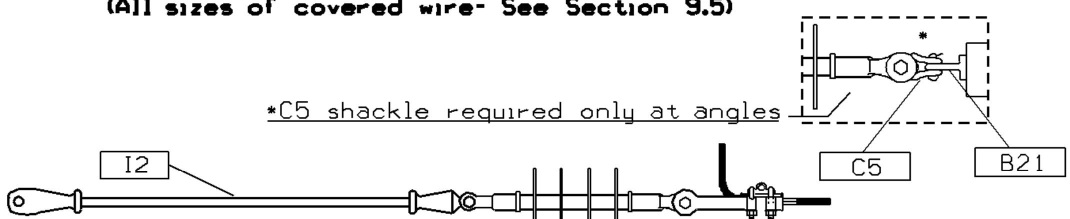


Dead-End Clamps
(All sizes of bare wire)

C13H	1/0
C13J	336.4
C13J	477
C13N	795



Dead-End Clamps
(All sizes of covered wire- See Section 9.5)



Inline Dead Ends

Notes:

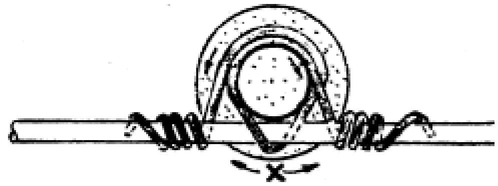
Maintain full impulse and flashover strength; see Section 7.
This drawing is for dead-ends on wood crossarms or wood poles.

See 2.8 for information on crossarm.
Use heavy duty crossarms(C31D) and braces(TB60) and gain plates(C37) for 3000 lb construction.

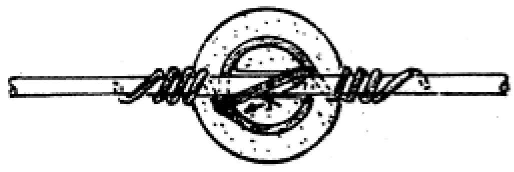
Supersedes 1/06 Issue – 25-35 kV Construction Information is Relocated to New Section 20

Supersedes 1/06 Issue – 25-35 kV Construction Information is Relocated to New Section 20

HAND WRAPPED TIES



LOOPED WESTERN UNION (LWU) - SIDE GROOVE TIE
FIG I



CROSS TOP (CT) TOP GROOVE TIE
FIG II

FIG I & II TO BE USED FOR ALL BARE AND COVERED CONDUCTOR OF #4 AWG OR SMALLER.

BRIDLE TIE SIDE GROOVE
FIG III

BRIDLE TIE TOP GROOVE
FIG IV

FIG III & IV TO BE USED ON ALL COPPER & ALUMINUM CONDUCTORS LARGER THAN #4 AWG

TIE CONDUCTORS

TABLE I – LENGTH AND TYPE - FOR BARE LINE CONDUCTOR

Line Conductor Size AWG-kcmil	Tie Wire Size AWG	Std Item	Class 55-4 Insulator – 15kV			
			Side Groove		Top Groove	
			Length (Inches)	Type	Length (Inches)	Type
# 6 Cu	# 6 Cu	W22A	28	LWU	32	CT
# 6A CW &CCW	# 6 Cu	W22A	32	LWU	36	CT
# 4 Cu	# 6 Cu	W22A	38	LWU	40	CT
# 3 Cu	# 6 Cu	W22A	55	Bridle	46	Bridle
# 2 Cu	# 4 Cu	W22BA	62	Bridle	54	Bridle
# 1/0 Cu	# 4 Cu	W22BA	70	Bridle	60	Bridle
# 4/0 Cu	# 4 Cu	W22BA	76	Bridle	64	Bridle
Larger Cu	# 4 Cu	W22BA	-	Bridle	-	-
# 4 ACSR	#4 AL	W22C	38	LWU	40	CT
# 2 ACSR	#4 AL	W22C	62	Bridle	53	Bridle
# 1/0 ACSR	#4 AL	W22C	66	Bridle	56	Bridle
# 4/0 AAC	#4 AL	W22C	78	Bridle	66	Bridle
336.4 AAC	#4 AL	W22C	86	Bridle	74	Bridle
336.4 ACSR3000#	#4 AL	TT1B	Preform	Bridle	Preform	Bridle
477.0 AAC	#4 AL	W22C	105	Bridle	93	Bridle
477.0 ACSR	#4 AL	W22C	105	Bridle	93	Bridle
795 AAC	#4 AL	W22C	108	Bridle	96	Bridle

TABLE II – LENGTH AND TYPE - FOR COVERED AND TREE LINE CONDUCTOR

Note: If insulation is removed 30”, use bare tie wire (see above)

Line Conductor Size AWG-kcmil	Tie Wire Size AWG	Std Item	Class 55-4 Insulator – 15kV			
			Side Groove		Top Groove	
			Length (Inches)	Type	Length (Inches)	Type
# 6 Cu	#4 AL TPR	W22D	28	LWU	32	CT
# 6A CW &CCW	#4 AL TPR	W22D	32	LWU	36	CT
# 4 Cu	#4 AL TPR	W22D	38	LWU	40	CT
# 3 Cu	#4 AL TPR	W22D	38	Bridle	50	Bridle
# 2 Cu	#4 AL TPR	W22D	62	Bridle	54	Bridle
# 1/0 Cu	#4 AL TPR	W22D	68	Bridle	60	Bridle
# 4/0 Cu	#4 AL TPR	W22D	77	Bridle	68	Bridle
Larger Cu	#4 AL TPR	W22D	-	Bridle	-	-
# 4 ACSR	#4 AL TPR	W22D	38	LWU	40	CT
# 2 ACSR	#4 AL TPR	W22D	62	Bridle	53	Bridle
# 1/0 ACSR	#4 AL TPR	W22D	66	Bridle	56	Bridle
# 4/0 AAC	#4 AL TPR	W22D	78	Bridle	66	Bridle
336.4 AAC	#4 AL TPR	W22D	86	Bridle	74	Bridle
477.0 AAC	#4 AL TPR	W22D	105	Bridle	93	Bridle
795 AAC	#4 AL TPR	W22D	108	Bridle	96	Bridle

Supersedes 1/06 Issue – 25-35 kV Construction Information is Relocated to New Section 20

SINGLE LOOP HOT LINE TIES

1. **USE SINGLE LOOP TIES FOR SPANS UNDER 160 FEET**. where lines are to be worked hot. Use double ties for spans over 160 feet. and for all angle poles.

Approx. ¾” Diameter.

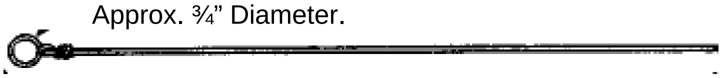


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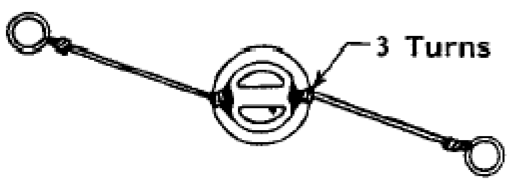
Figure A – Prepare Loop – Two Required



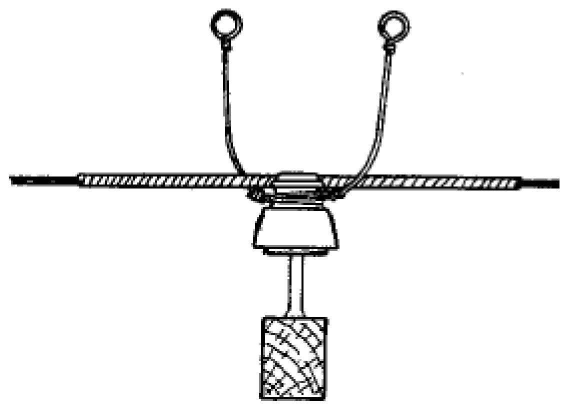


Figure B – Loops In Place On Insulator **Figure C – Conductor In Place**

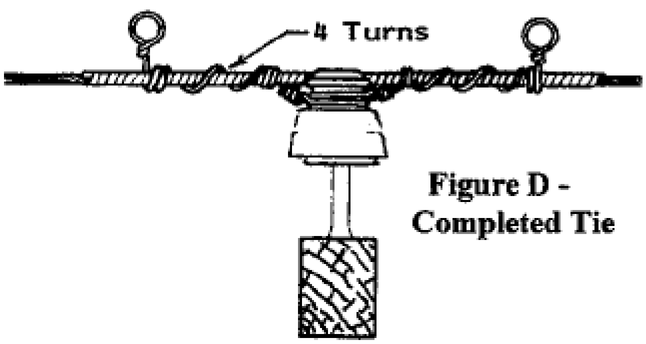


Figure D - Completed Tie

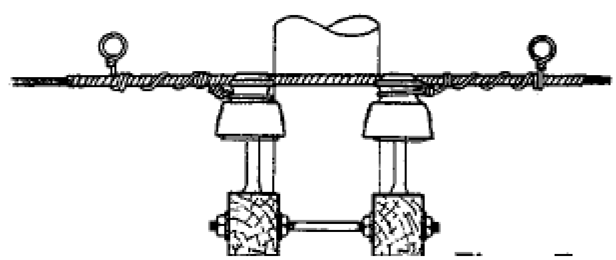


Figure E – On Double Arms

Line Wire Size AWG-kcmil	Tie Wire Size AWG-kcmil	Length “K” (Inches)			Line Wire Size AWG-kcmil	Tie Wire Size AWG-kcmil	Length “K” (Inches)
#3 Copper	#6 Copper	32			#1/0 6201 Al.	#4 Alum.	34
#1/0 Copper	#4 Copper	36			#4/0 6201 Al.	#4 Alum	40
#4/0 Copper	#4 Copper	40			336.4 ECA	#4 Alum	44
#4 ACSR	#4 Alum.	28			477.0 ECA	#4 Alum	46
#1/0 ACSR	#4 Alum.	34					

Supersedes 1/06 Issue – 25-35 kV Construction Information is Relocated to New Section 20

DOUBLE LOOP HOT LINE TIES

1. **<u>USE DOUBLE LOOP TIES FOR SPANS OVER 160 FEET</u>**. where lines are to be worked on hot and for all angle poles. Use single ties for spans under 160 feet.

Approx. ¾" Dia.
2 - Full Turns

Figure A- Prepare Loop – Two Required

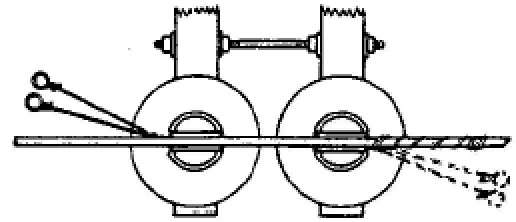


Figure E – Double Insulators
Conductor In Place – Top Groove

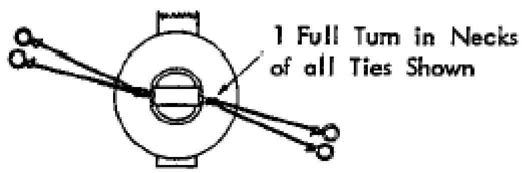


Figure B – Loops In Place On Insulator
(Top View)

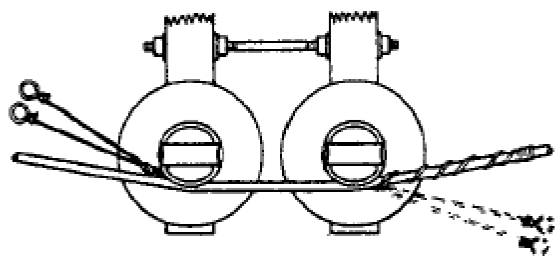


Figure F – Double Insulators
Conductor In Place – Side Groove

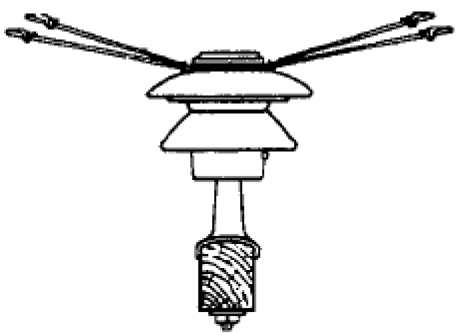


Figure C – Loops In Place On Insulator

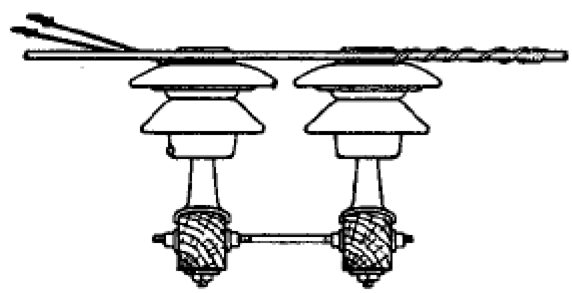


Figure G – Double Insulators Elevation

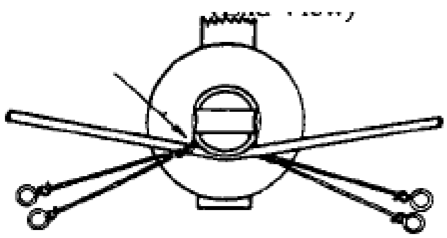


Figure D – Conductor In Place
(In Side Groove For Angle In Line)

Supersedes 1/06 Issue – 25-35 kV Construction Information is Relocated to New Section 20

Pole spans are limited primarily by the sag characteristics of the primary conductor relative to the horizontal and vertical separations provided by the standard pole top arrangement. Increases in separations at the pole may permit longer spans. Transverse wind loadings may not allow use of extremely long spans. Maximum spans are determined by the following criteria:

Horizontal Clearance (Distance between Phase Conductors at the same level):

Maximum spans are limited by the HORIZONTAL clearance of the primary conductors outlined in the NESC (National Electrical Safety Code) rule 235B.

The clearance at the supports of conductors shall not be less than the greater of the following:

- The clearance shown in Table 235-1 (NESC) shall be used if they give a greater separation than below formulas. This required clearance is:
  - 12" for supply conductors with 0 to 8.7 kV between conductors of the same or different circuits.
  - 15" for supply conductors with 8.7 to 15 kV between conductors of the same or different circuits.
  - See NESC Rule 235B1a and Table 235-1 for other voltages.
- The clearance given by one of the following formulas at a conductor temperature of 15°C (60°F), final unloaded sag and no wind:
  - For conductors smaller than AWG #2: $c = (0.3)(V) + 4.04\sqrt{s-24}$.
  - For conductors of AWG #2 and larger: $c = (0.3)(V) + 8\sqrt{s/12}$.

Where,

c = horizontal clearance between the primary conductors, in inches,
V = voltage between the conductors, in kV, and
s = sag of the conductor having the greater sag, in inches.

Clearances are between conductors located at the same level (i.e. the two outside phase conductors on standard crossarm or armless pole top construction or the two nearest phases on a crossarm).

Vertical Clearance (Primary to Secondary or Neutral)

Maximum spans are limited by the VERTICAL clearance between primary and secondary or neutral conductors outlined in NESC Rule 235C. The separation shown on the pole top drawings in this section maintain the 12 inch minimum mid-span clearance as shown in the Section 7. Clearances between conductors that are directly above and below each other are limited by the sag of the primary conductor and the sag of either 600 V secondary or neutral conductors.

A comparison of sags under two different operating conditions must be evaluated and the operating condition requiring the greatest separation at the structure must be used. These conditions are as follows:

- The upper conductor is at final sag at the maximum operating temperature for which the line is designed to operate and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, or
- The upper conductor is at final sag at 32° F with ½" radial thickness of ice, and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical or ice loading.

Generally, for crossarm or armless construction, the sag of primary conductor (bare or tree wire) at 194°F (90°C) is greater than its sag under ice loaded conditions. A comparison should, however, be made.

Primary conductors, bare or tree wire, are designed to limit the maximum conductor operating temperature to 194°F (90°C) for a summer ambient temperature of 100°F (37.7°C) and a winter ambient temperature of 50°F (10°C). The worst case clearance condition will occur when the lower conductor, secondary or neutral, is at the winter ambient temperature of 50°F (10°C).

Sag charts for bare and tree wire primary conductors and neutrals is in Section 6-Primary Conductors. Sag charts for secondary wires are in Section 10-Secondaries.

An additional limit on span lengths comes from NESC Rule 235C2b(3). For span lengths in excess of 150’, a supply conductor above 750V but less than 50kV shall not sag lower in the span than a straight line joining the points of support of the highest communication cable or conductor when the supply conductor is at a conductor temperature of 60°F (15°C), no wind displacement and final unloaded sag conditions.

Vertical Clearance (Secondary to Communications):

Maximum spans are limited by the VERTICAL clearance between secondary or neutral conductors and communication conductors outlined in NESC Rule 235C. The separation shown on the pole top drawings in this section while maintaining the 30 inch minimum mid-span clearance as shown in the Section 7. Clearances between conductors that are directly above and below each other and are limited by the sag of the 600V secondary or neutral conductors and the sag of the communication conductors.

A comparison of sags under two different operating conditions must be evaluated and the operating condition requiring the greatest separation at the structure must be used. These conditions are as follows:

- The upper conductor is at final sag at the maximum operating temperature for which the line is designed to operate and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical loading, or

- The upper conductor is at final sag at 32° F with ½” radial thickness of ice, and the lower conductor is at final sag at the same ambient conditions as the upper conductor without electrical or ice loading.

Generally, for secondary triplex or quadplex, the sag under ice loaded condition is greater than the sag at 120°F (50°C), the maximum operating temperature of the supporting neutral. A comparison should, however, be made.

Primary conductors, bare or tree wire, are designed to limit the maximum conductor operating temperature to 194°F (90°C) for a summer ambient temperature of 100°F (37.7°C) and a winter ambient temperature of 50°F (10°C). The worst case clearance condition will occur when the lower conductor, secondary or neutral, is at the winter ambient temperature of 50°F (10°C).

Sag charts for bare and tree wire primary conductors and neutrals is in Section 6-Primary Conductors. Sag charts for secondary wires are in Section 10-Secondaries.

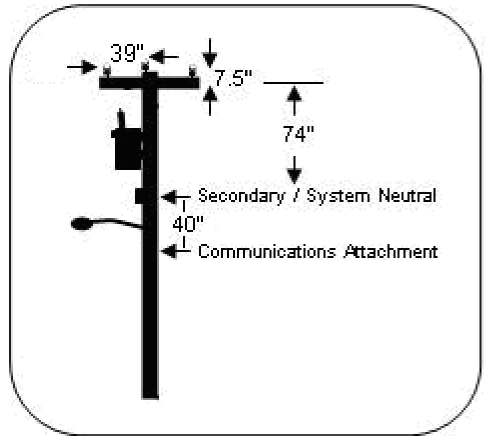
An additional limit on span lengths comes from NESC Rule 235C2b(3). For span lengths in excess of 150’, a supply conductor above 750V but less than 50kV shall not sag lower in the span than a straight line joining the points of support of the highest communication cable or conductor when the supply conductor is at a conductor temperature of 60°F (15°C), no wind displacement and final unloaded sag conditions.

Supersedes 7/07 Issue – Revised Horizontal Clearance Calculations.

EXAMPLE CALCULATION – MAXIMUM SPANS

Given:

15 kV class construction
Primary Voltage – 15kV effectively grounded
Pole Framed to 9-411A
Grade C construction
1 – 40 ft., class 3 wood pole JT NE (84" Allocated)
3 – 477 kcmil AAC bare conductors (W21BA)
1/0 AAAC triplex secondary cable (W15C)
Ø to Ø Primary Horizontal Separation = 39" (9-206)
Vertical Pole Spacing (74"+8" = 82")
(8" = thru bolt of xarm to conductor on top of insulator)
40" Spacing (Bottom Secondary Bracket to top of comm.)
For 300' Ruling Span
477 - Sag @ 60°F final, no wind, no ice = 121.92" (6-114).
For 135' Span*
477 - Sag @ 176°F final, no wind, no ice = 53"
1/0 Triplex - Sag @ 30F° final, no wind, no ice = 12"
* = Calculated Values (Steps 5-7)



Maximum Span Based on Horizontal Separations Between Primary Conductors: Steps 1-2

Step	Action	Use
1	Determine maximum primary conductor sag based on 39" horizontal separation between primary conductors. (see Page)	From above for #2 AWG and greater: c = (0.3) (V) + 8 $\sqrt{s/12}$. where, s = Sag (inches) = unknown c = Primary phase to phase separation (inches) = 39" V = Circuit voltage, phase-to-phase (kV) = 15kV Therefore, $s = 12 * \left(\frac{(c - .3V)}{8}\right)^2$ and $s = (12)\left(\frac{39 - (.3)(15)}{8}\right)^2$ $s = 223.2"$

Step	Action	Use
2	Determine the maximum span based on maximum primary conductor sag of 223.2" for 477kcmil AAC Bare Conductor.	$s_m = s_r * \frac{L_m^2}{L_r^2}$ Where, s_m = Maximum sag determined in Step 1 (inches) = 223.2" s_r = Ruling span sag (inches) = 121.9" L_m = Maximum span (feet) = unknown L_r = Ruling span (feet) = 300' Therefore, $L_m = L_r * \sqrt{\frac{s_m}{s_r}}$ and $L_m = 300 * \sqrt{223.2/121.9}$ L_m = 406'

Determine Sag of Actual Span versus Ruling Span:: Steps 3-7

Step	Action	Use
3	Determine Sags in "Other Span". (135' span)	$S_a = \frac{L_a^2}{L_r^2} * S_r$ Where, S_a = Sag of Actual Span (inches) S_r = Sag of Ruling Span (inches) L_a = Length of Actual Span (feet) L_r = Length of Ruling Span (feet)
4	Calculate sag for 135' span - 477 Sag @ 194°F (90°C) Final Unloaded (See 6-114)	S_a = Sag of Actual Span = Unknown S_r = Sag of Ruling Span = 45.24" (125' Ruling span) L_a = Length of Actual Span = 135' L_r = Length of Ruling Span = 125' $S_a = \frac{L_a^2}{L_r^2} * S_r$ $S_a = \frac{135^2}{125^2} * 45.24_k$ S_a = 52.77" = **53"**

Supersedes 7/07 Issue –Revised Horizontal Clearance Calculations.

Step	Action	Use
5	Calculate sag for 135' span - 1/0 Triplex Sag @ 30°F (0°C) (See 10-6)	S_a = Sag of Actual Span = Unknown S_r = Sag of Ruling Span = 10" L_a = Length of Actual Span = 135' L_r = Length of Ruling Span = 125', $S_a = \frac{L_a^2}{L_r^2} * S_r$ $S_a = \frac{135^2}{125^2} * 10$ S_a = 11.64" **= 12"**

Supersedes 7/07 Issue – Revised Horizontal Clearance Calculations.

Maximum Span Based on Vertical Separations between Primary, Secondary and Communication Conductors: Steps 8-10

Step	Action	Use
6	Calculate mid-span separation between primary and secondary	Vertical Spacing at Pole Primary to center of crossarm 8" Center of crossarm to secondary + 74" Total 82" Primary Conductor Sag - 53" Secondary Conductor Sag + 12" Mid-span vertical separation between primary and secondary 41" (12" minimum required per Section 7)
7	Calculate mid-span separation between secondary and communications	Vertical Spacing at Pole Secondary to communications 42" (40" + 2" from Sec cond to bottom of Sec Bracket) Secondary Conductor Sag - 12" Mid-span vertical separation between secondary and communications 30" (30" minimum required per Section 7) Note: This calculation is conservative because it makes no allowance for communications cable sag. If the communications cable sag is known, it may be accounted for as the secondary sag is accounted for in Step 6 above.

Determine Clearance between Sagged Primary Conductor and Communication's In-Line-of-Site (>150' & >750V NESC Rule 235C.2b.3): Steps 11-12

Step	Action	Use
8	Check whether sagged primary conductor is above or below communications line-of-sight.	Vertical Spacing at Pole Primary to center of crossarm 8" Center of crossarm to secondary 74" Secondary to communications 42" Total 124" Primary Conductor Sag 53"

		Sagged primary conductor **above** comm. line-of-sight 71" (0" minimum required per Section 7) Note: This NESC rule applies only for spans greater than 150'. The calculation is shown here as an example even though this span is less than 150'.

Conclusions:

Horizontal Clearances – The horizontal clearance of 39" will allow a maximum span of up to 406' for 477 B AAC before mid span contact becomes an issue between primary conductors. This calculated value, per NESC guidelines, is well beyond the span of 135' in the above example. (Steps 1 - 4)

Vertical Clearances – There are several vertical clearances that need to be evaluated regarding maximum spans. They are as follows:

` Primary to Secondary – The vertical mid-span clearance between the primary and secondary conductor was calculated to be 41" for a span of 135' in the above example. The NESC minimum clearance shown in Section 7, Page 7-19 indicates 12" is the minimum required at mid span. Therefore, mid span contact between primary and the conductor in the secondary position is not an issue in the above example. (Steps 6 & 7)

Secondary to Communications

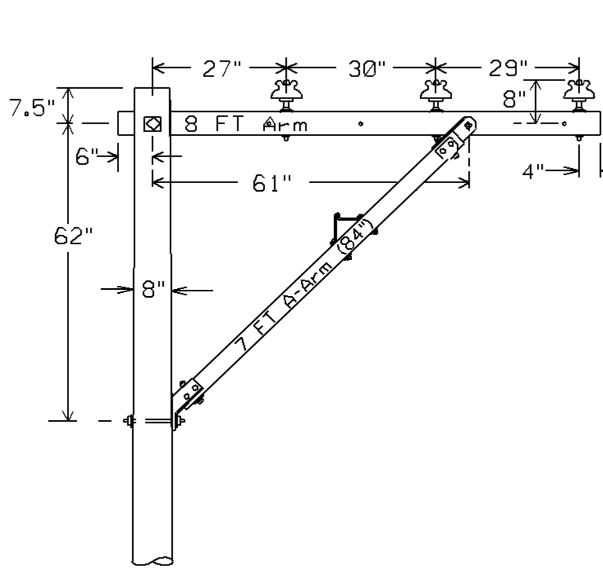
Span Requirements: The span of 135' will allow a vertical mid-span clearance of 30" between the secondary conductor (#1/0 Triplex) and the communications cable. Spans can be increased by increasing the at-pole separation between the secondary and communications by: (i) installing a taller pole, (ii) raising the secondary bracket to the minimum dimensions indicated in drawing (9-411A), (iii) requesting the communications company to lower their cable, or (iv) having the communications company sag their cable following the sag of the secondary conductor in the secondary position maintaining 30" mid span clearance.

Ice Loaded Conditions: Sag information for Conductors in the Secondary Position should be shared with the various Communication Companies to assist them in evaluating their cable sag requirements to meet NESC codes. Both Electric and Communication companies are allocated their attachment space on poles; however, a mid span clearance of 30" must be maintained when ice loading conditions occur. (See Section 7)

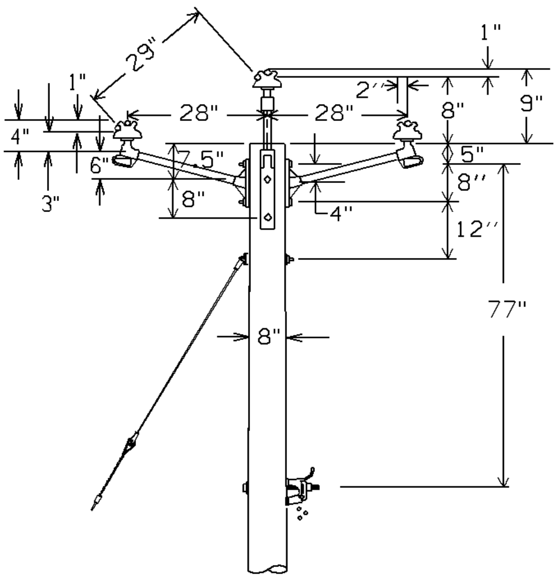
Maximum spans are also limited by pole, crossarm, pin and insulator loadings and strengths. See Section 2.

Supersedes 7/07 Issue – Revised Horizontal Clearance Calculations.

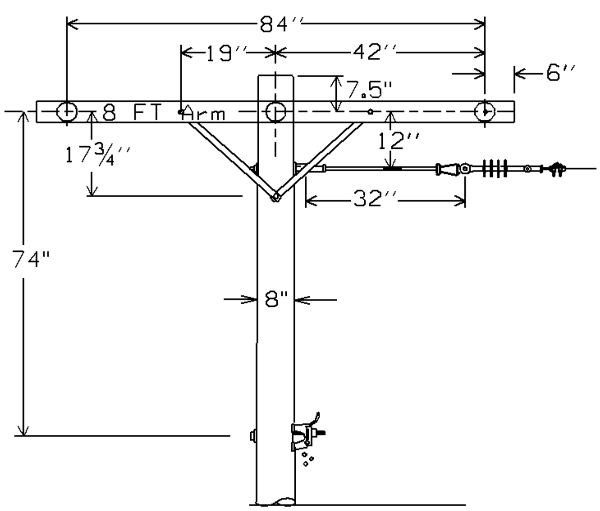
Supersedes 7/07 Issue – Revised Title.



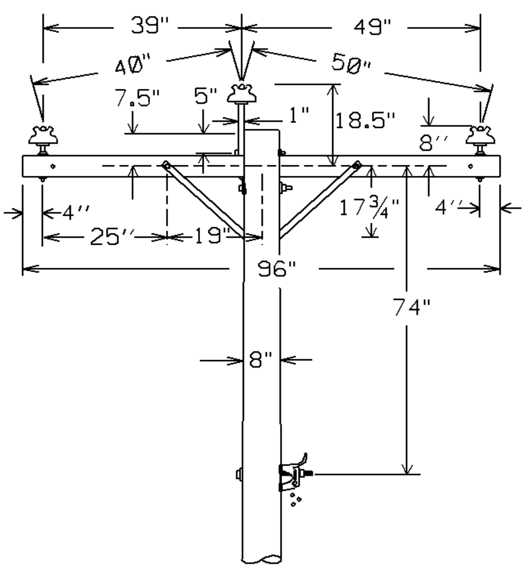
8′ - Alley Arm (C31B)
(Dwg. 9-437)



Armless
Tangent or Angle
(Dwg. 9-812)



8′ - Double (C31B)
Crossarm
Deadend with Tap
(Dwg. 9-419F1, 9-419 F2)



8′ - Crossarm (C31B)
Tangent
(Dwg. 9-411)

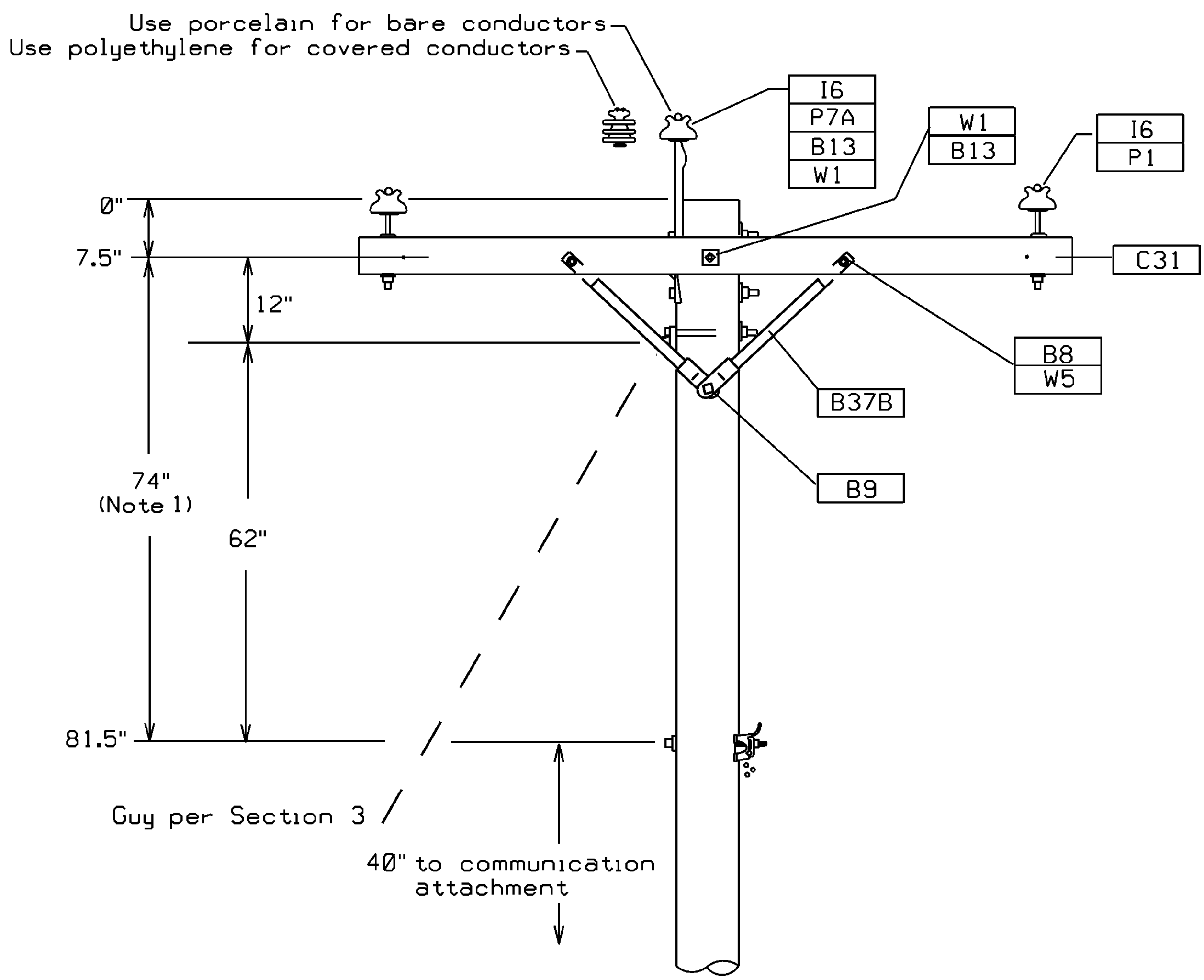
Notes:

-These dimensions are shown as general information for standard pole tops using standard materals. Refer to Section 9 primary drawings for other arrangements.

 Doc. # ST. 09.00.005

MU = @9-411A	0-15KV 3Φ - Bare	MU = @9-411ACL	0-15KV 3Φ - Covered
MU = @9-411B	0-15KV 1Φ - Bare	MU = @9-411BCL	0-15KV 1Φ - Covered

Supersedes 7/07 Issue - removed guying materials; edited notes; revised drawing title.



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

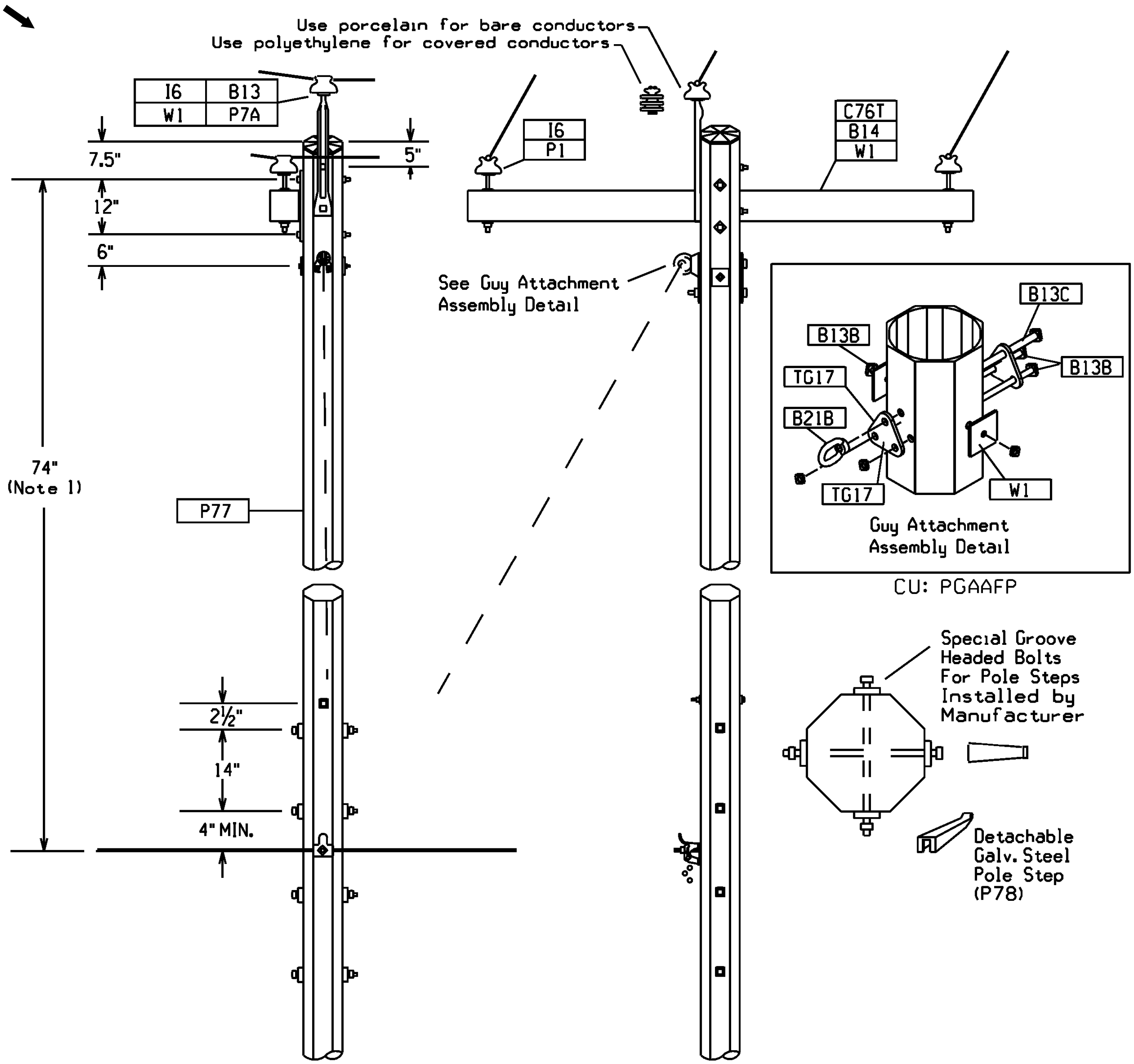
NOTES

1. This clearance can be reduced to a minimum of 48" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

1Φ (DELTA) AND 3Φ CROSSARM POLE TOP – 0-15 kV 0° - 10°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 9-411	ISSUE 7/11

 Doc. # ST. 09.00.005

MU = @9-411AF	0-15KV 3Φ - Bare	MU = @9-411AFCL	0-15KV 3Φ - Covered
MU = @9-411BF	0-15KV 1Φ - Bare	MU = @9-411BFCL	0-15KV 1Φ - Covered

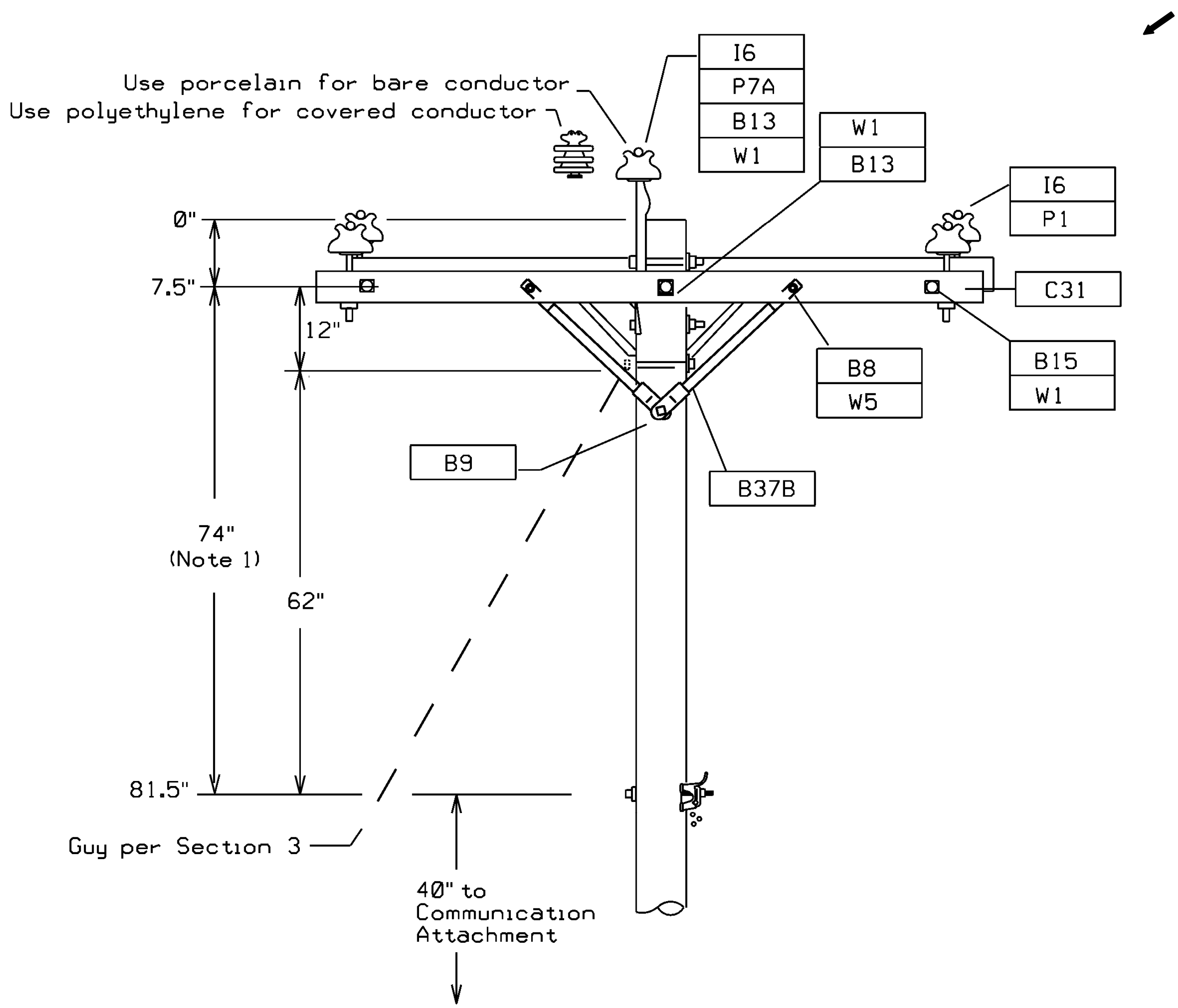


Supersedes 7/08 Issue - removed guying materials; edited notes; corrected guying detail Std Item #s; revised drawing title.

NOTES:

1. This clearance can be reduced to a minimum of 52" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. Detachable steel pole steps maybe left installed while maintaining an 8 foot minimum from ground level.
3. If grounding is necessary, install down ground & molding with appropriate grounding kit (Std Item S34) which includes nylon clips and self tapping screws. Place clips approximately 12"-18" apart.
4. Install 12.5M maximum guy wire. If 25M is required, install 2 separate 12.5M guys.
5. For single phase delta circuit construction, omit the center phase.

MU = @9-412A	0-15KV 3Φ - Bare	MU = @9-412ACL	0-15KV 3Φ - Covered
MU = @9-412B	0-15KV 1Φ - Bare	MU = @9-412BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

NOTES

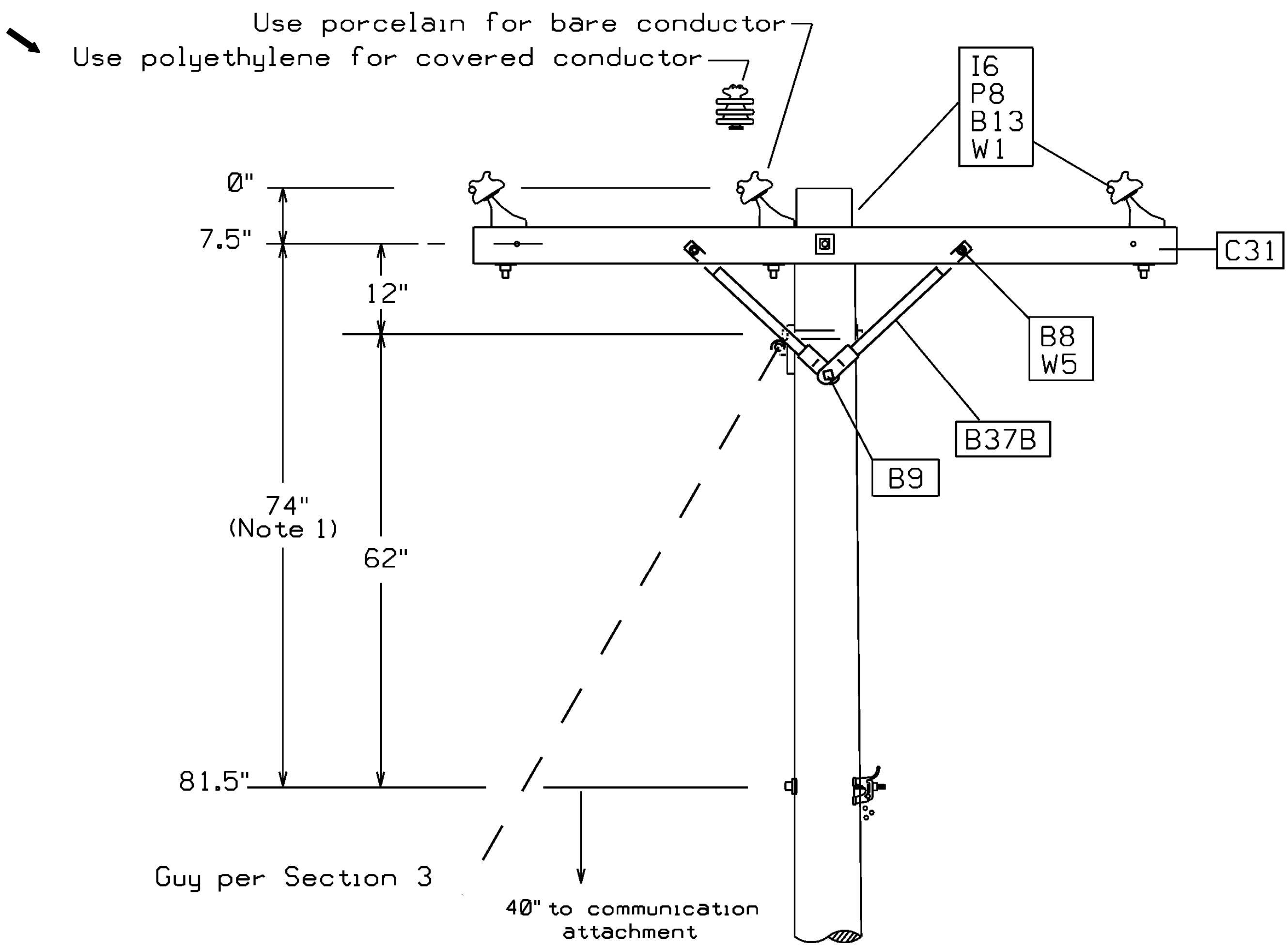
1. This clearance can be reduced to a minimum of 48” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

Supersedes 7/07 Issue – removed guying materials; edited notes; revised drawing title.

1Φ (DELTA) AND 3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV CROSSING AND ANGLES - 0° - 10°

 Doc. # ST. 09.00.005

MU = @9-413A	0-15KV 3Φ - Bare	MU = @9-413ACL	0-15KV 3Φ - Covered
MU = @9-413B	0-15KV 1Φ - Bare	MU = @9-413BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

NOTES

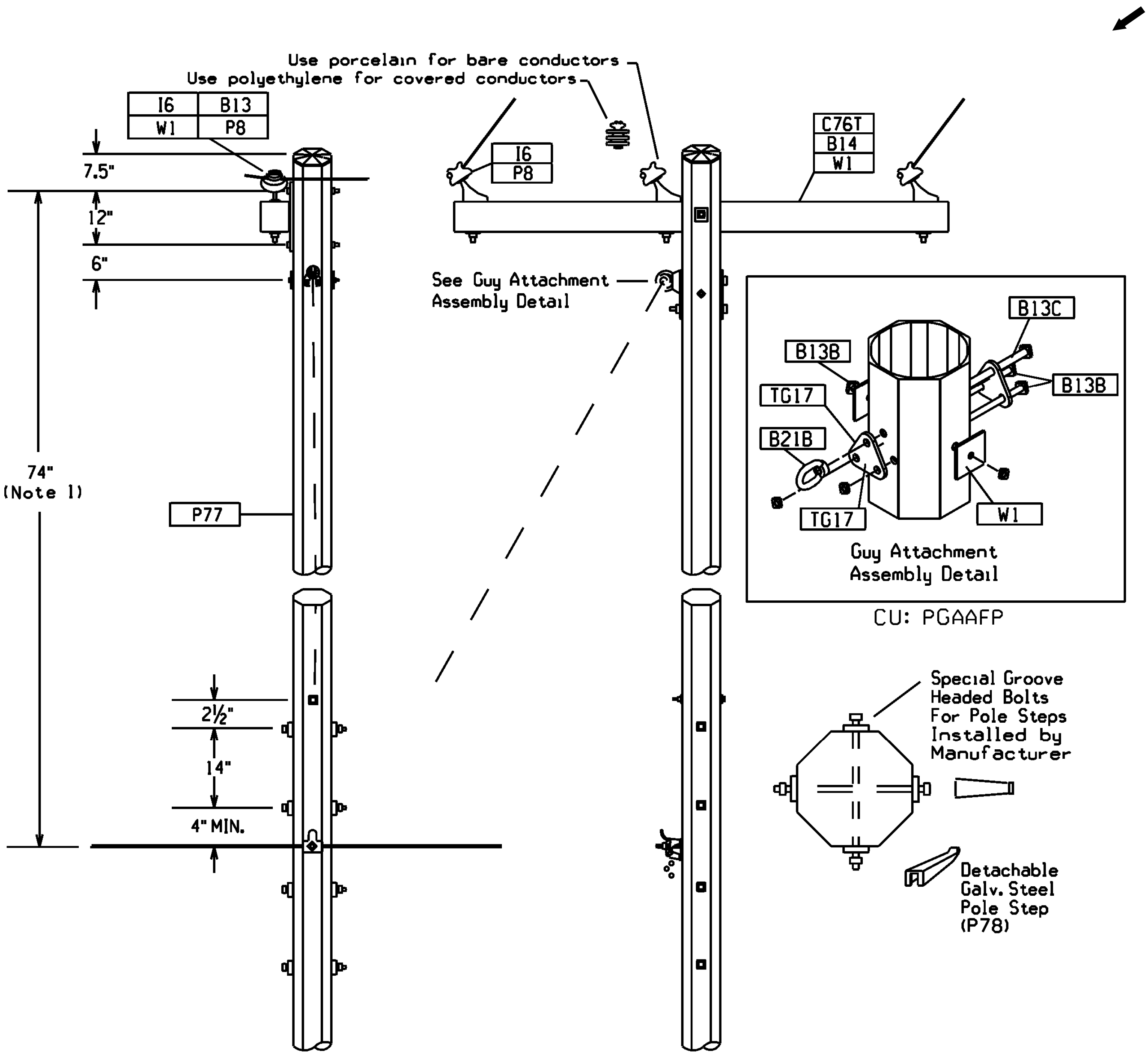
1. This clearance can be reduced to a minimum of 48" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

Supersedes 7/07 Issue – moved center phase to crossarm; removed guying materials; edited notes; revised drawing title.

1Φ (DELTA) AND 3Φ SINGLE CROSSARM POLE TOP – 0-15 kV 11° - 20°

Doc. # ST. 09.00.005

MU = @9-413AF	0-15KV 3Φ - Bare	MU = @9-413AFCL	0-15KV 3Φ - Covered
MU = @9-413BF	0-15KV 1Φ - Bare	MU = @9-413BFCL	0-15KV 1Φ - Covered



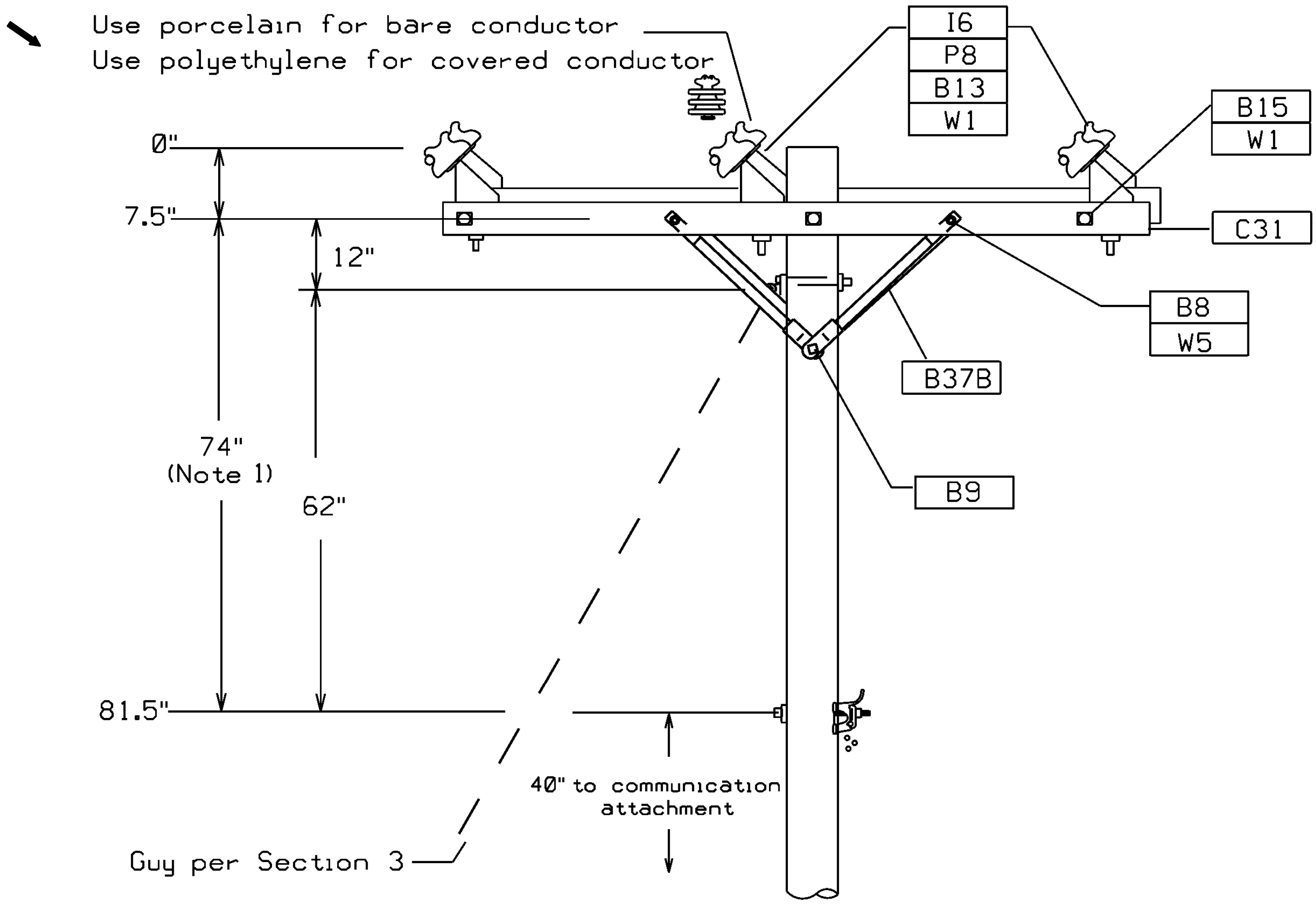
NOTES:

1. This clearance can be reduced to a minimum of 52" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. Detachable steel pole steps maybe left installed while maintaining an 8 foot minimum from ground level.
3. If grounding is necessary, install down ground & molding with appropriate grounding kit (Std Item S34) which includes nylon clips and self tapping screws. Place clips approximately 12"-18" apart.
4. Install 12.5M maximum guy wire. If 25M is required, install 2 separate 12.5M guys.
5. For single phase delta circuit construction, omit the center phase.

Supersedes 7/08 Issue - moved center phase to crossarm; removed guying materials; edited notes; revised drawing title; corrected guying detail Std Item #s.

 Doc. # ST. 09.00.005

MU = @9-414A	0-15KV 3Φ - Bare	MU = @9-414ACL	0-15KV 3Φ - Covered
MU = @9-414B	0-15KV 1Φ - Bare	MU = @9-414BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

Supersedes 7/07 Issue – moved center phase to crossarm; removed guying materials; edited notes; revised drawing title.

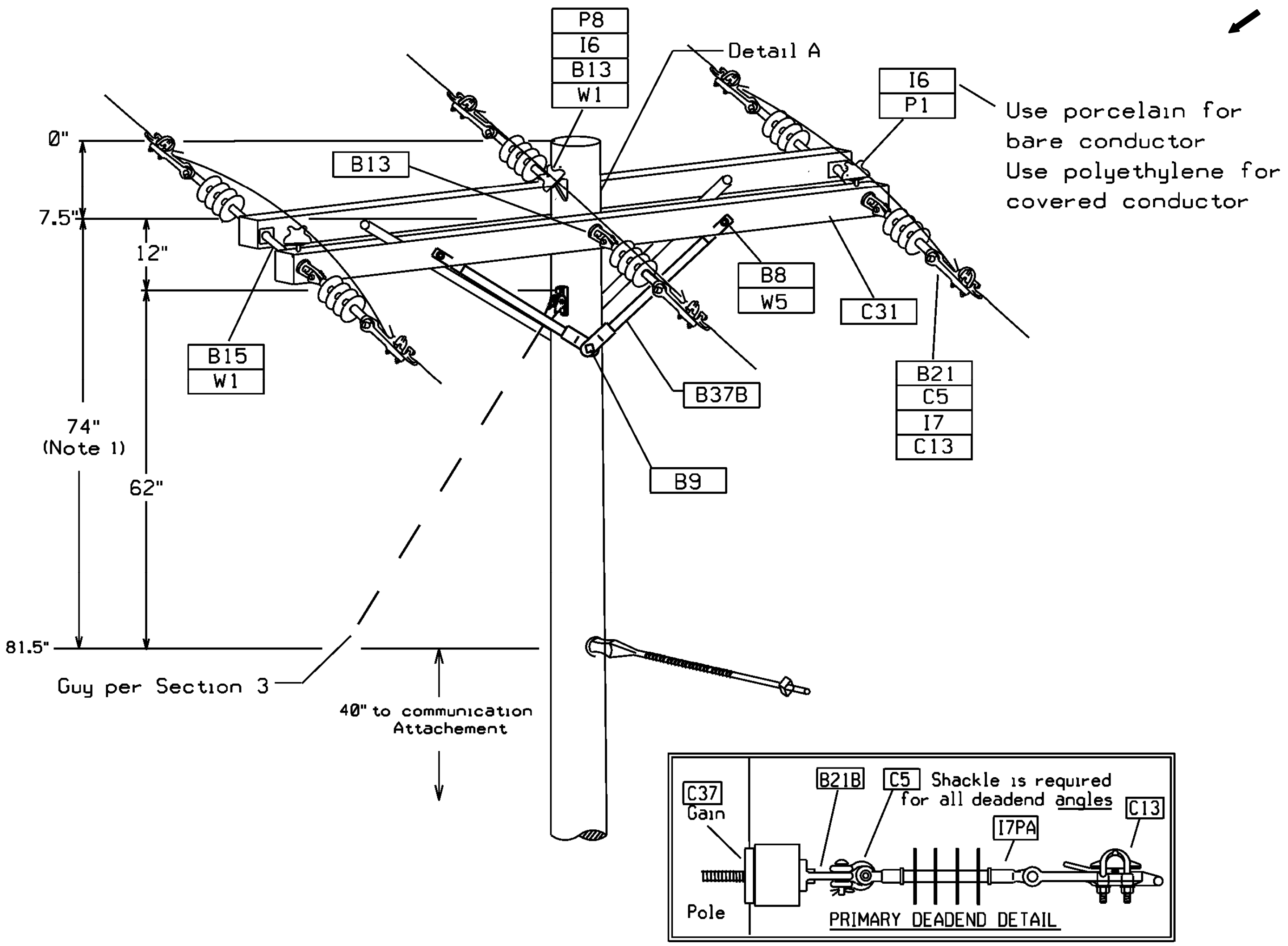
NOTES

1. This clearance can be reduced to a minimum of 48” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

1Φ (DELTA) AND 3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV CROSSINGS 11° - 45° / ANGLES - 21° - 45°			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/11	9-414		

MU = @9-415A	0-15KV 3Φ - Bare	MU = @9-415ACL	0-15KV 3Φ - Covered
MU = @9-415B	0-15KV 1Φ - Bare	MU = @9-415BCL	0-15KV 1Φ - Covered

Supersedes 7/07 Issue – removed guying materials; edited notes; revised drawing title.



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	45 JT-111"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	45 JT-111"	255	185	175
86	45 JT-111"	300	--	--
106	45 JT-111"	--	240	--
107	45 JT-111"	--	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

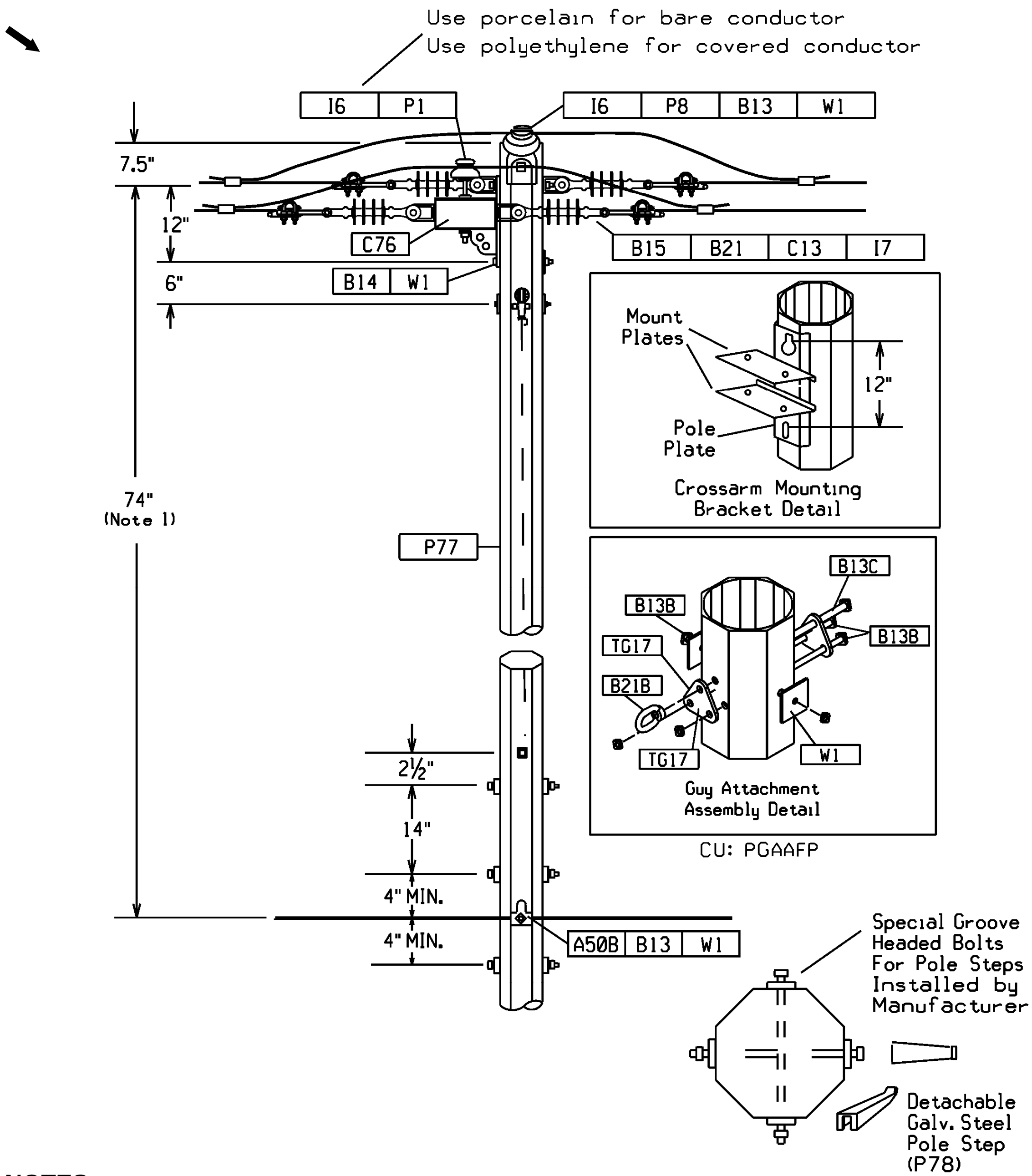
NOTES

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

1Φ (DELTA) AND 3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV 46° - 60° ANGLES / BACK-TO-BACK DEADENDS (TANGENT)			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 9-415	ISSUE 7/11

 Doc. # ST. 09.00.005

MU = @9-415AF	0-15KV 3Φ - Bare	MU = @9-415AFCL	0-15KV 3Φ - Covered
MU = @9-415BF	0-15KV 1Φ - Bare	MU = @9-415BFCL	0-15KV 1Φ - Covered



Supersedes 7/08 Issue - removed guying materials; edited notes; corrected guying detail Std Item #s; revised drawing title.

NOTES:

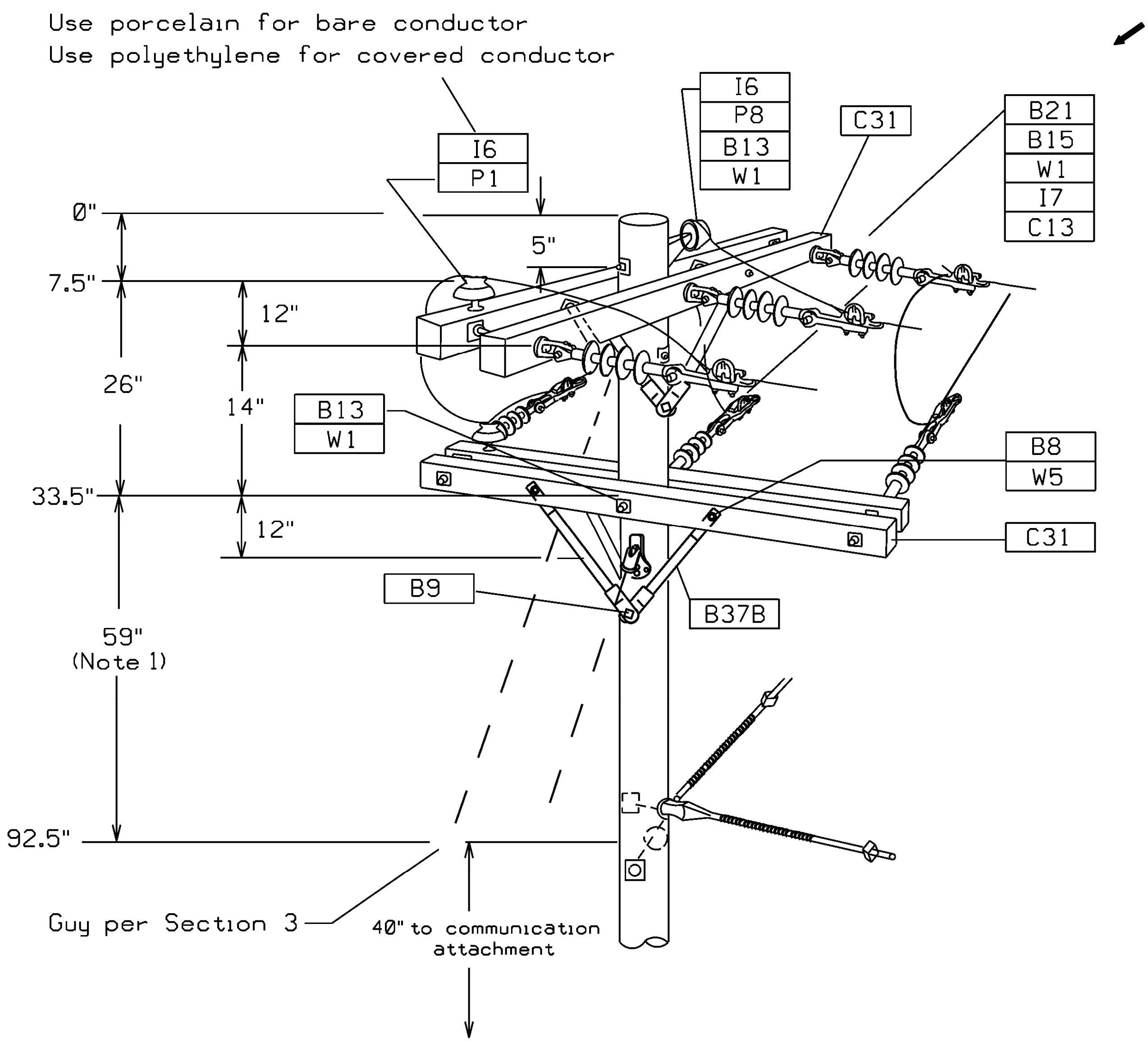
1. This clearance can be reduced to a minimum of 60” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. Detachable steel pole steps maybe left installed while maintaining an 8 foot minimum from ground level.
3. If grounding is necessary, install down ground & molding with appropriate grounding kit (Std Item S34) which includes nylon clips and self tapping screws. Place clips approximately 12”-18” apart.
4. Install 12.5M maximum guy wire. If 25M is required, install 2 separate 12.5M guys.
5. For single phase delta circuit construction, omit the center phase.

FIBERGLASS 1Φ (DELTA) AND 3Φ CROSSARM POLE TOP – 0-15 kV CROSSINGS 0° - 60° / ANGLES 21° - 60° / BACK-TO-BACK DEADENDS (TANGENT)			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/11	9-415F		

 Doc. # ST. 09.00.005

MU = @9-416A	0-15KV 3Φ - Bare	MU = @9-416ACL	0-15KV 3Φ - Covered
MU = @9-416B	0-15KV 1Φ - Bare	MU = @9-416BCL	0-15KV 1Φ - Covered

Supersedes 7/07 Issue – removed guying materials; edited notes; revised drawing title.



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
92.5	45 JT-111"	185	--	--
92.5	45 JT-111"	--	185	--
97.5	45 JT-111"	--	--	180
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
103.5	45 JT-111"	255	--	--
108.5	45 JT-111"	--	185	--
108.5	45 JT-111"	--	--	175
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

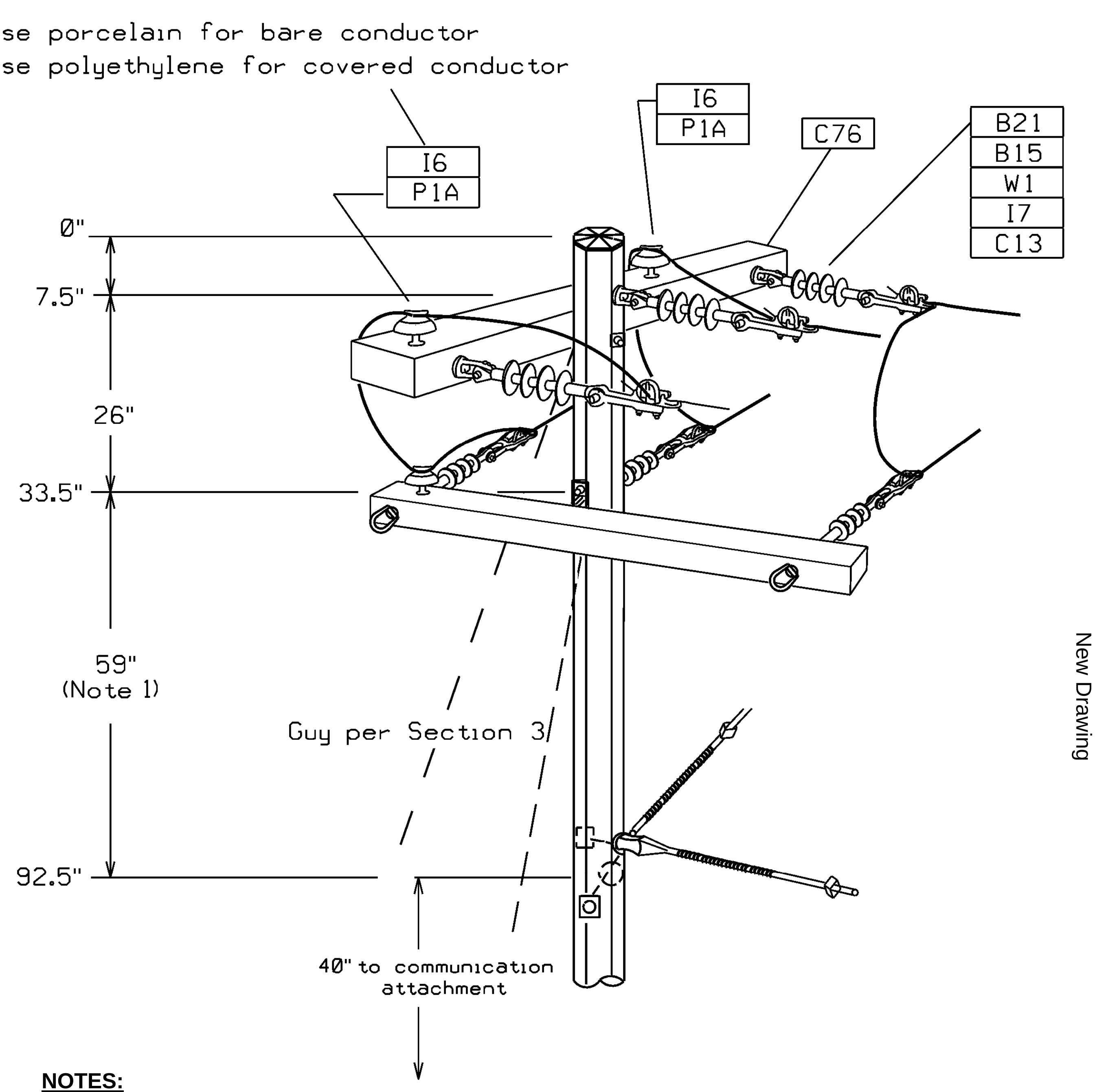
NOTES

1. This clearance can be reduced to a minimum of 56" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

1Φ (DELTA) AND 3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV ANGLES 61° - 90° AND DEADENDS			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		9-416	7/11

 Doc. # ST. 09.00.005

MU = @9-416AF	0-15KV 3Φ - Bare	MU = @9-416AFCL	0-15KV 3Φ - Covered
MU = @9-416BF	0-15KV 1Φ - Bare	MU = @9-416BFCL	0-15KV 1Φ - Covered

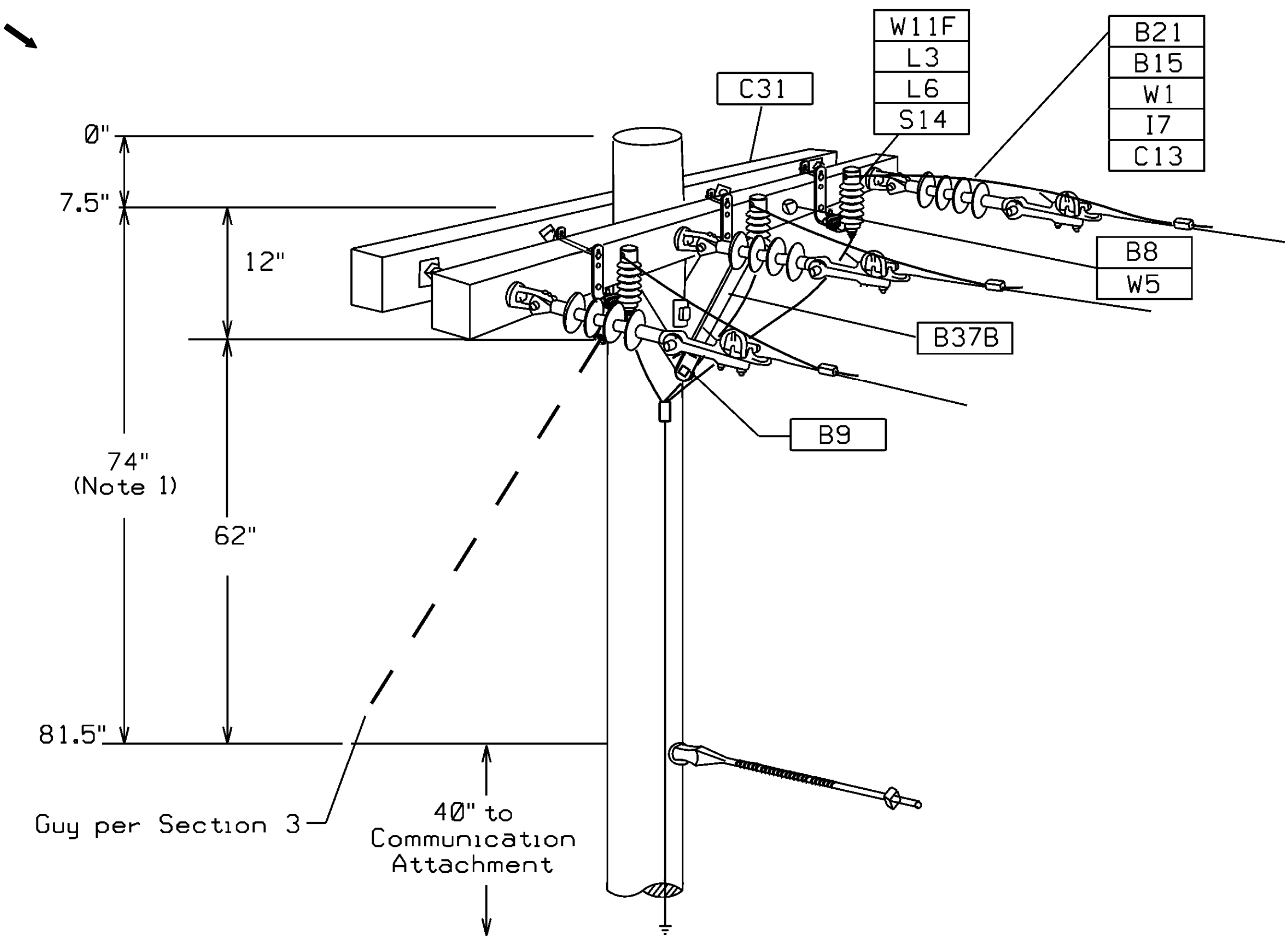


NOTES:

1. This clearance can be reduced to a minimum of 56" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. Detachable steel pole steps maybe left installed while maintaining an 8 foot minimum from ground level.
3. If grounding is necessary, install down ground & molding with appropriate grounding kit (Std Item S34) which includes nylon clips and self tapping screws. Place clips approximately 12"-18" apart.
4. Install 12.5M maximum guy wire. If 25M is required, install 2 separate 12.5M guys. The first guy in each direction can be placed on the crossarm bracket (see 9-417F for a side view of the fiberglass crossarm with a guy wire installed).
5. For single phase delta circuit construction, omit the center phase.

 Doc. # ST. 09.00.005

MU = @9-417A	0-15KV 3Φ - Bare	MU = @9-417ACL	0-15KV 3Φ - Covered
MU = @9-417B	0-15KV 1Φ - Bare	MU = @9-417BCL	0-15KV 1Φ - Covered



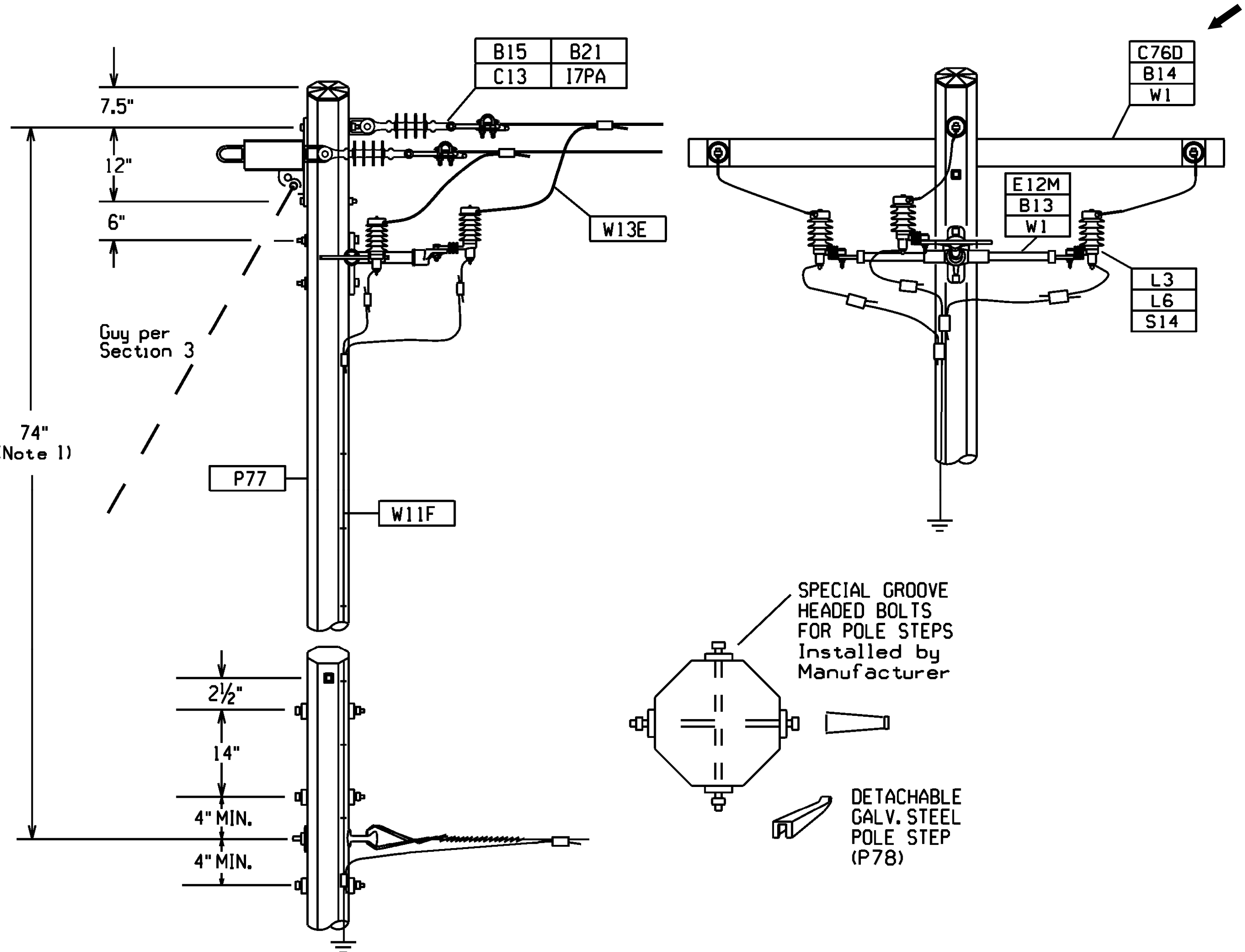
Supersedes 7/07 Issue – removed guying materials; edited notes; revised drawing title.

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	185	175
86	45 JT-111"	300	--	--
106	45 JT-111"	--	240	--
107	45 JT-111"	--	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

NOTES

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phase.

MU = @9-417AF	0-15KV 3Φ - Bare	MU = @9-417AFCL	0-15KV 3Φ - Covered
MU = @9-417BF	0-15KV 1Φ - Bare	MU = @9-417BFCL	0-15KV 1Φ - Covered

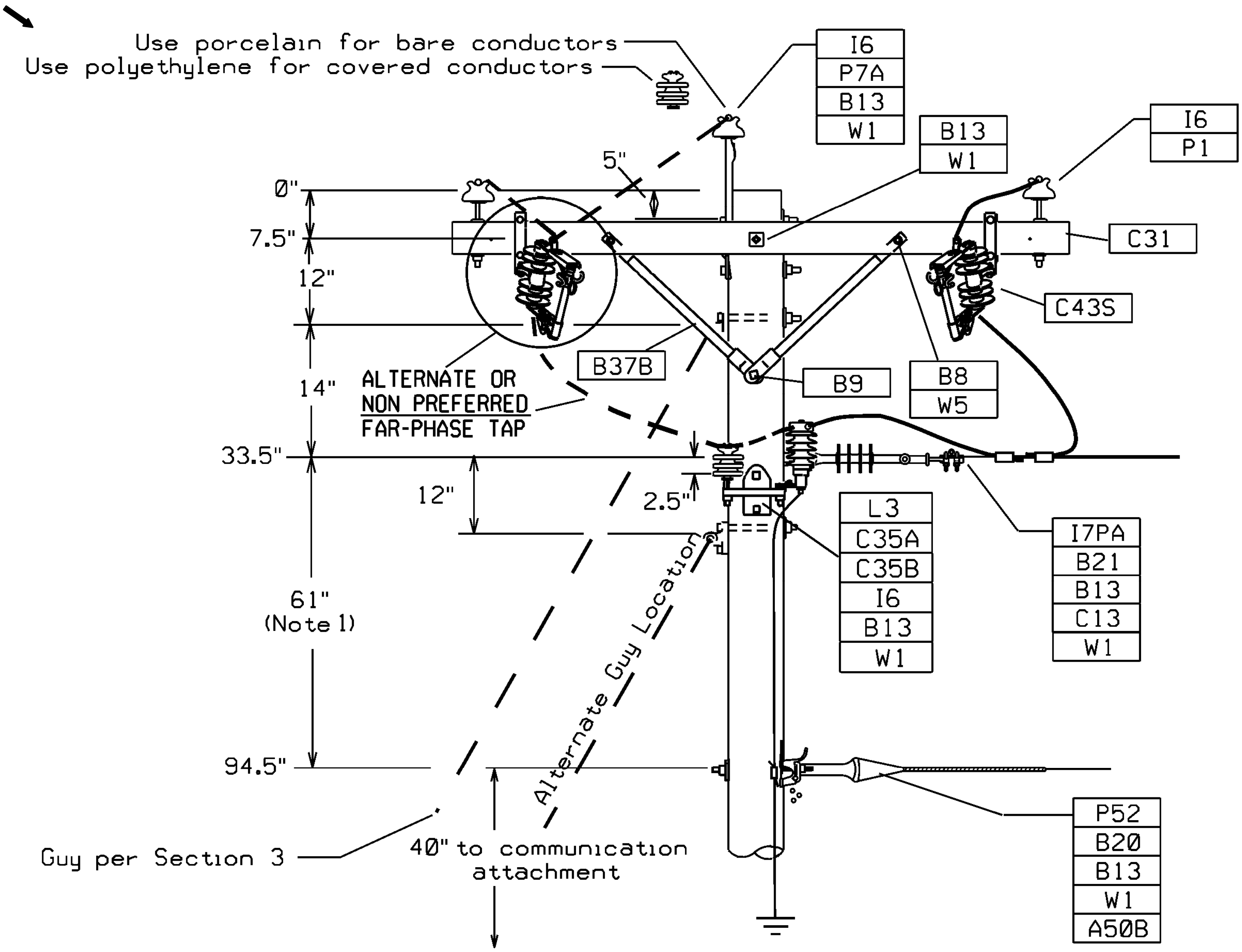


Supersedes 7/08 Issue - removed guying materials; edited notes; revised drawing title.

NOTES:
1. This clearance can be reduced to a minimum of 54” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. Detachable steel pole steps maybe left installed while maintaining an 8 foot minimum from ground level.
3. If grounding is necessary, install down ground & molding with appropriate grounding kit (Std Item S34) which includes nylon clips and self tapping screws. Place clips approximately 12”-18” apart.
4. Install 12.5M maximum guy wire. If 25M is required, install 2 separate 12.5M guys.
5. For single phase delta circuit construction, omit the center phase.

 Doc. # ST. 09.00.005

MU = @9-419F1A	0-15KV 3Φ - Bare	MU = @9-419F1ACL	0-15KV 3Φ - Covered
MU = @9-419F1B	0-15KV 1Φ - Bare	MU = @9-419F1BCL	0-15KV 1Φ - Covered



Supersedes 7/07 Issue – removed guying materials; edited notes; added arrester and cutout for tap; edited drawing title.

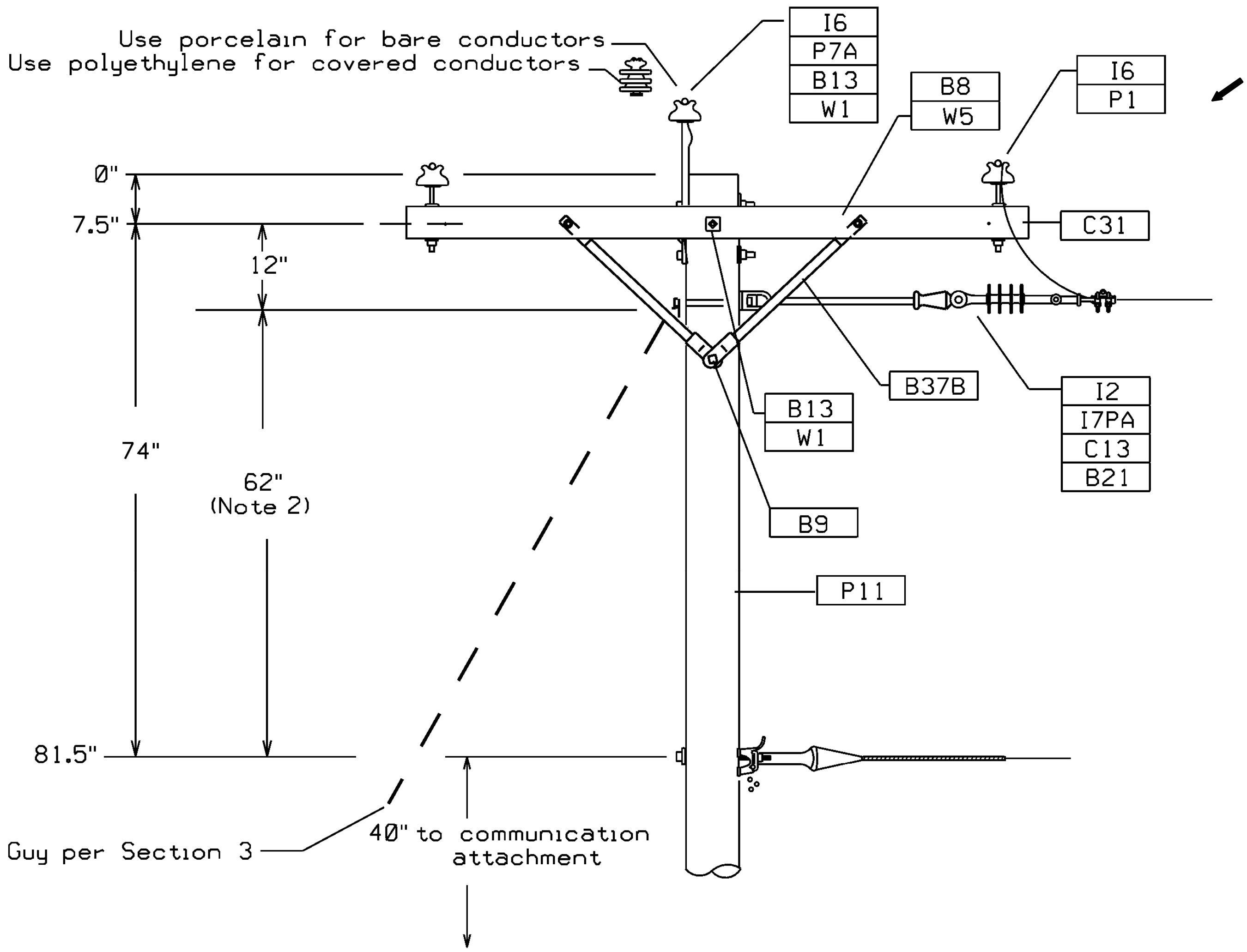
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	180	180	180	180
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
94.5	45 JT-111"	--	--	--	207
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

NOTES:

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

3Φ CROSSARM POLE TOP – 0-15 kV – (PREFERRED) 0° - 10° – TAP TO 1Φ ARMLESS			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/11	9-419 FIG 1		

MU = @9-419F2A	0-15KV 3Φ - Bare	MU = @9-419F2ACL	0-15KV 3Φ - Covered
MU = @9-419F2B	0-15KV 1Φ - Bare	MU = @9-419F2BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135	135
81.5	45 JT-111"	220	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	195	186	210
81.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
81.5	45 JT-111"	--	--	--	210
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

Supersedes 7/07 Issue – removed guying materials; updated notes; edited drawing title.

NOTES:

1. If this configuration is needed, the fused cutout and arrester for the tap **must** be placed on the next pole down the tap. Otherwise, Drawing 9-419 FIG1 shall be used.
2. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

3Φ CROSSARM POLE TOP – 0-15 kV (ALTERNATE)
0° - 10° – TAP TO 1Φ ARMLESS

Drawing 9-420 has been removed.

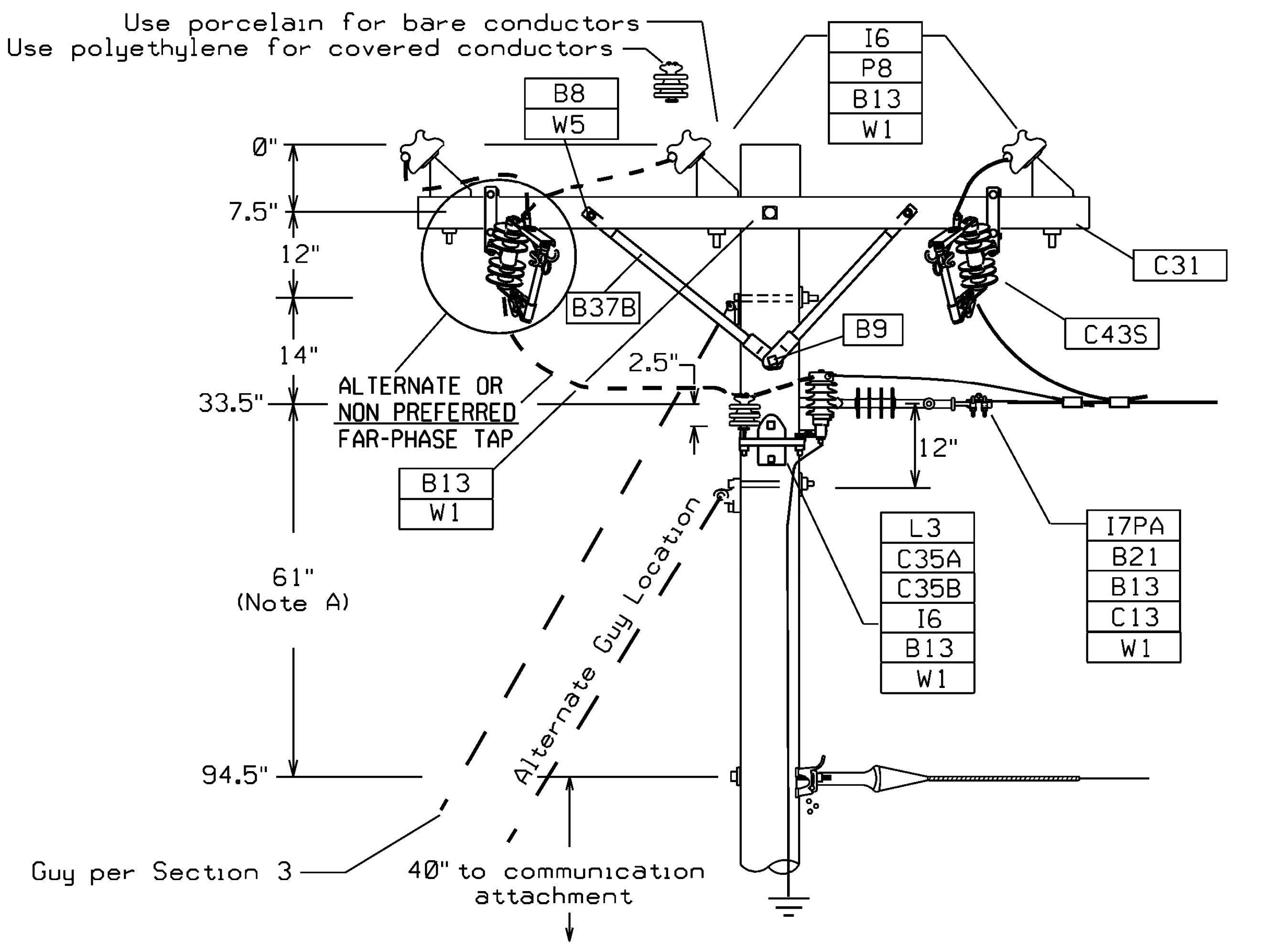
Refer to Drawing 9-435.

Supersedes 7/07 Issue - drawing no longer needed - refer to 9-435.

 Doc. # ST. 09.00.005

Supersedes 7/07 Issue – moved center phase to crossarm; removed guying materials; edited notes; added arrester and cutout for tap; edited drawing title.

MU = @9-421F1A	0-15KV 3Φ - Bare	MU = @9-421F1ACL	0-15KV 3Φ - Covered
MU = @9-421F1B	0-15KV 1Φ - Bare	MU = @9-421F1BCL	0-15KV 1Φ - Covered



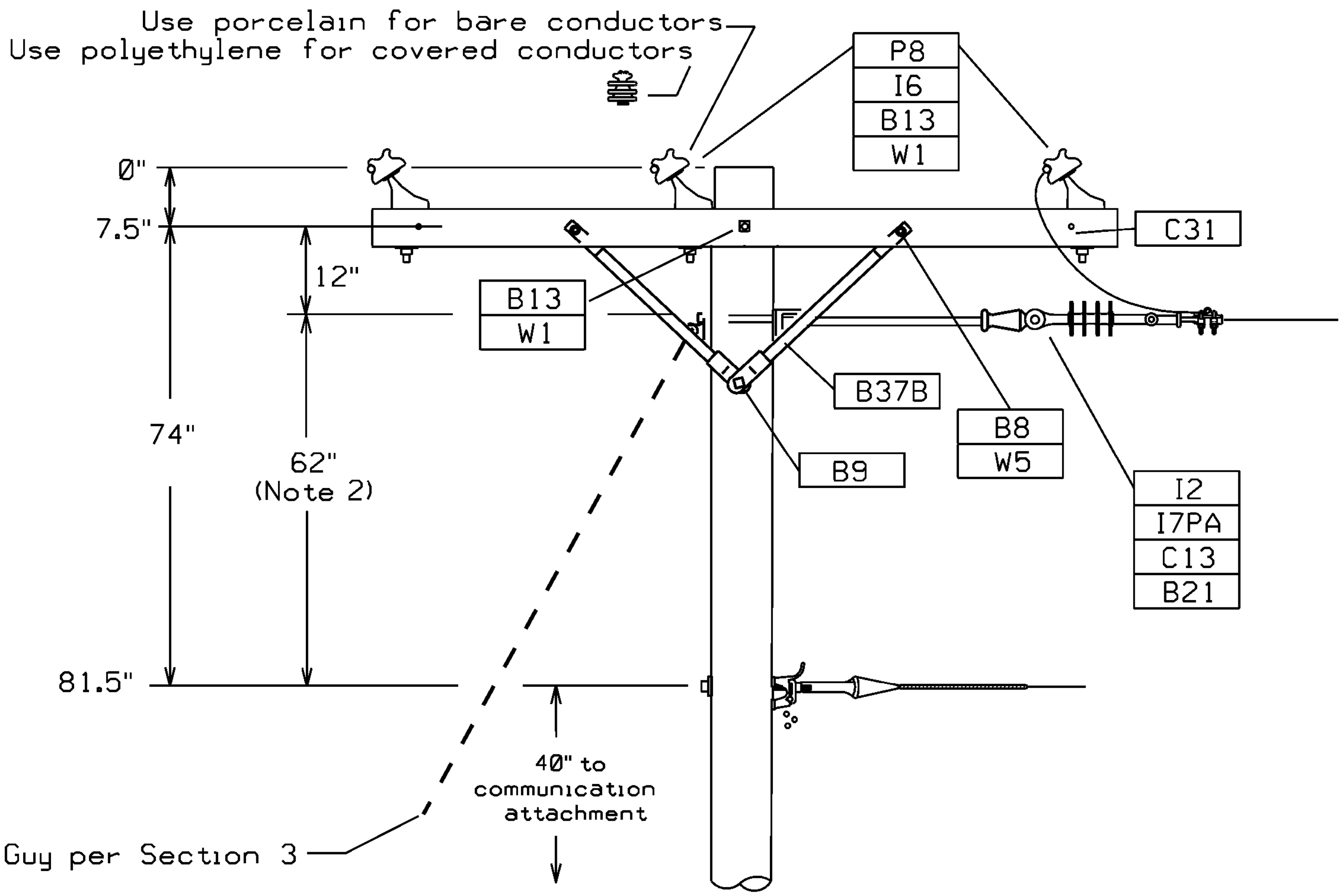
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	180	180	180	180
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
94.5	45 JT-111"	--	--	--	207
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

NOTES:

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

Doc. # ST. 09.00.005

MU = @9-421F2A	0-15KV 3Φ - Bare	MU = @9-421F2ACL	0-15KV 3Φ - Covered
MU = @9-421F2B	0-15KV 1Φ - Bare	MU = @9-421F2BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135	135
81.5	45 JT-111"	220	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	195	186	210
81.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
81.5	45 JT-111"	--	--	--	210
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

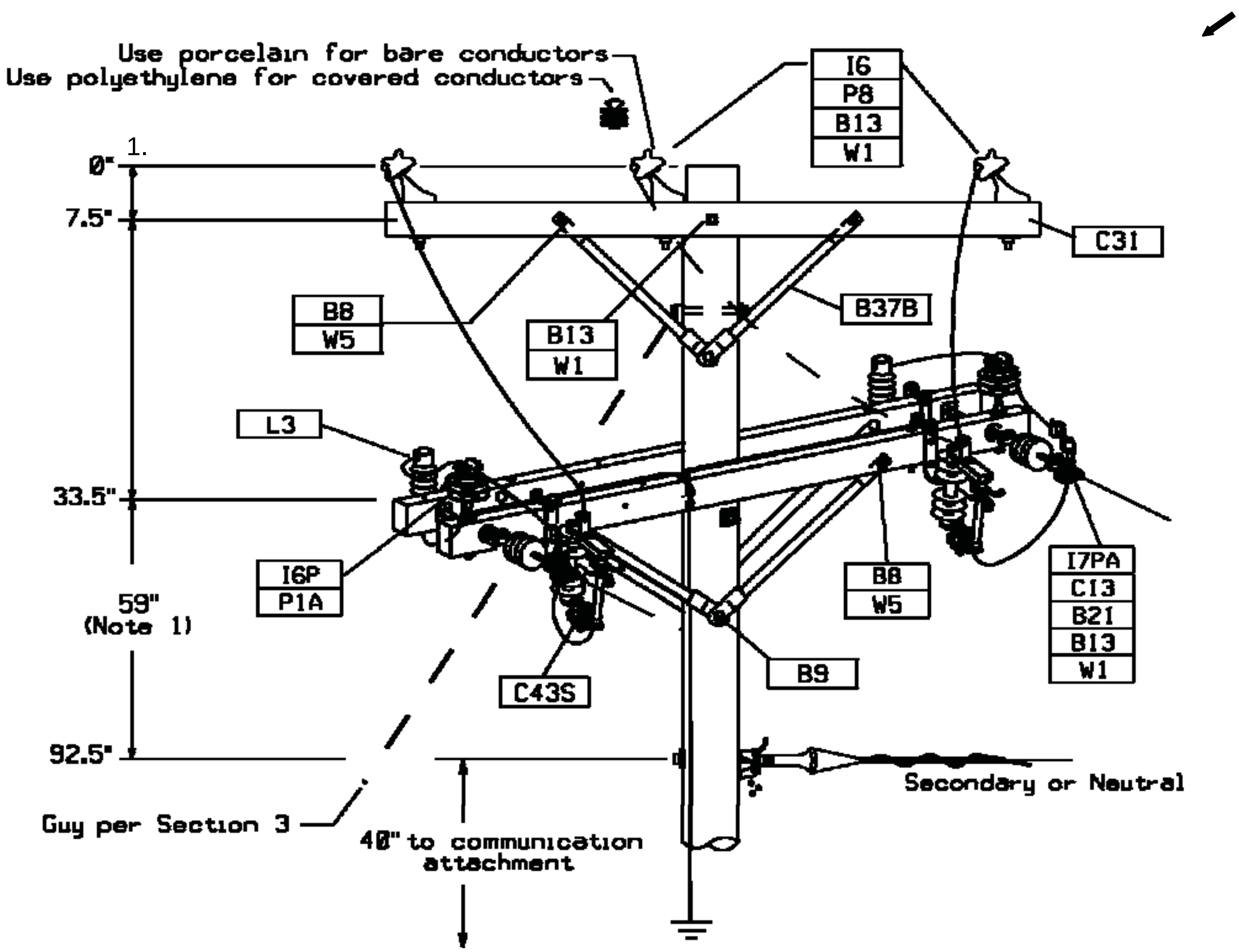
Supersedes 7/07 Issue – moved center phase to crossarm; removed guying materials; edited notes; edited drawing title.

NOTES:

1. If this configuration is needed, the fused cutout and arrester for the tap **must** be placed on the next pole down the tap. Otherwise, Drawing 9-421 FIG1 shall be used.
2. This clearance can be reduced to a minimum of 56" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

MU = @9-422A	0-5KV 3Φ - Bare	MU = @9-422ACL	0-5KV 3Φ - Covered
MU = @9-422B	0-5KV 1Φ - Bare	MU = @9-422BCL	0-5KV 1Φ - Covered

Supersedes 7/11 Issue – Moved cutouts to bottom Crossarms.



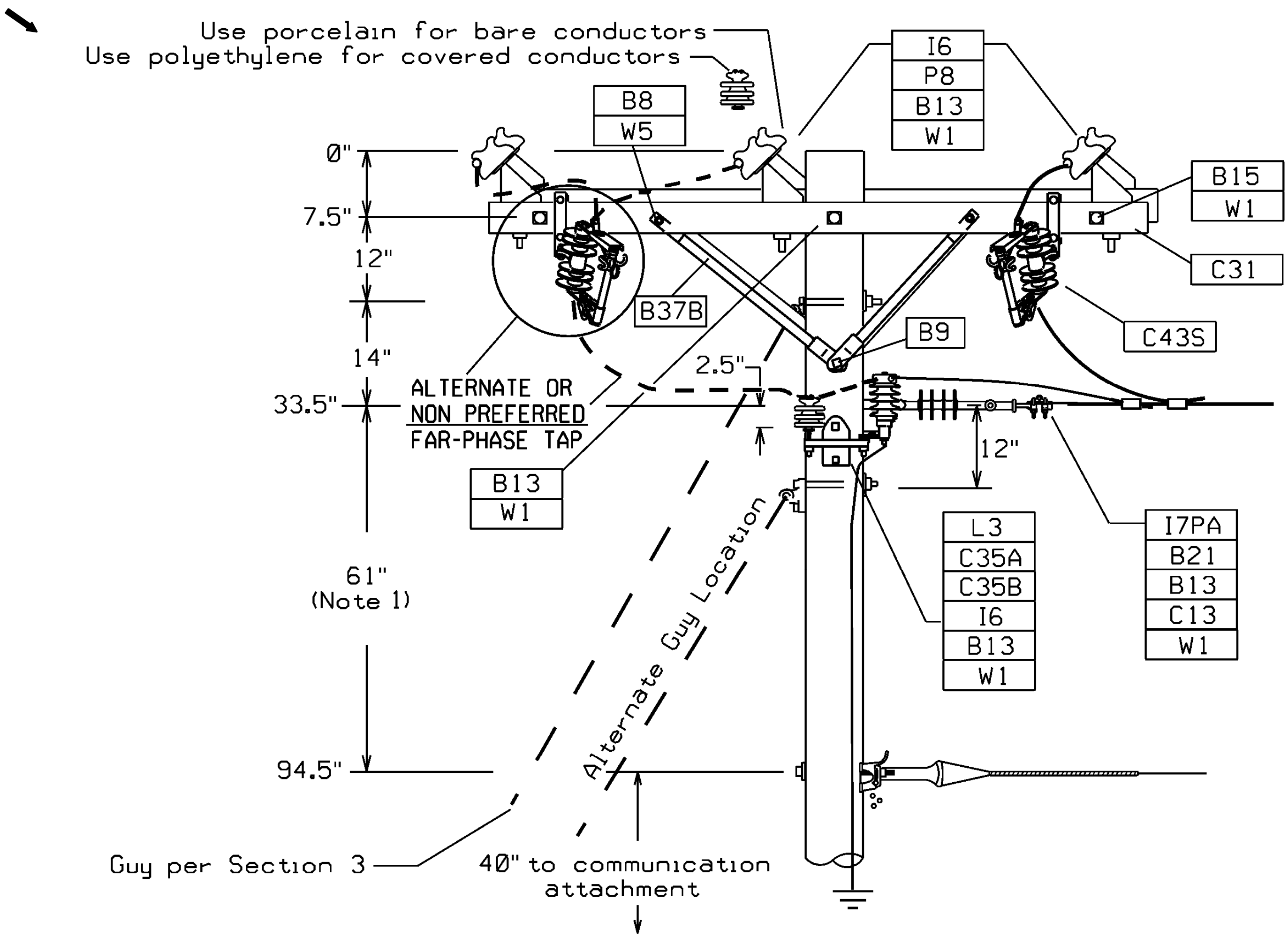
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135	100
81.5	45 JT-111"	220	220	220	100
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	195	186	80
81.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
81.5	45 JT-111"	--	--	--	85
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

NOTES:

1. This clearance can be reduced to a minimum of 56" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta main line, omit center phase on top crossarm.

MU = @9-423F1A	0-15KV 3Φ - Bare	MU = @9-423F1ACL	0-15KV 3Φ - Covered
MU = @9-423F1B	0-15KV 1Φ - Bare	MU = @9-423F1BCL	0-15KV 1Φ - Covered

Supersedes 7/07 Issue – moved center phase to crossarm; removed guying materials; edited notes; added arrester and cutout for tap; edited drawing title.



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	180	180	180	180
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
94.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
94.5	45 JT-111"	--	--	--	207
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

NOTES:

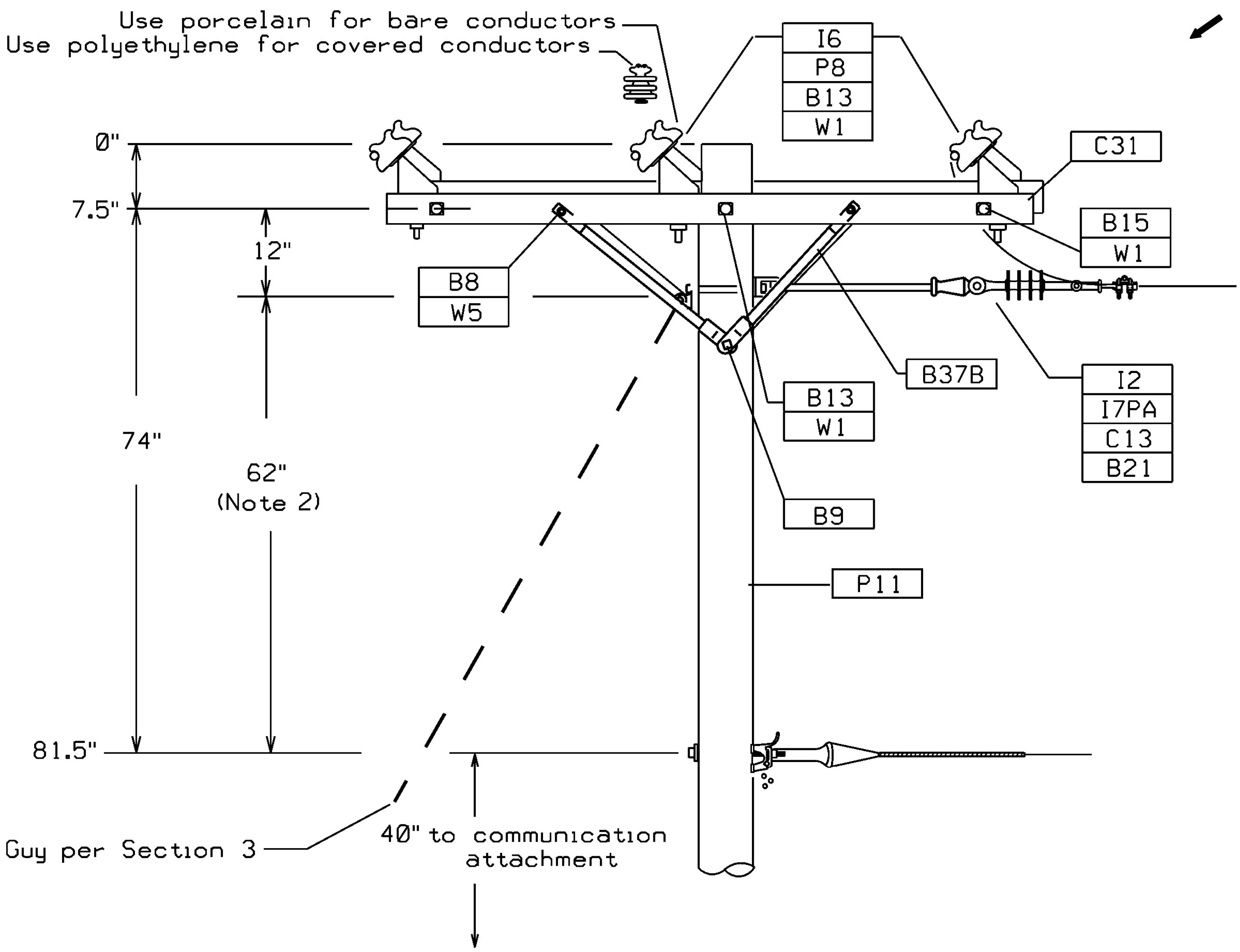
1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV (PREFERRED) CROSSINGS 11° - 45° / ANGLES - 21° - 45° – TAP TO 1Φ ARMLESS

ISSUE	PAGE NUMBER		
7/11	9-423 FIG 1	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

 Doc. # ST. 09.00.005

MU = @9-423F2A	0-15KV 3Φ - Bare	MU = @9-423F2ACL	0-15KV 3Φ - Covered
MU = @9-423F2B	0-15KV 1Φ - Bare	MU = @9-423F2BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135	135
81.5	45 JT-111"	220	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	195	186	210
81.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
81.5	45 JT-111"	--	--	--	210
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

NOTES:

1. If this configuration is needed, the fused cutout and arrester for the tap **must** be placed on the next pole down the tap. Otherwise, Drawing 9-423 FIG1 shall be used.
2. This clearance can be reduced to a minimum of 56" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

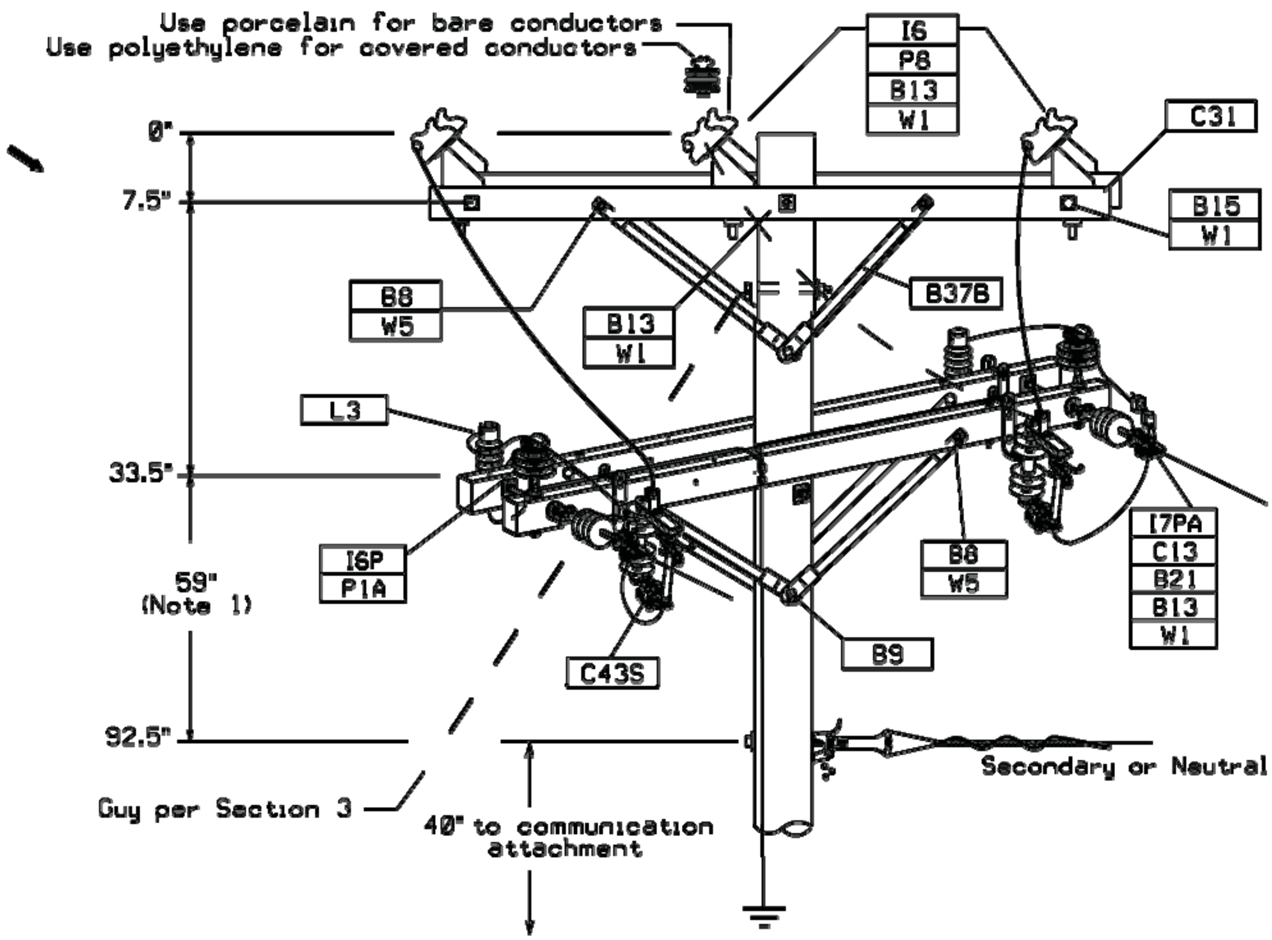
Supersedes 7/07 Issue – moved center phase to crossarm; removed guying materials; edited notes; edited drawing title.

3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV (ALTERNATE)
CROSSINGS 11° - 45° / ANGLES - 21° - 45° – TAP TO 1Φ ARMLESS

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		9-423 FIG 2	7/11

 Doc. # ST. 09.00.005

MU = @9-424A	0-5KV 3Φ - Bare	MU = @9-424ACL	0-5KV 3Φ - Covered
MU = @9-424B	0-5KV 1Φ - Bare	MU = @9-424BCL	0-5KV 1Φ - Covered



Supersedes 7/11 Issue – Moved cutouts to bottom crossarms.

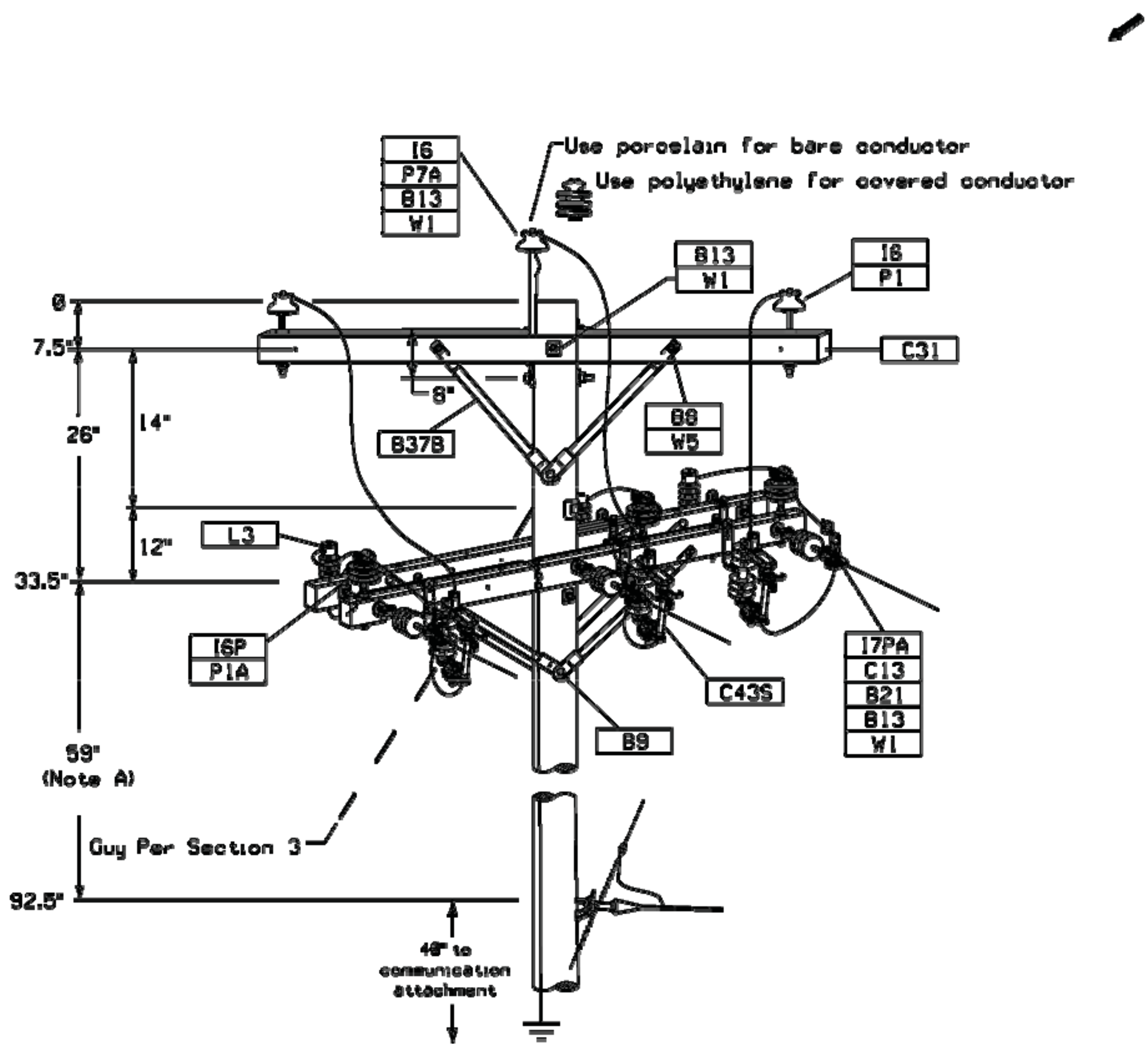
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	135	135	135	100
81.5	45 JT-111"	220	220	220	100
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
81.5	40 JT-84"	225	195	186	80
81.5	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
109	45 JT-111"	--	--	240	--
81.5	45 JT-111"	--	--	--	85
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

NOTES:

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta main line, omit center phase on top crossarm.

1Φ (DELTA) AND 3Φ DOUBLE CROSSARM POLE TOP – 0-15 kV CROSSINGS 11° - 45° / ANGLES - 21° - 45° – TAP TO 1Φ (DELTA) AND 2Φ (WYE)			
ISSUE	PAGE NUMBER	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities
7/13	9-424		

MU = @9-435A	0-15KV 3Φ - Bare	MU = @9-435ACL	0-15KV 3Φ - Covered
MU = @9-435B	0-15KV 1Φ - Bare	MU = @9-435BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
92.5	45 JT-111"	185	--	--
92.5	45 JT-111"	--	185	--
97.5	45 JT-111"	--	--	180
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
103.5	45 JT-111"	255	--	--
108.5	45 JT-111"	--	185	--
108.5	45 JT-111"	--	--	175
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

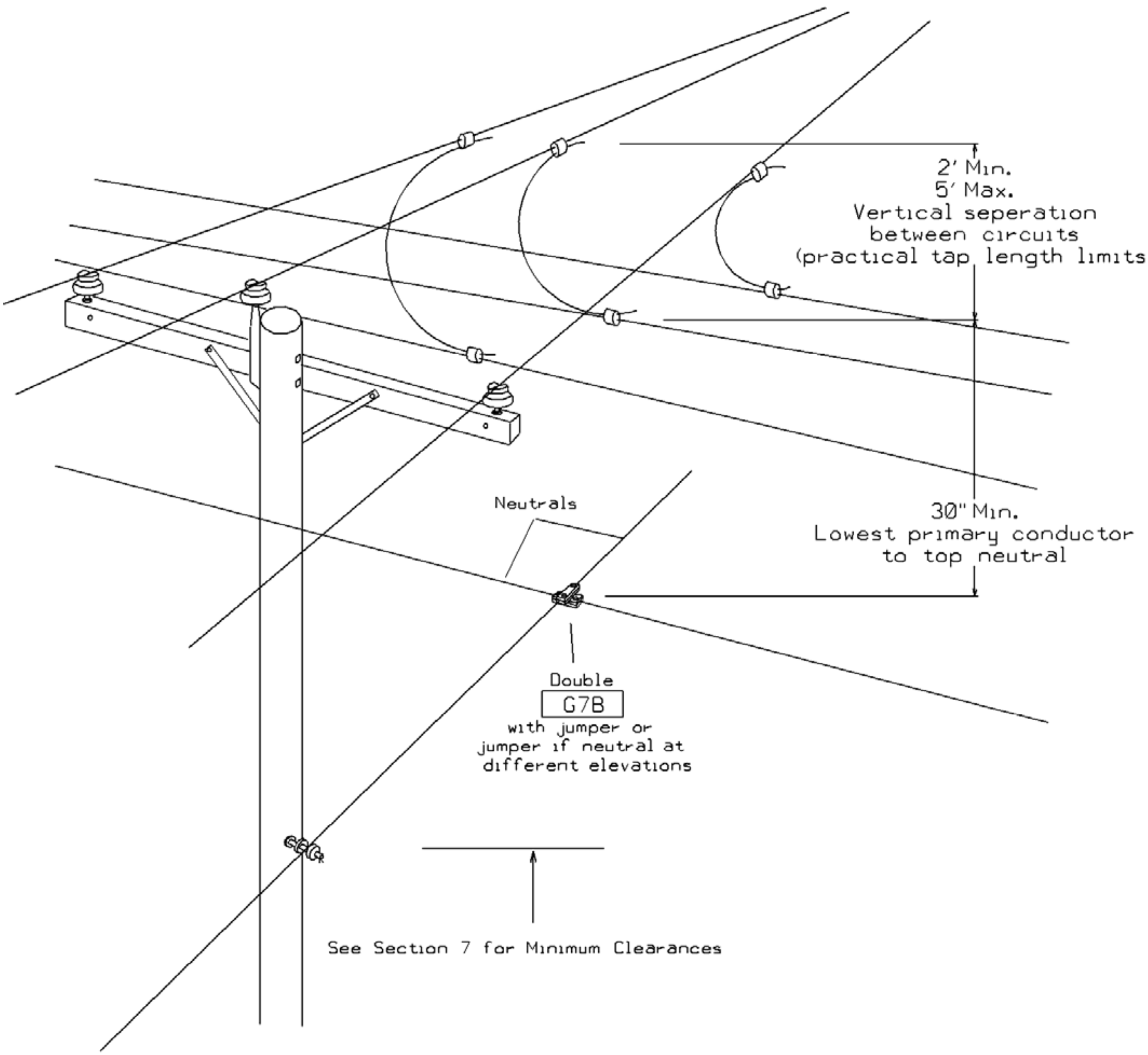
NOTES

1. This clearance can be reduced to a minimum of 56" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. For single phase delta circuit construction, omit the center phases.

Supersedes 7/07 Issue – removed guying materials; corrected top crossarm; added cutouts and arresters for taps; edited notes and drawing title..

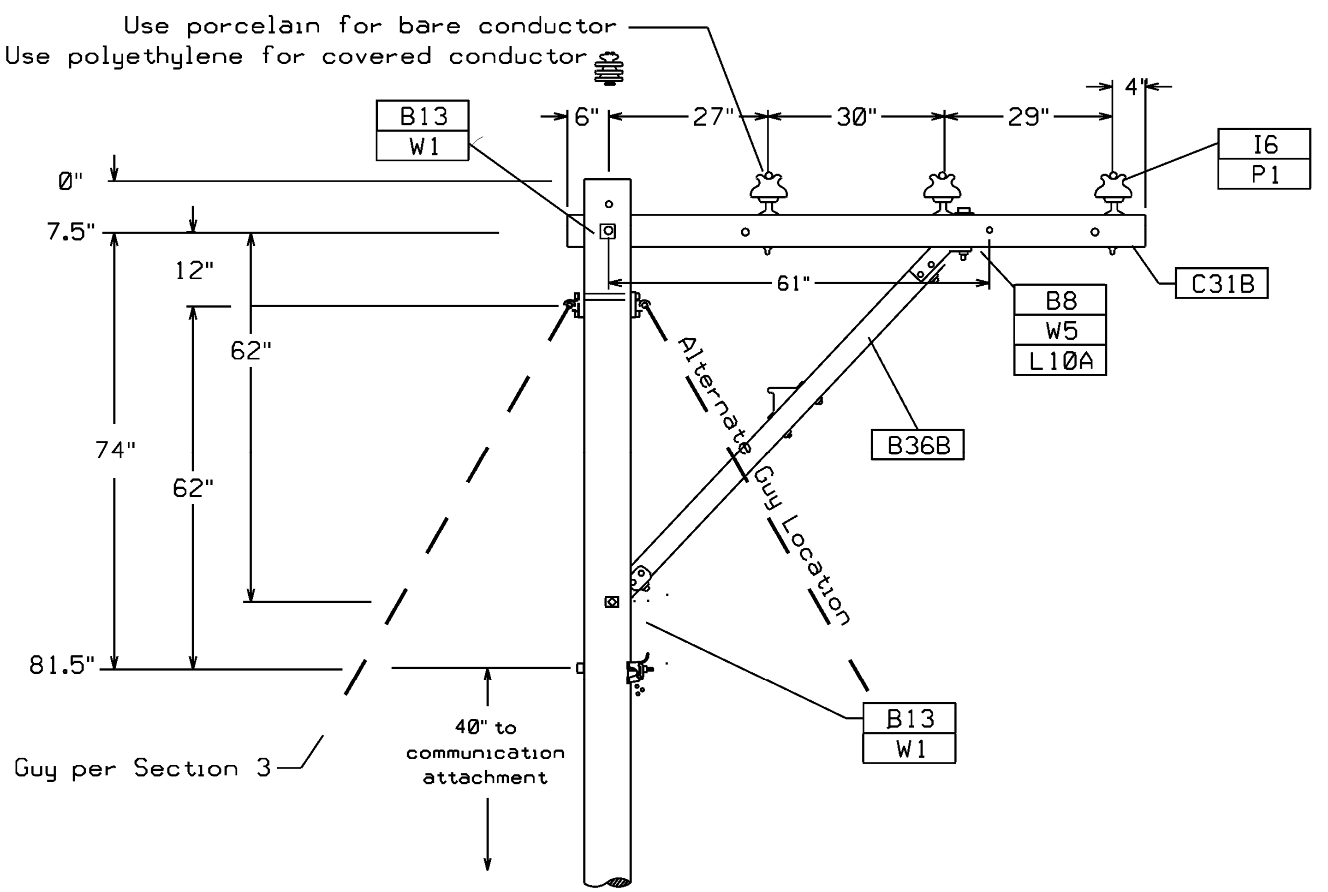
1Φ (DELTA) AND 3Φ CROSSARM POLE TOP – 0-15 kV – 0° - 10° – TAP TO 1Φ (DELTA) OR 3Φ CROSSARM			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		9-435	7/13

NOTES:
1. Midspan taps may be required where poles are set back at heavy intersections.
2. See Drawing 9-435 for standard 3-phase taps at the pole.
3. Refer to Page 9-105 for information on relative phase positioning.
4. Always wire brush the surface of conductors immediately before installing any type of connector.
5. See Section 5 for more details on connectors available.



Supersedes 7/07 Issue –Removed conductor Std Item #s; revised notes.

MU = @9-437A	0-15KV 3Φ - Bare	MU = @9-437ACL	0-15KV 3Φ - Covered
MU = @9-437B	0-15KV 1Φ - Bare	MU = @9-437BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

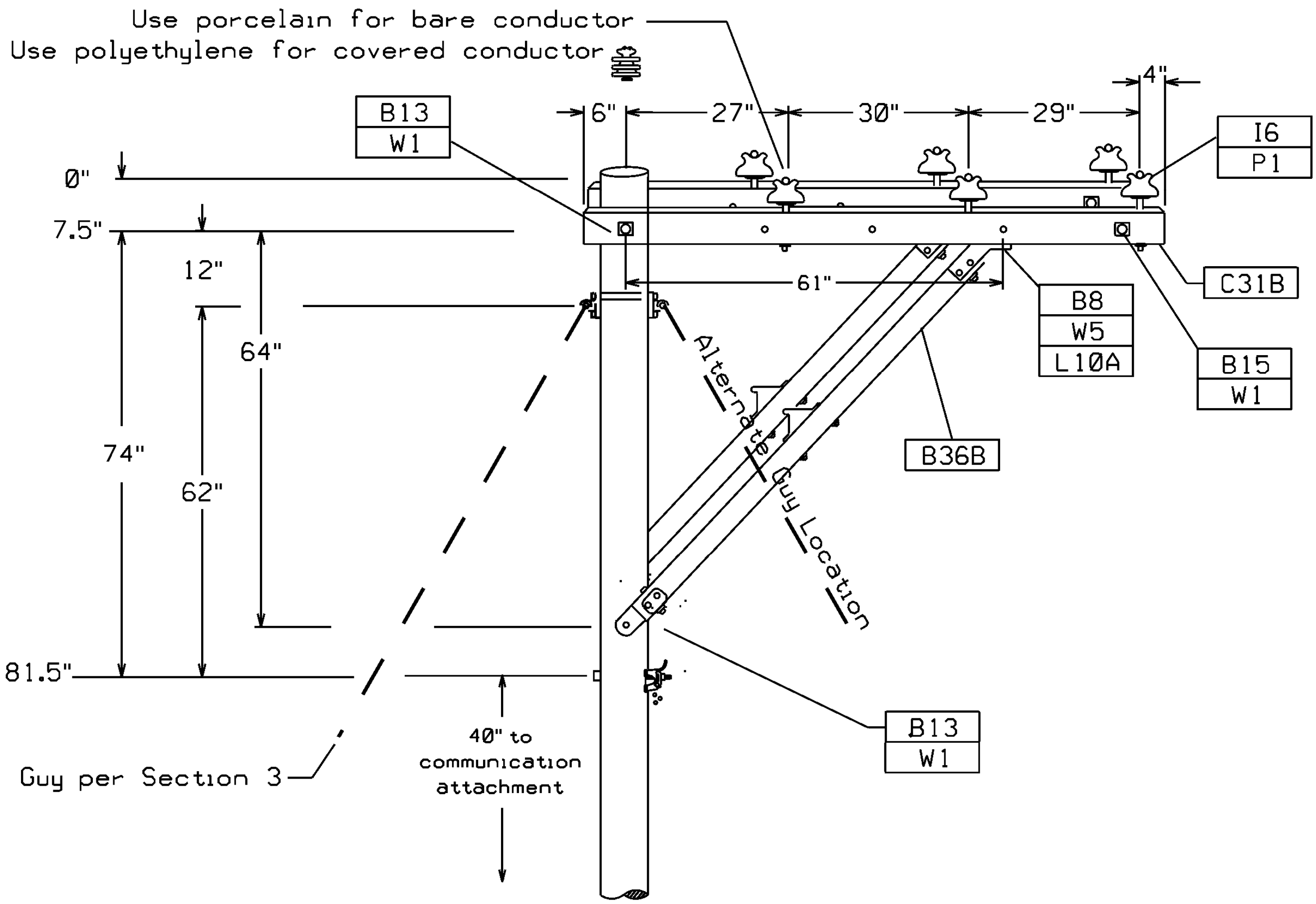
Supersedes 7/07 Issue – removed guying materials; edited notes; edited drawing title.

NOTES:

1. Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
2. For single phase delta, omit the center conductor.
3. Guying is not always necessary for in-line poles with offset arms unless calculated forces are exceeding pole strength (refer to Section 3 for guying information).
4. Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.

 Doc. # ST. 09.00.005

MU = @9-438A	0-15KV 3Φ - Bare	MU = @9-438ACL	0-15KV 3Φ - Covered
MU = @9-438B	0-15KV 1Φ - Bare	MU = @9-438BCL	0-15KV 1Φ - Covered



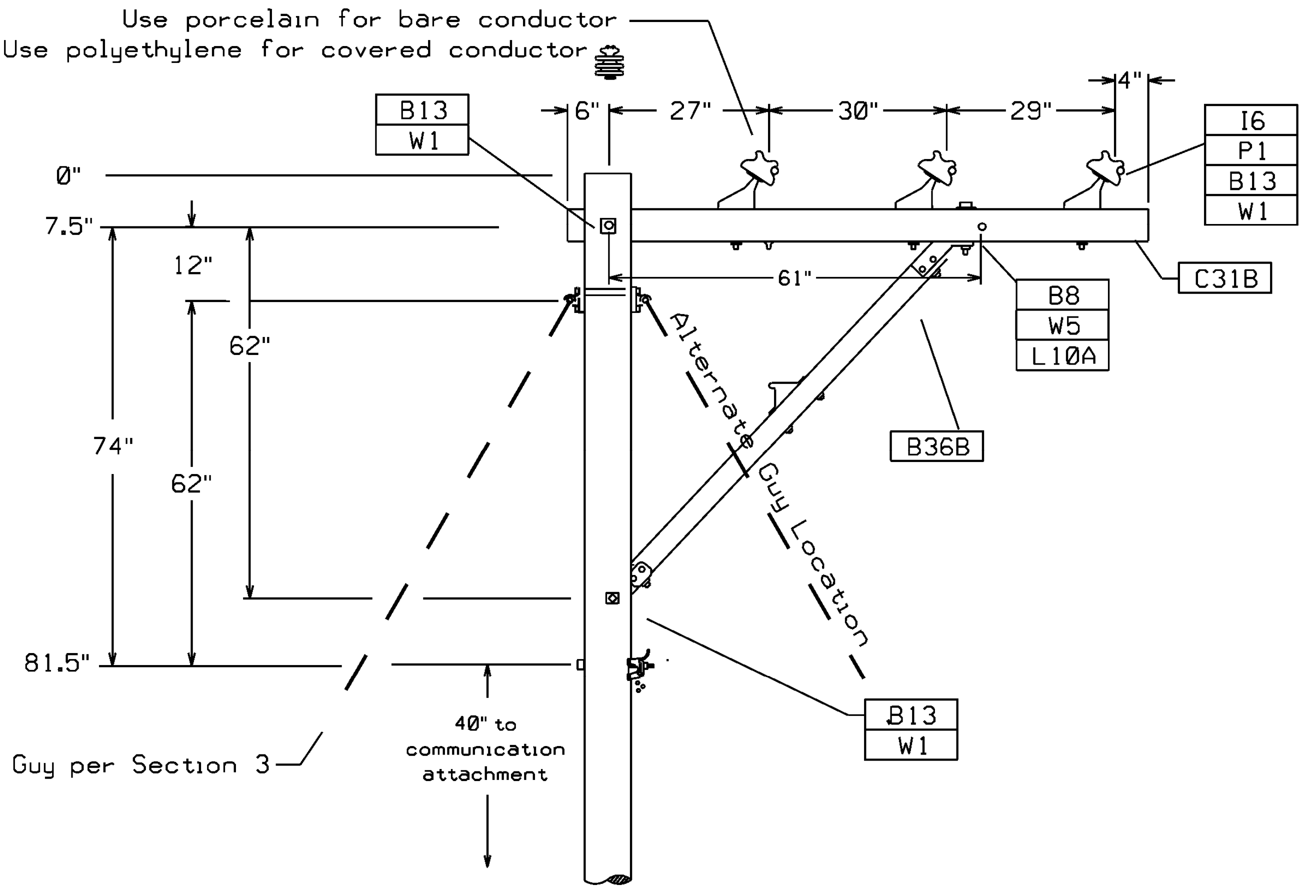
Supersedes 7/07 Issue – removed guying materials; edited notes; edited drawing title.

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

NOTES:

1. Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
2. For single phase delta, omit the center conductor.
3. Guying is not always necessary for in-line poles with offset arms unless calculated forces are exceeding pole strength (refer to Section 3 for guying information).
4. Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.

MU = @9-439A	0-15KV 3Φ - Bare	MU = @9-439ACL	0-15KV 3Φ - Covered
MU = @9-439B	0-15KV 1Φ - Bare	MU = @9-439BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

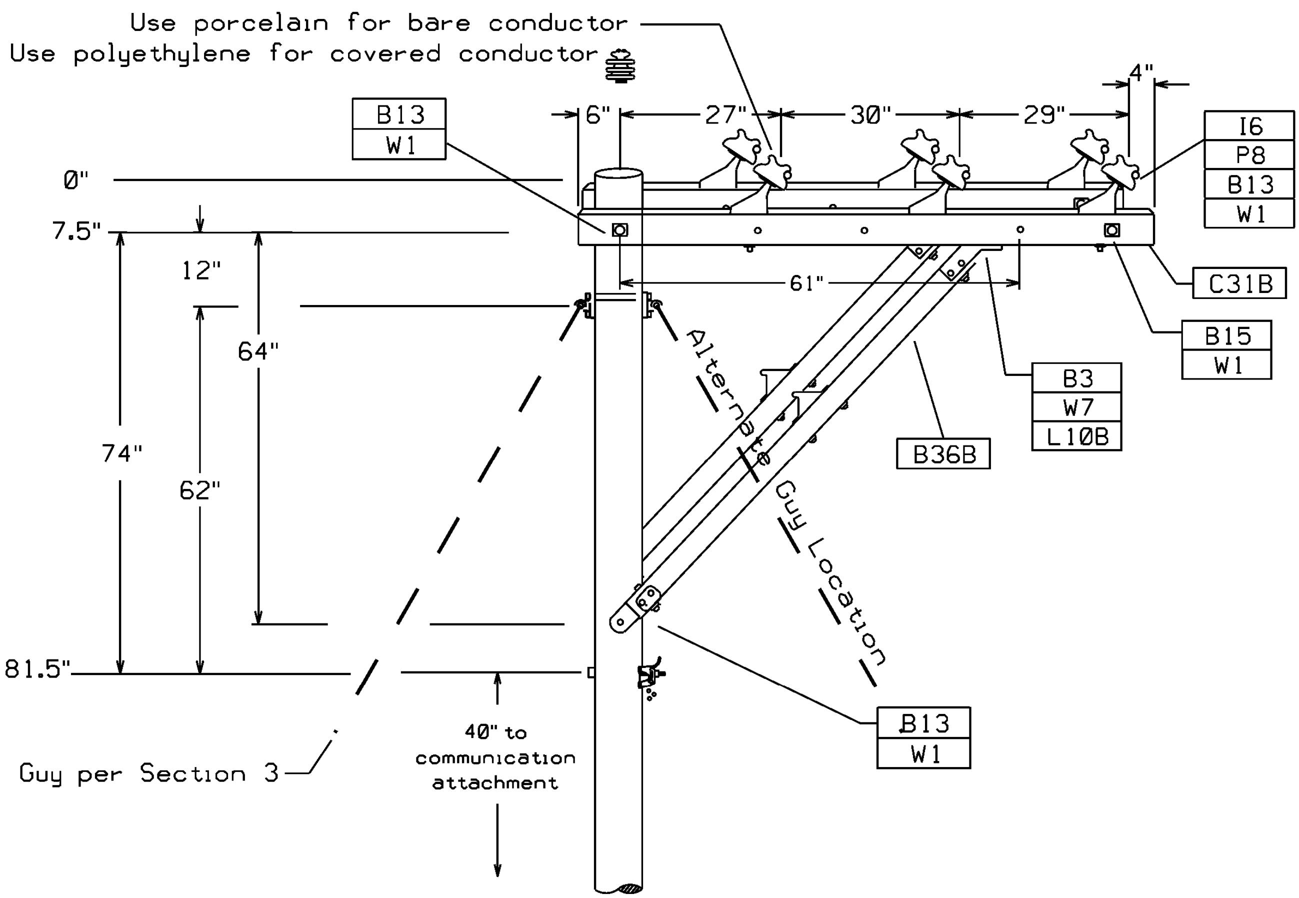
Supersedes 7/07 Issue – removed guying materials; edited notes; edited drawing title.

NOTES:

1. Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
2. For single phase delta, omit the center conductor.
3. Guying is not always necessary for in-line poles with offset arms unless calculated forces are exceeding pole strength (refer to Section 3 for guying information).
4. Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.

 Doc. # ST. 09.00.005

MU = @9-440A	0-15KV 3Φ - Bare	MU = @9-440ACL	0-15KV 3Φ - Covered
MU = @9-440B	0-15KV 1Φ - Bare	MU = @9-440BCL	0-15KV 1Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

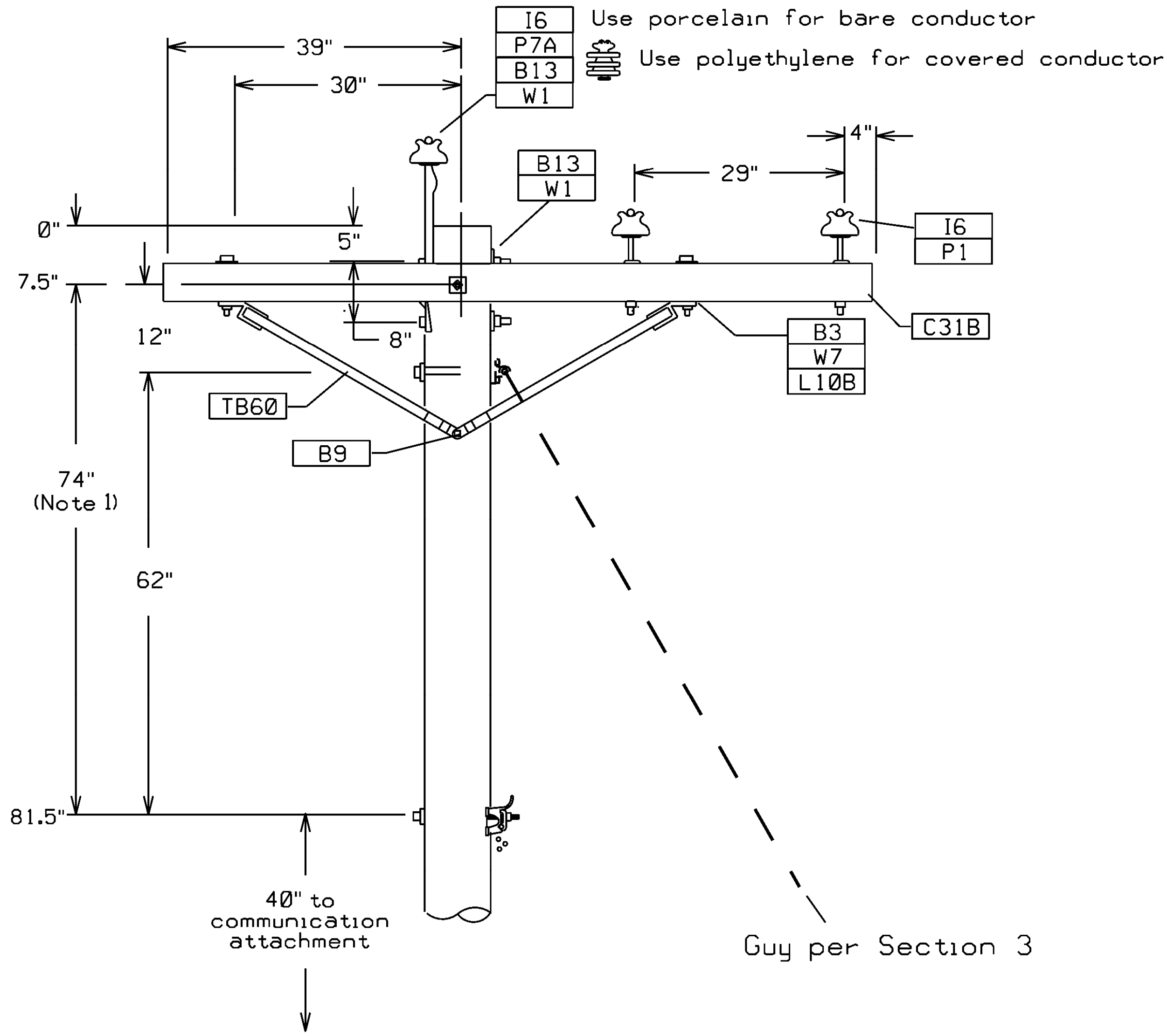
Supersedes 7/07 Issue – removed guying materials; edited notes; edited drawing title.

NOTES:

1. Alley arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
2. For single phase delta, omit the center conductor.
3. Guying is not always necessary for in-line poles with offset arms unless calculated forces are exceeding pole strength (refer to Section 3 for guying information).
4. Two or more adjacent poles with extension arms shall be used to reduce the excessive lateral stress.

MU = @9-441A	0-15KV 3Φ - Bare	MU = @9-441ACL	0-15KV 3Φ - Covered
MU = @9-441B	0-15KV 1Φ - Bare	MU = @9-441BCL	0-15KV 1Φ - Covered

Supersedes 7/07 Issue – removed guying materials; edited notes; edited drawing title.



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

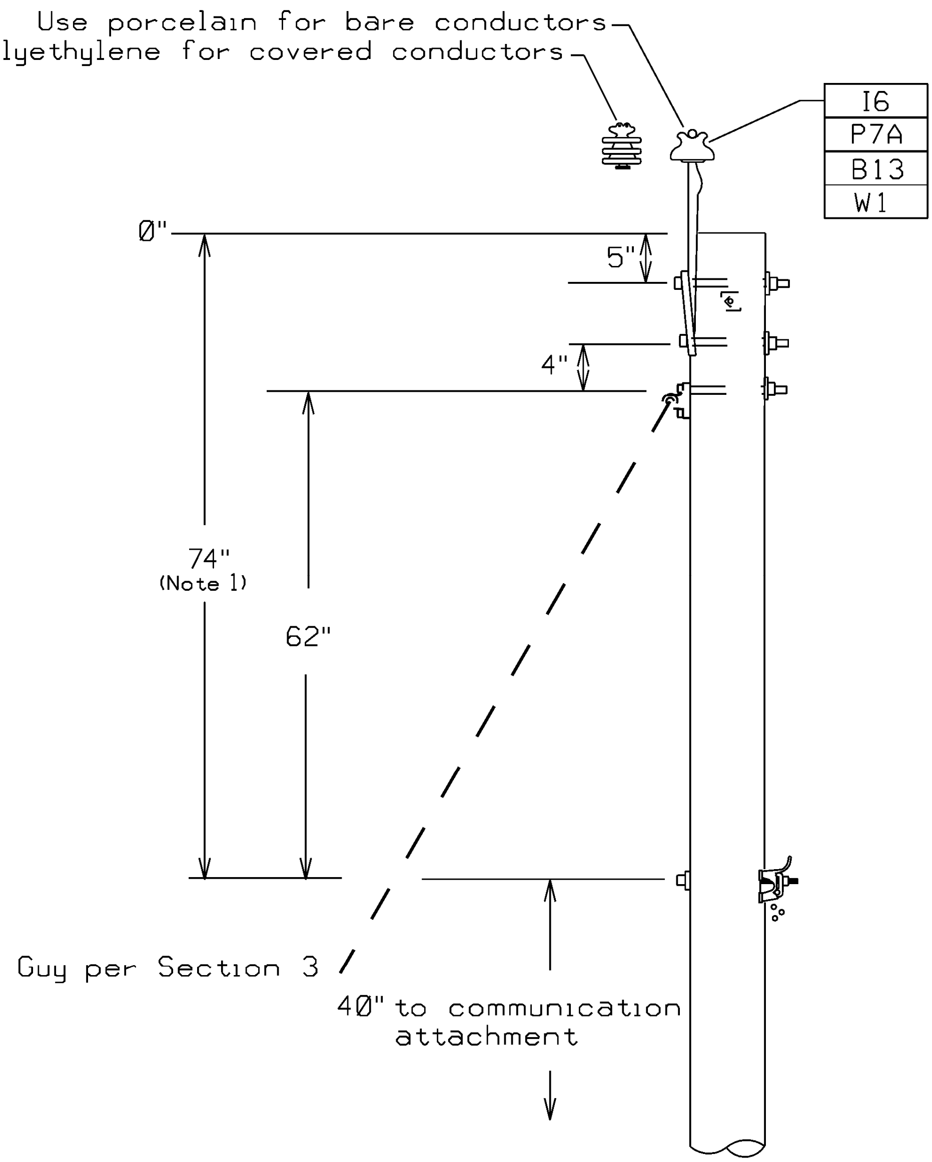
NOTES:

1. This clearance can be reduced to a minimum of 48” if needed.
2. Offset arm construction shall be used only as required for lateral clearance to avoid restricted tree trimming or to eliminate some offset line conditions.
3. For single phase delta, omit the center conductor.
4. Guying is not always necessary for in-line poles with offset arms unless calculated forces are exceeding pole strength (refer to Section 3 for guying information).

1Φ (DELTA) AND 3Φ SINGLE OFFSET POLE TOP – 0-15 kV – 0° - 10°

 Doc. # ST. 09.00.006

MU = @9-711	0-15KV 1Φ - Bare	MU = @9-711CL	0-15KV 1Φ - Covered	
MU = @9-711AF	0-15KV 1Φ - Bare	MU = @9-711AFCL	0-15KV 1Φ - Covered	Fiberglass pole



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/Ø TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/Ø AAAC	MAIN LINE 336.4 AAC	MAIN LINE 477 AAC
81.5	40 JT-84"	135	135	135
81.5	45 JT-111"	220	220	220
SPANS WITH 1/Ø AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/Ø AAAC	MAIN LINE 336.4 AAC	MAIN LINE 477 AAC
81.5	40 JT-84"	225	195	186
81.5	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
109	45 JT-111"	--	--	240
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

Supersedes 7/08 Issue – removed guying materials; edited notes; removed crossarm.

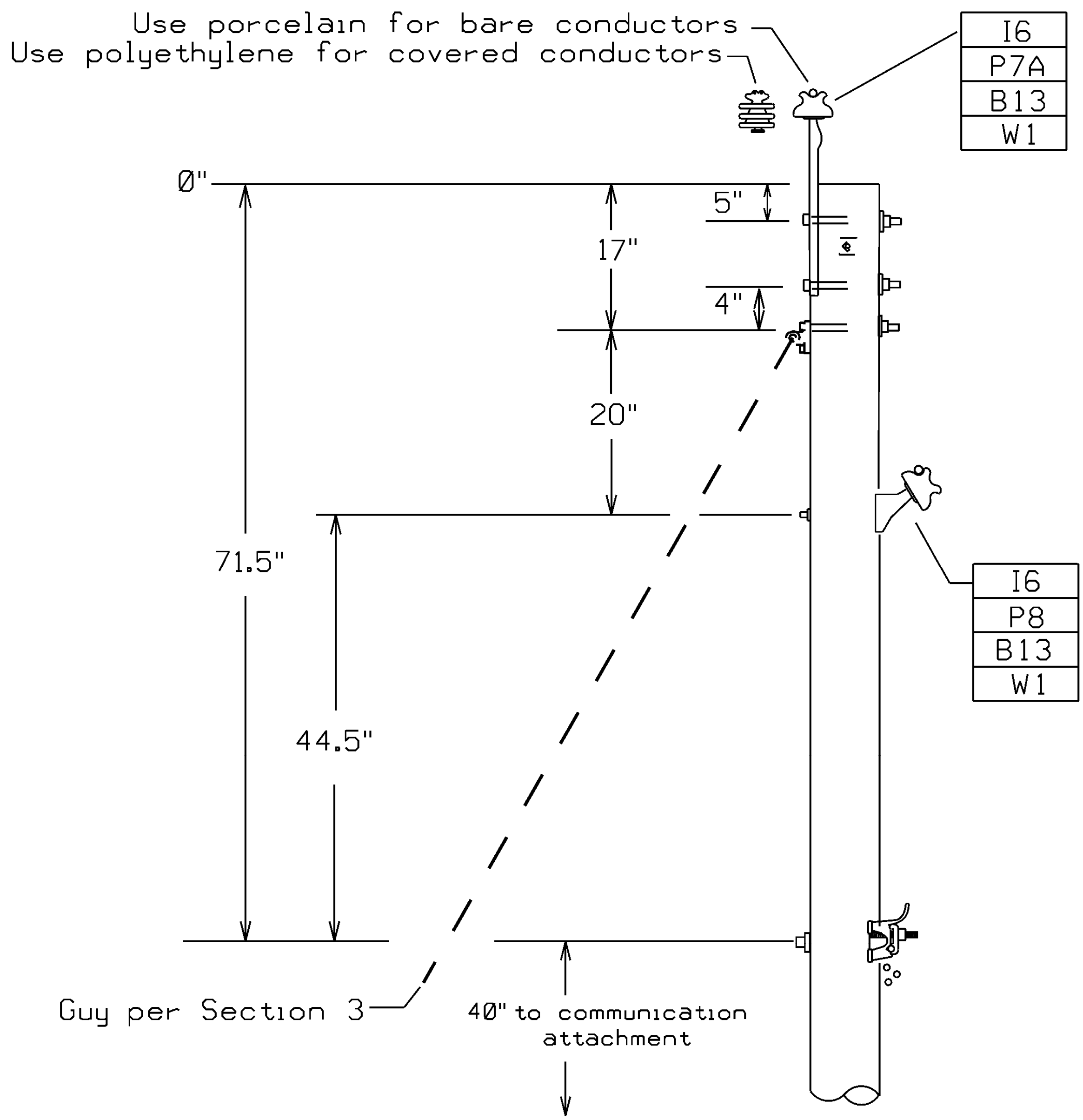
NOTES:

1. This clearance can be reduced to a minimum of 48” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

 Doc. # ST. 09.00.006

MU = @9-712	0-5KV 1Φ - Bare	MU = @9-712CL	0-5KV 1Φ - Covered	
MU = @9-712F	0-5KV 1Φ - Bare	MU = @9-712FCL	0-5KV 1Φ - Covered	Fiberglass Pole

Supersedes 7/08 Issue – removed guying materials; revised notes; removed crossarm.



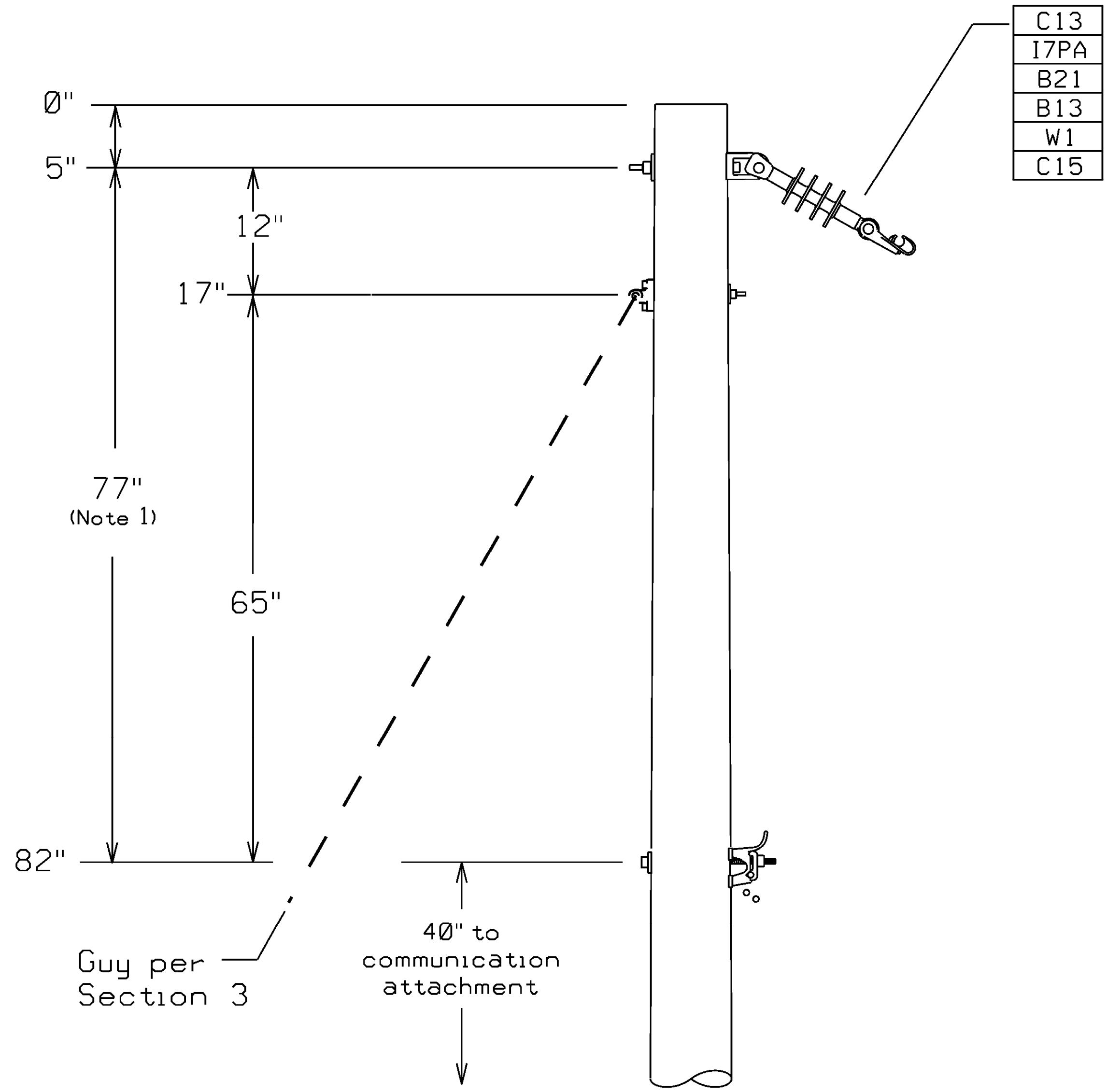
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS									
SPANS WITH 1/0 TRIPLEX SEC					SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC			1/0 AAAC	336.4 AAC	477 AAC
81.5	40 JT-84"	135	126	106	81.5	40 JT-84"	130	105	100
81.5	45 JT-111"	220	--	--	106	45 JT-111"	240	--	--
97	45 JT-111"	--	185	--	108	45 JT-111"	--	170	--
100	45 JT-111"	--	--	180	108	45 JT-111"	--	--	162
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE									

1Φ ARMLESS POLE TOP – 0-15 kV
0° - 20° - DELTA

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	9-712	7/11

 Doc. # ST. 09.00.006

MU = @9-713	0-15KV 1Φ - Bare	MU = @9-713CL	0-15KV 1Φ - Covered	
MU = @9-713F	0-15KV 1Φ - Bare	MU = @9-713FCL	0-15KV 1Φ - Covered	Fiberglass Pole



Supersedes 7/08 Issue – removed guying materials; edited notes.

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/Ø TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/Ø AAAC	336.4 AAC	477 AAC
82	40 JT-84"	135	135	135
82	45 JT-111"	220	220	220
SPANS WITH 1/Ø AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/Ø AAAC	336.4 AAC	477 AAC
82	40 JT-84"	225	190	180
83	45 JT-111"	300	--	--
106	45 JT-111"	--	240	--
108	45 JT-111"	--	--	230
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

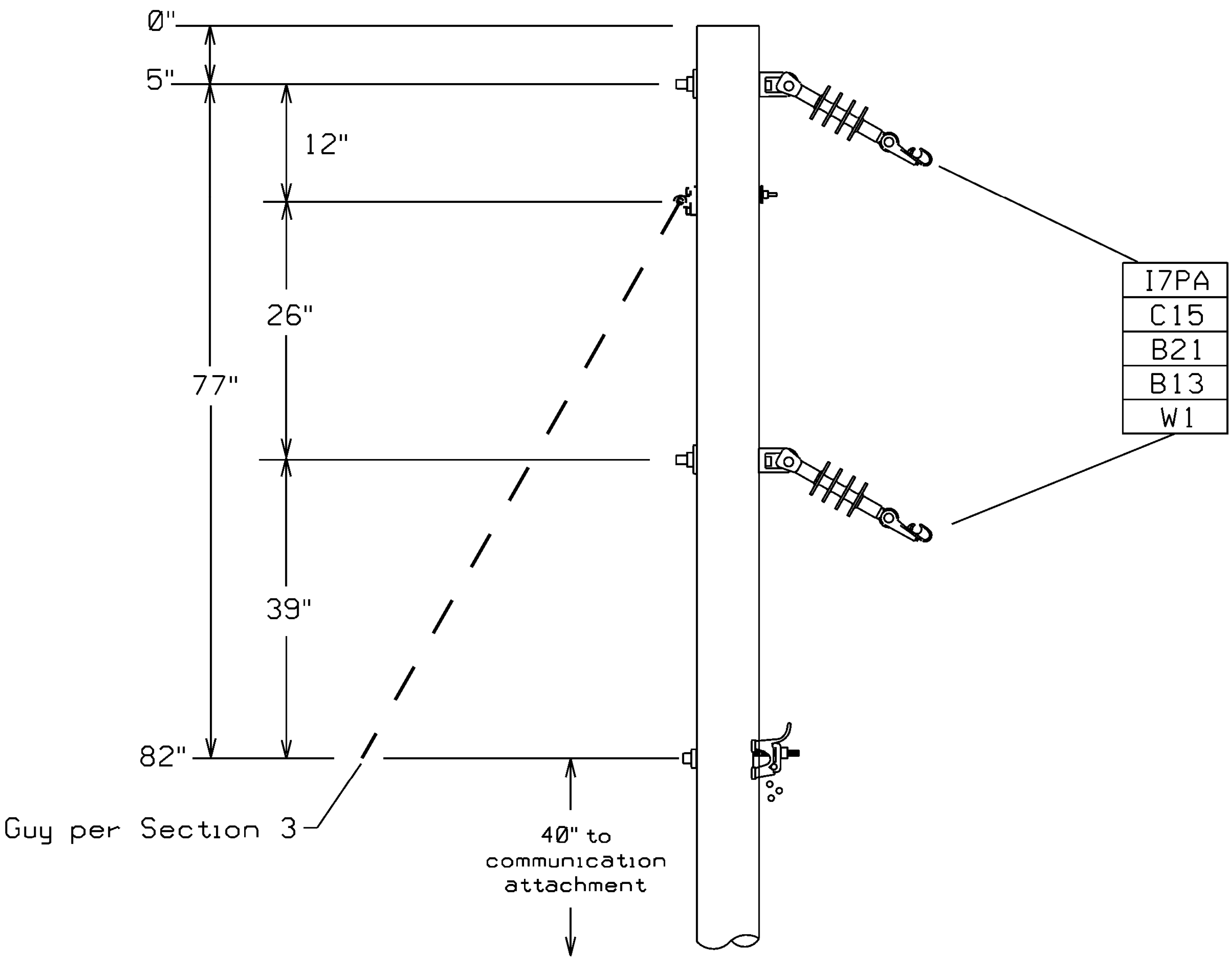
NOTES:

1. This clearance can be reduced to a minimum of 65" if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

1Φ ARMLESS POLE TOP – 0-15 kV
21° - 60°

ISSUE	PAGE NUMBER		
7/11	9-713	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

MU = @9-714	0-5KV 1Φ - Bare	MU = @9-714CL	0-5KV 1Φ - Covered	
MU = @9-714F	0-5KV 1Φ - Bare	MU = @9-714FCL	0-5KV 1Φ - Covered	Fiberglass Pole



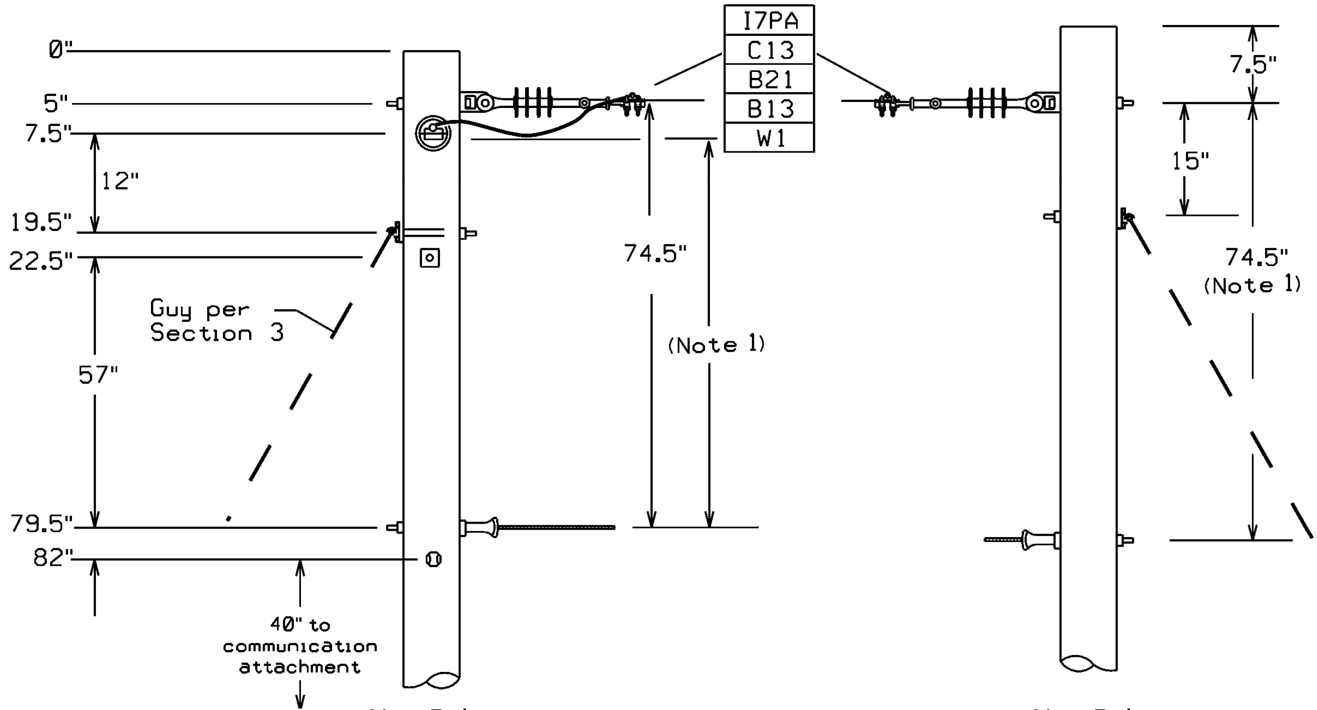
Supersedes 7/08 Issue – removed guying materials; revised notes.

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS									
SPANS WITH 1/Ø TRIPLEX SEC					SPANS WITH 1/Ø AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/Ø AAAC	MAIN LINE 336.4 AAC	MAIN LINE 477 AAC	SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/Ø AAAC	MAIN LINE 336.4 AAC	MAIN LINE 477 AAC
82	40 JT-84"	115	101	97	82	40 JT-84"	106	82	80
82	45 JT-111"	220	--	--	106	45 JT-111"	210	--	--
98	45 JT-111"	--	175	--	108	45 JT-111"	--	160	--
102	45 JT-111"	--	--	160	108	45 JT-111"	--	--	140
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE									

1Φ ARMLESS POLE TOP – 0-15 kV
21° - 60° - DELTA

 Doc. # ST. 09.00.006

MU = @9-715A	0-15KV 1Φ - Bare	MU = @9-715ACL	0-15KV 1Φ - Covered	
MU = @9-715B	0-15KV 1Φ DE- Bare	MU = @9-715BCL	0-15KV 1Φ DE- Covered	
MU = @9-715AF	0-15KV 1Φ - Bare	MU = @9-715AFCL	0-15KV 1Φ - Covered	Fiberglass Pole
MU = @9-715BF	0-15KV 1Φ DE- Bare	MU = @9-715BFCL	0-15KV 1Φ DE- Covered	Fiberglass Pole



New Pole
61° - 90°
Single Phase
(9-715A)

New Pole
Deadend
Single Phase
(9-715B)

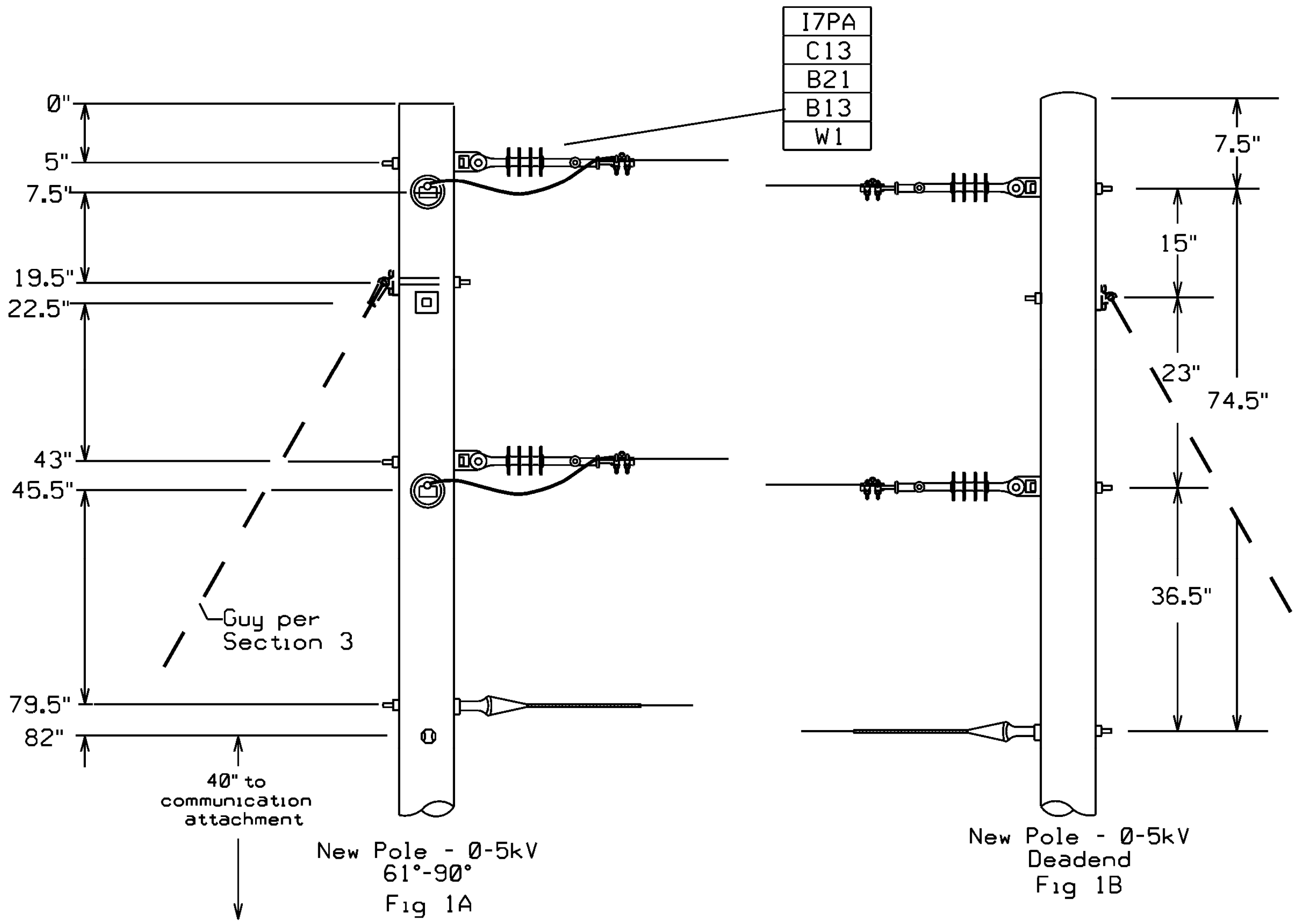
Supersedes 7/08 Issue – removed guying materials; revised notes.

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
82	40 JT-84"	135	135	135
82	45 JT-111"	220	220	220
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
82	40 JT-84"	225	185	175
86	45 JT-111"	300	--	--
105	45 JT-111"	--	235	--
107	45 JT-111"	--	--	225
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

NOTES:
1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
2. This configuration can also be used for back-to-back (tangent) deadends.

 Doc. # ST. 09.00.006

MU = @9-716A	0-5KV 1Φ - Bare	MU = @9-716ACL	0-5KV 1Φ - Covered	
MU = @9-716B	0-5KV 1Φ DE- Bare	MU = @9-716BCL	0-5KV 1Φ DE- Covered	
MU = @9-716AF	0-5KV 1Φ - Bare	MU = @9-716AFCL	0-5KV 1Φ - Covered	Fiberglass Pole
MU = @9-716BF	0-5KV 1Φ DE- Bare	MU = @9-716BFCL	0-5KV 1Φ DE- Covered	Fiberglass Pole



Supersedes 7/08 Issue – removed guying materials; revised notes; revised drawing title.

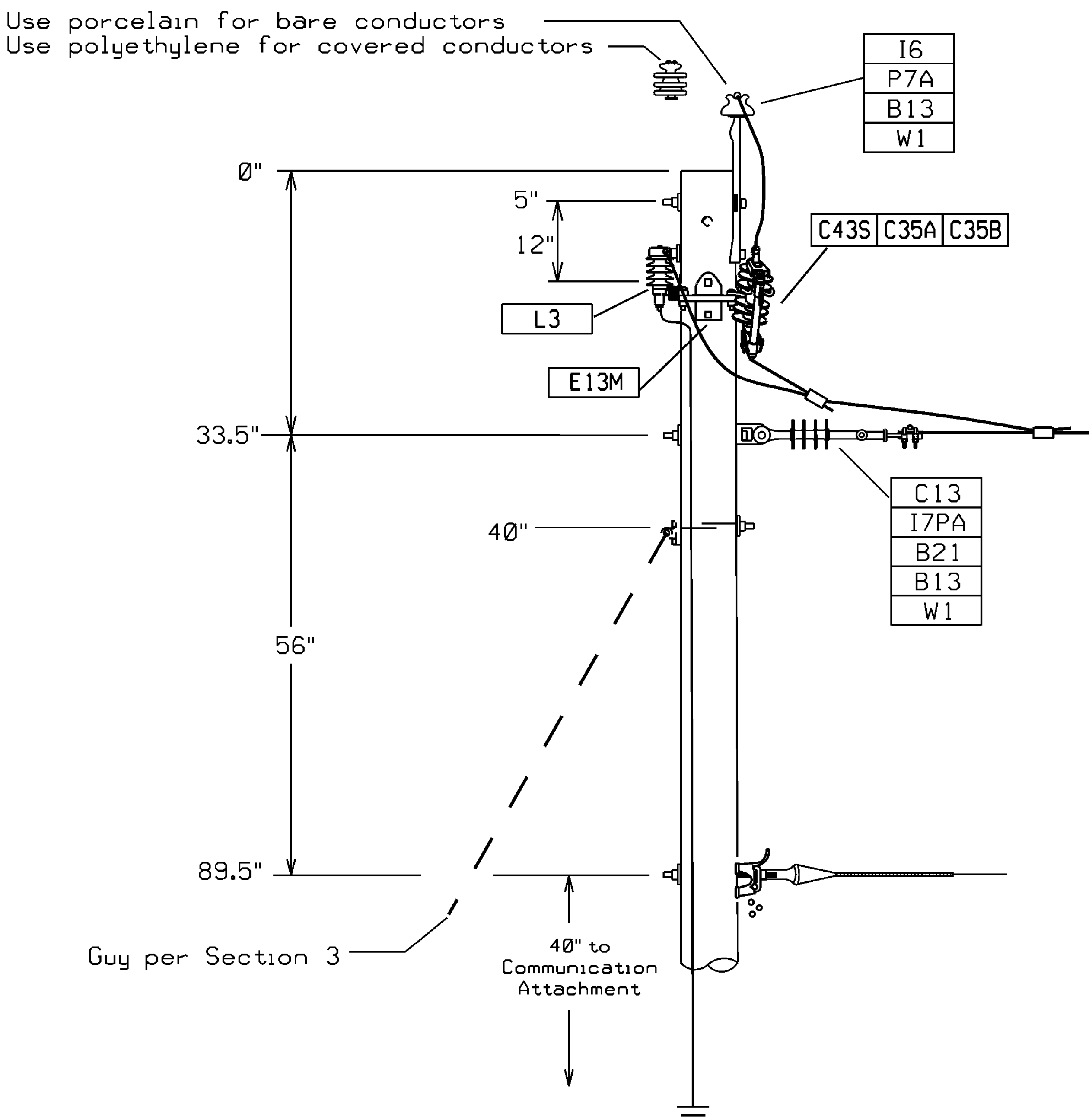
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS									
SPANS WITH 1/0 TRIPLEX SEC					SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC			1/0 AAAC	336.4 AAC	477 AAC
82	40 JT-84"	128	88	85	82	40 JT-84"	101	78	76
83	45 JT-111"	210	--	--	108	45 JT-111"	210	--	--
88	45 JT-111"	--	175	--	108	45 JT-111"	--	156	--
101	45 JT-111"	--	--	155	108	45 JT-111"	--	--	138
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE									

1Φ DELTA / 2Φ WYE ARMLESS POLE TOP – 0-15 kV 61° - 90° AND DEADEND

Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		9-716	7/11

Doc. # ST. 09.00.006

MU = @9-719	0-15KV 1Φ - Bare	MU = @9-719CL	0-15KV 1Φ - Covered	
MU = @9-719F	0-15KV 1Φ - Bare	MU = @9-719FCL	0-15KV 1Φ - Covered	Fiberglass Pole



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
89.5	45 JT-111"	200	200	200	200
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
89.5	45 JT-111"	300	225	205	200
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

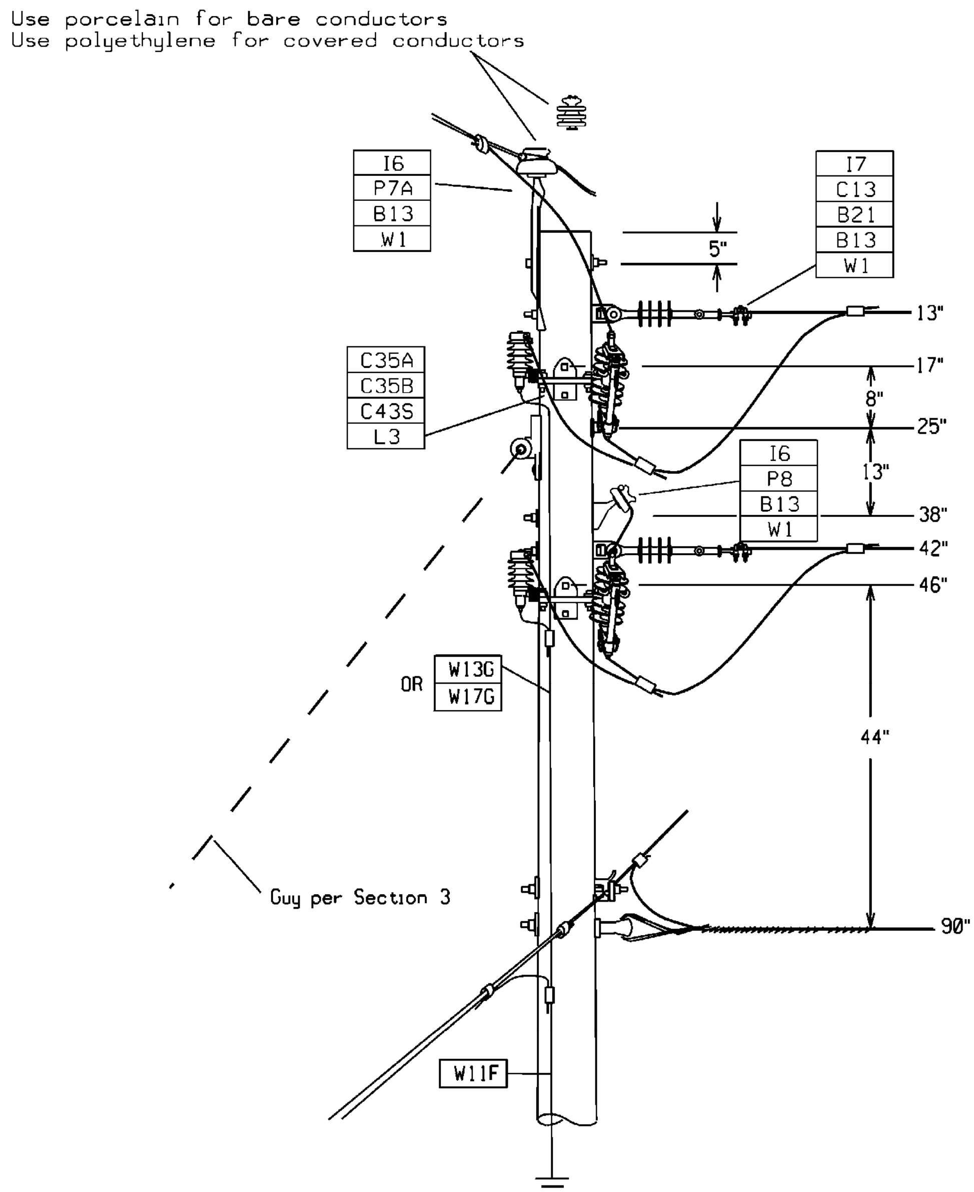
Supersedes 7/08 Issue – removed guying materials; added cutout and arrester for tap; edited notes.

1Φ ARMLESS POLE TOP – 0-7.2 kV
0° - 20° – TAP TO 1Φ ARMLESS

ISSUE	PAGE NUMBER		
7/11	9-719	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities

 Doc. # ST. 09.00.006

MU = @9-720	0-5KV 1Φ - Bare	MU = @9-720CL	0-5KV 1Φ - Covered	
MU = @9-720F	0-5KV 1Φ - Bare	MU = @9-720FCL	0-5KV 1Φ - Covered	Fiberglass Pole



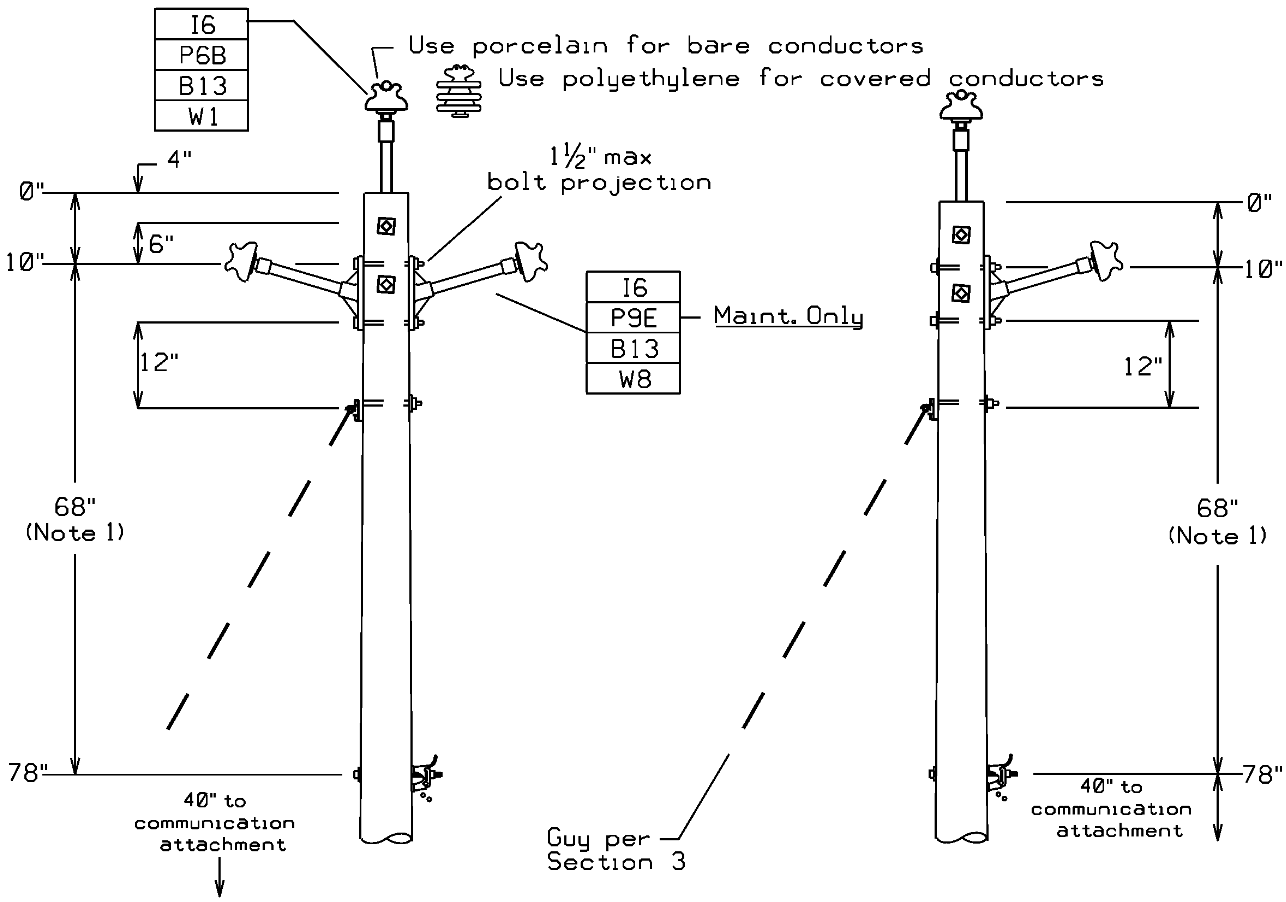
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
82	40 JT-84"	131	127	121	131
82	45 JT-111"	218	--	--	--
98	45 JT-111"	--	185	--	--
98	45 JT-111"	--	--	175	--
82	45 JT-111"	--	--	--	157
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
82	40 JT-84"	132	102	100	107
107	45 JT-111"	240	--	--	--
109	45 JT-111"	--	180	--	--
109	45 JT-111"	--	--	162	--
107	45 JT-111"	--	--	--	230
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

Supersedes 7/08 Issue – removed guying materials; added cutouts and arrester for taps; edited notes.

1Φ ARMLESS POLE TOP – 0-15 kV
0° - 20° – TAP TO 1Φ ARMLESS - DELTA

 Doc. # ST. 09.00.007

MU = @9-811A	0-15KV 3Φ - Bare	MU = @9-811ACL	0-15KV 3Φ - Covered
MU = @9-811B	0-15KV 3Φ - Bare	MU = @9-811BCL	0-15KV 3Φ - Covered



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
78	40 JT-84"	N/A	N/A	N/A
78	45 JT-111"	N/A	N/A	N/A
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
78	40 JT-84"	N/A	N/A	N/A
78	45 JT-111"	N/A	N/A	N/A
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

Supersedes 7/07 Issue – removed guying materials; edited notes.

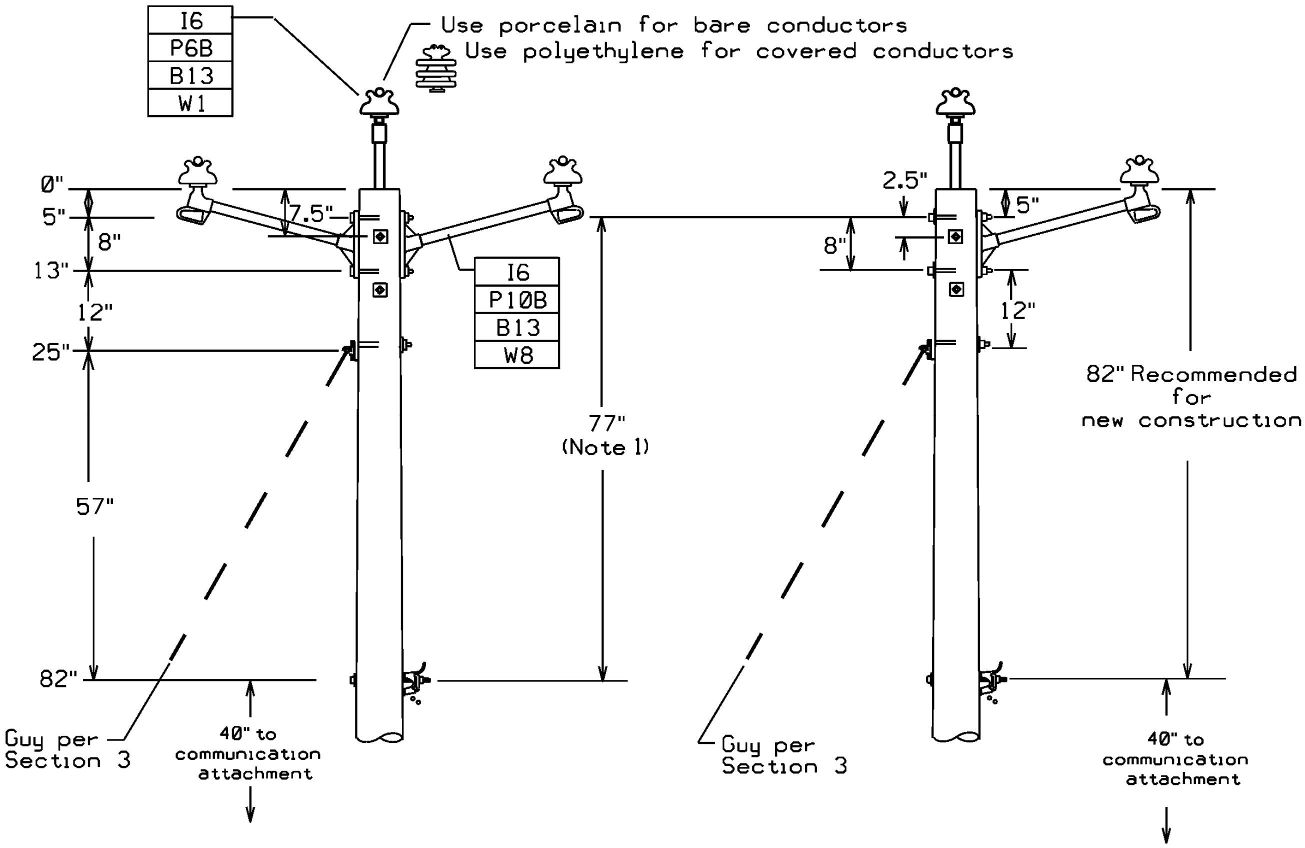
THIS DRAWING IS FOR MAINTENANCE PURPOSES ONLY

For new construction, see Drawing 9-812

NOTES:

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

MU = @9-812A	0-15KV 3Φ - Bare	MU = @9-812ACL	0-15KV 3Φ - Covered	
MU = @9-812B	0-15KV 1Φ - Bare	MU = @9-812BCL	0-15KV 1Φ - Covered	
MU = @9-812AF	0-15KV 3Φ - Bare	MU = @9-812AFCL	0-15KV 3Φ - Covered	Fiberglass Pole
MU = @9-812BF	0-15KV 1Φ - Bare	MU = @9-812BFCL	0-15KV 1Φ - Covered	Fiberglass Pole



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
82	40 JT-84"	131	131	131
82	45 JT-111"	218	218	218
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
82	40 JT-84"	221	206	187
82	45 JT-111"	300	--	--
102	45 JT-111"	--	250	--
107	45 JT-111"	--	--	235
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

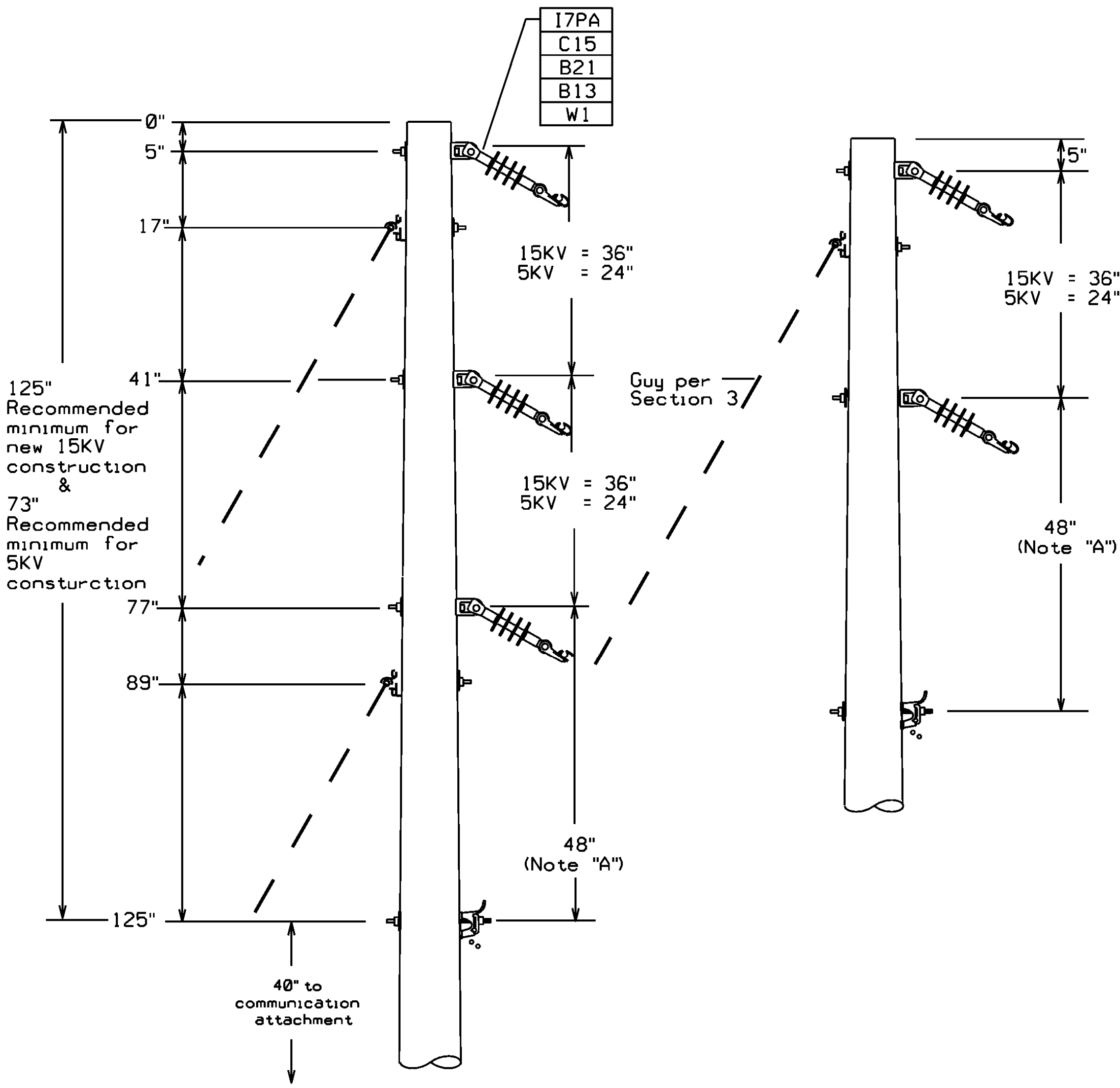
Supersedes 7/08 Issue – removed guying materials; edited notes.

NOTES:

1. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).

 Doc. # ST. 09.00.007

MU = @9-813A	0-15KV 3Φ - Bare	MU = @9-813ACL	0-15KV 3Φ - Covered	
MU = @9-813B	0-15KV 1Φ - Bare	MU = @9-813BCL	0-15KV 1Φ - Covered	
MU = @9-813AF	0-15KV 3Φ - Bare	MU = @9-813AFCL	0-15KV 3Φ - Covered	Fiberglass Pole
MU = @9-813BF	0-15KV 1Φ - Bare	MU = @9-813BFCL	0-15KV 1Φ - Covered	Fiberglass Pole



Supersedes 7/08 Issue – removed guying materials; edited notes; edited drawing title.

MAINTENANCE PURPOSES ONLY

Three-phase vertical construction shown in the figure above is not the preferred construction method. New line construction (including line extensions and taps) shall use crossarms, epoxy standoff insulator pins, or spacer cable configuration.

Note A

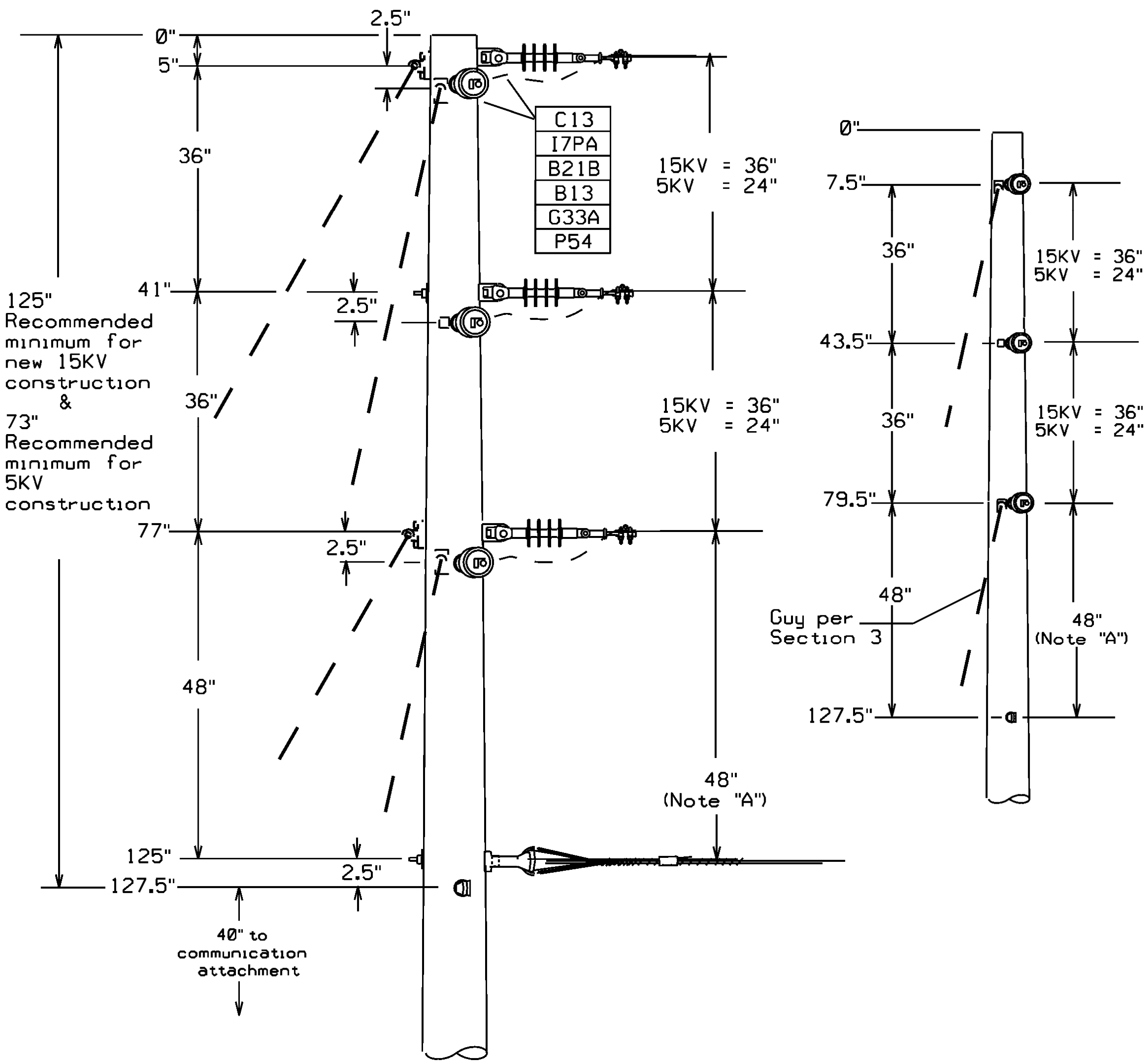
MINIMUM DIMENSIONS	
5KV OPERATION	20"
NEUTRAL ONLY-15KV OPERATION	20"
600V SECONDARY-15KV	48"

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
125	45 JT-125"	131	131	112
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
125	45 JT-125"	152	110	105
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

1Φ (DELTA) AND 3Φ **(MAINTENANCE ONLY)** ARMLESS POLE TOP – 0-15 kV 21°- 60°			
ISSUE	**PAGE NUMBER**	**OVERHEAD CONSTRUCTION STANDARD**	Liberty Utilities
7/11	**9-813**		

MU = @9-813A	0-15KV 3Φ - Bare	MU = @9-813ACL	0-15KV 3Φ - Covered
MU = @9-813B	0-15KV 1Φ - Bare	MU = @9-813BCL	0-15KV 1Φ - Covered

Supersedes 7/08 Issue – removed guying materials; edited notes; edited drawing title.



Note A

MINIMUM DIMENSIONS	
5KV OPERATION	20"
NEUTRAL ONLY-15KV OPERATION	20"
600V SECONDARY-15KV	48"

SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS				
SPANS WITH 1/0 TRIPLEX SEC				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
127.5	45 JT-127.5"	131	131	112
SPANS WITH 1/0 AAAC NEUTRAL				
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE		
		1/0 AAAC	336.4 AAC	477 AAC
127.5	45 JT-127.5"	152	110	105
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE				

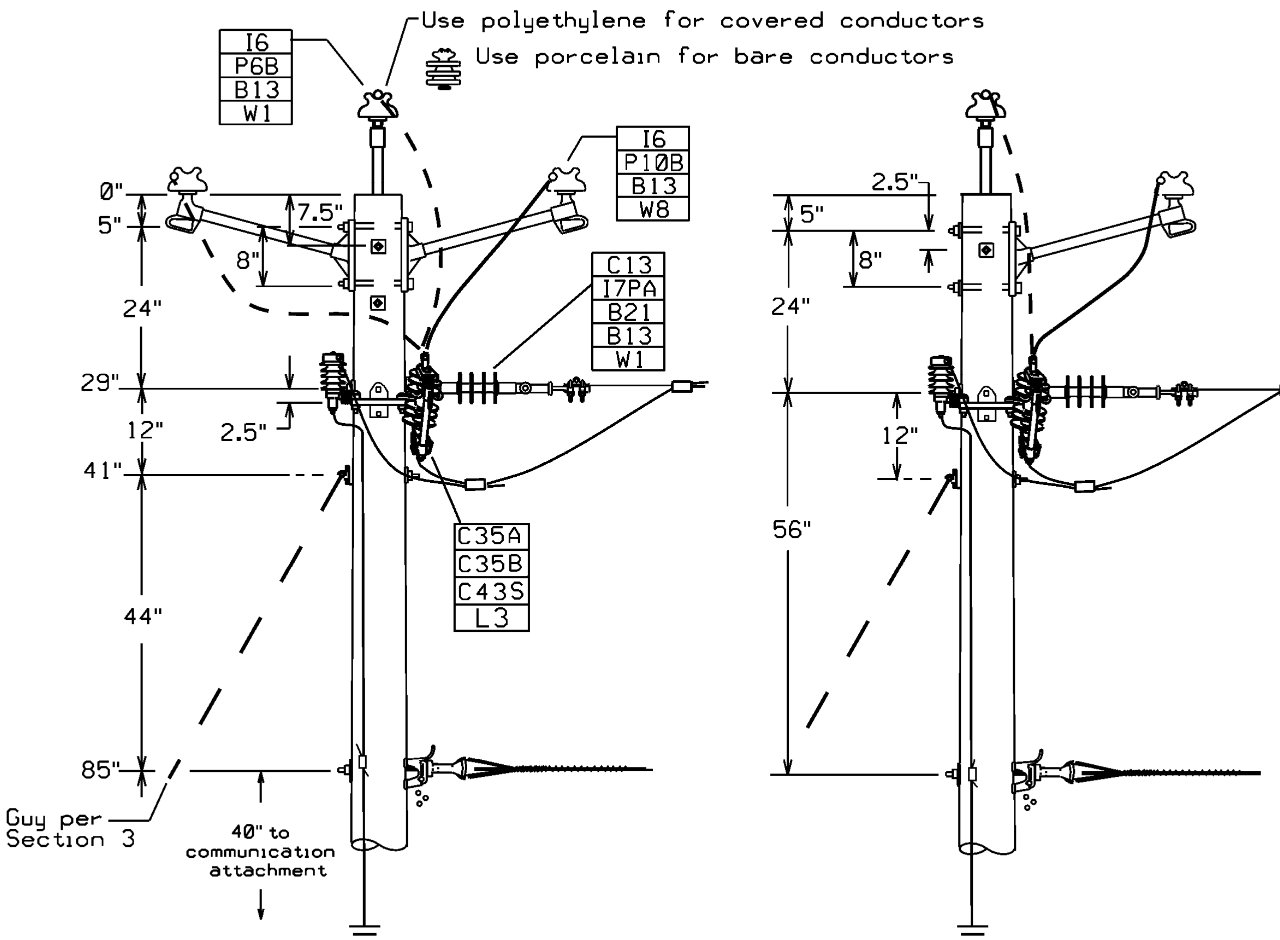
THIS DRAWING IS FOR MAINTENANCE PURPOSES ONLY

Three-phase vertical construction shown on this drawing is not the preferred construction method. New line construction (including line extensions and taps) shall use crossarms, epoxy standoff insulator pins, or spacer cable configuration. Single phase delta vertical construction may be used when all other options are not feasible.

1Φ (DELTA) AND 3Φ **(MAINTENANCE ONLY)** ARMLESS POLE TOP – 0-15 kV 21° - 60°			
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	PAGE NUMBER 9-814	ISSUE 7/11

 Doc. # ST. 09.00.007

MU = @9-823A	0-15KV 3Φ - Bare	MU = @9-823ACL	0-15KV 3Φ - Covered	
MU = @9-823B	0-15KV 1Φ - Bare	MU = @9-823BCL	0-15KV 1Φ - Covered	
MU = @9-823AF	0-15KV 3Φ - Bare	MU = @9-823AFCL	0-15KV 3Φ - Covered	Fiberglass Pole
MU = @9-823BF	0-15KV 1Φ - Bare	MU = @9-823BFCL	0-15KV 1Φ - Covered	Fiberglass Pole



SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
85	45 JT-111"	209	209	209	209
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
86	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
107	45 JT-111"	--	--	235	--
86	45 JT-111"	--	--	--	200
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

Supersedes 7/08 Issue – removed guying materials; added cutout & arrester for tap; removed notes; edited drawing title.

3Φ ARMLESS POLE TOP – 0-15kV (PREFERRED)
0° - 20° – TAP TO 1Φ ARMLESS

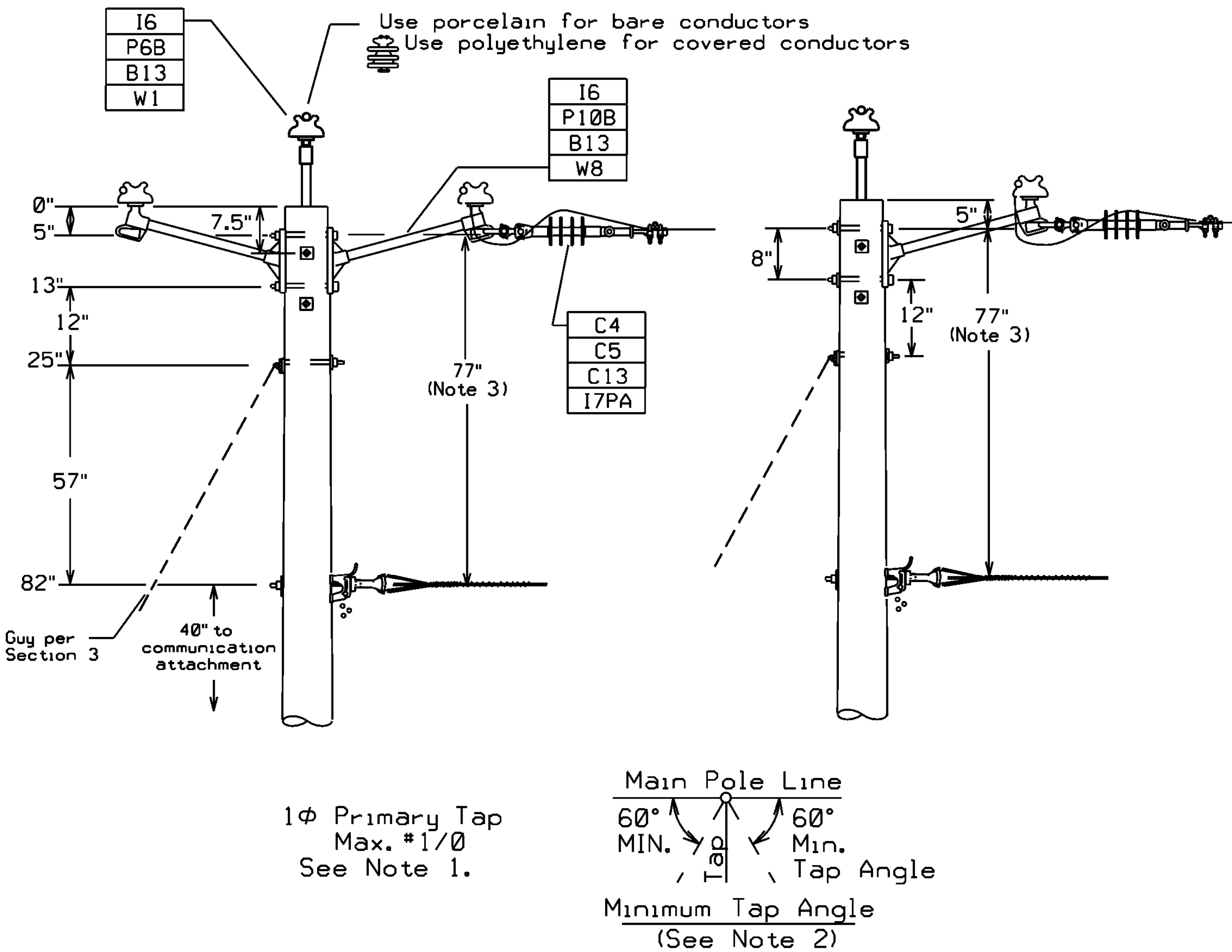
Supersedes 7/08 Issue - drawing no longer needed - refer to 9-835.

Drawing 9-824 has been removed.

Refer to Drawing 9-835.

 Doc. # ST. 09.00.007

MU = @9-825A	0-15KV 3Φ - Bare	MU = @9-825ACL	0-15KV 3Φ - Covered	
MU = @9-825B	0-15KV 1Φ - Bare	MU = @9-825BCL	0-15KV 1Φ - Covered	
MU = @9-825AF	0-15KV 3Φ - Bare	MU = @9-825AFCL	0-15KV 3Φ - Covered	Fiberglass Pole
MU = @9-825BF	0-15KV 1Φ - Bare	MU = @9-825BFCL	0-15KV 1Φ - Covered	Fiberglass Pole



Supersedes 7/08 Issue – removed guying materials; edited notes; edited drawing title.

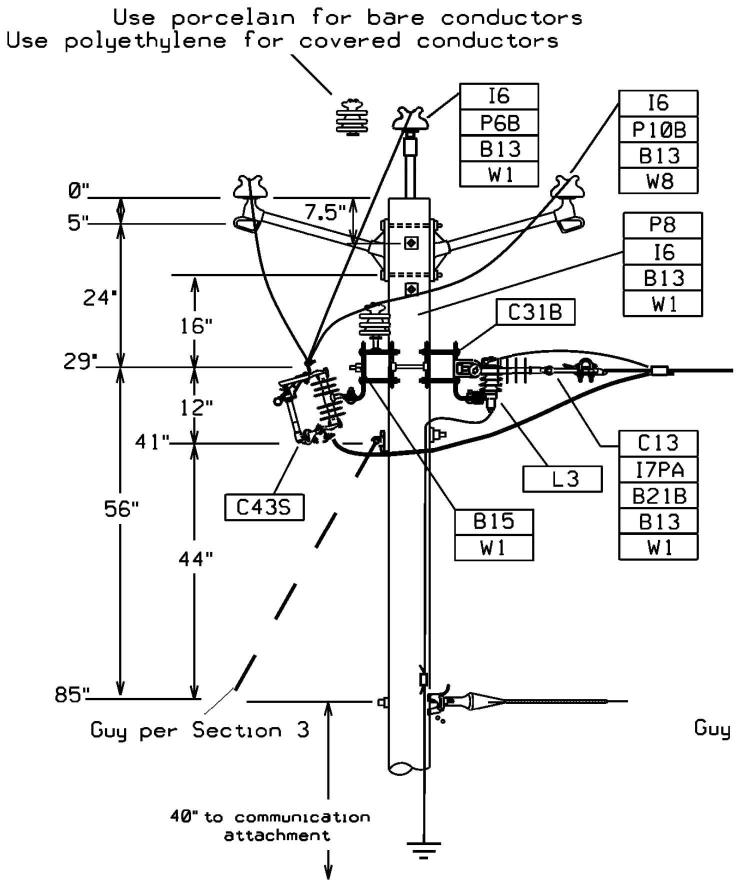
SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 336.4 AAC	MAIN LINE 477 AAC	TAP 1/0 AAAC
82	40 JT-84"	131	131	131	137
82	45 JT-111"	218	218	218	220
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE 1/0 AAAC	MAIN LINE 336.4 AAC	MAIN LINE 477 AAC	TAP 1/0 AAAC
82	40 JT-84"	221	206	187	230
82	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
107	45 JT-111"	--	--	235	--
82	45 JT-111"	--	--	--	300
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

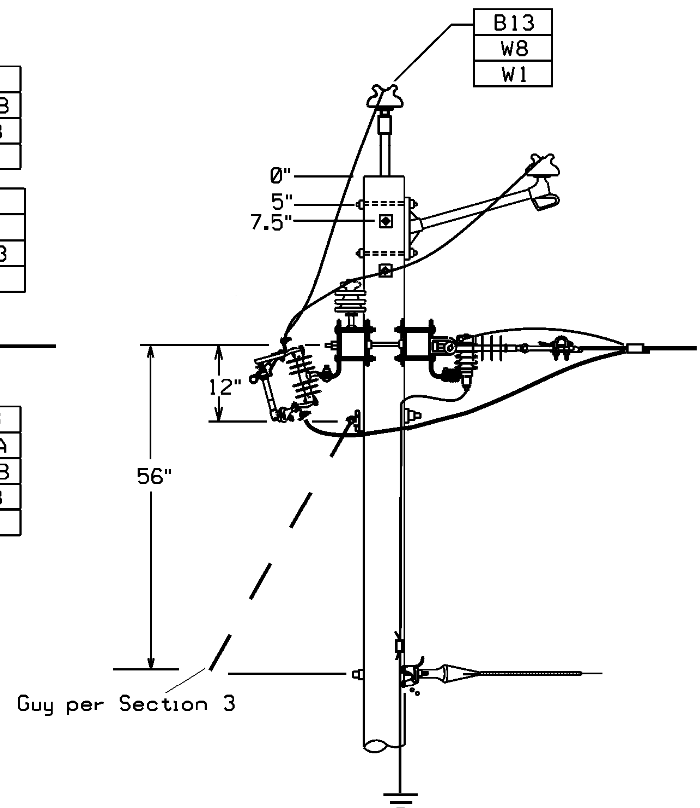
NOTES:

1. Tap shall be 1-phase and 1/0 maximum conductor.
2. Tap circuit angle shall be less than 60° off main pole line (see detail above).
3. This clearance can be reduced to a minimum of 56” if needed and if NESC midspan clearances are maintained (see Section 7.11 for required midspan clearances).
4. If this configuration is needed, the fused cutout and arrester for the tap **must** be placed on the next pole down the tap. Otherwise, Drawing 9-823 shall be used.

 Doc. # ST. 09.00.007

MU = @9-835A	0-15KV 3Φ - Bare	MU = @9-835ACL	0-15KV 3Φ - Covered	
MU = @9-835B	0-15KV 1Φ - Bare	MU = @9-835BCL	0-15KV 1Φ - Covered	
MU = @9-835AF	0-15KV 3Φ - Bare	MU = @9-835AFCL	0-15KV 3Φ - Covered	Fiberglass Pole
MU = @9-835BF	0-15KV 1Φ - Bare	MU = @9-835BFCL	0-15KV 1Φ - Covered	Fiberglass Pole





SEE 9-200 FOR ADDITIONAL INFORMATION ON MAXIMUM SPANS					
SPANS WITH 1/0 TRIPLEX SEC					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
85	45 JT-111"	209	209	209	209
SPANS WITH 1/0 AAAC NEUTRAL					
SEC BRKT ATTACHMENT	POLE SIZE	MAIN LINE			TAP
		1/0 AAAC	336.4 AAC	477 AAC	1/0 AAAC
86	45 JT-111"	300	--	--	--
102	45 JT-111"	--	250	--	--
107	45 JT-111"	--	--	235	--
86	45 JT-111"	--	--	--	200
THIS TABLE BASED ON EQUAL OWNERSHIP PERCENTAGE					

Supersedes 7/08 Issue – removed guying material; added cutouts and arresters for taps; edited drawing title.

1Φ (DELTA) AND 3Φ ARMLESS POLE TOP – 0-15 kV
0° - 20° – TAP TO 1Φ (DELTA) AND 3Φ CROSSARM

		PAGE NUMBER	ISSUE
Liberty Utilities	OVERHEAD CONSTRUCTION STANDARD	9-835	7/11

Version	Date	Modification	Author(s)	Approval by (Name/Title)
4	7/13	• Moved arresters to lower crossarms on 9-422, 9-424 and 9-435	Robert Johnson	
3	7/12	• Updated voltage regulation limits in Section 9.1.40.	G. Paul Anundson	Susan Fleck, VP of Standards, Policies, & Code
2	7/11	• Added (required) cutout(s) and arrester(s) to most tap drawings • Removed guy wire materials - refer to Section 3 for guying materials and CUs • Removed Drawing 9-420 - refer to Drawing 9-435 for new construction. • Removed Drawing 9-824 - refer to Drawing 8-435 for new construction. • Corrected drawing titles of those showing single phase delta taps. • Labeled vertical construction drawings as “Maintenance Only” as this is not the preferred construction method for new lines.	Katie Croteau	Susan Fleck, VP of Standards, Policies, & Code
1	07/08	• New construction drawings for Fiberglass Construction: 9-411F, 9-413F, 9-415F, 9-417F. • Added fiberglass MU information: 9-711, 9-712, 9-713, 9-714, 9-715, 9-716, 9-719, 9-720, 9-812, 9-813, 9-814, 9-823, 9-824, 9-825, 9-835.	Jeff Steiner	Allen Chieco, Director of Distribution Standards and Work Methods

DISTRIBUTION
OVERHEAD & UNDERGROUND
CONSTRUCTION STANDARDS

FOREWORD

Liberty Utilities develops internal Construction Standards that are intended to provide information on the acceptable materials, techniques, and assemblies, along with representative construction drawings for building those structures used in a repetitive manner. Within these Construction Standards will be found documentation of engineering calculations required to assure that non-standard construction can be designed correctly. Also, an explanation of the reasoning behind various selections of materials and construction techniques will be included. The Company is committed to providing the most modern and inclusive Distribution Standards in a format that is both practical and straight-forward. These Standards are prepared with the intent to coordinate the interests of safety, reliability, operability, uniformity, appearance, economy and the environment. Additionally, these Standards are intended to comply in all respects with requirements of the current edition of the National Electrical Safety Code (NESC), and are supplemented by applicable rules and regulations of governing public authorities. When a conflict occurs, the most stringent rule or regulation shall prevail. Questions regarding such conflict should be referred to the Director, Electric Distribution Engineering or the CQ&EM, Standards, Policies, and Codes Department for interpretation.

Liberty Utilities produces these Construction Standards for use by the Company's construction personnel, engineers, designers and contractors for construction of the Company's distribution system. These standards are issued in two hard covered office binders; "Overhead Construction Standards" and "Underground Construction Standards". The OH and UG Distribution Construction Standard documents will be stored on the Liberty Utilities CQ&EM SharePoint site for access by Liberty Utilities employees. For Document Control the latest version will be the document on this SharePoint site. In addition, certain Construction Standards will be issued in a permanently bound Handbook. This Handbook is intended for use by the Company's construction personnel. For each respective binder, new or updated Standards Documents will be released and issued via the CQ&EM SharePoint site and designated as a new document. It is the responsibility of the book holders, or Managers for designated office copies, to maintain their books with the latest issued updates. Liberty Utilities Contractors will be issued a CD containing the latest version of the OH and UG Construction Standards as part of the bid process.

Employees whose work calls for the application of these Construction Standards are expected to be thoroughly familiar with them. All new construction and rebuilding shall conform to these Standards. It is not, however, intended that existing construction be changed to comply with each current issue of these Standards. When Distribution construction for special applications is not covered by these documents, those applications shall be referred to Design Engineering or Electric Standards Engineering.

Liberty Utilities recognizes and appreciates the interest and contributions made by its employees toward the establishment and improvement of construction types and methods, and the Company solicits their continued cooperation. Suggestions submitted to the CQ&EM, Standards, Policies, and Codes team should be accompanied with justification, sketches, photographs, or other exhibits in order to be given complete consideration and to ensure that the maximum benefit may be derived from them. Each submittal shall be reviewed, and the results of that review discussed with the employee suggesting the change. Utilize the Form for Change Proposals which accompanies this document.

UG Construction Standards Table of Contents

Liberty Utilities Construction Standards - Bob Johnson - 508-849-8096 (C)
603-328-2762 (O)

Construction Guideline for Compliance with Distribution Standards

As part of the construction audit review, questions have been raised as to when existing construction shall be brought in compliance with current Distribution Standards. The following is a general outline as to what the Company expectations are with regard to this matter.

New Construction – All new construction shall be built to current Liberty Utilities Distribution Standards.

Existing Construction – Existing construction or maintenance work (i.e., outside of complete structure replacement, reconductoring or conversions) does not require that the existing structure be brought in compliance with the current Distribution Standards provided that the work being done maintains the integrity of the original structure's construction. Safety concerns (such as clearances) or potential reliability issues at the structure shall be addressed as part of the work that is being performed.

Emergency Construction – Emergency or temporary construction does not require that the existing structure be brought in compliance with the current Distribution Standards provided that the work being done maintains the integrity of the original structure's construction. Critical safety concerns that may result in undue hazard or potential harm to Company personnel or to the general public shall be addressed as part of the emergency work that is being performed. Potential reliability issues or general safety concerns at the structure shall be reported to local supervision. Emergency or temporary construction shall be brought into compliance with Distribution Standards as soon as practical.

Note 1: During structure replacement, reconductoring, or conversion work, all minimum clearances and separations per current Distribution Standards shall be followed.

Note 2: In all cases, work being completed on any given structure shall be in compliance with Liberty Utilities Electric Operating Procedures as well as all applicable federal, state or local law / ordinance. (e.g., For the case where a driven ground rod is found to be missing on a required structure, appropriate permissions (Dig Safe, Dig Safely, etc.) must be acquired prior to correcting the situation.)

Some examples of safety or potential reliability concerns include, but are not limited to:

- **Safety**
  - Clearances
  - Potted porcelain cutout on pole
  - Missing guy marker(s)
  - Missing structure or switch number
  - Missing equipment locks

- **Reliability**
  - Improper bonding and grounding
    - Missing or exposed ground rods
    - Street lighting
    - Metallic riser conduits
    - Guy wire (wye system)
    - Switch handles
    - Control cabinets
    - Equipment tank/mounts
    - Spacer cable supports (tangent, C and E-brackets)
    - Arresters (flexible braid utilized for arrester disconnector)
    - Secondary neutral
    - Down ground molding
  - Potted porcelain cutout on pole
  - Missing surge arrester(s)
  - Missing animal guard(s)

FORM FOR CHANGE PROPOSALS

OH & UG Construction Standards

(Submit a separate form for each proposal)

Liberty Utilities encourage and appreciate changes designed to improve construction types, work methods, and procedures. As a company we strive to be a leader in work safety and compliance with both Federal and State rules and regulations. In the interest of uniformity, this form may be used to submit proposed changes to existing company Standards and Electric Material Specifications.

Name: ____ Date: ___________________
Department: ______________________________________ Location: ___________________
Standard Document # (s): ____
Material Specification Document # (s): ____

Proposal: Include sketches, photos or other information useful to understanding the proposal.

Statement of problem, Reasons supporting change. Include safety, cost, reliability or other justification.

Send form to:

Robert J Johnson, MS | **Liberty Utilities (NH)** | Program Manager: CQ&EM, Standards, Policies, & Codes – Gas & Electric
P: 603-328-2762 | C: 508-849-8096 | F: 603-896-6175
E: Robert.johnson@libertyutilities.com
11 Northeastern Boulevard, Salem, NH 03079

Local and responsive, We care.

 Doc. # ST. 31.00.001

Supersedes 7/07 Issue – Page changes, new padmount signs, underground cable signs and minor updates

Supersedes 1/06 Issue –Updated Definitions to Include Overhead and Underground Terminology

31.0 DEFINITIONS

The following sources were used as a reference to define the following terms:

1. IEEE Standard Dictionary of Electrical & Electronic Terms – IEEE STD 100
2. The Lineman's and Cableman's Handbook
3. National Electrical Code
4. National Electrical Safety Code

A

AAC - (All Aluminum Conductor) A conductor made wholly of 1350 alloy aluminum.

AAAC - (All Aluminum Alloy Conductor) A conductor made wholly of 5005-H19 or 6201-T81 higher strength alloy aluminum.

ACSR - (Aluminum Conductor Steel Reinforced) A composite conductor made up of a combination of aluminum and steel wires. In the usual construction the aluminum wires surround the steel wires.

ACTUAL SPAN - The horizontal distance between two adjacent structures. The distance can be either to the structure ahead, Actual Span ahead, or to the back structure, Actual Span back. The Actual Span affects sags and clearances from the conductors to the ground.

ALIVE - Electrically connected to a source of potential difference, or electrically charged so as to have a potential difference from that of the ground. **Note:** The term "alive" is sometimes used in place of the term "current-carrying", where the intent is clear, to avoid repetitions of the longer term. (IEEE-100)

AMPACITY - The current-carrying capacity, expressed in amperes, of an electrical conductor under stated thermal conditions. (Per NESC)

ANCHOR - A device that serves as a reliable support to hold an object firmly in place. The term "anchor" is normally associated with cone, plate, screw, or concrete anchors, but terms "stub", "deadman", and "anchor log" are usually associated with pole stubs or logs set or buried in the ground to serve as temporary anchors. The latter are often used at pull and tension sites. (IEEE-100)

ANCHOR GUY MARKER - A protective cover over the guy, often a length of plastic or metal shaped to a semicircular or tubular section and equipped with a means of attachment to the guy. (IEEE-100)

ANODE - An electrode through which current enters any conductor of the nonmetallic class. (IEEE-100)

ARRESTER - See Surge Arrester

AWG - (American Wire Gauge) The standard system used for designating wire diameter, also referred to as the Brown and Sharpe wire gauge. This system is based on a direct correlation between gauge number, cross section, weight, and the DC resistance of conductors.

B

BAY-O-NET FUSE - A pad mount transformer fuse, used to protect the line-side system from damage caused by transformer faults. Provides transformer protection from overloading and secondary fault current.

BIL - (Basic Lightning Impulse Insulation Level) A specific insulation level expressed in kilovolts of the crest value of a standard lightning impulse. (IEEE-100)

BOLLARD - A series of short posts set at intervals to delimit an area (as a traffic island) or to exclude vehicles

BONDING - The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed. (IEEE-100)

The electrical interconnecting of conductive parts, designed to maintain a common electrical potential. (NESC)

BOOST - Raise or attempt to raise voltage.

BUCK - Lower or attempt to lower voltage.

BUCKARM - A crossarm placed approximately at right angles to the line crossarm and used for supporting branch or lateral conductors or turning large angles in line conductors. (IEEE-100)

BUSHING PLUG - An interface for a transformer/switch that allows cable to be attached with an elbow connector.

C

CABLE - A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable). (OSHA, NESC, IEEE-100)

CABLE JACKET - A protective covering over the insulation, core, or sheath of a cable. (IEEE-100)

CABLE RACK - A device usually secured to the wall of a manhole, cable raceway, or building to provide support for cables. (IEEE-100)

CABLE SHEATH - A conductive protective covering applied to cables. **Note**: A cable sheath may consist of multiple layers, of which one or more is conductive. (IEEE-100)

CATHODE - An electrode through which current leaves any conductor of the nonmetallic class. (IEEE-100)

CATHODIC PROTECTION - Reduction or prevention of corrosion by making a metal, the cathode in a conducting medium by means of a direct electric current. (IEEE-100)

CIRCULAR MIL - A unit of area equal to π/4 of a square mil (= 0.7854 square mil). The cross-sectional area of a circle in circular mils is therefore equal to the square of its diameter in mils. A circular inch is equal to one million circular mils. **Note**: One mil equals 0.0001 inches. There are 1974 circular mils in a square millimeter.

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CLEARANCE - The clear distance between two objects measured surface to surface.(OSHA, NESC)

CONDUCTOR - A material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current. (OSHA)

CONDUCTOR INSULATIONS -

BR	Butyl rubber
EPR	Ethylene propylene rubber
XLPE	Cross-linked polyethylene
TRXLPE	Tree-retardant polyethylene
PILC	Paper Insulated, lead covered
VC	Varnish Cambric

CONDUCTOR, BARE - One having no covering or insulation whatsoever. (IEEE-100)

CONDUCTOR COMPACT - A round stranded conductor having all layers stranded in the same direction and successively passed through forming dies that forms the round conductor strands into a diamond-like shape. This results in a smoother, more nearly circular outer surface and effectively eliminates the void between individual wire strands.

CONDUCTOR COMPRESSED - A concentric stranded conductor which, after completion of the stranding operation, is passed through forming dies that compress the strands of the outer layer into a diamond-like shape. This results in a smoother, more nearly circular outer surface, and reduces the void between individual strands in the outer layer.

CONDUCTOR CONCENTRIC - A single straight core wire strand surrounded by one or more layers of helically wound wires in a fixed round geometric arrangement. Each layer after the first has six more strands than the preceding layer and is applied in a direction opposite to that of the layer under it.

CONDUCTOR COVERED - A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.

CONDUCTOR INSULATED - A conductor covered with a dielectric (other than air) having a rated insulated strength greater than or equal to the voltage of the circuit in which it is used. (NESC)

CONDUIT SYSTEM - Any combination of duct, conduit, conduits, manholes, handholes and/or vaults joined to form an integrated whole. (IEEE-100)

CONNECTOR - A coupling device employed to connect conductors of one circuit or transmission element with those of another circuit or transmission element. (IEEE-100)

CONTINUOUS LOAD - A load where the maximum current is expected to continue for three (3) hours or more.

CORE LOSS, TRANSFORMER - The measured power loss, expressed in watts, attributable to the material in the core and associated clamping structure of a transformer that is excited, with no connected load, at a core flux density and frequency equal to that in the core when rated voltage and frequency is applied and rated load current is supplied. (IEEE-100)

CURRENT CARRYING PART - A conducting part intended to be connected in an electric circuit to a source of voltage. **Note:** Non-current carrying parts are those not intended to be so connected. (OSHA)

CURRENT LIMITING FUSE -	A fuse that, when it is melted by a current within its specified current-limiting range, abruptly introduces a high arc voltage to reduce the current magnitude and duration. **Note:** The values specified in standards for the threshold ration, peak let-through current, and I^2t characteristic are used as the measures of current-limiting ability. (IEEE-100)
CURRENT LIMITING FUSE CARRYING -	A pad mount transformer fuse that limits the potential for catastrophic failure of the transformer, due to internal faults.
CUTOUT -	An assembly of a fuse support with either a fuse holder, fuse carrier, or disconnect blade. When a fuse holder or fuse carrier is used, this device is used to automatically interrupt the flow of current through any particular apparatus or instrument. (IEEE-100)

D

DEAD -	Isolated, tagged, tested de-energized and grounded. (Safety Manual)
DEAD-FRONT (TRANSFORMERS & SWITCHGEAR) –	Without live parts exposed to a person on the operating side of the equipment. (IEEE-100)
DEADEND GUY -	An installation of line or anchor guys to hold the pole at the end of a line. (IEEE-100)
DE-ENERGIZED -	The absence of normal operating voltages associated with the operation of the system or control circuits. (Safety Manual) Disconnected from all sources of electrical supply by open switches, disconnectors, jumpers, taps, or other means. **Note:** De-energized conductors or equipment could be electrically charged or energized through various means, such as induction from energized circuits, portable generators, lightning, etc. (NESC)
DEMAND -	The load integrated over a specific interval of time. (IEEE-100)
DISCONNECT -	A device having a disconnecting blade for use as a disconnecting or isolating switch. (IEEE-100)
DUCT -	A single enclosed raceway for conductors or cables. (NESC)
DUCT BANK -	An arrangement of conduit providing one or more continuous ducts between two points. (IEEE-100)
DUCT SEALING -	The closing of the duct entrance for the purpose of excluding water, gas, or other undesirable substances. (IEEE-100)
DUPLEX CABLE -	A cable composed of two (2) insulated single conductors or one (1) insulated conductor and one (1) bare neutral conductor twisted together. (IEEE-100)

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DUTY - Continuous Duty – Operation at a substantially constant load for an indefinitely long time.

Intermittent Duty – Operation for alternate intervals of:
1) load and no load; or
2) load and rest; or
3) load, no load, and rest.

Periodic Duty - Intermittent operation in which the load conditions are regularly recurrent.

E

EFFECTIVELY GROUNDED - Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to limit the buildup of voltages to levels below that which may result in undue hazard to persons or to connected equipment. (NESC)

An alternating-current system or portion thereof may be said to be effectively grounded when, for all points on the system or specified portion thereof, the ratio of zero-sequence reactance to the positive-sequence reactance is less than three and the ratio of zero-sequence resistance to positive-sequence reactance is less than one for any condition of operation and for any amount of connected generator capacity. (IEEE-100)

ELBOW - A cable to apparatus connector.

ENCLOSED - Surrounded by case, cage, or fence designed to protect the contained equipment and limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects. (NESC)

EXTRA-HIGH VOLTAGE SYSTEM - See Voltage Systems

F

FAULT CURRENT - A current that flows from one conductor to ground or to another conductor owing to an abnormal connection (including an arc) between the two. **Note:** A fault current flowing to ground may be called a ground fault current. (IEEE-100)

FEEDER - A set of conductors originating at a main distribution center and supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two (2) types of equipment. (IEEE-100)

FEED-THRU - A device to electrically connect elbows or other accessories.

FUSE - An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it. (IEEE-100)

G

GROUND - A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth or to some conducting body of relatively large extent that serves in place of the earth. (IEEE-100)

GROUND CURRENT - Current flowing in the earth or in a grounding connection. (IEEE-100)

GROUND GRID -	A system of grounding electrodes consisting of interconnected bare cables buried in the earth to provide a common ground for electrical devices and metallic structures. (IEEE-100)
GROUND MAT -	A system of bare conductors, on or below the surface of the Earth, connected to a ground or a ground grid to provide protection from dangerous voltages. (IEEE-100)
GROUND ROD -	A rod that is driven into the ground to serve as a ground terminal, such as a copper-clad rod, solid copper rod, or galvanized iron pipe or rod. (IEEE-100)
GROUNDING TRANSFORMER -	A transformer intended primarily to provide a neutral point for grounding purposes. **Note:** It may be provided with a Delta winding in which resistors or reactors are connected. (IEEE-100)
GUARDED -	Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats or platforms, designed to limit the likelihood, under normal conditions, of dangerous approach or accidental contact by persons or objects. **Note:** Wires that are insulated but not otherwise protected are not normally considered to be guarded. See exceptions under applicable rules. (NESC)
GUY -	A tension member having one end secured to a fixed object and the other end attached to a pole, crossarm, or other structural part that it supports. (IEEE-100)

H

HANDHOLE -	An access opening, provided in equipment or in a below-the-surface enclosure in connection with underground lines, into which personnel reach but do not enter, for the purpose of installing, operating, or maintaining equipment or cable or both. (NESC)
HIGH VOLTAGE SYSTEM -	See Voltage Systems.

I

IMPEDANCE VOLTAGE (TRANSFORMER) -	The voltage required to circulate rated current through one of two specified windings of a transformer when the other winding is short-circuited, with the windings connected as for rated voltage operation. **Note:** It is usually expressed in per unit or percent, of the rated voltage of the winding in which the voltage is measured. (IEEE-100)
INRUSH CURRENT (TRANSFORMER) -	The maximum root-mean-square or average current value, determined for a specific interval, resulting from the excitation of the transformer with no connected load, and with essentially zero-source impedance, and using the minimum primary turns tap available and its rated voltage. (IEEE-100)
INSULATING CAP-	A cap that is used for insulating, shielding and sealing a bushing plug.
INSULATION-	That which is relied upon to insulate the conductor from other conductors or conducting parts or from ground (as applied to cable). (NESC)
INSULATOR -	Insulating material in a form designed to support a conductor physically and electrically separate from another conductor or object. (IEEE-100)
ISOLATED NEUTRAL SYSTEM -	A system that has no intentional connection to ground except through indicating, measuring, or protective devices of very high impedance. (IEEE-100)

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J

JACKET -	A protective covering over the insulation, core, or sheath of a cable. (NESC)

L

LATERAL CONDUCTOR -	A wire or cable extending in a general horizontal direction at an angle to the general direction of the line conductor. (IEEE-100)	
LAY (CABLE) -	The helical arrangement formed by twisting together the individual elements of a cable. (IEEE-100)	
LIGHTNING ARRESTER -	See Surge Arrester.	
LIVE -	See Alive.	
LIVE FRONT (TRANSFORMERS & SWITCHGEAR) -	With live parts exposed to a person on the operating side of the equipment.	
LOAD FACTOR -	The ratio of the average load over a designated period of time to the peak load occurring in that period. (IEEE-100)	
LOAD LOSSES (TRANSFORMER) -	Those losses which are incident to the carrying of a specified load. Load losses include I^2R loss in the winding due to load and eddy currents, stray loss due to leakage fluxes in the windings, core clamps, and other parts; and the loss due to circulating current (if any) in parallel windings, or in parallel winding strands. (IEEE-100)	
LOCATION -	Damp Location –	Partially protected locations under canopies, marquees, roofed open porches, and like locations; and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses.
	Dry Location –	A location not normally subject to dampness or wetness. Any location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
	Wet Location –	Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids such as vehicle washing area, and locations exposed to weather and unprotected.
LOSS FACTOR -	The ratio of the average power loss to the peak-load loss during a specified period of time. (IEEE-100)	
LOW VOLTAGE -	See Voltage Systems.	
LUG -	A wire connector device to which the electrical conductor is attached by mechanical pressure or solder. (IEEE-100)	
LUMINAIRE -	A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply. (IEEE-100)	

M

MANDREL -	A tapered or cylindrical axle used to pull through conduit for inspections.
MANHOLE -	A subsurface enclosure that personnel may enter and is used for the purpose of installing, operating, and maintaining submersible equipment and cable. (NESC)
MANUAL -	Operated by mechanical force, applied directly by personal intervention. (IEEE-100)
MANUAL OPERATION -	Operated by hand without using any other source of power. (IEEE-100)
MEDIUM VOLTAGE SYSTEM -	See Voltage System.
MULTI- GROUNDED NEUTRAL SYSTEM -	A distribution system of the 4 wire type where all transformer neutrals are grounded, and neutral conductors are directly grounded at frequent points along the circuit. (IEEE-100, NESC) A system of conductors in which a neutral conductor is intentionally grounded solidly at specified intervals. A multigrounded or multiple grounded systems may or may not be effectively grounded. (NESC)

N

NAMEPLATE -	A plaque giving the manufacturer's name and the rating of the equipment to which it is attached. (IEEE-100)
NETWORK -	An aggregation of interconnected conductors consisting of feeders, mains, and services. (IEEE-100)
NEUTRAL CONDUCTOR -	The conductor that is intended to be so energized, that, in the normal steady state, the voltages from every other conductor to the neutral conductor, at the terminals of entry of the circuit into a delimited region, are definitely related and usually equal in amplitude. (IEEE-100, NESC) A system conductor other than a phase conductor that provides a return path for current to the source. Not all systems have a neutral conductor. An example is an ungrounded delta system containing only three energized phase conductors. (NESC)
NO-LOAD LOSSES -	Those losses which are incident to the excitation of the transformer. No-load (excitation) losses include core loss, dielectric loss, conductor loss in the winding due to exciting current, and conductor loss due to circulating current in parallel windings. These losses change with the excitation voltage. (IEEE-100)
NOMINAL SYSTM VOLTAGE -	See Voltage, Nominal.
NON-EFFECTIVELY GROUNDED -	An alternating-current system or portion thereof may be said to be non effectively grounded when, for all points on the system or specified portion thereof, the ratio of zero-sequence reactance to the positive-sequence reactance is greater than three and the ratio of zero-sequence resistance to positive-sequence reactance is greater than one for any condition of operation and for any amount of connected generator capacity.

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NOT EFFECTIVELY GROUNDED -	Not permanently connected to earth through a ground connection or connections of sufficiently high impedance and not having sufficient current-carrying capacity to prevent the building up of voltages that may result in undue hazard to connected equipment or to persons.
NOVOID X -	Filling compound for G & W porcelain potheads and armored cable joint boxes.

O

OFC -	Oil Fused Cutout.
OPEN WIRE -	Single conductor, bare, covered or insulated, and separated by air from other conductors, e.g, not a cable.

P

PAD-MOUNTED -	A general term describing equipment positioned on a surface-mounted pad located outdoors. **Note**: The equipment is usually enclosed with all exposed surfaces at ground potential. (IEEE-100)
PAD-MOUNTED TRANSFORMER -	A transformer utilized as part of an underground distribution system, with enclosed compartment(s) for high voltage and low voltage cables entering from below and mounted on a foundation pad. (IEEE-100)
PARKING STAND -	A bracket designed for installation on an apparatus, suitable for holding accessory devices, such as insulated parking bushing and grounding bushing. (IEEE-100)
PILC-	Paper Insulated Lead Covered Cable
POLE-TYPE TRANSFORMER -	A transformer that is suitable for mounting on a pole or similar structure. (IEEE-100)
POTHEAD -	A device that seals the end of a cable and provides an insulated exit for the conductor or conductors. (IEEE-100)
POWER FUSE -	A fuse consisting of an assembly of a fuse support and a fuse unit or fuseholder that may or may not include the refill unit or fuse link. **Note:** The power fuse is identified by the following characteristics: (1) Dielectric withstand (basic impulse insulation level) strengths at power levels; (2) Application primarily in stations and substations; (3) mechanical construction basically adapted to station and substation mounting. (IEEE-100)
PRESSURE RELIEF DEVICE -	A means for relieving internal pressure in a transformer, possibly preventing explosive shattering of the tank or tank cover, following prolonged passage of fault current due to external faults or internal transformer faults. (IEEE-100)
PULLING EYE -	A device that may be fastened to the conductor or conductors of a cable or formed by or fastened to the wire armor and to which a rope may be directly attached in order to pull the cable into or from a duct. (IEEE-100)
PUSH BRACE -	A supporting member, usually of timber placed between a pole or other structural part of a line and the ground or a fixed object. (IEEE-100)

Q

QUADRUPLEX CABLE -	A cable composed of four (4) insulated single conductors or three (3) insulated conductors and one (1) bare neutral conductor twisted together.

R

RADIAL SYSTEM -	A system in which independent feeders branch out radially from a common source of supply. (IEEE-100)
RISER POLE -	Pole on which overhead wires connect to underground cable.
RULING SPAN -	A calculated deadend span length, which will have the same changes in conductor tension due to changes of temperature and conductor loading, as will be found in a series of spans of varying lengths between deadends. (IEEE-100)

S

SAG -	The distance measured vertically from a conductor to a straight line joining its two (2) points of support. Unless otherwise stated, the sag referred to is the sag at the midpoint of the span. (IEEE-100)
SECONDARIES -	Circuits 600 volts and below.
SEPARATION -	The distance between two objects, measured surface to surface, and usually filled with a solid or liquid material. (NESC)
SERVICE DROP -	The overhead conductors between the electric supply or communication line and the building or structure being served. (NESC)
SERVICE ENTRANCE CONDUCTORS, OVERHEAD SYSTEM –	The service conductors between the terminals of the service equipment and point usually outside the building, clear of building walls, where jointed by tap or splice to the service drop. (NEC)
SERVICE ENTRANCE CONDUCTORS UNDERGROUND SYSTEM -	The service conductors between the terminals of the service equipment and the point of connection to the service lateral. **Note:** Where service equipment is located outside the building walls there may be no service-entrance conductors, or they may be entirely outside the building. (NEC)
SERVICE LATERAL -	The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure with adequate space, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to be the point of entrance of the service conductors into the building. (NEC)
SIDE BREAK SWITCH -	A switch in which the travel of the blade is in a plane parallel to the base of the switch. (IEEE-100)
SIDEWALL PRESSURE -	The crushing force exerted on a cable during installation. (IEEE-100, NESC)

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SOLIDLY - GROUNDED	Grounded through all adequate ground connection in which no impedance has been inserted intentionally. **Note:** Adequate as used herein means suitable for the purpose intended. (IEEE-100)
SPACER CABLE -	A type of electric supply-line construction consisting of an assembly of one or more covered conductors, separated from each other and supported from a messenger by insulating spacers. (IEEE-100, NESC)
SPAN LENGTH -	The horizontal distance of two (2) adjacent supporting points of a conductor. (IEEE-100)
SPLICE -	A physical connection of two (2) or more conductors to provide electrical continuity. (IEEE-100)
SPLICE TYPES-	Double Wye: also known as a double double or an H splice, splices four cables together. Modula/Separable: A joint that is built that can be easily taken apart by mechanical means. Normal: A splice of two similar cables. Reducing: A type of splice that will join two different sizes of cable together. Reducing/Transition: To splice a PILC cable to a smaller solid dielectric cable. Transition: Splicing together PILC cable to solid dielectric cable. Trifurcating: Splicing a 1-3/C cable to a 3-1/C cable. Trifurcating/Transition: Splicing a 1- 3/C PILC cable to 3-1/C solid dielectric cable. Wye: Splicing 3 cables together.
STEP-DOWN TRANSFORMER -	A transformer in which the energy transfer is from a higher voltage circuit to a lower voltage circuit. (IEEE-100)
STEP-UP TRANSFORMER -	A transformer in which the energy transfer is from a lower voltage circuit to a higher voltage circuit. (IEEE-100)
SUBMARINE CABLE -	A cable designed for service under water. **Note:** Submarine cable is usually a lead-covered cable with a steel armor applied between layers of jute. (IEEE-100)
SUBMERSIBLE TRANSFORMER -	A transformer so constructed as to be successfully operable when submerged in water under predetermined conditions of pressure and time. (IEEE-100)
SUBWAY TRANSFORMER -	A submersible-type distribution transformer suitable for installation in an underground vault. (IEEE-100)
SURGE ARRESTER -	A protective device for limiting surge voltage on equipment by discharging or bypassing surge current; it prevents continued flow of follow current to ground, and is capable of repeating these functions as specified. (IEEE-100)
SWEEP -	A manufactured bend installed at pad mounted equipment locations.

SWITCH -	Disconnecting or Isolation Switch -	A mechanical switching device used for changing the connections in a circuit or equipment from the source of power. **Note:** It is required to carry normal load current continuously, and also abnormal or short-circuit currents for short intervals as specified. It is required to open or close circuits either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the switch poles occurs.
	Load-Interrupter Switch -	A disconnecting or isolating switch equipped with an interrupter and designed to interrupt currents not in excess of the continuous-current rating of the switch.
	Regulator Bypass Switch -	A specific device or combination of devices designed to bypass a regulator.

T

TERMINAL - A conducting element of equipment or a circuit intended for connection to an external conductor. (IEEE-100)

TERMINAL CONNECTOR - A connector used for attaching a conductor to a lead, terminal block, or stud of electric apparatus. (IEEE-100)

TERMINAL PAD - A usually flat conducting part of a device to which a terminal connector is fastened. (IEEE-100)

TERMINATOR - An insulator used to protect each cable conductor passing through the device and provide complete external leakage insulation between the cable conductor(s) and ground.

TERMINATOR /POTHEAD - A device that seals the end of a cable and provides insulated egress for the conductor or conductors. (IEEE-100)

TIE LINE - A transmission/distribution line connecting two (2) or more power systems. (IEEE-100)

TOTAL LOSSES - The sum of the no-load and load losses, excluding losses due to accessories. (IEEE-100)

TRIPLEX CABLE - A cable composed of three (3) insulated single conductors or two (2) insulated single conductors and a bare neutral conductor twisted together. (IEEE-100)

U

ULTRA HIGH VOLTAGE SYSTEM - See Voltage System

UNGROUNDED - A system, circuit, or apparatus without an intentional connection to ground except through potential indicating or measuring devices or other very high impedance devices. (IEEE-100)

UNIGROUNDED NEUTRAL SYSTEM - A system of conductors in which one conductor is intentionally grounded solidly at a specific location, typically at the source.

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V

VAULT - A structurally sound enclosure, including all side, top, and bottom, above or below ground where entry is limited to personnel qualified to install, maintain, operate, or inspect the equipment or cable enclosed. The enclosure may have openings for ventilation, personnel access, cable entrance, and other openings required for operation of equipment in the vault. (NESC)

VOLTAGE, - NOMINAL A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment. See "Electric Power Systems and Equipment – Voltage Ratings (60 Hz)" (ANSI C84.1-82, IEEE-100)

VOLTAGE - SYSTEMS

Low-Voltage System -	An electric system having a maximum root-mean-square alternating-current voltage of 1000 volts or less. (IEEE-100)
Medium Voltage System -	An electric system having a maximum root-mean-square alternating-current voltage above 1000 volts to 72,500 volts. (IEEE-100)
High Voltage System -	An electric system having a maximum root-mean-square alternating current voltage above 72,500 volts to 240,000 volts. (IEEE-100)
Extra-High Voltage System -	An electric system having a maximum root-mean-square alternating current voltage above 240,000 volts to 800,000 volts. (IEEE-100)
Ultra-High Voltage System -	An electric system having a maximum root-mean-square alternating current voltage above 800,000 volts to 2,000,000 volts. (IEEE-100)

VOLTAGE TO - GROUND For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded. For ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit. (IEEE-100)

W

WEIGHT SPAN - Distance to the low point in the Actual Span ahead + distance to the low point in the Actual Span back. The weight span is a calculated term used to determine the vertical loading in crossarms and poles from the weight of ice coated conductors.

WIND SPAN - ½ Actual Span ahead + ½ Actual Span back. The wind span is a calculated term used to determine the transverse loading on the pole from the wind on ice coated conductors.

WOUND - Single Wound – One cable wound on a reel.
Triple Wound – Three cables in parallel wound on a reel.

31.1 NO TRESPASSING SIGNS

31.1.10 General

This Section covers the specification and installation of a “No Trespassing” sign on substation gates and other fenced entrances to Company property.

31.1.20 Application

“No Trespassing” signs shall be installed at all locations on Company property where unauthorized entry is prohibited. Locations may include substations, control house buildings, etc.

31.1.30 Specifications

The 8 inch x 18 inch sign shall be constructed out of 63 mil thick aluminum plate. It shall have a painted white background on which “NO TRESPASSING” shall be printed in black with 2 inch high letters. The sign shall have six ¼ inch diameter holes for fence mounting.

Supersedes 2/06 Issue –Added Definition

Table 1
Standard Items

Item Description	Std. Item
“NO TRESPASSING” Sign	P23NT
8 Inch Stainless Steel Ties	P27T

Figure 1
“NO TRESPASSING” Sign

31.1.40 Installation

At substations, install the “NO TRESPASSING” sign on the fenced gates using stainless steel ties. The field will determine mounting options for other locations. The sign should be mounted so as to be clearly visible to anyone approaching the facility. Also ensure that the appropriate territory specific decal is affixed in the space provided on the sign.

Supersedes 7/11 Issue – Update Fig. 2 with Company Logo

31.1 PADMOUNT SIGNS

31.2.10 General

All distribution pad-mounted equipment containing energized parts shall be marked with a warning decal and a danger decal.

A. Warning Decal

This decal will be mounted on the outside of the equipment by the manufacturer on all new purchased pad mount equipment. Figure 2 shows the decal (Std. Item P25P).

For existing equipment not having warning or danger decals, the Company shall install these decals at the time of their on-site inspection.

Switchgear or transclosures with doors front and back shall have warning decals both front and back.

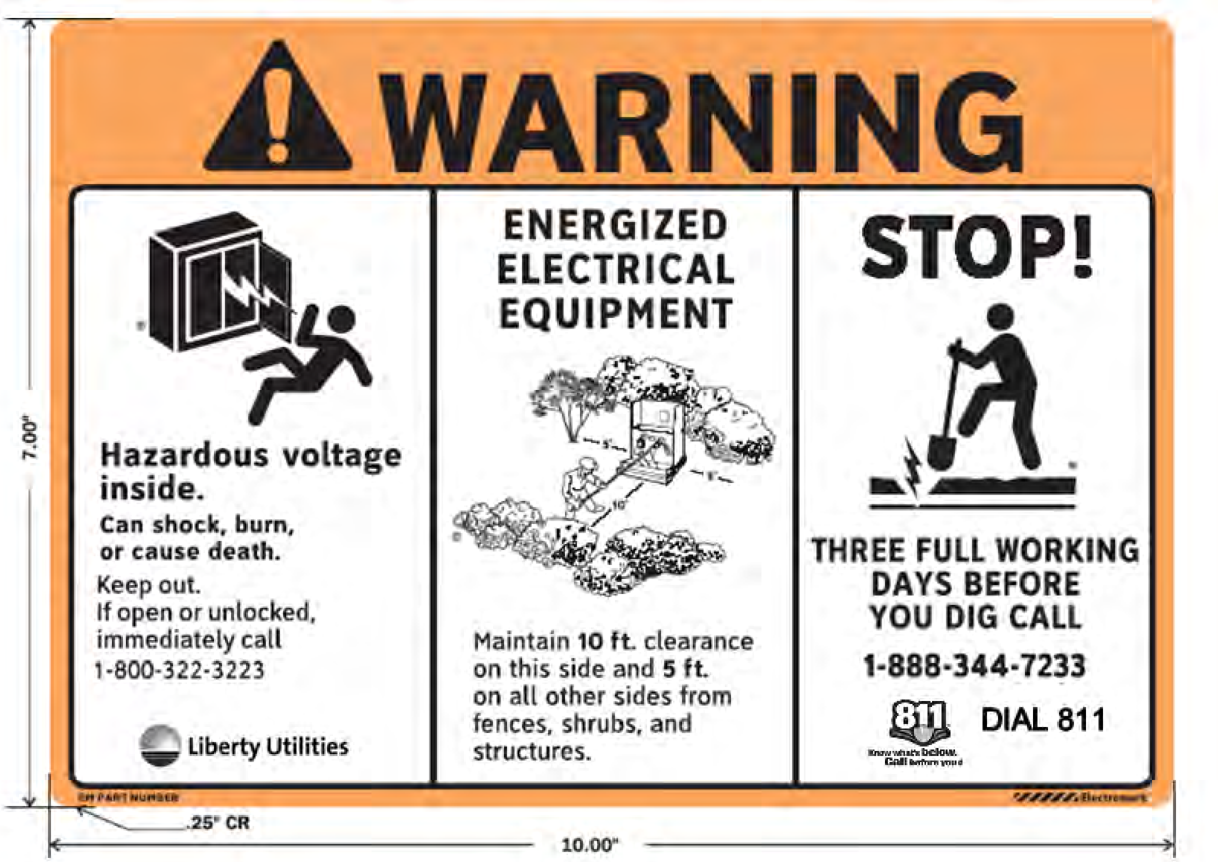


Figure 2

B. Danger Decal

This decal shall be mounted on the inside of the equipment. Multi-compartment equipment shall have a decal in each compartment.

Figure 3

The manufacturer shall install the danger decals (Std. Item P25PD) on all newly purchased pad-mounted equipment. See Figure 3 above for details.

For existing equipment not having warning or danger decals, the Company shall install these decals at the time of their on-site inspection.

Switchgear with barriers on the inside of the compartment areas shall have the danger decal installed on the front side of each barrier.

Supersedes 7/07 issue – Text update

C. Warning Decal For Step Down Padmounted Transformers

This decal will be mounted on the outside of the equipment by the manufacturer on all new purchased pad mount equipment.

Figure 4 shows this decal in detail (Std. Item P25ST).

Figure 4

.

D. Caution Decal for a containment barrier when installed below a concrete pad for Oil Filled Padmount Equipment.

This decal shall be installed by the field when an oil containment barrier is installed below a concrete pad for oil filled padmount equipment.

The decal shall be placed on the most visible location on the front door of the padmount transformer.

Figure 5 shows this decal in detail (Std. Item P25PC).

Supersedes 7/07 issue – Added figure number and Std Item and text update

Figure 5

E. <u>Live Front Decal for Livefront Style Padmount Equipment</u>.

This decal shall be installed in the primary compartments door channel area. This decal adds awareness to the worker before accessing the live front primary compartment of a padmounted transformer.

Figure 6 shows this decal and the decal installed in detail (Std. Item P25PL).

New Standard

Figure 6

F. Normal Open Decal for Padmount Equipment.

This N.O. label is an abbreviation for normal open and is to be used to label the open point in a loop feed underground system.

This peel off decal shall be installed on the upper center portion of the front door of padmount equipment.

Figure 7 shows this decal in detail (Std. Item P25PNO)

New Standard

Figure 7

G. <u>Warning Sign for Padmount Equipment - Tie Point Not in Phase</u>.

This sign shall be installed on all not in phase open tie points.

This magnetic decal shall be installed inside the primary compartment door area of padmount equipment.

Figure 8 shows this decal in detail (Std. Item P22P1)

New Standard

Figure 8

H. Caution Sign for Padmount Equipment - Feeder Tie Point.

This sign shall be installed on all in phase open tie points.

This magnetic decal shall be installed inside the primary compartment door area of padmount equipment.

Figure 9 shows this decal in detail (Std. Item P22P2)

Figure 9

New Standard

Text Shift and figure update

31.2.20 Equipment Numbering

Where applicable, pad-mounted equipment numbers shall be attached to each piece of equipment. Use 1¼ inch x 1 inch pressure sensitive mylar markers.

31.2.30 Mounting Locations

The recommended mounting locations for the signs and equipment numbers are illustrated in Figure 10. If the danger decal cannot be mounted in the recommended areas, then mount them in the most visible area when the doors are open

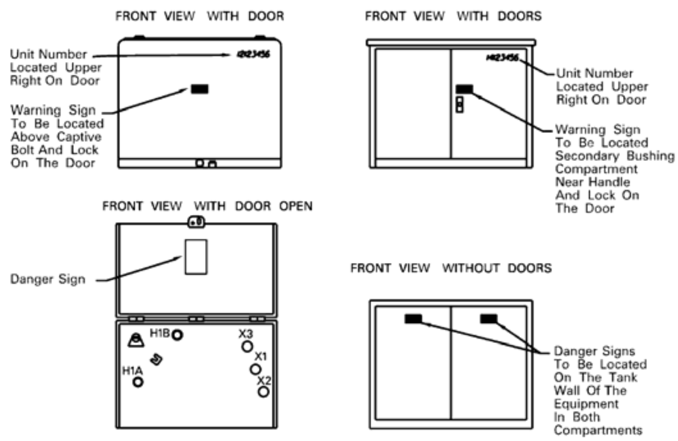


Figure 10

31.2.40 Alternate Mounting Locations

The recommended mounting locations for the signs and equipment numbers are illustrated below. If the warning decal cannot be mounted in the recommended areas, then mount them in the most visible area when the doors are open.

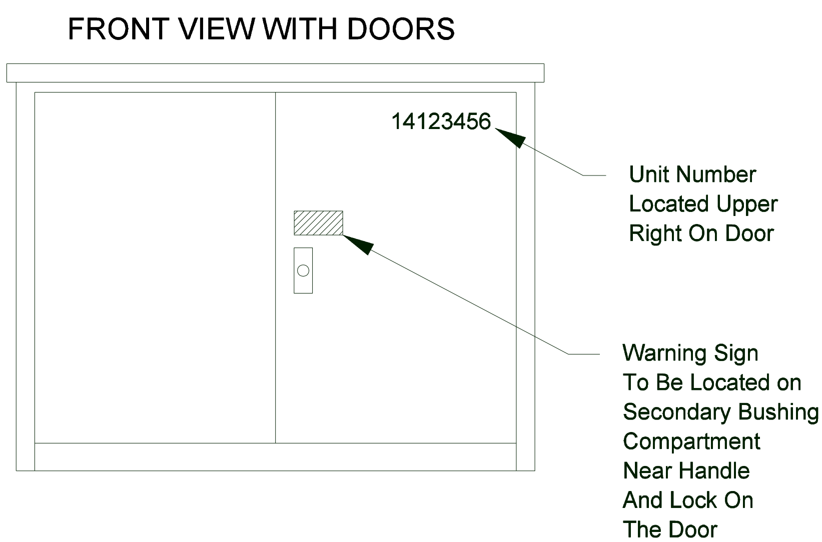


Figure 11

31.3 ACCIDENT PREVENTION SIGNS

Text Shift and figure reassignment

SIGN A

Figure 12

Std. Item P23A1 – 8 inches high x 18 inches wide high intensity reflective sign on rigid aluminum base. For use on substation fences, gates, and masonry walls; at R/W and substation access roadway and fences; and building vault masonry walls.

Std. Item P23A2 – 8 inches high x 18 inches wide high intensity reflective sign with removable backslit liner. For use on metal substation doors and panels, and building vault doors.

SIGN C

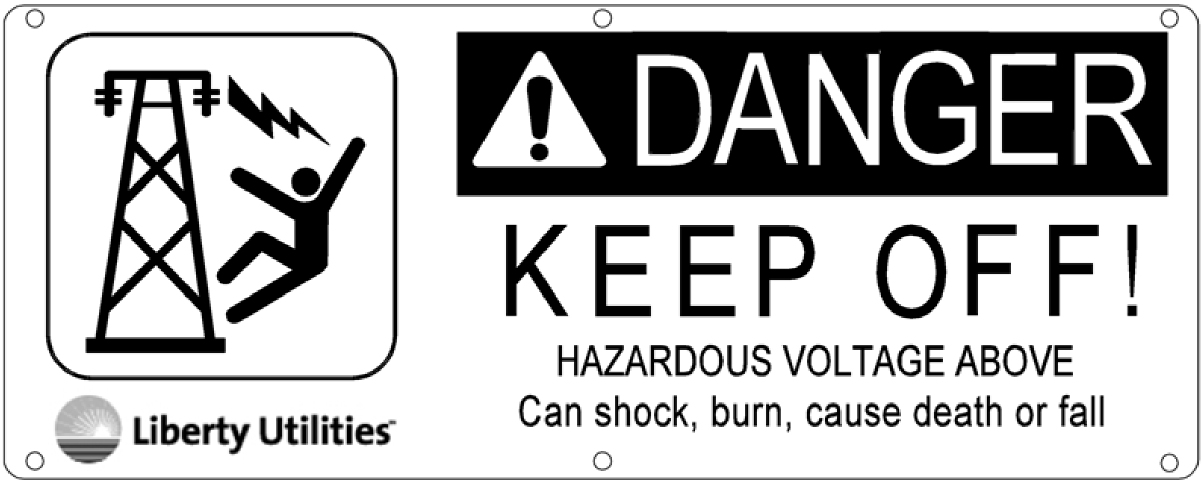


Figure 9

Std. Item P23C1 – 8 inches high x 18 inches wide high intensity reflective sign on rigid aluminum base. For use on metal towers and structures on rights-of-way.

Std. Item P23C2 – 8 inches high x 18 inches wide high intensity reflective sign on flexible aluminum base. For use on wood poles and structures on rights-of-way.

Std. Item P23C3 – 8 inches high x 18 inches wide high intensity reflective sign with removable backslit liner. For use on metal poles on rights-of-way.

Installation – The sign shall be mounted so as to be clearly visible to anyone approaching the facility or structure. Ensure that the appropriate territory specific decal is affixed in the space provided on the sign.

Exception: No decal is required at locations where property and fence is owned by the customer.

Text Shift and figure reassignment

Table 2

Device To Be Signed	Sign	Std. Item	State	Sign Type	Placement / Attachment
7' chain link fence enclosing open type structures, metal-clad gear, or indoor stations.	'A'	P23A1	All	High intensity reflective sign on rigid aluminum base.	Eye level on outside of fence/fasten to approved bracket using nonferrous fasteners - See notes below.
4' chain link fence enclosing locked metal-clad station.	'A'	P23A1	All	High intensity reflective sign on rigid aluminum base.	As high as possible on outside of fence/fasten to approved bracket using nonferrous fasteners - See notes below.
7' chain link fence gate as part of fence enclosing open type structures, metal-clad gear or indoor stations.	'A'	P23A1	All	High intensity reflective sign on rigid aluminum base.	Eye level - center and outside of gate/fasten to approved bracket using nonferrous fasteners - See notes below.
Locked metal door - indoor station enclosed by chain link fence; in masonry wall serving as part of fence enclosing station.	'A'	P23A2	All	Reflective self-adhesive sign with removable backslit liner.	Eye level - center and outside of door/clean metal surface remove backslit liner, apply sign.
Locked metal doors & panels of metal-clad stations enclosed by chain link fence.	'A'	P23A2	All	Reflective self-adhesive sign with removable backslit liner.	Eye level - center and outside of door panel/clean metal surface, remove backslit liner, apply sign.
Masonry walls adjacent to locked metal door - indoor station enclosed by chain link fence which serves as part of fence surrounding stations.	'A'	P23A1	All	High intensity reflective sign on rigid aluminum base.	Eye level - nonhinged side of door/use approved masonry fasteners - See notes below.
Access roadway gate, chain, cable, and fence.	'A'	P23A1	All	High intensity reflective sign on rigid aluminum base.	Midpoint of chain or eye level on outside of fence/use nonferrous wire or bracket with nonferrous fastenings.

Accident Prevention Signs For Substations

Text Shift

Notes (For Tables 2, 3 and 4):

1. Appropriate company name decals shall be applied indoors to above signs prior to sign installation.
2. Appropriate signs required by state law shall be strictly adhered to.
3. Sign placement along fence perimeters not to exceed 50 feet.
4. All station gates are to be signed.
5. All fence and wall sections adjacent to gates and doors shall be signed on the non-hinged side of the gate or door, where practical.
6. Tower signs shall not be free swinging - rigid mounting means are required.

Table 3
Accident Prevention Signs For Rights-Of-Way

Device To Be Signed	Sign	Std. Item	State	Sign Type	Placement / Attachment
All metal towers & structures	'C'	P23C1	NH	High intensity reflective signs on rigid aluminum base	10'-15' above ground - minimum of two signs on opposite sides/rigid attachment - detail by Transmission Department
All steel poles	'C'	P23C3	NH	High intensity reflective signs with removable backslit liner	10'-15' above ground - opposite sides/ detail by Transmission Department
All wood poles & structures	'C'	P23C2	NH	High intensity reflective signs on flexible aluminum base	10'-15' above ground - opposite sides/ aluminum roofing nails
Access roadway gate, chain, cable, fence	'A'	P23A1	All	High intensity reflective signs on rigid aluminum base	Midpoint of chain or eye level on outside of fence/use nonferrous wire or bracket with nonferrous fasteners

Table 4
Accident Prevention Signs For Building Vaults

Text Shift

Device To Be Signed	Sign	Std. Item	State	Sign Type	Placement / Attachment
Locked metal door at vault entrance	'A'	P23A2	All	High intensity reflective signs with removable backslit liner	Eye level, center and outside of door/remove backslit liner, apply sign
Masonry wall adjacent to vault entrance door	'A'	P23A1	All	High intensity reflective signs on rigid aluminum base	Eye level, non-hinged side of door/approved masonry fasteners

 | Doc. # ST. 31.00.001

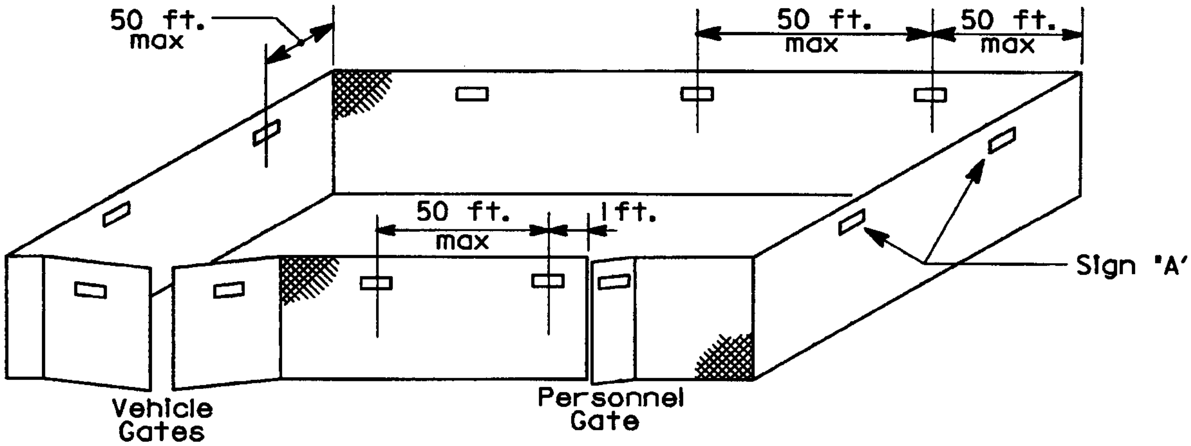


Figure 15
Posting Substations Enclosed With Chainlink Fence

Notes:

1. Sign chainlink fences using sign "A".
2. Place all signs as close to eye level as possible. Attach signs as level as possible.
3. Sign all gates at eye level with sign at gate center.
4. Fence sides that contain no gates should have symmetrical sign placement as much as is possible.
5. Maximum distance between signs along fence perimeter not to exceed 50 feet.
6. Refer to Figure 15 for fastening detail.
7. Sign unhinged side of single gates at eye level one foot from gate post.
8. Remove old signs and return to stores for disposal.
9. On stations where customer owns fence and property and the Company owns equipment inside the fence – do not install Company name decal to sign.

Text Shift and figure reassignment

31.4 UNDERGROUND CABLE SIGN

Underground cable marker used in locations for identifying permanently buried electric cables. The marker shall be used in right of ways for an added method to identify cables are buried below. They should be spaced approximately every 200 feet.

Figure 16 shows this decal in detail (Std. Item P22R1)

Figure 16

888 – 344 – 7233 (Dig Safe # New Hampshire)

Liberty Utilities

888 – 625 - 3723

CONCRETE

31.5.10 General

Use reinforced and plain concrete, when job specifications are not being issued. Not for use when placing concrete underwater (Tremie concrete).

31.5.20 Materials

Cement shall be a standard brand of Portland Cement Type II conforming to ASTM C150. If concrete is to be in contact with sea water or soils other than clean gravel, or if job conditions require earlier strength development than Type II provides, notify Standards Engineering for use of a higher strength or high-early strength concrete.

Sand shall be sharp and clean and shall conform to ASTM C33, latest revision.

Coarse aggregate shall be of gravel, crushed gravel or crushed stone and conform to ASTM C33, latest revision.

Water shall be from a potable water supply or tested and approved by Standards Engineering, assuring it is clean and free from injurious amounts of oil, acids, alkali, organic materials, or other harmful substances.

31.5.30 Ready-Mix Concrete

Ready-mix concrete shall be proportioned at the plant. Mixing and delivery shall be in accordance with ASTM C94, latest revision. Mixes shall conform to Table 6 for minimum 28 day strength, nominal maximum size aggregate, and slump.

An air-entraining agent shall be added to concrete mixes in which the surface will be exposed to the elements. No other admixtures shall be used without approval of Standards Engineering. Air- entrainment content shall be as follows:

Table 5

Mix M2 and M3:	7.0% plus or minus 2.0%
Mix M4:	5.0% plus or minus 1.5%
Mix M5:	4.5% plus or minus 1.5%
Mix M6:	6.0% plus or minus 1.0%
Mix M7:	6.0% plus or minus 1.0%

The purchaser reserves the right to make tests at any time on materials used and concrete furnished by the ready-mix concrete supplier. The batch plant, equipment, and operating procedures are subject to inspection and approval by Standards Engineering or their qualified representative.

Supersedes 7/07 Issue –Added Mix M7 and section renumbering

Table 6

Mix Number	Strength Minimum 28 Day (Lbs./Square Inch)	Aggregate Maximum Size Nominal	Slump Not More Than	Typical Applications
M1	2,000	1-½”	2”	Bedrock and Floor Fill
M2	2,000	½”	2”	Duct Lines – Tier Method
M3	2,000	½”	6”	Duct Lines – Unit Method
M4	3,000	1-½”	2”	Footings, Slabs on Ground, Foundation Walls, and Pile Caps
M5	3,000	1”	2”	Floor and Roof Slabs on Forms
M6	4,000	1”	2”	Hi-Strength Slabs and Walls
M7	5,000	1”	2”	Hi-Strength Slabs and Walls

Concrete Mixes

Note: If a greater slump is required, contact Standards Engineering for an additive to meet the specific job requirements.

Ready-mix concrete shall be ordered in accordance with this Section. The cubic yards, delivery point, time schedule, and applicable mix number for the particular application shall be specified on the order.

Delivery of a concrete batch in excess of the rated mixer drum capacity is cause for rejection. The latest drum inspection certificate should be available for verification.

31.5.40 Delivery And Mixing

In the event that delivery of concrete is called for when the air temperature is below 40 degrees Fahrenheit, the following shall apply:

A. When the air temperature is between 30 degrees Fahrenheit and 40 degrees Fahrenheit, the concrete shall be delivered in excess of 55 degrees Fahrenheit.

B. When the air temperature is between 0 degrees Fahrenheit and 30 degrees Fahrenheit the concrete shall be delivered at a temperature in excess of 60 degrees Fahrenheit.

In hot weather concrete shall be delivered at a temperature which will not cause difficulty from loss of slump, flash set, or cold joints. Discharge of concrete at the job site shall be completed within one hour of adding the mixing water.

31.5.50 Forms

Formwork shall be designed and constructed in accordance with the American Concrete Institute's "Recommended Practice For Concrete Formwork", ACI 347, of latest date.

Forms shall be built substantially; true to form, lines, dimensions, and grades shown. They shall be braced and tied to maintain position and shape, without yielding to pressure of fluid concrete or other forces, including those produced by vibratory compaction.

Supersedes 7/07 Issue – Added M7 mix and section renumbering

Forms shall be constructed of ¾ inch BB grade plywood supported with 2 x 4 studs on 16 inch centers. Forms shall not exceed a 10 foot pour height and form tie spacing shall not exceed 2 feet. Form ties and accessories, manufactured by Richmond Screw Anchor Company or equal, shall be used. Prefabricated forms are allowed after approval by Standards Engineering. The forms shall be vertical and symmetrical and in the largest sizes practicable. Sheets showing torn grain, worn edges, hole patches, or other defects, which impairs the texture of the concrete surface, shall not be used. Forms shall be treated with approved form oil, before erection or reinforcing steel placement, to prevent adhesion of the concrete.

Forms shall be mortar-tight. For surfaces which will be exposed, the form faces shall be smooth and mortar-tight.

Forms shall be removed carefully to avoid damage to the concrete surfaces. The removal time is governed by the concrete's condition, curing temperature, curing time, and the forces the new concrete may be subjected. Under favorable curing conditions, forms may be removed no sooner after placement than the following:

C. 7 days for supported floor and roof slabs

D. 48 hours for wall and columns

E. 24 hours for footing walls and piers

F. 12 hours for underground duct lines

If high-early strength concrete is used, the above time periods may be reduced by one-half.

These periods presented are the cumulative number of days or fractions thereof, not necessarily consecutive, during which the concrete temperature is above 50 degrees Fahrenheit. Whenever formwork is removed during the curing period, the exposed concrete shall be repaired immediately, finished, and cured as specified under Section 31.4.70.

Text Shift and section renumbering

31.5.60 **<u>Placement</u>**

Concrete shall not be placed until the forms, previously poured concrete surfaces, reinforced steel, and embedded parts have been cleaned of laitance, loose or defective concrete, soil on rock surface, and any other foreign materials.

All concrete placed when the air temperature is above 45 degrees Fahrenheit shall be placed at the coolest temperature as practicable. Concrete placement is not permitted when hot weather conditions prevent proper placement and consolidation. Concrete will not be accepted if its temperature is in excess of 80 degrees Fahrenheit.

When the mean daily temperature falls below 40 degrees Fahrenheit, the minimum concrete temperature shall be 55 degrees Fahrenheit and as close to this minimum as possible.

When the air temperature is below 40 degrees Fahrenheit, provide suitable protection so the concrete can be maintained at a minimum of 50 degrees Fahrenheit throughout the curing period. The protection and heat source, shall maintain the required temperature and moisture conditions without injury due to concentration of heat. All materials which the concrete contacts such as reinforcing, forms, ground, etc., shall be free of frost prior to placement.

Concrete temperature changes during and immediately following the curing period shall be as uniform as possible and shall not exceed 5 degrees Fahrenheit in any one hour, nor 40 degrees Fahrenheit in any 24 hour period. When heaters are used, prevent local surface heating and drying and provide adequate ventilation to prevent carbonation damage to exposed concrete surfaces. Thermostatic temperature controls shall be provided to control the heated enclosures to 50 degrees Fahrenheit. Temperatures exceeding 80 degrees Fahrenheit are to be avoided.

Concrete shall not be allowed to fall from the end of a chute, tube, or bucket more than 5 feet to point of deposit and shall have a fall free from obstructions. Chutes shall be metal or metal-lined. Pumping equipment, pipelines, procedures, etc., shall be in accordance with ACI 304R, latest revision, and Standards Engineering shall be consulted for mix design of any pumped application. Conveying equipment for pumped concrete shall be of suitable kind, without "Y" sections and with adequate pumping capacity. No aluminum pipe shall be used. Placement shall be controlled so there is no separation in the discharged concrete. The maximum loss of slump in pumping equipment shall be 1½ inches.

Concrete shall be deposited as near to its final position as possible to avoid long flows in the forms. Concrete shall not be moved more than 10 feet from point of deposit. Concrete shall be placed in successive horizontal layers, ranging in thickness from 6–15 inches, maximum. Concrete shall be placed within 1½ hours after addition of cement to the aggregate.

Text Shift and section renumbering

Where conditions make it difficult to place concrete uniformly and perform compaction at the bottom of forms, batches of mortar containing the same proportion of cement to sand as in the concrete mix shall be deposited first and spread over the cleaned surface to a depth of approximately 1 inch.

Segregated, unworkable, and excessive slump concrete shall not be placed or, if placed, shall be removed and wasted as directed. High slump concrete resulting from addition of approved additives is acceptable for placement. Free water accumulating on new concrete during placement shall be removed as directed by the Engineer.

Placement and compaction methods shall ensure homogeneous concrete with maximum consolidation without segregation. Consolidate concrete by internal vibration, spading, or rodding by working it thoroughly around reinforcement, embedded items, and into corners of forms to eliminate all air or stone pockets which cause honeycombing, pitting, or planes of weakness. Concrete contacting all formed surfaces shall be spaded manually to eliminate air bubbles.

Place horizontal construction joints at uniform vertical spacing unless otherwise shown on the drawings. Concrete shall not be placed to a depth of more than 10 feet in any 24 hour period, unless approved by Standards Engineering. All concrete placements shall be such as to keep cold joints from forming.

Whenever work is suspended on any section for more than one hour, the horizontal edges of the concrete next to the forms shall be brought to a plane perpendicular to the form face, and treated so no irregular, rough, or feathered edge joints show in the finished work. Before placing the next lift, clean the joint surface and remove all laitance. Immediately before placing new concrete wet the joint surface and remove all standing water.

Unless adequate weather protection is provided, do not place concrete during rain, sleet, or snow.

31.5.70 Curing

Protect freshly deposited concrete from premature drying and hot or cold temperatures. Maintain a constant temperature throughout the curing period without drying.

All exposed concrete surfaces shall be kept continuously moist overnight by ponding, sprinkling, or by use of an approved membrane type curing compound, which conforms to ASTM C309, latest revision, and applied in conformance with the manufacturer's recommendations.

Curing shall continue, using one of the above methods or waterproof paper, for a 7 day period (3 days for high-early strength concrete) maintaining the concrete at a minimum temperature of 50 degrees Fahrenheit as is practical. Protective covering with tarpaulins, hay, straw, etc. shall be provided to retard moisture evaporation during hot weather and to prevent rain damage before hardening. Protective covering shall be available for immediate use at all times.

During the curing period, the concrete shall be protected from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration.

31.5.80 <u>Surface Finish</u>

All surface fins shall be removed. Exposed concrete surfaces shall not be given any special treatment to enhance appearance, such as rubbing with a stone, without permission of Standards Engineering.

31.5.90 <u>Loading Of Concrete</u>

Normal concrete structures shall not be subjected to external loads in less than:

1. Four days for foundations, manhole floors, and walls.

2. Seven days for floors, roofs, and columns.Each concrete placement shall be allowed to set 48 hours before addition of a subsequent pour upon it. If high-early cement is used this time period may be reduced by one-half.

Trenches containing concrete encased duct lines constructed on undisturbed original ground may be backfilled not less than two hours after placement. Compaction by light tamping equipment may proceed immediately. Loading of the backfill by heavy equipment or traffic is not permitted before 12 hours after placement.

31.5.100 <u>Waterproofing</u>

Waterproofing is provided by the density of the concrete mix and the thickness of concrete. Care must be used in placing and compacting the concrete to eliminate all voids and potential leakage paths. When structures less than 8 inches thick must be waterproof, consult Standards Engineering to revise the mix design to achieve the desired waterproof result.

Note: If a greater slump is required, contact Standards Engineering for an additive to meet the specific job requirements.

Text Shift and section renumbering

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2.1	7/13	• Minor updates to make New Hampshire and Liberty Utilities specific	Robert Johnson	Robert Johnson Program Manager
2.0	7/11	• Minor updates, modified document for documentum, several pages text shift • Added new decals • Added underground cable markers • Added concrete mix M7	John Vartanian	Susan Fleck, VP of Standards, Policies, & Code
1.0	07/07	• Modified definitions to match OH construction book • Added new decals	John Vartanian	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/08 Issue – Added Section 32.17 Bridge and Overpass Conduit Support

32.0 GENERAL

The following Standard is to be followed when designing and installing direct buried (DB) conduit systems. This Standard shall apply to primary and secondary systems installed by both the Company and/or customers.

32.1 APPLICATION

Direct Burial (DB) conduit is to be used where ducts are to be direct buried or encased in concrete. The amount of ducts should provide for present and future planned installations by the Company and need to include spare ducts (unoccupied and designated as a spare for emergency replacements). The minimum number of ducts shall be two. If inner duct is needed, Standards Engineering shall be contacted.

Routes through unstable materials such as mud, shifting soils, etc., or through highly corrosive soils, shall be avoided. If construction in these soils can not be avoided, the conduit system shall be constructed in such a manner as to minimize movement and/or corrosion.

32.2 TYPE

Ducts are to be purchased in 20 foot lengths. They are to have a bell end or coupling on one end. See Table 1.

Type	Size	Std. Item
Direct Buried (DB)	2”	UK6A2
	3”	UK6A3
	4”	UK6A4
	5”	UK6A5
	6”	UK6A6

Table 1 - Std Item Numbers for DB Conduit

32.3 BENDING

32.3.10 Bends within a Duct Bank Section:

PVC conduit has the ability to be bent without any heating of the material. Therefore hot bending will not be used for the installation of conduits. The degree of cold bending will be a function of temperature. Bends that exceed the cold bending availability will be made with 5 degree couplings. The minimum length of duct segments between single 5 degree couplings is 40 inches. This construction yields a 40 foot radius of curvature, which is the minimum requirement for any size conduit. If a tighter radius is required, consult Standards Engineering.

32.3.20 Sweeps at Equipment:

Sweeps needed at equipment locations, e.g. pad-mount transformers, shall be made using manufactured sweeps. Acceptable sweeps are listed in Table 5. The radius of the sweep shall be a minimum of 24 inches for 2 inch conduit, 36 inches for 3 – 5 inch conduit and 48 inches for 6 inch conduit. 90 degree conduit “elbows” shall not be used; the radius of these bends are not adequate and will cause damage to cable insulation.

32.4 SPACING

32.4.10 Ductbanks

Spacers must provide a 1½ inch minimum separation between ducts (except 6 inch ducts which require 2 inches of separation) and 3 inches between the ducts and the surface of the ductbank. Spacers lock vertically and horizontally. Intermediate spacers shall be used as a cap on the top tier of a duct back to prevent floating during encased burial installations. Spacers shall be placed at 5 – 8 foot intervals and shall be placed at each coupling. See Table 2 for duct bank dimensions and Table 3 for spacer information. See Figures 1 thru 6 and 2A thru 5A for typical ductbank configurations. If special circuit loading conditions are required by Distribution Design, consult Standards Engineering for assistance with ductbank configuration.

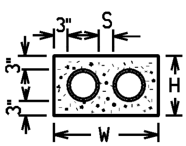


FIGURE 1
2 DUCTS

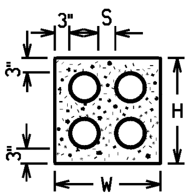


FIGURE 2
4 DUCTS

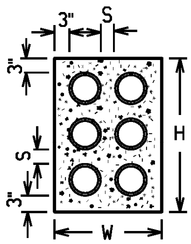


FIGURE 3
6 DUCTS

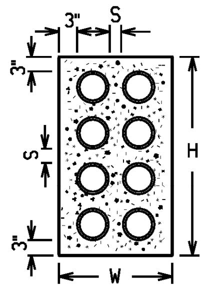


FIGURE 4
8 DUCTS

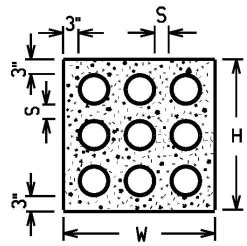


FIGURE 5
9 DUCTS

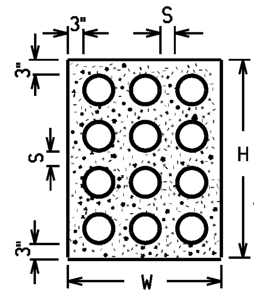


FIGURE 6
12 DUCTS

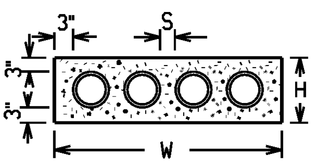


FIGURE 2A
4 DUCTS

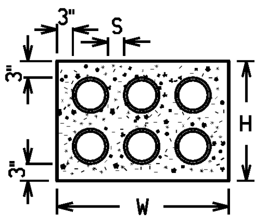


FIGURE 3A
6 DUCTS

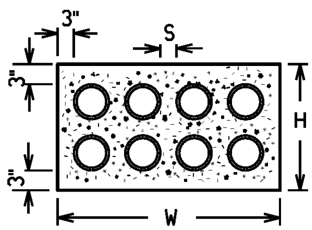


FIGURE 4A
8 DUCTS

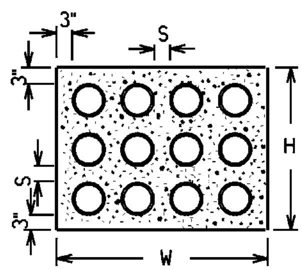


FIGURE 5A
12 DUCTS

Supersedes 2/06 Issue - Added Figure 5, updated dimensions in Table 2.

Dimensions in Inches									
Figure	4" Duct			5" Duct			6" Duct		
	W	H	S	W	H	S	W	H	S
1	16 ½	10 ½	1½	18 ¾	11 ¾	1½	21 ¼	12 ¾	2
2	16 ½	16 ½	1½	18 ¾	18 ¾	1½	21 ¼	21 ¼	2
2A	28½	10 ½	1½	32 ¾	11 ¾	1½	38 ½	12 ¾	2
3	16 ½	22 ½	1½	18 ¾	25 ¾	1½	21 ¼	30	2
3A	22 ½	16 ½	1½	25 ¾	18 ¾	1½	30	21 ¼	2
4	16 ½	28 ½	1½	18 ¾	32 ¾	1½	21 ¼	38 ½	2
4A	28 ½	16 ½	1½	32 ¾	18 ¾	1½	38 ½	21 ¼	2
5	22 ½	22 ½	1½	25 ¾	25 ¾	1½	30	30	2
5A	28 ½	22 ½	1½	32 ¾	25 ¾	1½	38 ½	30	2
6	22 ½	28½	1½	25¾	32 ¾	1½	30	38 ½	2

Table 2 - Duct Bank Spacing

Size	Intermediate	Base
3"	UK5E	UK4E
4"	UK5F	UK4F
5"	UK5G	UK4G
6"	UK5H	UK5H

Table 3 - Conduit Spacer Std Item Numbers

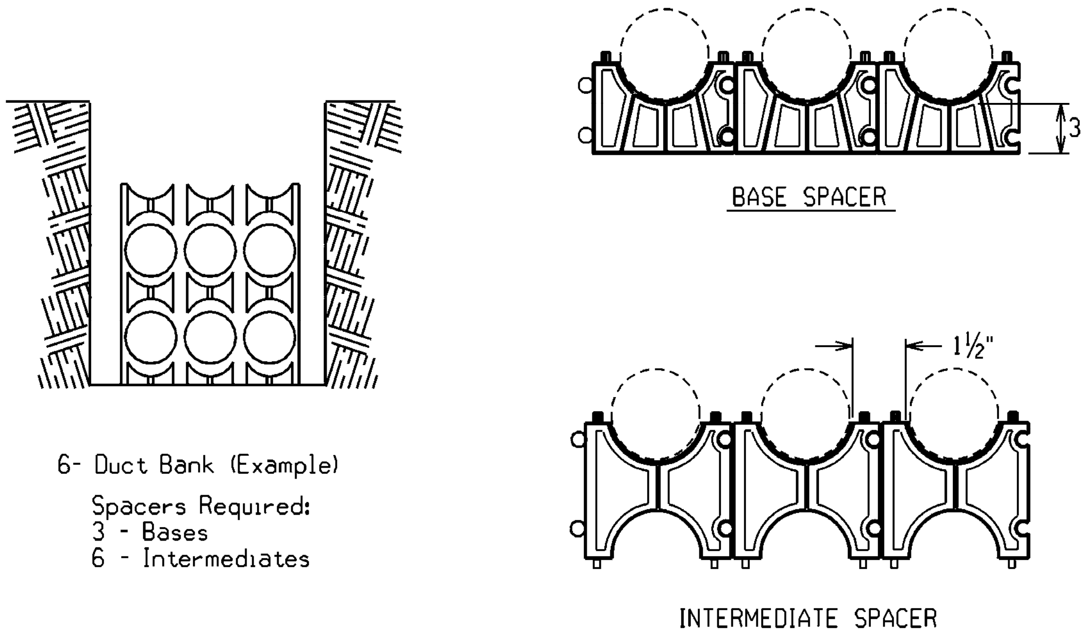


Figure 6

Supersedes 2/06 Issue - Added 32.4.2, re-numbered Tables.

32.4.20 Ductbank Face (In Maholes)

The spacing is increased at the manhole face to allow the cables within the ducts to enter the manhole freely without being too close to the cables from the adjacent ducts and to allow for the use of bell end conduit.

Use the following table and Figure 7 as a guideline for installing ducts at the manhole face:

	6” Conduit	5” Conduit	4” Conduit
Spacing between conduits (S)	9”	9”	8”
Spacing between conduit and edge of ductbank (E)	6”	6”	6”

Table 4 - Spacing at Ductbank Face (in Manholes)

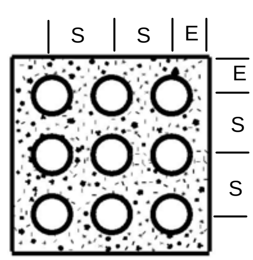


Figure 7

32.5 FITTINGS

Fittings and accessories will be joined with PVC cement (Std. Item UK6S). Additional fittings can be found in the Section 50–Materials Catalog.

Description	2"	3"	4"	5"	6"
Adapter (PVC-Square Tile)	-	-	UK7SA	-	-
Adapter - Female (Threaded)	UK6F2	UK6F3	UK6F4	UK6F5	UK6F6
Adapter – Male (Threaded)	-	UK7M3	-	-	-
Adapter Coupling - Flexible (4"-5")	-	-	UK7F	UK7F	-
Bend - 90°(a)	UK6B2A	UK6B3	UK6B4	UK6B5	UK6B6
Bend - 90°, 48"R	-	UK6B3A	UK6B4	UK6B5	UK6B6A
Bell End	UK6E2	UK6E3	UK6E4	UK6E5	UK6E6
Coupling – Straight	UK6C2	UK6C3	UK6C4	UK6C5	UK6C6
Coupling – Split	-	UK7CC3	UK7CC4	-	-
Coupling - 5° Female x Male	UK6D2	UK6D3S	UK6D4S	UK6D5S	UK6D6S
Coupling - 5° Female x Female	-	UK6D3	UK6D4	UK6D5	UK6D6
Duct - Split(b)(c)	-	-	UK7S4	-	-
Plug	UK6G2	UK6G3	UK6G4	UK6G5	UK6G6
Reducer - 4" to 3" male x male	-	UK7E	-	-	-
Reducer - 4" to 3" male x female	-	UK7D	-	-	-

(a) Minimum radius for 2 inch is 24 inches; for 3 inch, 4 inch and 5 inch is 36 inches; and for 6 inch is 48 inches.
(b) Type DB.
(c) Use cable tie (Std. Item UK7ST) where needed. Cable ties included with split duct furnished by Carlon.

Table 5 - Conduit Fittings

32.6 PITCH

Ducts are to pitch toward manholes and have a minimum slope of no less than 3 inches per 100 feet.

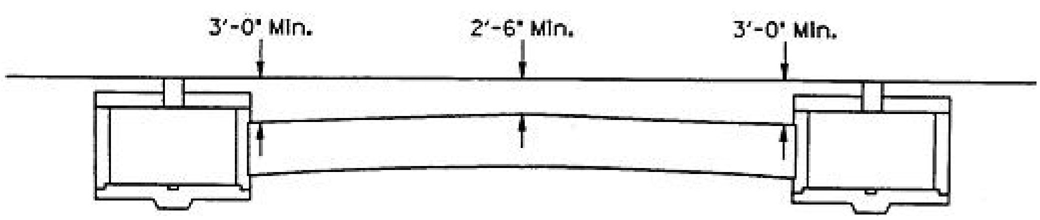


Figure 8

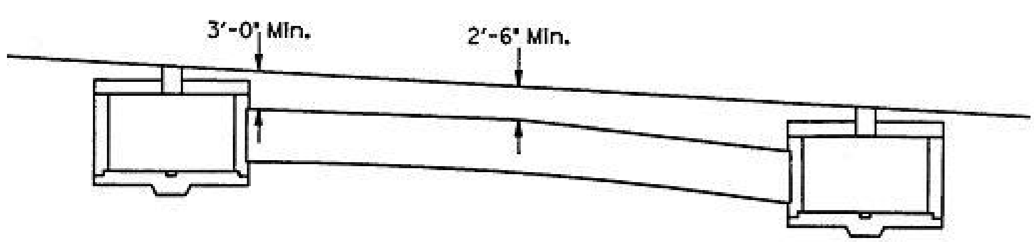


Figure 9

Supersedes 2/06 Issue - Re-numbered Figures and Table, text shift due to formatting.

Supersedes 2/06 Issue - Re-numbered Table, text shift due to formatting.

32.7 BURIAL DEPTHS

The minimum burial depth between the top of the completed conduit, conduit bank or direct buried cable and grade is 30 inches. If these minimum burial depths cannot be achieved due to ledge or solid rock conditions, the following will apply for all installations, both in public ways and private property:

32.7.10 For Duct Applications:

Supplemental protection is required to prevent potential damage. The minimum excavation depth can be reduced to 21 inches and the conduit encased in concrete. The concrete envelope is to be a minimum of 3 inches thick in all directions around the conduit. Minimum cover over the concrete encasement shall not be less than 12 inches.

32.7.20 For Direct Buried Applications:

If a 30 inch burial depth cannot be achieved, the cable must be placed in a properly sized DB conduit encased in concrete. The minimum excavation depth can be reduced to 21 inches. The concrete envelope is to be a minimum of 3 inches thick in all directions around the conduit. Minimum cover over the concrete encasement shall not be less than 12 inches.

32.8 CLEARANCES

Clearances between the conduit envelope and major subsurface pipes or structures shall be a minimum of 6 inches; clearances to services and laterals shall be a minimum of 2 inches. Electric conduit crossing above other utilities must have suitable support under the electric conduit, on each side of the other utility line, to maintain the minimum clearance if the other utility's facilities ever have to be dug out.

Type	Clearance Min (in.)
Communication Systems	12[1]
Natural Gas Lines	12
Sewers, Sanitary and Storm	12
Water Lines	12
Fuel Lines	Opposite side of Street[2]
Steam Lines	Opposite side of Street or 8 feet with insulation
Rail Road Crossings	50[3]

Notes:
1. 3 inches of concrete or 4 inches of masonry is also acceptable.
2. Where this is not practical, clearance shall be sufficient to allow the use of pipe maintenance equipment.
3. Maybe reduced by agreement of concerned parties, but in no case shall it be less than 6 inches from ballast.

Table 6 - Clearances Required From Other Utilities

32.9 EXCAVATION

Excavation for an entire run shall be completed prior to conduit installation to preclude encountering unexpected obstructions. The trench shall be excavated and trimmed in such a way that backfill is not required to establish the proper line of grade.

The trench bottom shall be solid, undisturbed earth. Earth showing extensive signs of peat, cinders, rubble, frozen material, or any conditions not suitable for a stable foundation, shall be reported to Standards Engineering for recommendation. Small pockets (up to 1 cubic yard) of unsuitable soil shall be excavated and replaced with compacted gravel (maximum 2 inches of stone).

Where the earth walls of the trench are firm enough to sustain themselves, and all OSHA requirements are met, they may be used as the forms for concrete encasement. The walls of these trenches shall be carefully trimmed to allow the proper thickness (minimum 3 inches) of concrete around the outside conduits, but shall not be so wide as to require an excessive amount of concrete to fill the trench. If shoring and/or sheeting are necessary, they shall be placed as required to maintain the excavation and shall be removed prior to concrete encasement and/or as the backfilling progresses so that all shoring is removed as the job is completed.

Excess excavation material shall be removed from the job site as soon as possible.

32.10 INSPECTION

Company inspectors shall perform on site inspection of the installation after the duct sections are compete and prior to pouring concrete or backfilling any portion of the installation.

32.11 CONCRETE

Shall be in accordance with Section 31 – General; mix M3 without air entrainment agents. Concrete mix shall be a minimum of 2000 psi. When the interval between pours is greater than 2 hours, #4 reinforcing bars 6 feet long shall be installed in the corners and between ducts on the top and bottom rows.

32.12 BACKFILL

Concrete will be cured for a minimum of 2 hours before backfilling over it. Before any backfill is installed, a Company employee or representative shall inspect and approve the duct construction and backfill material. Flowable fill is a viable backfill if available and when deemed necessary.

32.12.10 Direct Buried Duct Systems

Backfill material shall consist of sand or earth, or a mixture which may contain rocks, provided the rocks do not exceed 2 inches in any dimension and have no sharp edges. Additionally, the rocks shall not comprise more than 50% of the backfill material by volume. Backfill material shall be adequately compacted in 6 inch lifts. Peat, cinders, rubble and frozen material are not suitable backfill material.

32.12.20 Concrete Encased Duct Systems

Backfill within 6 inches of the top of the concrete shall be free of solid material greater than 4 inches maximum dimension, or, with sharp edges likely to cause damage. The balance of backfill shall be free of solid material greater than 8 inches, maximum dimension. Backfill material shall be adequately compacted in 6 inch lifts. Peat, cinders, rubble and frozen material are not suitable backfill material.

32.13 WARNING TAPE

Warning tape (Std. Item UT8) shall be installed 12–18 inches below finished grade and directly above electric conduit.

32.14 MANDREL

An approved flexible mandrel, no less than ¼ inch smaller in diameter than the duct nominal inside diameter, shall be pulled through all completed ducts. 2,500 pound rated pulling tape, often referred to by the trade name “Muletape”, shall be left in all conduits. One such tape manufacturer would be Arnco Corporation, manufacturer number DLWP25.

Supersedes 2/06 Issue - text shift due to formatting.

32.15 REPAIR

Repairs of occupied conduits shall be made from PVC loc-duct (Std. Item UK9A), of the same outside diameter, wall thickness and approximate length as the damaged section. Split couplings (Std. Item UK9C) shall also be the same dimensions as the damaged section and used along with PVC loc-duct (Std. Item UK9A). Place plastic strap (Std. Item UK9S) around the loc-duct, 12 inches from the end of the coupling and another strap 12 inches from the end of the top half section of loc-duct. Apply duct seal (Std. Item S3) and/or vinyl tape (Std. Item 1WBP) to seal all slots and openings.

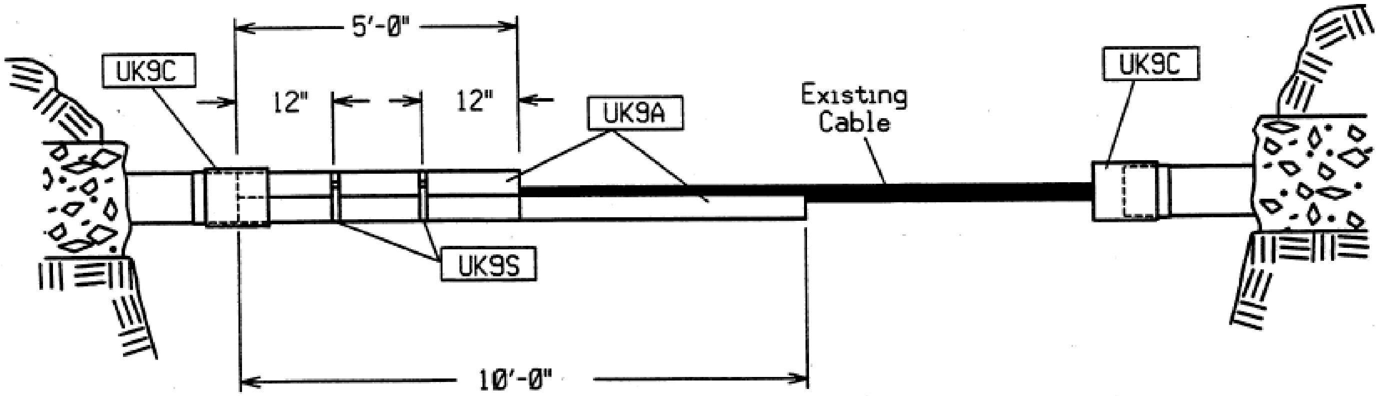


Figure 10

32.16 DUCT SIZING FOR 3 SOLID DIELECTRIC PARALLEL CABLES

Cables are required to have ¾ inch clearance through the conduit. Also multiple cables might have a possibility of jamming. Table 7 will aid in the selection of the proper conduit size for 3 parallel conductors. “NO” means the conduit is not suitable for the conductors, “YES” means the conduit is suitable for the conductors.

Acceptable conduit size was selected by determining jamming possibility and a ¾ inch clearance. Jamming was calculated using the formula D/d. Where D = inside diameter of duct and d = single cable nominal OD. If D/d ratio is greater than 2.8 and less than 3.2 there is a possibility that the cables may jam. Actual clearance (c) is calculated using the following formula:

$$c = \frac{D}{2} - 1.366 * d + \frac{D-d}{2} * \sqrt{1 - \left(\frac{d}{D-d}\right)^2}$$

Supersedes 2/06 Issue - Re-numbered Figure, text shift due to formatting.

3 Cables Parallel Wound Conduit Sizing					
Conductor Size	**kV**	**Conduit Size**			
		3"	**4"**	**5"**	**6"**
4/0	5	NO	YES	YES	YES
500	5	NO	NO	YES	YES
2	15	NO	YES	YES	YES
4/0	15	NO	YES	YES	YES
350	15	NO	NO	YES	YES
500	15	NO	NO	YES	YES
750	15	NO	YES	NO	YES
1000	15	NO	NO	YES	NO
1/0	25	NO	YES	YES	YES
4/0	25	NO	NO	YES	YES
350	25	NO	YES	NO	YES
500	25	NO	YES	NO	YES
1000	25	NO	NO	YES	NO
1/0	35	NO	NO	YES	YES
2/0	35	NO	NO	YES	YES
750	35	NO	NO	YES	NO
1000	35	NO	NO	NO	YES

Table 7 - Appropriate Conduit Size for use with Standard Cables

Supersedes 7/08 Issue - Updated Table 7 to reflect actual conduit inner diameter sizes.

32.17 BRIDGE AND OVERPASS CONDUIT SUPPORT SYSTEM GUIDELINES

This standard is intended as a guideline for the installation of Liberty Utilities conduits in or on bridges and overpasses. The final conduit support system design will be the responsibility of the Project Engineer.

32.17.10 Process

1. Liberty Utilities personnel need to coordinate with the regulating body of the bridge or overpass to secure occupancy rights on the structure, to assure that the proper load limits are designed for, and to meet the project construction timetable.
2. Liberty Utilities' Engineering Planning Department shall specify system requirements, e.g. size and number of conduits. Spare conduits shall be included in the design.
3. Design should have no sharp bend of conduits. Design should minimize cable pulling tension.
4. Final design shall be stamped by a professional engineer registered in the state where the construction is taking place.
5. Liberty Utilities design acceptance should include review by but not limited to Underground, Distribution Design, Construction Standards, Engineering Planning and Project Management Departments.

32.17.20 Type – Conduit Specification

1. Conduit material shall be type Heavy Wall (HW) Reinforced Thermosetting Resin Conduit (RTRC) in conformance with NEMA TC-14. The conduit and fittings shall have fire resistance properties in accordance with test procedures of Underwriters Laboratories UL 2515.
2. Conduits shall be joined by bell and spigots manufactured integrally as part of the conduit. Adhesive shall be recommended by the conduit manufacturer.
3. Field bending of the conduit shall be accomplished by use of fittings made of the same material as the conduit.
4. Conduit and fittings shall have an ultraviolet inhibitor.

32.17.30 Expansion/Deflection Fitting

1. Expansion/deflection fittings shall be installed in/at all structural expansion joints or at 200 feet maximum spacing, whichever is the lesser distance and on the bridge side of the abutments.
2. Expansion/deflection joints shall be located no closer than 12" from any support.
3. The expansion and deflection setting shall be determined by the Project Engineer.
4. Expansion/deflection fittings shall only be installed on straight portions of conduit runs.
5. Double bell (B-B) stop couplings shall be installed at bridge abutments.

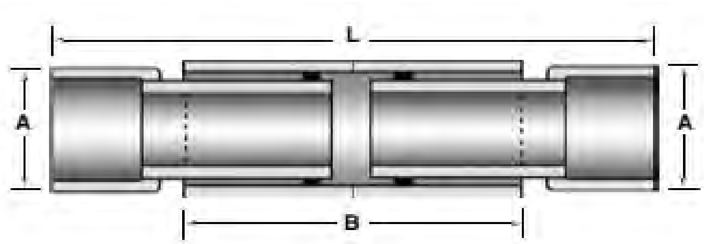


Figure 11 – Expansion / Deflection Joint

32.17.40 **Hanger Supports**

1. The conduit support system may be made up of anchor hangers and intermediate hangers. All conduit support hardware shall be fiberglass with the exception of bolts. All bolts shall be hot dipped galvanized in accordance with ASTM A153. Attachment of supports to bridge needs to be determined and designed by the Project Engineer.
2. Anchor hangers are required where more than one expansion joint is installed. Anchor hangers have adjustable braces and shall be installed at the midway point between expansion/deflection joints. Split stop rings restrict conduit movement and shall be installed at all anchor hangers.
3. Intermediate conduit hanger supports shall be at 10-12 foot maximum spacing.
4. Squares that enclose conduit in supports should be approximately ½" larger than the OD of the conduit.
5. Support shall permit conduit to expand and contract with temperature and bridge.
6. When needed, windows, sleeves and casings should be designed to permit the conduit to pass through bridge abutments in the same alignment as the hanger support. Such design will make rolling or bending the conduit unnecessary.

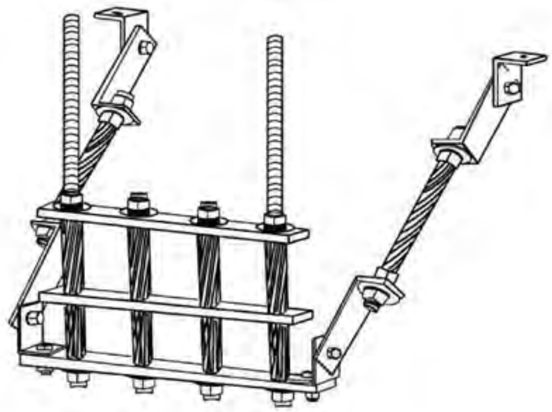


Figure 12 - Anchor Hanger

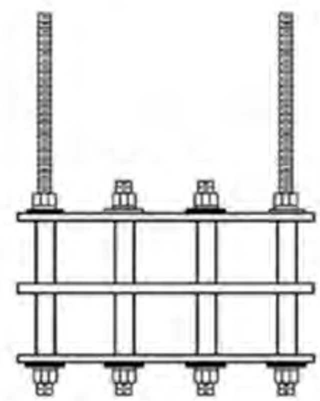


Figure 13 - Intermediate Hanger

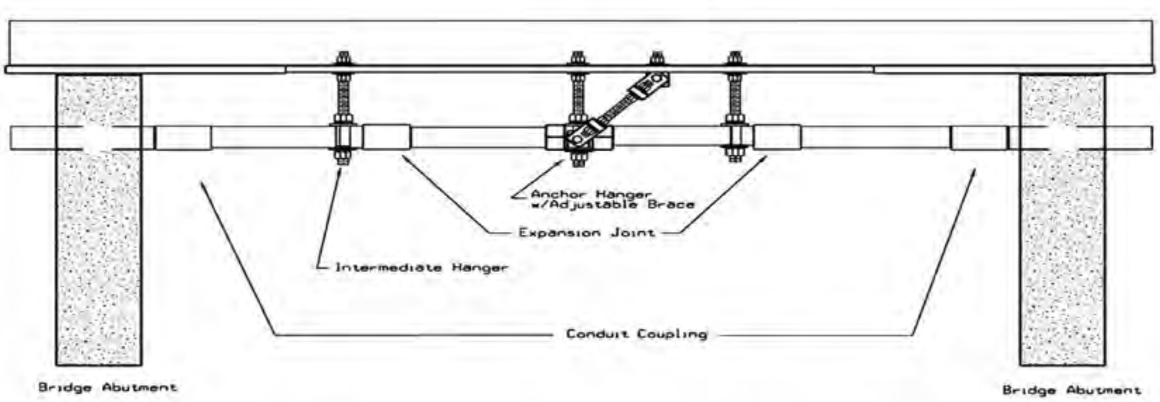


Figure 14 – Typical Bridge and Overpass Conduit Support System

Version	Date	Modification	Author(s)	Approval by (Name/Title)
3	7/13	• Added Section 32.17 BRIDGE AND OVERPASS SUPPORT SYSTEM GUIDELINES	Robert Johnson	Robert Johnson Program Manager
2	7/10	• Updated Table 7 to reflect actual conduit inner diameter sizes.	Katie Croteau	Allen Chieco, Director of Distribution Standards and Work Methods
1	07/08	• Changed 32.4 from "Spacers" to "Spacing." • Added Figure 5, updated dimensions in Table 2 • Added section 32.4.2, re-numbered Tables • Re-numbered Figures and Table, text shift due to formatting	Katie Croteau	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/09 Issues

33.0 HANDHOLES / MANHOLES

The following Standard is the practice to be followed when designing and installing underground handholes and manholes. This Standard shall apply to primary and secondary systems installed by both the Company and a customer/developer. Distribution handholes shall be used where the use of manholes is not required. The criteria for use of the various handholes and manholes are as follows:

A. HDPE Handhole URD Direct Buried system (**Maintenance Only**) – 17 x 30 inch Cover – High Density Polyethylene, used for secondary services (600 volts and below) Std. Item UR10PE. Item ID # 8830-5643077

Polymer Concrete Handhole URD Conduit system – 17 x 30 inch Cover – Polymer concrete, with fiberglass flared sidewalls, used for secondary services (600 volts and below) Refer to Page 33-101 for construction details (Std. Item UR10G). Item ID # 8830-5643082

B. Precast Concrete Heavy Duty Handhole - 30 inch Cover and Frame - Where the ultimate use of the handhole, including the number, size, voltage and type of cables/conductors to be installed, meets the following criteria (Std. Item UM19).

1. Use of single conductor cables only.
2. Secondary mains and services requiring intermediate locations in the cable run, or additional space in the handhole, for cable pulling, due to duct length, or, for service laterals.
3. Primary services (13.2 kV maximum) from either an underground or overhead system requiring additional locations in the cable run for cable pulling due to duct length.

Refer to Page 33-102 for construction details.

C. Manholes – All other uses require a full size manhole – See Section 33.0.20

D. Primary Pull / Splice Box – 30”W x 60”L x 36”D with two piece Polymer Cover – used for URD primary systems up to 15kV class. Pull box can facilitate, two three phase circuits up to # 2 cable. For cables larger than #2 cable installations, shall be in a manhole. Refer to Page 33-100 for construction details (Std. Item UR6). Item ID # 8830-5640808

33.0.10 Handholes

A. Location

Light Duty Handholes are only allowed in sidewalk or grass areas for building services or street lighting.
Heavy Duty Handholes may be installed in roadways, driveways, sidewalks or grassed areas. It is preferable to place them away from high traffic locations as much as possible, to avoid and minimize potential contact with pedestrians.

B. Maximum Conductor Size

Maximum conductor size which is to be installed in a handhole is indicated in Table 1.

Table 1

Voltage	Handhole	Conductor Size
600 V	Light Duty	500 kcmil
600 V	Heavy Duty	500 kcmil
5 – 15 kV	Heavy Duty	4/0

Supersedes 7/11 Issue – Update, added info in Section 33 A

C. Maximum Number Of Cables

The maximum number of cables (not including secondary taps) in Table 1 shall be two sets of three 1/C phase conductors and one 1/C neutral conductor per set. Where the number of secondary taps is sufficient to cause congestion in the handhole and make the installation of a second set of cables undesirable then only one set of cables shall be installed.

Leave sufficient cable in handhole to permit making cable joint above grade over the handhole.

33.0.20 Manholes

Specify for each manhole:

1. Standard Item number of each manhole. Refer to Standards Engineering for additional approved precast concrete distribution manhole vendor designs.
2. Duct formation (Refer to Section 32 – Conduit).
3. Manhole chimney shall be a minimum of two layers of brick to allow for future grade changes or an adequate number of precast concrete rings. The maximum chimney height shall be less than 3 feet from inside the bottom of the manhole roof.
4. A 36 inch manhole frame (Std. Item UM14F) with a 26 to 36 inch manhole ring (Std. Item UM14R) and a 26 inch manhole cover (Std. Item UM14C) shall be used for new construction. Set frame to proper grade with mortar or rubber grading rings.

A. Furnishing Material

Any material required to be furnished by the customer shall comply with the Company Material Specifications.

B. Preparation For Installation

Fill bottom of excavated hole with a minimum of 1 foot of well compacted crushed bank gravel.

C. Foreign Structures

All parts of the manhole structure should have at least 6 inches clearance from all pipes and structures.

D. Duct Entrances

Duct entrances shall be constructed such that end bells are flush with manhole walls.

1. Formation – Project plans shall specify the duct entrance formation and size required or show special arrangements when this is required. Refer to Pages 33-103 thru 33-113 for manhole duct entrance construction drawings.
2. Relative Location – Ducts with staggered alignment are to have opposite formations on opposite walls.
3. Bell ends shall be used on all ducts, entering a manhole or handhole, if bell ends are missing install fairleaders to protect cable egress.

Supersedes 2/06 Issue –Text Shift

E. Placing Frame, Ring And Cover

Use minimum of two courses of brick, or an adequate number of precast concrete pieces, and set the frame to grade on a bed of mortar or rubber grading ring (Std. Item UM15Dx). Mound concrete around brick and cover base of frame with one inch of concrete.

Field Changes

If a contractor finds it impossible to hold to the accepted plans, or these Standards, Distribution Design Engineering shall be contacted for modifications.

33.1 CAST IN PLACE MANHOLES

If a precast manhole cannot be used (preferred installation), refer to this Section for cast in place manholes. Stamped approved drawings shall be furnished for the install by the person requesting the installation.

Specify for each manhole:

1. Duct formation.
2. Dimensions “H” and “G”.
3. Grade.
4. Unistrut for cable racks if desired.
5. Reinforcing.

33.1.10 Concrete & Reinforcing

Concrete shall be mix M6, 4,000 pounds per square inch minimum, in accordance with Section 31 – General. Reinforce as indicated on the latest current version of the Material Specifications. Use steel bars of the deformed type conforming to ASTM A615 – Grade 60.

33.1.20 Construction Joints

Construction joints shall be thoroughly cleaned and grouted immediately before placing the wall and roof slab against the surface.

33.1.30 Furnishing Material

All material required to be furnished by the customer shall comply with the Company Material Specifications.

33.1.40 Foreign Structures

All parts of the manhole structure shall have at least a 6 inch clearance from all pipes and structures.

33.1.50 Floor

Place a concrete slab with minimum thickness of 8 inches and conforming to the overall dimensions of the particular manhole.

A. SUMP – 12 inch square and 4 inch deep shall be installed directly below the center of the manhole opening. **Note**: 2 inch minimum floor thickness is maintained at the bottom of the sump.

B. PITCH – 1 inch from all sides to drain towards sump.

C. RECESS FOR ALL WALLS of 2 inches as shown on the drawings shall be provided.

Supersedes 7/11 Issue – Text added 33.1

D. REINFORCING when specified shall be installed as shown on the plans for the particular manhole. Locate 2 inches (clear) from the top surface.

33.1.60 Walls

Walls of concrete 12 inches thick shall be used. A “V” shaped recess 3 inches x 1½ inch shall be provided and centered in the top of the walls to lock with the roof slab. To prevent future leakage, form ties shall be of the water-seal type, or where exterior ends of ties are to be left in place, the ties shall be sealed and covered after removal of forms.

33.1.70 Duct Entrances

Duct faces shall be recessed 6 inches and duct lines shall extend 2 inches into the wall.

A. Formation – Project plans shall specify the duct entrance formation required as shown in Conduit - Section 32, page 32-2 Figures 1 thru 6 and 2a thru 5a or show a special arrangement when this is required.

B. Ductbank Face – Ductbank face space formation of the conduits is shown in Section 32, page 32-3 figure 7 and Table 4. The spacing allows adequate space for the cables within the ducts to enter the manhole freely with out being too close to the cables from the adjacent ducts and to allow enough separation for the use of bell ends.

C. Relative Location – Ducts with staggered alignment are to enter manholes so that opposite formations are of opposite hand when viewed from the center of the manhole.

D. End Bells shall be used on all ducts.

E. Reinforcing Bars shall be used to lock the duct line to the manhole walls. Use three ¾ inch Number 6 bars a minimum of 24 inches long located as shown in the drawings.

33.1.80 Pull Irons

Two pull irons, one 6 inches below the ceiling and one 6 inches above the floor shall be installed in the opposite wall from each duct entrance. Install eye horizontally as shown in Detail Z on Pages 33-103 thru 33-113. Pulling iron pocket and lid are approved for use at Liberty Utilities, and are shown in detail on Pages 33-103.

33.1.90 Roof Slab

The roof slab shall have a minimum thickness of 12 inches of reinforced concrete plus a 2 inch pitch from the opening to the edges.

A. Reinforcing shall be installed as shown on the plans. Note the 2 inch clearance requirement of the reinforcing from manhole ceiling surface.

B. Opening of 3 feet 2 inches by 3 feet 2 inches with 3 inch downward bevel shall be provided.

33.1.100 Chimneys

Chimneys, when required to increase the height of manhole openings, shall be constructed of either brick or precast concrete.

Supersedes 7/09 Issue – Text Shift

33.1.110 Placing Frame And Cover

Use minimum of two courses of brick, or an adequate number of precast concrete pieces, and set the frame to grade on a bed of mortar or rubber grading ring (Std. Item UM15Dx). Mound concrete around brick and cover base of frame with one inch of concrete.

33.1.120 Dimensions "H" And "G"

Dimensions "H" and "G" shall be given on Project Plans for each manhole.

A. "H", which represents the head room, varies with the number of ducts, but should not be less than 6 feet 6 inches. If it exceeds 7 feet 6 inches, additional reinforcing in the walls may be required.

B. "G" varies with height of the manhole frame and height of the brick required. A minimum of two courses of brick, or equivalent precast concrete rings (Std. Item UM15x),, should be provided for in this dimension to allow for changes in grade. To adjust frame to final height use mortar or rubber grading rings (Std. Item UM15Dx).

C. Dimensions "F", as noted on duct plans, will influence dimensions "H"and "G".

33.1.130 Brick Walls & Rails Or Structural Steel Roofs

This construction is discouraged, but may be used if it is determined to be absolutely necessary. In such cases, refer to Distribution Engineering for complete design. Brick must be solid (not cored) and shall conform to A.S.T.M. specifications C-32, Grade MA.

33.1.140 Field Changes

If the customer/developer finds it impossible to hold to plans or these Standards, the division engineer/project engineer shall be contacted for modifications.

33.1.150 Unistrut

Unistrut shall be 1 5/8" x 1 5/8" galvanized steel (Item ID 8830-2015133), installed horizontally 18" from top and bottom, 6" from ends on walls without duct entrances. During concrete pour Unistrut shall be covered and sealed tape. This covering or tape shall be removed and unistrut cleaned out after concrete has cured.

Supersedes 7/09 Issue –Text Shift

33.2 MANHOLE GROUND BUS / EQUIPMENT GROUNDING

For the purpose of the requirements of this section, the term 'manhole' is defined as an enclosure which has a minimum interior height greater than six feet. Some areas of the company have traditionally called enclosures with less height by different titles, including manhole, which is causing confusion on these grounding requirements. A ground bus / anode system is only required in an enclosure which has a minimum interior height greater than six feet or if there are switching devices (such as an MVI / MVS) installed. In locations where there are manholes with an interior height of less than six feet, a ground bus/anode system can be installed if required by Design Engineering or Electric Operations.

33.2.10 Grounding And Bonding

All conductive material in the manhole / vault shall be solidly connected to the ground bus. Bonding / grounding of the equipment enhances personnel safety when working in the manhole. Grounding of all neutrals provides quicker clearing during cable faults and limits the damage caused by the excessive fault current flowing on the cable concentric neutral or shield.

New manholes will be constructed per this standard. Existing manholes will be upgraded to meet this standard when substantial new construction is performed. Refer to Pages 33-114 and 33-115 for grounding detail.

33.2.20 Equipment To Be Grounded

All conductive material in the manhole shall be solidly connected to the ground bus, including but not limited to:

A. Cable concentric neutral.

B. Separate neutrals.

C. Cable rack stanchion.

D. Switch bases.

E. Transformer and other equipment cases.

F. Switches, MVS's MVI's NMVI's

33.2.30 Connection To Earth

Each manhole ground bus is to have a minimum two connections to an earth ground.

New precast manholes have 2 – 4/0 copper ground leads, connected to the reinforcing rods, which are to be connected to the ground bus.

Existing manholes, without the bonds to the reinforcing rods, are to have a ground rod installed through the floor of the manhole. This rod (Std. Item TG20) is to be installed as close to the corner of the manhole as possible, to prevent a trip hazard in the manhole.

Connections to the earth ground are to be made with 4/0 bare copper wire (Std. Item W19G).

Supersedes 7/07 Issue –Text Shift

Supersedes 1/07 Issue – Update to text in 33.1.10

33.2.40 Manhole Ground Bus

The manhole ground bus shall be 4/0 bare copper (Std. Item W19G), run along the top of the cable rack stanchions. The manhole ground bus shall make a complete loop around the manhole. Connections between the manhole ground bus and earth are to be made with 4/0 leads and compression connectors (Std. Item S14K).

The manhole ground bus is to be supported by the connectors on the cable stanchions. Tinned connectors are required between galvanized steel and copper to prevent corrosion. Use Std. Item C18B connector for new installations with heavy duty manhole racks. Other versions of this connector are available (Std. Items C18A, C18C) for retrofit or light duty racks. For Uni-strut racks, use Std. Item C18B connector and a spring nut (Std. Item US1N).

All connections to the manhole ground bus are to be made as high as possible to minimize submerged connections, therefore minimizing corrosion of the connections.

33.2.50 Anode

Magnesium anodes (Std. Item UA17) shall be located in manholes and connected to the ground bus to reduce corrosion. There shall be two anodes in each manhole, unless other equipment exists (such as switches / transformers / etc.). Two additional anodes shall be installed for each piece of equipment installed in the manhole. The maximum number of anodes required in a manhole is 6.

The two anodes for general protection shall be located in diagonally opposite corners of the manhole.

The two additional anodes for equipment protection shall be located immediately adjacent to the equipment to be protected.

All anodes are to have their #12 lead connected to the ground bus with a compression connector (Std. Item C21).

33.2.60 Cable Splices

Connect bonds from each cable splice to the manhole ground bus, using a properly sized compression connector.

Bonding wires from new splices will be #4 solid tinned (Std. Item W11F1) copper, two leads per splice – use compression connector Std. Item S14H.

Existing splice bonds shall be connected to the bus with compression connector Std. Item S14 of the proper size to accommodate the existing bonding conductor.

Refer to the Section 36 – Connectors/Splices for splice bonding wire specifics.

33.2.70 Equipment Bonds

Equipment located in the manhole will have a #4 solid, tinned bond wire (Std. Item W11F1), connected from the bonding connection point on the equipment to the manhole ground bus. Use compression connector Std. Item S14 at the bus end.

33.2.80 Neutrals

Concentric neutral cables without splices may pass through the manhole without bonding to the manhole ground bus. If bonding of the neutral is needed, use grounding kit Std. Item UR89G. Use #4 solid tinned (Std. Item W11F1) for the ground lead. Follow the manufacturer's instructions for installation of the kit.

Concentric neutral cables with splices shall be bonded to the manhole ground bus. New splices shall be bonded with #4 solid tinned copper (Std. Item W11F1), connected to the ground bus with Std. Item S14H connector.

All neutral conductors shall be connected to the ground bus.

Neutrals of 4/0 copper and smaller shall be separately connected to the ground bus. Use Std. Item S14 compression connector of the appropriate size.

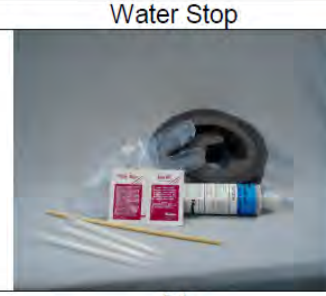
Neutrals larger than 4/0 copper shall have a 4/0 tap, W19G, connected to the manhole ground bus with Std. Item S14K compression connector.

33.3 MANHOLE CONDUIT SEALING

The chart below shows when conduit sealing is used. All services shall be sealed. Sealing the rest of the conduits is recommended, but electric field operations shall determine the correct practice that they will adhere too.

Conduit type	Conventional UG sealing required	Conventional UG sealing recommended	Network UG sealing required	Network UG sealing recommended
Primary		Water or Fire Stop		Fire Stop
Secondary		Water or Fire Stop		Fire Stop
Spare MH		Water Stop		Fire Stop
Service MH end	Fire Stop		Fire Stop	
Service Cust. end	Water Stop		Fire Stop	
Spare for service	Fire Stop		Fire Stop	

The chart below shows the type and use of sealants available

Sealant	Fire Stop	Water Stop
SEALANT INFORMATION		
STANDARD ITEM	UF20	S4
STORAGE TILL USE	UPRIGHT, ROOM TEMP	ROOM TEMP
USE	SHAKE CAN FOR 30 SECONDS INSERT NOZZLE DISPENSE UPSIDE DOWN	REMOVE CAP FROM RESIN TUBE, INSERT NOZZLE WITH RESIN CAP LOAD INTO CUALKING GUN AND DISPENCE.

Supersedes 7/07 Issue – Added text to 33.3

33.3.10 CONDUIT SEALING SERVICE TO BUILDINGS

Service conduit sealing shall be required on all network and conventional manhole conduits to stop the flow of water and fire into buildings. Fire-stop service conduit sealing is required at the manhole end for all service conduits. For the building end of the service conduits the following apply, for conventional underground service conduits shall be sealed with water-stop conduit sealant. Before sealing, clean cables and conduits with cable degreaser (Std. Item UC80F). Wipe dry with a towelette (Std. Item UC80D). See figures below for installation details.

Fire-stop sealant installation

Install rags for backing at least 3 inches into clean conduit for small cables, dispense foam until conduit filled

Water stop sealant installation

Install foam backing 6 inches into clean conduit, install second foam backing at conduit opening.
Dispense resin into conduit between foam until it overflows out of foam.

33.3.20 CONDUIT SEALING IN COVENTIONAL UNDERGROUND AREAS

Water stop conduit sealing with (Std. Item S4) is recommended in all primary, secondary and spare conduits. Sealing will prevent the flow of water, dirt, and gases into the manhole. See figures below for installation.

When deemed necessary by electric operations water stop conduit may be a requirement.

Water stop sealant installation

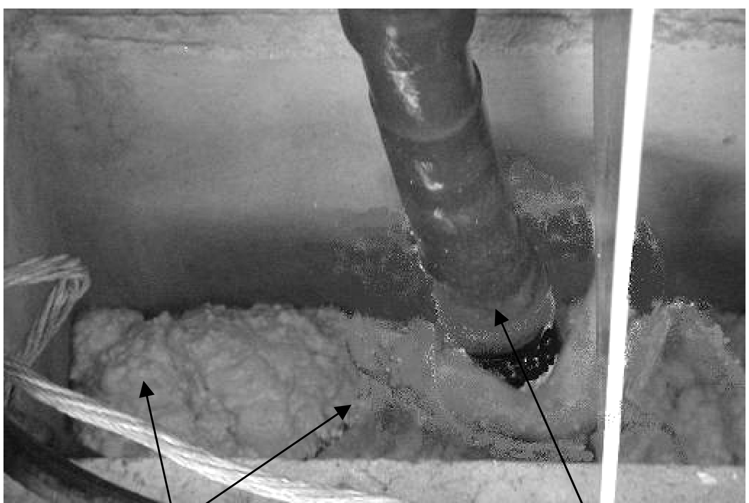
Install foam backing 6 inches into clean conduit, install second foam backing at conduit opening.
Dispense resin into conduit between foam until it overflows out of foam.

33.4 NUMBERING SPECIFICATIONS

All Manholes and Handholes are to be numbered in the field to provide for correct determination of work location. The number of each manhole / handhole shall be provided by local operations engineers / planners. The numbers shall be located on the chimney of the manhole / handhole such that it is readily visible from above after removal of the cover. Polyethylene numbers / letters / tag holders are to be used. Select item from Section 50 – Materials Catalog (Std. Item UP21P). Fasten the tag holder to the chimney with masonry fasteners.

33.5 SWITCHGEAR COLLAR SEALING

New installations of switchgears installed over manholes shall be sealed to minimize moisture into the switchgear. Existing installation should be sealed when feasible. Sealing the area can be accomplished by installing cardboard into the opening of the switchgear collar between the cables and the walls of the collar opening. Spray expanding foam (STD Item UF10) 1" to 2" thick into area stuffed with cardboard to make an airtight seal. Position foam in lower portion of collar opening to allow room for cable tags. See figure 3 for expanding foam in collar and around terminator.



Expanding foam

Terminator

Figure 3

Supersedes 7/09 Issue – Added text to 33.5

33.6 MANHOLE USES

Listed below are some of the different applications for the various manholes besides the conventional 2, 3, or 4- way manhole with just cable installed.

Sidewalk Satellite Manhole (STD ItemUM28) - use for the installation of submersible switches STD Items US40, US40B, US40C, US40D, US41A, US42A and US42B.

Switchgear manhole (STD Item UM20A through D) **-** use of collars A, B, C or D for the installations of conventional padmounted switchgears

Switchgear manhole (STD Item UM20E) **-** use for the installation of any of the standard submersible switches
.
Switchgear manhole (STD Item UM35) alternate – larger switch manhole, for submersible switch installation where more space is needed.

33.7 Manhole Racks

Unistrut is embedded in all new manholes horizontally and shall be used for mounting cable racks in all manholes. Unistrut (STD item UM18D4) is to mounted perpendicular with support stanchion, screws and nuts (STD items UM18D8, UM18F2 and UM18F). Cable support racks (STD item UM18D_) are to be mounted along the wall where applicable to the vertically installed unistrut. Insulators (STD item UM18A or UM18B) shall be installed into the racks to hold and directly support the cable being installed. See Figure 4. For existing manholes with out unistrut embedded in the wall, use “Z” shaped support stanchions (STD Item UM18D8) to mount unistrut to wall as shown in figure 4 on the unistrut installed horizontally on the bottom..

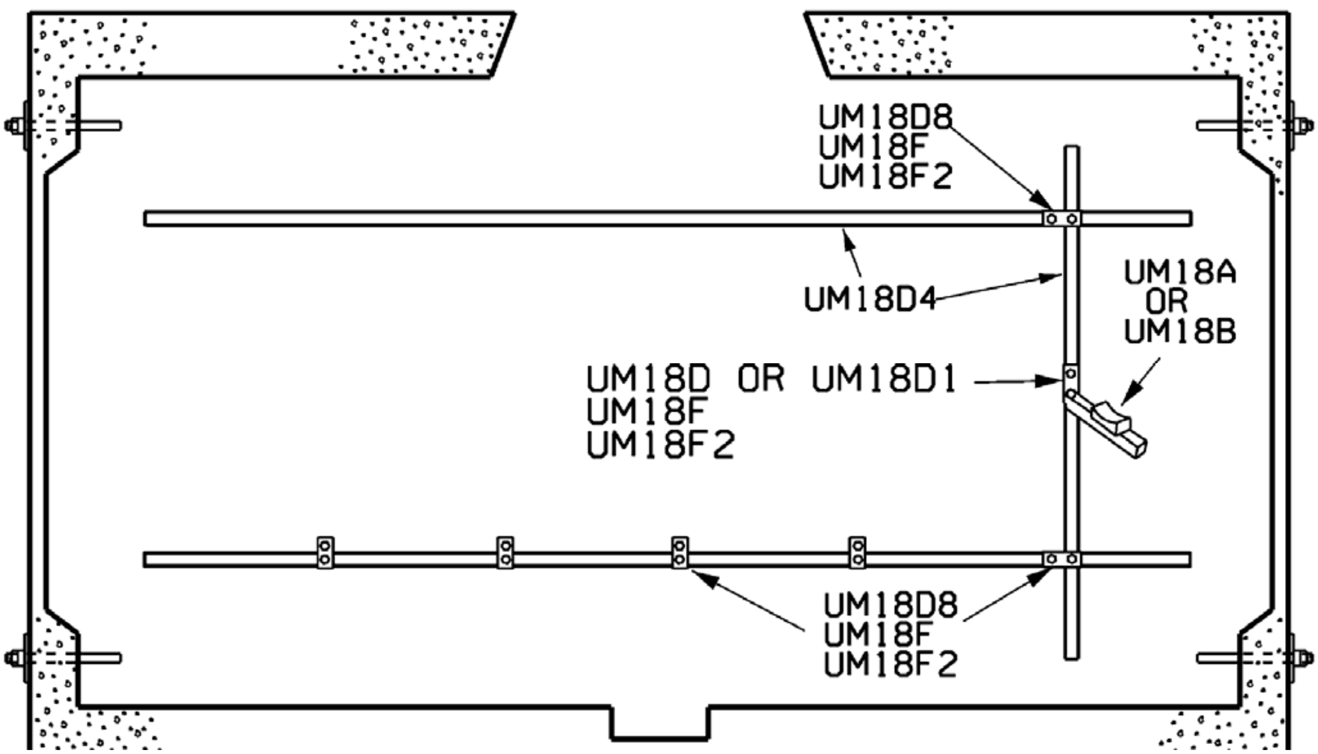


Figure 4 (Typical side wall of a manhole)

33.8 MANHOLE ROOF MAINTENANCE

Deteriorated roofs can be replaced if feasible. There are a few precast roof replacements available. They are shown on 33-122 and 33-123. Specific jobs or maintenance may also require rebuilding existing roofs. Refer to Distribution Engineering Services for further assistance with the application.

33.9 MANHOLE CHIMNEY GRADING

All manhole chimneys shall have a minimum of two courses of brick base or equivalent before installing the manhole frame ring and cover. For existing installations where the grade around the manhole is changing, the maximum allowable chimney height shall be no higher than 36" from the manhole roof to proposed finished grade

33.10 MANHOLE / VAULT HATCHES

Manholes with large equipment utilize hatches. All new hatches are required to be bolted down and locked. The figures below illustrate the hatch features. To access hatch area, remove padlock in recessed padlock area. In recessed padlock area remove T lock wrench. Unbolt hatch bolts from hatch corners. Unscrew T lock cover and insert T lock wrench. To open hatch rotate T lock wrench 90 degrees and apply upward pressure onto hatch lifting handle. Open hatch past 90 degrees until it locks open. Check hatch locked open by pushing it inward, at this time the locking lever will hold hatch open.

Standard item UM31 installed in side walk

Hatch opened, large access area

Switch installed in manhole

Recessed pad lock area

,Hatch opening lock

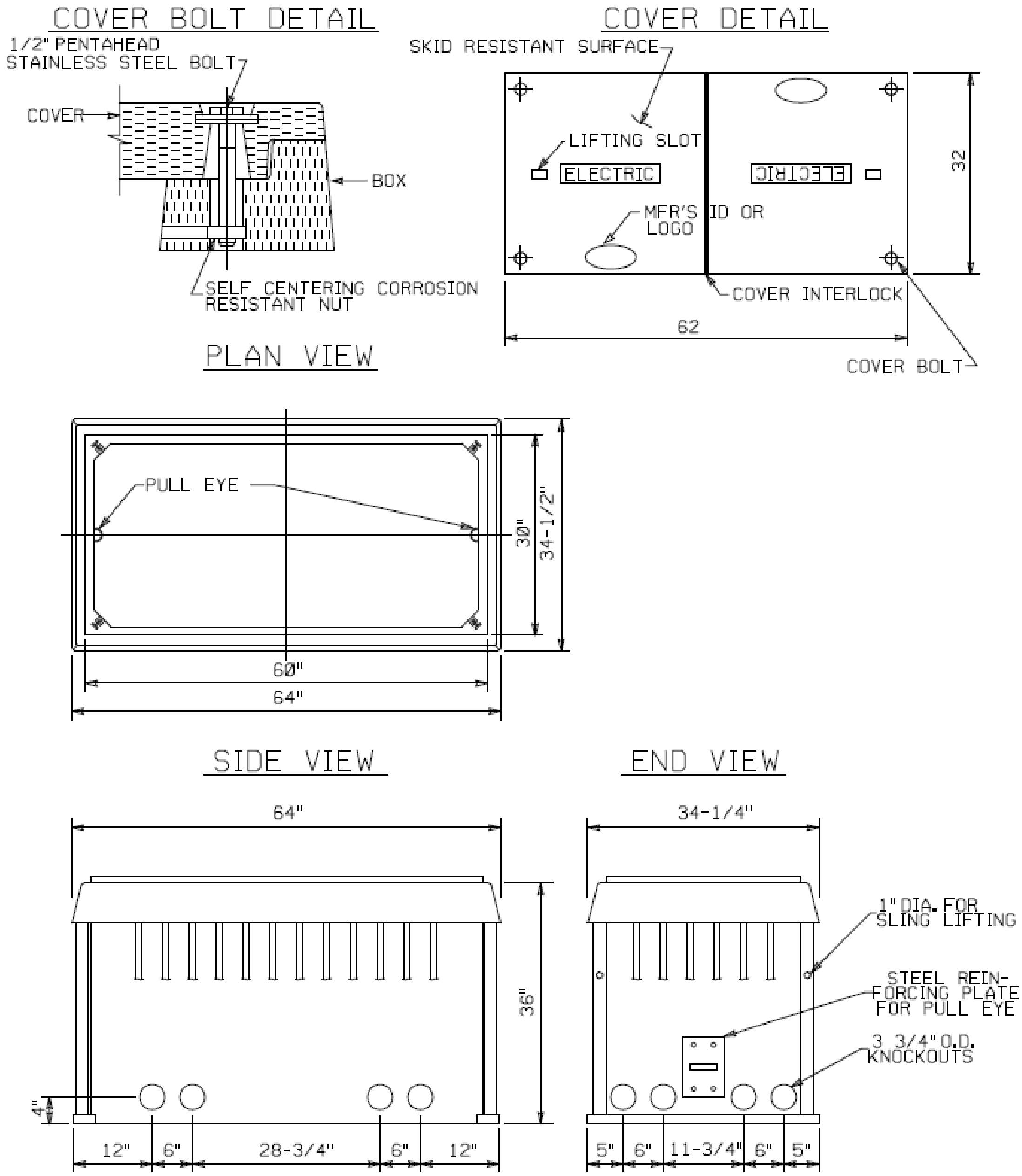
Hatch bolts

Pad lock area opened

T wrench installed into hatch lock opener, if wrench is missing a large flathead screw driver can be used.

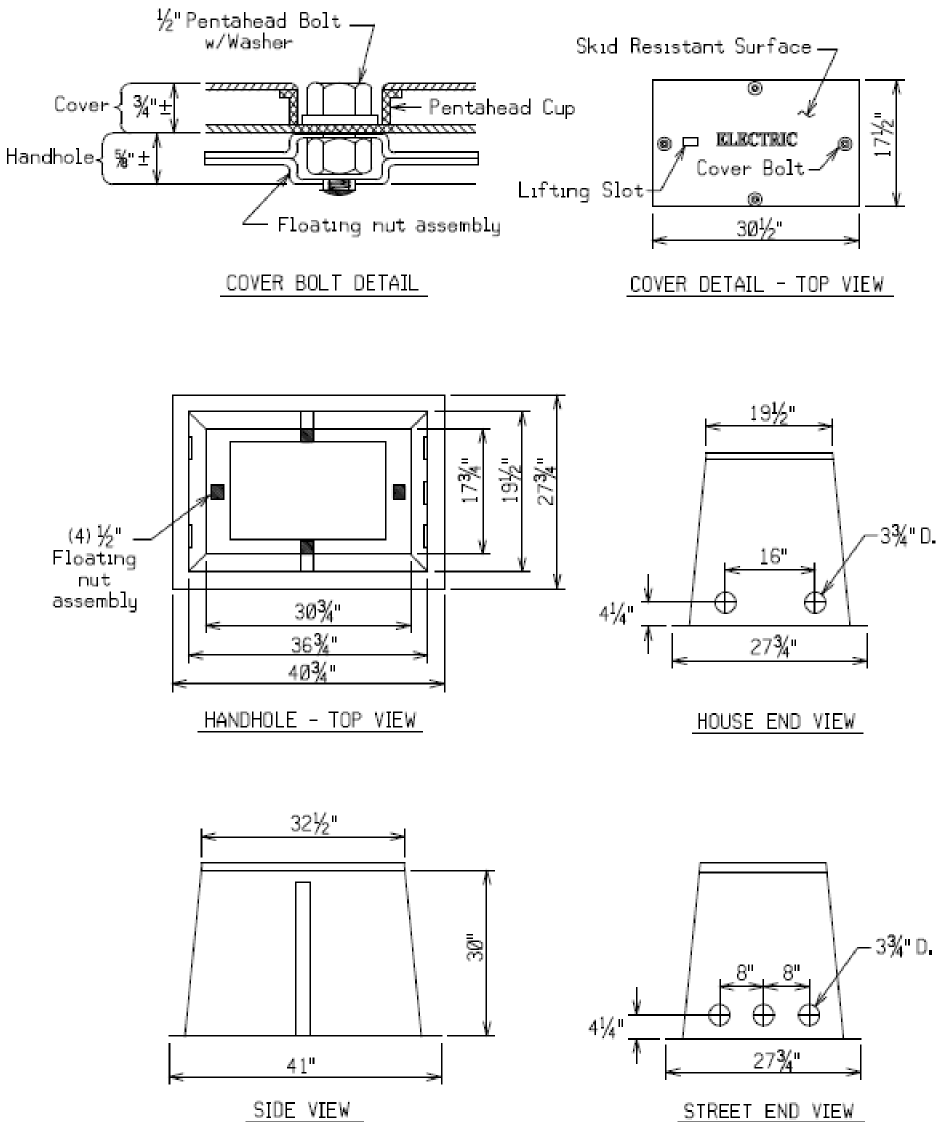
View of locked open hatch, to close latch, push locking arm inward then apply pressure onto hatch to close it

Std. Item	UR6



Primary cable pull / splice box, fiberglass with two piece polymer concrete cover, cable pulling eyes, and conduit knockouts. For use with conduit URD systems and in accordance to Liberty Utilities Material Specification MS 5057.
Item ID # 8830-5640808

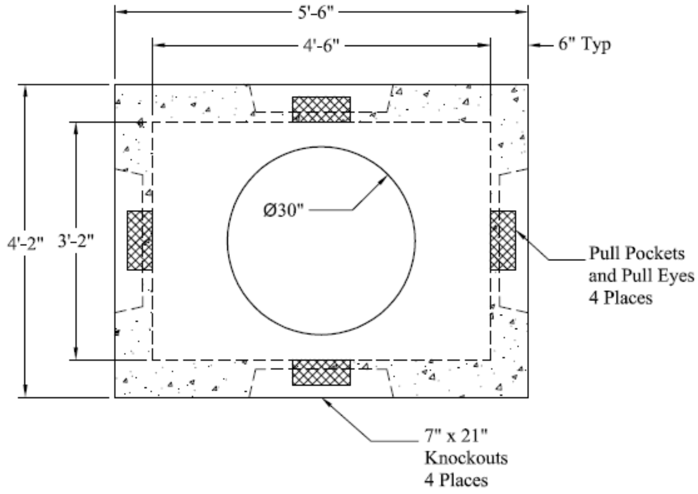
Std. Item	UM10G

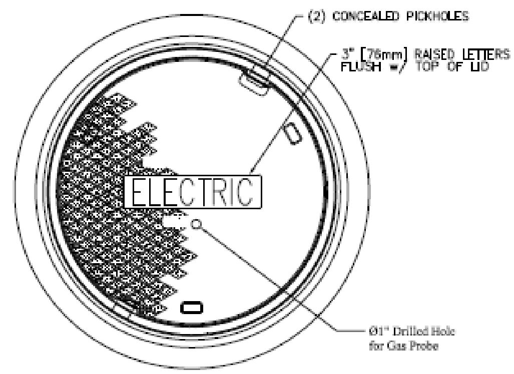


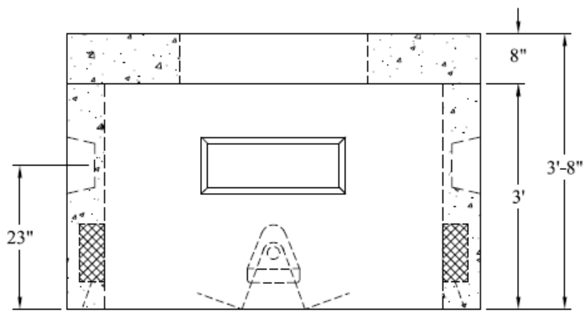
Fiberglass reinforced polymer secondary service handhole with cover complete with four ½" Pentahead self-centering stainless steel bolts complete with washers and "floating" nut assembly and conduit knockouts. For use with conduit URD systems and in accordance with Liberty Utilities Material Specification MS 5051. Item ID # 8830-5643082

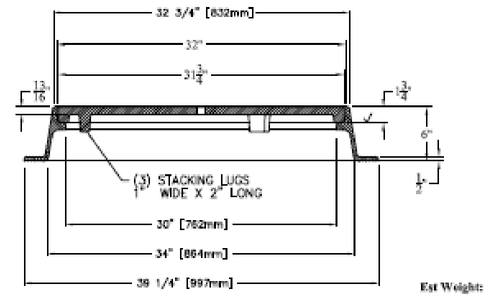
Doc. # ST.33.00.001

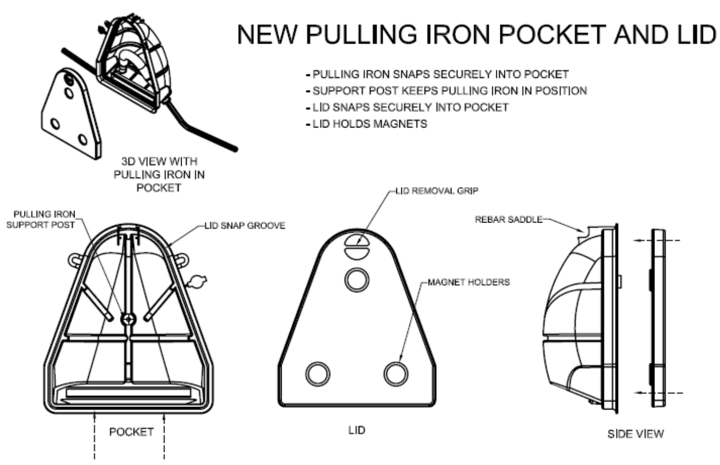
Std. Item	UM19

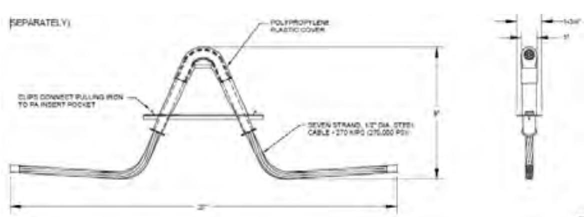








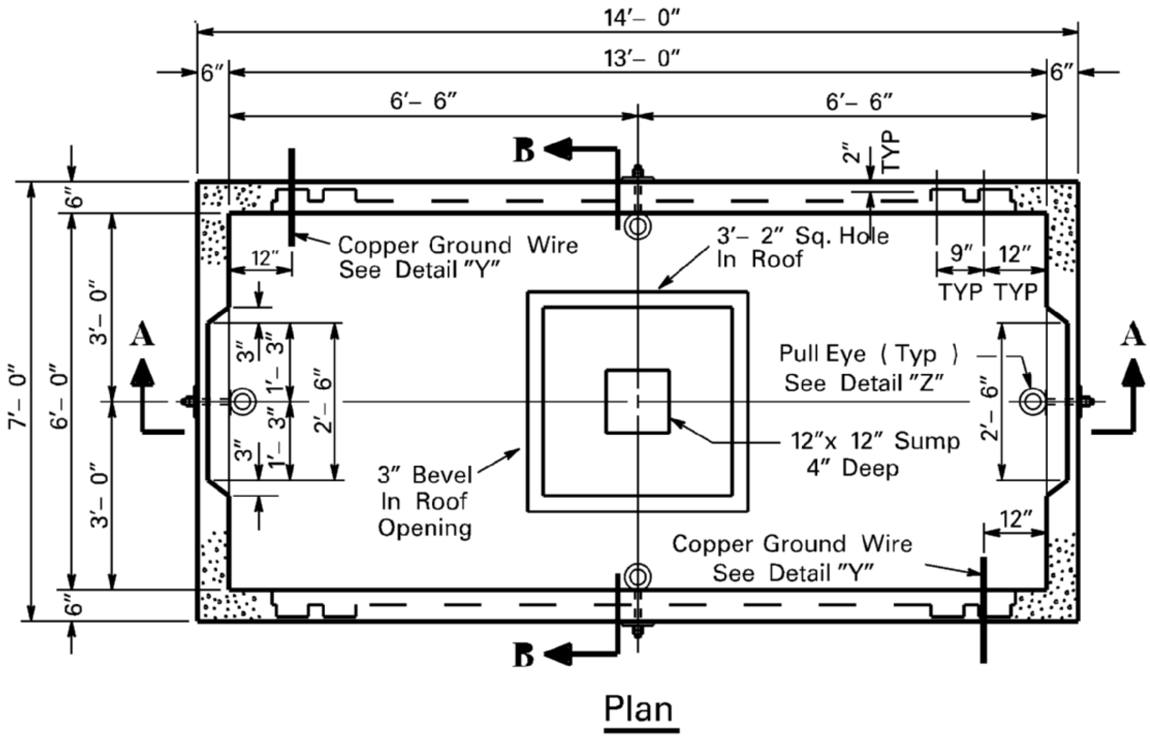


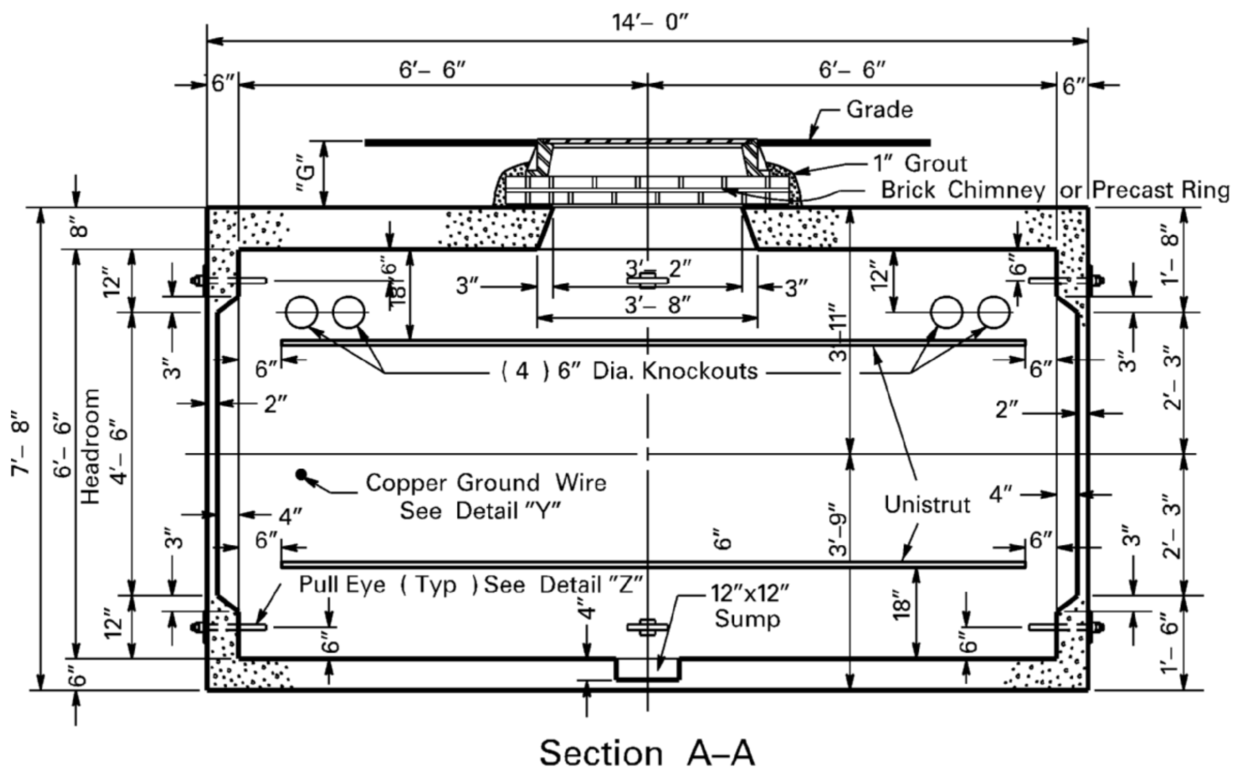


Precast concrete heavy duty handhole with cast iron 30" cover and frame with pulling iron pocket and lid. Refer to Liberty Utilities Material Specifications MS 3334. Item ID # 8830-9201354. Chimney height should be kept to minimum to facilitate placing completed splices in handhole from above grade.

 Doc. # ST. 33.00.001

Std. Item	UM22





<table>
<tr><td colspan="4">PRECAST CONCRETE MANHOLES
2 WAY DISTRIBUTION – 6 FEET X 13 FEET (INSIDE)</td></tr>
<tr><td>ISSUE</td><td>PAGE NUMBER</td><td rowspan="2">UNDERGROUND
CONSTRUCTION STANDARD</td><td rowspan="2">Liberty Utilities</td></tr>
<tr><td>7/09</td><td>33-103</td></tr>
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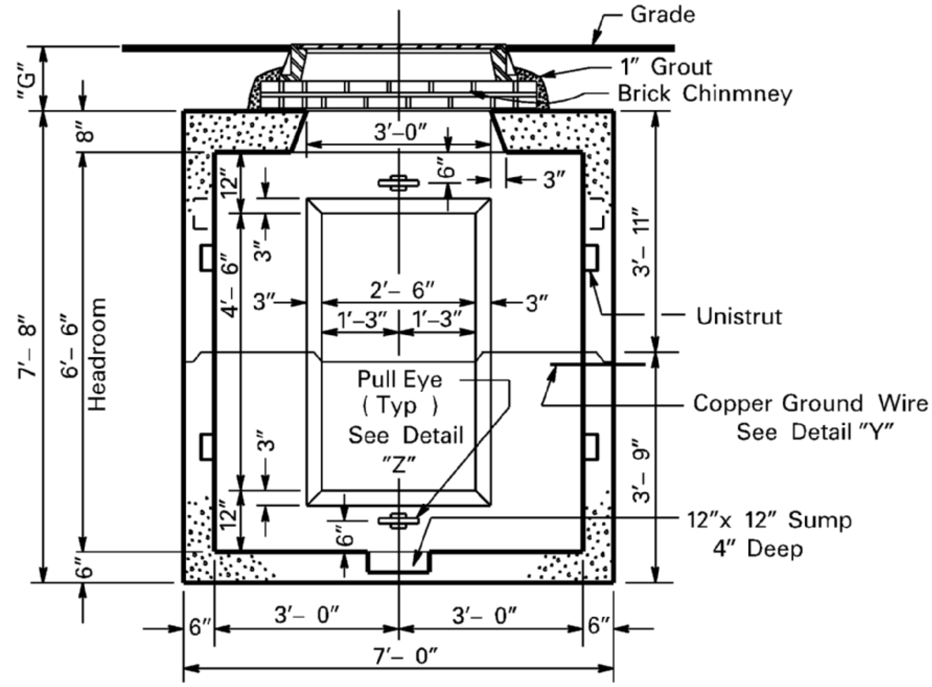
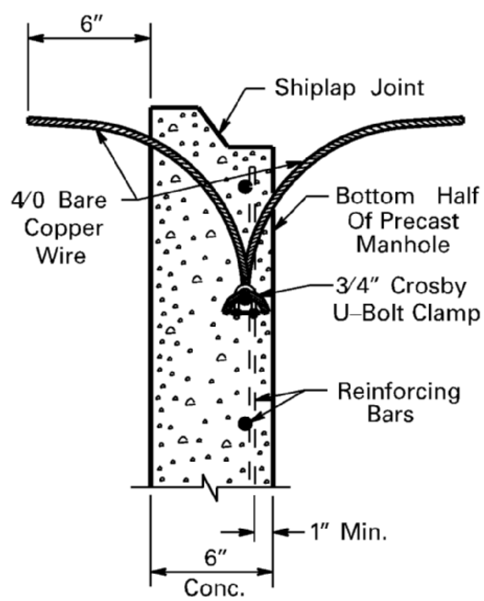
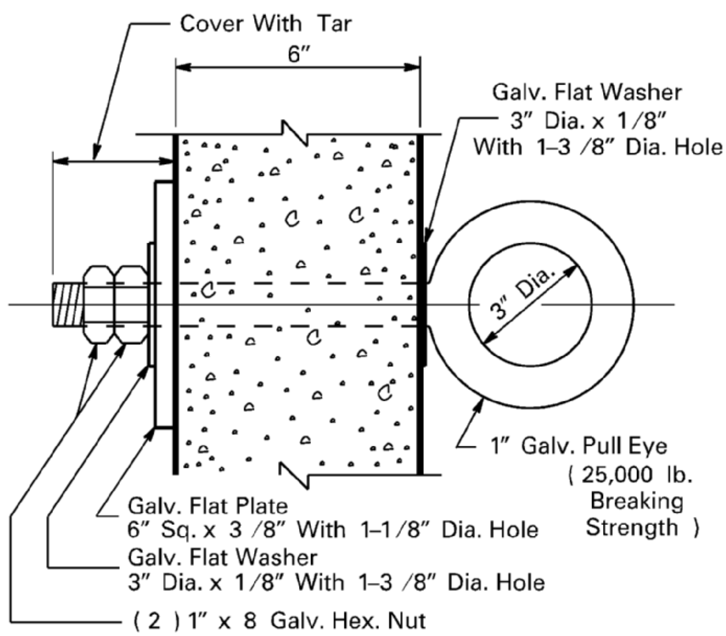
Std. Item	UM22



Section B–B



Detail "Y"
2 Required



Detail "Z"
4 Required

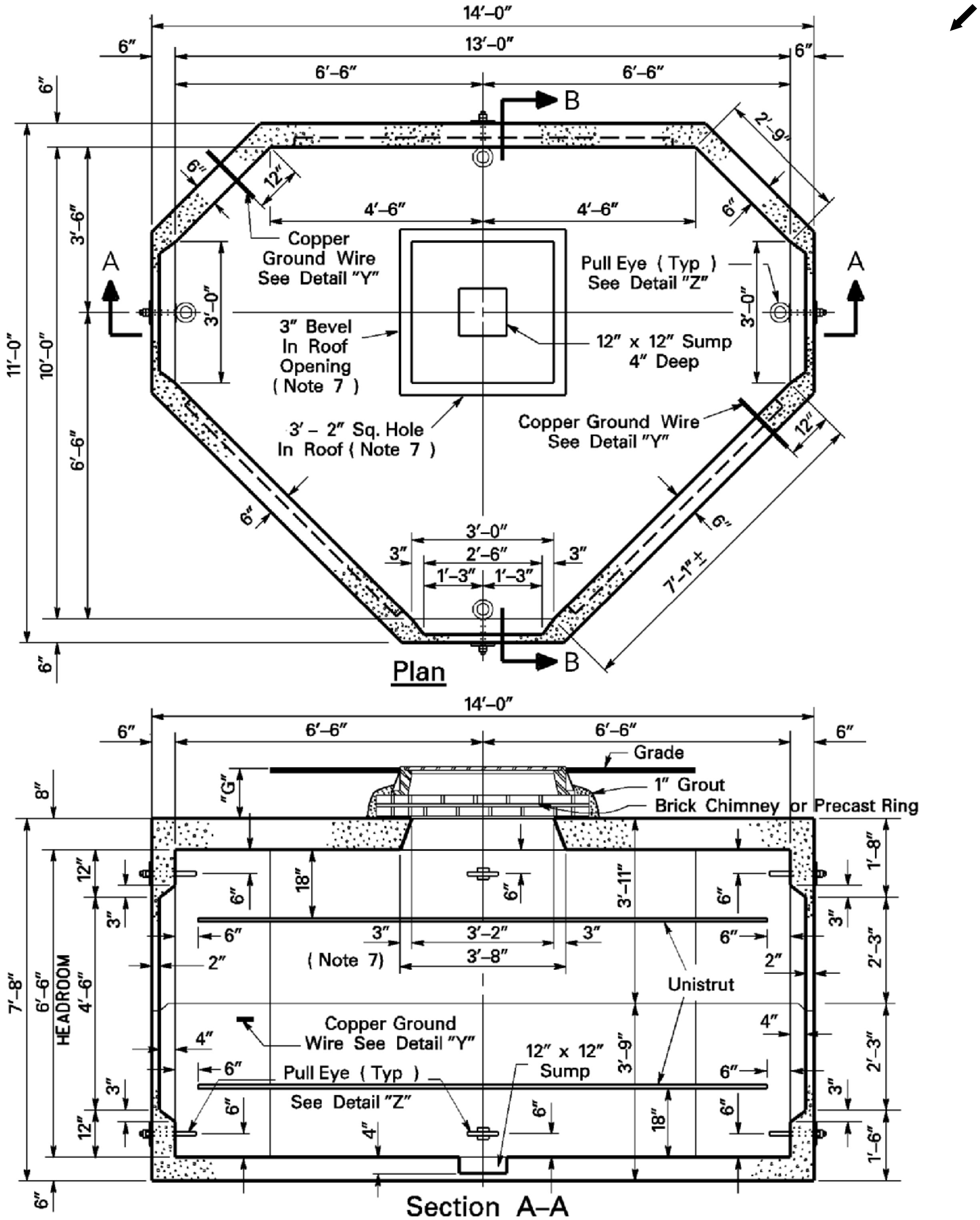
Note: Construction joint to be sealed with asphalt or equivalent.

Supersedes 1/07 Issue –Drawing Update

Doc. # ST. 33.00.001

Std. Item	UM23

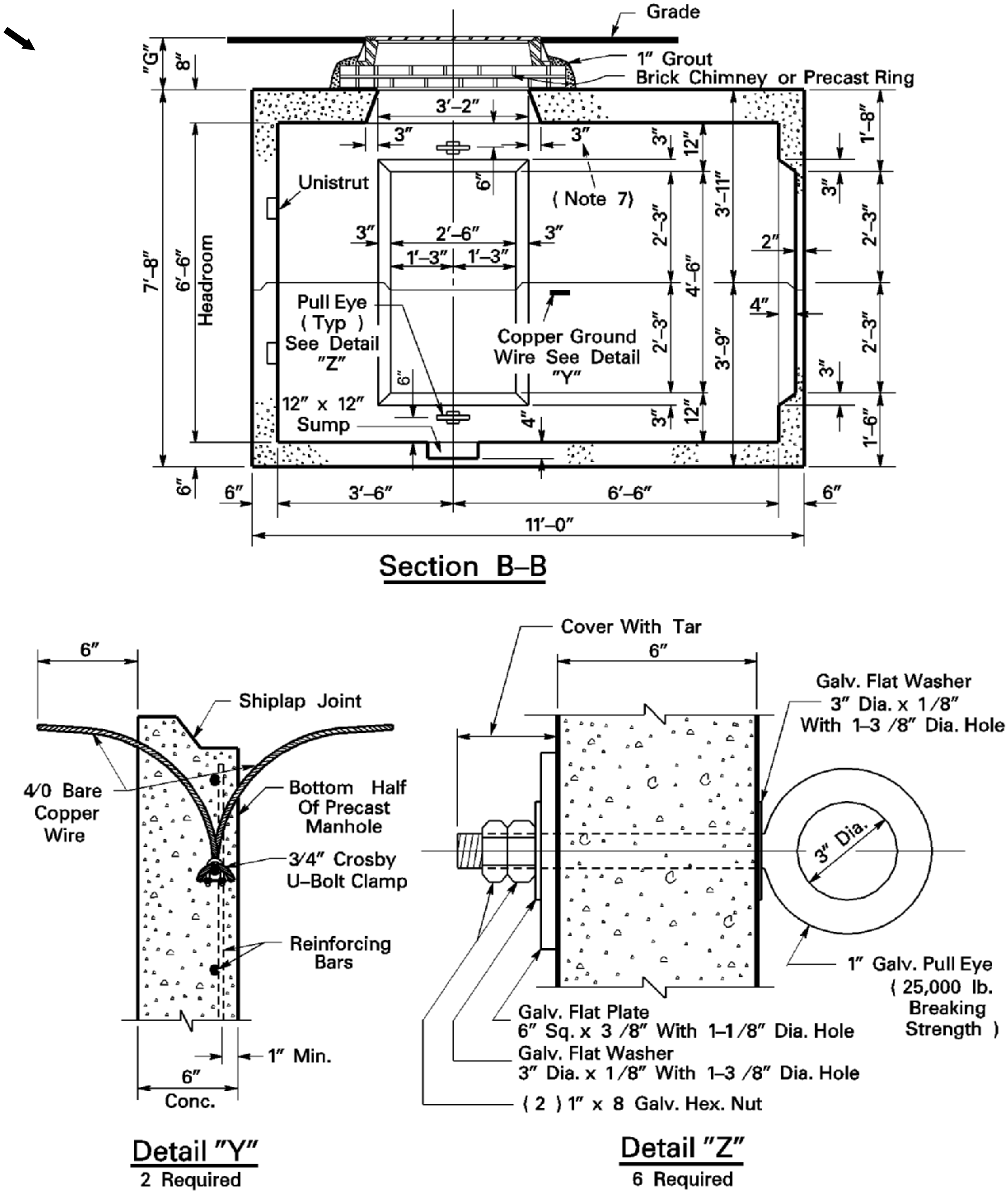
Supersedes 1/07 Issue – Drawing Update



PRECAST CONCRETE MANHOLES 3 WAY DISTRIBUTION – 10 FEET X 13 FEET (INSIDE)			
ISSUE	**PAGE NUMBER**	**UNDERGROUND CONSTRUCTION STANDARD**	Liberty Utilities
7/09	**33-105**		

Doc. # ST. 33.00.001

Std. Item	UM20



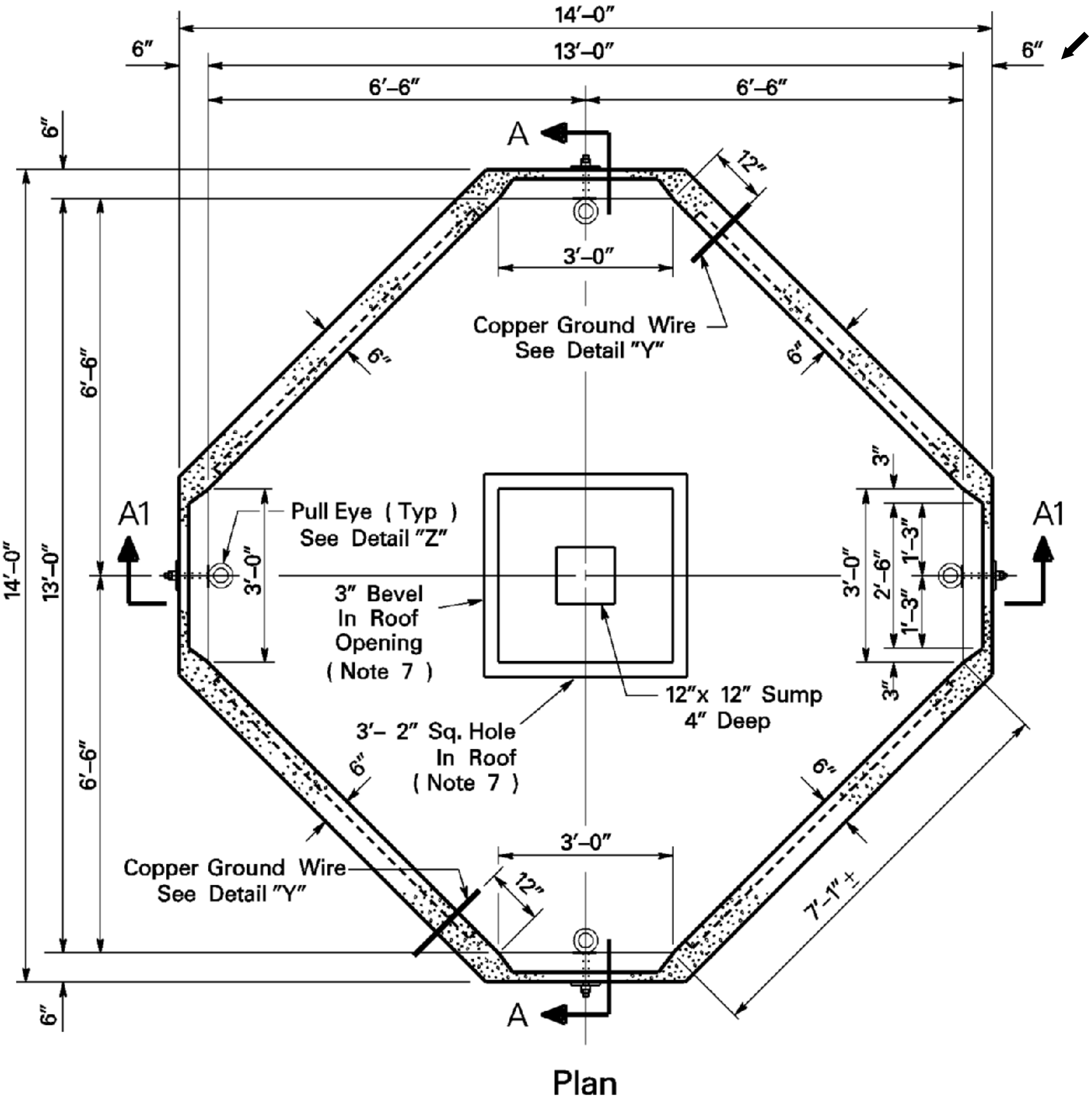
Supersedes 1/07 Issue –Drawing Update

PRECAST CONCRETE MANHOLES 3 WAY DISTRIBUTION – 10 FEET X 13 FEET (INSIDE)			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 33-106	ISSUE 1/09

Doc. # ST. 33.00.001

Std. Item	UM24

Supersedes 1/07 Issue – Drawing Update



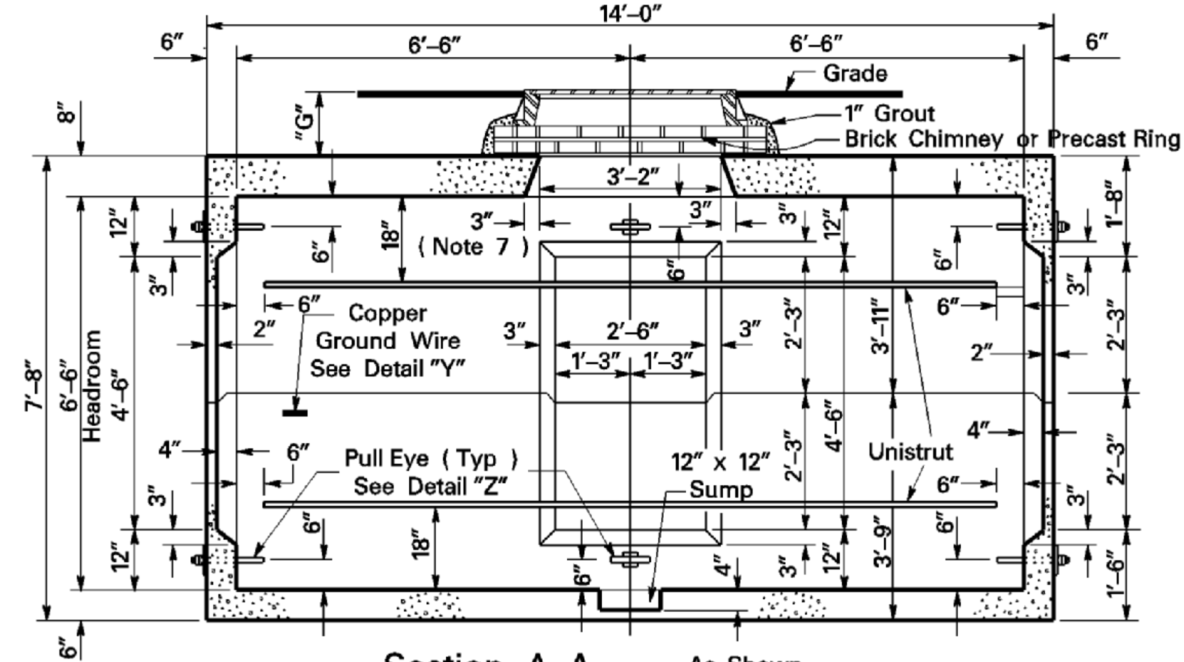
Plan

PRECAST CONCRETE MANHOLES
FOUR WAY DISTRIBUTION – 13 FEET X 13 FEET (INSIDE)

ISSUE	PAGE NUMBER		
7/09	**33-107**	**UNDERGROUND CONSTRUCTION STANDARD**	Liberty Utilities

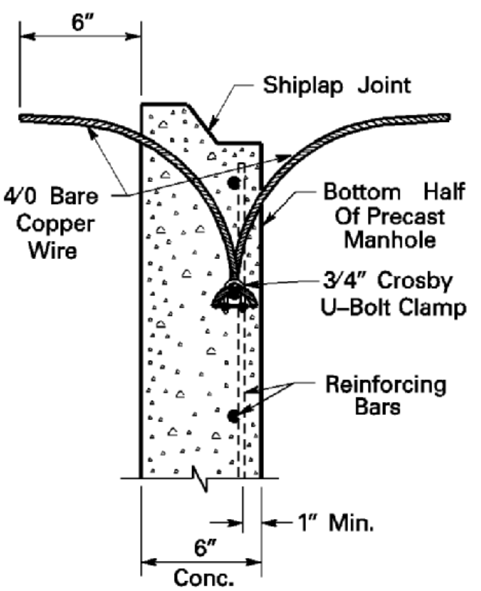
Doc. # ST. 33.00.001

Std. Item	UM24

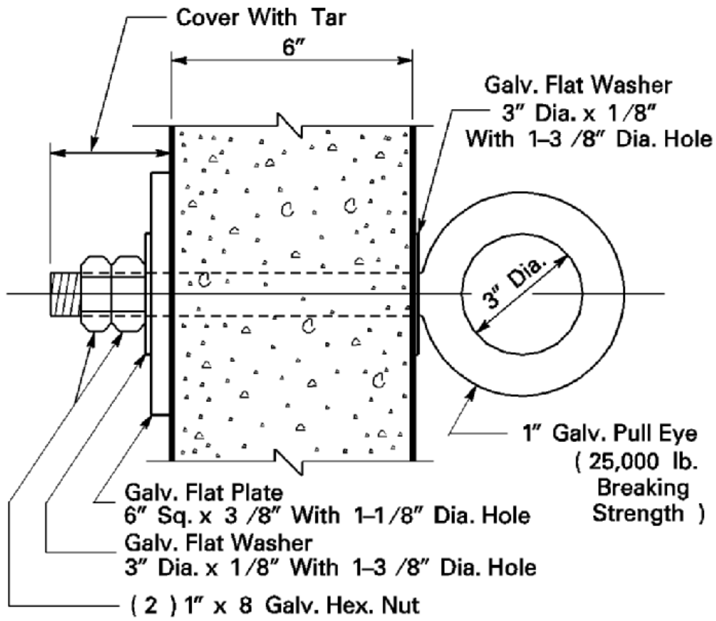


Section A–A
As Shown

Section A1–A1
Same As Section A–A With Exception Of Copper Ground Wire Location



Detail "Y"
2 Required



Detail "Z"
8 Required

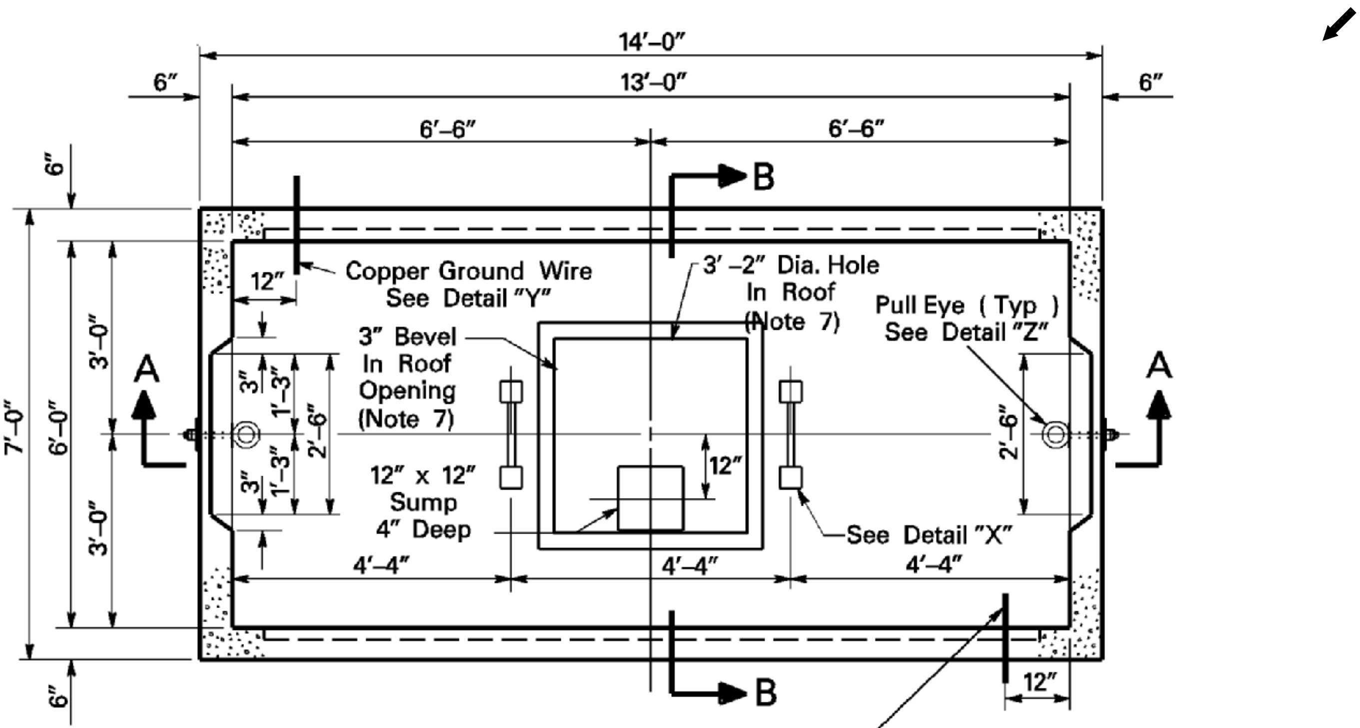
Note: Construction joint to be sealed with asphalt or equivalent.

Supersedes 1/07 Issue –Drawing Update

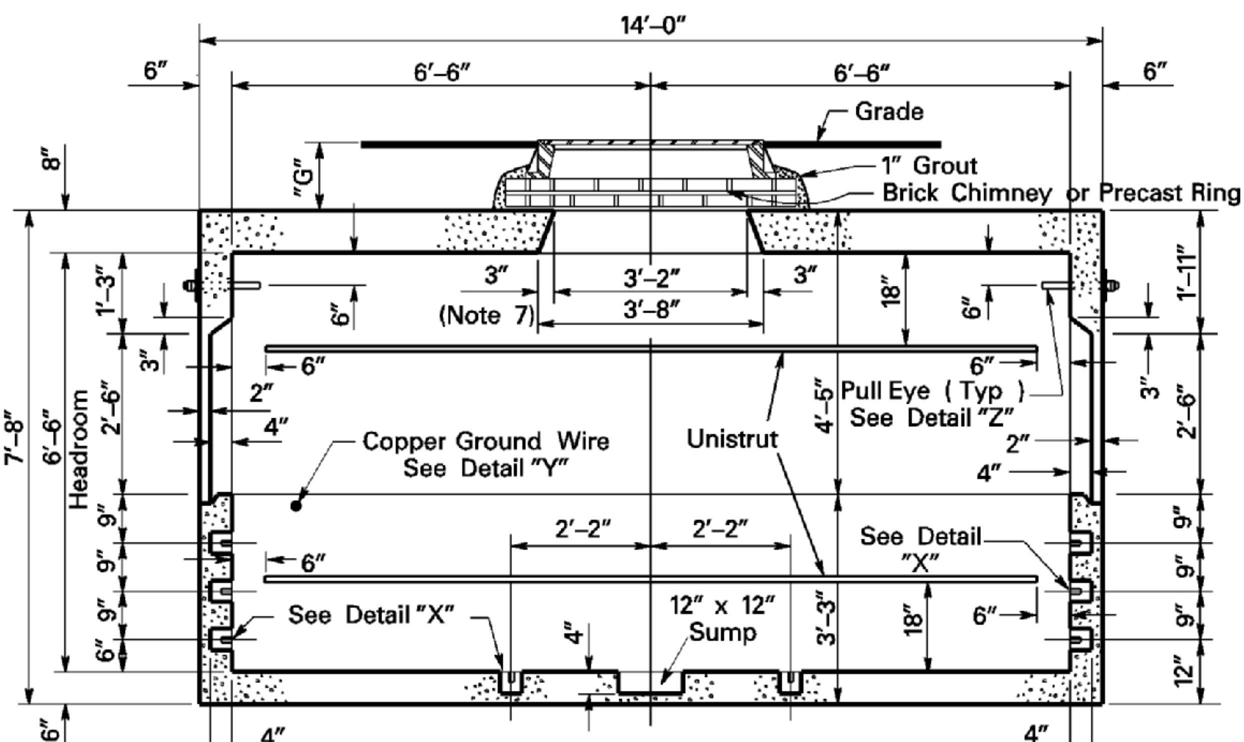
PRECAST CONCRETE MANHOLES FOUR WAY DISTRIBUTION – 13 FEET X 13 FEET (INSIDE)			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER **33-108**	ISSUE **7/09**

Std. Item	UM22S

Designed For Use Around Existing Cables

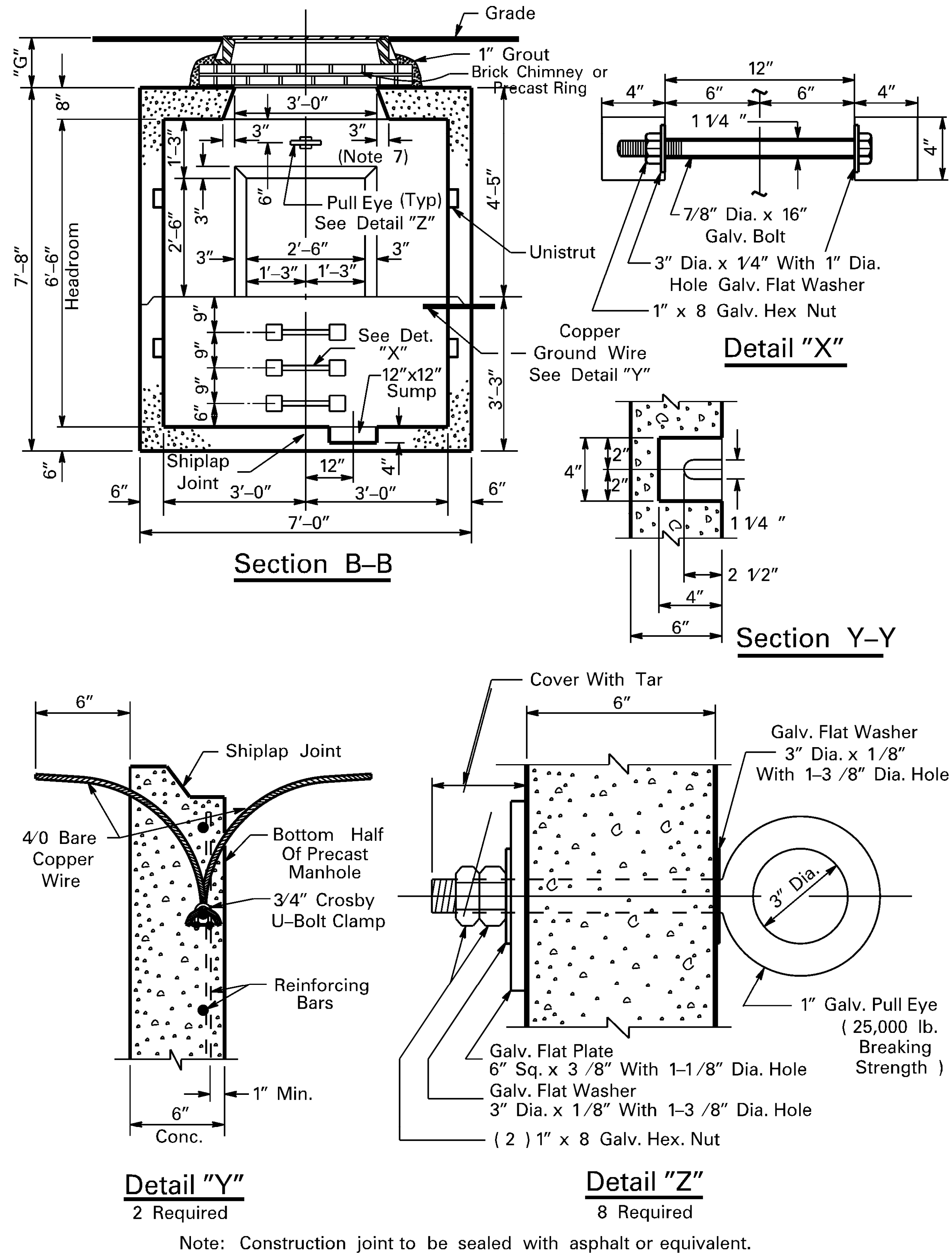


Plan



Section A–A

PRECAST CONCRETE MANHOLES TWO WAY SPLIT BOTTOM DISTRIBUTION – 6 FEET X 13 FEET (INSIDE)			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/09	33-109		



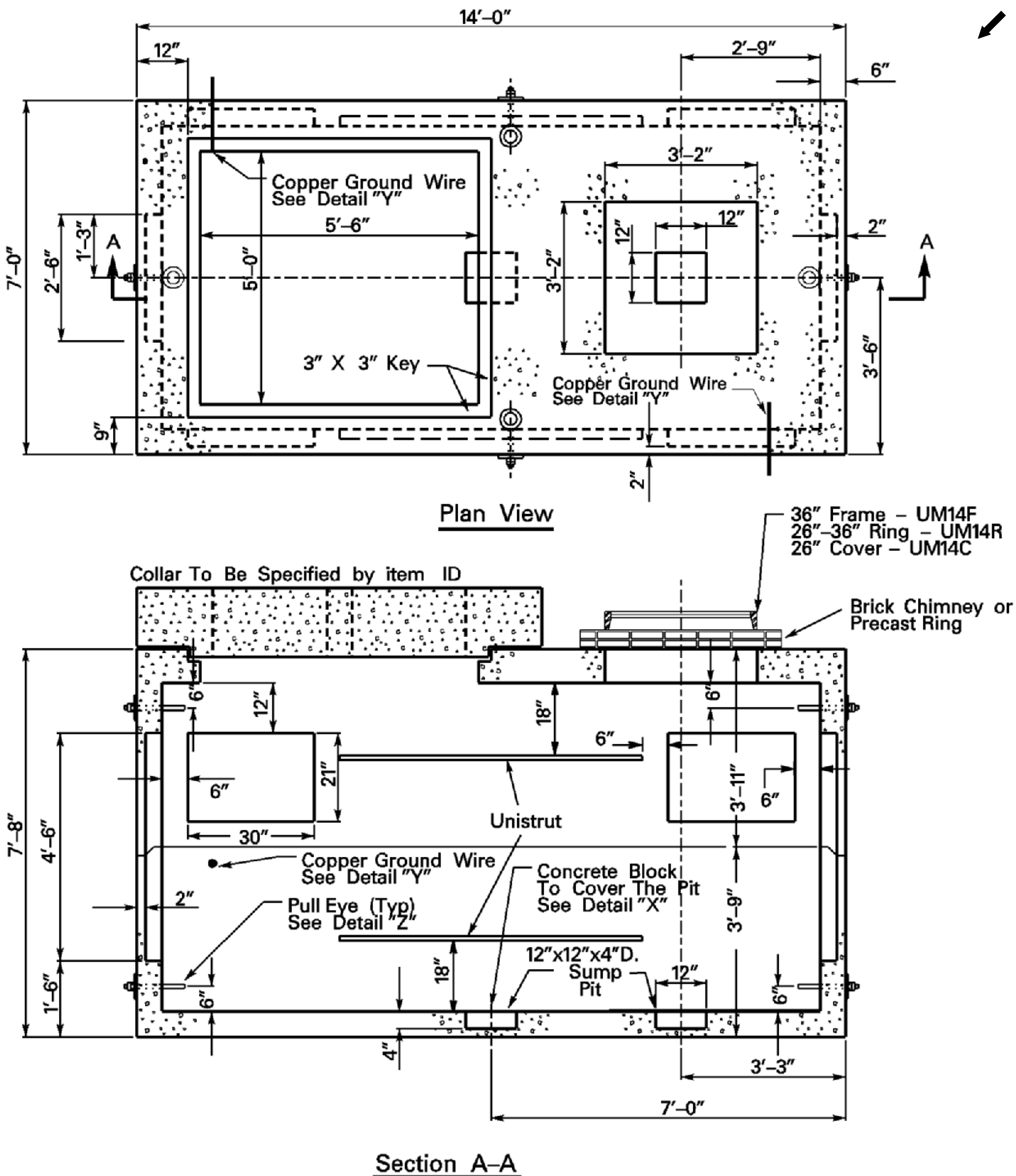
Note: Construction joint to be sealed with asphalt or equivalent.

Supersedes 1/07 Issue –Drawing Update

PRECAST CONCRETE MANHOLES
TWO WAY SPLIT BOTTOM DISTRIBUTION – 6 FEET X 13 FEET (INSIDE)

 Doc. # ST. 33.00.001

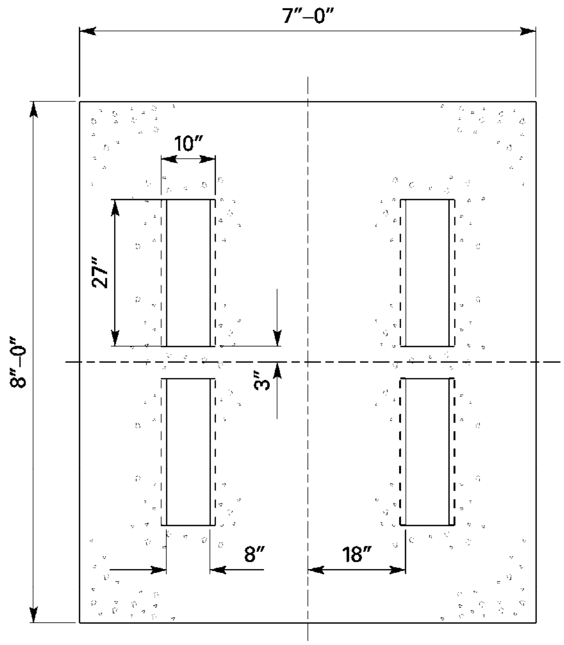
Supersedes 1/07 Issue – Drawing Update and added collars D and E



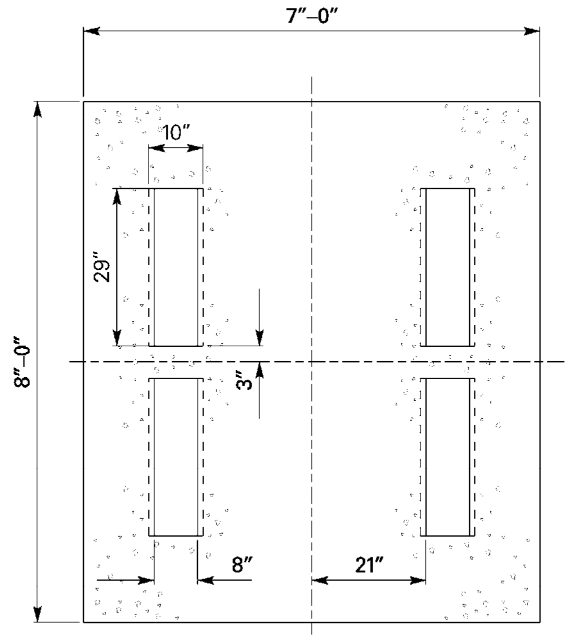
	Std. Item
With Specified Collar "A"	UM20A
With Specified Collar "B"	UM20B
With Specified Collar "C"	UM20C
With Specified Collar "D"	UM20D
With Specified Collar "E"	UM20E

PRECAST CONCRETE MANHOLES
SWITCHGEAR MANHOLE – 6 FEET X 13 FEET (INSIDE)

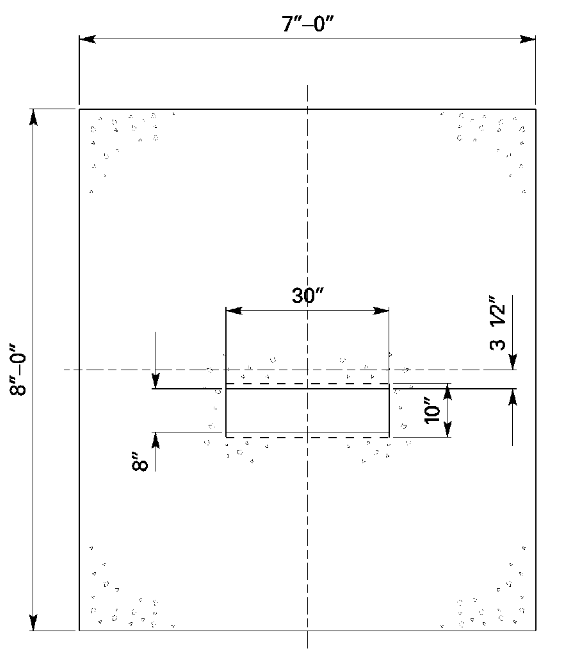
ISSUE	PAGE NUMBER		
7/09	33-111	OVERHEAD CONSTRUCTION STANDARD	Liberty Utilities



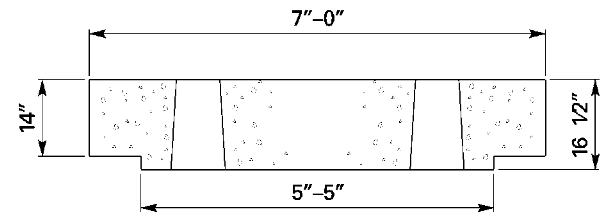
Collar "A"
15kV S/G Collar



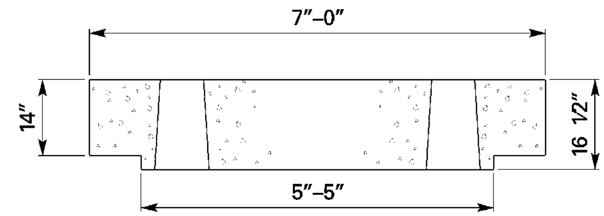
Collar "B"
25/35kV S/G Collar



Collar "C"
PWVE Cooper Recloser



Collar "A"



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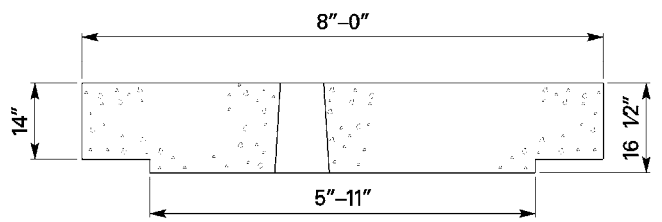
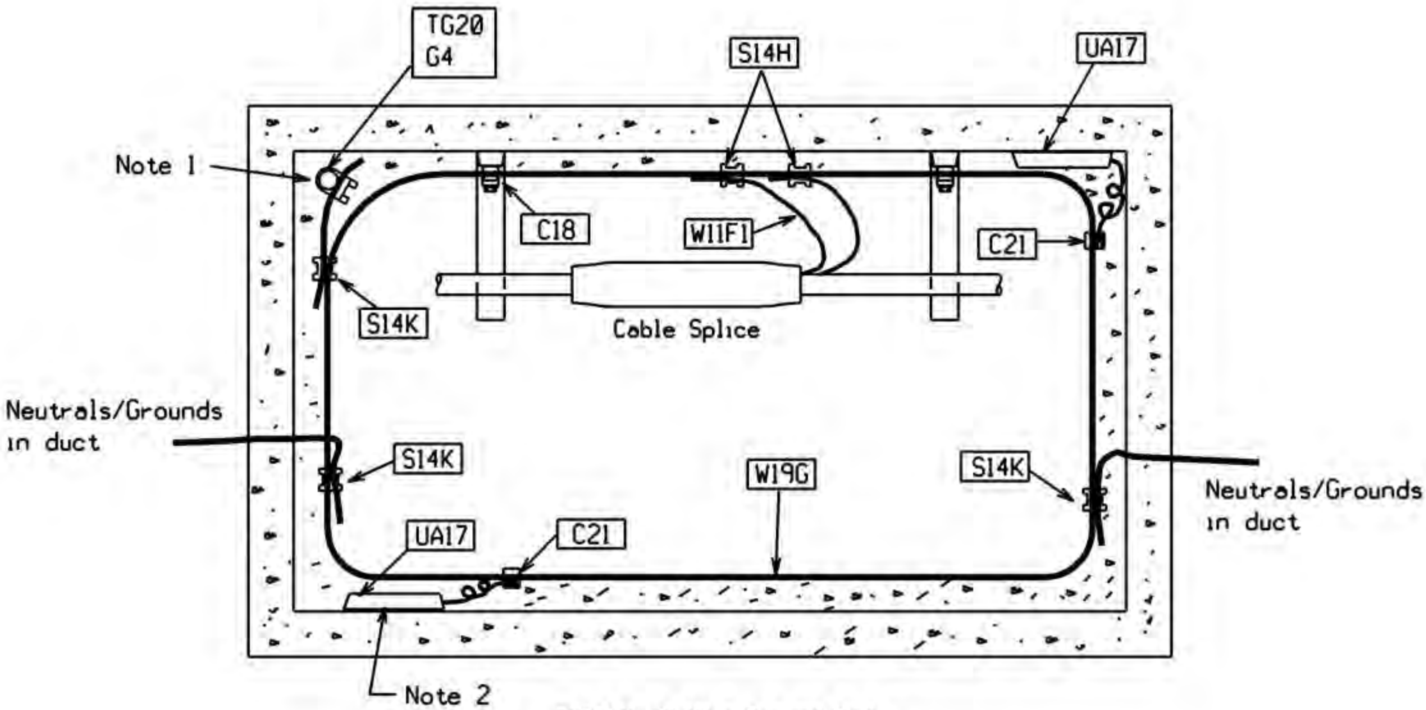
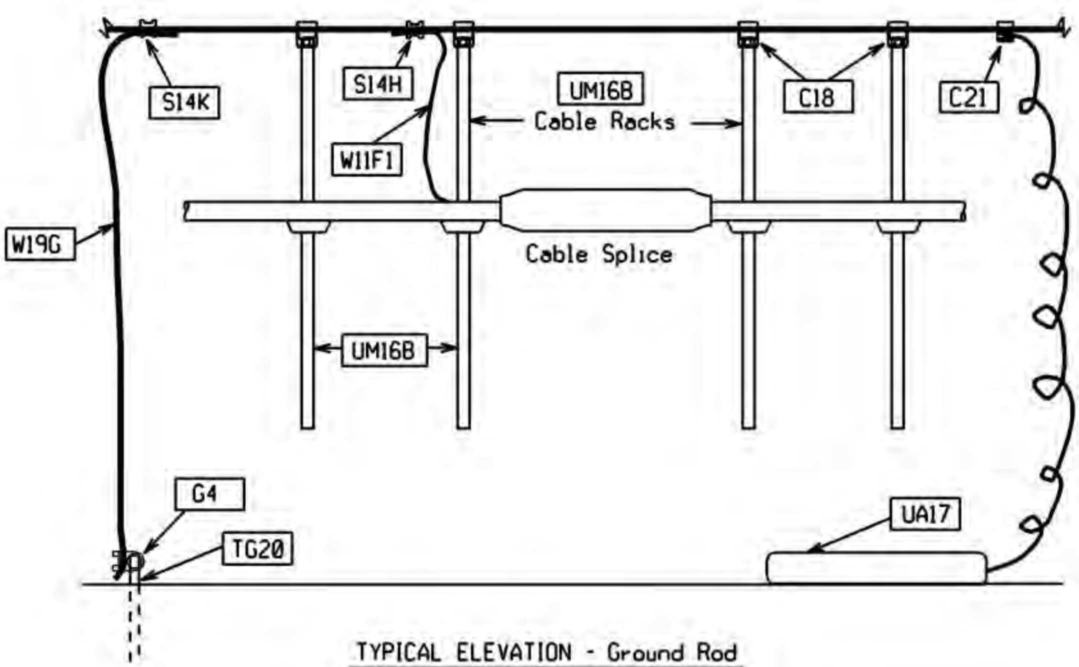


Collar "C"



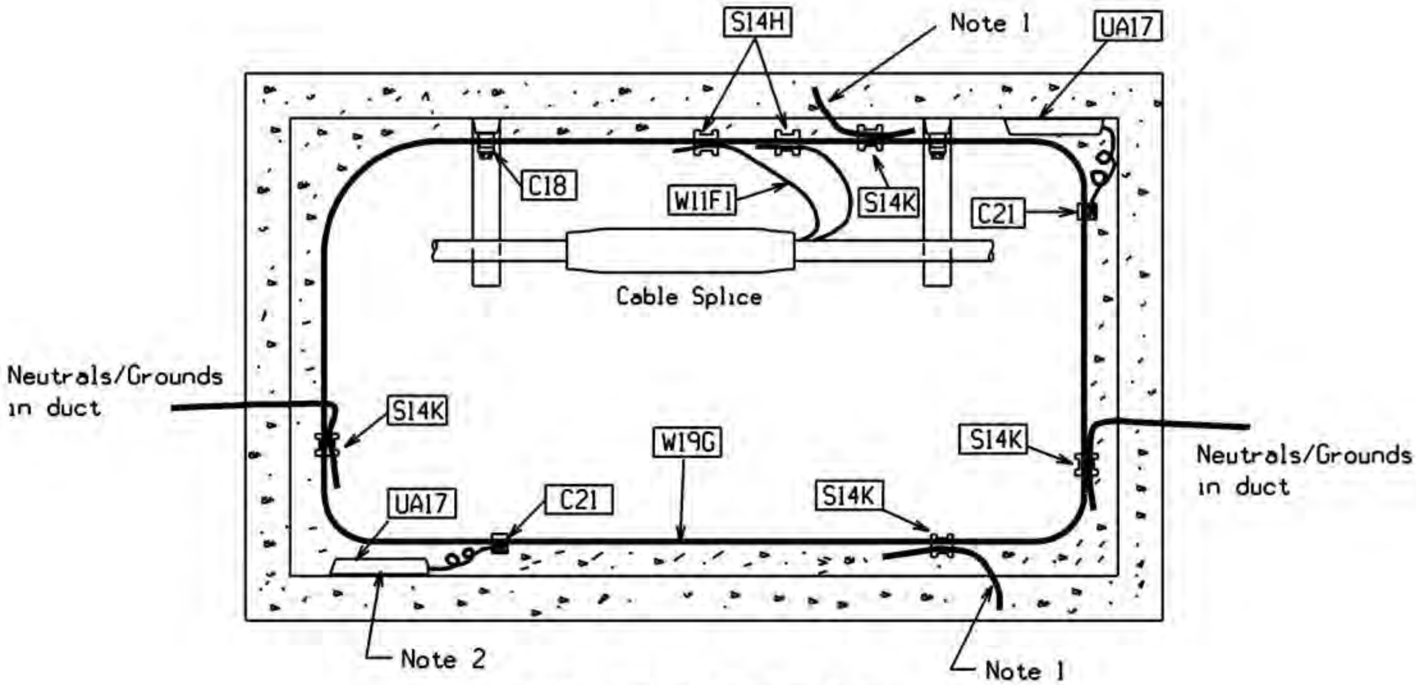
TYPICAL PLAN - Ground Rod



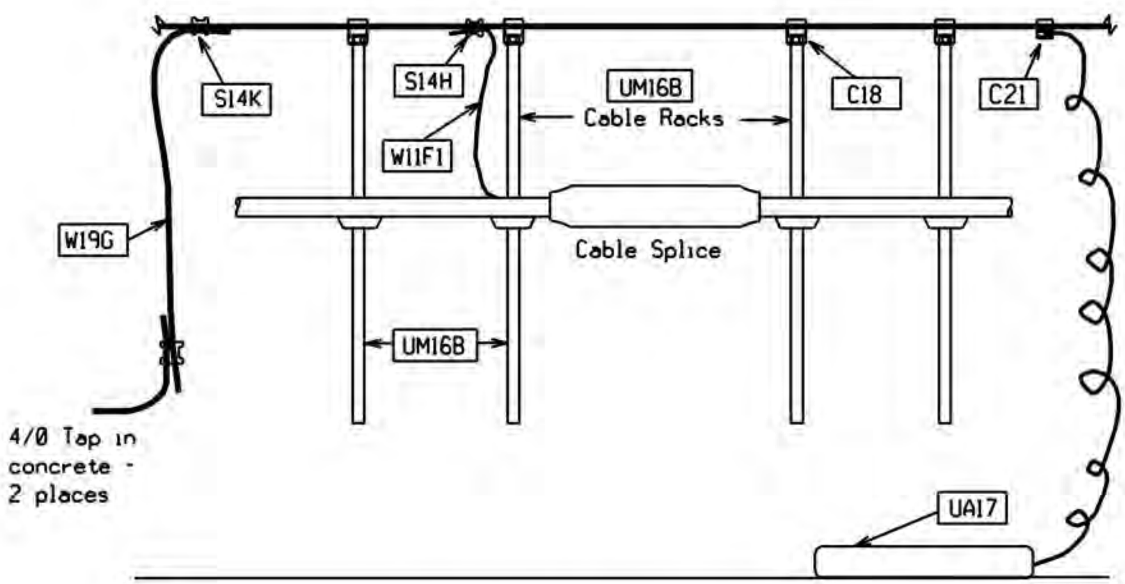
TYPICAL ELEVATION - Ground Rod

Note 1. Drive ground rod in corner of manhole - connect to ground bus
Note 2. Install annode in 2 corners of M.H. connect ground lead

EXISTING MANHOLE GROUND BUS			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/13	33-114		



TYPICAL PLAN - Ground on Rebar



TYPICAL ELEVATION - Ground on Rebar

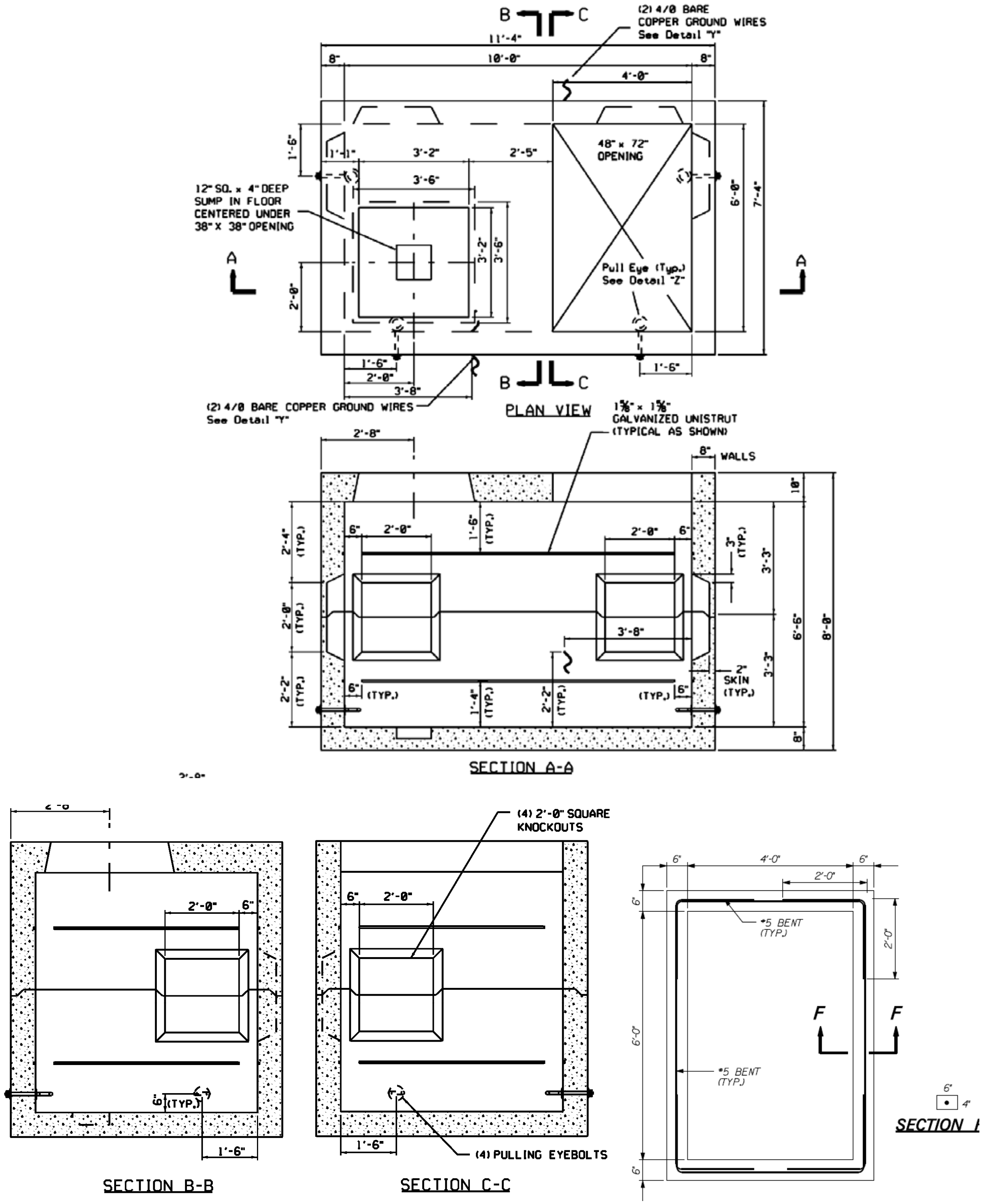
Note 1. 4/0 Tail poured in concrete 2 places
Note 2. Install annode in 2 corners of M.H. connect ground lead

NEW PRECAST MANHOLE GROUND BUS			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 33-115	ISSUE 7/13

Doc. # ST. 33.00.001 | .001

Std. Item	UM28

New Standard



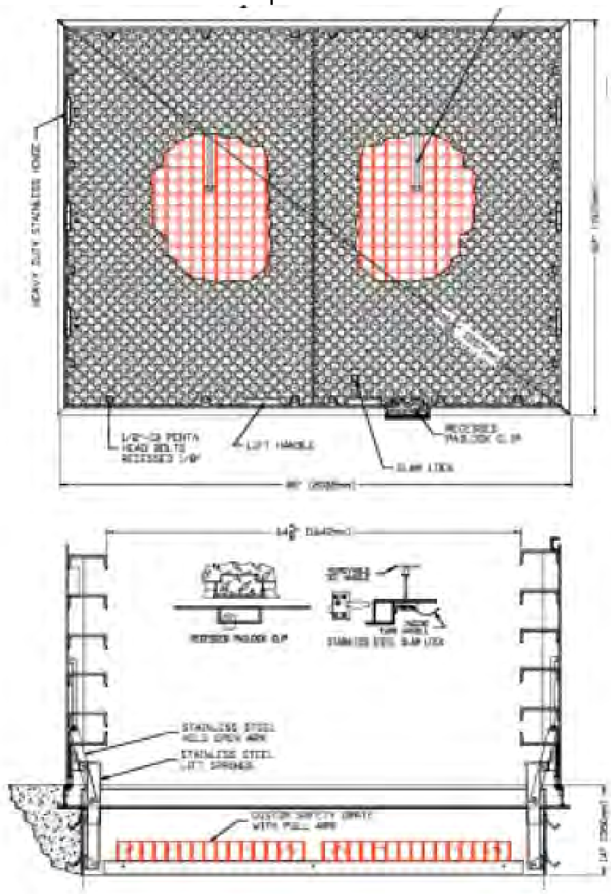
Grading Ring

New Standard

PRECAST CONCRETE MANHOLES PRECAST SATELLITE SIDEWALK MANHOLE 6' X 10' (Inside)			
ISSUE	**PAGE NUMBER**	**UNDERGROUND CONSTRUCTION STANDARD**	Liberty Utilities
7/09	**33-120**		

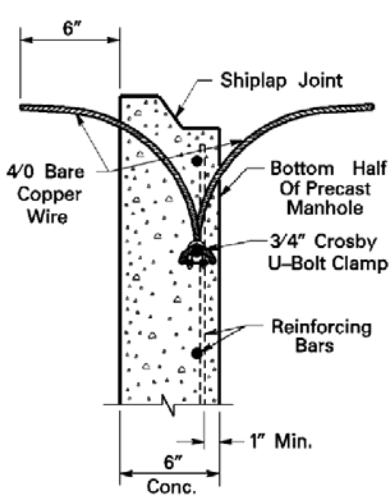
Superseded 7/09 Issue Updated Hatch with walking safety grate.

Hatch top and side views

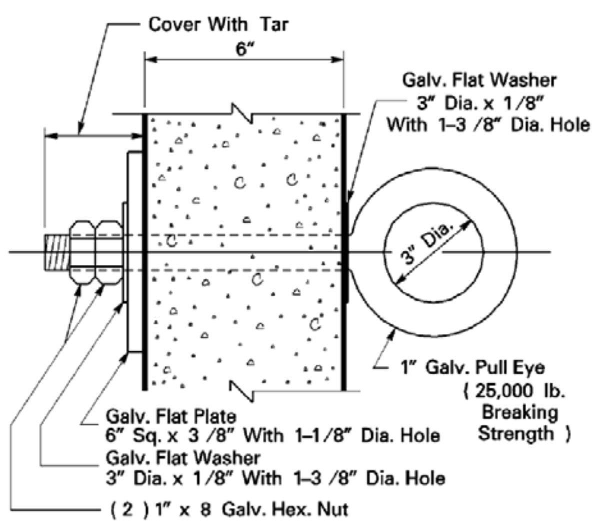


Notes:

1. Construction joint to be sealed with asphalt or equivalent.
2. Grading rings to be installed to build up hatchway for final grade.
3. Hatch to be cast into place at final grade



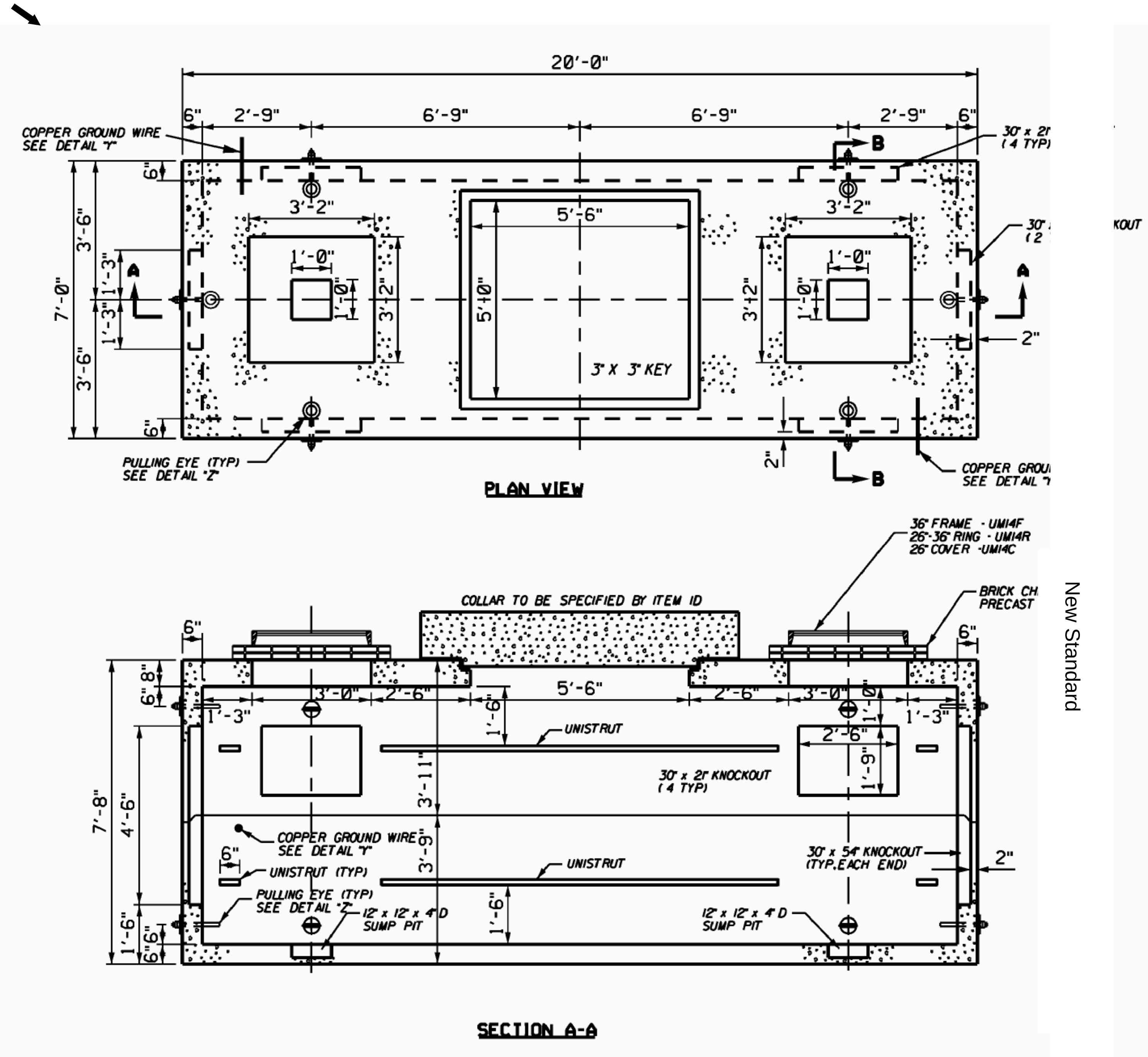
Detail "Y"
2 Required



Detail "Z"
4 Required

Doc. # ST. 33.00.001

Std. Item	UM31

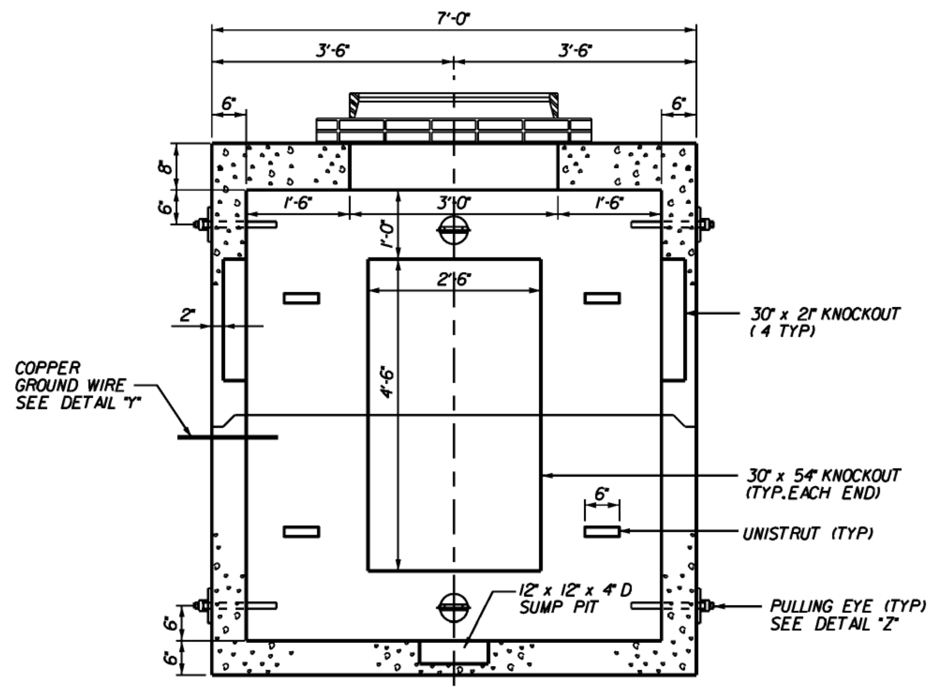


New Standard

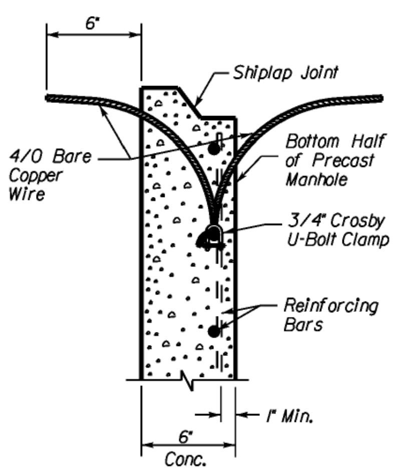
PRECAST CONCRETE MANHOLES –
DOUBLE ENTRY SWITCHGEAR MANHOLE 6' X19' (Inside)

ISSUE	PAGE NUMBER		
7/09	33-124	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

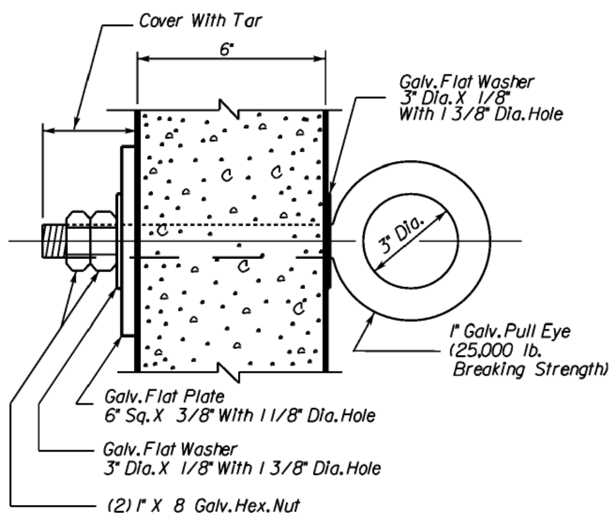
Std. Item	UM31



SECTION B-B



Detail "Y"
2 Required



Detail "Z"
4 Required

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2	7/13	• Updates to 33.0,33.1,33.3,33.4,33.5,33.7,33.8,33.9 • New Section 33.10 • New Drawings 33-100, -101 • Drawing updates 33-102, -120, -121 • Removed drawings 33-99, -116, -117, -122, -123	Robert Johnson	Robert Johnson Program Manager
1.1	7/10	• Minor update to 33.0	John Vartanian	Allen Chieco, Director of Distribution Standards and Work Methods
1	07/09	• Updated sections 33.1.10, 33.1.70 and 33.3. 4 • Inserted 33.5, 33.6, 33.7and 33.8 (new sections). • Drawing updates pages 33-103 thru 33-111and 33-113. • New drawings on pages 33-116 thru 33-125.	John Vartanian	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/07 Issue - Added Page 34-111.

GENERAL

This Standard is a list of tools and dies to be used when splicing and terminating underground primary and secondary conductors. The number of crimps for each half of the connector is indicated in the table.

34.0 CONNECTORS

All connectors will be tinned and have center oil/water stop. Connectors will be roll marked with crimp lines and die information. Copper connectors are to be used only on copper conductors. Aluminum connectors are used on aluminum conductors, and aluminum to copper transition splices. Reducing connectors shall be of a one piece design, inserts shall not be used. Conductors must be cut square. It is essential to wire brush both aluminum and copper conductors until they are clean and bright. Use different brushes for aluminum and copper, as the copper particles caught in the brush will deposit on aluminum conductors and corrode that conductor. Tables in this Section are for cables with concentric, compressed round or compact conductor stranding only. Other types of stranding may require different connectors.

If other connector sizes are needed, contact Standards Engineering.

34.1 CRIMPING

Circumferential crimping is required on aluminum and is preferred on copper connectors. Crimp the connector, working from the center out. Crimp lugs, working from the top of the barrel to the open end. Make crimps between the guide marks. Die-less indent presses are acceptable and shall be calibrated according to manufacturer's recommendations.

34.2 INSULATING

Where insulating is required, any excess inhibitor from the conductor and connector must be removed before proceeding to insulate. Do not remove inhibitor from the barrel of the connector prior to insertion of the conductor. All voids must be filled with inhibitor. Remove only the inhibitor that is pushed out of the connector barrel after insertion of the conductor and crimping.

34.3 ADAPTERS

Y-35 dies can be used on Y-46 tool. Use Burndy U die with Burndy adapter P-UADP.

Supersedes 2/06 Issue – Update 34.0 & 34.2

CONNECTOR, COMPRESSION, COPPER								
Description	Tinned copper compression connector with center oil / water stop. Designed for joining copper conductors end to end. These connectors are selected to meet the dimensional requirements of all high voltage splice kits used in the company. Splice shall be in accordance with ANSI C119.4, Class A, Class 2 min.							
Wire Size	**BCT 500 / PATMD6814V**		**Y35 / 12 Ton**		**Y46 / 15 Ton**		**Die Index**	**Std. Item**
	Die	****Crimp**	**Die**	****Crimp**	**Die**	****Crimp**		
4	W4CRT	2	U4CRT	2			8	UC60A
2	W2CRT	2	U2CRT	2	*	2	10	UC60B
1/0	W25RT	4	U25RT	2	*	2	12	UC60C
2/0	W26RT	4	U26RT	2	*	2	13	UC60D
4/0	W28RT	4	U28RT	2	*	2	15	UC60E
250 / 250 Comp	W29RT	4 4	U29RT	2	*	2	16	UC60F
300 / 300 Comp	W30RT	2	U30RT	4	*	4	17	UC60H
350 / 350 Comp	W31RT	2	U31RT	4	*	4	18	UC60K
400 Comp	W32RT	2	U32RT	4	*	4	19	UC60L
500 / 500 Comp	W34RT	2	U34RT	4	*	4	20	UC60M
750			U39RT	4	P39RT	4	24	UC60P
1000				4	P44RT	4	27	UC60R

* Use PUADP-1 Adapter with "U" dies in Y-46 Hypress
** Crimps are defined as per side of connector

Supersedes 7/07 Issue – General Revision & Update, Added Die Index Column

Supersedes 7/07 Issue – General Revision & Update, Added Die Index Column

CONNECTOR, COMPRESSION, ALUMINUM									
Description	Tinned aluminum compression connector with center oil / water stop. Designed for joining 2 aluminum conductors or copper to aluminum conductors end to end. These connectors are selected to meet the dimensional requirements of all high voltage splice kits used in the company. Splice shall be in accordance with ANSI C119.4, Class A, Class 2 min.								
Wire Size	**BCT 500 / PATMD6814V**		**Y35 / 12 Ton**		**Y46 / 15 Ton**		**Die Index**	**Std. Item**
	Die	****Crimp**	**Die**	****Crimp**		****Crimp**		
2	W241	2	U25ART	2	*	2	296	UC61A
1/0	W241	2	U25ART	2	*	2	296	UC61B
4/0	W660	4	U28ART	2	*	2	298	UC61C
350	W31ART	4	U31ART	4	*	4	299	UC61D
500	**	--	U34ART	4	*	4	300	UC61E
750	**	--	U39ART2	4	*	4	936	UC61F
1000	**	--	U39ART2	4	*	4	936	UC61G

* Use PUADP-1 Adapter with “U” dies in Y-46 Hypress
** Crimps are defined as per side
Note: Do Not use BCT500 on aluminum conductor larger than 350.

CONNECTOR, COMPRESSION, COPPER REDUCING								
Description	Tinned copper compression connector with center oil / water stop. Designed for joining two different size copper conductors end to end. These connectors are selected to meet the dimensional requirements of all high voltage splice kits used in the company. Splice shall be in accordance with ANSI C119.4, Class A, Class 2 min.							
Wire Size	**BCT 500 / PATMD6814V**		**Y35**		**Y46**		**Die Index**	**Std. Item**
	Die	****Crimp**	**Die**	****Crimp**	**Die**	****Crimp**		
2 Str. to 3 Sol.	W2CRT	2					10	UC62A1
2 to 1/0	W25RT	2	U25RT	1	*	2	12	UC62A2
2 to 4/0	W28RT	2	U28RT	1	*	2	15	UC62A3
2 to 350	W31RT	4	U31RT	2	*	2	18	UC62A4
2 to 500	W34RT	2	U34RT	2	*	2	20	UC62A5
1/0 to 4/0	W28RT	2	U28RT	1	*	2	15	UC62B1
1/0 to 350	W31RT	4	U31RT	2	*	2	18	UC62B2
2/0 to 4/0	W28RT	2	U28RT	1	*	2	15	UC62C1
2/0 to 350	W31RT	4	U31RT	2	*	2	18	UC62C2
3/0 to 4/0	W28RT	2	U28RT	1	*	2	15	UC62D1
4/0 to 250	W29RT	4	U29RT	2	*	2	16	UC62E1
4/0 to 300	W30RT	4	U30RT	2	*	2	17	UC62E2
4/0 to 350	W31RT	4	U31RT	2	*	2	18	UC62E3
4/0 to 450	W33RT	4	U33RT	2	*	2	326	UC62E4
4/0 to 500	W34RT	4	U34RT	2	*	2	20	UC62E5
250 to 350	W31RT	4	U31RT	2	*	2	18	UC62F1
250 to 500	W34RT	4	U34RT	2	*	2	20	UC62F2
300 to 500 Comp.	W34RT	4	U34RT	2	*	2	20	UC62G1
350 to 500 / 500 Comp	W34RT	4	U34RT	2	*	2	20	UC62H1
350 to 750			U39RT	2	P39RT	2	24	UC62H2
450 to 500 Comp.	W34RT	4	U34RT	2	*	2	20	UC62J1
500 / 500 Comp to 750	--	--	U39RT	2	P39RT	2	24	UC62K2
500 / 500 Comp to 1000	--	--	--	--	P44RT	2	27	UC62K4
750 to 1000	--	--	--	--	P44RT	2	27	UC62L1

Supersedes 7/07 Issue – General Revision & Update, Added Die Index Column

* Use PUADP-1 Adapter with "U" dies in Y-46 Hypress
** Crimps are defined as per side

CONNECTOR, COMPRESSION, ALUMINUM REDUCING								
Description	Tinned aluminum compression connector with center oil / water stop. Designed for joining 2 aluminum conductors or copper to aluminum conductors end to end. These connectors are selected to meet the dimensional requirements of all high voltage splice kits used in the company. Splice shall be in accordance with ANSI C119.4, Class A, Class 2 min.							
Wire Size	**BCT 500 / PATMD6814V**		**Y35**		**Y46**		**Die Index**	**Std. Item**
	Die	****Crimp**	**Die**	****Crimp**	**Die**	****Crimp**		
2 Str. to 3 Sol.	W241		U25ART	2	*	2	296	UC63A
2 to #6	W241		U25ART	2	*	2	296	UC63B
2 to 1/0	W241		U25ART	2	*	2	296	UC63C
2 to 4/0	W660		U28ART	2	*	2	298	UC63D
1/0 to 2/0	W245		U26ART	2	*	2	297	UC63N
1/0 to 4/0	W660		U28ART	2	*	2	298	UC63E
1/0 to 350	W31ART	4	U31ART	2	*	2	299	UC63F
4/0 to 350	W31ART	4	U31ART	2	*	2	299	UC63G
4/0 to 500			U34ART	4	*	4	300	UC63H
350 to 500			U34ART	4	*	4	300	UC63J
500 to 750			U39ART-2	4	P39ART-2	4	936	UC63K
500 to 1000			U39ART-2	4	P39ART-2	4	936	UC63L
750 to 1000			U39ART-2	4	P39ART-2	4	936	UC63M

* Use P-UADP-1 Adapter with "U" dies in Y-46 Hypress
** Crimps are defined as per side

Supersedes 2/06 Issue – General Revision & Update, Added Die Index Column

LUG, TERMINAL, COPPER

9/16" Holes X 1¾" Spacing

Description	Tinned copper lug with NEMA 2 or 4 hole pad (9/16" holes @ 1¾" spacing). Lugs are sealed to prevent water intrusion into the cable. For use on copper cable terminations.							
Wire Size	**BCT 500 / PATMD6814V**		**Y35**		**Y46**		**Die Index**	**Std. Item**
	Die	****Crimp**	**Die**	****Crimp**	**Die**	****Crimp**		
4	W4CRT	2	U4CRT	2	*	2	8	UL15A
2	W2CRT	2	U2CRT	2	*	2	10	UL15B
1/0	W25RT	4	U25RT	2	*	2	12	UL15C
2/0	W26RT	4	U26RT	2	*	2	13	UL15D
4/0	W28RT	4	U28RT	2	*	2	15	UL15E
350	W31RT	4	U31RT	2	*	2	16	UL15K
500	W34RT	4	U34RT	4	*	4	20	UL15M
500 (Stacking)	W34RT	4	U34RT	4	*	4	20	UL15MS
600	**	--	U36RT	4	*	4	22	UL15N
750	**	--	U39RT	4		4	24	UL15P
1000 2 Hole	**	--	--	--	P44RT	4	27	UL15R
1000 4 Hole	**	--	--	--	P44RT	4	27	UL15R4

* Use PUADP-1 Adapter with "U" dies in Y-46 Hypress
** Do Not Use BCT 500 on Copper Conductors Over 500 kcmil

Supersedes 7/10 Issue – General Revision & Update, Added Die Index Column

Supersedes 7/10 Issue – General Revision & Update, Added Die Index Column

LUG, TERMINAL, ALUMINUM

$^{9}/_{16}$" Holes X 1¾" Spacing

Description	Tinned aluminum lug with NEMA 2 or 4 hole pad ($^{9}/_{16}$" holes @ 1 ¾" spacing). Lugs are sealed to prevent water intrusion into the cable. For use on aluminum cable terminations.

Wire Size	BCT 500 / PATMD6814V		Y35		Y46		Die Index	Std. Item
	Die	**Crimp	Die	**Crimp	Die	**Crimp		
4	W162	4	U4CABT	2	*	2	375	UL16A
2	W239	4	U2CABT	2	*	2	348	UL16B
1/0	W241	4	U25ART	2	*	2	296	UL16C
2/0	W245	4	U26ART	2	*	2	297	UL16D
4/0	W660	4	U28ART	2	*	2	298	UL16E
350	W31ART	4	U31ART	2	*	2	299	UL16K
500	**	--	U34ART	4	*	4	300	UL16M
600	**	--	U36ART	4	*	4	473	UL16N
750	**	--	U39ART-2	4	*	4	936	UL16P
1000 2 Hole	**	--	--	--	P44ART	4	302	UL16R
1000 4 Hole	**	--	--	--	P44ART	4	302	UL16R4

* Use PUADP-1 Adapter with "U" dies in Y-46 Hypress
** Do Not Use BCT 500 on Aluminum Conductors over 350 kcmil

TOOLS LISTED IN THIS SECTION CAN ALSO BE FOUND IN THE ON-LINE TOOL CATALOG SECTION OF THE INFONET.
http://mawbrapp16v/ToolCatalog

END STRIPPER
Utility Tool Model WS 5 and WS 6
Bushing Application Table

Conductor Size	Voltage Class kV	Insulation Thickness Inches	Diameter Over Insulation ± 0.30 Inches	Tool	Bushing Model # (insulation only)	Bushing Model # (over semicon)
1/0	5	0.115	0.650	WS 5	0.675	0.750
500 kcmil	5	0.115	1.090	WS 5	1.125	1.175
750 kcmil	5	0.115	1.280	WS 6	1.300	1.375
#2	15	0.175	0.695	WS 5	0.700	0.775
4/0	15	0.175	0.920	WS 5	0.950	1.000
350 kcmil	15	0.175	1.080	WS 5	1.125	1.175
500 kcmil	15	0.175	1.210	WS 6	1.225	1.325
750 kcmil	15	0.175	1.400	WS 6	1.425	1.500
1000 kcmil	15	0.175	1.545	WS 6	1.575	1.650
1/0	25	0.260	0.940	WS 5	0.975	1.025
4/0	25	0.260	1.090	WS 5	1.125	1.175
350 kcmil	25	0.260	1.260	WS 6	1.300	1.350
500 kcmil	25	0.260	1.390	WS 6	1.425	1.500
1000 kcmil	25	0.260	1.725	WS 6	1.750	1.850
1/0	35	0.345	1.110	WS 5	1.125	1.200
2/0	35	0.345	1.155	WS 6	1.175	1.250
1000 kcmil	35	0.345	1.900	WS 50	1.925	--

Supersedes 7/10 Issue – Add Column for Insulation Only Bushing.

CABLE INSULATION END STRIPPER	
	
Description	For 600 Volt to 35 kV cables, adjustable strip lengths up to 2.5”. For use on XLPE and EPR cable insulation.
Tool Catalog Number	MHTUG01
Manufacturer	Ripley Company
Catalog Number	Model WS5B for insulation OD of 0.26” to 1.25” Model WS6 for insulation OD of 0.96” to 1.90”

EXTENSION FOR CABLE INSULATION END STRIPPER	
	
Description	Accessory for WS-6 to increase the strip length to 5.5”. Also allows use of the SW2 ratchet wrench.
Tool Catalog Number	NS0000286
Manufacturer	Ripley Company
Catalog Number	WA3

RATCHET WRENCH FOR WS6	
	
Description	Ratchet wrench for WS6 Stripper. Requires WA3 accessory.
Tool Catalog Number	0000588
Manufacturer	Ripley Company
Catalog Number	WA3

Supersedes 2/06 Issue – Added Tools, Updated Tool Information, Page Shift

ADJUSTABLE JACKET STRIPPER	
	
Description	Universal tool for end stripping or mid spanning outer jackets or insulation. Dual position jaw for cable sizes from½ in. to 2½ in. (12.7 to 63.5 mm) cable O.D. Compact design for tighter work space requirements.
Tool Catalog Number	MHTUG02
Manufacturer	Ripley Company
Catalog Number	WS64-U

ADJUSTABLE BLADE SEMI-CON SCORER	
	
Description	Designed to score the semi-conductive shield of high voltage cable without nicking or damaging the cable. Adjustable blade depth for variations in thickness of 0.001" to 0.100"
Tool Catalog Number	0000158
Manufacturer	Reliable Equipment
Catalog Number	Model 1700-SS

Supersedes 2/06 Issue – Updated Tool Information, Page Shift.

Supersedes 7/07 Issue – Updated Tool Information, Page Shift

LOAD BREAK PROBE WRENCH

Description	Holds the load break probe and acts as a handle while positioning and installing the probe into the threaded eye of the elbow crimp connector. Preset torque rating of 10 ft-lb.
Tool Catalog Number	0000166
Manufacturer	Reliable Equipment
Catalog Number	Model #LPW1525R/TK120X-N for 15 & 25 kV Model #LPW35R/TK120X-N for 35 kV

LOAD BREAK BUSHING INSERTION TOOL

Description	For 200 Amp Bushing Well Insert with internal hexagon socket drive. Preset torque setting of 15 ft-lb. Secures Bushing Well Insert for positive installation and removal.
Tool Catalog Number	0000182
Manufacturer	Utility Tool Co.
Catalog Number	Model #LBIT-1T

URD INSULATION CHAMFER TOOL

Description	Creates a 45 bevel approximately 0.125 in. long. For pre-molded splices, elbows and terminations.
Tool Catalog Number	0000554
Manufacturer	Ripley
Catalog Number	Model # IC1 for cable O.D. range 0.650 – 1.260 Model # IC2 for cable O.D. range 1.250 – 1.875 Model # CB163 is a replacement Blade

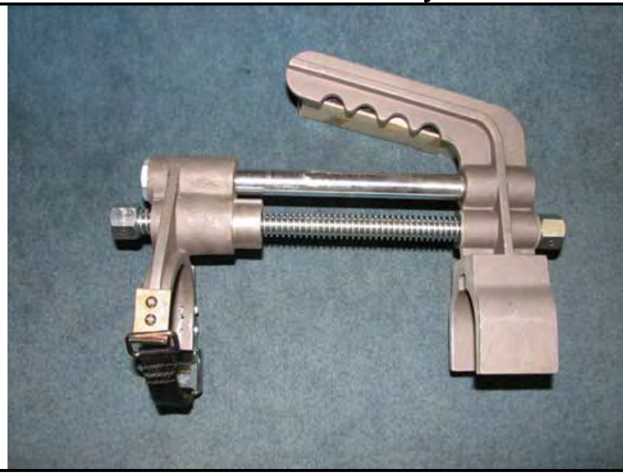
Cable Adapter / Dead Break Elbow Installation Tool

Description	Installs cable adapters required for 600 amp dead break elbows and premolded Y and H joints. Also installs 600 amp dead break elbow bodies. See Tool Catalog for more information.
Tool Catalog Number	NS0000236
Manufacturer	Speed Systems
Catalog Number	600 TAT

New Page – Added Tools, Updated Tool Information, Page Shift.

New Page – Additional Tools

Y and H Joint Assembly Tool



Description	Assembles premolded Y and H joints. Includes strap to hold tool in place during use. See Tool Catalog for more information.
Tool Catalog Number	NS0000160
Manufacturer	Richards
Catalog Number	P6JAT3

Torque Wrench / Assembly Tool for 600 Amp Dead Break Elbows

Description	Assembles 600 amp Dead Break Elbows. Preset Torque rating. Includes tool for new style connector plugs. See Tool Catalog for more information.
Tool Catalog Number	NS0000075
Manufacturer	Ripley
Catalog Number	TRW5060

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2	07/11	• Update Index Page 34-i • Add Die Index and correct Die Information on Pages 34-100, 34-101, 34-102, 34-103, 34-104, 34-105 • Update Tool Information, Add Tools – Pages 34-107, 34-108, 34-109 • Add new Pages – Additional Tools – Pages 34-110, 34-111	Tim Hayden	Susan Fleck, VP of Standards, Policies, and Codes
1	07/10	• Add Standard Item UL15MS Page 34-104 • Correct Crimping Information for Standard Item UL16P on Page 34-105 • Corrected link to Tool Catalog on page 34-106	Tim Hayden	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 1/07 Issue – Update Page Numbers due to Revisions

Supersedes 1/07 Issue – Update last paragraph of 35.0

35.0 GENERAL

Cables for use in the Company underground system are available in a variety of types. Conductor material is either copper or aluminum. Stranding on most cables is standard or compressed. Compact stranding is used only for special, reduced diameter cables. Insulation for secondary cables is XLPE, except jacketed EPR for network secondary conductors. New medium voltage (1 kV to 35 kV) cable is insulated with EPR (Ethylene Propylene Rubber). Existing stock of XLPE insulated cables can be used up. In service XLPE cables will remain until end of useful life. All medium voltage cables are shielded and include a polyethylene jacket over the concentric neutrals. Single conductor URD cables for direct burial have a semi-conductive jacket to allow random lay with communication cables. Concentric neutrals are #14 copper wire with the exception of reduced diameter cables which use flat strap neutrals. All concentric neutrals are sized to be equal to 1/3 of the ampacity of the conductor. All cables have surface printing indicating the conductor size and material, the voltage rating, the year of manufacture, and the manufacturer. Some cables have footage and phase markings.

All cable installations which are funded and installed by the company shall be placed in conduits. This requirement includes substation feeder get away cables, main line feeder cables (where cables are needed for clearance), customer requests to move facilities underground for aesthetics, etc. This requirement does not apply to URD and UCD installations where the customer is required to make a contribution to construction. These URD and UCD installations may remain with direct buried cables until these requirements are changed by the appropriate regulatory agencies. However, conduit installation is preferred by the company and is allowed if the customer desires to install conduit or if the earth conditions are extremely rocky.

Duct size needs to be carefully considered to avoid duct jamming issues. Select the proper size of duct per the sizing calculations to avoid cable jamming issues. For example, 15kV, 1000 MCM cable fits in 5” conduit but jams in 6” conduit. Duct size calculations are shown in 35.10.20 and also in the Section 32 – Conduit.

The vast majority of standard cables are stocked in lengths of 1000 circuit feet per reel. The notable exception is the #2 15 kV aluminum URD cable, which is 3000 feet per reel. On large projects, it is preferred to determine the pulling lengths and order the cable cut to those lengths. This will limit the amount of short lengths of cable, which are most often scrapped since they are unusable.

All cables available throughout the Company service territories are listed in the Section 50 – Materials Catalog with the corresponding standard item number UC__. See Tables 1 through 8 below. Aerial cables are listed in Table 9.

35.1 STANDARD PRIMARY CABLES FOR NEW CONSTRUCTION

35.1.10 Medium Voltage Cables (Non-URD)

Standard primary cables for new construction should be selected from Table 1. These cables are rated from 15 kV to 35 kV, standard insulation thickness, concentric neutral and insulating polyethylene jacket. These items are triple conductor parallel lay on the reel with the exception of Std. Item UC12TB, which is single conductor. This cable is intended for all new three-phase underground applications. This cable is suitable for direct burial. This cable is not preferred to be direct buried in random lay with communication cables, but, when done so, a bare #2 ground wire shall be laid in close proximity to the power cable. This bare ground wire must be tied in with all grounds, concentric neutrals and bonded to all other services in the trench. Alternatively, the jacket on the cables can be stripped and a ground rod tied in every 600 feet of cable. Cable with a semi-conducting jacket is preferred for random lay installation with communication cables (See 35.1.20). Additional cable information is available in Section 50 – Materials Catalog.

 Doc. # ST. 35.00.001

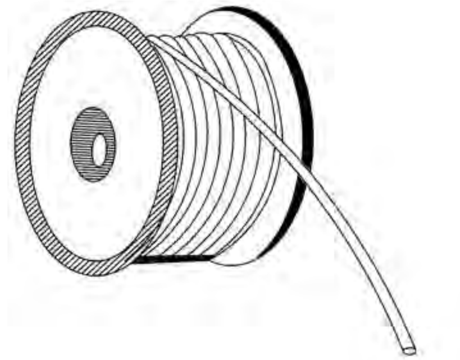


Figure 1
Single Lay Conductor

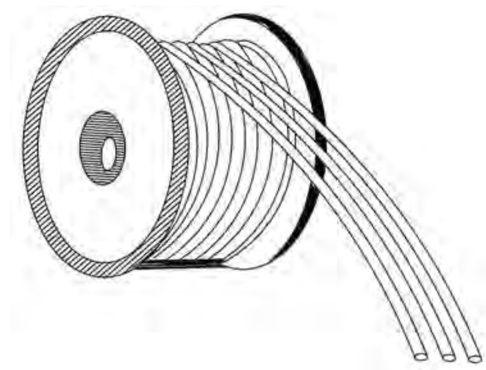


Figure 2
Triple Lay Conductor

Table 1

Voltage (kV)	Conductor	Packaging	Std. Item
15	#2 AL	3-1/C Parallel	UC11BJ
15	#2 CU	1-1/C	UC11BK
15	#2 CU	3-1/C Parallel	UC11BL
15	#4/0 CU	3-1/C Parallel	UC11E
15	350 CU	3-1/C Parallel	UC12F
15	500 AL	3-1/C Parallel	UC12GG
15	500 CU	3-1/C Parallel	UC17
15	750 AL	3-1/C Parallel	UC12HG
15	1000 AL	3-1/C Parallel	UC12TA
15	1000 AL	1-1/C	UC12TB
15	1000 CU	3-1/C Parallel	UC12TC
25	#1/0 CU	3-1/C Parallel	UC23CJ
25	#4/0 CU	3-1/C Parallel	UC23EC
25	350 AL	3-1/C Parallel	UC23FA
25	350 CU	3-1/C Parallel	UC23FJ
25	500 AL	3-1/C Parallel	UC23GA
25	500 CU	3-1/C Parallel	UC23GJ
25	1000 CU	3-1/C Parallel	UC23TC
25	1000 AL	3-1/C Parallel	UC23TA
35	#1/0 AL	1-1/C	UC35C1
35	#1/0 AL	3-1/C Parallel	UC35C3
35	#2/0 CU	3-1/C Parallel	UC35DJ
35	500 CU	3-1/C Parallel	UC35GJ
35	750 CU	3-1/C Parallel	UC35HJ
35	1000 CU	3-1/C Parallel	UC35TC
35	1000 AL	3-1/C Parallel	UC35TJ

Supersedes 1/07 Issue –Updated packaging description, added UC23TC and UC35C1 in Table 1

Supersedes 7/07 Issue – Modify 35.1.20 to prohibit copper in URD, correct packaging in Table 3

35.1.20 URD Primary Cables

Primary cables for URD construction shall be selected from standard items as listed in Table 2. Copper conductor cable shall never be used for URD applications. This cable is rated for installation in ducts or direct buried. The cable construction is normal insulation thickness, concentric neutral with a semi conducting jacket. This jacket makes it suitable for either duct or random lay direct buried installations. It is suitable for random lay with communication cables. This cable is single conductor (1-1/C) lay on the reel. Additional cable data is available in Section 50 – Materials Catalog.

Table 2

Voltage (kV)	Conductor	Std. Item
15	#2 AL	UC11BC

35.2 SECONDARY CABLES

35.2.10 Network Systems

Network UG secondary cable shall be selected from cables listed in Table 3. These cables are copper conductor with ethylene propylene rubber (EPR) insulation and a cross linked heavy duty black chlorosulfonated polyethylene jacket (Dupont trade name is Hypalon). This conductor is good for wet or dry locations, 90 degrees Celsius normal temperature and 130 degrees Celsius emergency. This is a premium cable and shall be used only for networked secondary systems. It is for installation in ducts. Refer to Section 50 – Materials Catalog for packaging details and additional cable data.

Table 3

Conductor Size	Packaging	Std. Item
# 2	1-1/C	UC9B
# 4/0	3-1/C Parallel	UC9E3
# 4/0	4-1/C Parallel	UC9E4
300 kcmil	4-1/C Parallel	UC9F4
500 kcmil	1-1/C	UC9G
500 kcmil	4-1/C Parallel	UC9G4

35.2.20 Non-Network In Ducts

All conventional (radial feed) UG secondary cable shall be selected from standard items as listed in Table 4. These cables are copper conductor with cross linked polyethylene insulation. The normal installation is in ducts of all types, however with the exception of # 2, this cable can be direct buried if necessary. When installed in ducts, check duct size to determine if adequate space exists and that the jam ratio is not a problem. Cables are available single and triple wound. Identification of the neutral conductor shall be by white tape at all termination and splice locations. Additional cable data is available in Section 50 – Materials Catalog.

Do not use 600 V aluminum secondary/service drop cable in conventional duct and manhole systems (URD secondary construction is an exception).

Table 4

Conductor Size	Packaging	Std. Item
# 2	1-1/C	UC5B
# 1/0	1-1/C	UC5C
# 2/0	1-1/C	UC5D
# 4/0	1-1/C	UC5E
350 kcmil	1-1/C	UC5F
500 kcmil	1-1/C	UC5G
750 kcmil	1-1/C	UC5H
# 1/0	3-1/C parallel	UC5C1
# 2/0	3-1/C parallel	UC5D1
# 4/0	3-1/C parallel	UC5E1
350 kcmil	3-1/C parallel	UC5F1
500 kcmil	3-1/C parallel	UC5G1
750 kcmil	3-1/C parallel	UC5H1

35.2.30 URD

URD secondary cable shall be selected from Std. Items UC8__ as listed in Section 50 – Materials Catalog. These cables consist of cross linked polyethylene insulated aluminum conductors, triplexed together, suitable for installation in ducts or direct buried. The neutral is designated by 3 yellow stripes placed longitudinally along the insulation. Installations in NY are direct buried. New installations in NE are in PVC duct. Older NE installations may be found direct buried. Additional cable data is available in Section 50 – Materials Catalog.

Supersedes 1/07 Issue –Updated Packaging in Table 3, Move 35.3 to next page.

35.3 REDUCED DIAMETER CABLES

Several medium voltage cables have been specially designed to fit in existing, non-standard duct systems. The available cables are listed in Table 5. All cables are 3-1/C, copper conductor, compact stranding, and flat strap neutrals with polyethylene or polypropylene jacket. Thicknesses of all components have been reduced to allow installation in older, small size ducts. Additional cable data is available in Section 50 – Materials Catalog.

Table 5

Voltage (kV)	Conductor	Std. Item	Minimum Conduit ID
5	500	UC7G1	3”
15	500	UC16G	3 ½”
25	250	UC23G	3 ½”
25	350	UC23GG	3 ½”
25	400	UC23GK	3 ½”
25	500	UC23GL	4”
35	400	UC33GK	4”
35	500	UC33GJ	4”

35.4 REPLACEMENT CABLES for PAPER INSULATED, LEAD COVERED (PILC) CABLES

Several cables are available which are constructed especially as replacements for 3 conductor PILC cables, which are only installed on the Company’s system in special circumstances (See 35.5.20). These cables are listed in Table 6. These cables are pre-assembled, 1-3/C, with compact copper conductor, tape shields, separate neutral and an overall polyethylene jacket. Insulation thicknesses are reduced from standard values. When these cables are terminated or spliced, heat shrink breakout boot and phase re-jacketing material must be installed to keep moisture out of the cable and to protect the copper tape shield. These materials are part of the splicing kit. Additional cable data is available in Section 50 – Materials Catalog.

These cables are all discontinued. Existing stock may be used up. Utilize cables in Section 35.3 when these are used up.

The reduced diameter cables listed in Table 5 may be used instead of these preassembled cables. Use of these cables will require less effort to splice, but may require a separate neutral be installed along with the conductors. See 35.11.

Table 6

Voltage (kV)	Conductor	Std. Item	Minimum Conduit ID
15	500 CU	UC18	3 ½”
25	350 CU	UC25FJ	3 ½”
25	500 CU	UC25GJ	4”
35	300 CU	UC34EF	3 ½”
35	400 CU	UC34FG	4”

Supersedes 1/07 Issue – Modify 35.3 & 35.4, Add item to Table 5, Text Shift

35.5 SPECIAL USE CABLES

35.5.10 Jacketed Concentric Neutral

There are a few special use cables that are available, listed in Table 7. Cables UC7E and UC7G are 5 kV rated. These cables should only be used on 5 kV systems that will not be converted to 15 kV. Cables UC10B and UC10G are 15 kV solid dielectric insulated, shielded cables with a lead sheath. These cables are quadruplexed with a neutral. The standard cables to each of these are also listed in Table 7. Use the standard cables where ever possible. Additional cable data is available in Section 50 – Materials Catalog.

Table 7

Voltage (kV)	Conductor	Std. Item	Duct ID	Special Use Item
5	#4/0 CU	UC11E	3”	UC7E
5	500 CU	UC17	3 ½”	UC7G
15	#2 CU	UC11BK	3”	UC10B
15	500 CU	UC17	4 ½”	UC10G

35.5.20 PILC

A limited number of PILC cables remain available for special uses. In all cases, a solid dielectric insulated, jacketed concentric neutral cable shall be used to replace failed PILC cables. Only in cases of duct size limitations may PILC cable be installed in ducts. In this case, notify Standards Engineering so a determination can be made if a compact conductor, solid dielectric replacement cable can be used. Another allowed use for PILC cable is for primary leads on older network transformers which have lead wipe cable entrances. Remaining PILC cables are shown in Table 8. Additional cable data is available in Section 50 – Materials Catalog.

Table 8

Voltage (kV)	Conductor	Std. Item
15	1-1/C 1/0	UC14CJ
15	1-1/C 4/0	UC14EJ
15	1-3/C 350	UC15FJ
15	1-3/C 500	UC15GJ
35	1-1/C 2/0	UC30DJ
35	1-3/C 500	UC31GJ
35	1-1/C 750	UC30JH

35.6 OBSOLETE CABLES

35.6.10 Concentric Neutral

There is one 23kV, 750 kcmil, aluminum, concentric neutral cable (Std. Item UC23HJ) which has been determined as obsolete, use for repair only. It is currently stocked only in Buffalo. There are no plans to order any more cable of this size. It is acceptable to use up the remaining cable for repairs. This cable shall not be used for new construction.

35.6.20 Drain Wire Shield

Most drain wire shielded cables have been determined to be obsolete, with two specific items remaining in inventory for specific location repairs. This cable shall not be used for new construction. Standard, jacketed, concentric neutral cable shall be used for all new construction.

Supersedes 7/07 Issue –Modify Conductor description in Table 8, add cable description to 35.6.10; text shift

35.7 AERIAL CABLE

There are several pre-assembled aerial cables available (Std. Item A60__), listed in Table 9. This cable is rated 15 through 35kV, EPR insulated, jacketed concentric neutral, 3 phase construction with an EHS copperweld messenger held together with a covered copper binding tape. Older cable is copper or cupro-nickel tape shielded and may or may not be jacketed. The messenger can be utilized as the neutral conductor. The messenger shall be bonded to the secondary neutral, if present, at every pole. The messenger shall be bonded to a driven ground rod a minimum of every 800 feet. See Section 16 – Aerial/Spacer Cable in the Overhead Construction Standards Manual for installation and sagging instructions.

If the cable is a copper or cupro-nickel tape shielded construction see Section 36.2.30 and 36.2.60 for splicing, Section 36.7.90 for splice grounding and bonding and Section 37.1.60 for termination instructions.

Other applications which require an aerial cable shall be referred to Standards Engineering for cable selection and design.

Table 9

Voltage (kV)	Conductor	Messenger	Std. Item
15	4/0 CU	7/16”	A60E
23	350 AL	7/16”	A61FA
23	500 CU	7/16”	A61G
35	2/0 CU	7/16”	A62D
35	350 CU	7/16”	A62F
35	500 CU	1/2”	A62G

35.8 SUBMARINE CABLE

There are two standard submarine cables available (Std. Items UC12BL and UC12BR). Both of these cables are single phase, #2 aluminum, 15 kV, with a concentric neutral.

Std. Item UC12BL is intended for crossing lakes, ponds or other bodies of water which have no flowing water. This cable has 22 #12 BWG aluminum armor wires applied over the insulation semi-conducting layer. These armor wires are used as the neutral conductor.

Std. Item UC12BR is intended for crossing streams, rivers or other waterways which have flowing water. This cable has (10) # 14 copper wires over the insulation semi-conducting layer. These #14 copper wires are the concentric neutral. There is an additional semi-conducting jacket over the concentric neutrals, and then a layer of #12 BWG galvanized steel armor wires. The armor wires shall be bonded to the ground grid / system neutral at riser locations. However, make sure to connect the copper concentric neutrals to the system neutral at all risers since the steel armor wires are not an effective neutral conductor.

Other applications which require a submarine cable shall be referred to Standards Engineering for cable selection and design.

Supersedes 1/07 Issue – Modify aerial cable description in 35.7; Add Table 9; Modify first paragraph of 35.8; Text Shift

35.9 CABLE STORAGE AND HANDLING

Standard reels are of wood construction and most are non-returnable. Steel reels are available at an additional charge. Steel reels should only be ordered on specialty types of cable or any assurance cables that are to be in storage for a long period of time. All reels should be stored on the flanges, never laid on the side. Lifting with fork lift trucks shall be with a lifting rod, instead of the forks, through the center hole in the flanges, or, if necessary, from the side of the reel, with the forks bearing on the flanges. Never lift the reels from one flange or place the forks against the cable. Store cable reels on solid ground, preferably on concrete pads or pressure treated planks. Use chocks to secure the reels from rolling. Lifting reels with an overhead crane or boom truck may be accomplished by placing an arbor through the reel holes and attaching the sling to the arbor. Utilize a spreader or make the sling sufficiently long to prevent damage to the flanges of the reel.

All cable ends shall be sealed up from the elements at all times. Four sizes of cold shrink end caps (Std. Item UC90) are available. These caps will fit on all Company cables. Immediately after cutting a cable, install a cold shrink end cap on each end. Water intrusion into the strands of the conductor or between the shield and the jacket causes cable damage and will lead to future cable failures. Moisture in the air, humidity, can be driven into the open ends of cable as the air pressure constantly changes. Storage of cables inside does not keep water out of the cable, unless cold shrink end caps are installed. Wrapping the cut ends of cables with electrical tape is not adequate. See Section 35.12.

Supersedes 1/07 Issue –Change number of caps in first line of second paragraph of 35.9; text shift

35.10 CABLE INSTALLATION

Shielded power cable must be installed in properly sized and installed ducts to avoid damage during installation. Larger is not necessarily better. The work methods, including pulling tensions, are also critical to allow for proper, damage free cable installation and for future operation.

The ultimate pulling tension / sidewall pressure of the cable, or tension on the grip used, must not be exceeded. Perform all the following calculations found in Sections 35.10.10 to 35.10.30 on each run of cable. Work methods which can be employed to reduce these values are: Clean ducts before pulling cable, properly and adequately lubricate the cable, properly size the ducts to avoid the jam ratio, locate the cable reel close to the bends, pull cable down riser pipes, and pull downhill if possible.

35.10.10 Bending Radius

Insulated power cable, especially shielded cable, can be damaged by bending too sharply. Sharp bends also increase pulling tension, increasing the likelihood of inflicting cable damage. The minimum bending radius is a multiple of the outer diameter of the cable. Refer to Table 10 for the minimum bending radius for different types of cables.

Table 10

Type of Cable	Minimum Bending Radius
Secondary, non network	4 X OD
Secondary, network	5 X OD
Medium Voltage, tape shielded	12 X OD
Medium Voltage, concentric neutral	8 X OD

35.10.20 Duct Sizing / Jam Ratio

For new construction, first determine the cable to be installed and then size the conduit to accommodate that cable. It is possible to oversize the conduit to allow for future replacement with larger cable. However, care must be used to avoid the jam ratio when over-sizing the conduit. Cables may jam in the conduit during installation if the ratio of the duct ID to the cable OD (D/d) is between 2.8 and 3.2. For instance, 6 inch conduit would seem to be the best conduit to use since it appears to accommodate all cable sizes and voltages. But 15 kV, 1000 kcmil cable is within the jam ratio range for 6 inch conduit (D/d is 6.25/1.98 = 3.15). Six inch conduit should only be installed for circuits requiring 1000 kcmil 23 kV or 1000 kcmil 35 kV cable. The normal clearance between the duct and cable is a minimum of ¾ inch, but this can be reduced to ½ inch if needed. The approximate size of parallel cable assemblies is given by the following formula, where OD is the individual cable outer diameter:

Total diameter of 3 parallel cables = OD X 2.16

If the exact OD of 3 parallel cables is needed, the following formula can be used:
Where:
1. c is the clearance
2. D is the inside diameter of the duct
3. d is the outside diameter of an individual cable

$$c = \frac{D}{2} - 1.366 * d + \frac{D-d}{2} * \sqrt{1 - \left(\frac{d}{D-d}\right)^2}$$

If the calculated clearance is less than ¾ inch, a mandrel the same size as the ID of the conduit must be pulled through the conduit prior to cable installation.

Refer to Section 32 – Conduit for more information.

Supersedes 1/07 Issue – Change Table number to 10, update last line of 35.10.10; Text Shift

35.10.30 Pulling Tension

Allowable pulling tensions shall never be exceeded, to prevent inflicting damage on the cables during installation. The tensions in this Standard are in accordance with AEIC publication G5-90 Underground Extruded Power Cable Pulling Guide. Three single-phase cables with a separate, bare neutral can generally be considered as three cables.

Cables may be pulled using pulling eyes or basket grips. When using basket grips, the safe working limit of the grip must not be exceeded.

Pulling eyes may be installed by either the factory or the field. Compression type eyes are used for aluminum conductors. Compression or solder type eyes are used for copper conductors. When using pulling eyes, the strength of the eye and the tensile strength of the conductor must be considered. When three cables are pulled with three eyes, the total load is assumed to be carried by two of the cables.

When using basket grips the cable should be cleaned and two half-lapped layers of friction tape wrapped over the cable before the grip is installed. The back end of the grip should be secured with a steel band or equivalent device. Upon completion of the pull, the cable should be cut off a minimum of 2 feet beyond the end of the basket to eliminate any potentially damaged cable.

Pulling lubricant (compound), (Std. Item UC75), shall be used for all pulls regardless of length, or the number or severity of bends.

The information needed to calculate the pulling tension, along with examples, follows. For more assistance, contact Distribution Engineering Services. Table 16, with notes, contains some typical permissible pulling lengths for URD/UCD cables.

Supersedes 1/07 Issue –Modify first & fifth paragraph and add paragraph 6 to 35.10.30; text shift

A. Calculated Pulling Tension

Pulling tensions anticipated for an installation are determined by cable size, weight, length of run, and number and angle of bends. Usually only approximations can be made, based on the following simple assumptions, giving safe guideline limits. The pulling tension must be calculated in sections, from the reel to the pulling point.
Calculation for different sections:

1. Pulling Straight Horizontal Run:

$$T = W \times L \times N \times CF$$

Where:
T = tension in pounds
W = cable weight in pounds / foot
L = length of run in feet
N = number of cables
CF = coefficient of friction

The coefficient of friction will vary between 0.3 (well lubricated cables / new, smooth wall ducts) to 0.5 (well lubricated cables / rough or dirty ducts).

2. Pulling Bends:

The multiplying factors, shown below, must be used to estimate the increase in tension due to pulling around bends. The tension at the point just ahead of the bend is multiplied by the appropriate factor from the table with the result being the tension that exists immediately past the bend. This factor must be applied in the calculation of the estimated pulling tension at each point where the cable encounters a bend as it is pulled. The multiplying factor for the bend is determined from Table 11. It is a function of the coefficient of friction and the angle of the bend. The tension at the exit of the bend is equal to the tension at the entrance of the bend multiplied by the factor from Table 11.

$$T_{\text{EXIT OF BEND}} = T_{\text{ENTRANCE OF BEND}} \times F$$

Table 11

	Angle of Bend (degrees)					
Coefficient of Friction	**15°**	**30°**	**45°**	**60°**	**75°**	**90°**
0.3	1.08	1.17	1.27	1.37	1.48	1.60
0.4	1.11	1.23	1.37	1.52	1.69	1.87
0.5	1.14	1.30	1.48	1.69	1.92	2.19

Multiplying Factor (F) for Bends

The highest tension will be at the pulling eye or grip. To determine the ultimate tension on a pulling section, calculate the tension in each section. The tension at the beginning end of the duct will be zero (assuming that the cable is manually pulled off the reel or a powered reel is used). The tension at the end of each section is the tension for the beginning of the next section. The tension at the end of the last section must then be compared to Tables 12 through 15 to determine if the pulling eye, pulling grip and cable can withstand that tension without damage.

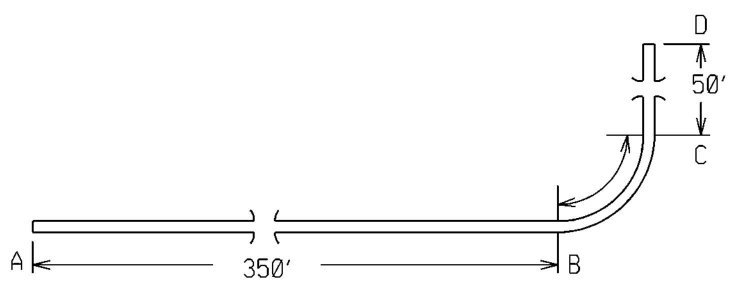


Figure 3

B. Pulling Tension Example Calculation:

Install 3 – 1/C #2 aluminum, 15 kV Concentric Neutral cable in horizontal duct shown in Figure 3. Cable weight is 500 lbs/1000 ft. (W = 0.5 lbs/ft; CF = 0.4; F = 1.87, cable hand pulled off reel so $T_{\text{POINT A}} = 0$)

With the reel at Point A, Pulling winch at Point D

$T_{\text{POINT B}}$ = $T_{\text{POINT A}}$ + W x L x N x CF
= 0 lbs + 0.5 lbs/ft x 350 ft x 3 cables x 0.4
= 210 lbs.

$T_{\text{POINT C}}$ = $T_{\text{POINT B}}$ x F
= 210 lbs x 1.87
= 392.7 lbs

$T_{\text{POINT D}}$ = $T_{\text{POINT C}}$ + W x L x N x CF
= 392.7 lbs + 0.5 lbs/ft x 50 ft x 3 cables x 0.4
= 392.7 lbs + 30 lbs
= 422.7 lbs.

Therefore, the tension on the winch and ultimate tension on the cable is 422.7 lbs.

If we move the reel to the other end, point D and the winch to point A we get (all other conditions equal):

Now $T_{\text{POINT D}}$ = zero

$T_{\text{POINT C}}$ = $T_{\text{POINT D}}$ + W x L x N x CF
= 0 + 0.5 lbs/ft x 50 ft x 3 cables x 0.4
= 30 lbs

$T_{\text{POINT B}}$ = $T_{\text{POINT C}}$ x F
= 30 lbs x 1.87
= 56.1 lbs

$T_{\text{POINT A}}$ = $T_{\text{POINT B}}$ + W x L x N x CF
= 56.1 lbs + 0.5 lbs/ft x 350 ft x 3 cables x 0.4
= 56.1 lbs + 210 lbs
= 266.1 lbs

The second scenario shows that positioning the cable reel close to the bends reduces the total pulling tension.
Now check the total calculated pulling tension to the eye / grip / cable limits in Tables 12 through 15 to be sure that the equipment is capable of the pull and that the cable will not be damaged.

Supersedes 1/07 Issue –Increase Table reference number by 1; text shift

Supersedes 7/07 Issue – Increase Table reference by 1; Text Shift

Table 12
Single Cable Pulled With A Single Eye Or Grip
Maximum Allowable Tension (Pounds)

With Pulling Eye (All Cables)

SIZE	COPPER		ALUMINUM
	SOLDER EYE	COMPRESSION EYE	COMPRESSION EYE
#2	863	730	531
1/0	1372	1161	844
4/0	2751	2328	1693
250	3250	2750	2000
350	4550	3850	2800
500	6500	5500	4000
750	9750	8250	6000
1000	13000	11000	8000

With Pulling Grip - Max Tension Varies By Cable Type*

Conductor Size	COPPER		ALUMINUM	
	Secondary	Primary	Secondary	Primary
#2	863	863	730	730
1/0	1372	1372	1161	1161
4/0	2000	2751	2000	2328
250	2000	3250	2000	2750
350	2000	4550	2000	3850
500	2000	6500	2000	5500
750	2000	9750	2000	8250
1000	2000	10000	2000	10000

Table 13
Three Cables Pulled With Three Eyes Or Grips
Maximum Allowable Tension (Pounds)

With Pulling Eye (All Cables)*

SIZE	CU CONDUCTOR		AL CONDUCTOR
	SOLDER EYE	COMPRESSION EYE	COMPRESSION EYE
#2	1726	1460	1062
1/0	2743	2321	1688
4/0	5502	4655	3386
250	6500	5500	4000
350	9100	7700	5600
500	13000	11000	8000
750	19500	16500	12000
1000	26000	22000	16000

With Pulling Grip (All Cables)*

SIZE	CU CONDUCTOR	AL CONDUCTOR
#2	1726	1460
1/0	2743	2321
4/0	5502	4655
250	650	5500
350	9100	7700
500	13000	11000
750	19500	16500
1000	20000	20000

* Do Not Exceed the Maximum Safe Working Load of the Grip

Supersedes 7/07 Issue –Increase Table reference number by 1; text shift

Supersedes 7/07 Issue – Increase Table Index by 1; Text Shift

Table 14
Three Cables Pulled With A Single Grip
Maximum Allowable Tension (Pounds)

With Pulling Grip (All Cables)*

SIZE	CU CONDUCTOR	AL CONDUCTOR
#2	1726	1460
1/0	2743	2321
4/0	5502	4655
250	6500	5500
350	9100	7700
500	10000	10000
750	10000	10000
1000	10000	10000

* Do Not Exceed The Maximum Safe Working Load Of The Grip. The maximum allowable sidewall bearing pressure varies by cable construction type. These sidewall bearing pressures by cable type are listed in Table 14.

Table 15
Maximum Sidewall Bearing Pressure by Cable Type

Construction	(Lbs/Ft)
Network Secondary, EPR/CSP, 600 V	1,000
All other Secondary, XLPE, 600 V	1,200
Primary Cable, EPR, Concentric Neutral	2,000
Primary Cable, EPR, Flat Strap Neutral	2,000

Table 16
URD/UCD Cable Installation Maximum Pull Chart

Straight cable pull chart typical maximum pulls						
	15kV Class			35kV Class		
Wire Size	Riser to Pad	Riser to Pull Box	Pull box to Pull Box	Riser to Pad	Riser to Pull Box	Pull box to Pull Box
#2 AL	530	605	750	n.a.	n.a.	n.a.
1/0 AL	n.a.	n.a.	n.a.	320	360	750
2/0 CU	n.a.	n.a.	n.a.	615	695	750
4/0 CU	695	720	750	n.a.	n.a.	n.a.

Notes to Table 16:
1) All Calculations are based on a straight pulls
2) All conduits are 4”
3) Assume 50Lb reel drag
4) Assume .5 for coefficient of friction
5) Pulls are in feet
6) Pulls distances are shown from worst case pulling end.

35.11 NEUTRAL PRACTICE

The preferred primary cables are constructed with concentric neutrals, either #14 round wires or equivalent flat straps. Separate neutrals are not required for circuits utilizing these cables.

Circuits with cables which have other metallic shielding types (drain wire - any wire smaller than #14 - or copper tape) require a separate neutral. The separate neutral shall be 4/0 copper, 600 volt insulated cable (Std Item UC5E). The number of separate neutrals required in a ductbank is listed in Table 17 below.

Table 17

Number of Circuits with Drain Wire or Copper Tape Shields	Number of 4/0 Neutrals
1	1
2-4	2
5 or more	3

For new substation feeder get away cable installations, a separate neutral shall be installed (4/0 copper, 600 volt insulated cable Std. Item UC5E 8830-9201033). The number of separate neutrals required in a ductbank is listed in Table 17 above. Each neutral shall be separately connected to the substation ground grid and the system neutral at the risers. All neutrals shall be connected together with the ground grid in each manhole. The preferred ground connection should be a compression connection or a substitute connection approved by Standards Engineering.

The neutral of all cables spliced in a manhole shall be bonded to ground in that manhole. The neutrals shall be connected to the manhole ground bus. Refer to Section 33.90 for details. If there is no ground bus in the manhole, one shall be installed.

Supersedes 7/07 Issue – Add New Table 16, Change Old Table 15 to 17, Minor Revisions, Text Shift

Supersedes 7/07 Issue – Change end caps to Four; Make Paragraph 35.13 mandatory, re-define requirements; Increase Table Index by 2; Text Shift

35.12 END CAPS

All cables shall have cold shrink end caps installed when the cable is cut. Four end cap sizes are available which will fit all Company cables (Std. Item UC90_). Left over cable on reels shall also have end caps installed. Water intrusion into the conductor or neutral strands promotes future cable failure. Clean the jacket on the end of the cable prior to installing the end cap. Hold the cap firmly against the end of the cable while removing the core to achieve the best seal. See Section 35.9.

35.13 ARC & FIRE PROOFING CABLES

The installation of arc and fireproofing materials on cables and splices located in manholes and vaults will limit cable damage from faults within the manhole or vault. Arc and fireproofing shall be installed per the following:

- NETWORK MANHOLES (any manhole with primary or secondary for a network system) – all cables and splices above 600 V.
- MANHOLES CONTAINING CIRCUITS ABOVE 10 kV – all cables and splices above 10 kV when another circuit above 1000 V is present in the same manhole.
- OTHER MANHOLES AND AREAS – When deemed necessary by the Operating Department due to field conditions.

Wipe the cables off with rags to remove most dirt and dust. Wipe with cable cleaner and degreaser (Std. Item UC80F) to remove remaining dirt, grease and oil. Allow to air dry.

Cover the entire length of the cable with ½ lapped layer of arc and fireproofing tape (Std. Item T1F) as shown in Figure 4. To form a continuous wrap, the cable will have to be lifted off of racks or supports. When starting a new roll of tape, overlap the previously applied tape by at least six inches. Tape is available in two widths. Choose the width which best conforms to the cable.

Table 17 gives the approximate number of rolls of tape needed for different cable configurations. Each roll of tape is 20 feet long.

Apply a random wrap of glass cloth tape (Std. Item T1G5) as shown in Figure 4 to hold the arc and fireproofing tape in place.

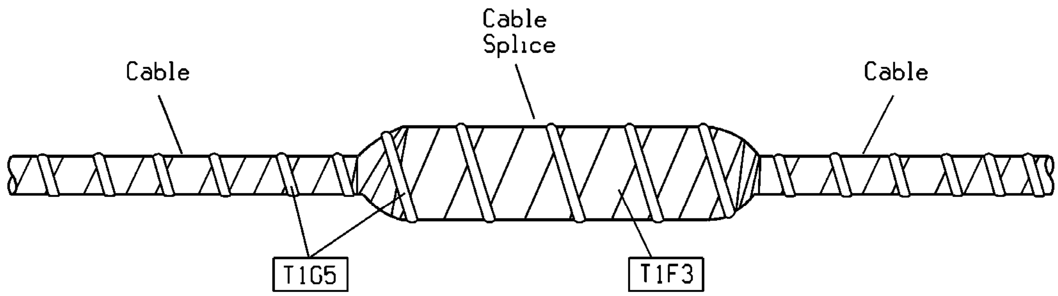


Figure 4

Table 18
Fireproofing Tape – Quantities Required

Cable Diameter * (Inches)	Tape Width (Inches)	No. Rolls Per 100' Of Cable
1	1½	21
1½	1½	32
2	3	21
3	3	32
4	3	42
5	3	53

35.14 CABLE AMPACITY

Cable ampacity is determined by a combination of conductor size, conductor material and the ability of the cables to dissipate heat. The dissipation of heat is affected by other sources of heat, including other cables. The allowable cable ampacity therefore varies widely due to different cable arrangements, duct bank configuration, cable loadings, adjacent duct banks, burial depth, ambient temperature, season of the year, etc.

Some examples of cable ampacity for 3 common sizes of main line cables are shown below. Keep in mind that the actual configuration of the particular duct bank as well as the loading of all circuits in the subject duct bank and any other heat source (including other electrical duct banks) within 10 feet in any direction will affect the allowable loading.

Contact Distribution Engineering Services for detailed ampacity ratings of any configuration if needed.

Supersedes 7/07 Issue – Change Table to 18; Text Shift

35.14.10 Ampacity Examples

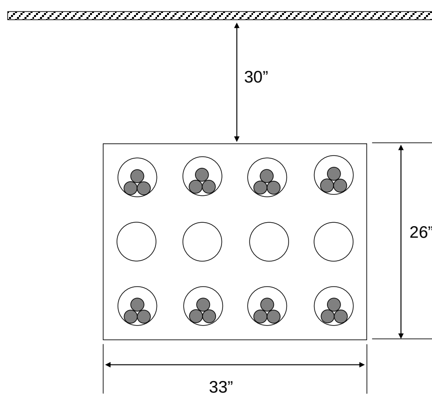
For each example the duct banks are constructed with 5-inch PVC conduits encased in concrete. These calculations presented are for estimating purposes only since actual field conditions are likely to be different. It has been assumed that there are no other heat sources within 10 feet of the ductbank(s) (steam pipes, other electric utility ducts, etc.). If cables are arranged differently (more cables, less cables, different arrangement, etc.), the cable ratings will change.

The emergency ratings are calculated for one circuit carrying the emergency ampacity with the other circuits carrying normal ampacity. Burial depth is assumed to be a minimum of 30".

Standard cables used in the examples are:

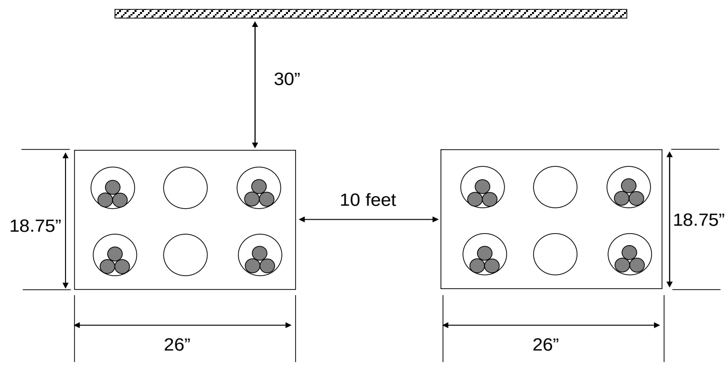
Cable	Standard Item
750 Al	UC12HG
1000 Al	UC12TA
1000 Cu	UC12TC

EXAMPLE 1: 12-way ductbank with 8 circuits:



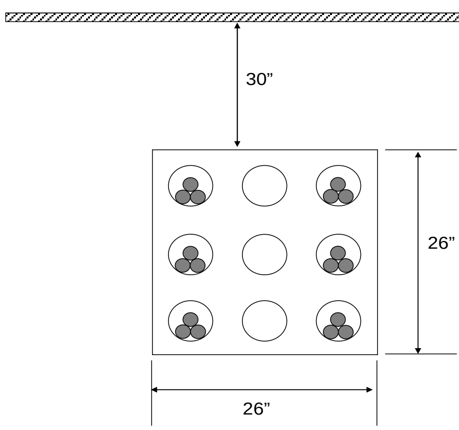
Duct Bank Configuration	Conductor	Ampacity			
		Winter		Summer	
		Normal	Emerg. (24 hrs)	Normal	Emerg. (24 hrs)
12 Way	750 Al	306	490	272	472
	1000 Al	360	576	323	556
	1000 Cu	433	716	389	668

EXAMPLE 2: Two 6-way duct banks, each with 4 circuits – these duct banks are separated by 10' and go to different manholes:



Duct Bank Configuration	Conductor	Ampacity			
		Winter		Summer	
		Normal	Emerg. (24 hrs)	Normal	Emerg. (24 hrs)
2-6 Way	750 Al	403	549	361	523
	1000 Al	471	644	424	614
	1000 Cu	568	774	511	738

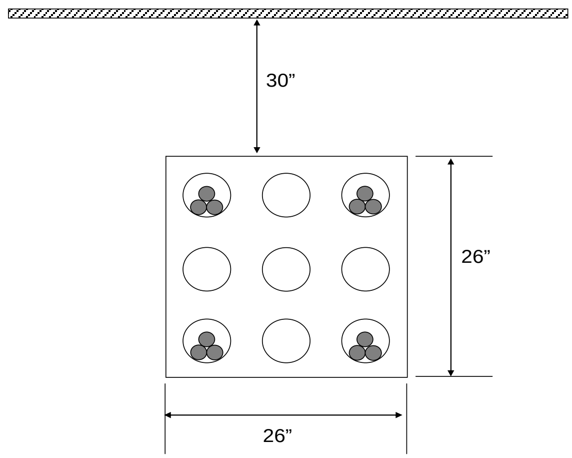
EXAMPLE 3: 9-way duct bank with 6 circuits:



Duct Bank Configuration	Conductor	Ampacity			
		Winter		Summer	
		Normal	Emerg. (24 hrs)	Normal	Emerg. (24 hrs)
9 Way	750 Al	350	516	313	494
	1000 Al	410	605	369	581
	1000 Cu	494	727	444	698

Supersedes 7/07 Issue – Text Shift

EXAMPLE 4: 9-way duct bank with 4 circuits:



Duct Bank Configuration	Conductor	Ampacity			
		Winter		Summer	
		Normal	Emerg. (24 hrs)	Normal	Emerg. (24 hrs)
9 Way	750 Al	418	559	375	531
	1000 Al	490	655	441	624
	1000 Cu	590	788	531	750

35.15 CABLE RACKING

The preferred arrangement in a manhole with a splice is to loop the manhole with cable and put the splice on the long wall opposite the duct entrances. This arrangement will allow some extra cable for future repairs. Cables in manholes shall be neatly arranged and secured on cable racks designed for the purpose. Cables shall be arranged to prevent stress on the cable at the duct mouth. Cables will attempt to move due to load cycling and fault currents therefore they must be adequately restrained to prevent movement which will cause mechanical stress on the cable and eventual cable failure. Cable ties (Std. Item P27TA) may be utilized for cable restraint. See Section 36 for splices and Section 37 for terminations.

Supersedes 7/07 Issue – Text Shift

35.16 CABLE IDENTIFICATION TAGS

35.16.10 Primary Cables

All primary cables shall be identified at each access point (such as handhole, manhole or pullbox) and at every termination. Individual tags are available with a variety of phrases (e.g.: “To Riser”, “B Phase”, “To MH”, “XMFR”), See Std. Item UP21P. The circuit number may be omitted from radial URD / UCD cables.

A. Manhole, Handhole, Pullbox:

The required identification shall include the circuit number and the next location where the cable can be accessed. The next location shall be placed adjacent to each entrance and / or exit. It is recommended to place the circuit number in a location where it can be viewed from above the hole. Other locations may be used according to local practice, as long as the circuit identifier is somewhere on the cable(s). Phase tags should be installed where the phase is known. On cables with two or three phases, all labels shall be installed on each phase unless the cable is fireproofed or the cables are otherwise bundled to indicate that they go together.

Where a cable circuit bifurcates or trifurcates, each section of cable shall have a unique identifier – such as 2391X & 2391Y or 13L1X and 13L1Y.

B. Terminations (Including Elbows):

The required identification shall include the circuit number, the next location where the cable can be accessed and the phase. The tags shall be located immediately below the termination, but not on the termination itself. For 3 phase loop feed transformers, the bushing (H1A, H2A, etc) shall be included in the tag. Where the three phases of a circuit are bundled together, only one label with the circuit number and the next location is required.

C. Switchgear:

For switchgear installations the circuit number, the next location where the cable can be accessed and the phase shall be placed immediately below the termination. It is acceptable to place the circuit number and the next location on the inside of the door for the compartment and not place them on the cables. The phase label is still required on each cable. For switchgear installed on a switchgear manhole, the circuit and the next location where the cable can be accessed shall also be placed on the cables in the manhole, as required in ‘A’ above. In this case, the next location label below the termination may be eliminated.

A complete selection of numbers and letters, 3 sizes of tag holders, various phrase tags and cable ties can be found in Section 50 – Materials Catalog (Std. Item UP21_).

Supersedes 7/07 Issue – Revise paragraph 35.16.10; Text Shift

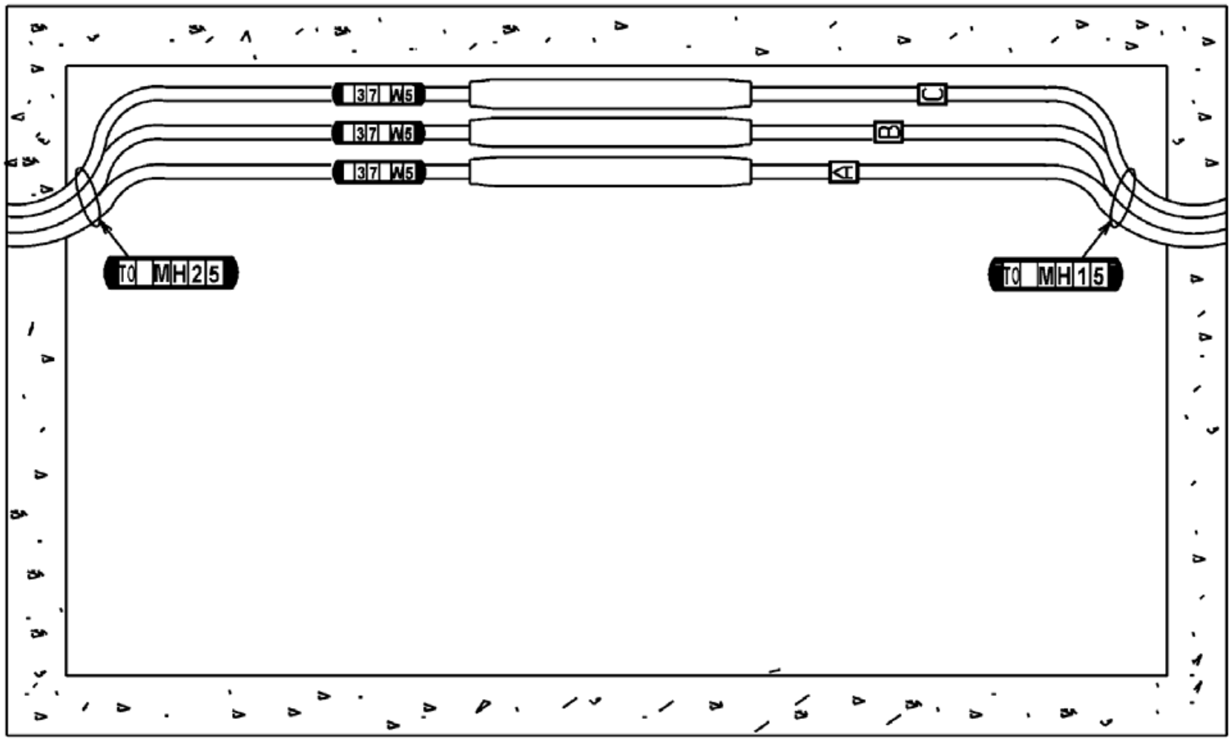


Figure 5

35.16.20 Secondary Cables

A. Company Owned Cable:

The letter N identifies Company owned 600 V secondary cable. The dash followed by a number, e.g. 15, identifies the transformer / manhole / handhole that the cable goes to.

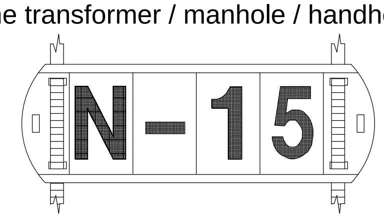


Figure 6
Identification Tags

B. Customer Owned Service Cable:

The letter C identifies the customer owned 600 V service cable. The number, e.g. 155, identifies the customer's building or apartment number.

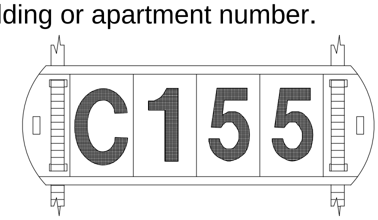


Figure 7
Identification Tags

Supersedes 7/07 Issue – Insert Figure 5, Increase Figure Numbers by 1, Text Shift

C. <u>For Parallel Secondary Services:</u>

Install a parallel service tag in the tag holder along with the building or apartment number.

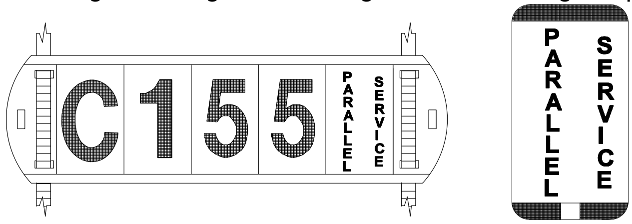


Figure 8
Identification Tags

35.17 CABLE LOCATION MARKERS

A cable marker (Std. Item P22R1) is available for permanent marking of Company owned underground facilities (See Figure 8). The marker is red fiberglass / plastic composite. It comes complete with a pre-applied label which denotes the company name and contact numbers as well as Dig Safe / Dig Safely contact information. The marker is installed with a drive tool (Std Item P21R2).

Figure 9

Location Marker **Close up of Label**

New Page – Revise paragraph 35.17; Insert New Figure 9, Text Shift

New Page – Increase Figure Numbers by 1, Text Shift

35.18 SUBMARINE CABLE SIGNS

The installation of Submarine Cable signs shall be limited to those applications deemed necessary, for public awareness of the submarine cable location, by the Operating Department. These locations are generally where the cable crosses navigable waters that may be subject to anchoring or dredging.

The signs shall be installed on a field fabricated structure and located an adequate distance from the water for protection from tides and ice. The sign shall face the water. The exact design of the support structure may vary due to field conditions. Suggested mounting structure designs are included in Figure 11.

Two sizes of standard signs for marking submarine cable locations are available. The large sign (see Figure 10) is 12 feet wide X 8 feet high (Std. Item UP22W1) and the small sign (see Figure 12) is 24 inches wide X 15 inches high (Std. Item UP22W2). These signs are not maintained in stock, but can be special ordered. When placing a request for a sign, include the appropriate local telephone number to be on the sign.

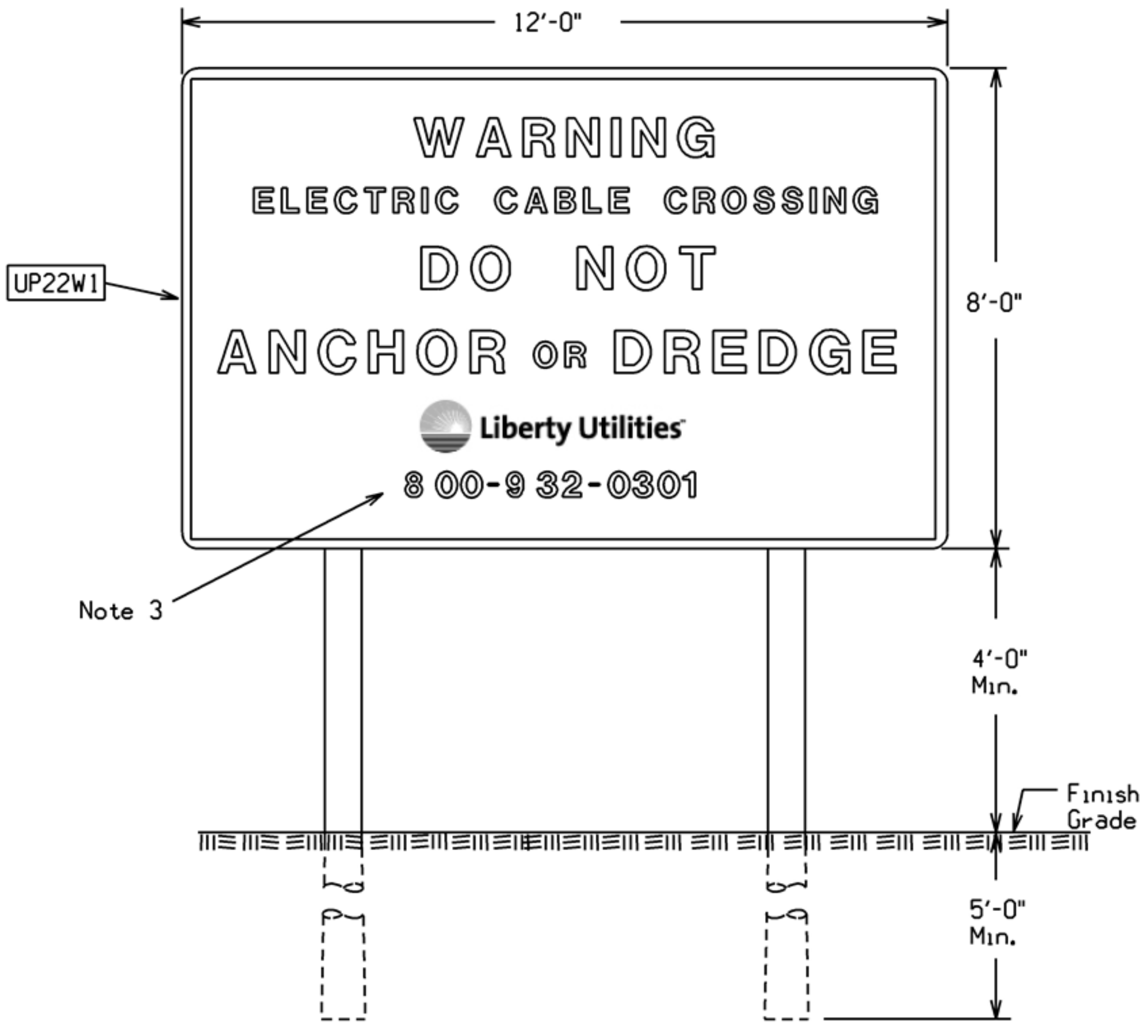
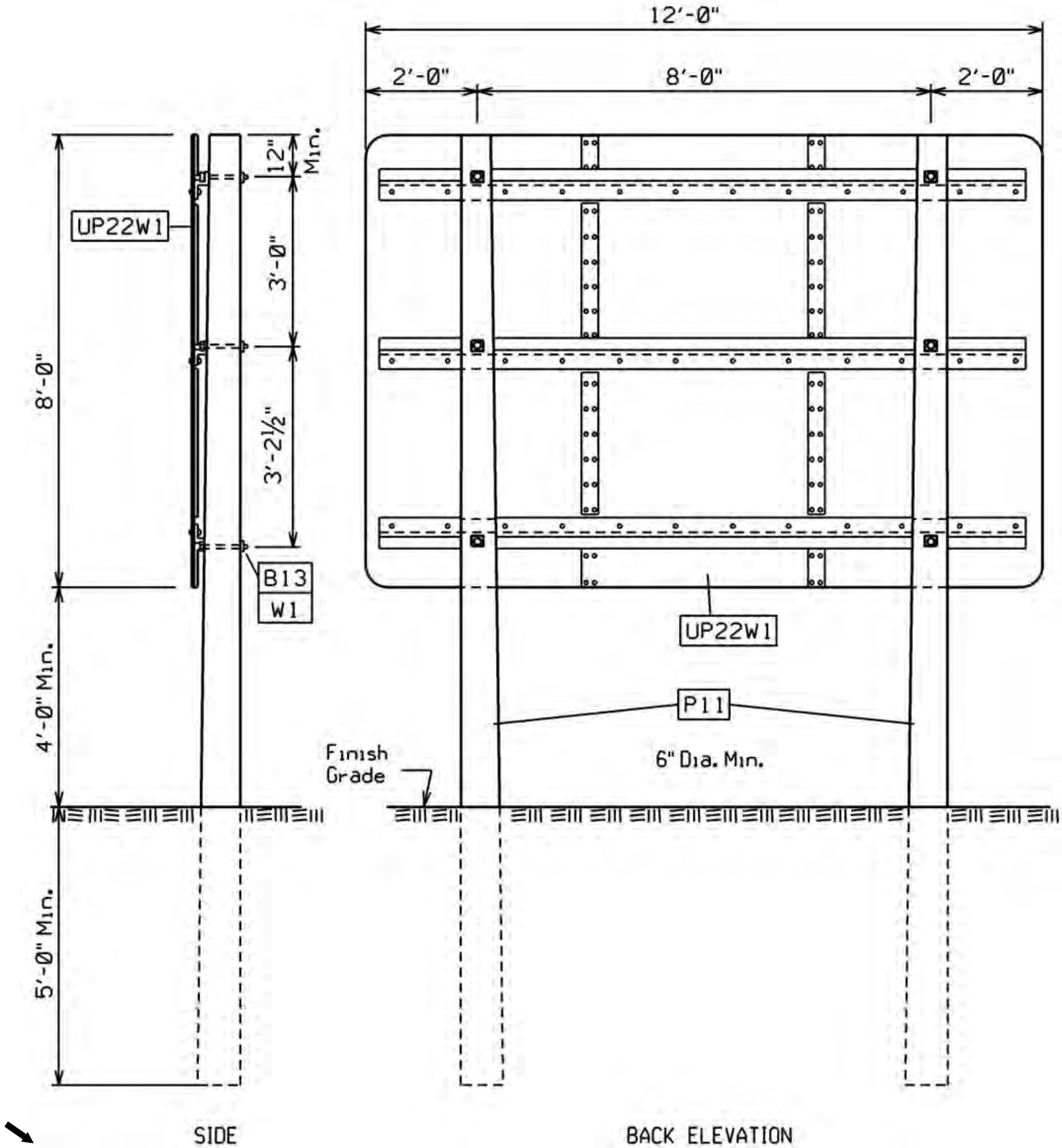


Figure 10
Signs for Submarine Locations



New Page – Change Figure 10 to 11, Text Shift

Figure 11
Signs for Submarine Locations

New Page – Change Figure 11 to 12, Text Shift

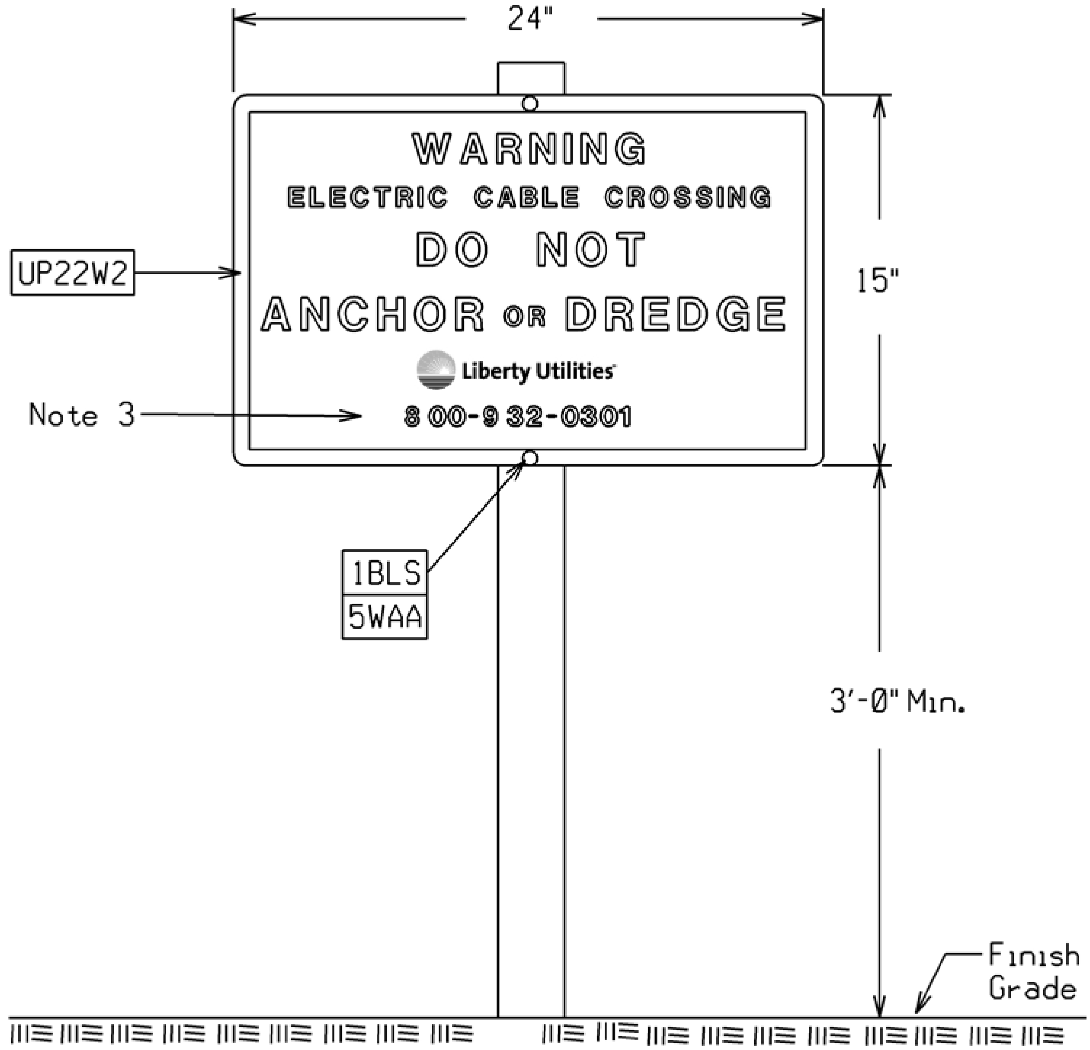


Figure 12
Signs for Submarine Locations

Note 3: Verify company emergency contact number to be used in for installation area.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1.1	07/13	• Update branding for Liberty Utilities NH specific	Robert Johnson	Robert Johnson Program Manager
1	07/09	• Revise last paragraph of 35.0 • Correct packaging on Tables 2, 3 & 4 • Add two items to Table 2 • Revise Sections 35.1.20, 35.3, 35.4, 35.,7, 35.11, 35.13, 35.16.10 & 35.17 • Add Minimum Conduit Column and 2 cables to Table 5 • Change the title of 35.4 • Correct conductor description in Table 8 • Add cable description to 35.6.10 • Add Tables 9 & 16, change subsequent table numbers and references accordingly • Change cable caps to 4 in 35.9 • Add new end paragraph to 35.10.30 • Add Figures 5 & 9, increase subsequent figures accordingly	Tim Hayden	Allen Chieco, Director of Distribution Standards and Work Methods

New Page – Add Change Table

Supersedes 1/07 Issue – Update Page Numbers due to Revisions

Supersedes 1/07 Issue – Update # 2 & 6 of 36.0.10, Text Shift

36.0 GENERAL

36.0.10 Splices

Cable Splices used throughout the Company are pre-engineered kits of either the cold shrink or heat shrink type. These splice kits have superior electrical stress relieving capabilities for long life. Types of splice kits to be used, in order of preference, are:

1. Cold Shrink – solid dielectric.
2. Premolded Quicksplice - #2 Aluminum in URD / UCD applications installed in a pullbox or direct buried only
3. Heat Shrink – solid dielectric, where manhole space precludes use of cold shrink.
4. Heat Shrink – PILC to solid dielectric transition, PILC to PILC.
5. Heat Shrink – For Y splices where re-entry or disconnection not required.
6. Premolded Y or H splice – solid dielectric Y and H splices where re-entry or disconnection required.
7. Hand Tape Splice – special applications only.
8. Dead Break Tee – Maintenance / Restricted Space applications only.

36.0.20 General Splice Installation / Cable Handling

Follow the installation instructions packaged with each kit, except as detailed in this document for non-standard cables, such as drain wire and copper tape shielded cables. See Sections 36.0.40 and 36.7 for bonding / grounding of the neutral / shield.

The proper preparation of the cable is the most critical portion of the splice installation. Perform all steps carefully, taking care to use the proper dimensions. Keep the cable clean and dry. Use the standard cable preparation tools as they reduce the chance of damage to the cable insulation and shielding system. Almost every splice failure is the result of improper cable preparation, improper cutback dimensions, lack of cleanliness or incorrect splice assembly.

DO NOT make any substitutions for materials supplied in the splice kit, except as detailed in this Section.

See Section 36.1 for additional information.

36.0.30 Connectors

Standard splice connectors are the compression type with an oil stop. Connectors may be crimped with indent type or die type tools. Connectors for copper-to-copper cables are tinned copper. Connectors for aluminum-to-aluminum or aluminum-to-copper cables are tinned aluminum. Various reducing connectors are available. These reducers have uniform outside diameters so the same die can be used on both sides of the connector. Do NOT use inserts in place of reducing connectors.

36.0.40 Grounding & Bonding

For proper circuit protective device operation and protection of the cable system, the concentric neutrals / shields shall be bonded to ground at all splices. In general, the bonding shall consist of two #4 solid, tinned copper conductors exiting the splice and connected to the manhole ground grid, or a locally driven ground rod. The method of connection between the concentric neutrals / shields differs depending on specific cable construction. These methods are detailed in Section 36.7.

The only splices where the neutral is not grounded are those in 15 kV, #2 aluminum cable in URD / UCD applications, installed either direct buried or in a pullbox.

36.0.50 Arc & Fire Proofing

See Section 35.13 for Arc and Fireproofing Requirements.

36.1 GENERAL SPLICE INSTALLATION INSTRUCTIONS

Always read, understand and follow the manufacturer's installation instructions that are packaged with the splice kit, unless exceptions are indicated within this Section.

Select the proper connector from Section 36.10 for the cables being joined. All connectors are tinned, with oil stop barriers in the center of the barrel. Use tinned copper connectors to join two copper cables, tinned aluminum connectors to join two aluminum cables and tinned aluminum connectors to join aluminum cable with copper cable. Be sure the connector selected is within the diameter and length required by the splice kit to be used.

Follow the cable end preparation instruction in the specific splice kit being used. Cables should be racked into their final position prior to cutting for splicing. Make sure that there is sufficient space to park the splice tubes over the cable. All conductor cuts should be made square. Insulation cutbacks are also made square, without tapering, penciling or stepping, unless otherwise indicated by the installation instructions.

Keep the cable and splice free of moisture, dirt, metal particles etc. during the entire preparation and splice installation process. If work must be stopped prior to completion, protect the exposed portions of the cable insulation and conductor with a half lapped layer of vinyl tape (Std. Item T2W1 or T2W2), a half lapped layer of silicon rubber tape (Std. Item T5S1) and another layer of vinyl tape. When work resumes clean all adhesive residue off of the insulation and conductor with cable cleaner (Std. Item UC80__).

Clean the cable jackets back from the ends of the cable to provide a space for parking the splicing tubes. Maintain the splice tubes and the cable clean and dry during the entire splicing operation.

Until such time as the cable is ready to be terminated, the cable ends shall remain sealed to prevent moisture from entering the conductor strands. Use cold shrink end caps (Std. Item UC90__) to protect the cable until splicing is performed. DO NOT splice cable that shows evidence of moisture in the conductor strands.

Paper lead cable shall be checked for moisture prior to splice installation. Remove 2-3 layers of paper from the end of the cable (where the splice barrel will be located) and test by placing a short piece of paper in a pot of hot oil. If *any* foaming occurs, moisture is present in the papers and this cable is not suitable for splicing. Do not attempt to 'boil out' the end of the cable. This technique, while employed for many years, does not remove all the moisture. Some of the moisture is merely driven further into the cable. The presence of any moisture in a paper insulated cable will cause a future cable failure. Refer to EOP UG005 for more information on PILC cable repairs & splicing.

Supersedes 2/06 Issue – Revise Paragraph 2 of 36.0.40 & 7th paragraph of 36.1, Text Shift

Supersedes 2/06 Issue – Revise paragraph 1, 3 &5 of 36.2, Text Shift

Be sure to remove any semi-conducting layer, either extruded or tape type, from the insulation during the preparation process. If there is any question about whether a material is semi-conducting or not, consult Standards Engineering.

Older types of cable have a fabric tape type of semi-conducting insulation shield material. When this type of semi-conducting material is found, cut this material back ¼ - ½ inch more than needed. Then wrap the entire exposed portion of the semi-con fabric tape with new semi-com tape (Std. Item T1S) applied half lapped, until the semi-con cutback dimension needed is reached. Trim this tape square to the cable at the required cutback.

Thoroughly clean the surface of the insulation after removal of the semi-conducting material. Sand the insulation to remove all visible traces of the material, then clean the insulation with cable cleaner (Std. Item UC80__). Always wipe the cleaner from the conductor end toward the semi-conductor cutback. The solvent will pick up the carbon black in the semi-conducting material and spread it on the insulation if the wiping direction is the opposite. This will contaminate the insulation and cause a future splice failure.

36.2 COLD SHRINK SPLICES

Cold Shrink Rubber Splices are the preferred splicing system to be used throughout the Company. These materials have been found to be superior to all other splicing methods, within their ratings. They are rated from 5 kV through 35 kV, cover a wide range of sizes and can be used on cable size transitions and remain flexible after shrinking. They can be used in manholes, handholes, pullboxes and direct buried applications. They can be used outdoors by replacing the normal outer jacket with a special silicone rubber, ozone resistant outer jacket (Std Item UR49D_). They can be used on all types of solid dielectric cable (EPR or XLPE) with any type of shielding system (concentric neutral, drain wire, copper tape). They are not for use on oil impregnated cables. For oil impregnated cables, use a heat shrink transition splice. See Section 36.3 for details.

Cold shrink splices are available for cables from #4/0 5 kV to 1000 kcmil 35 kV. The determining factor for splice kit selection is the insulation OD (under the semi-con). Each kit lists the minimum and maximum cable insulation OD that it covers. These splices can also be used for size transitions, provided the insulation OD on both cables is within the range of the splice kit being used. These splice kits are listed in Section 50 – Materials Catalog (Std. Item UR49__).

The instructions included with the kit detail the dimensions required for splicing two concentric neutral cables. See Sections 36.2.10 to 36.2.40 for dimension changes required to splice cables with other types of neutral / shielding. Contact Distribution Engineering Services for assistance if needed.

The kits do not include connectors. All conductor connectors are tinned copper or tinned aluminum, with an oil/water stop disc in the center of the connector. Use copper connectors to join two copper cables, aluminum connectors to join copper to aluminum and aluminum to aluminum cables. Select the proper connector from Section 50 – Materials Catalog (Std. Items UC60__ to UC63__). See Section 36.10 for additional information. If indent type compression tools are used, the indents do not have to be filled when using a cold shrink splice kit. Remove all sharp flashing from the connector after crimping.

All splices (except #2 aluminum 15 kV used in URD / UCD in pullboxes or direct buried) are to have their neutral / shield connected together and bonded to ground. The Company has specific instructions for making these connections. See Section 36.7 for the details on grounding / bonding.

36.2.10 Standard Concentric Neutral Cable Applications

The instructions packed with the kit are for jacketed concentric neutral (JCN) cable. Follow the instructions packed with the splice kit for cable preparation, cutbacks and splice installation.

See Section 36.7 for details on the grounding and bonding. Choose the correct section depending on the cable shield / neutral type on each side of the splice.

36.2.20 Drain Wire Shield Cable Applications

The instructions packed with the kit are for jacketed concentric neutral (JCN) cable. These same directions shall be used for drain wire shielded cables. Follow the instructions packed with the splice kit for cable preparation, cutbacks and splice installation.

See Section 36.7 for details on the grounding and bonding. Choose the correct section depending on the cable shield / neutral type on each side of the splice.

36.2.30 Copper Tape Shielded Cable Applications

The instructions packed with the kit are for jacketed concentric neutral (JCN) cable. Use the kit instructions with the following modifications for copper tape shielded cable:

A. Make the copper tape cutback 3½ inches from the jacket cutback. There will be 3 inches of semi-con showing when complete.

   1. For unjacketed cable, place a tape marker on the copper tape shield at the dimension given in the instructions for the Jacket Cutback. Then make all other measurements from this tape marker.

B. If copper tape shielded cable is being spliced to concentric neutral or drain wire shielded cable, it is recommended that the outer jacket tube be parked on the copper tape shielded cable with the loose end of the core facing the concentric neutral / drain wire shielded cable. This will aid in core removal from the outer jacket tube.

See Section 36.7 for details on the grounding and bonding. Choose the correct section depending on the cable shield / neutral type on each side of the splice.

36.2.40 Flat Strap Neutral Cable Applications

The instructions packed with the kit are for jacketed concentric neutral (JCN) cable. The cutback dimensions for flat strap neutral cable are identical. Care must be used when handling the flat strap neutrals. Use the kit instructions with the following modifications for flat strap neutral cable:

A. After removing the cable jacket, trim the flat strap neutrals so 3-1/2 inches remain. There will be 3 inches of semi-con showing.

B. When removing the core of the splice body, make sure that the ends of the splice body do not overlap the flat straps.

See Section 36.7 for details on the grounding and bonding. Choose the correct section depending on the cable shield / neutral type on each side of the splice.

Supersedes 1/07 Issue – Revise 36.2.40, Text Shift

Supersedes 7/07 Issue – Revise 1st paragraph of 36.2.50 & Add 4th paragraph of 36.2.60, Text Shift

36.2.50 URD / UCD Applications

For #2, Aluminum 15 kV URD / UCD applications in pullboxes or direct buried, premolded quicksplices (Std. Item UR50) are an acceptable splice. These come packaged with a crimp connector for aluminum-to-aluminum or aluminum-to-copper connections. Do not use on copper-to-copper connections. These splices are for use in Pullboxes or direct buried only. They are not to be installed in any enclosure which a person can physically enter.

For repair of direct buried #2 URD cable, a special repair splice is available (Std. Item UR50R). The splice includes a long connector to replace up to 6 inches of damaged cable without having to add a piece of cable and a second splice. For jacketed cable, also use the cold shrink re-jacketing kit (Std. Item UR75A).

Connect the concentric neutrals across the splice with a #2 connector. The neutral on these cables does not have to be grounded.

When both cables are jacketed, also use the cold shrink re-jacketing kit (Std. Item UR75A).

36.2.60 Aerial Cable

New design aerial cables are jacketed, concentric neutral with a covered lashing tape. Older aerial cables have a copper tape metallic shield and can be jacketed or unjacketed. For unjacketed cable, place a tape marker on the copper tape at the distance given in the instructions for the jacket cutback. Then make all other measurements from this tape marker.

Splices are to be cold shrink. Each splice is to be externally bonded. The outer jacket in the splice kit must be replaced with a silicon outer jacket (Std Item UR49D) since the outer jacket in the splice kit is not UV resistant. For installation on concentric neutral cable follow the instructions in 36.2.10 for installing the splice and 36.7.20 for grounding and bonding. For installation on copper tape shielded cable follow the instructions in 36.2.30 for installing the splice and 36.7.90 for grounding and bonding.

Terminations are to be cold shrink. For installation on concentric neutral cable follow the instructions in 37.1.50. For installation on copper tape shielded cable follow the instructions in 37.1.60.

Similar information for splicing and terminating aerial cables can be found in Overhead Standards Section 16.

36.3 HEAT SHRINK SPLICES

Heat shrink splices are utilized for a variety of specialty applications. They should not be used in lieu of a cold shrink splice unless adequate installation space is not available. The most common application throughout the Company is for making a transition from PILC cable to solid dielectric cable. However, other approved uses include splices between two PILC cables, splices in manholes with limited working room and Y tap splices.

The various heat shrink splices are listed in Section 50 – Materials Catalog (Std. Items UR81__ for 5 kV, UR82__ for 15 kV, UR83__ for 23 kV and UR84__ for 35 kV). The different styles of splice kit are:

A. Transition splices are for single conductor PILC cable to single conductor solid dielectric jacketed cables.

B. Trifurcating splices are for 3 conductor solid dielectric cables with a single overall jacket to 3 single solid dielectric jacketed conductors.

C. Trifurcating transition splices are for 3 conductor PILC cable to 3 single solid dielectric jacketed conductors.

D. Straight joints for PILC to PILC cables, both single conductor and 3 conductor.

E. Y splices are for tapping a main line single conductor cable, any combination of solid dielectric and PILC cables.

36.3.10 Heat Shrink Splices – General Instructions

The kits do not include connectors. Select the proper connector from Section 50 – Materials Catalog (Std. Items UC60__ to UC63__). If indent crimping is used, the indents have to be filled prior to installation of the splice. Use small pieces of Raychem Stress Relief Mastic (SRM or Yellow Mastic) to fill the indents. Remove all flashing or sharp edges from the connector prior to installing the splice. Be sure that the surface of the cable / connector is uniform with no extreme discontinuities. The first heat shrink tube must be able to shrink down smoothly with no voids underneath it. Any voids under this tube will lead to splice failure.

Choose the correct kit for the application. Follow instructions packed with the kit for cable preparation and splice installation. The cable shield / neutral is to be connected across the splice and bonded to ground at each splice. See Section 36.7 for details on this grounding / bonding.

Supersedes 7/07 Issue – Revise 1st Paragraph of 36.3.10, Text Shift

Supersedes 1/09 Issue – Revise 3rd paragraph of 36.4

36.4 PREMOLDED H & Y SPLICE

Premolded H & Y splices can be used to join various types and sizes of solid dielectric cables. They are not suitable for PILC cables. They are not to be used on any cable with #2 aluminum conductor. They are rated 600 A, up to 35 kV.

These splices are the preferred method of making an H or Y joint in solid dielectric cables. Dead break elbows are permitted to be used as a splice in a few limited cases. See 36.11 for details.

One joint is used for all voltages up to 25 kV, a different joint is needed for 35 kV applications. The lugs are the same for all voltages. The 25kV class cable adapters are to be used for all voltages including 35kV. The insulating caps are different for the different voltage ranges.

The basic joint is available and listed in Section 50 – Materials Catalog (Std. Item UR71__). The accessories are cable adapter (Std. Item UR64_), lug, (Std. Item UR63__), retaining rings (Std Item UR72) and insulating cap, (Std. Item UR73__). Be sure to select the correct parts for the applied voltage.

Follow the instructions packed with the kit for assembly. Use approved tools to assemble and disassemble the joint. **Torque** the connecting bolts to the proper value using a torque wrench. Be sure that the boots are completely installed. Tools for installation of the boots are listed in the Tool Catalog.

The concentric neutrals must be connected across the joint and bonded to ground. For jacketed concentric neutral cables, clean and sand the jacket. Apply 2–3 layers of sealing compound (Std. Item T5M) lay the concentric neutrals into the sealing compound, then apply 2–3 additional turns of sealer. Apply two layers of splicing tape (Std. Item T5B) half lapped, from the end of the cable housing to the outside of the sealing compound. The splicing tape should lap 1 inch onto the cable housing. Complete the seal with two half lapped layers of vinyl tape (Std. Item T2W).

Connect a #14 copper wire from the grounding eyelet of the splice body and each cable housing to the concentric neutral / bond connection. Connect the concentric neutrals to the manhole ground bus with #4 solid, tinned copper wire (Std. Item W11F1) and C crimps (Std. Item S14__).

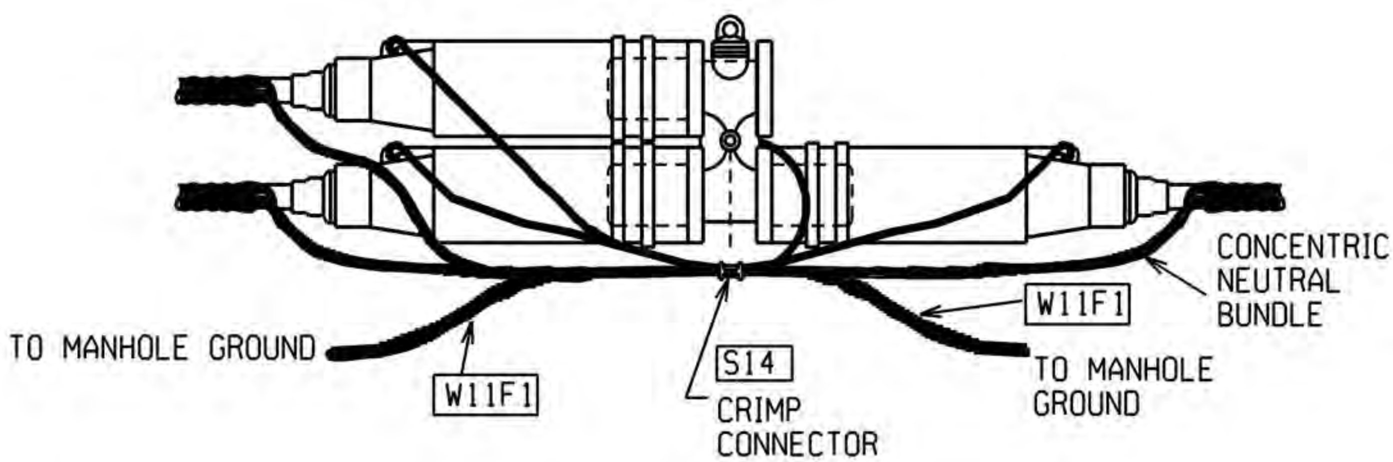


Figure 1
Typical Y Joint

36.5 HAND TAPED SPLICES

Hand taped splices should be limited to special conditions such as:

A. Small size cables which are outside of the range of the cold shrink or heat shrink splices.

B. Space limitations prevent using either cold shrink or heat shrink splices due to lack of room to park the tubes on the cable.

Hand taped splices shall always be the last choice due to lower reliability and installation time.

Refer to Table 1 for all letter designated dimensions.

Table 1

Cable Size AWG-kcmil	Voltage (kV)	A	B	C	D	G- Adder* Al	G- Adder* Cu	P	L
2	5	7-¾	3-½	½	4-0	½	½	½	2-½
1/0	5	7-¾	3-½	½	4-0	½	½	½	2-½
4/0	5	7-¾	3-½	½	4-0	½	½	½	2-½
350	5	7-¾	3-½	½	4-0	½	½	½	2-½
500	5	7-¾	3-½	½	4-0	½	½	½	2-½
750	5	8-0	3-½	¾	4-¼	½	½	½	2-½
1000	5	8-0	3-½	¾	4-¼	½	½	½	2-½
2	15	11-¼	7-0	½	7-½	13/16	13/16	1-0	5-½
1/0	15	11-¼	7-0	½	7-½	13/16	13/16	1-0	5-½
4/0	15	11-¼	7-0	½	7-½	11/16	11/16	1-0	5-½
350	15	11-¼	7-0	½	7-½	11/16	11/16	1-0	5-½
500	15	11-½	7-0	¾	7-¾	⅝	⅝	1-0	5-½
750	15	11-¾	7-0	1-0	8-0	⅝	⅝	1-0	5-½
1000	15	11-¾	7-0	1-0	8-0	⅝	⅝	1-0	5-½
1/0	25	14-½	9-¼	1-½	10-¾	1-¼	1-⅜	2-¼	6-½
4/0	25	14-½	9-¼	1-½	10-¾	1-0	1-⅜	2-¼	6-½
350	25	14-½	9-¼	1-½	10-¾	1-0	1-0	2-¼	6-½
500	25	14-½	9-¼	1-½	10-¾	1-0	1-0	2-¼	6-½
750	25	14-½	9-¼	1-½	10-¾	1-0	1-0	2-¼	6-½
1000	25	14-½	9-¼	1-½	10-¾	1-0	1-0	2-¼	6-½
750	35	16-½	10-½	2-¼	12-¾	1-½	1-½	3-½	6-½
1000	35	16-½	10-½	2-¼	12-¾	1-½	1-½	3-½	6-½

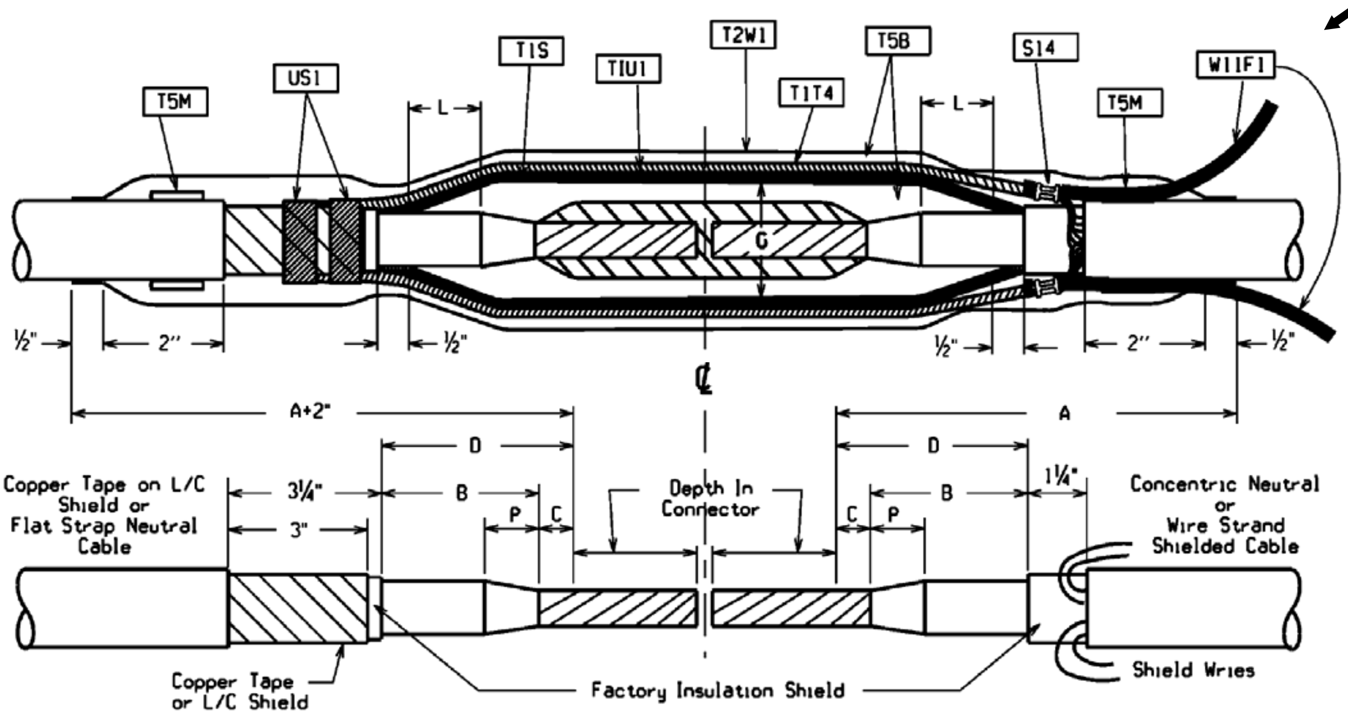


Figure 2

Supersedes 1/07 Issue – Revise Figure 2

36.5.10 Cable Preparation

Train and rack cables into position. Cables must be straight for a distance equal to the entire length of the completed joint. Cut ends square, with the ends at the centerline of the splicing space.

Wipe jackets clean for a minimum distance of A plus 8 inches. On cables with concentric neutrals or drain wire shields, mark the jacket at a distance D plus 1¼ inches. On cables with copper tape shield, L/C shield or flat strap neutrals, mark the jacket at a distance of D plus 3¼ inches. Abrade the jackets from the mark outward for an additional 3 inches with abrasive cloth (Std. Item T5U1). Remove the jacket to the mark with approved jacket removal tool.

A. L/C or Copper Tape Shield Cables – mark the metallic shield 1 inch from the jacket cutback. Remove the shield, using scissors to make a square cut

B. Concentric Neutral, Flat Strap Neutral, Drain Wire Shield Cables – Remove mylar tape if present and bend the conductors back along the jacket. Hold in place temporarily with vinyl tape (Std. Item T2W1). Bend the flat straps carefully to prevent breaking them.

Remove the insulation semi-con a distance of D plus the 'depth in connector'. Use approved removal tools, using care not to cut or nick the cable insulation.

Remove the cable insulation and conductor shield a distance of C plus the 'depth in connector'.

36.5.20 **Pencil The Insulation**

Hand taped joints require penciling of the cable insulation. Use an approved penciling tool. Check that the penciling tool will form the correct pencil length and is equipped with a bushing sized to fit snugly over the cable insulation. Be sure the blade is sharp. Adjust the blade so that the tool will not leave a step at the conductor. On the last few turns of the tool, apply only light pressure, assuring that the blade will not gouge the insulation.

If a penciling tool is not available, carefully form the pencil using a sharp knife. Smooth the cuts with a file.

Sand the entire surface of the factory insulation with abrasive cloth (Std. Item T5U1). There must be a narrow band of conductor shield material exposed at the end of the penciling.

36.5.30 **Install The Connector**

Clean the conductor with a wire brush, being sure to remove all oxidation and any foreign material. Use copper connectors to join two copper cables, aluminum connectors to join copper-to-aluminum and aluminum-to-aluminum cables. Select the proper connector from Section 50 – Materials Catalog (Std. Items UC60__ to UC63__). See Section 36.10 for additional information.

Crimp with approved crimper and, if needed, correct dies. File off and sand any sharp edges and wipe off excessive anti-oxide compound.

36.5.40 **Final Cable Check & Cleaning**

Check to see that the factory insulation has been sanded thoroughly along its entire length. All traces of semi-con material must be removed. Check to see that all surfaces are smooth with no nicks, gouges, dents, cuts or other blemishes. Clean the entire area, from jacket to jacket with a cable prep kit (Std. Item UC80F). Wipe from the insulation toward the cable jacket to prevent dragging any carbon from the semi-con onto the insulation. Thoroughly clean the connector to remove oil & grease.

36.5.50 **Connector / Conductor Shielding Tape**

A. For 25 And 35 kV Cable Only – apply one layer, half lapped, of Teflon tape (Std. Item T2T) over the exposed bare conductor. Start taping ⅛ inch from the connector and end ⅛ inch from the end of the pencil. Do not put tape onto the connector or the cable semi-con.

Fill any indents in the connector with small pieces of semi-con tape (Std. Item T1S). The outer surface of the connector must be as smooth and uniform as possible, with no voids, to prevent partial discharge stress points. Build up a smooth layer of semi-con tape from the end of the connector to the end of the penciling, just covering the exposed cable semi-con at the end of the penciling. Do not allow the semi-con tape to touch the cable insulation at the end of the penciling. The final surface of the semi-con tape will be at a slope, opposite to the penciling, from the end of the connector to the end of the penciling. Repeat for the second side.

Apply one half-lapped layer of semi-con tape over the connector, with a half lap turn on the semi-con build up at both ends of the connector.

Supersedes 7/07 Issue – Revise 2nd Paragraph of 36.5.50

36.5.60 High Voltage Splicing Tape

Using calipers, determine the maximum diameter over the connector and shielding tape. Add 'G' dimension to this maximum diameter and set the calipers to this total. This will be the finished diameter over the high voltage splicing tape. Preserve this caliper setting for the final check of the tape diameter.

Calculate the difference between the caliper setting and the cable insulation OD, in sixteenths of an inch. This number of sixteenths is approximately the number of layers of tape required to build the reinforcement tapers. Divide 16 by this number, and then multiply by L from the table. The result is the "step distance", in eighths of an inch, needed to build the reinforcement tapers.

Apply high voltage splicing tape (Std. Item T5__) in the V shaped spaces between the pencil and the end of the connector. Use a level wind technique. The tape edges must butt against the pencil. Do not apply the high voltage tape such that it lays flat against the pencil. Once the tape diameter reaches the connector diameter on the first side, repeat the process on the other side of the connector.

Apply the tape with sufficient, uniform tension to reduce its width to 50%. Build up the tape evenly, using half lapped layers forming a smooth, even surface.

When the diameter of the hand applied tape equals the diameter of the cable insulation, start to form the reinforcement tapers. The first layer of tape should end ½ inch from the cable insulation shield cutback. Form the tape so that its edge is perpendicular to the cable axis and parallel to the edge of the insulation shield.

Reverse direction of taping and immediately form the tape so that its edge is displaced toward the center of the joint by the "step distance" calculated above.

Continue to tape to the other end of the joint or to the connector if the tape diameter has not yet reached the connector diameter. Continue taping end to end, each time stopping a "step distance" less than the last layer, or one "step distance" closer to the center of the joint. Stop taping when the stepped distance equals dimension 'L'. Check the diameter over the connector. It should be slightly more than the caliper setting made previously.

36.5.70 Insulation Semi-Con Tape

Starting at the center of the joint, apply a tightly stretched, half-lapped layer of semi-conducting tape (Std. Item T1S) over the high voltage tape. Butt this semi-con tape snugly against the edge of the insulation shield. Apply as many turns at the insulation shield interface as needed to reach the insulation shield diameter. Then apply one final turn, overlapping the insulation shield by ¼ inch. Repeat the semi-con tape application from the center of the joint to the other end. Overlap the tape ½ inch at the center of the joint. Be sure not to leave a gap or void at the cable insulation shield interface or at the center of the joint.

36.5.80 Shielding, Neutral, Bonding & Grounding

Refer to the appropriate portion of Section 36.7, depending upon the cable combinations being spliced, for installation of splice shielding, neutral connection across splice, bonding and grounding the shield.

After these connections are made, return to Section 36.5.90 for splice completion instructions.

36.5.90 Sealing & Jacket Tape

Wrap a 1-2 inch wide strip, 2-3 laps thick, of sealing compound (Std. Item T5M) around each jacket where it was previously cleaned and abraded. Where the solid #4 bond wires exit the splice, firmly press the wires into the sealing compound, and then apply 2-3 layers over the bond wires.

Apply two tightly wrapped, half-lapped layers of high voltage splicing tape over the entire joint, covering the sealing mastic on each end.

Apply two half-lapped layers of vinyl tape (Std. Item T2W__) extending ½ inch beyond the high voltage splicing tape. Wrap tightly at both ends. Apply 2-3 final turns of tape without stretching to prevent flagging of the end.

36.6 SHRINKING TUBES

36.6.10 Cold Shrink Splices

Locate the tube over the splice as directed and begin to remove the core. Note that during the initial stages (before any part of the tube has shrunk down to the cable) the entire tube may be rotated to facilitate core removal. When the splice begins to contact the cable, recheck the location of the tube per the installation instructions. When the tube is properly located, continue removing the core. The core *must* be unwound around the cable to prevent jamming the core against the cable. Do not pull the core hard as breakage may result. Give a slight pull on the core, then unwind it one turn around the cable and then give another slight pull. The amount of pulling is actually small and the amount of unwinding is large. If the effort to pull the core increases, first relax the tension and attempt to unwind one or two turns, then attempt to pull again. Remember, unwinding is more important than pulling. This operation is especially important when installing the outer jacket, as the core could get caught on the bonding / grounding connectors.

36.6.20 Heat Shrink Splices

Locate the tube over the splice as directed in the installation instructions. Use the approved propane torch, adjusted for a bushy flame. Contact the tube with only the outer 1-2 inches of the flame. Keep the flame moving to prevent scorching or burning the tube. Start heating at the center of the tube and move toward one end, heating evenly all around the circumference. Once one end is complete, return to the center and work the heat shrink process toward the opposite end. Avoid applying heat to the semi-con material. When multiple tubes are required, make sure that the surface of the last tube installed is still warm. If it has cooled, re-heat the entire previous tube before continuing. When shrinking of a tube is complete, check for uniform wall thickness, conformance to underlying shape, flat spots and that adhesive sealant flows evenly from both ends if that tube was coated. Some outer jackets have a green speckled surface. These green spots are heat indicators and they will turn black when the tube has been sufficiently heated. Check these tubes for any green spots that need additional heating. Be especially observant of the back side of the cable.

Supersedes 1/07 Issue – Move 36.3.30 to next page

Supersedes 1/07 Issue – Revise 36.6.30, 1st paragraph, add 2nd paragraph, Move 36.7.20 to next page

36.6.30 Oil Barrier Tubes

Shrinking the oil barrier tubes on PILC transition splices requires careful use of the propane torch. These tubes are very sensitive to heat and will split longitudinally if too much heat is applied. However, too little heat will result in an improper shrinking of the tube, which will result in splice failure. This is especially critical when working with 3 conductor PILC cable. It is suggested that all three ends be prepared for the oil barrier tubes and that the three tubes be shrunk together. An alternate is to use a heat shield to protect the other phases while shrinking one phase. If an oil barrier tube splits, it must be removed and replaced. Attempting to use the Raychem Stress Relief Mastic (yellow mastic) to repair the split tube is **NOT** acceptable.

Be sure that the oil barrier tubes are properly shrunk down onto the paper insulation. Inadequate shrinking will result in splice failure. The outer surface of the oil barrier tube after shrinking shall be smooth with no wrinkles. There shall be no air bubbles under the tube.

36.7 GROUNDING AND BONDING

All splices will have the metallic shield / concentric neutral bonded across the splice and connected to the system neutral and/or a driven ground rod. The connection to the neutral / driven ground rod provides a path for any fault current to exit the cable at the first splice. This will reduce the possibility of additional cable damage at a site away from the initial failure. For direct buried URD cable (#2 15 kV) refer to Section 36.2.50.

36.7.10 General

General requirements are that the bond connection to the system neutral / driven ground will be with two #4 solid tinned copper conductors (Std. Item W11F1). The use of solid conductors makes the sealing of the splice from moisture more reliable. The tin coating reduces the chances of corrosion in high moisture level environments.

Connection of the concentric neutrals / flat strap neutrals / drain wire shield / copper tape shield / lead sheath across the splice will be with either two solid #4 tinned copper wires (Std. Item W11F1) or two heavy duty braids (Std. Item T1T4 – equivalent to #4). The braid is used if one or both sides of the splice have copper tape shield, lead sheath or flat strap neutrals. The method of connecting the braid to the copper tape, lead sheath or flat strap neutrals using constant force springs is critical and has to be performed correctly. See Section 36.8 for the acceptable method of making the braid / spring connection.

Connection to concentric neutrals (#14 bare copper strands, varying quantity depending on cable specifics) to the solid #4 tinned copper conductor (Std. Item W11F1) will be with a C crimp (Std. Item S14__) of the appropriate size. Connection to drain wire shields (generally #20 gauge copper) to the solid #4 tinned copper conductor (Std. Item W11F1) will also be with a C crimp (Std. Item S14__) of the appropriate size.

The C crimps should be located outside the end of the splice tubes, before the cable jacket begins. Prior to installing the C crimps, put 4-5 layers of copper mesh shielding tape (Std. Item T1U__) on the cable, starting ½ inch from end of jacket cutback to ½ inch from edge of slope on splice body. The mesh should cover the cable semi-con and the narrow end of the splice body. This mesh provides a cushion for the C crimps and protects the cable.

36.7.20 Concentric Neutral Cable, Both Sides – Refer to Figure 3

1. Cut the concentric neutrals on both sides of the splice to a convenient length. They must extend to the upward slope of the splice body.

2. Make a protective bedding for the C crimp connectors at both ends of the splice, by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

3. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

4. Divide the concentric neutrals in half and twist each bundle together tightly. The bundles should be on opposite sides of the cable. Trim the bundle so that it ends prior to the upward slope of the splice body – the bundle must lay flat against the cable and the ends must not contact the splice body.

5. Side 1: Connect one end of the #4 solid bond wire to one of the concentric neutral bundles using a C Crimp connector (Std. Item S14__). File out any sharp edges. Repeat for the second bond wire.

6. Side 2: Lay each #4 solid bond wire along the splice with sufficient length to connect to the manhole ground bus. Connect each bond wire to one of the concentric neutral bundles using a C Crimp connector (Std. Item S14__). File out any sharp edges.

7. Apply 4-5 half lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

8. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or bond wires across the splice (barber pole style) to secure them prior to installing the outer jacket.

9. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

10. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

11. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6- 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

12. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

Supersedes 1/07 Issue – Revise 36.7.20 #8, Move Figure 3 to next page

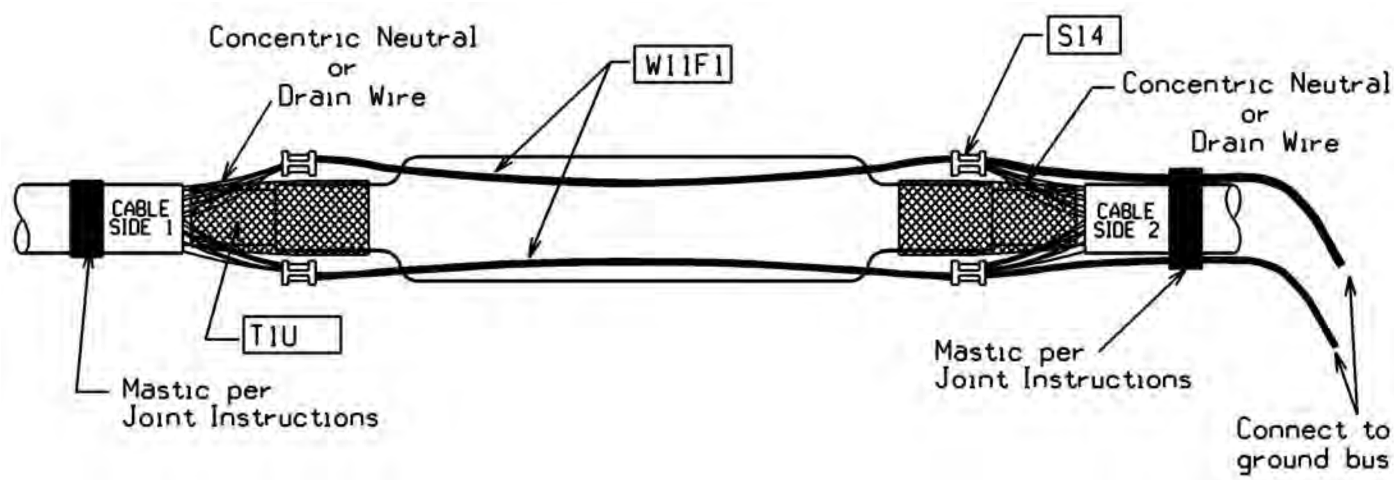


Figure 3

36.7.30 Concentric Neutral Cable One Side, Drain Wire Other Side – Refer To Figure 3

1. Cut the concentric neutrals / drain wires on both sides of the splice to a convenient length. They must extend to the upward slope of the splice body.

2. Make a protective bedding for C crimp connectors at both ends of the splice by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

3. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

4. Divide the concentric neutrals / drain wires in half and twist each bundle together tightly. The bundles should be on opposite sides of the cable. Trim the bundle so that it ends prior to the upward slope of the splice body – the bundle must lay flat against the cable and the ends must not contact the splice body.

5. Side 1: Connect one end of the #4 solid bond wires to one of the concentric neutral bundles using a C Crimp connector (Std. Item S14__). File out any sharp edges. Repeat for the second bond wire.

6. Side 2: Lay each #4 solid bond wire along the splice with sufficient length to connect to the manhole ground bus. Connect each bond wire to one of the drain wire bundles using a C Crimp connector (Std. Item S14__). File out any sharp edges. Note: The bond wires can exit from the splice on either side of the concentric neutral cable or drain wire cable.

7. Apply 4-5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

Supersedes 1/07 Issue – Text Shift

8. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or bond wires across the splice (barber pole style) to secure them prior to installing the outer jacket.

9. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

10. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

11. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

12. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.40 **<u>Concentric Neutral Cable One Side, Copper Tape Shield Other Side – Refer To Figure 4</u>**

Tinned braids will have to be connected to the copper tape shield in this instance. Connection of the braids to the copper tape is with constant force springs. See Section 36.8 for details on this connection.

For ease of connections, it is recommended that the #4 bond wires exit the splice on the concentric neutral cable side. Make the connection between the concentric neutrals, braid and #4 bond wires first. Then extend the braids across the splice and connect each to the copper tape shield with the constant force springs.

1. Cut the concentric neutrals to a convenient length. They may extend to the upward slope of the splice body.

2. Make a protective bedding for C crimp connectors at the concentric neutral end of the splice by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

3. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

4. Divide the concentric neutrals in half and twist each bundle together tightly. The bundles should be on opposite sides of the cable. Trim the bundle so that it ends prior to the upward slope of the splice body – the bundle must lay flat against the cable and the ends must not contact the splice body.

5. Side 1: Connect one end of the tinned braid (Std. Item T1T4) to one of the concentric neutral bundles and a #4 solid ground wire using a C Crimp connector (Std. Item S14__). The tail of the #4 solid must point away from the splice and have sufficient length to connect to the manhole ground bus. The tail of the braid must point toward the splice and have sufficient length to reach the other side of the splice. File out any sharp edges after crimping. Repeat for the second neutral bundle.

Supersedes 1/07 Issue – Revise 36.7.30 # 8 & 36.7.40 #5, Text Shift

Supersedes 1/07 Issue – Revise 36.7.40 # 6 & 8, Revise Figure 4, Text Shift

6. Side 2: Lay each tinned braid along the splice. Vinyl tape (Std. Item T2W1) may be used to secure the braid to the splice to aid handling. Connect each braid to the copper tape shield by stretching the braid width for the last 4-5 inches. Place the braid on the copper tape shield, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the copper tape shield. The goal is to maximize the surface contact area of the braids with the copper tape shield. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional copper tape, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape can be placed over the springs if desired.

7. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

8. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

9. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

10. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

11. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

12. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

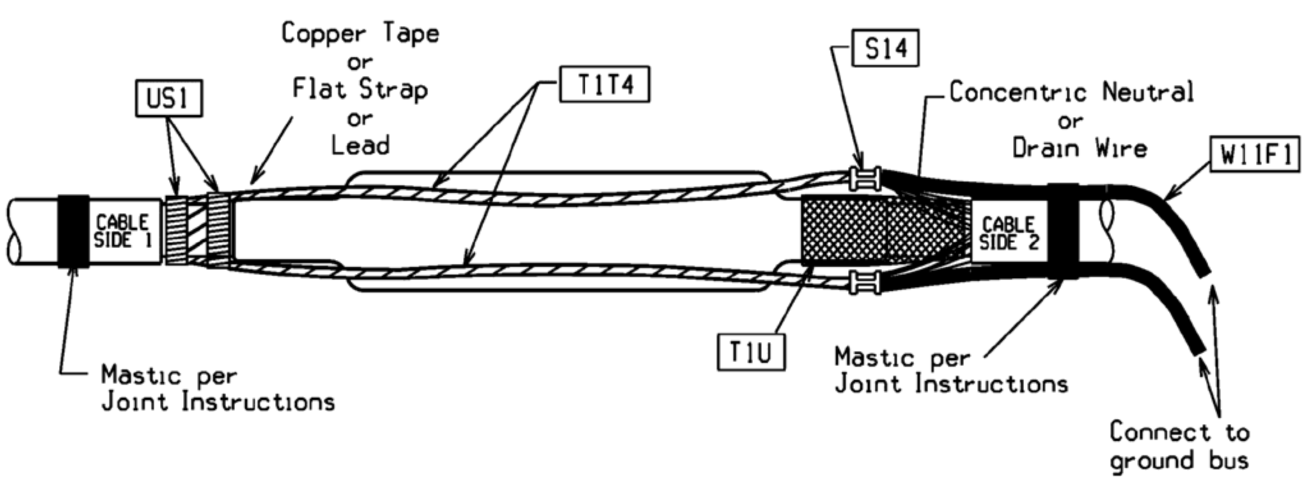


Figure 4

36.7.50 **Concentric Neutral Cable One Side, Lead Sheathed Cable Other Side – Refer To Figure 4**

Tinned braids will have to be connected to the lead sheath in this instance. Connection of the braids to the lead sheath is with constant force springs. See Section 36.8 for details on this connection.

For ease of connections, it is recommended that the #4 bond wires exit the splice on the concentric neutral cable side. Make the connection between the concentric neutrals, braid and #4 bond wires first. Then extend the braids across the splice and connect each to the lead sheath with the constant force springs.

1. Cut the concentric neutrals to a convenient length. They may extend to the upward slope of the splice body.

2. Make a protective bedding for C crimp connectors at the concentric neutral end of the splice by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

3. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

4. Divide the concentric neutrals in half and twist each bundle together tightly. The bundles should be on opposite sides of the cable. Trim the bundle so that it ends prior to the upward slope of the splice body – the bundle must lay flat against the cable and the ends must not contact the splice body.

5. Side 1: Connect one end of the tinned braid (Std. Item T1T4) to one of the concentric neutral bundles and a #4 solid ground wire using a C Crimp connector (Std. Item S14__). The tail of the #4 solid must point away from the splice and have sufficient length to connect to the manhole ground bus. The tail of the braid must point toward the splice and have sufficient length to reach the other side of the splice. File out any sharp edges after crimping. Repeat for the second neutral bundle.

6. Side 2: Lay each tinned braid along the splice. Vinyl tape (Std. Item T2W1) may be used to secure the braid to the splice to aid handling. Clean the lead sheath in the area where the braids will be connected. Connect each braid to the lead sheath by stretching the braid width for the last 4-5 inches. Place the braid on the lead sheath, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the lead sheath. The goal is to maximize the surface contact area of the braids with the lead sheath. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional lead sheath, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape can be placed over the springs if desired.

7. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

Supersedes 1/07 Issue – Revise 36.7.50 # 5 & 6, Text Shift

Supersedes 1/07 Issue – Revise 36.7.50 # 8 & 36.7.60 # 5, Text Shift

8. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

9. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

10. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

11. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

12. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.60 **<u>Concentric Neutral Cable One Side, Flat Strap Neutral Other Side – Refer To Figure 4</u>**

Tinned braids will have to be connected to the flat strap neutral in this instance. Connection of the braids to the flat straps is with constant force springs. See Section 36.8 for details on this connection.

For ease of connections, it is recommended that the #4 bond wires exit the splice on the concentric neutral cable side. Make the connection between the concentric neutrals, braid and #4 bond wires first. Then extend the braids across the splice and connect each to the flat strap neutrals with the constant force springs.

1. Cut the concentric neutrals to a convenient length. They may extend to the upward slope of the splice body.

2. Make a protective bedding for C crimp connectors at the concentric neutral end of the splice by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

3. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

4. Divide the concentric neutrals in half and twist each bundle together tightly. The bundles should be on opposite sides of the cable. Trim the bundle so that it ends prior to the upward slope of the splice body – the bundle must lay flat against the cable and the ends must not contact the splice body.

5. Side 1: Connect one end of the tinned braid (Std. Item T1T4) to one of the concentric neutral bundles and a #4 solid ground wire using a C Crimp connector (Std. Item S14__). The tail of the #4 solid must point away from the splice and have sufficient length to connect to the manhole ground bus. The tail of the braid must point toward the splice and have sufficient length to reach the other side of the splice. File out any sharp edges after crimping. Repeat for the second neutral bundle.

6. Side 2: Lay each tinned braid along the splice. Vinyl tape (Std. Item T2W1) may be used to secure the braid to the splice to aid handling. Connect each braid to the flat strap neutrals by stretching the braid width for the last 4-5 inches. Place the braid on the flat straps, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the flat straps. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional flat straps, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape can be placed over the springs if desired.

7. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

8. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

9. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

10. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

11. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

12. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.70 **<u>Flat Strap Neutral Cable, Both Sides – Refer To Figure 5</u>**

Tinned braids will have to be connected to the flat strap neutrals in this instance. Connection of the braids to the flat straps is with constant force springs. See Section 36.8 for details on this connection.

The #4 solid bond wires will be used to exit the splice and may exit the splice on either side.

1. Make a protective bedding for C crimp connectors at the end of the splice where the #4 solid bond wires will exit by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

2. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

Supersedes 1/07 Issue – Revise 36.7.60 # 6 & 8, Text Shift

Supersedes 1/07 Issue – Revise 36.7.70 # 3, 4 & 7, Text Shift

3. Starting on the side opposite where the #4 solid bond wires will exit, stretch the braid width for the last 4-5 inches. Place the braid on the flat straps, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the flat straps. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional flat straps, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the springs if desired.

4. Extend the braids to the other side of the splice. The braids need to extend beyond the constant force spring location to allow for crimping on the solid #4 tinned bond wires.. Stretch the braid width at the location where the constant force springs will be installed. Place the braid on the flat straps, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the flat straps. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional flat straps, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the springs if desired.

5. Connect the #4 solid bond wires to the respective tails of the tinned braids with C crimp connectors (Std. Item S14__). File out any sharp edges after crimping.

6. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

7. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

8. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

9. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

10. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

11. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

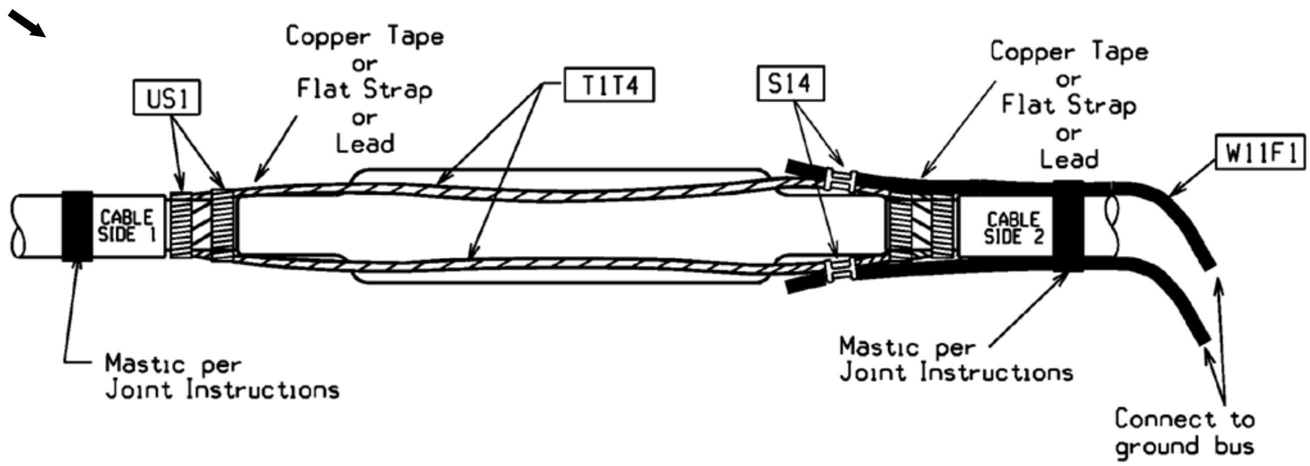


Figure 5

36.7.80 <u>**Flat Strap Neutral Cable One Side, Lead Sheathed Cable Other Side – Refer To Figure 5**</u>

Tinned braids will have to be connected to the flat strap neutrals in this instance. Connection of the braids to the flat straps is with constant force springs. See Section 36.8 for details on this connection.

The #4 solid bond wires will be used to exit the splice and should exit on the flat strap neutral cable side.

1. Make a protective bedding for C crimp connectors at the flat strap neutral end of the splice by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

2. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

3. Starting on the lead sheath cable side, clean the lead sheath where the connection will be made. Stretch the width of one braid for the last 4-5 inches. Place the braid on the lead sheath, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the flat straps. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional lead sheath, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the spring if desired.

Supersedes 1/07 Issue – Revise 36.7.80 # 3 & Figure 5, Text Shift

4. Extend the braids to the other side of the splice. The braids need to extend beyond the constant force spring location to allow for crimping on the solid #4 tinned bond wires.. Stretch the braid width at the location where the constant force springs will be installed. Place the braid on the flat straps, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the flat straps. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional flat straps, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the springs if desired.

5. Connect the #4 solid bond wires to the respective tails of the tinned braids with C crimp connectors (Std. Item S14__) of the proper size. File out any sharp edges after crimping.

6. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

7. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

8. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

9. Apply the mastic supplied with the splice kit at the cleaned area, under and over the #4 solid bond wires.

10. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Heat the tube completely. If the tube had green spots, check that all green spots have turned black, which indicate sufficient heating has been done.

11. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.90 <u>Copper Tape Shielded Cable, Both Sides – Refer To Figure 5</u>

Tinned braids will have to be connected to the copper tape shield in this instance. Connection of the braids to the copper tape is with constant force springs. See Section 36.8 for details on this connection.

The #4 solid bond wires will be used to exit the splice and may exit the splice on either side.

1. Make a protective bedding for C crimp connectors at the end of the splice where the #4 solid bond wires will exit by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of jacket cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

Supersedes 1/07 Issue – Revise 36.7.80 # 4 & 7, Text Shift

2. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

3. Start on the side opposite where the #4 solid bond wires will exit. Stretch the first braid width for the last 4-5 inches. Place the braid on the copper tape, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the lead sheath. The goal is to maximize the surface contact area of the braids with the copper tape. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional copper tape, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the springs if desired.

4. Extend the braids to the other side of the splice. The braids need to extend beyond the constant force spring location to allow for crimping on the solid #4 tinned bond wires.. Stretch the braid width at the location where the constant force springs will be installed. Place the braid on the copper tape, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the copper tape. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional copper tape, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the spring if desired.

5. Connect each #4 solid bond wires to the respective tails of the tinned braids with C crimp connectors (Std. Item S14__) of the proper size. File out any sharp edges after crimping.

6. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

7. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

8. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

9. Apply the mastic supplied with the splice kit at the cleaned area under and over the #4 solid bond wires.

10. Install and shrink the outer jacket tube, being sure the tube extends from mastic seal to mastic seal. Use care removing the core from the first 6– 8 inches of the jacket. The core can become jammed on the narrow end of the splice body and the C crimps.

Supersedes 1/07 Issue – Revise 36.7.90 # 3, 4 & 7, Text Shift

11. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.100 <u>Copper Tape Shielded Cable One Side, Lead Sheathed Cable Other Side – See Figure 5</u>

Tinned braids will have to be connected to the copper tape and lead sheath in this instance. Connection of the braids is with constant force springs. See Section 36.8 for details on this connection.

The #4 solid bond wires will be used to exit the splice and should exit on the copper tape shield cable side.

1. Make a protective bedding for C crimp connectors at the copper tape end of the splice by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting a ½ inch from end of copper tape cutback and ending a ½ inch before the edge of the upward slope of the splice body. The mesh should cover the cable semi-con and the narrow end of the splice body.

2. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

3. Starting on the lead sheath cable side, clean the lead sheath where the connection will be made. Stretch the first braid width for the last 4-5 inches. Place the braid on the lead sheath, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the lead sheath. The goal is to maximize the surface contact area of the braids with the lead sheath. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional lead sheath, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the spring if desired.

4. Extend the braids to the other side of the splice. The braids need to extend beyond the constant force spring location to allow for crimping on the solid #4 tinned bond wires.. Stretch the braid width at the location where the constant force springs will be installed. Place the braid on the copper tape, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the copper tape. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional copper tape, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the spring if desired.

5. Connect each #4 solid bond wires to the respective tails of the tinned braids with C crimp connectors (Std. Item S14__) of the proper size. File out any sharp edges after crimping.

Supersedes 1/07 Issue – Revise 36.7.100 # 3 & 4, Text Shift

6. Apply 4–5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

7. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

8. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

9. Apply the mastic supplied with the splice kit at the cleaned locations, under and over the #4 solid bond wires.

10. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Heat the tube completely. If the tube had green spots, check that all green spots have turned black, which indicate sufficient heating has been done.

11. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.110 **Lead Sheathed Cable, Both Sides – Refer To Figure 5**

Tinned braids will have to be connected to the lead sheath in this instance. Connection of the braids to the lead is with constant force springs. See Section 36.8 for details on this connection.

The #4 solid bond wires will be used to exit the splice and may exit on either cable side.

1. Make a protective bedding for C crimp connectors at the end of the splice where the #4 solid bond wires will exit by applying 4-5 half-lapped layers of tinned copper shielding mesh (Std. Item T1U__) starting at the end of the splice body and continuing out for 2-3 inches.

2. Apply 2 half-lapped layers of shielding mesh across the entire splice. This will provide for mechanical protection for the splice body. Alternatively, the pad supplied with the splice kit may be used for this mechanical protection.

3. Starting on the side opposite where the #4 Solid Bond wires will exit, clean the lead sheath where the connection will be made. Stretch the first braid width for the last 4-5 inches. Place the braid on the lead sheath, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the lead sheath. The goal is to maximize the surface contact area of the braids with the lead sheath. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional lead sheath, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the spring if desired.

Supersedes 1/07 Issue – Revise 36.7.100 # 7, 36.7.110 # 3, Text Shift

Supersedes 1/07 Issue – Revise 36.7.110 # 4 & 7, Text Shift

4. Clean the lead sheath on the opposite side of the splice where the connection will be made. Extend the braids to the other side of the splice. The braids need to extend beyond the constant force spring location to allow for crimping on the solid #4 tinned bond wires.. Stretch the braid width at the location where the constant force springs will be installed. Place the braid on the lead sheath, parallel to the cable. Repeat for the second braid, placing it on the opposite side of the cable. The goal is to maximize the surface contact area of the braids with the lead sheath. One or two laps of vinyl tape may be placed on the braids to temporarily hold them in place. Install a constant force spring (Std. Item US1_) over the two braids. Place a second constant force spring next to the first. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. If there is not sufficient room for both springs, trim back the cable jacket to expose additional lead sheath, but keep this additional jacket cutback to a minimum. A couple laps of vinyl tape may be placed over the spring if desired.

5. Connect each #4 solid bond wires to the respective tails of the tinned braids with C crimp connectors (Std. Item S14__) of the proper size. File out any sharp edges after crimping.

6. Apply 4-5 half-lapped layers of shielding mesh over the C crimp connectors to provide a smooth surface for the outer jacket.

7. If desired, vinyl tape (Std. Item T2W1) can be wrapped over the mesh and / or braids (barber pole style) to secure them prior to installing the outer jacket.

8. Clean and abrade the cable jacket where the outer splice jacket tube will contact the cable jacket. This seal is important to protect the splice components and cable from moisture. Consult the splice instructions to determine the proper dimensions for cleaning.

9. Apply the mastic supplied with the splice kit at the cleaned locations, under and over the #4 solid bond wires.

10. Install and shrink the outer jacket tube. Be sure the tube extends from mastic seal to mastic seal. Heat the tube completely. If the tube had green spots, check that all green spots have turned black, which indicate sufficient heating has been done.

11. Complete the bonding and grounding by connecting both #4 bond wires to the manhole ground system with crimp connector (Std. Item S14H) per Section 33 – Handholes / Manholes.

36.7.120 Direct Buried Installations

In direct buried installations of conductors larger than #2 (typically non-URD), drive a ground rod (Std. Item TG20) adjacent to the splice and connect both #4 bond wires to the ground rod with a connector (Std. Item G4). See Figure 6 for details.

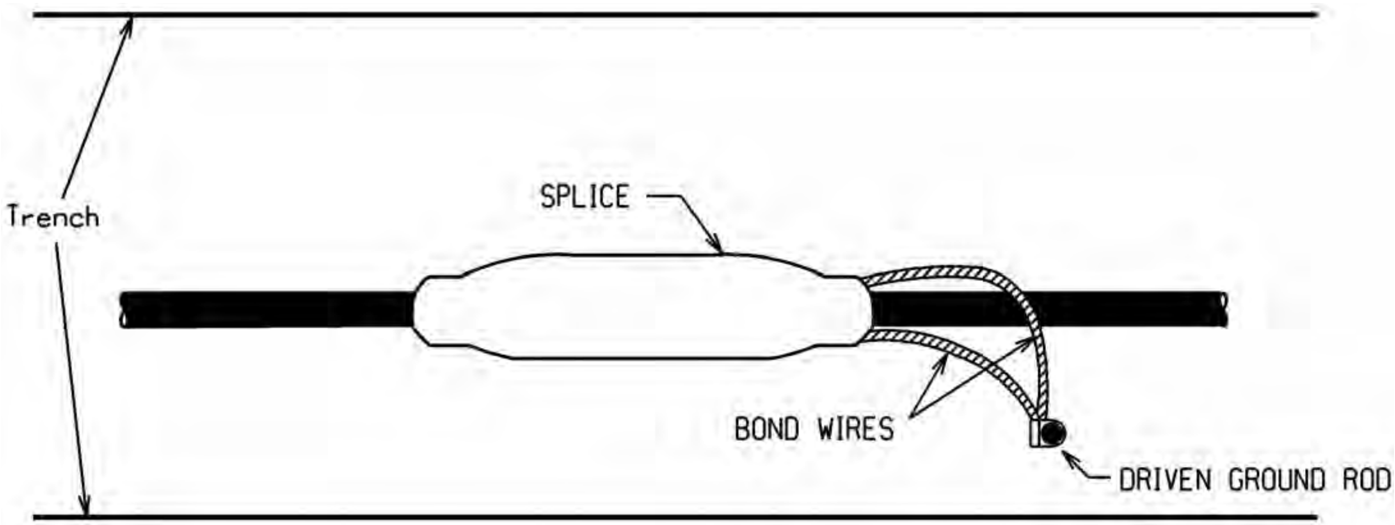


Figure 6

Supersedes 1/07 Issue – Text Shift

36.8 CONSTANT FORCE SPRING INSTALLATION

The **only** acceptable method of braid to shield connection is the following:

1. Clean the surface of the metallic shield where the connection is to be made.

2. Stretch the width of the end of the braid for 4 – 5 ". Place the braid on the metallic shield, parallel to the cable. Repeat with a second braid located on the opposite side of the cable. The goal is to maximize the contact area of the braid with the metallic shield. Wrap the first constant force spring over the braids. Place a second spring next to the first one. Use up all of the spring. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. Refer to Figure 7.

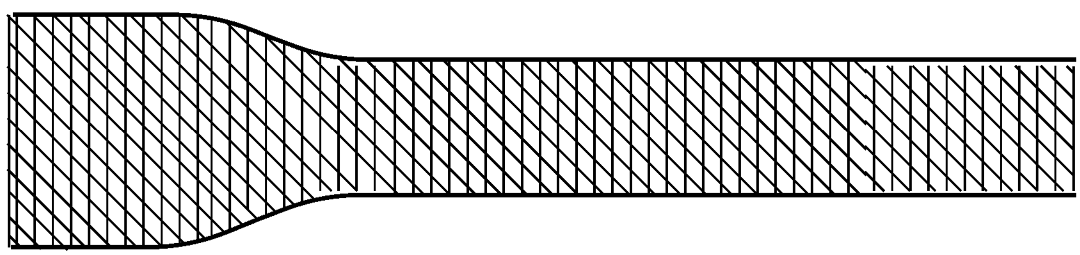


Figure 7

3. Extend the braid to the other side of the splice, parallel with the cable. Cut to an appropriate length, leaving a sufficient tail for connection to the solid #4 tinned wires. Refer to Figure 8.

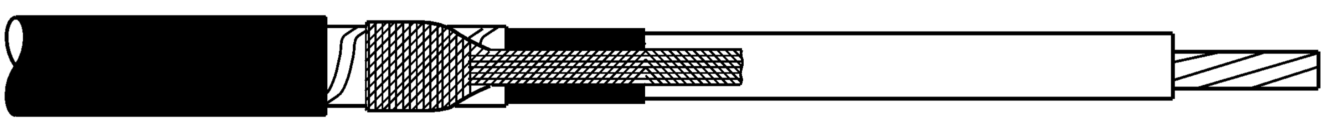


Figure 8

Supersedes 1/07 Issue – Revise 36.8, Figures 7 & 8, Text Shift

4. Stretch the width of the first braid at the location where the constant force springs will be installed. Repeat with the second braid, located on the opposite side of the cable. The goal is to maximize the contact area of the braid with the copper tape / lead sheath / flat straps. A couple laps of vinyl tape may be placed on the braids to temporarily hold them while the springs are installed. Wrap the first constant force spring over the braids. Place a second spring next to the first one. Use up all of the spring. Caution: There must be some metal to metal contact between the braids and the springs – to prevent any partial discharge at this location. Refer to Figure 9.

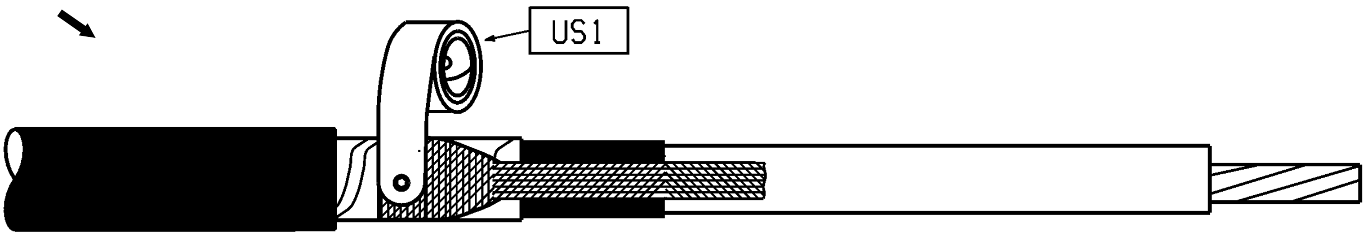


Figure 9

5. If necessary, one to two laps of vinyl tape (Std. Item T2W1) may be placed over the springs to hold them in place. Refer to Figure 10.

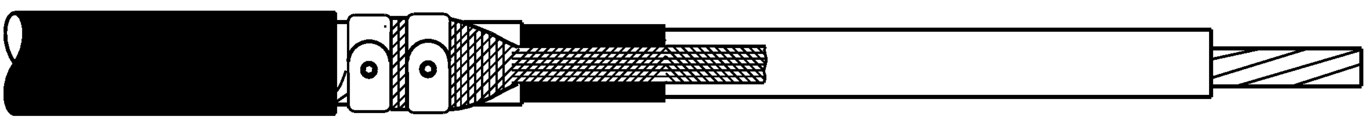


Figure 10

This connection method provides sufficient contact area of the braid to the cable shield and keeps the high resistance spring out of the electrical circuit. The spring is used solely as the mechanical force for the connection.

The traditional method of connecting the braid to the copper tape or lead has been to place one wrap of the constant force spring around the cable, then lay the braid over the spring parallel to the run of cable and then continue wrapping the spring around the cable until all the spring is used up. This connection depends on the spring to carry current from the cable shield to the braid, since the spring is the only material in contact with the shield. **This practice is no longer acceptable as** the spring steel has a relatively high resistance.

36.9 AERIAL INSTALLATIONS

In aerial installations (or any installation where the joint will be exposed to direct sunlight), an overall silicone jacket (Std. Item UR49D) shall be used in place of the EDPM (black rubber) jacket supplied in the joint kit. The silicone tube is 24" long; therefore a splice will require two silicone jackets, overlapped in the middle. No mastic sealer is needed at the overlap of the jackets as they shrink down tightly enough over each other to prevent water intrusion. New aerial cables are jacketed concentric neutral construction. Older aerial cables have a copper tape shield. See 36.2.60 for splicing instructions. Connect the bond wires exiting the splice to the messenger wire and/or other grounded conductor.

Supersedes 1/07 Issue – Revise 36.8 #4, & 36.9, Figures 9 & 10, Text Shift

Supersedes 1/07 Issue – Revise 36.11 last paragraph, Text Shift

36.10 CONNECTORS

Approved connectors are the compression type. Connectors are available in tinned copper and tinned aluminum. Connector dimensions (OD and length) must fall into the allowable range for the cold shrink and heat shrink splice kits. Use tinned copper connectors for copper-to-copper cables. Use tinned aluminum connectors for aluminum-to-aluminum and aluminum-to-copper cables. Choose the correct connector from Section 50 – Materials Catalog (Std. Items UC60__ to UC63__).

Reducing connectors are one piece, without inserts. These connectors have been designed to have a uniform outside diameter which allows the same tooling to be used on both sides of the connector. Notify Standards Engineering if the correct reducer is not listed in the Section 50 – Materials Catalog.

All connectors have a stop disk in the center of the barrel. This disk is sealed to prevent the migration of oil or water from one cable to the other. The stop disk also aids in correct splice assembly.

Connectors have little or no taper in order that the joint length remain in the range of the cold shrink and heat shrink kits.

Crimping can be with circumferential dies or indent style tools. If indent tools are used, the indents must be filled in when using heat shrink splice kits or hand taping. See Section 36.3 for heat shrink and Section 36.5 for hand tape instructions. The indents do not have to be filled in when using a cold shrink splice kit. Compress the connector with the correct tools / dies and using the proper number of compressions. See Section 34 – Tools / Dies for complete information.

Always compress the connector from the center to each end. Compress the connector only between the marks on the barrel. Rack the cables prior to compressing the connector. Straighten the cable for 3-4 feet on both sides of the connector prior to compressing. Rotate the tool 90 degrees between successive compressions.

36.11 DEAD BREAK TEE JOINTS

Dead Break Tee joints (also known as T-Body or Hammerhead) shall not routinely be used to form a splice. The preferred method of creating a re-enterable splice is to use a premolded Y or H joint – see Section 36.4.

However, there are many locations where these dead break elbows exist to make a joint. Installation of a dead break tee to make a joint is limited to the following:

1. Maintenance of existing units - replacement of an existing elbow
2. Addition of an elbow to an existing splice
3. Installation in a location which does not have space for a premolded Y or H
4. Installation on #2 aluminum conductor

In these locations, caution MUST be exercised to ensure a reliable installation. The lug must have a smooth hole. Lugs with a threaded hole are incorrect and will lead to joint failure. Any lugs found in service with a threaded hole shall be replaced the correct lug. The cables and joint must be secured to the cable racks to prevent movement from loading and fault currents. Each segment of the joint must be tightened separately, one joint at a time. Attempting to tighten a complete assembly (end to end) will result in improper torquing of the joint. The connectors must be torqued to 60 foot pounds and must not be moved after final tightening. The torque setting is reduced to 45 foot pounds when the spanner wrench is used. This is due to the increased length of the wrench with the spanner wrench added. Keep the spanner wrench and the torque wrench aligned in a straight line.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1	07/09	• Revise 36.0,10 paragraph 2 & 6 • Revise 36.0.40 paragraph 2 • Revise 36.1 paragraph 7 • Revise 36.2 paragraphs 1, 3 & 5 • Revise 36.2.40 A & B • Revise 36.2.50 paragraph 2 • Revise 36.2.60 last paragraph • Revise 36.3.10 paragraph 1 • Revise 36.4 paragraphs 4 & 5 • Revise 36.5.50 paragraph 2 • Revise 36.6.30 paragraph 1, add paragraph 2 • Revise #8 of 36.7.20 and 36.7.30 • Revise #5, 6 & 8 of 36.7.40, 36.7.50 & 36.7.60 • Revise #3, 4 & 7 of 36.7.70, 36.7.80, 36.7.90, 36.7.100 & 36.7.110 • Revise 36.8 paragraphs 1 thru 4 • Revise 36.9 • Revise 36.11 paragraph 3 • Revise Figures 2, 4, 5, 7, 8, 9 & 10	Tim Hayden	Allen Chieco, Director of Distribution Standards and Work Methods

New Page – Add Change Table

 Doc. # ST. 37.00.001

Supersedes 1/07 Issue – Revise Page Numbers

Supersedes 1/07 Issue – Revise Paragraphs 1, 3, 4, 5, 6, 7, 8, 9 & 10 of Section 37.0

37.0 GENERAL

For cables with conductor size of 1000 kcmil and smaller, cable terminations shall be cold shrink type, packaged in a kit with appropriate installation instructions. With the exception of the kit for 15kV, #2 aluminum cable the kits do not include a connector lug or a mounting bracket. Both of these items are available separately. These terminators have superior electrical stress relieving capabilities to ensure long cable life. The installation instructions packed with each kit shall be followed, except as detailed below for non-standard cables, such as drain wire and copper tape shielded cables.

The preparation of the cable has been proven to be the most critical portion of the installation process. Perform all steps carefully, taking care to use the proper dimensions.

The use of standard cable preparation tools is required, as it limits the chance of damage to the cable insulation and shielding system. Company approved tools are listed in the Tool Catalog which can be found on the Distribution Engineering Services web site (http://mawbrapp16v/ToolCatalog/TCFrame.aspx).

DO NOT make any substitutions for materials supplied in the appropriate kit, except as detailed in this Standard for drain wire or tape shielded cables.

Older types of cable may have a fabric tape semi-conducting insulation shield material. When cable with this type of semi-conducting material needs to be terminated, this material shall be cut back ¼ - ½ inch more than specified here-in for extruded semi-con layers. The exposed portion of the fabric tape semi-con shall then be wrapped with semi-con tape (Std. Item T1S), applied half lapped, until the specified semi-con cutback is reached. This tape shall then be trimmed square to the cable at the required cutback.

Until such time as the cable is ready to be terminated, the cable ends shall remain sealed. This prevents moisture from ground water or the atmosphere entering the conductor strands. DO NOT terminate cable that shows evidence of moisture in the conductor strands. Cold shrink end caps are available and shall be used on all open ends of cable. See Section 35.12 for additional details.

Keep the cable and termination free of moisture, dirt, and metal particles during the entire preparation and installation process. Once started, terminations shall be completed during one work session. If work must be stopped prior to completion of the termination, the exposed portions of the cable insulation and conductor shall be protected with a half lapped layer of vinyl tape (Std. Item T2W1 or T2W2) a half lapped layer of silicon rubber tape (Std. Item T5S1) and another half lapped layer of vinyl tape.

Be sure to remove any semi-conducting layer, either extruded or tape type, from the insulation during the preparation process. If there is any question about whether a material is semi-conducting or not, consult either Standards Engineering or Work Methods.

The surface of the insulation shall be thoroughly cleaned after removal of the semi-conducting material. Sand the insulation only to remove all visible traces of the semi-conducting material then clean the insulation with cleaning kit (Std. Item UC80F) or bottle and wipes (UC80D & UC80B). Always wipe the cleaner from the conductor end toward the semi-conductor cutback. The solvent will pick up the carbon black in the semi-conductor and spread it onto the insulation if the wiping direction is the opposite. This will contaminate the insulation and cause a future termination failure. CAUTION: Do not attempt to sand the 'grooves' out of EPR insulated cables. These grooves occur due to the manufacturing process where the concentric neutral wires are in contact with the insulation. These grooves will disappear when the cable is heated up. If it is necessary to remove the grooves to properly clean the insulation, gently heat the cable to remove the grooves.

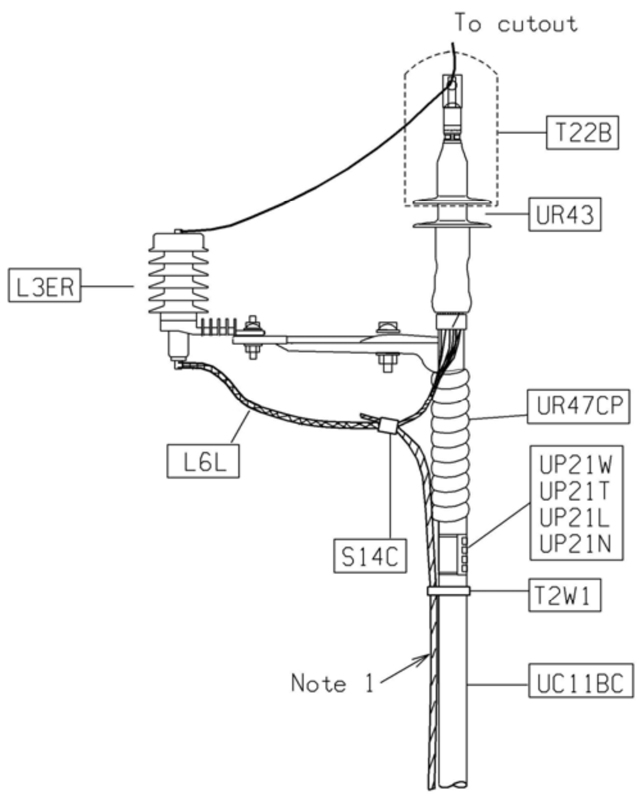
On concentric neutral cable, cut the cable and prepare the end such that the bundled concentric neutral wires form a tail a minimum of 18 inches in length outside of the terminator. Alternatively a piece of bare wire can be spiced to the concentric neutrals per Table 2. On drain wire, tape shielded and LC shielded cables the braid will be the neutral.

For #2, 15 kV, URD cables, use the mounting bracket packaged with the terminator (Std. Item UR42). For all other cables, use a cable positioning device (Std. Item UR47CP) to mount the terminator. On wooden riser poles utilize a 3 position bracket (Std. Item C35A for single phase, Std. Item E12M for three phase). In stations or on steel structures, mount the cable positioning device to an appropriately located structural member. A surge arrester shall be installed in an adjacent hole of the three position bracket. See Figure 1 below for terminator mounting details.

37.0.10 Grounding And Bonding

For proper cable protection from lightning and other surges, a riser type surge arrester (Std. Items L3DR – L3JR) shall be installed immediately adjacent to the termination. Riser type arresters are identified by a yellow band on the dis-connector unit on the bottom of the arrester. Utilize an adjacent mounting hole in the bracket to mount the arrester. Install the flexible ground lead (Std. Item L6 or L6L) on the arrester. Extend the flexible ground lead to the system neutral with a tap lead sized according to the Table 2. Connect the flexible ground lead, the neutral from the cable and a neutral tap lead with an appropriately sized C crimp connector (Std. Item S14_) as shown. The tap lead shall be sized according to Table 2 below. Keep all lead lengths as short as possible for the best cable system protection from lightning and surges. Route the neutral tap along the primary cable or allow it to float in air. Tape (Std. Item T2W1) may be used as needed for a neat installation. DO NOT tape or route the neutral along the fiberglass terminator mounting bracket. On risers with more than one phase, connect the neutrals together when they reach the pole then run a single conductor of equivalent size, connecting it to system neutral. A #4 solid, covered ground conductor shall be connected to the system neutral and driven ground per standard grounding procedures.

Supersedes 2/06 Issue – Revise 37.0.10; Revise Figure 1 & add note 2; Text Shift



Note 1: Continue to system neutral and driven ground rod.

Caution: *This is a current carrying portion of the cable; make all connections prior to energizing.*

Note 2: Some items will vary depending on cable size.

Figure 1

Supersedes 2/06 Issue – Revise 37.1.40

37.1 COLD SHRINK TERMINATIONS

Cold shrink silicone rubber terminations shall be used for terminating shielded, high voltage power cables, 5 kV through 35 kV. These terminators have a wide cable range, can be used indoor or outdoor and are suitable for any solid dielectric insulation and any type of shielding.

A. Cold Shrink for Concentric Neutral / Jacketed Concentric Neutral, 5 – 35 kV
B. Cold Shrink for Copper Tape / Drain Wire Shield, 5 – 25 kV
C. Cold Shrink for Copper Tape / LC Shield, 35 kV

37.1.10 Application

Termination kits are supplied based on voltage and diameter of the insulation under the semi-con layer. Conductor size can be used as a guide, however, the diameter of the insulation shall be the final determining factor. The same kit is suitable for copper or aluminum conductors, indoor or outdoor application.

37.1.20 Type Of Cable

These kits can be installed on any type of solid dielectric cables.

The basic kit contains all parts for the concentric neutral cable & jacketed concentric neutral cable (See Section 37.1.50).

Ground braid, constant force springs and additional mastic are required for cables with copper tape, drain wire or LC shielding. For details refer to the following Sections of this Standard:

Application	Section
Concentric Neutral 5 kV thru 35 kV	Section 37.1.50
Copper Tape Shield or Flat Strap Neutral – 5 kV thru 25 kV	Section 37.1.60
Drain Wire Shield – 5 kV thru 25 kV	Section 37.1.70
Copper Tape / LC Shield – 35 kV	Section 37.1.80

37.1.30 Terminal Lugs

Pin type terminals shall be used for #2 conductor terminations on riser poles only. These terminals are included with (Std. Item UR42). All other terminals shall be 2-hole pad style lugs (Std. Item UL15 / UL16) and are separate from the termination kit. The terminal lug material shall match the conductor material – aluminum lug for aluminum conductor, copper lug for copper conductor. Install the connector as directed in the instructions packaged with the terminator. Do not substitute lugs – approved lugs are sealed to prevent water intrusion and subsequent cable failure.

37.1.40 Termination Kit Selection

Select the proper kit from Table 1 below. Insulation OD will always be the final determining factor as to kit choice. If an overlap exists, choose the kit where the cable insulation OD falls closest to the middle of the range of the termination.

Table 1
Termination Kit Selection

Std. Item	Insulation OD	Conductor Size Range			
		5 kV	**15 kV**	**25 kV**	**35 kV**
UR42 [1]	0.64” – 1.08”	-	#2	-	-
UR43 [2]	0.64” – 1.08”	4/0 – 400	#2	-	-
UR44B	0.64” – 1.08”	4/0 – 400	#2		
UR44C	0.83” – 1.53”	500 – 1500	4/0 – 500	1/0 – 350	-
UR44D	1.05” – 1.80”	-	750 – 1000	500	-
UR44E	1.53” – 3.32”	-	-	1000	-
UR45B1	0.72” – 1.29”	-	-	-	1/0 – 2/0
UR45C3	1.05” – 1.80”	-	-	-	300 – 500
UR45H	1.53” – 2.32”	-	-	-	750 – 1000

Notes:

1. This kit is for #2 URD applications only. It comes packaged with a pin terminal connector and mounting bracket
2. This is a 2 skirt terminator, with no connector or mounting bracket in the kit. This item is being phased out – remaining stock can be used on URD / UCD riser poles. It is not recommended for switchgear. Use UR44B (4 skirt) for switchgear applications.

Supersedes 1/07 Issue – Revise Note 2 to Table 1 of Section 37.1.40

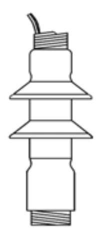


Figure 2
Typ. 5 – 15 kV

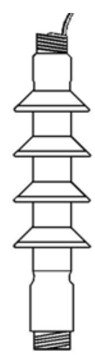


Figure 3
Typ. 15 – 25 kV

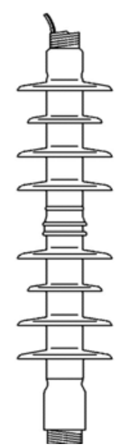


Figure 4
Typ. 35 kV

Table 2
Neutral Tap Wire

Conductor	# of Neutrals	Neutral Tap	Std. Item
#2 – #1/0	10 – 16	#2 stranded bare	W13G
#2/0 – 1000 kcmil	18 – 30	#2/0 stranded, bare	W17G

37.1.50 <u>Terminations For Concentric Neutral & Jacketed Concentric Neutral Cable</u>

The termination kit contains all materials needed for installation on these cables. Follow the manufacturer’s instructions packed with the kit.

37.1.60 Terminations For Copper Tape Shield – 5 kV Thru 25 kV (Includes Aerial Cable)

In order to adapt the termination kit for use on cables rated for 5 kV through 25 kV with copper tape shield, an accessory kit will be necessary. This kit contains a solder blocked ground braid and constant force spring. Follow the instructions below for preparation of the cable and installation of the ground braid. The instructions packed with the accessory kit are for a different type of cable.

Select the accessory kit based upon the OD over the shield of the cable, as listed in the following table.

Table 3

Shield OD	Accessory Kit
0.82" – 1.63"	UR47T4
1.15" – 2.42"	UR47T5

If the cable has fabric or tape semi-con, this material shall be cut back ¼ - ½ inch more than specified here-in for extruded semi-con layers. The exposed portion of the fabric tape semi-con shall then be wrapped with semi-con tape (Std. Item T1S) applied half lapped, until the specified semi-con cutback is reached. This tape shall then be trimmed square to the cable at the required cutback.

A. Prepare Cable:

1. Check to be sure cable size fits within kit range as shown in Table 1 (cover page) of the termination instructions packaged with the kit.

2. Prepare cable using dimensions shown in Figure 5. Be sure to allow for the depth of the terminal lug and growth of Aluminum Lug (if used – see chart below). If necessary to prevent tape shield from unraveling, TEMPORARILY hold down the edge with a single wrap of vinyl electrical tape.

Table 4

Aluminum Cable Size	#2 – 350 kcMil	400 – 650 kcMil	750 – 1000 kcMil
Growth Allowance	0.25"	0.50"	0.75"

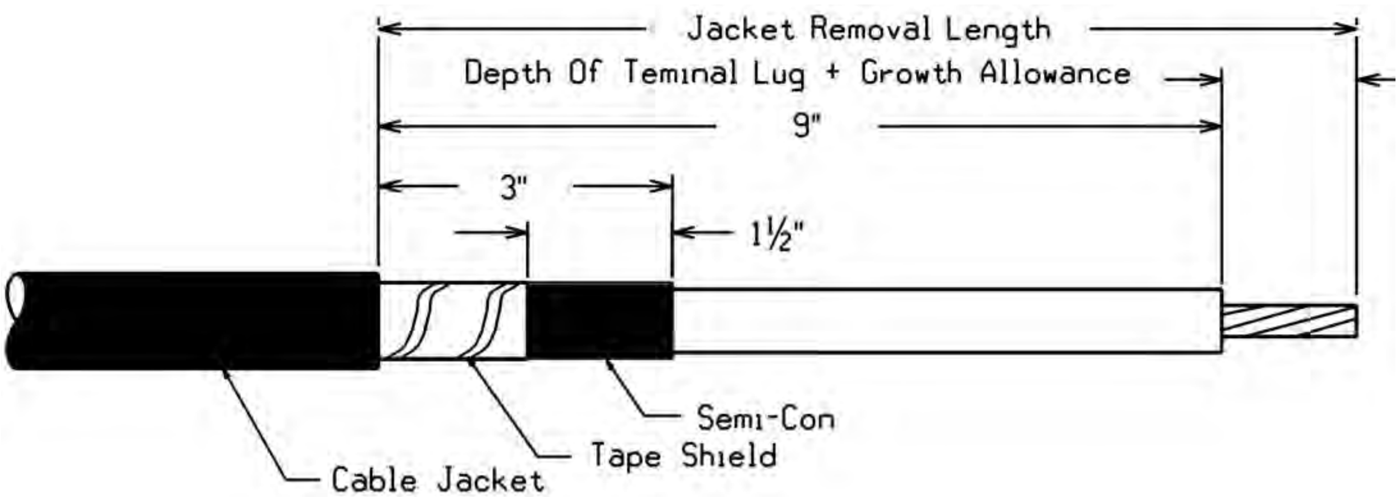


Figure 5

B. Install Ground Braid:

1. Select one of the mastic strips from the termination kit and remove the white release liners. Using light tension, apply a single wrap of mastic around the cable jacket ¼ inch from the cut edge. Cut off excess mastic. See Figure 6.

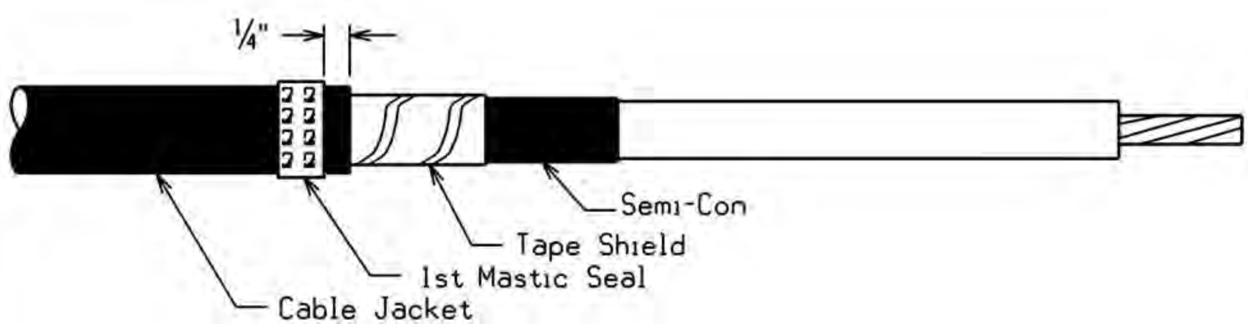


Figure 6

2. Position pre-formed "U" shaped ground braid over tape shield directly adjacent to the cable jacket cut edge. The long tails should extend over the cable jacket, with the solder block of one tail positioned over the mastic. Secure this tail to the cable jacket with a vinyl tape marker, located 4½ inches from the edge of the cable semi-con. See Figure 7.

Note: Position this vinyl tape with care as it will serve as the marker for final termination location on the cable.

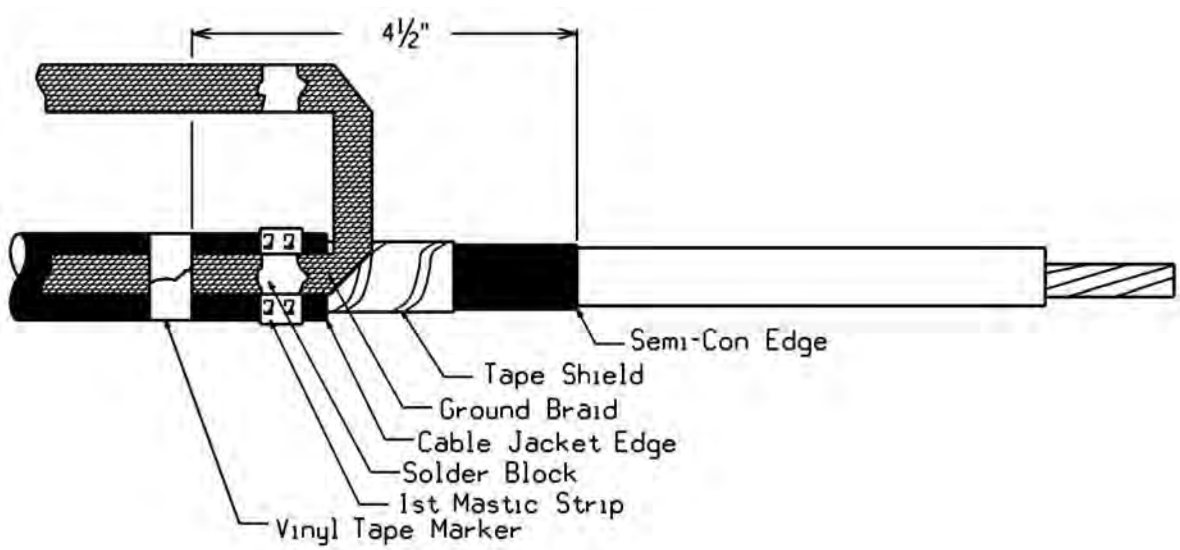


Figure 7

Supersedes 2/06 Issue – Revise 37.1.60 B3 & B4

3. Wrap the ground braid around the tape shield, placing the solder block on the second tail on the mastic applied in Step 1. Secure with a constant force spring. Using the second mastic strip from the termination kit, remove the liners and wrap mastic over the solder blocks and the first mastic strip. If the solder blocks overlap each other, mastic must be applied between the solder blocks as well as over them. See Figure 8.

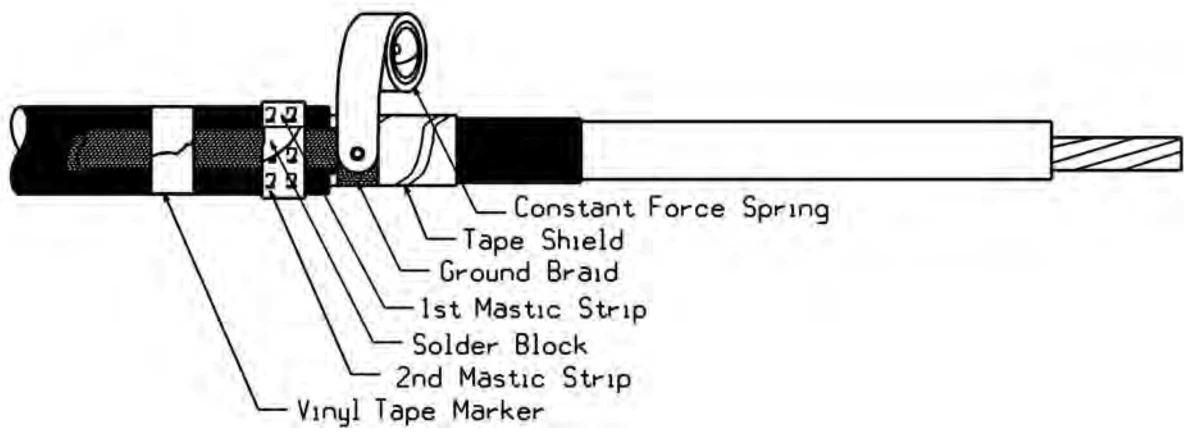


Figure 8

4. Wrap two half-lapped layers of vinyl tape around the mastic seal, constant force spring and exposed metallic shield. Do not allow the vinyl tape to lap onto the cable semi-con. Do not apply more than 2 half-lapped layers. **Note:** If vinyl tape was used to hold the copper tape in place in Step 2, remove it just prior to applying this tape. See Figure 9.

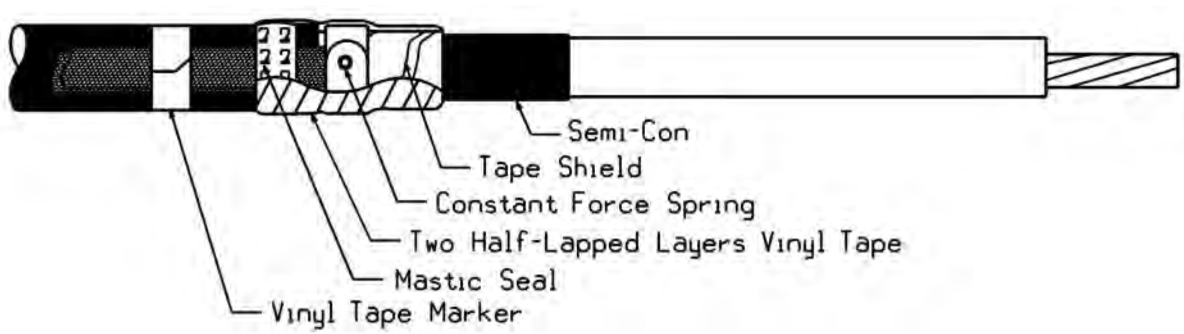


Figure 9

Continue with termination installation instructions, starting with the “Install Lug or Connector” section to complete the termination installation.

37.1.70 Terminations For Drain Wire Shield – 5 kV Thru 25 kV

In order to adapt the termination kit for use on cables rated for 5 kV through 25 kV with drain wire shield, an accessory kit will be necessary. This kit contains a solder blocked ground braid and constant force spring. Follow the instructions below for preparation of the cable and installation of the ground braid. The instructions packed with the accessory kit are for a different type of cable.

Select the accessory kit based upon the OD over the shield of the cable as listed in the following table.

Table 5

Shield OD	Accessory Kit
0.82”-1.63”	UR47T4
1.15”-2.42”	UR47T5

If the cable has fabric or tape semi-con, this material shall be cut back ¼ - ½ inch more than specified here-in for extruded semi-con layers. The exposed portion of the fabric tape semi-con shall then be wrapped with semi-con tape (Std. Item T1S) applied half lapped, until the specified semi-con cutback is reached. This tape shall then be trimmed square to the cable at the required cutback.

A. Prepare Cable:

1. Check to be sure cable size fits within the kit range, as shown in Table 1 (cover page) of the termination instructions packaged with the kit.

2. Prepare cable using dimensions shown in Figure 10. Be sure to allow for depth of terminal lug and growth of the aluminum lug (if used – see chart below).

Table 6

Aluminum Cable Size	#2 – 350 kcmil	400 – 650 kcmil	750 – 1000 kcmil
Growth Allowance	0.25”	0.50”	0.75”

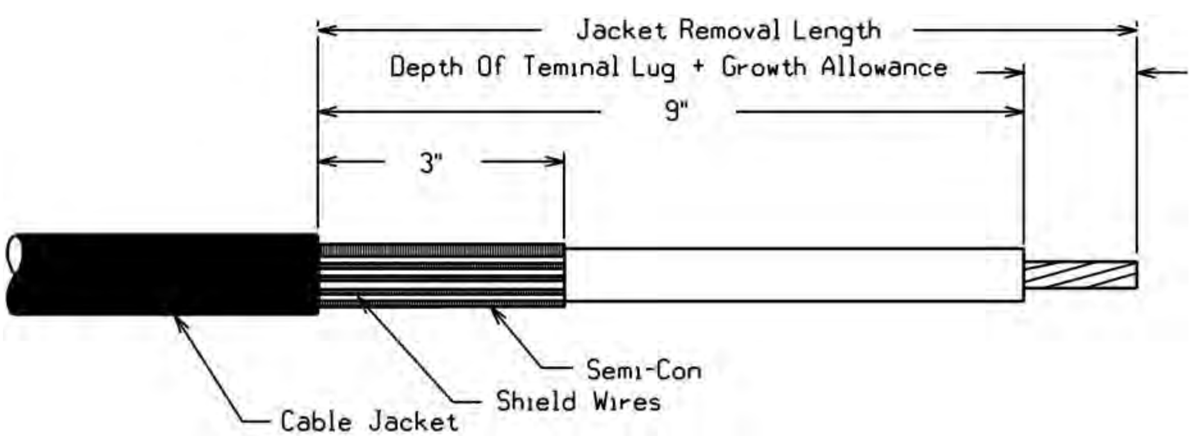


Figure 10

3. Bend the leading 1½ inches of exposed shield wires back upon themselves with the end of each wire close to the cut edge of the cable jacket. See Figure 11.

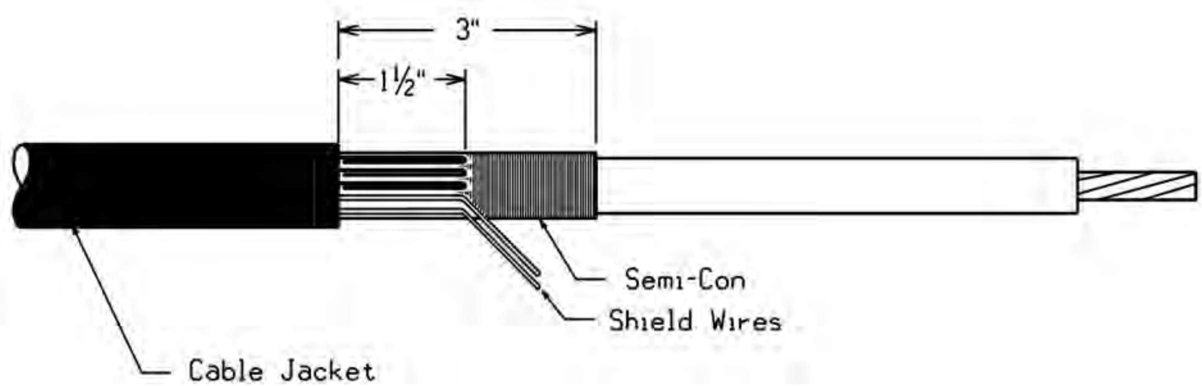


Figure 11

B. Install Ground Braid:

1. Select one of the mastic strips from termination kit and remove the white release liners. Using light tension apply a single wrap of mastic around the cable jacket ¼ inch from the cut edge. Cut off excess mastic. See Figure 12.

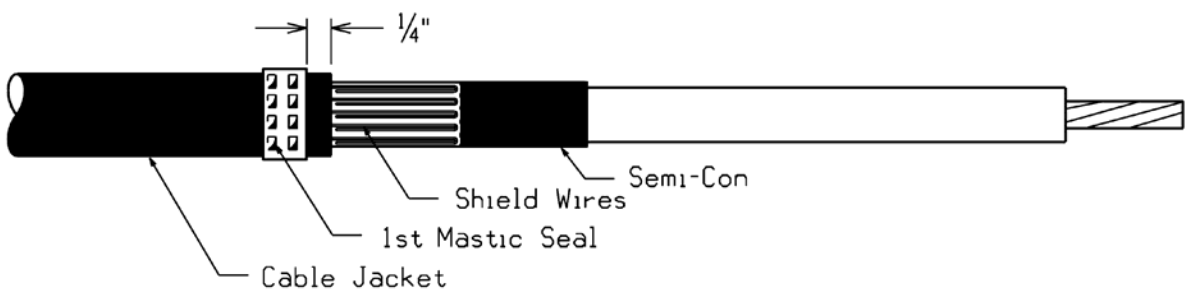


Figure 12

2. Position pre-formed "U" shaped ground braid over tape shield directly adjacent to cable jacket cut edge. The long tails should extend over the cable jacket with the solder block of one tail positioned over the mastic. Secure this tail to the cable jacket with a vinyl tape marker located 4½ inches from the edge of the cable semi-con. See Figure 13.

   Note: Position this vinyl tape with care as it will serve as the marker for final termination location on the cable.

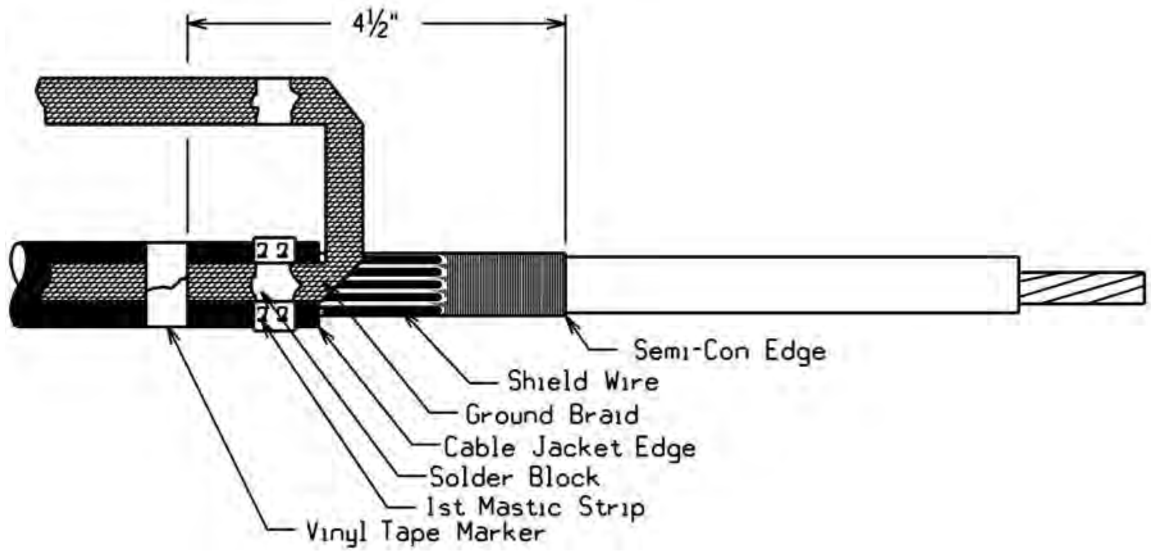


Figure 13

3. Wrap the ground braid around the metallic shield, placing the solder block on the second tail on the mastic applied in Step 1. Secure with a constant force spring. Using the second mastic strip from the termination kit, remove the liners and wrap mastic over the solder blocks and the first mastic strip. If the solder blocks overlap each other, mastic must be applied between the solder blocks as well as over them. See Figure 14.

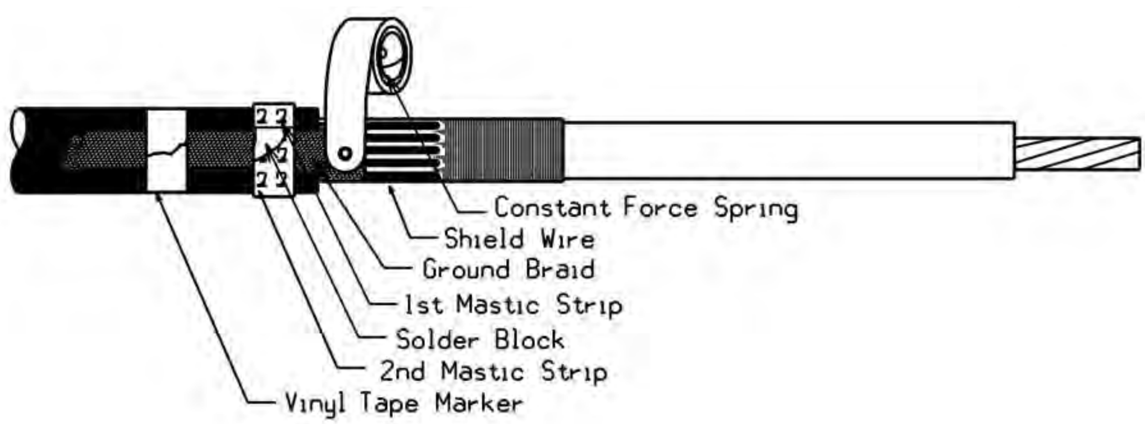


Figure 14

Supersedes 1/07 Issue – Revise 37.1.70 B3

4. Wrap two half-lapped layers of vinyl tape around the mastic seal, constant force spring and exposed metallic shield. Do not allow the vinyl tape to lap onto the cable semi-con. Do not apply more than 2 half lapped layers. See Figure 15.

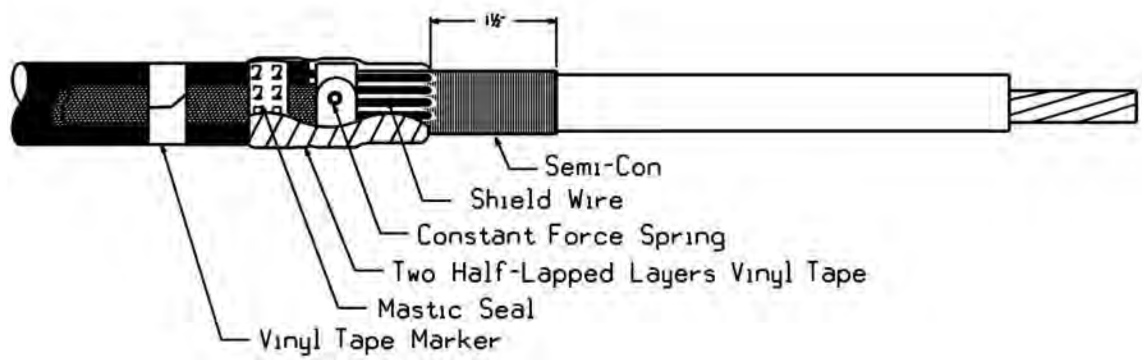


Figure 15

Continue with termination installation instructions, starting with the “Install Lug or Connector” section to complete the terminator installation.

Supersedes 1/07 Issue – Revise 37.1.70 B4

37.1.80 Terminations For Copper Tape / LC Shield 35 kV

In order to adapt the termination kit for use on 35 kV cables with copper tape or LC shield, an accessory kit will be necessary. This kit contains a solder blocked ground braid and constant force spring. Follow the instructions below for preparation of the cable and installation of the ground braid. The instructions packed with the accessory kit are for a different type of cable.

Select the accessory kit based upon the OD of the cable shield, as listed in the following table.

Table 7

Shield OD	Accessory Kit
0.82”-1.63”	UR47T4
1.15”-2.42”	UR47T5

If the cable has fabric or tape semi-con, this material shall be cut back ¼ - ½ inch more than specified here-in for extruded semi-con layers. The exposed portion of the fabric tape semi-con shall then be wrapped with semi-con tape (Std. Item T1S) applied half lapped, until the specified semi-con cutback is reached. This tape shall then be trimmed square to the cable at the required cutback.

A. Prepare Cable:

1. Check to be sure cable size fits within the kit range as shown in Table 1 (cover page) of the termination instructions packaged with the kit.

2. Prepare cable using the dimensions shown in Figure 16 and the Semi-Con Cutback in Table 9 below. Be sure to allow for the depth of terminal lug and growth of the Aluminum Lug (if used – see Table 8 below). If necessary to prevent tape shield from unraveling, TEMPORARILY hold down the edge with a single wrap of vinyl electrical tape.

Table 8

Aluminum Cable Size	**#2 – 350 kcmil**	**400 – 650 kcmil**	**750 – 1000 kcmil**
Growth Allowance	0.25”	0.50”	0.75”

Table 9
35 kV Termination Semi-Con Cutback

Insulation O.D. (ins)	**Splice Kit**		
	UR45B1	**UR45C3**	**UR45H**
0.72 – 1.08	13.5”	N/A	N/A
0.88 – 1.29	13.0	N/A	N/A
0.83 – 1.21	N/A	13.5”	N/A
0.98 – 1.53	N/A	13.0”	N/A
1.53 – 1.85	N/A	N/A	13.5”
1.65 – 2.32	N/A	N/A	13.0”

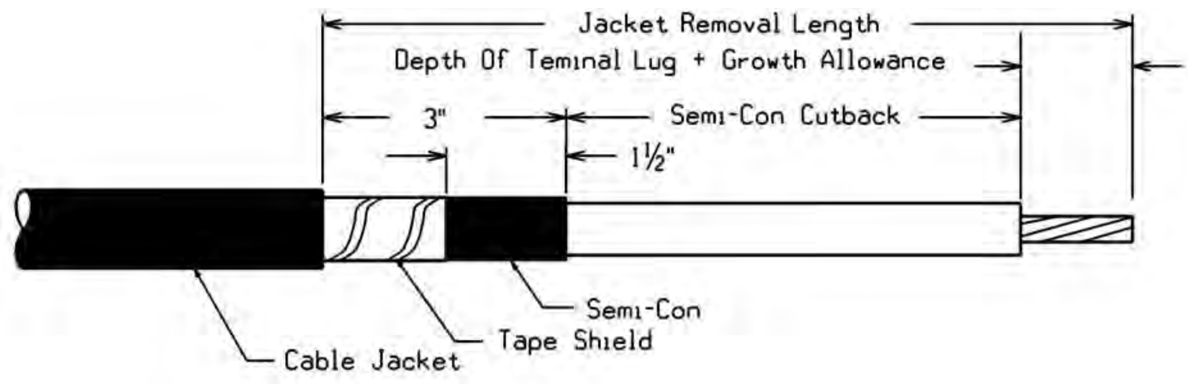


Figure 16

B. Install Ground Braid:

1. Select one of the mastic strips from the termination kit and remove the white release liners. Using light tension apply a single wrap of mastic around the cable jacket ¼ inch from the cut edge. Cut off excess mastic. See Figure 17.

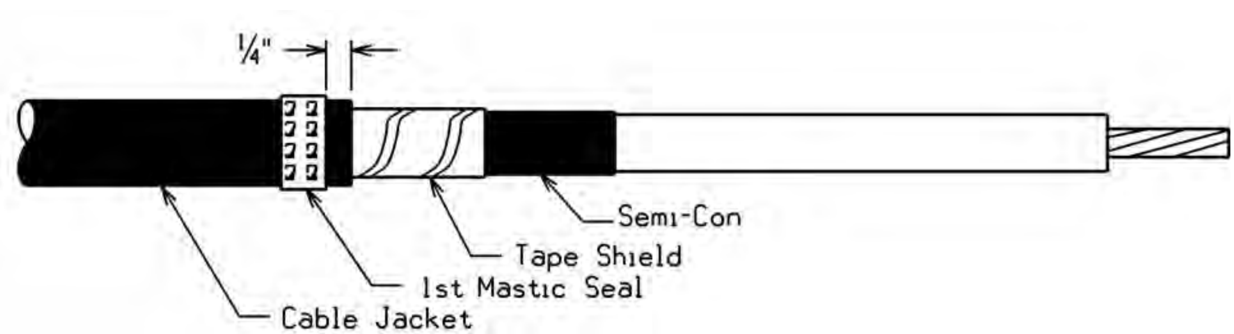


Figure 17

2. Position pre-formed "U" shaped ground braid over tape shield directly adjacent to cable jacket cut edge. The long tails should extend over the cable jacket with the solder block of one tail positioned over the mastic. Secure this tail to the cable jacket with a vinyl tape marker located 4½ inch from the edge of the cable semi-con. See Figure 18.

   Note: Position this vinyl tape with care as it will serve as the marker for final termination location on the cable.

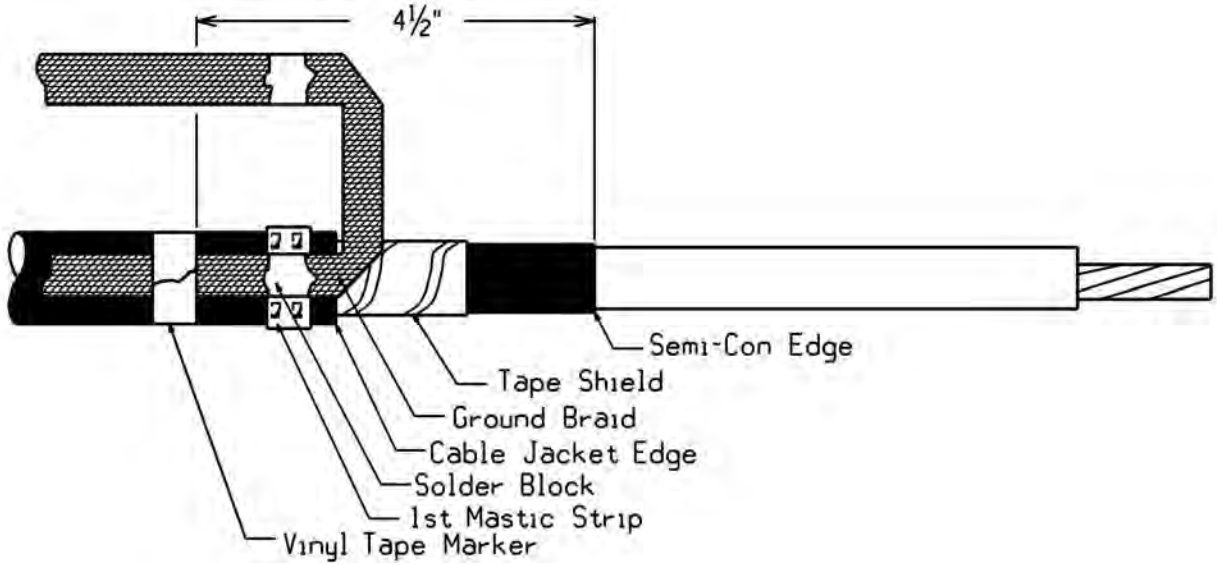


Figure 18

3. Wrap the ground braid around the metallic shield, placing the solder block on the second tail on the mastic applied in Step 1. Secure with a constant force spring. Using the second mastic strip from the termination kit, remove the liners and wrap mastic over the solder blocks and the first mastic strip. If the solder blocks overlap each other, mastic must be applied between the solder blocks as well as over them. See Figure 19.

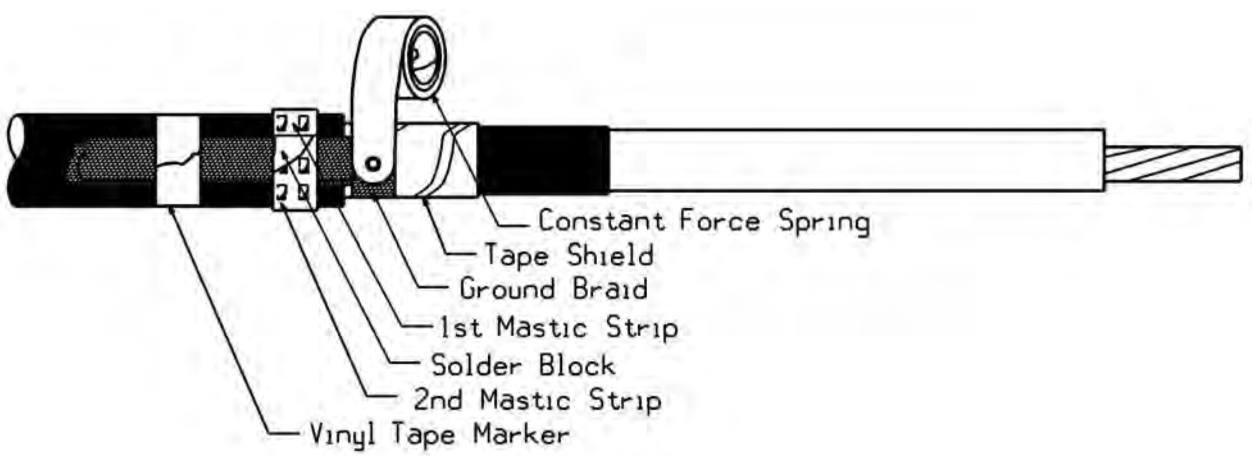


Figure 19

Supersedes 1/07 Issue – Revise 37.1.80 B3

4. Wrap two half-lapped layers of vinyl tape around the mastic seal, constant force spring and exposed metallic shield. Do not allow the vinyl tape to lap onto the cable semi-con. Do not apply more than 2 half-lapped layers. **Note:** If vinyl tape was used to hold the copper tape in place in Step 2 of preparing the cable, remove it just prior to applying this tape. See Figure 20.

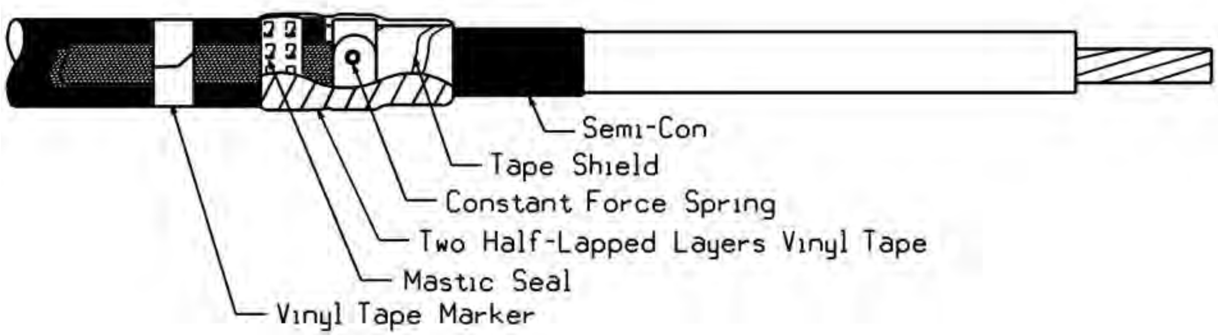


Figure 20

Continue with termination installation instructions, starting with the "Install Lug or Connector" section to complete the termination installation.

37.2 OBSOLETE TERMINATIONS

The following types of terminations are obsolete and shall not be installed on the Company system any longer:

A. Pre-molded slip on
B. Lead wiped pothead
C. Porcelain slip on (maintenance only, see section 37.4 below)
D. 200 Amp deadbreak elbows (replace with 200 Amp loadbreak equipment)

37.2.10 Pre-Molded Slip On

Pre-molded slip on type terminations are not to be installed. For any new terminations, use cold shrink terminations – See Section 37.1.

If an existing pre-molded termination is damaged, remove it and replace it with a cold shrink termination. Adjust the cutbacks of the insulation, semi-con and jacket as needed. When replacing an old slip on terminator, examine the conductor carefully to determine if there is any damage from corrosion due to water ingress – which happens frequently with this termination. The alternate repair would be to cut the cable further away from the terminator location and splice in a new piece of cable, using a cold shrink splice, as described in Section 36 – Connectors/Splices. Splices in #2 cables may be located on the pole, provided they are completely covered by U-duct. Other cable sizes will require splicing away from the pole – either direct buried or at the first pullbox / handhole / manhole.

37.2.20 Lead Wiped Pothead

Do not install any lead wiped potheads. If an existing pothead is damaged, it must be replaced with a cold shrink termination. Cut the cable back and install a piece of solid dielectric cable with a lead transition heat shrink splice as described in Section 36 – Connectors/Splices. Then install the new cold shrink termination. Check the PILC cable carefully for the presence of moisture. If moisture is present, the PILC cable must be cut back to eliminate the moisture.

Supersedes 1/07 Issue – Revise 37.1.80 B4; Paragraph 2 of Section 37.2.10; Revise Section 37.2.20

Supersedes 1/07 Issue - Revise Section s 37.2.30 and 37.2.40; Text

37.2.30 Porcelain Slip On

Pre-molded terminations with porcelain insulators (typical manufacturer was G&W) may be maintained if the cable is in good condition. Air side connectors and porcelain bodies are in stock. Repairs may be made if only these parts are needed. If more work is needed, replace the entire termination with a cold shrink termination – See Section 37.1. Check carefully for moisture damage as noted in Section 37.2.10.

37.2.40 200 Amp Deadbreak Elbows

200 Amp deadbreak elbows are not standard on the Company system, although some do still exist in service. If repair or replacement of a deadbreak elbow is needed for any reason, it should be replaced with a standard 200 Amp loadbreak elbow (Std. Item UR23). The corresponding accessories will also have to be replaced. The bushing wells are compatible on the transformer side, so after replacing a deadbreak elbow with a loadbreak elbow at a transformer or other piece of equipment, replace the bushing well insert with a loadbreak type (Std. Item UR36B).

37.3 SPECIALTY APPLICATIONS

The following types of terminations may be used in special applications only:

A. Heat shrink (only where cold shrink terminations do not fit the cable size)
B. Hand tape (only for cables smaller than #2) consult Standards Engineering for approval.

There are some applications in the Company system which will require the use of a non-standard termination. For instance, there are some cables in use having dimensions which are outside the range of the cold shrink splices. One of these cables is used for substation bus tie and / or transformer secondary main applications. Where this cable is used, heat shrink terminations will be required to meet the cable dimensions. Since this cable is never used without consultation with Underground Cable Engineering, the termination will be specified as part of the design by the Underground Cable Engineering group.

Other special applications include small size (less than #2 conductor) and low voltage (less than 5 kV), non-standard cables for some customer service installations. These will require a hand taped termination due to small dimensions of the cables. Consult Standards Engineering for hand taped termination designs as needed.

37.4 MAINTENANCE ONLY ITEMS

G&W porcelain slip on terminators may be maintained in the New England service territory for main line cables. The housing is being retained in stock (Std. Item UR47). If the terminator fails and causes cable damage, replace the entire terminator with a cold shrink termination.

G&W porcelain slip on terminations were widely used in the New England service territory over the past 25 years. These terminators are now non-standard and shall not be used for new construction or replacement where the cable has been damaged and will be pieced out. For these applications, use cold shrink splices as described in Section 37.1.

However, the porcelain bodies of the terminators, filled with the gel at the factory, are being retained in stock. If the porcelain body is damaged, but the cable is intact and does not require any repairs, the housing only may be replaced. Also, the air side connectors are also being retained at this time to allow replacement of the connector only if needed. If the air side connector is replaced, thoroughly clean the top stud of the terminator and apply oxide inhibitor prior to installing the new air side connector.

If a particular termination has been repeatedly replaced due to leaks of the gel, replace the entire termination with a cold shrink termination. If the location of the termination must remain unchanged, cut the cable further back and splice in a new piece using a cold shrink splice as described in Section 36 - Connectors/Splices.

37.5 600 AMP DEADBREAK ELBOWS (T-BODY)

600 Amp deadbreak elbows (Std. Item UR60) shall be routinely used only as a termination. They shall not be normally used as a splice. There are a few exceptions to the use as a splice, see Section 36.11 for details. These terminations are generally needed for connection to vacuum switches, SF6 insulated switchgear, network transformers, pad-mount transformers and similar equipment. These elbows shall not be used as an alternate for straight splice or a T splice. For straight splices, use a standard cold shrink splice as described in Section 36 – Connectors/Splices. For T splices, use a pre-molded 'Y' splice as described in Section 36 – Connectors/Splices.

The elbows are available in two voltage classes, 25 kV and 35 kV. The 25 kV elbow may be used for all voltages from 5 kV through 25 kV. Follow the installation instructions in the elbow package. Be sure that the correct cable adapter (Std. Item UR64) and connector (Std. Item UR63) are used. The connectors are not voltage sensitive, only conductor size sensitive. The cable adapters are voltage sensitive – the lower voltage adapters are good for 5 – 25 kV applications, while the higher voltage ones are good for 35 kV only. The cable adapter is selected according to the OD of the cable insulation, under the semi-con layer. Pick the cable adapter where the cable insulation OD is as close as possible to the middle of the adapter range.

Some existing 35 kV elbows are 'stick-op' style for use on the 35 kV distribution feeders. These elbows utilize a different lug, connecting plug and dead end plug. The appropriate fittings are available to convert these to the normal deadbreak style elbows. Contact Standards Engineering for more information.

Orient the connector with the equipment prior to crimping on the connector. This will prevent excessive twisting of the cable to install the elbow after installation. All bolted connections shall be made using a torque wrench. The dead end plugs shall be tightened to 55 foot-pounds +/- 5 foot-pounds. Minimize cable movement after final tightening to prevent loosening the connection.

Any time these dead break elbows are installed as connections to equipment – transformers, switchgear, etc – the preferred method of installation is to install a reducing tap well (Std Item UR68_) on the outside of the elbow and use an insulating cap (UR24 for 15kv and UR 91 for 35 kV) to complete the installation. This allows for a location to perform a direct voltage test and install personal protective grounds as needed for maintenance work.

When a multi way submersible switch is installed, elbows with grounding provisions and short cables with live end caps shall be installed on any unused ways. Installation of these cables will prevent any nuisance voltages from developing on the unused ways. Also, grounding elbows can be installed on the unused way while the live end caps are removed and straight splices installed to make use of the way on the switch. See Figure 21.

Supersedes 1/07 Issue – Add Paragraphs 5 & 6 to Section 37.5, Text Shift

Supersedes 1/07 Issue – Add New Figure 21; Text Shift

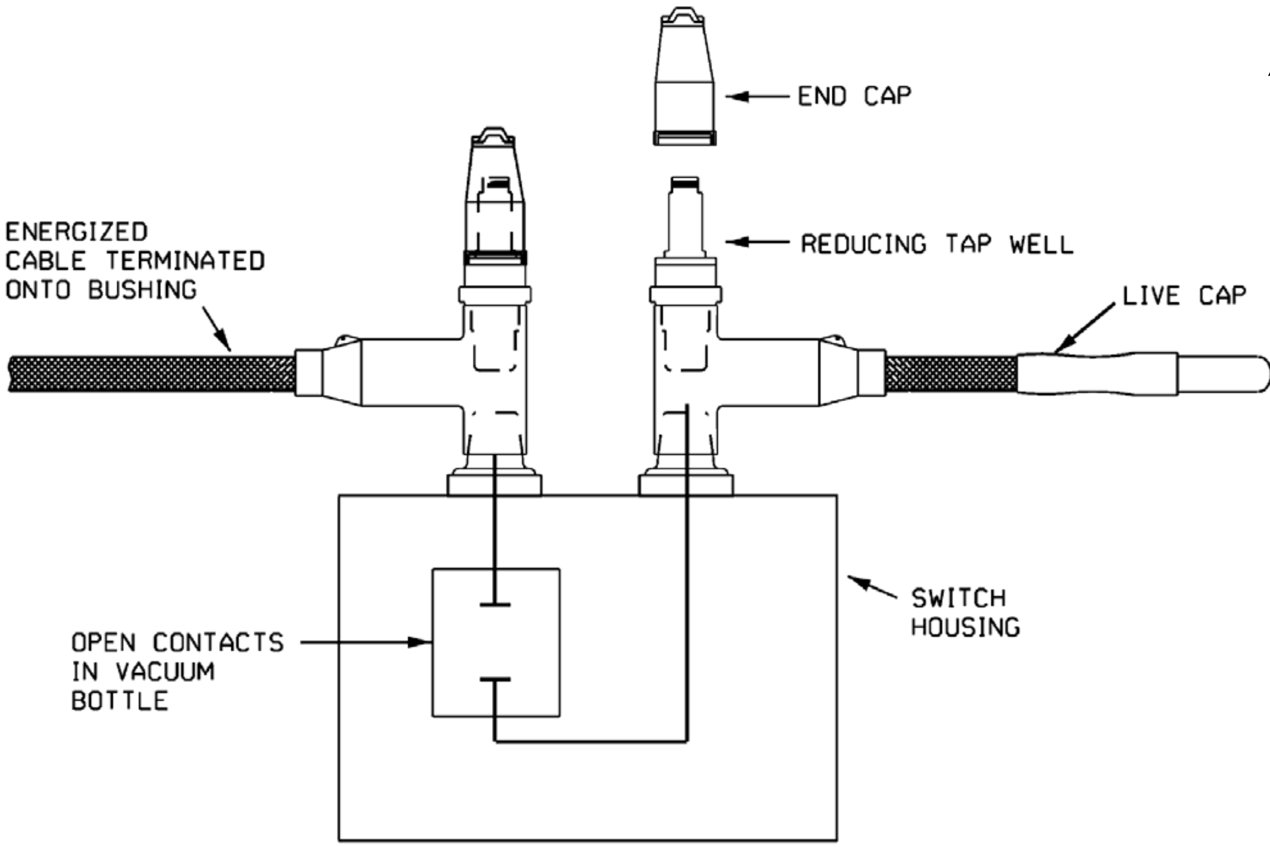


Figure 21

37.6 200 AMP LOADBREAK ELBOWS

200 Amp loadbreak elbows (Std. Item UR23 for 15 kV or UR90 for 35 kV), are the primary termination used for all pad-mount transformers, except those used on 23 kV, delta connected (ungrounded or resistance grounded) systems. They are not used on these systems since the phase to ground voltage can exceed the rating of the elbow during phase to ground fault events. They are used for all subway and subsurface transformer primary connections, and connections to various types of equipment, such as vacuum switches.

Follow the installation instructions included with the elbow. The kit is size sensitive due to the connector to be crimped on the end of the conductor and the cable insulation OD range. Consult Standards Engineering for applications where the cable dimensions do not meet the requirements of the in stock elbow kits.

Elbows installed on jacketed concentric neutral cable must have a jacket sealing kit (Std. Item UR23B) installed. This will prevent the ingress of moisture under the jacket which could cause corrosion of the concentric neutral wires. After making the required jacket cutback, install one of the mastic strips on the cable jacket as described in the sealing kit instructions. Then bend the neutrals back and bed them in the mastic. Slide the cold shrink sealing tube over the cable and the neutrals. Continue with the installation of the elbow and then complete the jacket sealing kit. Use caution when threading the loadbreak probe into the connector to prevent cross threading – which is a common failure mode. Tighten the probe with the one time tool included with the elbow or use the torque limited tool designed for the purpose.

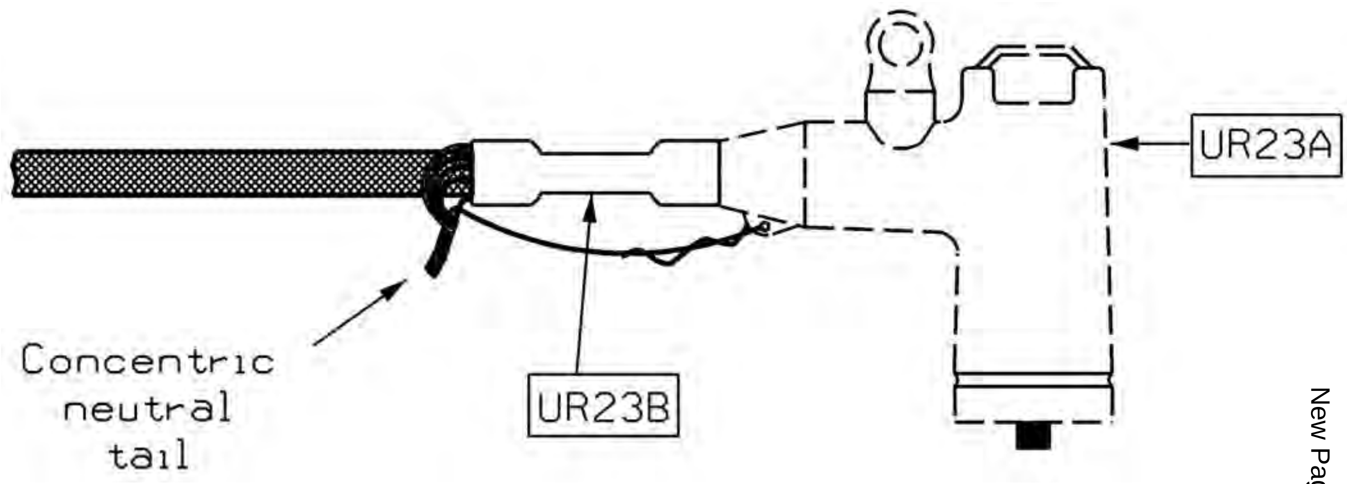


Figure 22

37.7 LIVE END SEAL, HEAT SHRINK

Live end seals (Std. Item UR77) are available for systems from 5 kV through 25 kV. They can be installed on paper lead and solid dielectric cables. Choose the correct seal kit based on the OD of the cable insulation. Follow the instruction in the kit for installation, being sure to heat the outer cap sufficiently to ensure a tight seal to the lead sheath or the cable jacket.

Live end seals on solid dielectric 35 kV cable consist of a 600 Amp deadbreak elbow with two insulating plugs. This method is also an alternate to the live end seal kits on solid dielectric 5 kV through 25kV cables. See Section 37.5.

Be sure to bond the concentric neutral / drain wires / lead sheath to ground when installing a live end seal.

New Page – Renumber Figure 21 to 22, Revise Paragraph 2 of Section 37.7

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1	07/10	• Revise Paragraphs 1, 3, 4, 5, 6, 7 8, 9, &10 of Section 37.0 • Revise Section 37.0.10 • Revise Figure 1 and add Note 2 • Revise Note 2 to Table 1 of Section 37.1.40 • Revise Section 37.1.40 • Revise Paragraph 2 of Section 37.2.10 • Revise Section 37.1.60 B3 & B4 • Revise Section 37.1.70 B3 & B4 • Revise Section 37.1.80 B3 & B4 • Revise Section 37.2.20 • Revise Section 37.2.30 • Revise Section 37.2.40 • Add new Paragraphs 5 & 6 and Figure 21 to Section 37.5 • Renumber Figure 21 to 22 on page 37-18 • Revise Section 37.7 Paragraph 2	Tim Hayden	Allen Chieco, Director of Distribution Standards and Work Methods

New Page – Add Change Table

Supersedes 7/08 Issue – Added Drawings 38-200 and 38-204.

Supersedes 2/06 Issue - Text shift due to editing.

38.0 GENERAL

The following Standard is the practice to be followed when designing the application of, and installing underground (UG) distribution system switches and their related equipment. This Standard is not intended to apply to secondary networks.

Switches designed for use with underground systems provide operational control and worker protection for the UG distribution system. UG switches and switchgear can be used as isolation points to remove a section of underground cable from the energized system. Switchgear and vacuum switches provide fused or electronic interrupting protection for the underground distribution system.

38.1 CUSTOMER REQUIREMENTS

In general, the Company's customer service policies require that customers "having the potential to exceed 75 kVA of transformer capacity are required to supply space for electrical equipment on private property" (See the *SPECIFICATIONS FOR ELECTRICAL INSTALLATIONS* or *ELECTRICAL SERVICE, INFORMATION AND REQUIREMENTS* for specific information related to different operating areas.). This generally requires the customers whose loads may reasonably be expected to exceed 75 kVA at some point in the future to provide a location for a pad-mounted transformer and pad-mounted switchgear. This could reasonably be expected to include any three-phase customer.

38.2 SWITCHING EQUIPMENT INSTALLATIONS

Listed below are guidelines for the installation of switching equipment and transformation in urban UG areas. These guidelines are listed in order of preference. Every effort should be made to install equipment serving new customers in accordance with the first choice below. The responsible engineer, the engineering manager, and the operations manager must review exceptions to these guidelines.

A. The first choice in expanding or developing new UG systems is to install a completely pad-mounted system. All switchgear and transformers should be pad-mounted and easily accessible to operating personnel using standard tools.

B. The second choice is to build a system where switchgear and transformers are installed below grade, but are completely accessible from grade using standard tools for operation and grounding. Generally, equipment should be installed in vaults that are not intended to be accessed by personnel on a regular basis, so-called half vaults, hand holes, etc. Building vaults on customer property would also fit into this category.

C. The third choice is to install switchgear and transformers in manholes intended for personnel access. This equipment shall be accessible remotely and not require personnel to be in the manhole during switching operations. This remote operation can be accomplished through use of standard tools or by rigging, remote operators, or other means.

Switches and transformers with load break elbows, or other separable connections, may be installed in locations that require personnel to be in a manhole when operating elbows PROVIDED adequate means have been designed to allow the elbows or other connectors to be removed de-energized following all applicable safety rules and policies.

38.3 SWITCHING EQUIPMENT

38.3.10 Standard Underground Switching Equipment

A. 15 kV, 23 kV, and 35 kV Three Phase Pad-Mounted Switchgear – Available in several configurations (See Sections 38.4 38.5 and 38.6).

B. 15 kV and 35 kV Submersible Switches – Two way and multiple way switches available in several configurations (See Section 38.7).

C. 15 kV Switching Junction Enclosure and Fused Switchpad (See Section 38.8).

D. Oil Fuse Cutouts – “Information provided for maintenance only” (See Section 38.9).

38.4 THREE PHASE PAD-MOUNTED SWITCHGEAR – 15 kV

A) LIVEFRONT TERMINATION STYLE

This Section covers the design, installation, and construction of three phase, pad-mounted switchgear (Std. Items US36H, US36HS, US36J, US36K, and US36L). This Section shall apply in conjunction with the Section 44 – UCD (Underground Commercial Distribution) and Section 45 – URD (Underground Residential Distribution) of the Underground Construction Standards Manual.

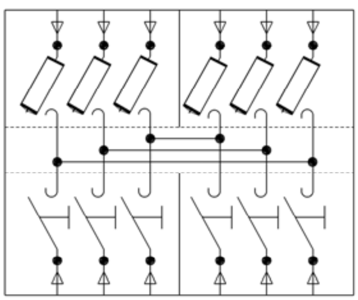


Figure 1
PMH-9 US36H & US36HS

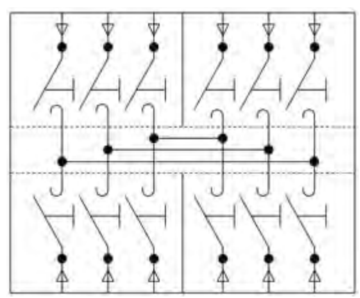


Figure 2
PMH-10 US36J

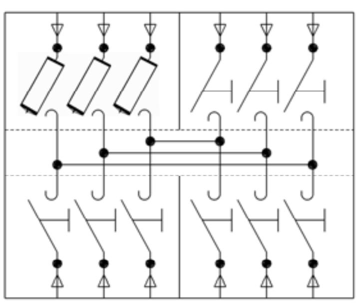


Figure 3
PMH-11 US36K

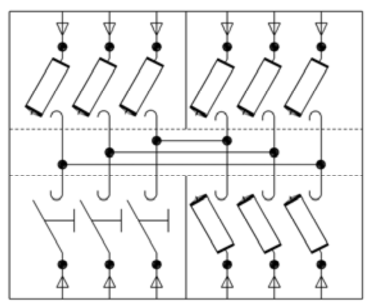


Figure 4
PMH-12 US36L

B) ELBOW TERMINATION STYLE

38.4.10 Locations And Clearances

Three phase pad-mounted switchgear shall be located in an easement area, exact size of this area to be determined by Distribution Design. A minimum of 10 feet on the door sides of the switchgear and 5 feet on the non-door sides must be clear for switching and maintenance. Refer to Section 44 – UCD for additional clearance information and for bollard locations.

Supersedes 7/08 Issue – Text Update in 38.3.10 and added sub header in 38.4

38.4.20 Foundation

Either the fiberglass reinforced plastic vault pad (Std. Item UF3) or the pre-cast switchgear manhole (Std. Item UM20A shall be used as the foundation for PMH style switchgear (Std. Items US36H, US36HS, US36J, US36K, or US36L). For cable sizes of 500 and greater for terminating onto the switchgear, the switchgear manhole is preferred.

A. Fiberglass Reinforced Plastic Vault Pad – (Std. Item UF3) Excavation for the vault pad shall be to the proper grade so that the foundation rests well tamped and/or undisturbed earth.

B. Pre-Cast Switchgear Manhole (Std. Item UM20A - manhole and collar) – Fill the bottom of the excavated hole with 1 foot of well compacted, crushed, bank gravel.

38.4.30 Installation

A. Switchgear on a Fiberglass Reinforced Plastic Vault Pad – Prior to installation review drawing 38-104 and 38-106 for proper conduit entry way and install the conduits. Install the vault pad, ground rods and a ground grid as shown on Page 38-100. For direct burial installation drawing 38-102 shows typical cable arrangement under the vault pad. Note: primary cable shall be brought into the vault pad allowing a minimum of four inches of soil between the cable and the vault pad vertical walls. Loop the cables around the inside of the vault pad and train the cable so that it can be extended two or three feet above the top of the vault pad. Backfill around the vault pad in 6 inch lifts to proper grade.

B. Pre-Cast Switchgear Manhole – Set precast manhole and collar. Install ground rods and ground grid shown on Page 38-101.

Install the three phase, pad-mounted switchgear on the vault pad or manhole and remove the lifting provisions from the switchgear.

After the switchgear is secured to the vault pad, fill the space, if any, between the base of the switchgear and the top of the vault pad or switchgear manhole collar (Use Std. Item S2 or S3). Terminate the primary cable in its respective compartment as required; see Page 38-102 for terminating pad assembly detail. Cable termination brackets shall be mounted in the horizontal position to maximize clearance between cable neutrals and live components. Make the neutral and grounding connections. Neutral and ground connections must be made before the switchgear is energized.

38.4.40 Fusing

Standard fuses (Std. Items F6E and F6K) shall be used as required with fuse end fittings (Std. Item C51). Note that older installations may have different style fuses (Std. Item F4E) with corresponding fuse holder (Std. Item C49B). Additional information is in Section 39 for fusing details, fuse sizing and coordination.

38.4.50 Labeling

Install identification information on switchgear as shown on Page 38-103. At a minimum the Control Center will issue a six digit number for all mainline switch devices and require the property address or location number to be labeled. Refer to Page 38-103 for switchgear labeling and security system.

Supersedes 2/06 Issue – Text Updates

38.5 THREE PHASE PAD-MOUNTED SWITCHGEAR – 23 kV

This Section covers the design, installation, and construction of three phase, pad-mounted switchgear (Std. Item US37H). This Section shall apply in conjunction with the Section 44 – UCD (Underground Commercial Distribution) and Section 45 – URD (Underground Residential Distribution) of the Underground Construction Standards Manual.

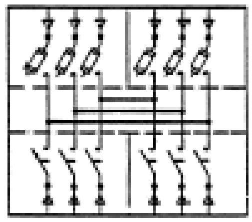


Figure 5 PMH-9 US37H

23 kV pad-mounted switchgear may be dead front design if the 23 kV system is effectively grounded - per Material Specification 2790. This switchgear is rated 200 A, available with 2 switched positions and either 1 or 2 fused positions. If the 23 kV system is delta, resistance grounded or a single point grounded design (not effectively grounded) or in the event that 600 A switchgear is needed, contact Standards Engineering for assistance.

Supersedes 2/06 Issue 38.5 Update
Supersedes 2/06 Issue –Updates in 38.5

38.5.10 Locations And Clearances

Three phase pad-mounted switchgear shall be located in an easement area, exact size of this area to be determined by Distribution Design. A minimum of 10 feet on the door sides of the switchgear and 5 feet on the non-door sides must be clear for switching and maintenance. Refer to Section 44 – UCD for additional clearance information and for bollard locations.

38.5.20 Foundation

Either the fiberglass reinforced plastic vault pad (Std. Item UF4) or the pre-cast switchgear manhole (Std. Item UM20B) shall be used as the foundation for PMH style switchgear. For cable sizes of 500 and greater terminating onto the switchgear, the use of the switchgear manhole is preferred.

A. Fiberglass Reinforced Plastic Vault Pad – (Std. Item UF4) Excavation for the vault pad shall be to the proper grade so that the foundation rests well tamped and/or undisturbed earth.

B. Pre-Cast Switchgear Manhole (Std. Item UM20B - manhole and collar) – Fill the bottom of the excavated hole with 1 foot of well compacted, crushed, bank gravel.

38.5.30 Installation

A. Switchgear on a Fiberglass Reinforced Plastic Vault Pad – Prior to installation review drawing 38-105 and 38-106 for proper conduit entry way and install the conduits. Install the vault pad, ground rods and a ground grid as shown on Page 38-100. For direct burial installation drawing 38-102 shows typical cable arrangement under the vault pad. Note: primary cable shall be brought into the vault pad allowing a minimum of four inches of soil between the cable and the vault pad vertical walls. Loop the cables around the inside of the vault pad and train the cable so that it can be extended two or three feet above the top of the vault pad. Backfill around the vault pad in 6 inch lifts to proper grade.

B. Pre-Cast Switchgear Manhole – Set precast manhole and collar. Install ground rods and ground grid shown on Page 38-101.

Install the three phase, pad-mounted switchgear on the vault pad or manhole and remove the lifting provisions from the switchgear.

After the switchgear is secured to the vault pad, fill the space, if any, between the base of the switchgear and the top of the vault pad or switchgear manhole collar (Use Std. Item S2 or S3). Terminate the primary cable in its respective compartment as required; see Page 38-102 for terminating pad assembly detail. Cable termination brackets shall be mounted in the horizontal position to maximize clearance between cable neutrals and live components. Make the neutral and grounding connections. Neutral and ground connections must be made before the switchgear is energized.

38.5.40 Fusing

Standard fuses (Std. Items F19_) shall be used as required with fuse end fittings (Std. Item C49_). Additional information is in Section 39 for fusing details, fuse sizing and coordination.

38.5.50 Labeling

Install identification information on switchgear as shown on Page 38-103. At a minimum the Control Center will issue a six digit number for all mainline switch devices and require the property address or location number to be labeled. Refer to Page 38-103 for switchgear labeling and security system.

Supersedes 2/06 Issue – Section 38.5 and 38.6 Updates

38.6 THREE PHASE PAD-MOUNTED SWITCHGEAR – 35 kV

This Section covers the design, installation, and construction of three phase, pad-mounted switchgear (Std. Items US38C, US38D, US38E and US38F). This Section shall apply in conjunction with the Section 44 – UCD (Underground Commercial Distribution) and Section 45 – URD (Underground Residential Distribution) of the Underground Construction Standards Manual.

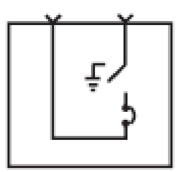


Figure 6
US38C 2 way
1 way fault interrupter

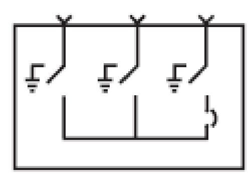


Figure 7
US38D 3 way
2 ways load interrupters,1 way fault interrupter

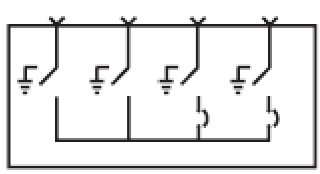


Figure 8
US38E 4 way
2 ways load interrupters and
2 ways fault interrupter

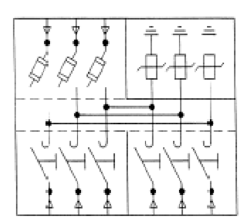


Figure 9
US38F 3 way
2 ways load interrupters, 1 way fuses
(1 way surge arrester compartment)
Maintenance use only

38.6.10 Locations And Clearances

Three phase pad-mounted switchgear shall be located in an easement area, exact size of this area to be determined by Distribution Design. A minimum of 10 feet on the door sides of the switchgear and 5 feet on the non-door sides must be clear for switching and maintenance. Refer to Section 44 – UCD for additional clearance information and for bollard locations.

38.6.20 Foundation

Either the fiberglass reinforced plastic vault pad (Std. Item UF5A, UF5B) or the pre-cast switchgear manhole (Std. Item UM20C or UM20D shall be used as the foundation for switchgear in figures 6, 7 and 8. (Std. Items US38C, US38D or US38E).

A. Fiberglass Reinforced Plastic Vault Pad – Excavation for the vault pad shall be to the proper grade so that the foundation rests on undisturbed earth.

B. Pre-Cast Switchgear Manhole (Std. Item UM20C or UM20D - manhole and collar) – Fill the bottom of the excavated hole with 1 foot of well compacted, crushed, bank gravel.

38.6.30 Installation

Install ground rods and a ground grid as shown on Page 38-100, for the fiberglass reinforced plastic vault pad. Refer to Page 38-101 for grounding instructions for the pre-cast switchgear manhole.

Install the vault pad or manhole before the ground grid is installed. If going direct buried into a vault pad, the primary cable shall be brought into the vault pad allowing a minimum of four inches of soil between the cable and the vault pad vertical walls. Loop the cables around the inside of the vault pad and train the cable so that it can be extended two or three feet above the top of the vault pad. Backfill around the vault pad in 6 inch lifts to proper grade.

Install the three phase, pad-mounted switchgear on the vault pad or manhole and remove the lifting provisions from the switchgear.

After the switchgear is secured to the vault pad, fill the space, if any, between the base of the switchgear and the top of the vault pad (Use Std. Item S2 or S3). Terminate the primary cable in its respective compartment as required; see section 37.5 for information on deadbreak elbow terminations. Make the neutral and grounding connections. Neutral and ground connections must be made before the switchgear is energized.

Supersedes 2/06 Issue –Update in 38.6

38.6.40 Fusing

Standard items US38C, US38D and US38E are supplied with programmable over current controls. Field engineering can select appropriate standard E or K relay curves for proper coordination.

For standard item US38F standard fuses (Std. Items F7_) shall be used as required with fuse end fittings (Std. Item FH). Additional information is in Section 39 for fusing details, fuse sizing and coordination.

38.6.50 Labeling

Install identification information on switchgear as shown on Page 38-103. At a minimum the Control Center will issue a six digit number for all mainline switch devices and require the property address or location number to be labeled. Refer to Page 38-103 for switchgear labeling and security system.

38.7 SUBMERSIBLE SWITCHES

This Section covers the design, installation, and construction of single phase and three phase, submersible mounted switches (Std. Items US40_, US41_, and US42_). They are intended for use in UG distribution systems, 15 kV and below, where pad-mounted switches cannot be installed. Application on other systems requires engineering review.

38.7.10 Locations

Submersible switches may be installed below grade where the switch is completely accessible from grade using standard tools. Generally, equipment should be installed in locations that are not intended to be commonly accessed by personnel on a regular basis (e.g. so-called half vaults, sidewalk vaults, etc.). Building vaults on customer property would also fit into this category.

Where conditions require that submersible switches be installed in spaces intended for personnel access, typical manholes for instance, the switch should be accessible remotely and not require personnel to be in the manhole during switching operations. This remote operation can be accomplished through use of standard tools or by rigging, remote operators, or other means.

38.7.20 Installation

All submersible switches up to a three phase, three way switch shall be installed in a sidewalk manhole as a minimum. Three phase, four way switches shall be installed in a switchgear manhole. Typical switch installations are shown on pages 38-120 thru 38-122. The sidewalk manhole, standard item UM28 will accommodate up to a three way switch. Four way switches shall be installed in a switchgear manhole with the switchgear collar E entry way, standard item UM20E shown on page 38-122. All switches shall be mounted on a stand (see table 1). The stand and switch shall be properly grounded to the manhole along with anodes to keep corrosion to a minimum, see section 33.2 for further details on grounding and bonding.

For submersible switch installation in existing infrastructure, the structure shall be modified with two openings, one for entry way and the other for equipment installation and maintenance.

Switch Std Item	Switch Stand Std Item
US40A	US40F
US40B	US40G
US40C	US40F
US40D	US40G
US41A	US41AA
US41B	US41BA
US41C	US41CA
US42A	US42AA
US42B	US42BA

Table 1

Supersedes 2/06 Issue – Section 38.7 Text Updates

Standard submersible switches, rated 15 kV, and are to be built with 15 kV 600 A separable connectors, with a 200 amp reducing tap plug that allows the installation of a standard grounding elbow (See Figure 10).

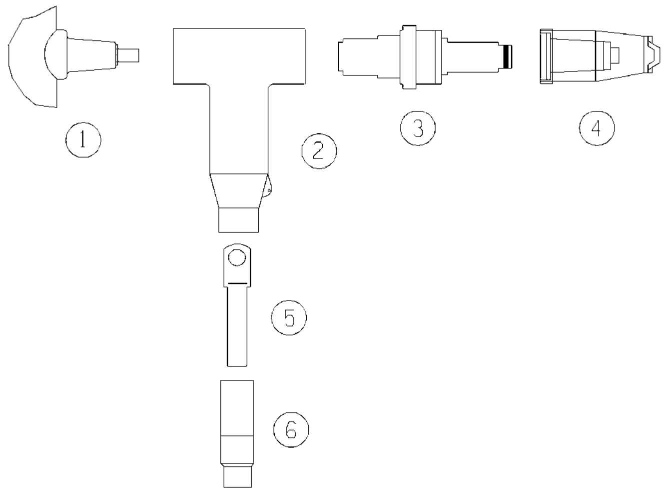


Figure 10

Identifier	Material Description	Std. Item	CU Code
1	600 A Apparatus Bushing		
2	600 A Elbow Connector	UR60A	CPCS * K ** SNE
3	Reducing Tap Well	UR68A1	CPCSRTW
4	Loadbreak Insulating Receptacle	UR24	CLIC15K
5	Terminal Lug	UR63__	Part of elbow conn.
6	Cable Adapter	UR64__	Part of elbow conn.

* Voltage 5, 15, or 25 kV
** Cable sizes #2, 1/O, 4/O, 350, 500, 750 and 1000

Table 2

38.7.30 Fusing

Electronic fuse protection is available in some submersible switches. Submersible switches US40C and US40D have an internal programmable relay. Submersible switches US41A and US41C have an external programmable relay that comes with each switch. Software and assistance for programming is available, refer to Distribution Engineering for assistance.

38.7.40 Ratings And Limitations

Standard submersible switches are rated 15 kV and have 600 A separable connectors, with a 200 A reducing tap plug that allows the installation of a standard grounding elbow (Std. Item UR32).

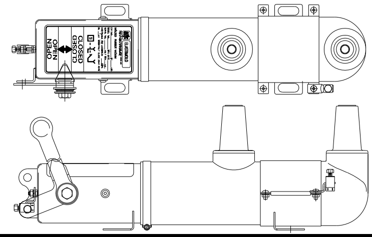
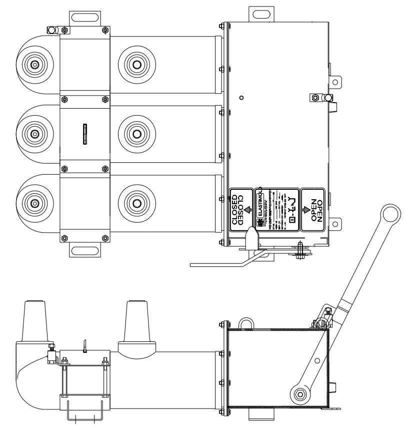
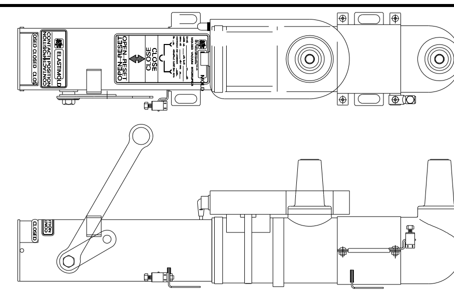
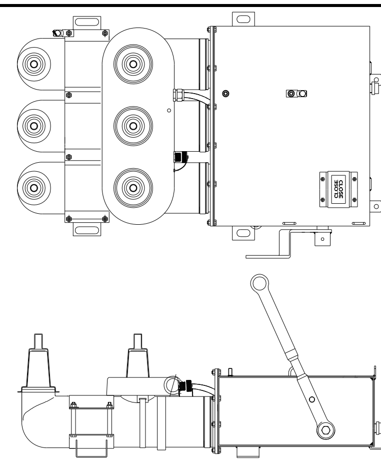
The 200 A loadbreak elbow interface has a 10,000 A symmetric, 10 cycle momentary and fault close rating. Therefore submersible switches should not be used in locations where the short circuit duty exceeds 10,000 A symmetric.

Supersedes 2/06 Issue – Section 38.7 Text Update

38.7.50 Switching Equipment

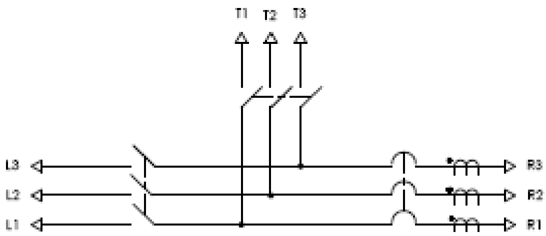
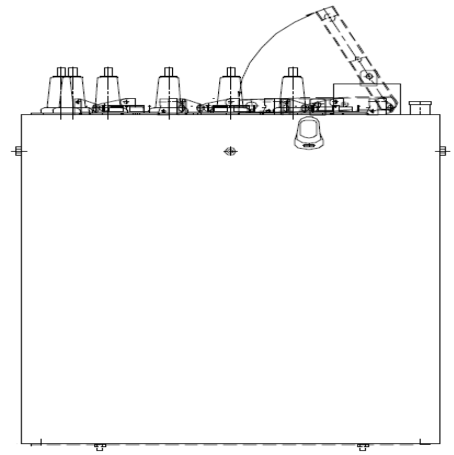
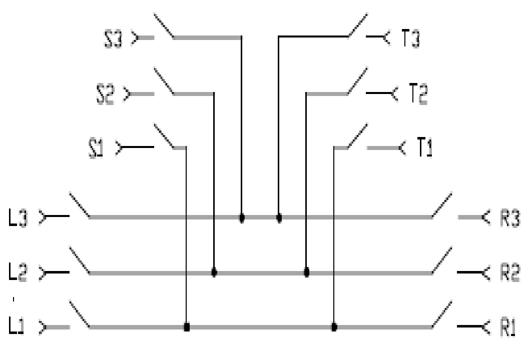
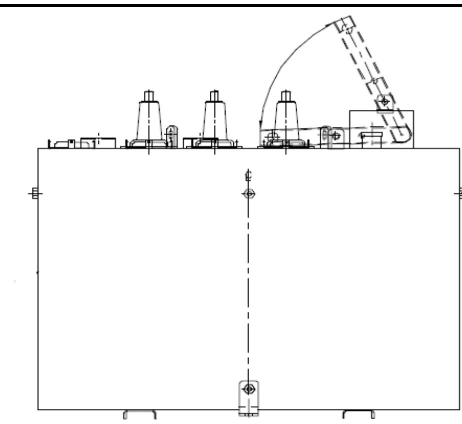
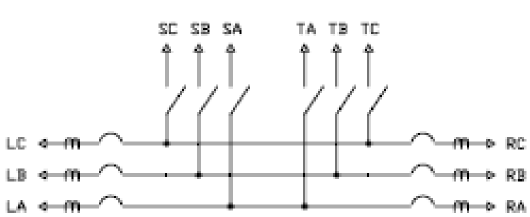
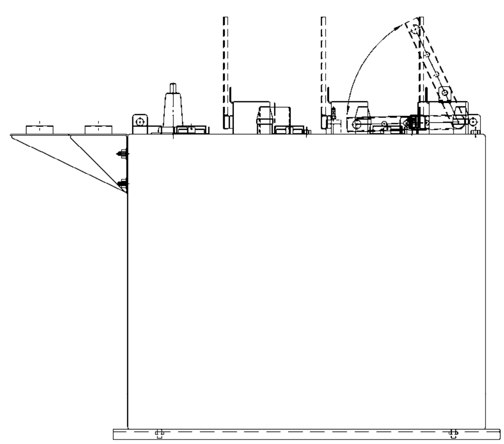
The following submersible switches are standard for underground application at voltage levels 15 kV and below. For three phase operation, gang operated switches shall be used.

Table 3
Standard Submersible Switches – 15 kV

Std. Item	Phases	Description	Illustration
US40A	1	With no overcurrent protection	
US40B	3	With no overcurrent protection	
US40C	1	With overcurrent protection	
US40D	3	With overcurrent protection	
US40E	-	Control cable	For use with US40 switches only

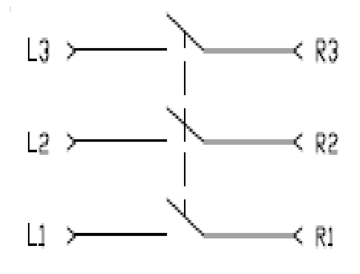
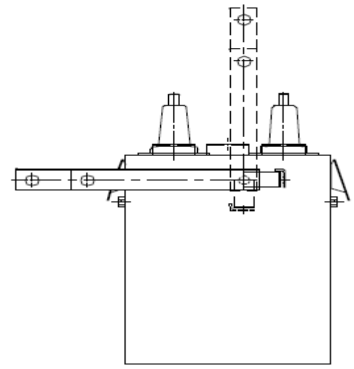
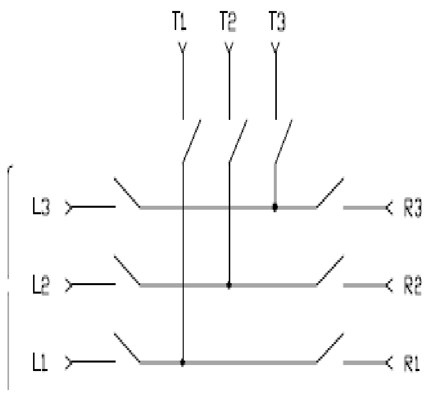
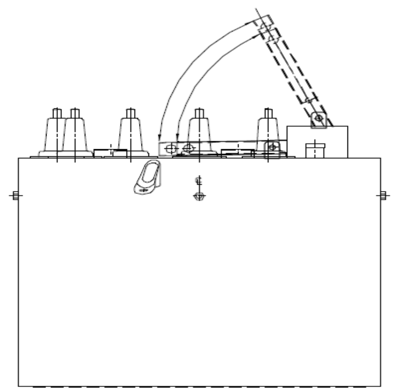
Supersedes 2/06 Issue - Text shift.

 | Doc. # ST. 38.00.001

Std. Item	Wiring One Line Diagram / Description	Illustration
US41A		
US41AR	Programmable External Relay for US41A	
US41B		
US41C		
US41CR	Programmable External Relay for US41C	

Supersedes 2/06 Issue – Update to US41A and Added US41AR, US41C and US41CR

Standard Submersible Switches – 23 kV
(can be used at 15kV Class also)

Std. Item	Wiring One Line Diagram	Illustration
US42A		
US42B		

Supersedes 2/06 Issue – Section 38.8 Update

38.8 SWITCHING JUNCTIONS

Single phase padmounted junctions 200 Amp

Single phase junctions (STD Item US33F1) are to be used for terminating cable points in URD's where there are radial sidetaps. The single phase junctions are to be mounted on a minipad boxpad. Single phase junction comes complete, fiberglass reinforced cabinet with a four position junction, parking stand and ground bus bar installed. See figure 11 for typical schematic detail.

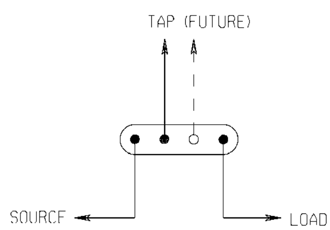


Figure 11

Three phase padmounted junctions 200 Amp

Three phase junctions are available in two styles.

1) Std Item US33F1 is to be used for terminating cable points in URD's and UCD's where there are radial sidetaps. The three phase junctions US33F1 are to be mounted on a primary pull/splice box (Std Item UR6). This three phase junction comes complete, fiberglass reinforced cabinet with four position junctions, parking stands and ground bus bar installed. See figure 12 for schematic detail. Preferred installation method.

2) Std Item US33 is to be used for terminating cable points in URD's and UCD's where there are radial sidetaps. The three phase junction US33, is to be mounted on a URD minipad boxpad. This three phase junction comes with grounding attachment points. Junctions and mounting hardware applicable Std. Items UR28C, UR28D, UR28CH, UR28DH can be chosen for proper installation. See figure 12 for schematic detail. Alternate installation method.

Supersedes 2/06 Issue – Update in 38.8 and Figure 12

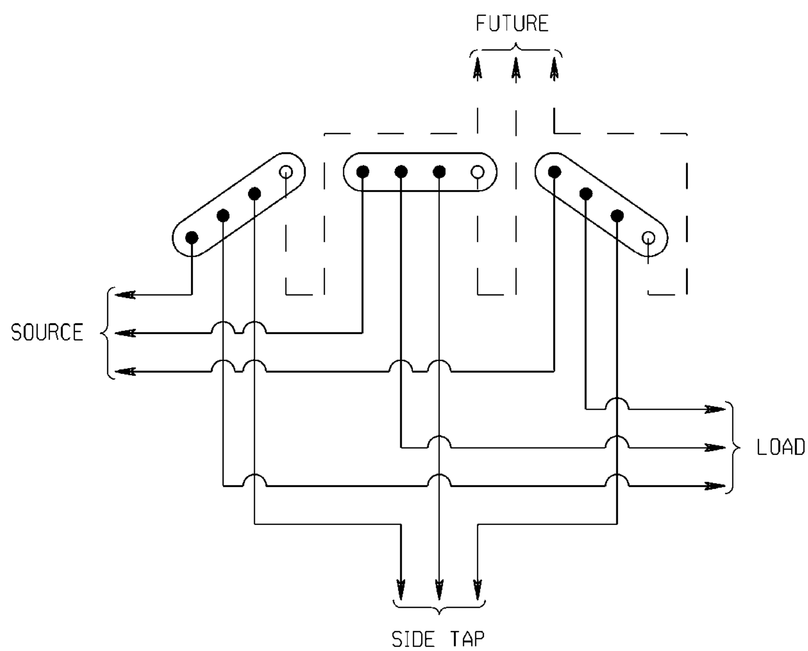


Figure 12

38.8.10 Clearance

The enclosure shall be located in an easement, the exact size of such shall be determined by local engineering. A minimum of 10 feet on the door side of the enclosure, and 5 feet on the non-door sides, shall be kept clear for switching and maintenance.

Supersedes 2/06 Issue – Update 38.8 and Renumbered Figure 13

38.8.20 Grounding

Copperclad ground rods (Std. Item TG20) and grid shall be installed as shown on Page 38-110 and 38-111.

38.8.30 Installation

In a direct buried application, the primary cable shall be brought into the vault pad allowing a minimum of four inches of earth between the cable and the base of the vault pad. Loop the cable around the bottom of the vault and train the cable so that it can be extended two or three feet above the top of the vault pad to permit operation of the loadbreak elbows and accessory devices. Backfill around the vault pad in well tamped layers not to exceed 6 inch lifts to the proper grade. Install the enclosure on the vault pad. Fill the space, if any, between the base of the enclosure and the top of the vault pad with sealing compound or duct seal (Std. Items S2 or S3). Train the primary cable and install loadbreak elbows (Std. Item UR23) so that the cable is located in the final assembled position, with enough slack to provide adequate clearance for removing the elbow and to prevent strain on the electrical connections. Neutrals shall be compression clamped to the ground grid as show on Page 38-112. These connections must be made before the elbows are energized. See Pages 38-112 and 38-113 for a typical three phase 3-way junction installed.

Install identification information on enclosure and cables as shown on Page 38-114 and as detailed in Section 35 – Cables.

38.9 MAINTENANCE ON OIL FUSE CUTOUTS

38.9.10 Application

No new installations will be allowed. See Section 38.7 for other submersible switches.

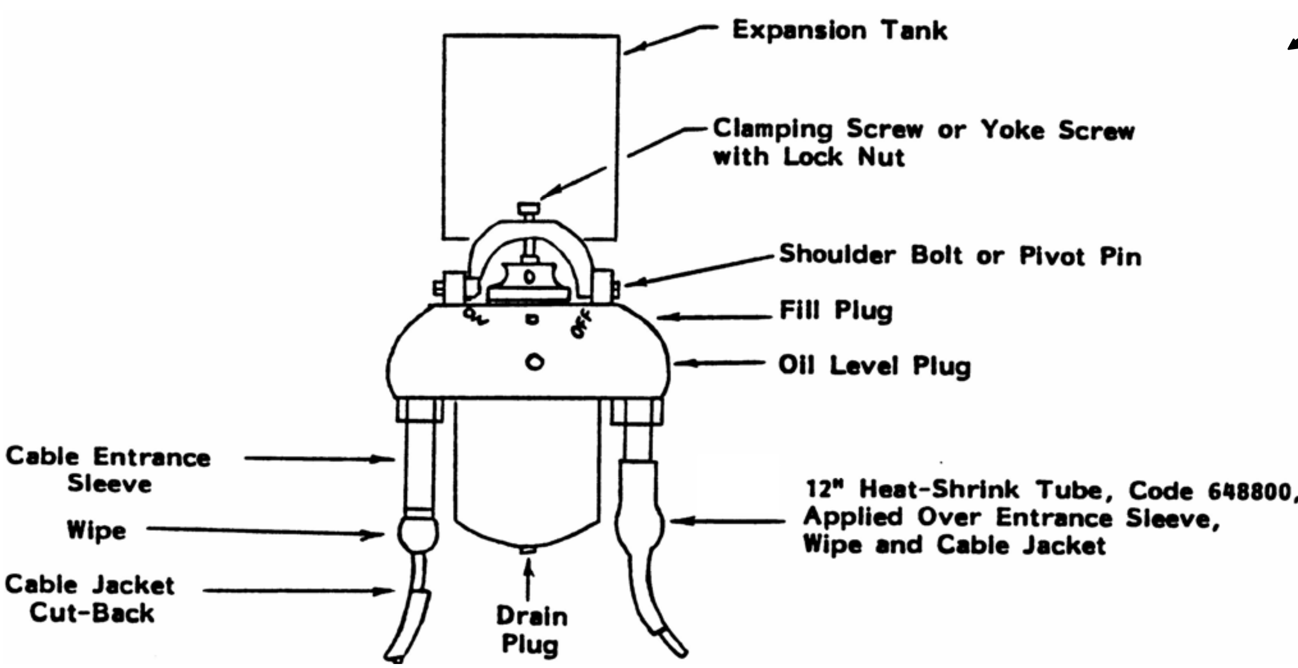


Figure 13

38.9.20 Associated Equipment

Table 4

Std. Item	Description
F17A	Sleeve entrance for GE 200 A OFC for solid dielectric cable
F17B	Sleeve entrance for GE 100 A OFC for solid dielectric cable
F17C	Sleeve entrance for GE 200 A OFC for lead covered cable
F18	Expansion chamber for GE OFC

38.9.30 Fuse Links

Table 5
Fuse Links

Current Rating (Amps)	Std. Item		Current Rating (Amps)	Std. Item		Current Rating (Amps)	Std. Item	
	GE	G & W		GE	G & W		GE	G & W
10	F15A10	F16A10	65	F15A65	F16A65	150	F15015	F16015
15	F15A15	F16A15	75	F15A75	--	200	F15020	F16020
25	F15A25	F16A25	100	F15010	F16010	250	F15025	--
40	F15A40	--	125	F15012	--	300	F15030	--
50	F15A50	F16A50	140	--	F16014	Solid	F150S	--

Application Data pertaining to GE Oil Fused Cutouts:

A. Fuses 5 A through 100 A – For use in cutouts rated 100, 200 or 300 A.

B. Fuses 125 A through 200 A – For use in cutouts rated 200 A or 300 A.

C. Fuses 250 A through 300 A – For use in cutouts rated 300 A.

D. Solid Blade – For use in cutouts rated 200 A or 300 A.

38.9.40 Superseded Designs

The GE carrier with plastic body may be used in all OFCs. The older carrier with a wooden body does not fit newer OFCs - Cat. #9F32 series.

Supersedes 2/06 Issue – Renumbered Tables

Supersedes 2/06 Issue – Renumbered Tables

38.9.50 Transformer Fusing in Oil Fused Cutouts

Table 6
Single Phase, 2400 Volt Transformers
3Φ Wye, Open Delta & Open Wye Connected

Transformer kVA Per Phase	Fuse	Rating
	G & W Type FL	GE Type 9F57
10	10	10
15	15	15
25	25	25
37.5	40	40
50	50	50
75	65	75
100	100	100
150	140	150
167	140	150
200	140	150

Table 7
2400 Volt Transformers
3Φ Delta Connected

Transformer kVA Per Phase	Fuse	Rating
	G & W Type FL	GE Type 9F57
30	15	15
45	25	25
75	40	40
112.5	65	65
150	65	75
225	100	100
300	140	125
450	Check relay curves before using 200 A fuse.	
500		
600		

38.9.60 Coordination

Since characteristics of G&W, GE, K and N fuses are different, coordination problems involving different types should be referred to Distribution Design.

38.9.70 Installation Considerations

Lubricate shoulder bolts, clamping screw and all plugs with Never Seize sealing compound, (Std. Item UC77). Apply a 12 inch length of heat-shrinkable tubing (Std. Item UT7E) over wipe from cable to entrance sleeve for mechanical strength and corrosion protection.

38.10 CABLE ENTRANCES GE OIL FUSED CUTOUTS

38.10.10 General

Cable entrance terminals are interchangeable between paper and solid dielectric insulated cables.

The sweat copper contact will accept up to 2/0 conductor on the 100 A cutout and 4/0 on the 200 A cutout.

Be sure that all parts are dry, clean, and in good mechanical condition. To check the interior, remove the fuse carrier. Temporarily mount the cutouts in their final location with the carrier end upward and check that it hangs vertically. Allow room for the expansion tank, removal of fuse carrier, and line up gang operating mechanism if used. Cutouts are to be removed later for filling with petrolatum.

All cutouts are to be properly grounded.

38.10.20 Connection To Lead-Sheathed Cable

A. Disassemble Terminal – Figure 14, removing the union nut (3), wiping sleeve (5), gasket (4), insulating sleeve (7), and plug contact (8) leaving the terminal as shown in Figure 14. To remove sleeve (7), pull with a steady twisting motion.

B. Slide Heat-Shrink Tube **–** (Std. Item UT7E) on cable for future installation.

C. Remove Lead Sheath And Cable Insulation – using gage furnished with cutout, Figure 16. Be sure that current (A) rating on gage is same as cutout.

D. Sweat Plug Contact – (8) onto cable, Figure 16. To prevent migration of petrolatum, apply two tightly half-lapped layers of dacron-glass tape, T3V, on the exposed conductor, insulation and ½ inch of lead sheath.

E. Cut End Of Wiping Sleeve – (5) on taper so that sleeve will just pass over cable. Pass the nut (3) and the wiping sleeve (5) over the cable keeping the union nut (3) in the position shown in Figure 17.

F. Push Plug Contact – (8) into assembly fixture as far as possible, Figure 18, and turn union nut up tightly by hand. Be sure to omit gasket (4) at this time. Assembly fixture is a tool which allows the cable to be wiped to wiping sleeve, outside the cutout body. If an assembly fixture is not available, use the cutout, being sure to omit gasket. Mark the cable at the end of the wiping sleeve and lower sleeve on cable. Apply additional layer of dacron-glass tape on cable to make a snug fit into the wiping sleeve. This will center the cable and prevent lead from flowing into sleeve. Reassemble as in Figure 13, again omitting gasket.

G. Wipe Joint – between cable and sleeve (5), Figure 19.

H. Uncouple Union – Turn cutout upside down.

I. Melt Petrolatum – (Std. Item UC76) Approximate melting point is 135 degrees Fahrenheit; do not overheat. Fill the molded insulation members in the cover with melted petrolatum, Figure 20. The petrolatum should be poured up to the inside shoulder of the molded insulation members. Proceed immediately with Steps J and K while petrolatum in cutout

Supersedes 2/06 Issue – Renumbered Figures thru out Text

is cooling. Allow petrolatum to cool only sufficiently so that the cutout may be righted in its permanent position.

J. Heat Wiping Sleeve – (5), Figure 21, to about melting point of petrolatum and fill sleeve with melted petrolatum up to base of plug contact (8), Figure 14.

K. Push Insulating Sleeve – (7), Figure 22, slowly but promptly into the wiping sleeve (5) until the ring (9), (Figure 14) snaps into the groove on the end of the insulating sleeve (7). Do this while petrolatum is warm and with wood block closing the end of the insulating sleeve (7).

L. Place Gasket – (4) on top of wiping sleeve (5) flange, Figure 14, and push the assembled terminal back into position until the union nut (3) catches onto the threads of the cutout, allowing the excess petrolatum to squeeze out through the gasket joint. Tighten the union nut sufficiently to seal the joint.

M. Apply Heat-Shrink Tube – over cable terminal per Section 36 – Connectors/Splices. Install expansion tank and secure cutout in its permanent position.

N. Fill Cutout With 10c Oil – exactly to the level indicated by the nameplate and pipe plug on the front of the cutout, or to the oil-level mark on the fuse carrier.

Supersedes 2/06 Issue – Renumbered Figures thru out Text

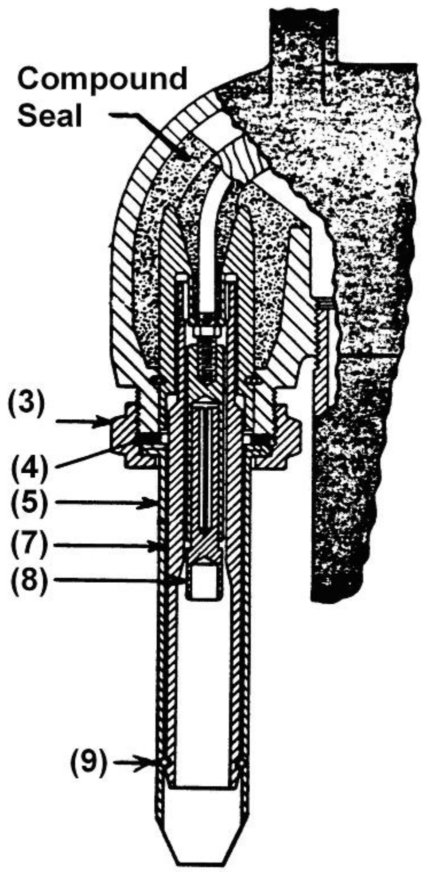


Figure 14
Assembled View Of Terminal

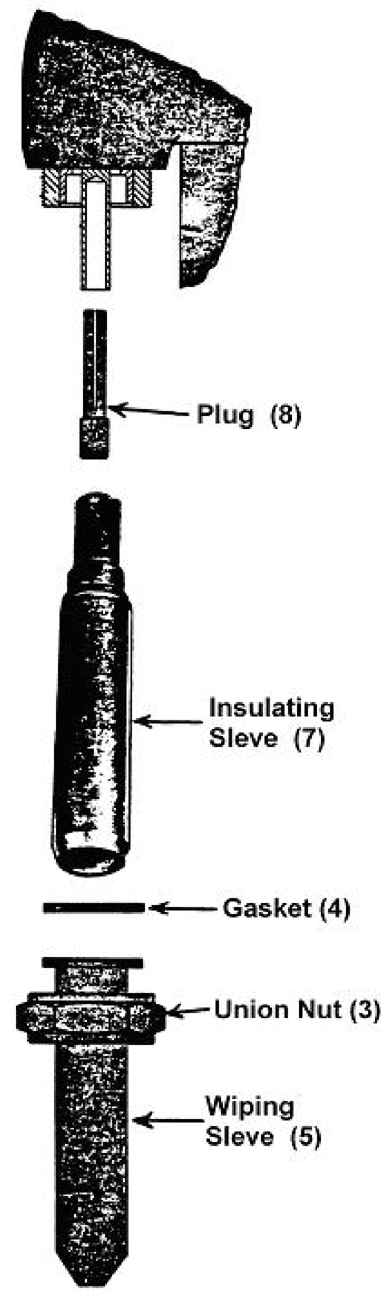


Figure 15
Disassembled View Of Terminal

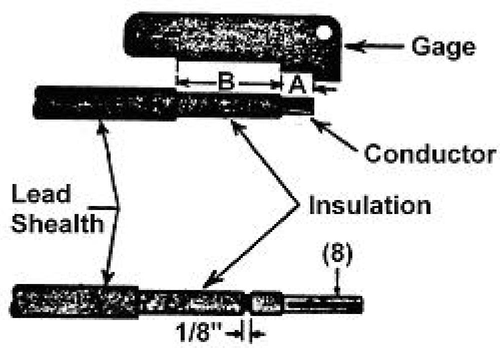


Figure 16

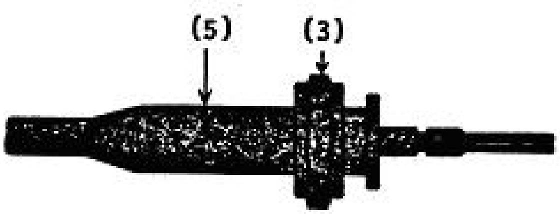


Figure 17

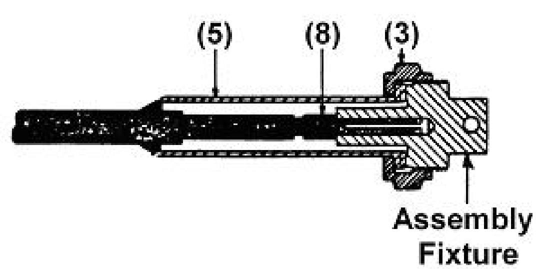


Figure 18

Supersedes 2/06 Issue – Renumbered Figures

38.10.30 Connection To Solid Dielectric Cable

A. Entrance Terminal – for solid dielectric cable is listed in Section 39 – Fuses. Refer to Figure 23 for details. The bronze stud on the end is the equivalent of 1/0 stranded cable. Slip the union nut (3) on the entrance terminal before connecting terminal to cable.

B. Connect – solid dielectric cable to the stud at the end of the entrance terminal as if two cables were being spliced. Refer to Figure 24 and use standard splicing material and procedures. Select connector from Section 36 – Connectors/Splices. For shielded cable, extend shielding mesh over joint and solder to metal sleeve.

C. Fill The Cover – with petrolatum as described in Step I, Figure 20. Then fill wiping sleeve (5) with melted petrolatum up to base of plug (8), Figure 14.

D. Reassemble Terminal – as described in Step L, install expansion tank, and secure cutout in its permanent position.

E. Fill Cutout With 10C Oil – as described in Step N.

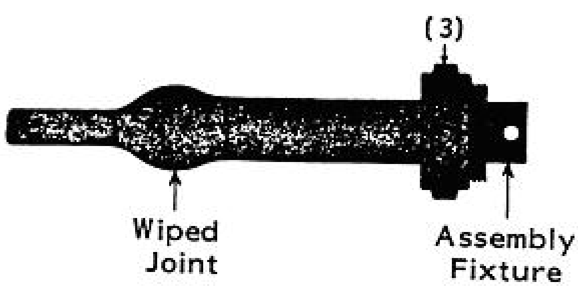


Figure 19

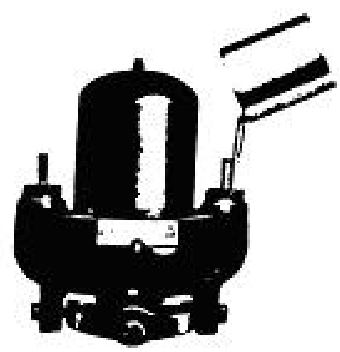


Figure 20

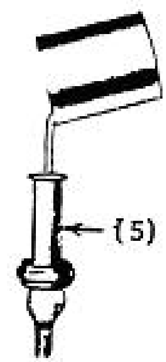


Figure 21

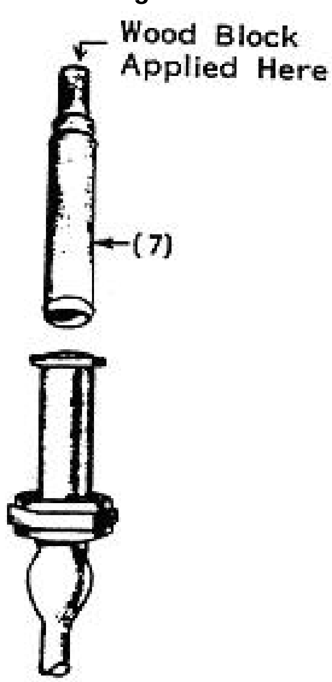


Figure 22

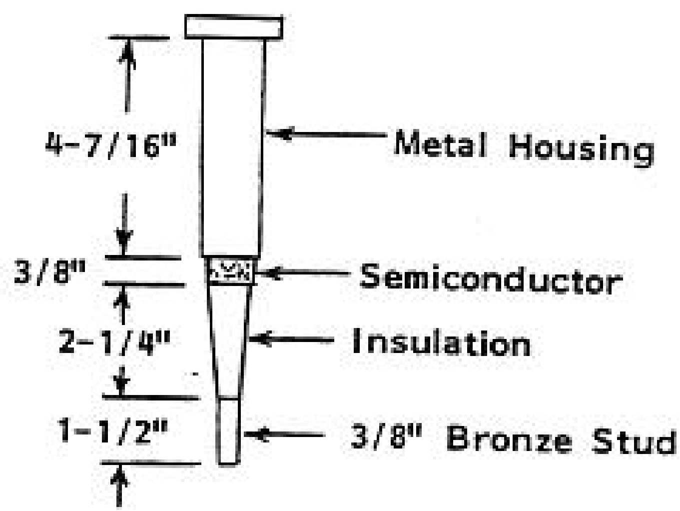


Figure 23

Supersedes 2/06 Issue – Renumbered Figures thru out Text

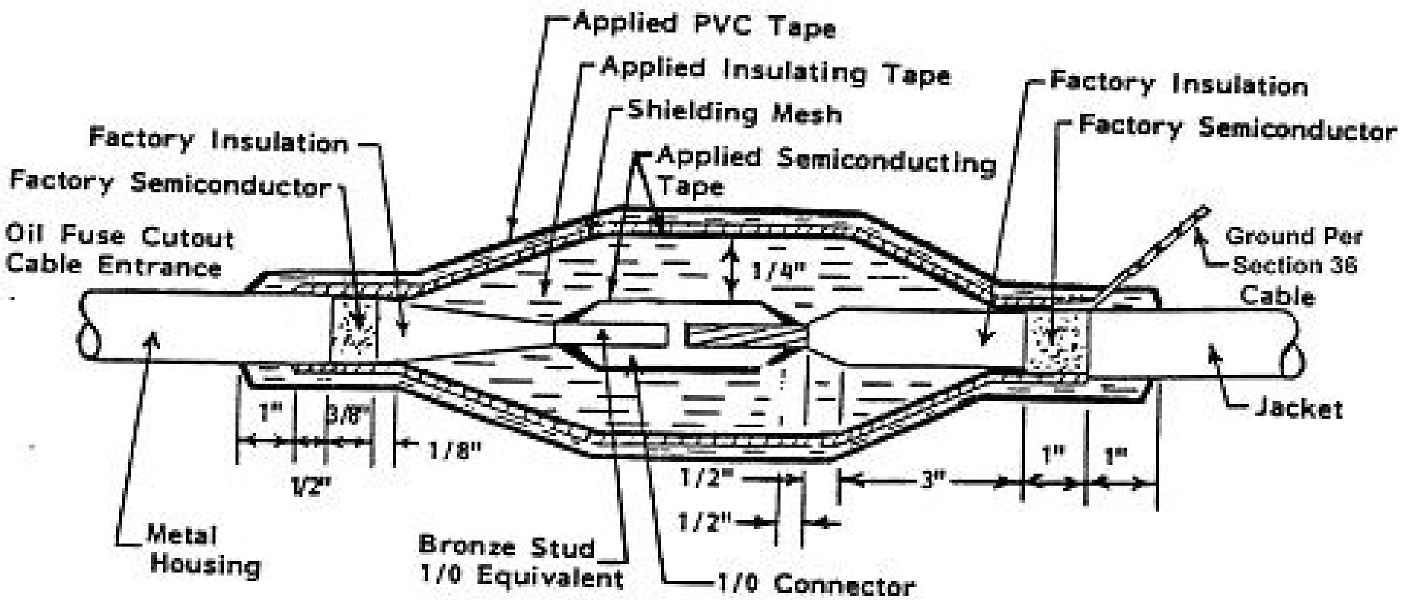


Figure 24

38.11 CABLE ENTRANCES – G&W OIL FUSED CUTOUTS

Cable entrance terminals to be used with paper and lead covered cable. Connector size must be specified when ordering. Maximum connector size is 4/0 copper.

Be sure that all parts are dry, clean and in good mechanical condition. If the humidity indicator packed inside the body shows excessive moisture, check the Bakelite fuse carrier with a 2500 Volt meggar. The resistance between clips should be a minimum of 5000 megohms. To dry the carrier, heat in an oven for 12 hours at 250 degrees Fahrenheit and recheck the resistance after the carrier has cooled.

Mount the cutouts in their final location with carrier end upward and check that it hangs vertically. Allow room for expansion chambers, removal of fuse carrier and gang operating mechanism, if used.

Ground cutouts and operating mechanism.

A. Temporarily Assemble The Complete Cable Terminal **–** to the cutout body. Train the cable alongside the cable terminal and mark the cable sheath at location “M”, bottom of wiping sleeve, Figure 15. Remove cable terminal from cutout body.

B. Measure – and record the length “X” between the bottom surface of the connector and the bottom surface, “M”, of the wiping sleeve.

C. Remove The Connector – from the porcelain, Figure 26, measure and record the depth “L” of the connector socket. Cut the cable at the measured distance “X” plus “L” inches above cable sheath mark, “M”, made in Step A.

D. Remove Lead Sheath – a distance “L” plus 4 inches from the cable end. Remove insulation down to bare conductor a distance “L” plus ½ inch.

E. Cut End Of Wiping Sleeve – on taper so that sleeve will just fit over cable. Slide the wiping sleeve down over the cable.

Supersedes 2/06 Issue – Renumbered Figures Thru Out Text

F. Sweat Connector – to cable conductor. Be sure that locking fins on connector will align with internal grooves in porcelain. Clean surface of insulation thoroughly. Apply additional half-lapped layers of dacron-glass tape over cable insulation to at least the outside diameter of the lead sheath.

G. Slide Cable Up Into Terminal Porcelain – making sure that locking fins on connector align with grooves in porcelain. Slide hoodnut gasket over the exposed end of the connector and assemble hoodnut to connector. Hand tighten hoodnut, since hoodnut must be loosened for venting while compound is being poured.

H. Assemble Cable Terminal – parts to cutout body and wipe sleeve to cable

I. Secure Cable Terminal – assembly in a vertical position detached from the cutout body. Install a standpipe in filling plug hole. The top of the standpipe should be level with, or slightly higher than the top of the porcelain. Loosen hoodnut to vent cable terminal.

J. Heat Compound – to proper pouring temperature. Pour compound into the standpipe rapidly, but not so fast that it will gush from the top of the cable terminal. Be careful to have the compound fill to within ½ inch of the gasket surface and at the same time it must not flow onto the gasket surface. Any compound on the gasket surface must be removed since it will interfere with the seal. When the compound reaches the proper level, tighten hoodnut. Keep the standpipe hot and full of compound until the cable terminal cools to ambient temperature. In cold weather it may be necessary to warm the cable terminal to room temperature before pouring in compound. Remove standpipe and replace filler plug.

K. Install Cable Terminal **–** assembly in cutout body.

L. Check Operation – Tighten all nuts and cap screws. Close cover and check operation for mechanical interference.

M. Fill With Oil – furnished with cutout. Fill cutout to 3 inches below the cover gasket with cover and fuse carrier assembly removed. Remove oil level plug to allow excess oil to flow out when cover and fuse carrier assembly are placed in position. Replace oil level plug. If supplemental oil is required, use 10C oil.

New page due to text shift.

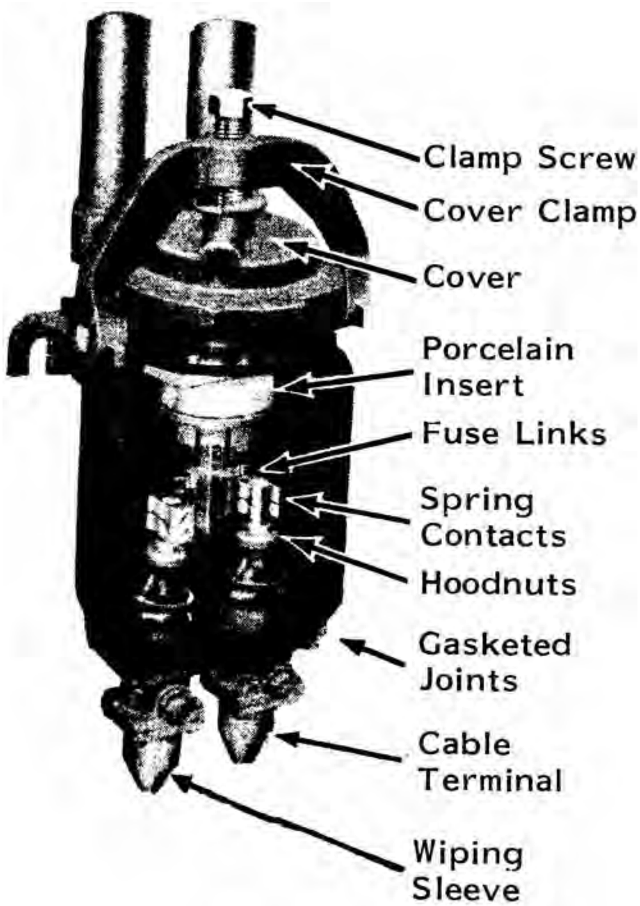


Figure 24

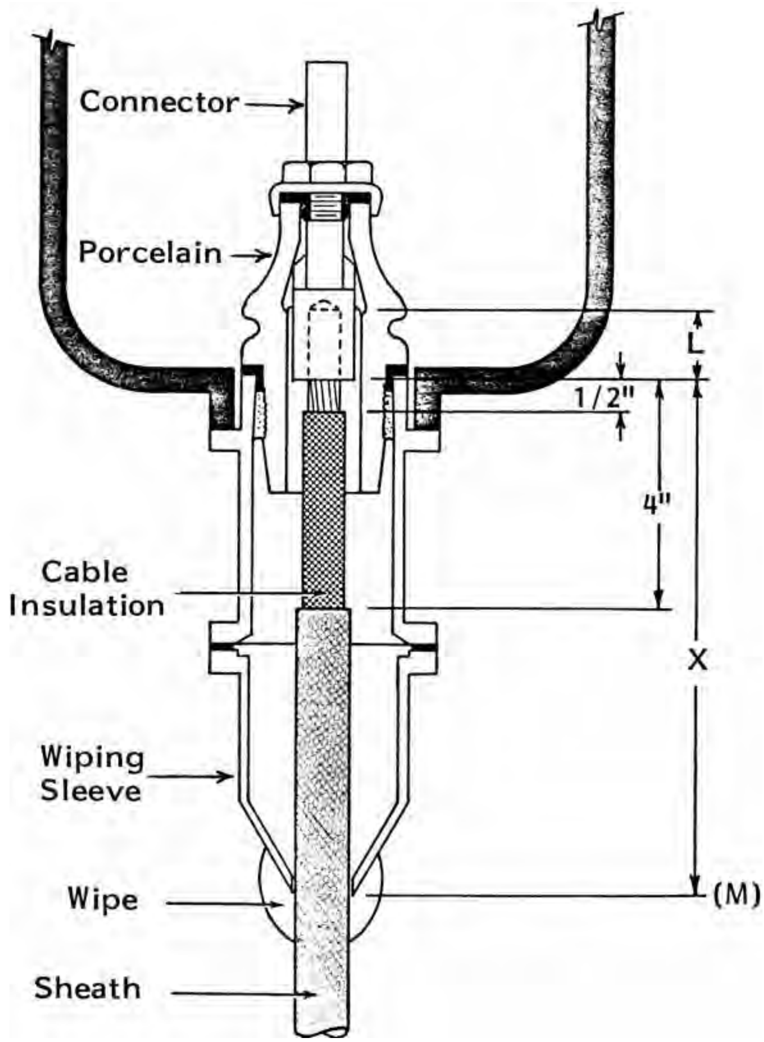


Figure 25

Supersedes 2/06 Issue – Renumbered Figures

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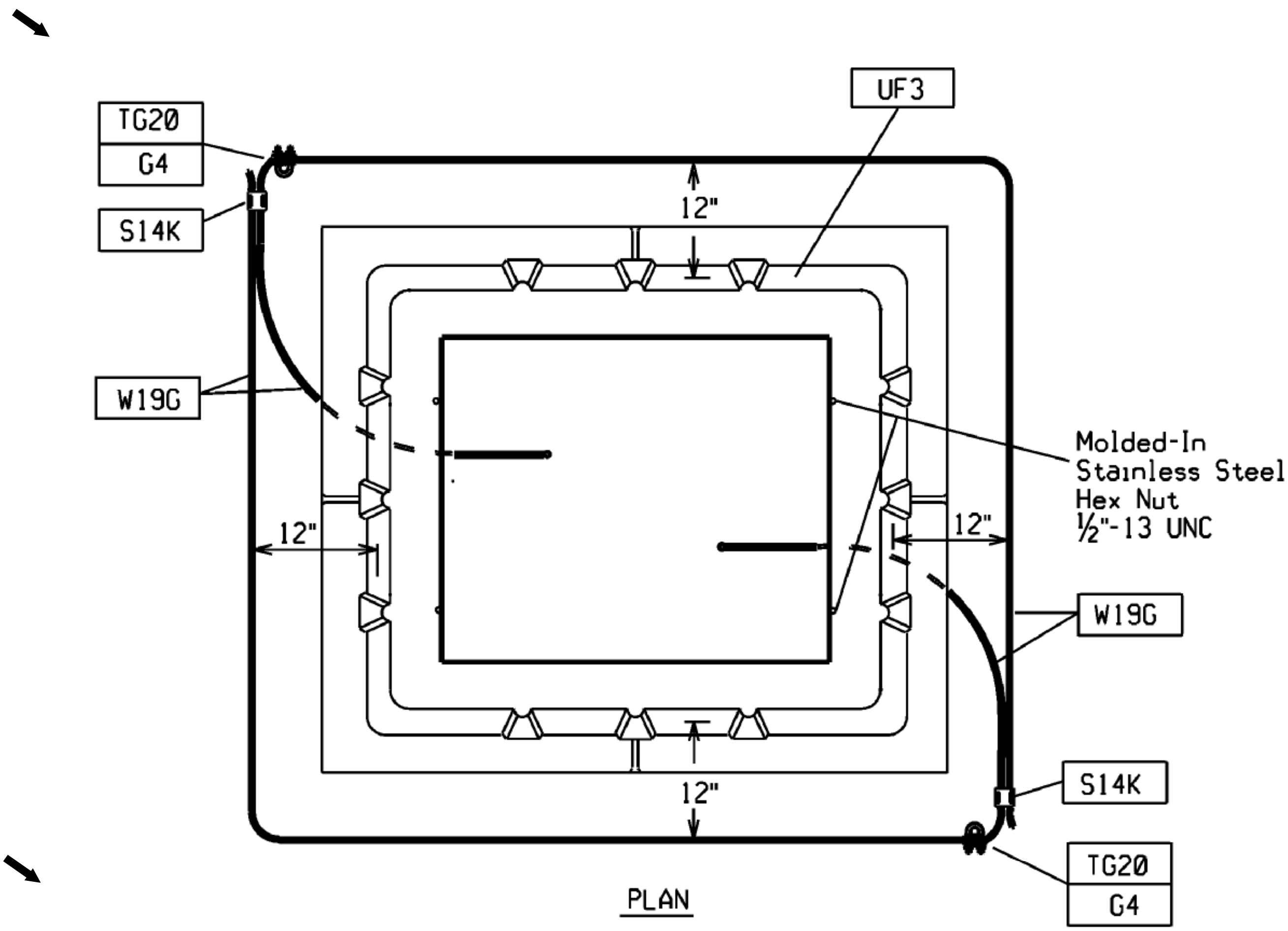
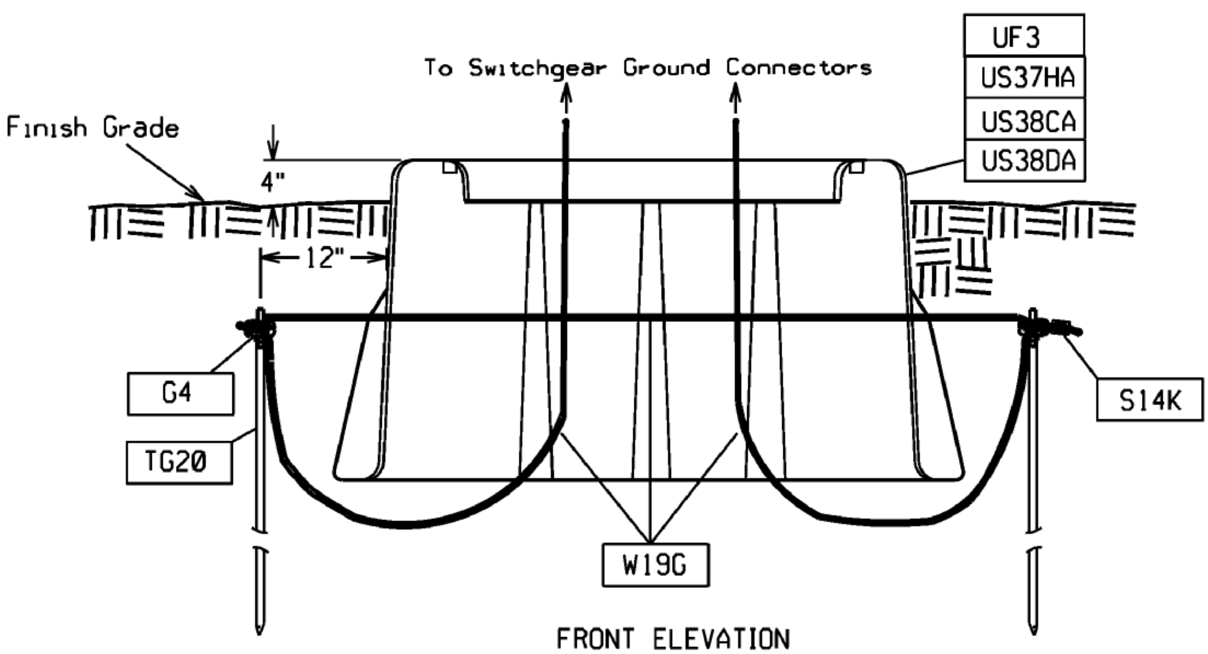
 Doc. # ST. 38.00.001





Supersedes 7/08 Issue –Updated Std items and ground rod detail.

THREE PHASE PAD-MOUNTED SWITCHGEAR FIBERGLASS BASE INSTALLATION WITH GROUND GRID			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/09	38-100		

Supersedes 1/07 Issue – Drawing Update

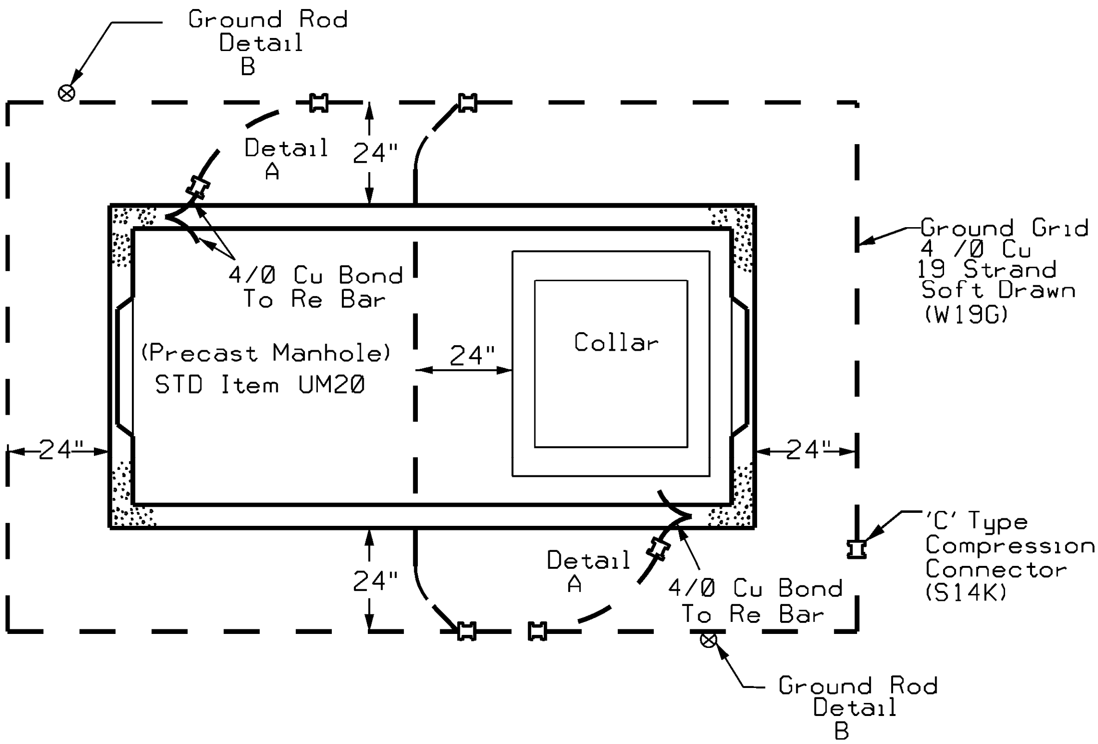
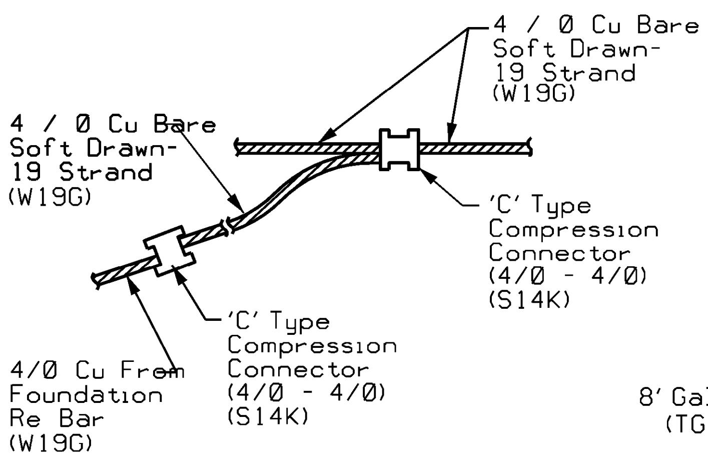
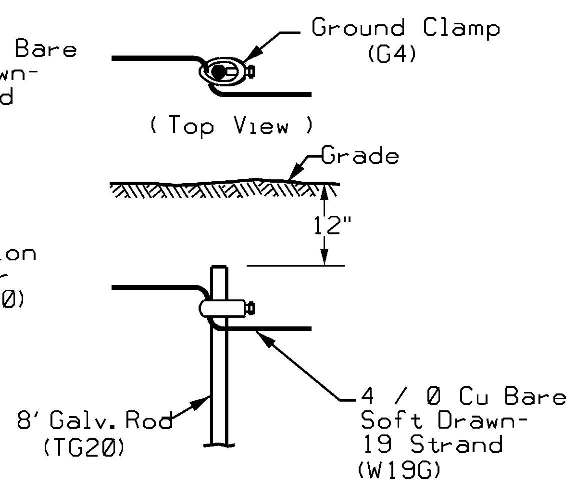


FIG. 1 - PLAN



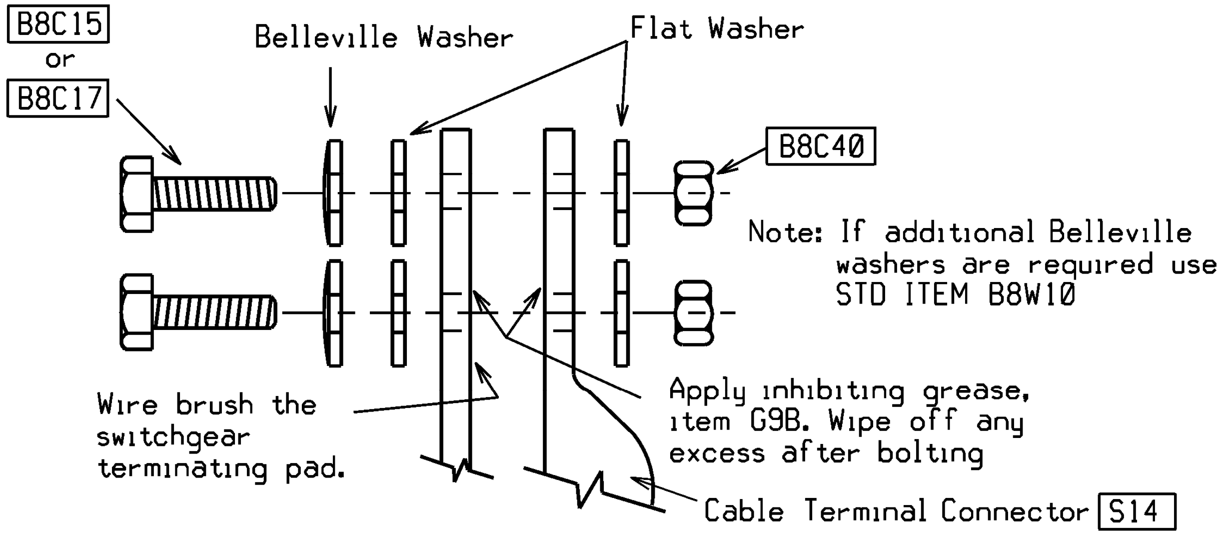
Detail A



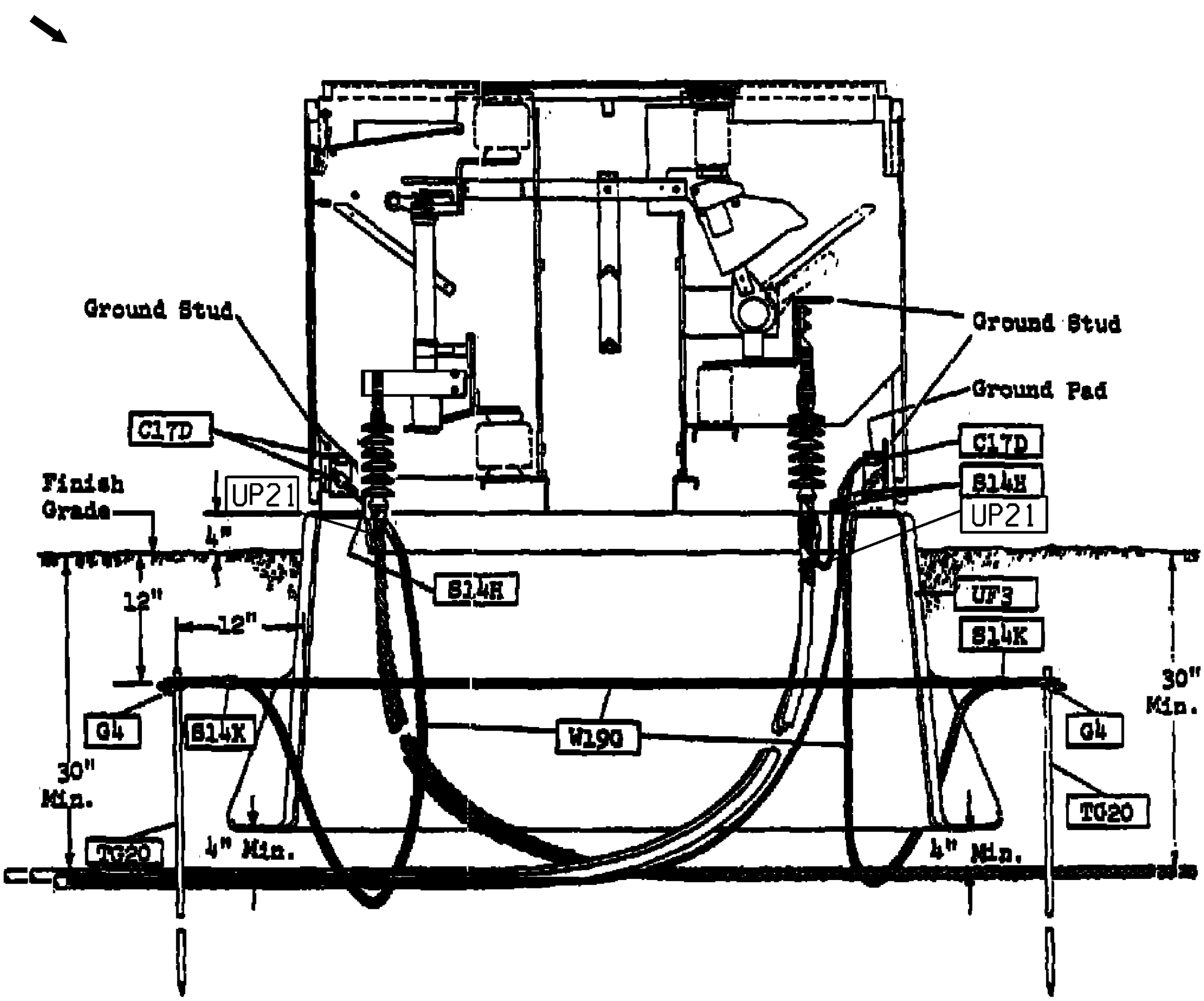
Detail B

THREE PHASE PAD-MOUNTED SWITCHGEAR MANHOLE INSTALLATION WITH GROUND GRID			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		38-101	7/08 2010

 | Doc. # ST. 38.00.001



TERMINATING PAD ASSEMBLY DETAILS



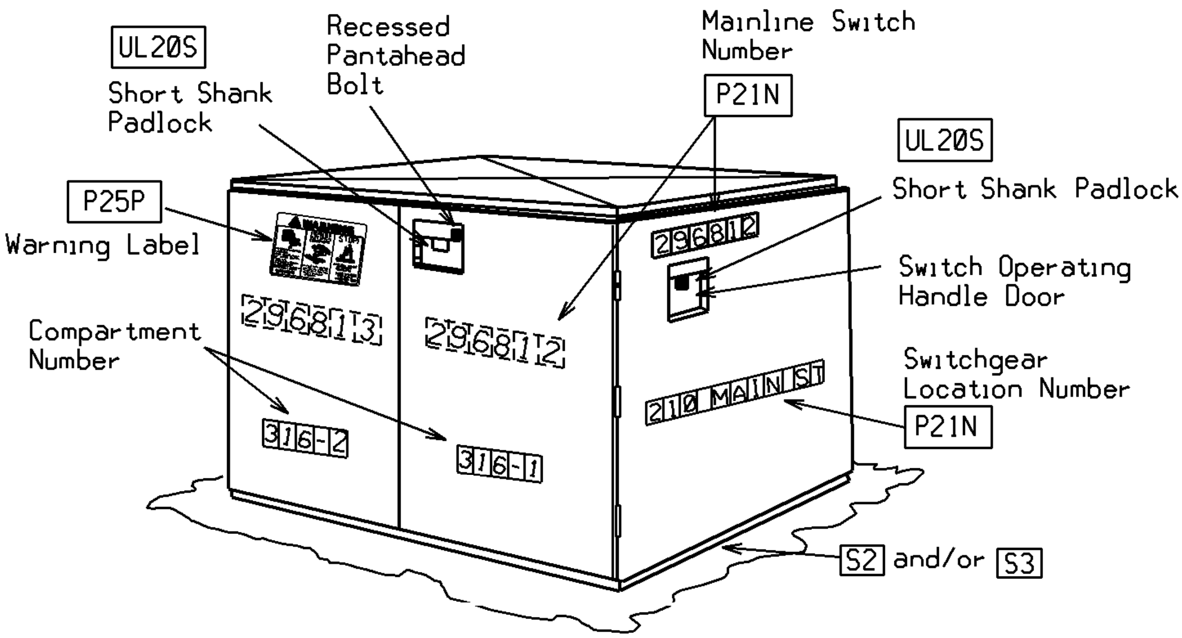
Supersedes 2/06 Issue –Drawing Update

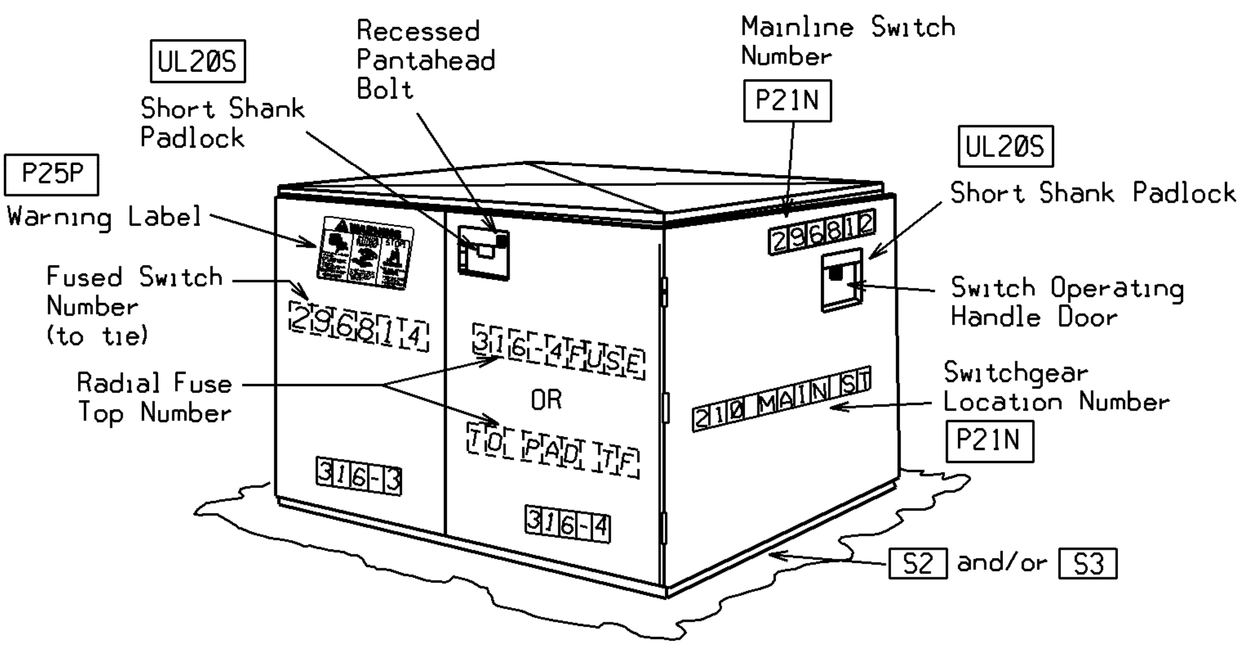
THREE PHASE PAD-MOUNTED SWITCHGEAR – CABLE TERMINATIONS

ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/08	38-102		

 Doc. # ST. 38.00.001

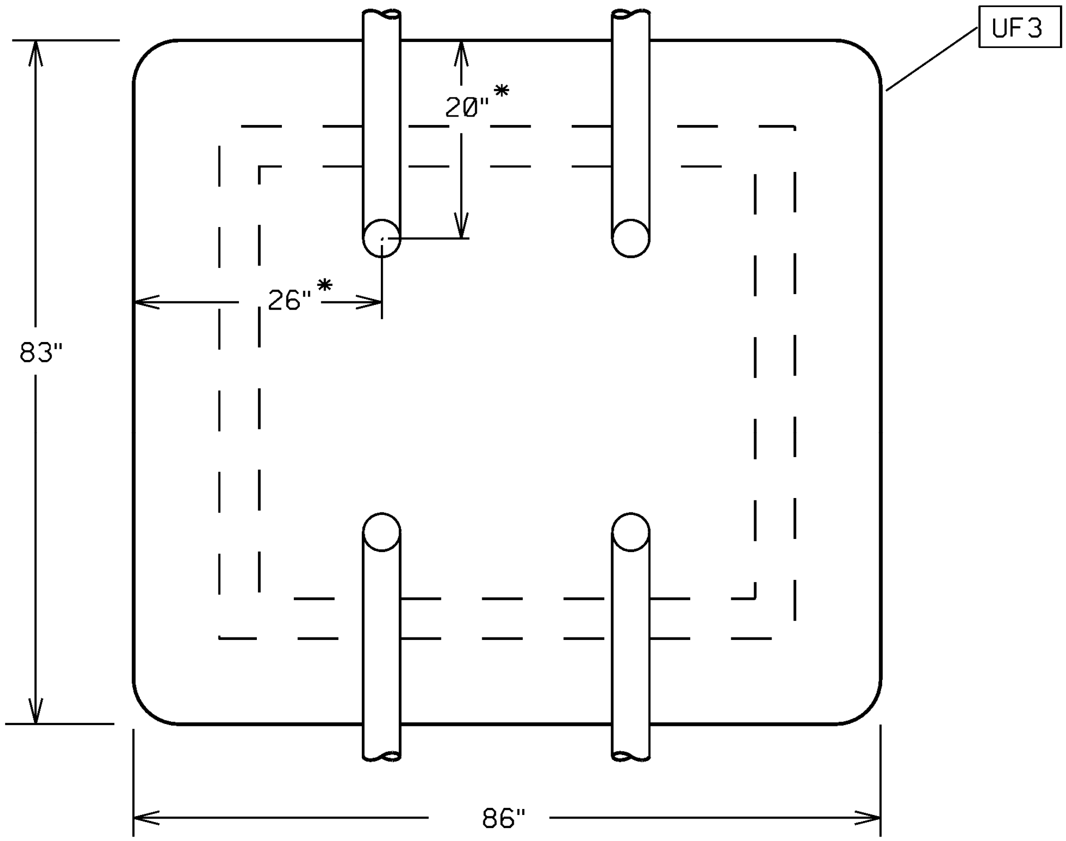
Supersedes 2/06 Issue – Drawing Update





THREE PHASE PAD-MOUNTED SWITCHGEAR TYPICAL IDENTIFICATION AND LABELING			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 38-103	ISSUE 7/08

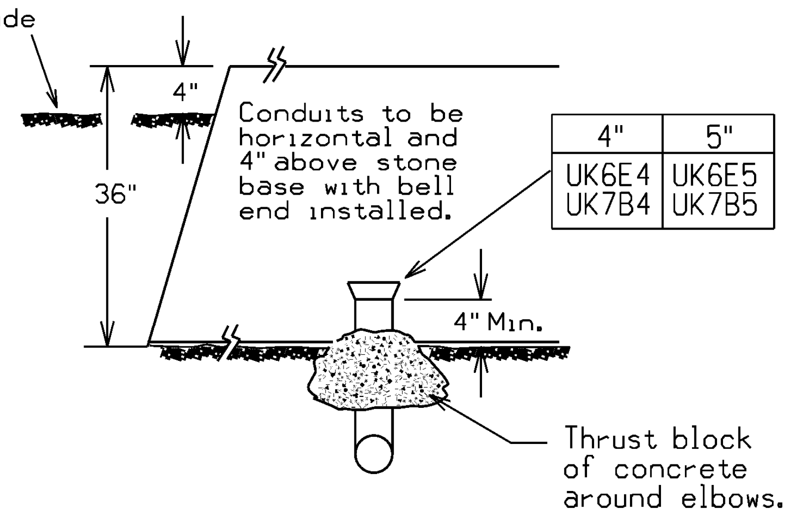
 Doc. # ST. 38.00.001



* Typical Measurement For Each Quadrant

NOTE: 4" OR 5" CONDUIT - 1 OR 2 CONDUITS PER QUADRANT AS REQ.

PLAN VIEW



4"	5"
UK6E4 UK7B4	UK6E5 UK7B5

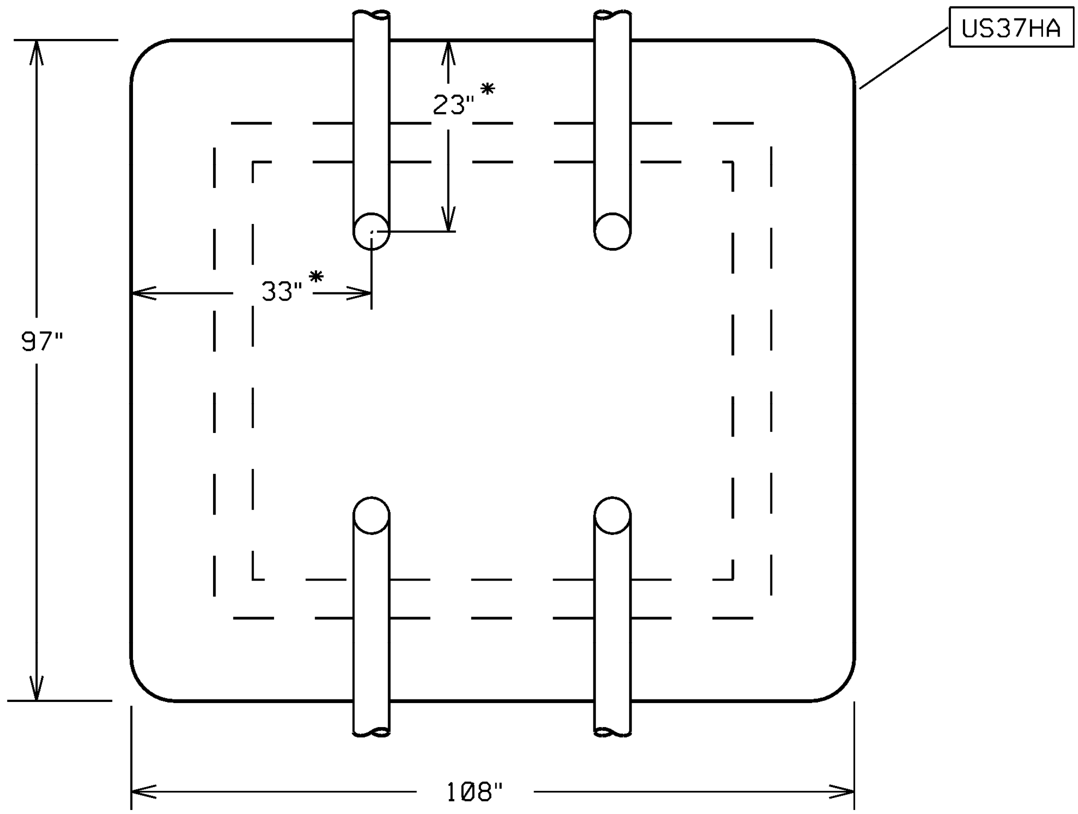
TYPICAL SIDE VIEW

New Drawing

THREE PHASE PAD-MOUNTED SWITCHGEAR – 15 kV
FIBERGLASS BASE CONDUIT ENTRY VERTICAL

ISSUE	PAGE NUMBER		
7/08	38-104	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

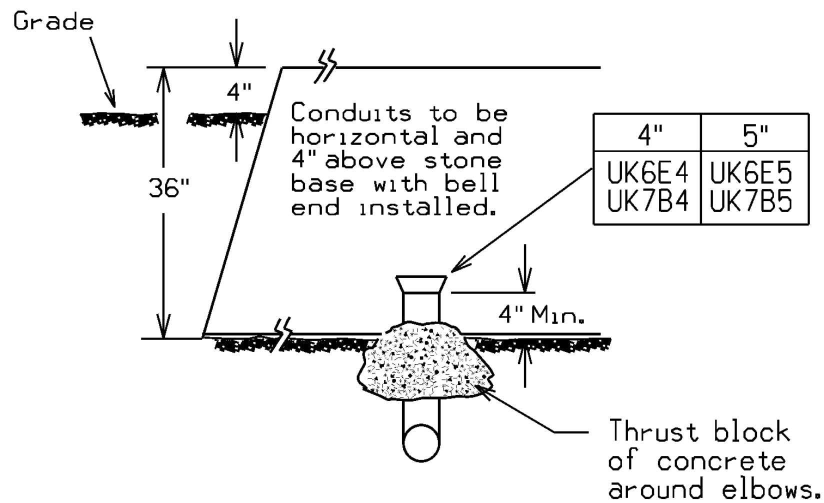
Supersedes 7/08 Issue - Updated Std Item Number



* Typical Measurement For Each Quadrant

NOTE: 4" OR 5" CONDUIT - 1 OR 2 CONDUITS PER QUADRANT AS REQ.

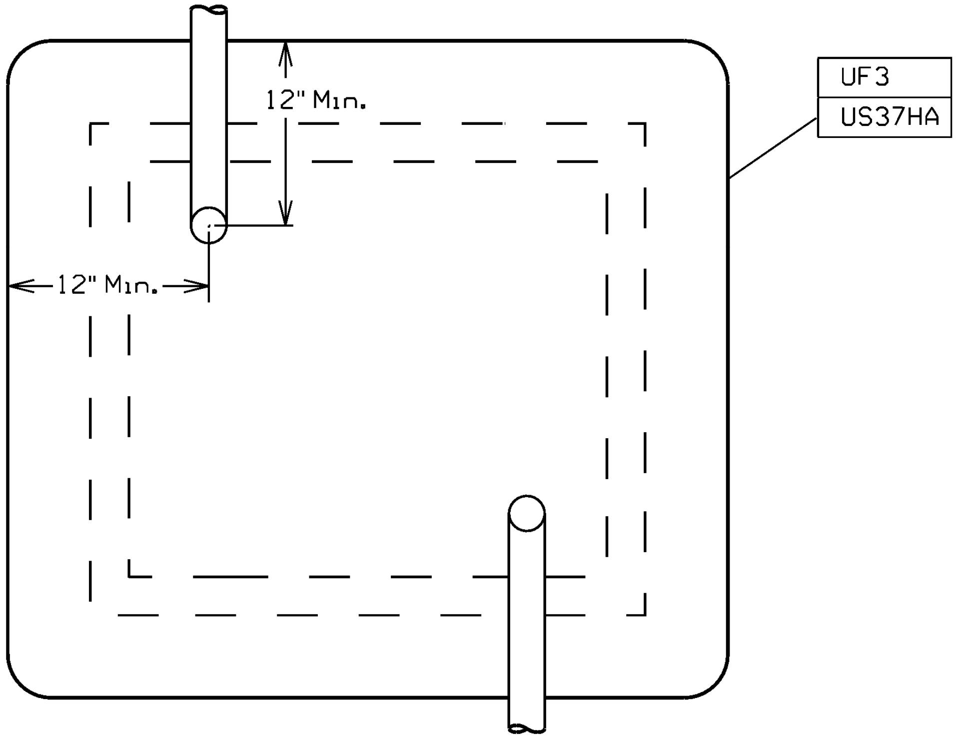
PLAN VIEW



4"	5"
UK6E4 UK7B4	UK6E5 UK7B5

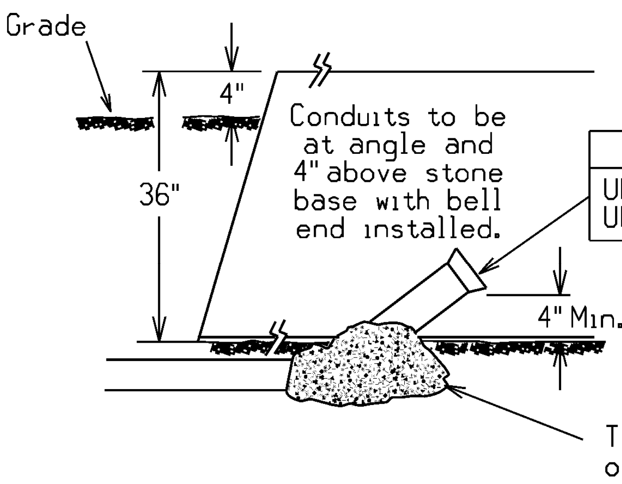
TYPICAL SIDE VIEW

THREE PHASE PAD-MOUNTED SWITCHGEAR – 23 kV
FIBERGLASS BASE CONDUIT ENTRY VERTICAL



NOTE: 4" OR 5" CONDUIT - 1 OR 2 CONDUITS PER QUADRANT AS REQ.

PLAN VIEW



4"	5"
UK6E4 UK7B4	UK6E5 UK7B5

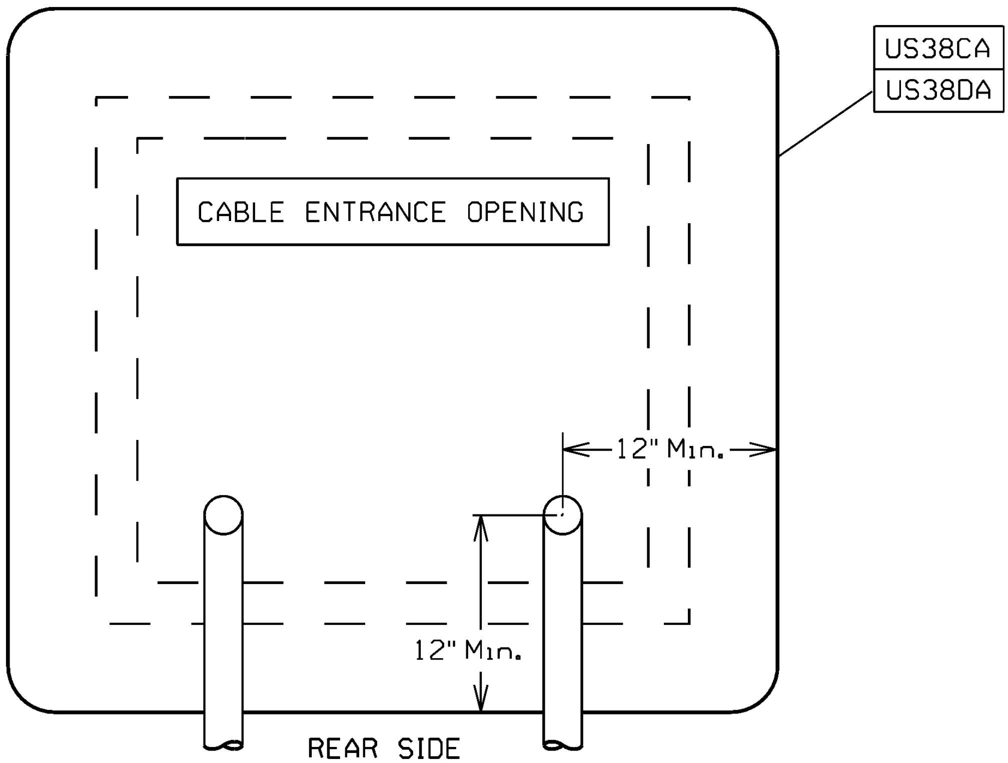
TYPICAL SIDE VIEW

Supersedes 7/08 Issue - Updated Std Item Number

THREE PHASE PAD-MOUNTED SWITCHGEAR FIBERGLASS BASE CONDUIT ENTRY HORIZONTAL15kV AND 23kV			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/09	38-106		

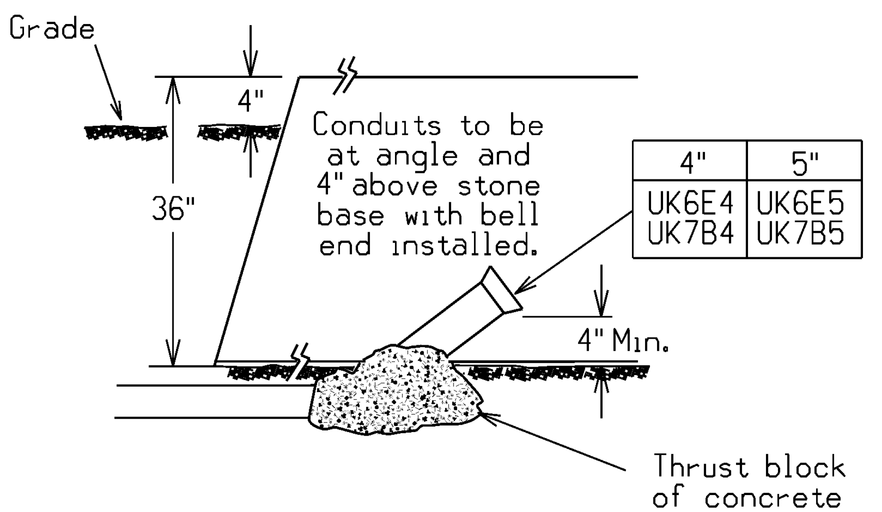
 Doc. # ST. 38.00.001

Supersedes 7/08 Issue - Updated Std Item Number



NOTE: 4" OR 5" CONDUITS TO ENTER FROM REAR OF BOXPAD.

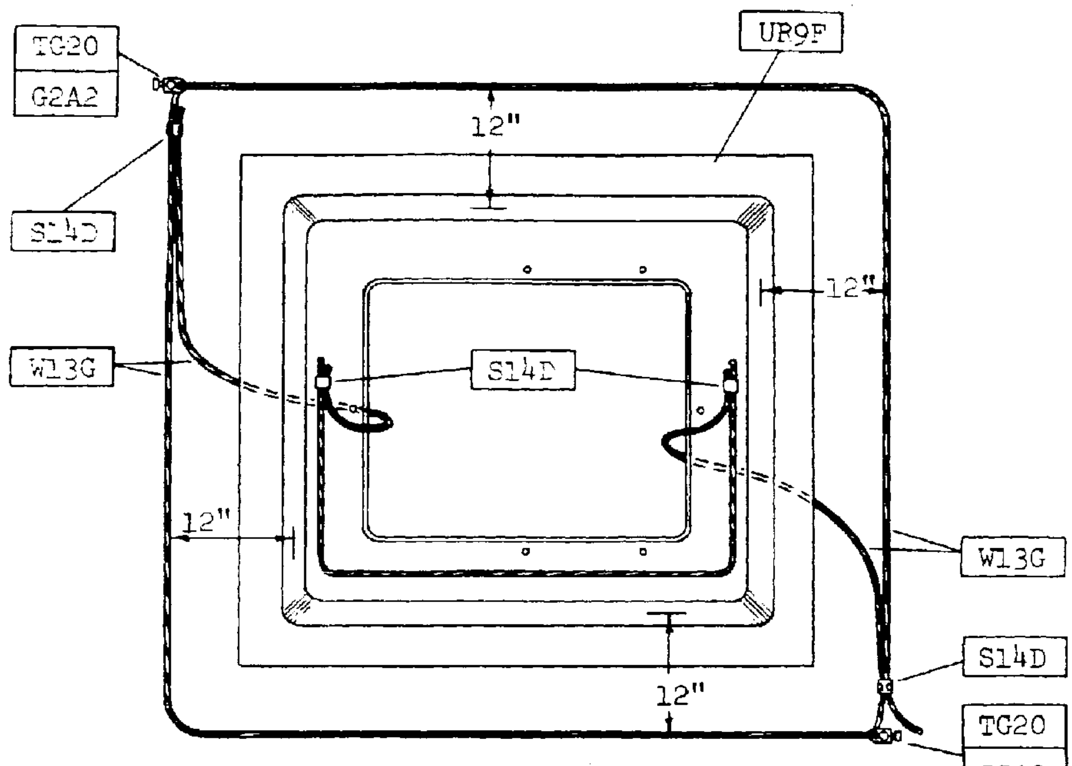
PLAN VIEW



4"	5"
UK6E4 UK7B4	UK6E5 UK7B5

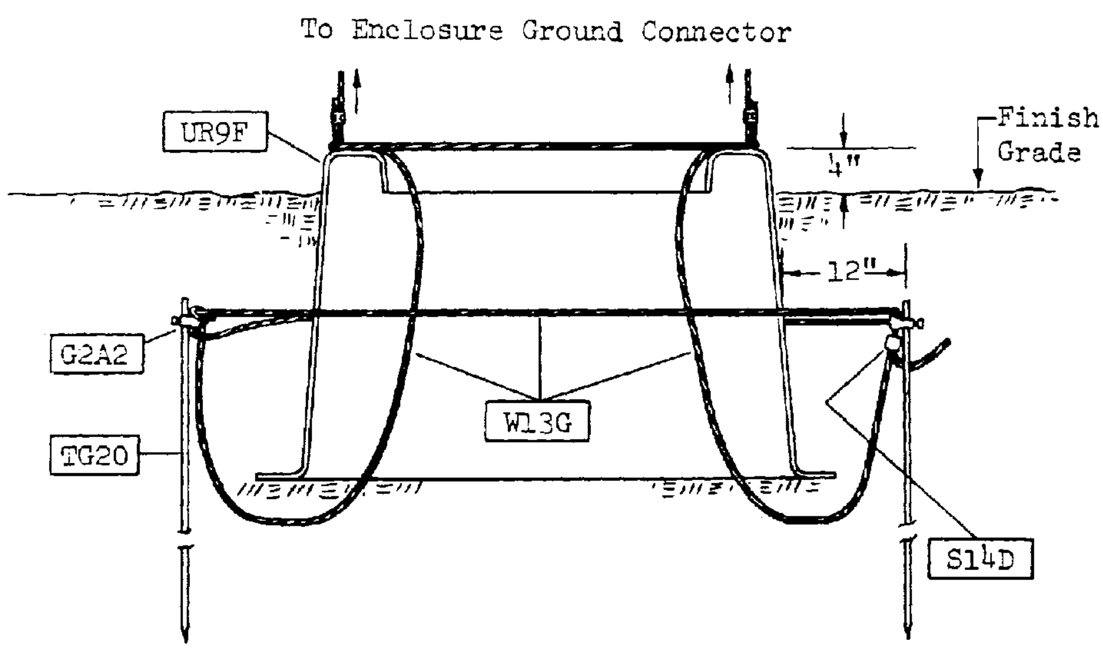
TYPICAL SIDE VIEW

THREE PHASE PAD-MOUNTED SWITCHGEAR - 35KV FIBERGLASS BASE CONDUIT ENTRY HORIZONTAL			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 38-107	ISSUE 7/09



PLAN

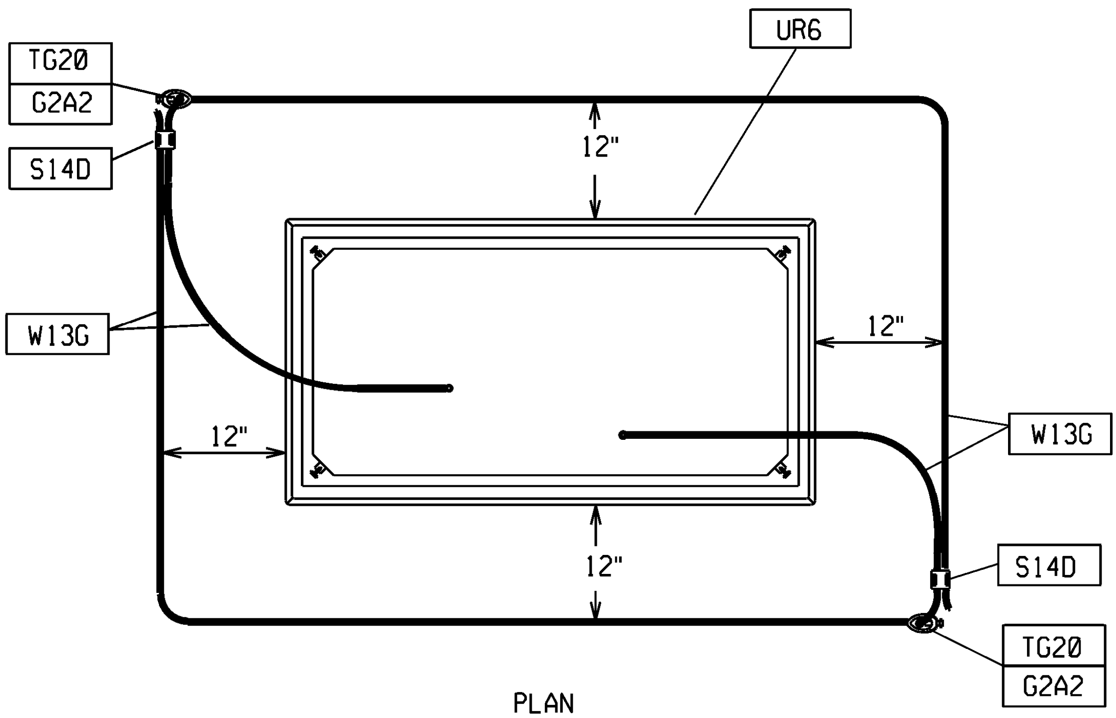
STREET SIDE AND POSITION OF FRONT
OF PAD MOUNTED ENCLOSURE



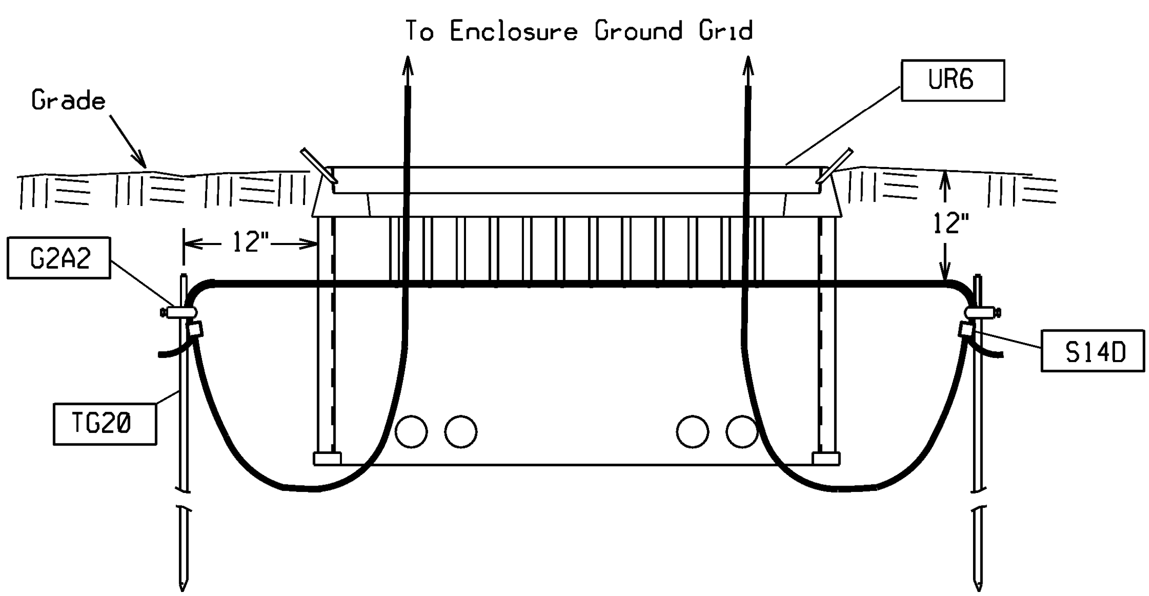
Supersedes 2/06 Issue –Drawing Update

 Doc. # ST. 38.00.001

New Drawing



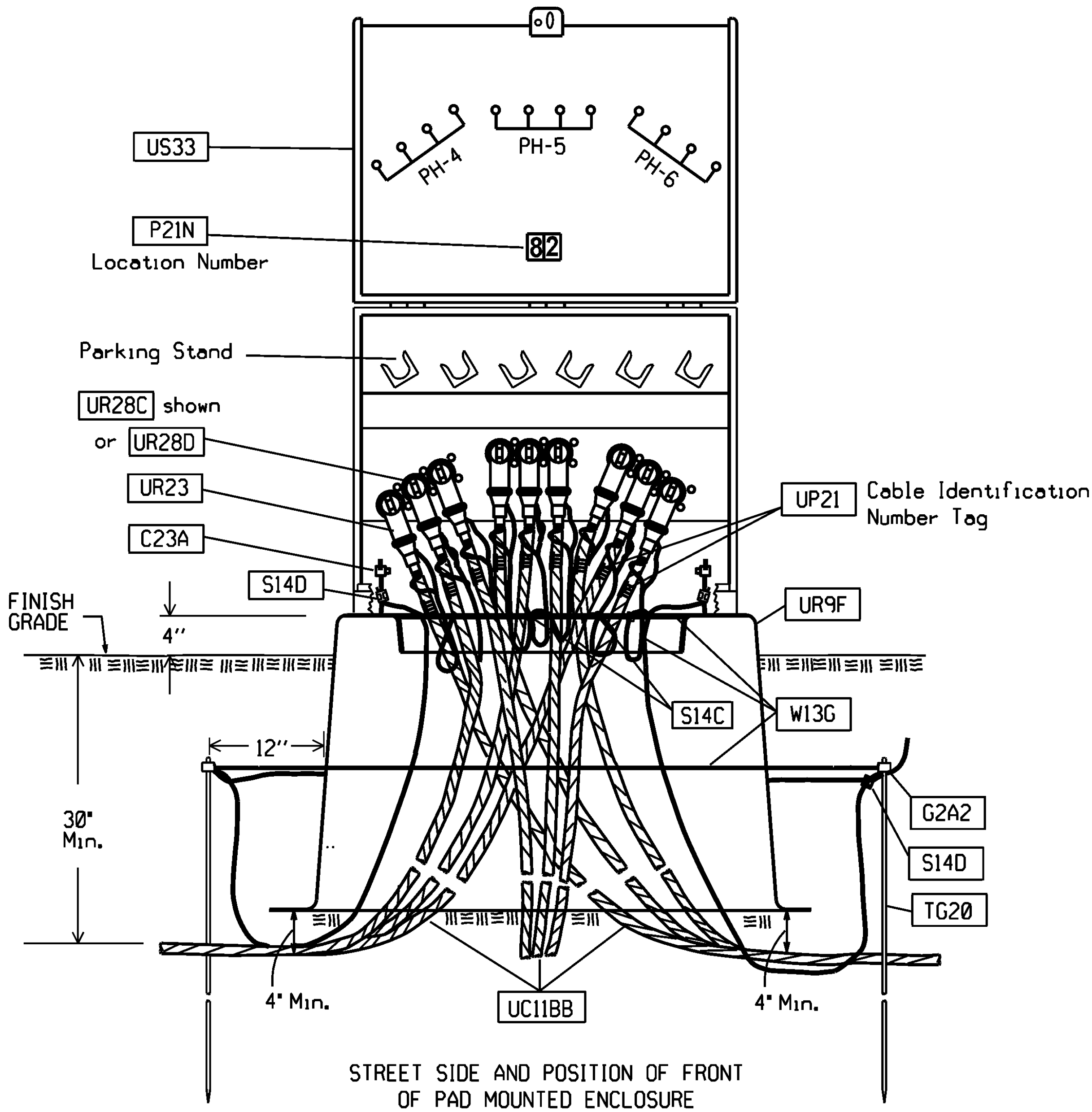
PLAN



PAD MOUNTED JUNCTION ENCLOSURE GROUND GRID FOR BASE UR6

Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		38-111	7/08 2007

 Doc. # ST. 38.00.001

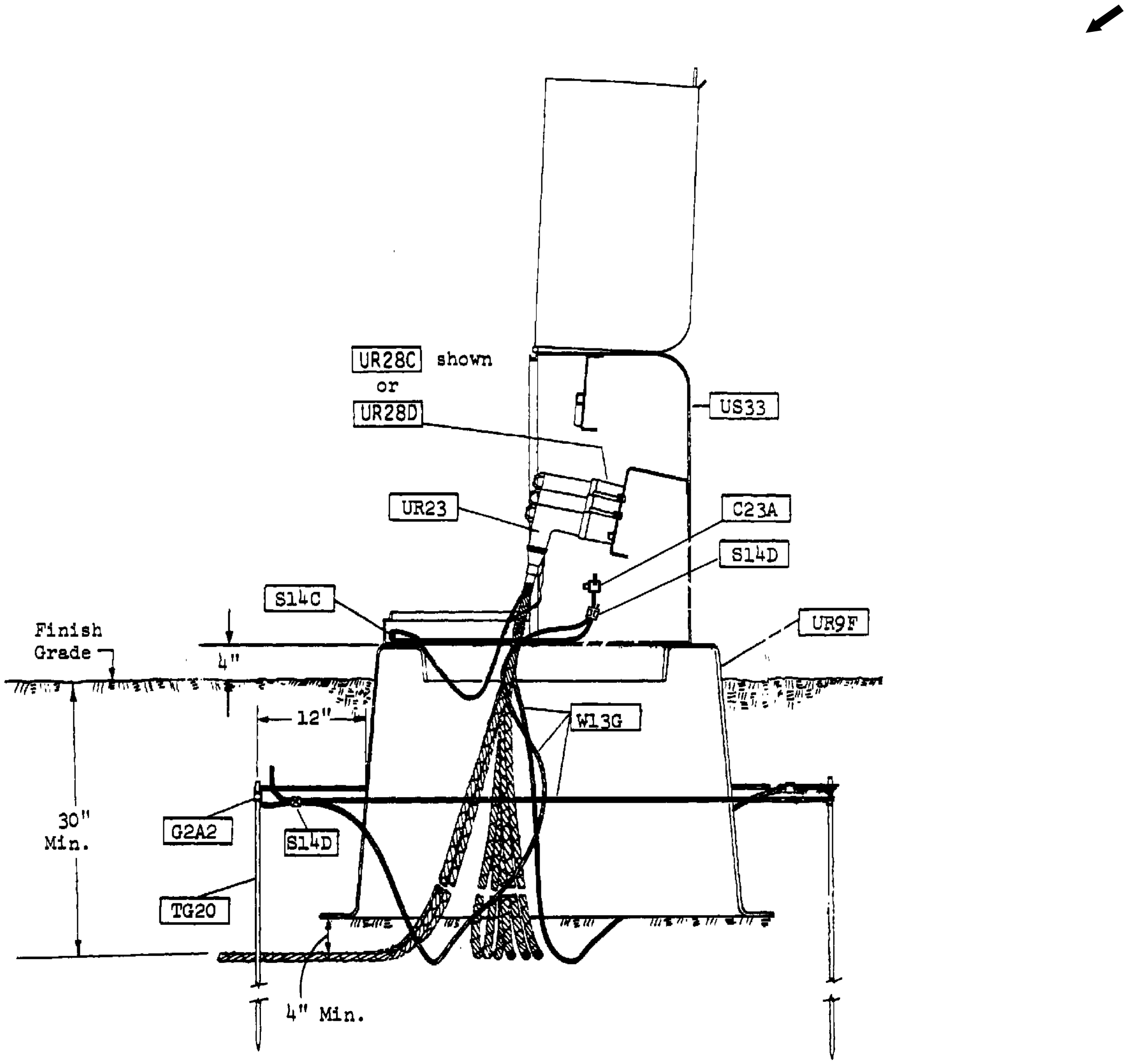


Supersedes 2/06 Issue –Drawing Update and previously was drawing 38-111

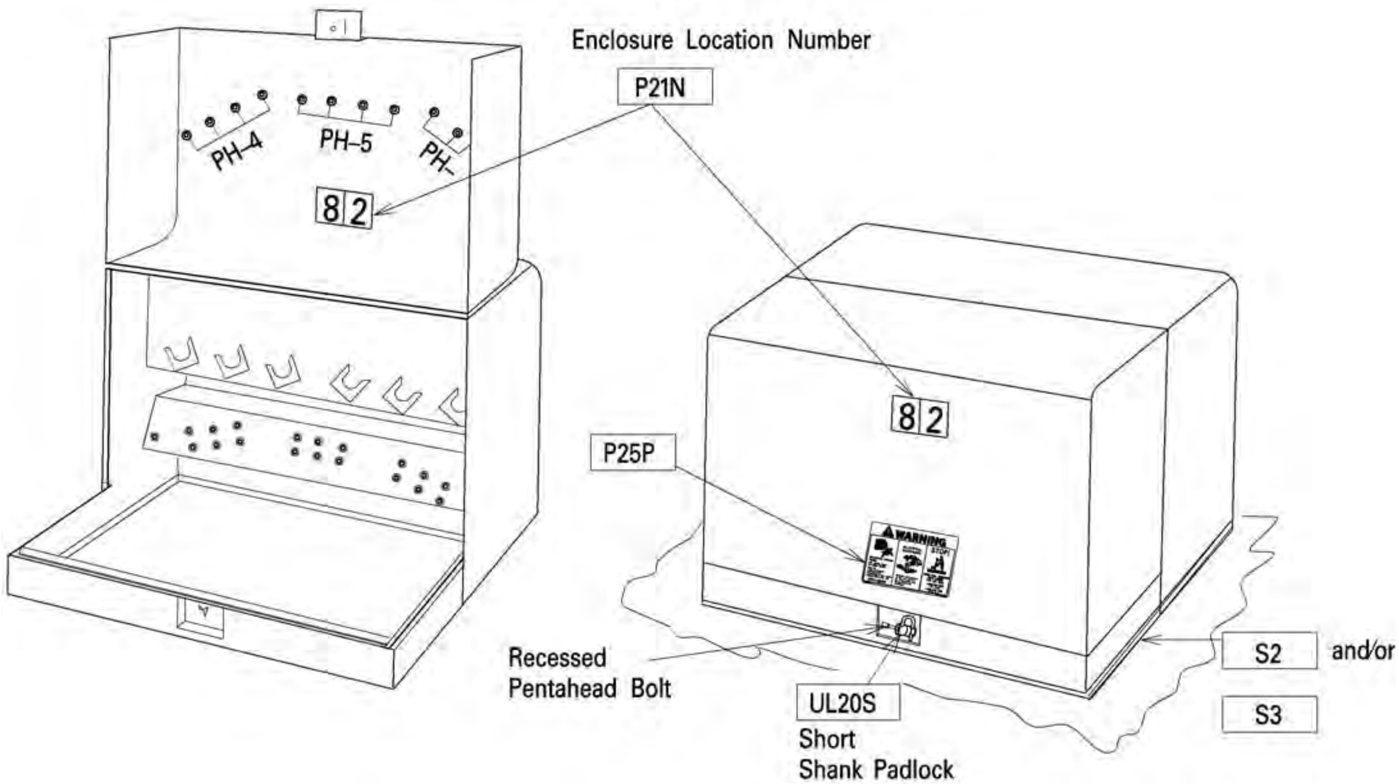
PAD MOUNTED JUNCTION ENCLOSURE TYPICAL INSTALLATION
SHOWN WITH US33

ISSUE	PAGE NUMBER		
7/08	38-112	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

Supersedes 2/06 Issue– Drawing Update and was previously drawing 38-112



PAD MOUNTED JUNCTION ENCLOSURES DIRECT BURIAL SHOWN WITH US33			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 38-113	ISSUE 7/08

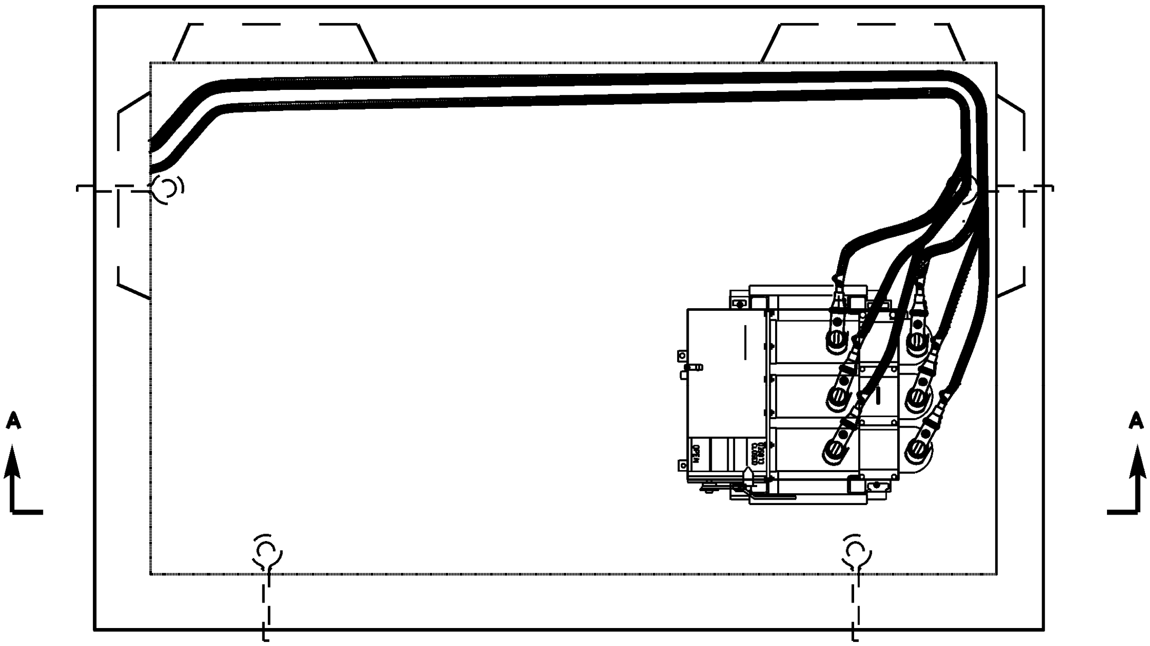


Supersedes 2/06 Issue – Previously was drawing 38-113

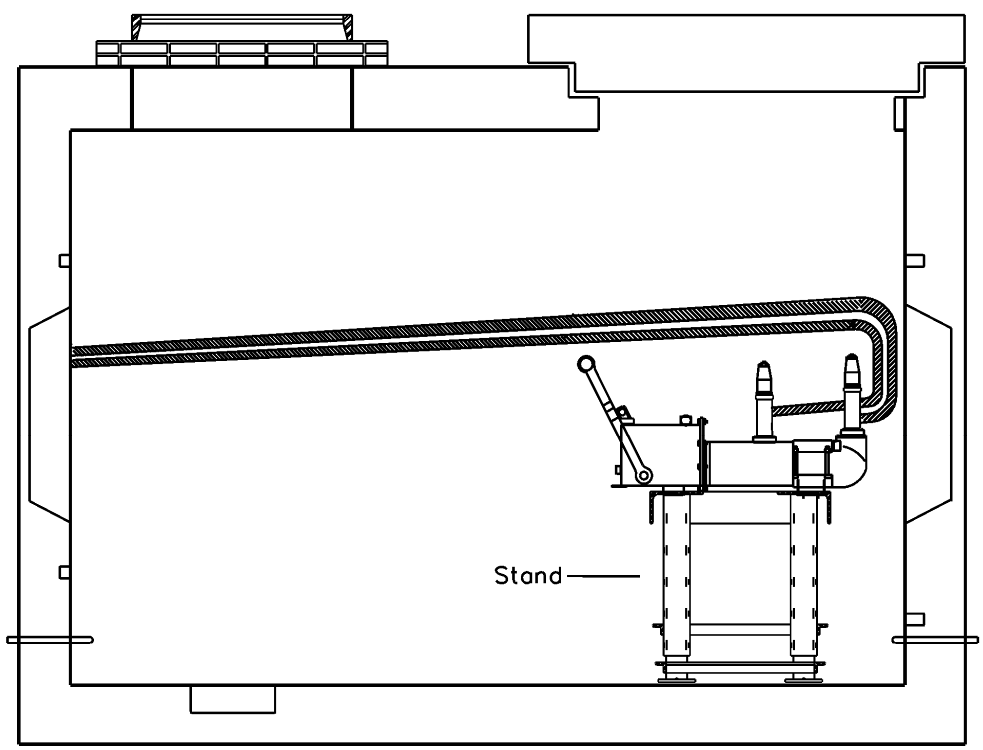
PADMOUNTED JUNCTION TYPICAL LABELING

ISSUE	PAGE NUMBER		
7/08	38-114	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

New Drawing

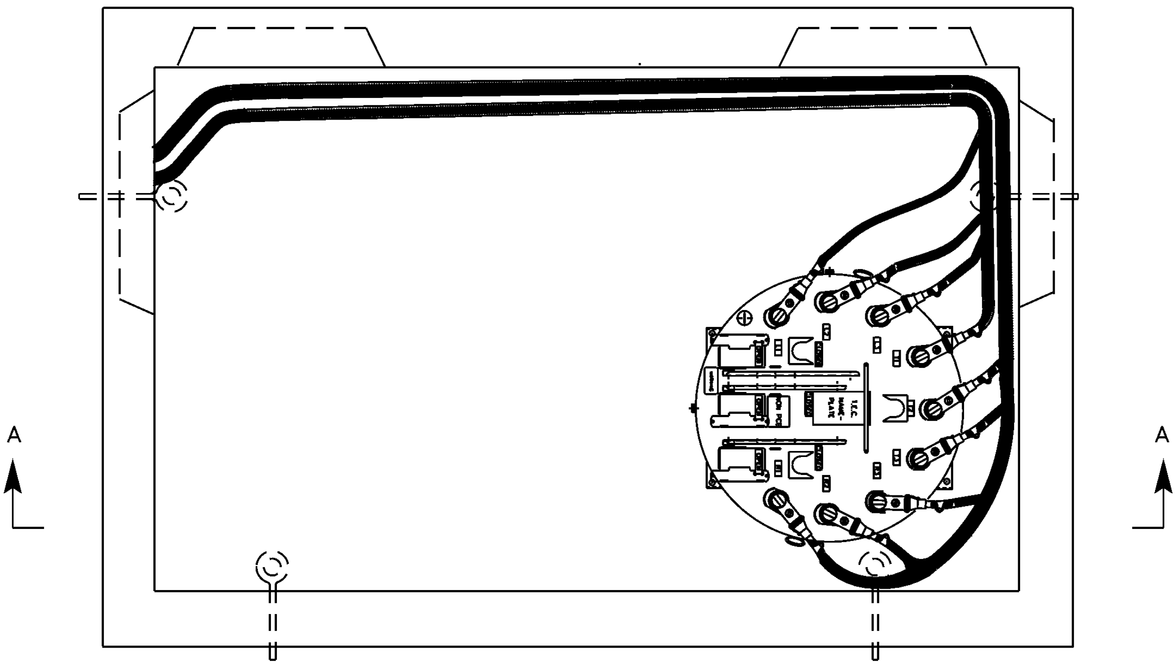


PLAN VIEW

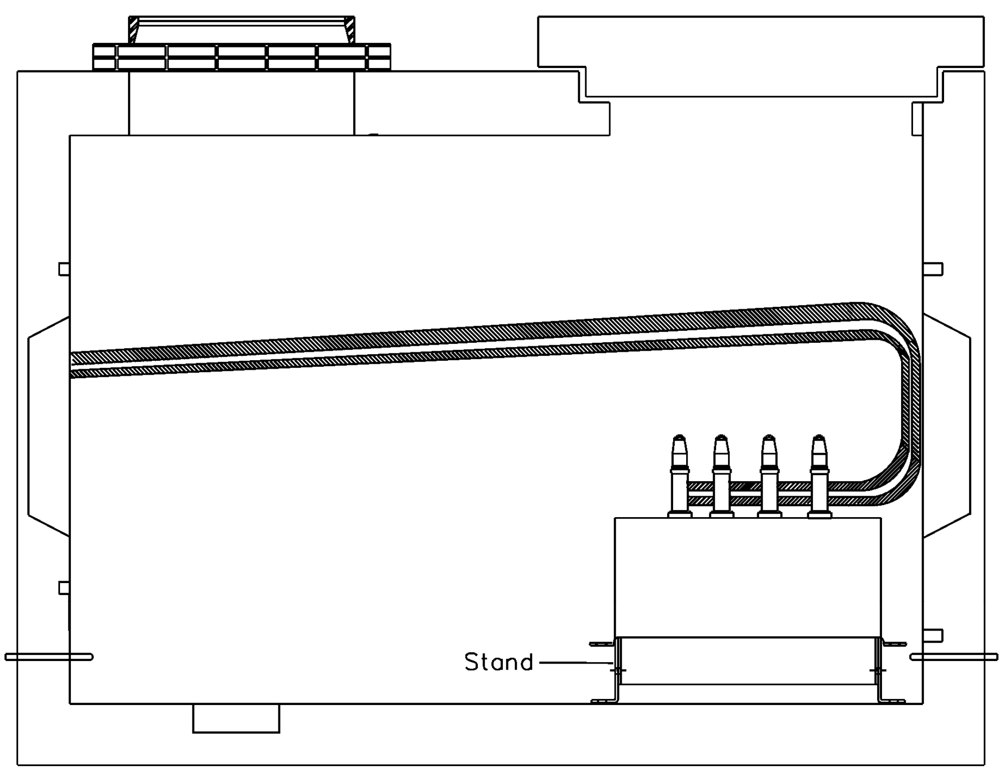


SECTION A-A

ONE WAY SUBMERSIBLE SWITCH INSTALLED IN A 6'X10' SIDEWALK MANHOLE(STD ITEM UM28)			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		38-120	7/08



PLAN VIEW

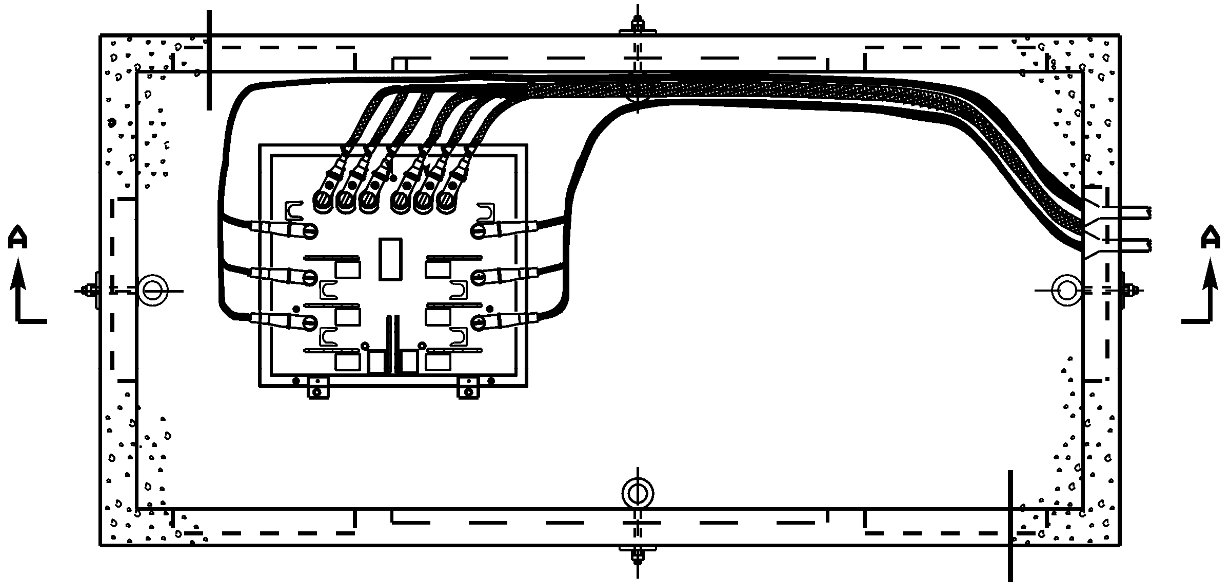


SECTION A–A

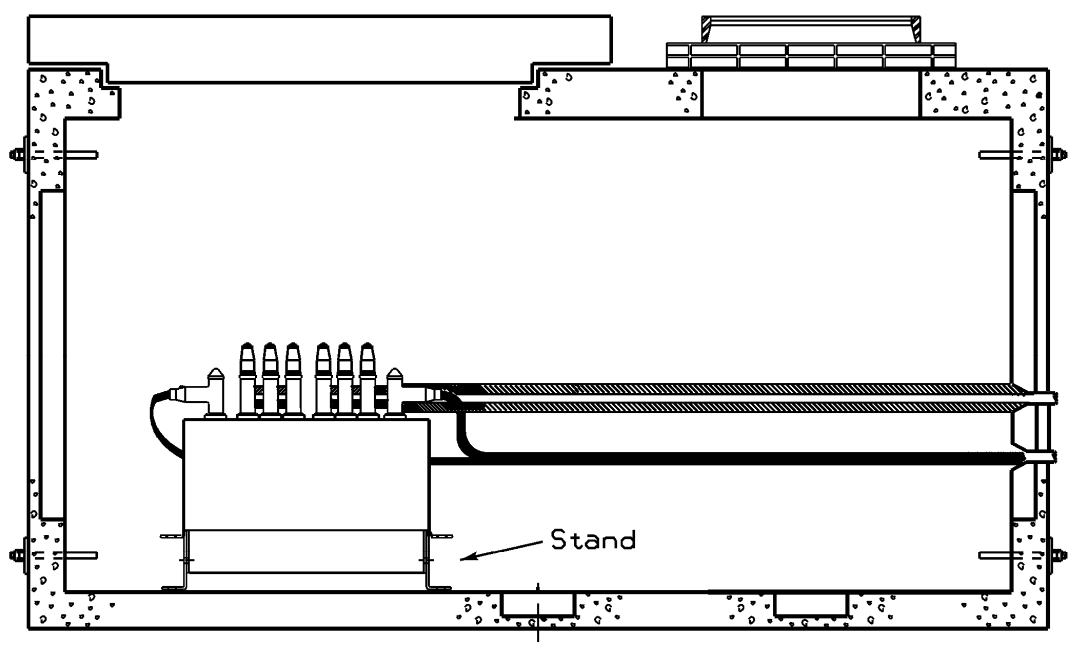
New Drawing

THREE WAY SUBMERSIBLE SWITCH INSTALLED IN A 6'X10' SIDEWALK MANHOLE (STD ITEM UM28)			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/08	38-121		

New Drawing



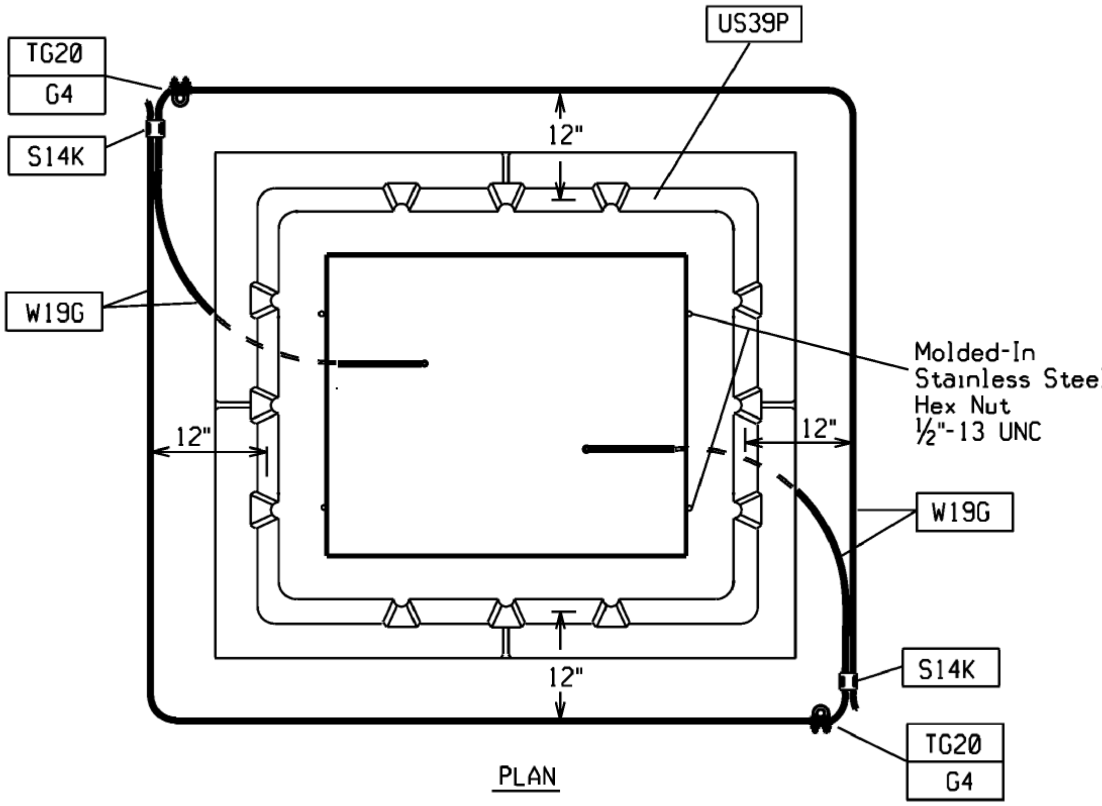
Plan View

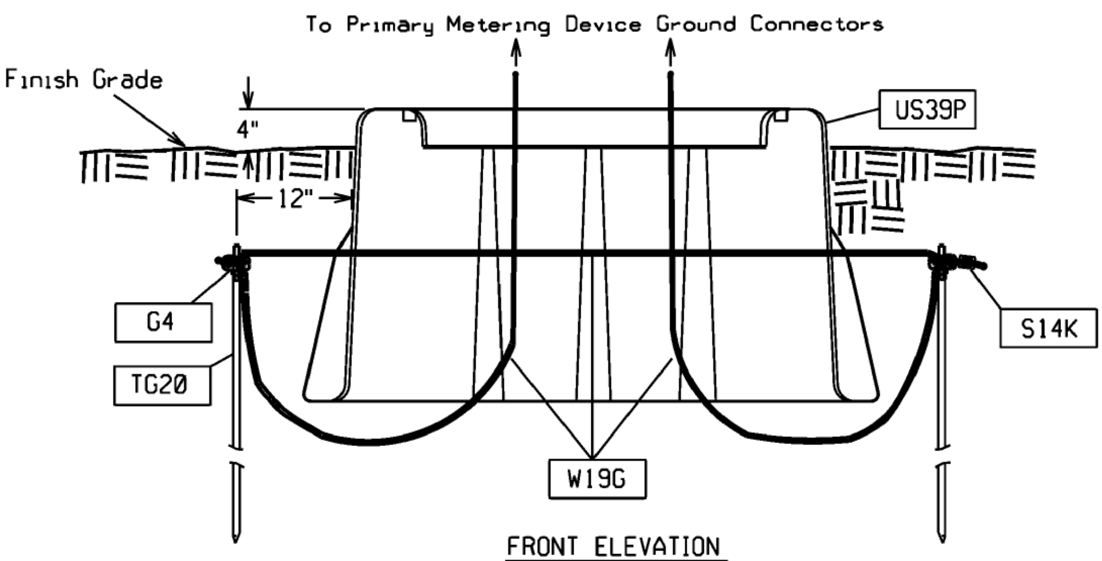


A-A View

FOUR WAY SUBMERSIBLE SWITCH INSTALLED IN A SWITCHGEAR MANHOLE (STD ITEM UM20E)			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		38-122	7/08

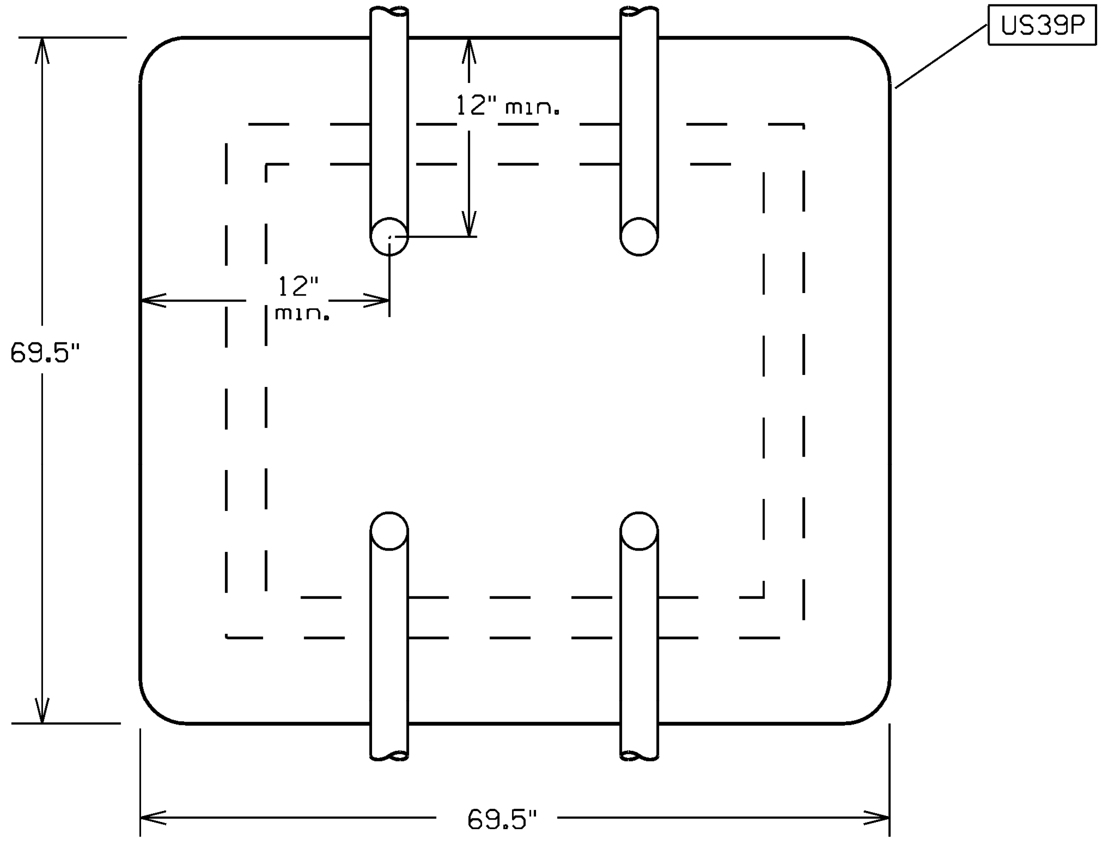
 Doc. # ST. 38.00.001





New drawing.

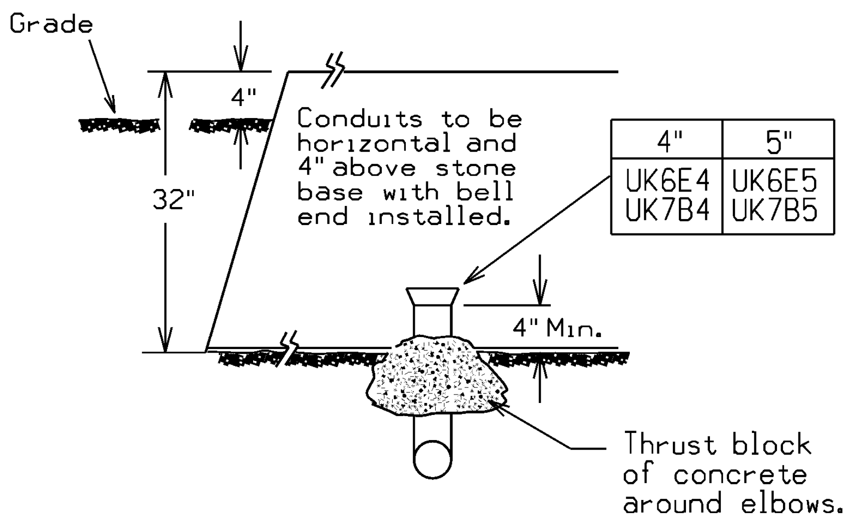
THREE PHASE PAD-MOUNTED PRIMARY METERING FIBERGLASS BASE INSTALLATION WITH GROUND GRID			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/09	38-200		



New drawing.

NOTE: 4" OR 5" CONDUIT - 1 OR 2 CONDUITS PER QUADRANT AS REQ.

PLAN VIEW



TYPICAL SIDE VIEW

THREE PHASE PAD-MOUNTED PRIMARY METERING FIBERGLASS BASE CONDUIT ENTRY HORIZONTAL15kV			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 38-204	ISSUE 7/09 2006

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2	7/09	• Updated Std Item numbers on Drawings 38-100, 38-105, 38-106, and 38-107. • Added new drawings for Primary Metering fiberglass boxpad installation (Drawings 38-200 and 38-204).	Katie Croteau	Al Chieco, Director of Distribution Standards and Work Methods
1	07/08	• Updated Std Item numbers in section 38.4. • Updated section 38.5. • Updated section 38.6. • Updated section 38.7. • Update to US41A and Added US41AR, US41C and US41CR on page 38-10. • Updated section 38.8 and inserted Figure 12. • Renumbered Figures and Tables throughout text • Std Item numbers updated on page 38-100. • Drawing updated on pages 38-101, 38-102, 38-103, 38-110. • New construction drawings on pages 38-104, 38-105, 38-106, 38-107, 38-111, 38-120, 38-121, 38-122. • Drawing updated on page 38-112 and previously was drawing 38-111 (renumbered). • Drawing updated on page 38-113 and was previously drawing 38-112 (renumbered). • Page 38-114 was previously drawing 38-113 (renumbered).	John Vartanian	Al Chieco, Director of Distribution Standards and Work Methods

Supersedes 2/06 Issue – Page Change, Added 39.8

Supersedes 2/06 Issue – Spelling update in Table 1

39.0 GENERAL

The following Standard is to be followed when designing and installing fuses. This Section shall apply to primary and secondary systems.

Listed below is a general guide to power fuse nomenclature used by S&C Electric, the power fuse manufacturer. In the event that greater detail is necessary, the manufacturer should be contacted.

Table 1
S&C Power Fuse Nomenclature

SM - _	Basic designation for power fuses
SML - _	Refers to a mounting with “uni-rupter”, for single pole switching (Indoor use)
SMU - _	Fuse “unit”. No refills **-** replace entire “unit” when blown (e.g. SMU-20)
SM-4Z and SML-4Z	Refers to fuse holder. The “Z” denotes a silencer (indoor use**)**
SM-5S and SM-5SS	Refers to a fuse holder. Includes “snuffler” or “super snuffler” (indoor use)
SMD -20	Refers to an outdoor disconnect mounting.

SM-4 and SM-5 mountings generally do not include fuse holders or refills but do include silencers where appropriate. SM-20 mountings may not include end fittings.

39.1 APPLICATION

Fuses will be used where there is a need to protect line-side equipment from high currents caused by failures within the equipment on the load-side of the fuse. Fuses will also be installed to protect equipment from overload and fault currents, and will be used to minimize the potential catastrophic failure of transformers due to internal faults.

39.2 CURRENT LIMITING FUSES

In areas of high fault currents, an energy limiting device may be required to limit let-through short circuit current to a level which will minimize the potential of failures to transformers and other distribution equipment. A full range current limiting fuse is such a device and is designed to interrupt any current large enough to melt its fuse element up to its maximum interrupting rating. A type C fuse is a full range current limiting fuse which will melt the fuse element at 1000 seconds when carrying 170 – 240% of its continuous current rating. They can be applied at locations where the available fault current is as high as 50,000 A, RMS symmetrical.

Full range current limiting fuses are to be installed where recommended by Distribution Design (e.g. pad-mounted transformers, switchgear, etc.). Refer to Section 50 – Materials Catalog for clip style full range current limiting fuses (Std. Item F12C) and for current limiting fuses with an arc strangler switch (Std. Item F13C).

39.3 POWER FUSES

Power fuses are used on the distribution system when increased interrupting or current carrying capacity is required, or where expulsion fuses are otherwise not suitable. Power fuses are to be used only when specified by Distribution Design. Refer to appropriate power fuse located in Section 50 – Materials Catalog (Std. Items F4 – F8 and F19 – F24).

39.4 INTERRUPTING CAPACITY

Table 2
SM-4 Fuses

Nominal System Voltage (kV)	Nominal Fuse Rating (kV)	Interrupting Rating (kA)	
		Asymmetric	Symmetric (X/R=15) *
2.4 – 4.8 kV Grounded or Ungrounded	7.2[1]	27.5	17.2
8.32 kV Grounded Wye	14.4[2]	25.0	15.6
11.5 – 13.8 kV Grounded or Ungrounded	14.4[2]	20.0	12.5
22.9 – 24.9 kV Grounded or Ungrounded	25.0	15.0	9.4
34.5 kV Grounded Wye	34.5	10.0	6.25

* For other X/R ratios refer to manufacturer's catalog
1. 7.2 kV refills and holders in 4.8 kV mountings
2. 14.4 kV refills and holders in 13.8 kV mountings

Table 3
SM-5 Fuses (SM-5, SM-5S, SM-5SS)

Nominal System Voltage (kV)	Nominal Fuse Rating (kV)	Interrupting Rating (kA)	
		Asymmetric	Symmetric (X/R=15) *
2.4 – 4.16 kV Grounded or Ungrounded	4.16[1]	60.0	37.5
2.4 – 4.16 kV Grounded or Ungrounded	7.2[2]	44.5	28.0
4.8 kV Delta	7.2[2]	43.5	27.0
8.32 – 13.8 kV Grounded or Ungrounded	14.4[3]	40.0 **	25.0 **
22.9 – 24.9 kV Grounded or Ungrounded	25.0	32.0	20.0
22.9 – 34.5 kV Grounded or Ungrounded	34.5	28.0	17.5

* For other X/R ratios refer to manufacturer's catalog
** SM-5SS Ratings greater
1. 4.16 kV refills in 7.2 kV holders in 4.8 kV mountings
2. 7.2 kV refills and holders in 4.8 kV mountings
3. 14.4 kV refills and holders in 13.8 kV mountings

Table 4
SM-20 Fuses (SM-20, SML-20, SMD-20)

Nominal System Voltage (kV)	Nominal Fuse Rating (kV)	Interrupting Rating (kA)	
		Asymmetric	Symmetric (X/R=15) *
8.32 – 13.8 kV Grounded or Ungrounded	14.4[1]	22.4	14.0
22.9 – 24.9 kV Grounded or Ungrounded	25.0	20.0	12.5
22.9 – 34.5 kV Grounded or Ungrounded	34.5	13.5	8.45

* For other X/R ratios refer to manufacturer's catalog
1. 14.4 kV fuse units in 13.8 kV mountings

39.5 FUSE HOLDERS AND END FITTINGS

The following fuse holders are for outdoor use. Silencer/snuffler are available separately if needed.

Table 5
SM-4/SM-5

Nominal Voltage (kV)	SM-4		SM-5	
	Std. Item	S&C Catalog No.	Std. Item	S&C Catalog No.
7.2	C49A	86051	C50A	86151R2
14.4	C49B2	86052	C50B	86152R2
25.0	C49C	86053	C50C	86153R2
34.5	C49D	86054	F7H	86154R2

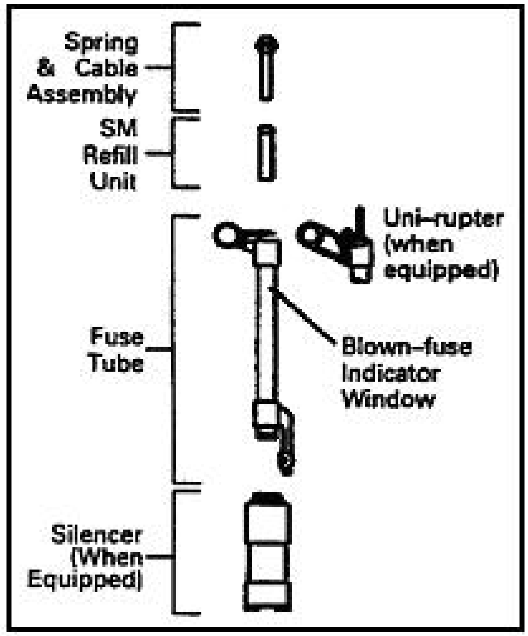


Figure 1
SM-4 (SM-5 Similar)

The following fuse holders are for indoor use, including pad-mounted switchgear, and incorporate silencer/snuffler.

Table 6

Nominal Voltage (kV)	SM-4	
	Std. Item	S&C Catalog No.
14.4	C49B__	92352
25.0	C49C1	92353

The following end fittings are for indoor use with SMU-20 fuse units, including pad-mounted switchgear. Silencer and uni-rupter fitting included.

Table 7
SMU-20

End Fittings	Std. Item	S&C Catalog No.
SML-20	C51	3097

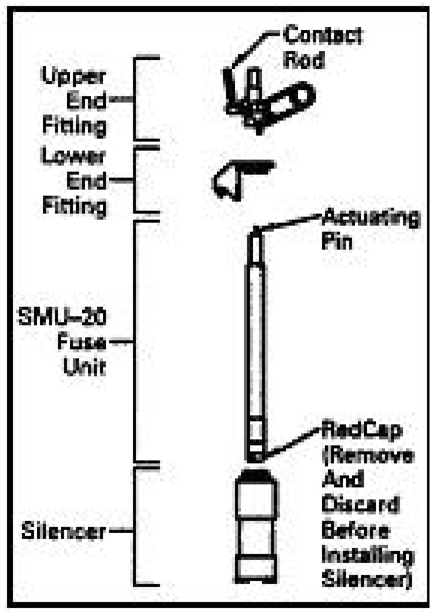


Figure 2
SMU-20

39.6 TRANSFORMER FUSING

Pad-mounted transformers are equipped with different types of fusing depending on date of purchase and/or voltage class. The transformer nameplate should be consulted to determine the type of fusing for any given transformer. Current designs utilize a Bay-O-Net fuse under oil in series with an internal, non-replaceable current limiting fuse. Older designs had a Bay-O-Net fuse in a drywell canister, both with and without current limiting fuses

When a transformer must be re-fused, a fuse of the same type and rating as that originally supplied by the manufacturer must be used. When this information is not available, the following tables shall be used to determine the replacement fuse.

39.6.10 Single Phase Transformers

A. Bay-O-Net Fuse

A Bay-O-Net fuse may be used alone or in conjunction with a current limiting fuse. In general, the Bay-O-Net fuse is designed to protect the line-side system from damage caused by transformer faults, and the transformer from overload and secondary fault currents. The current limiting fuse is designed to minimize the potential of catastrophic failure of the transformer due to internal faults. The current limiting fuse is not accessible externally. When the current limiting fuse operates, the transformer must be replaced.

When a single phase pad-mounted transformer is equipped with a Bay-O-Net fuse only, or with a Bay-O-Net fuse in series with current limiting fuse, the following table should be used to determine the replacement fuse.

Table 8

kVA		Primary Voltage				
		3740 GrdY/2160 4160 GrdY/2400	8320 GrdY/4800	12470 GrdY/7200	13200 Grd/7620 13800 GrdY/7920	34500 GrdY/19920
25	Rating (A)	25	10	10	6	3*
	Std. Item	F3B25	F3B10	F3B10	F3B8	F3A3
50	Rating (A)	40	25	15	15	3*
	Std. Item	F3B40	F3B25	F3B15	F3B15	F3A3
75	Rating (A)	65	25	25	15	8*
	Std. Item	F3B65	F3B25	F3B25	F3B15	F3A8
100	Rating (A)	65	40	25	25	10
	Std. Item	F3B65	F3B40	F3B25	F3B25	F3B10
167	Rating (A)	140	65	40	40	15*
	Std. Item	F3B140	F3B65	F3B40	F3B40	F3A15

* Dual (load) sensing fuse, all others are current (fault) sensing.

B. Full Range Current Limiting Fuse In Drywall Canister

Single phase transformers, 15 kV class and below, may be equipped with a full range current limiting fuse in a loadbreak drywell canister. In these cases the following table should be used to determine the appropriate replacement fuse.

Supersedes 2/06 Issue – STD. Item update in Table 8

Table 9

kVA		Primary Voltage		
		3740 GrdY/2160 4160 GrdY/2400	**8320 GrdY/4800**	**12470 GrdY/7200 13200 GrdY/7620 13800 GrdY/7970**
25	**Rating (A)**	18C	10C	8C
	Voltage (kV)	4.36	5.5	8.3
	Std. Item	F12C1	F12C6	F12C10
50	**Rating (A)**	35C	18C	12C
	Voltage (kV)	4.3	5.5	8.3
	Std. Item	F12C2	F12C7	F12C11
75	**Rating (A)**	50C	25C	18C
	Voltage (kV)	4.3	5.5	8.3
	Std. Item	F12C4	F12C8	F12C12
100	**Rating (A)**	65C	40C	25C
	Voltage (kV)	4.3	5.5	8.3
	Std. Item	F12C4	F12C9	F12C13
167	**Rating (A)**	100C	--	40C
	Voltage (kV)	4.3	--	8.3
	Std. Item	F12C5	--	F12C14

39.6.20 Three Phase Transformers

A. Bay-O-Net Fuse

Bay-O-Net fuses may be used alone or in conjunction with current limiting fuses. In general, the Bay-O-Net fuse is designed to protect the line-side system from damage caused by transformer faults and the transformer from overload and secondary fault currents. The current limiting fuse is designed to minimize the potential of catastrophic failure of the transformer due to internal faults. The current limiting fuse is not accessible externally. When the current limiting fuse operates, the transformer must be replaced.

When a three phase pad-mounted transformer is equipped with Bay-O-Net fuses only, or with Bay-O-Net fuses in series with current limiting fuse, the following table should be used to determine the replacement fuse.

Table 10

kVA		Primary Voltage						
		2400	3740	4160 4800	8320	11500	12470 13200 13800	34500
75	Rating (A)	25	25	25	10	10	10	3*
	Std. Item	F3B25	F3B25	F3B25	F3B10	F3B10	F3B10	F3A3
150	Rating (A)	65	40	40	25	15	15	3*
	Std. Item	F3B65	F3B40	F3B40	F3B25	F3B15	F3B15	F3A3
300	Rating (A)	--	65	65	40	25	25	10
	Std. Item	--	F3B65	F3B65	F3B40	F3B25	F3B25	F3B10
500	Rating (A)	--	100	100	65	40	40	15
	Std. Item	--	F3B100	F3B100	F3B65	F3B40	F3B40	F3B15
750	Rating (A)	--	100	140	100	65	65	25*
	Std. Item	--	F3B100	F3B140	F3B100	F3B65	F3B65	F3A25
1000	Rating (A)	--	--	--	100	100	65	25*
	Std. Item	--	--	--	F3B100	F3B100	F3B65	F3A25
1500	Rating (A)	--	--	--	--	--	100	50*
	Std. Item	--	--	--	--	--	F3B100	F3A50

* Dual (load) sensing fuse, all others are current (fault) sensing.

B. <u>Full Range Current Limiting Fuses In Type EL Bay-O-Net Holders</u>

Some transformers rated 34.5 kV may be equipped with Cooper type ELS full range current limiting fuses in Bay-O-Net holders.

When a three phase pad-mounted transformer is equipped with type ELS current limiting fuses in Bay-O-Net holders, the following table should be used to determine the replacement fuse.

Table 11

Type ELS Current Limiting Fuse – 34.5 kV Application		
Transformer kVA	**Fuse Size**	**Std. Item**
750	20 A	F14A20
1000	20 A	F14A20
1500	25A	F14A25

Supersedes 2/06 Issue – Added 39.65

39.65 MINIPAD TRANSFORMER FUSE COORDINATION

This section of the standards will assist in fuse coordination with underground transformers and riser pole fuses. The coordination is where two adjacent fuses operate in series, the “protected fuse” is on the supply side and the “protecting fuse” is on the load side. If a fault occurs beyond the protecting fuse, it should clear before the protected fuse has reached 75% of its melting time. In high fault duty areas, current limiting fuses may be required. More information on current limiting fuses is available in the overhead standards book in section 12.4.20.

39.65.1 Coordination with Bayonet Type Fuses for Single Phase Minipads

A. K Link Sectionalizing fuse

TABLE 12

Std. Item	Bayonet Type Amps	Minimum Sectionalizing Fuse Size K Link		Std Item	Bayonet Type Amps	Minimum Sectionalizing Fuse Size K Link
F3A3	3*	10		F3B25	25	65
F3A8	8*	25		F3B40	40	100
F3A15	15*	65		F3B65	65	**
F3B6	8	15		F3B100	100	**
F3B10	10	15		F3B140	165	**
F3B15	15	25				

* Dual (load) sensing fuse, all others are current (fault) sensing.
** Refer to Field Engineering for coordination.

B. T Link Sectionalizing fuse

TABLE 13

Std. Item	Bayonet Type Amps	Minimum Sectionalizing Fuse Size T Link		Std Item	Bayonet Type Amps	Minimum Sectionalizing Fuse Size T Link
F3B6	6	15		F3B40	40	65
F3B15	15	25		F3B65	65	100
FB325	25	40		F3B140	165	**

** Refer to Field Engineering for coordination.

39.65.2 Coordination with Full Range Current Limiting Type Fuses for Single Phase Minipads

TABLE 14

Full Range Current Limiting Fuse Size	Minimum Size Sectionalizing Fuse (K Type)		
	Current Limiting Fuse Voltage Rating		
	4.16kV 3.74kV	8.32kV	12.47kV 13.2kV 13.8kV
8C			25
10C		25	
12C			40
18C	40	65	65
25C		65	100
35C	100		
40C		100	140
50C	140		
65C	140		
100C	**		

** Refer to Field Engineering for coordination.

New Standard

39.7 BAY-O-NET FUSE ASSEMBLY DETAIL

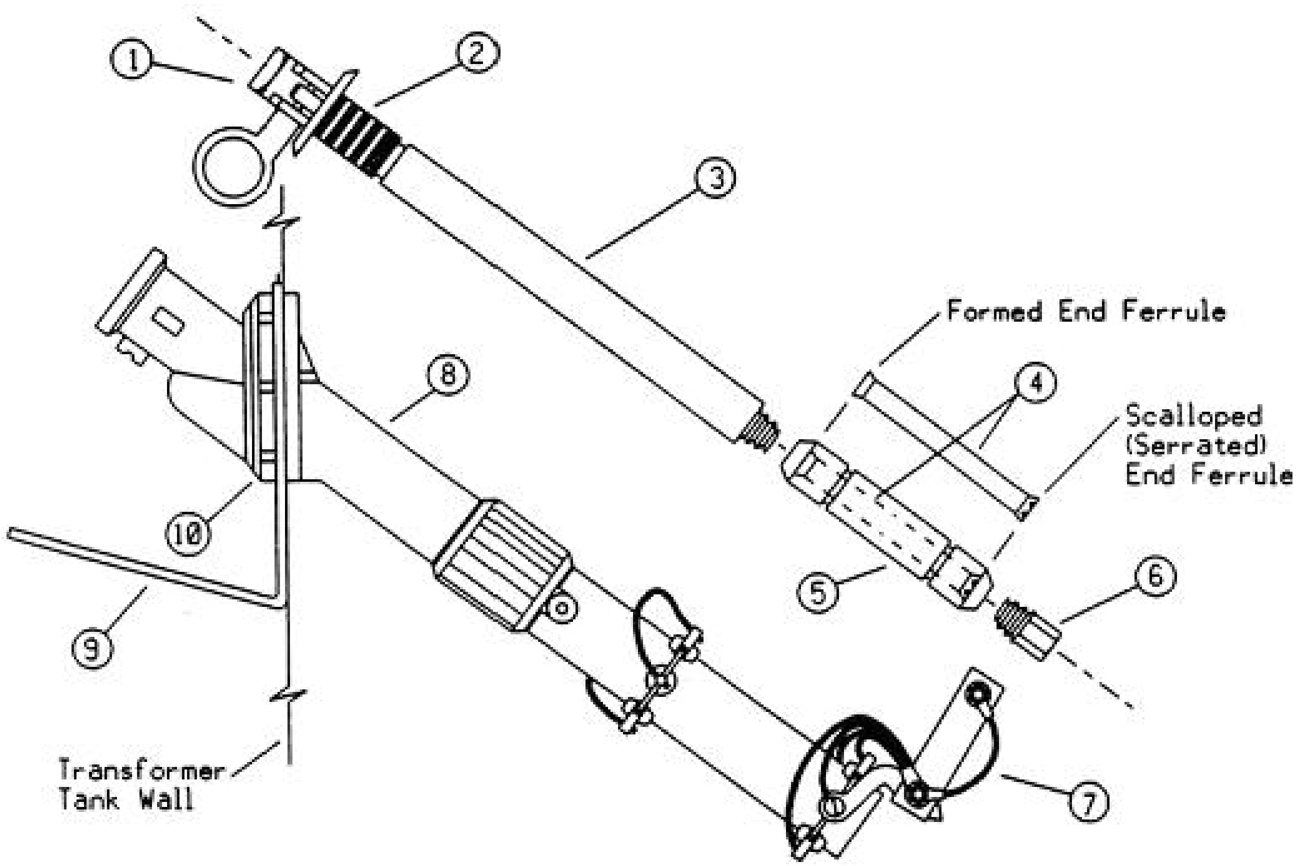


Figure 3

A. Assembly List

1. Switch Stick Operated Handle
2. Neoprene Gasket Seal
3. Inner Fuse Cartridge Holder
4. Load Sensing Fuse Link
5. Fuse Cartridge
6. Screw-In End Plug
7. Isolation Link
8. Outer Fuse Housing
9. Drip Shield
10. Mounting Nut and Gasket

39.8 FAULT CIRCUIT INDICATORS (FCI's)

Automatic reset Fault Circuit Indicators (FCI, Std. Item UF50_) are available for use to aid in trouble shooting underground systems during emergencies. The FCI's have load tracking circuitry that monitors the load and adjusts the trip current range automatically (200Amp minimum trip). During a fault, the indicator flashes a bright red LED light for 8 hours. The indicator will reset automatically on current or time. The indicators shall be mounted at cable termination points. See figure 4 for installation details.

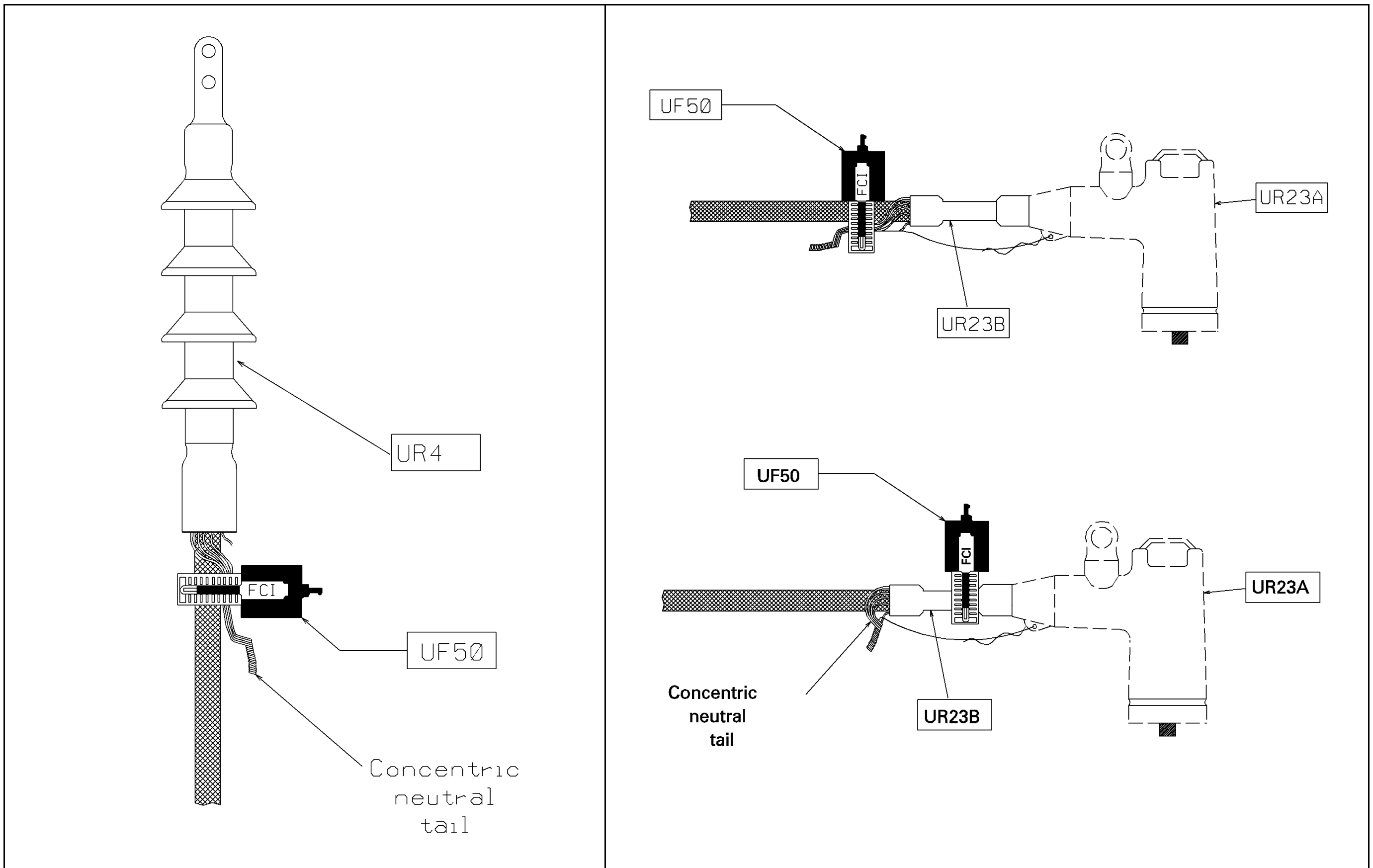
To test or reset the FCI, use reset magnet Std. Item UF50A. To test the indicator, attach reset magnet to end of switch stick and position the magnet to the left side of the indicator labeled "test" and the red light will flash. To reset the indicator, attach reset magnet to the end of a switch stick and position the magnet to the right side of the indicator labeled "reset" and the red light will stop flashing.

Section 44 and 45 explain the uses of the indicators in UCD's and URD's.

Note: When the automatic reset type FCI's are first installed, and there is more current than the minimum trip setting, the FCI needs to adjust and will begin to flash, The red LED will turn off after one minute if there is no fault current.

New Standard

Figure 4



Termination Installation Install indicator over neutral tail	Elbow Installations Install indicator over neutral tail or before neutral tail

40.0 GENERAL

This Section covers the details of installing and connecting underground single and three phase transformers. It also provides guidance on selection of dual voltage rated vs. single voltage rated transformers. While dead front transformers are the preferred transformers for 15 kV and 35 kV applications, live-front transformers will be covered for 23 kV applications and maintenance purposes. Fusing details are covered in Section 39 - Fuses, grounding details can be found in Section 44 – UCD and Section 45 – URD and lightning protection is covered in this Section.

40.1 CUSTOMER REQUIREMENTS

The Company's customer service policies require that customers "having the potential to exceed 75 kVA of transformer capacity are required to supply space for electrical equipment on private property" (*SPECIFICATIONS FOR ELECTRICAL INSTALLATIONS* or *ELECTRICAL SERVICE, INFORMATION AND REQUIREMENTS* for company specific information). This requires the customers, whose load may reasonably be expected to exceed 75 kVA at some point in the future, to provide a location for a pad-mounted transformer and pad-mounted switchgear. All secondary cable, connectors and connector fasteners shall be furnished, installed, owned and maintained by the Customer. Final electrical connections to the transformer secondary terminals shall be inspected by the Company. The Company's transformer will be equipped with bushings that accept NEMA standard two-hole spade terminals mounted in the secondary cabinet.

40.2 LOCATION

The physical location where transformers should be placed is discussed in Section 44 – UCD and Section 45 – URD. In general, transformers shall be placed as near as possible to the center of the load.

40.3 SIZING AND LOADING

ANSI/IEEE C57.91 and C57.92 "Guidelines for Loading Mineral Oil Immersed Transformers" along with recent IEEE Papers were used to determine maximum kVA loading for single and three phase pad-mounted transformers.

40.3.10 Single Phase Mini-Pads

Based on load research data for actual customer loading, it was found that single phase transformers were pre-loaded to approximately 40-60% and the peak load duration was around 2 hours. Using an ambient temperature in summer of 95 degrees Fahrenheit and 32 degrees Fahrenheit in the winter, the respective overload levels of 140% and 160% were chosen. Different preloads and overload durations may affect these overload percentages. Contact Standards Engineering for specific situations.

40.3.20 Three Phase Padmounts

Based on ANSI/IEEE temperature limits the loading was based on not exceeding a maximum hot spot winding temperature of 140 degrees Celsius. This gives a corresponding top oil temperature of approximately 110 degrees Celsius which is safely below the flash point of mineral oil.

Based on these temperature limits and an 8-hour overload cycle with a pre-load of 100% of nameplate, the overload guides were determined to be 120% of nameplate in the summer and 140% of nameplate in the winter. Different preloads and overload durations may affect these overload percentages. Contact Standards Engineering for specific situations.

40.4 INSTALLATION

Detailed transformer installation can be found in Section 44 – UCD and Section 45 – URD.

40.5 PRIMARY CABLE TERMINATIONS

40.5.10 Dead Front – Radial or Loop Feed

Use loadbreak bushing well insert (Std. Item UR36B or UR94) and loadbreak elbow connector (Std. Item UR23 or UR90) with concentric neutral cable.

40.5.20 Live Front – Radial Feed

Use cable terminators per Section 37 – Terminations.

40.6 SECONDARY CABLES

40.6.10 Three Phase Pads

Three phase pad size and number of secondary cables shall be in accordance with The National Electrical Code and shall be approved by the appropriate inspection agency or Wire Inspector of the Town or City involved. Maximum number of secondary cables to be physically connected to the Company's pad-mounted transformer is outlined below:

4 Hole Spades	6 sets 750 kcmil Max.
6 Hole Spades	8 sets 750 kcmil Max.
10 Hole Spades	10 sets 600 kcmil or 8 sets of 750 kcmil

Secondary requirements greater than this shall necessitate a separate compartment, handhole, or bus duct and should be referred to Distribution Design. Refer to Section 44 – UCD for more detail.

40.6.20 Single Phase Mini-Pads

No more than six sets of secondary conductors are permitted in a single phase mini pad. Maximum size secondary cable shall not exceed 500 kcmil.

Note: Secondary conductors installed in metallic conduit shall contain a complete set of phase conductors and a neutral conductor in each conduit to prevent excessive heating.

40.7 SECONDARY CABLE CONNECTIONS

40.7.10 Three Phase Pads

Secondary cable connections will be made with a cable to flat clamp or compression type connector, with a minimum of two holes in the flat pad and two clamping elements or two compressions per cable. See Section 44 – UCD for details of secondary cable terminations.

40.7.20 Single Phase Mini-Pads

Secondary cable connections use Std. Item UR21.

40.8 GROUNDING

Standard grounding connections are shown in Section 44 – UCD and Section 45 – URD. Bonding of the conduits in the transformer primary and secondary compartments is required when the conduit is metallic.

Concentric neutral conductors in a grounded wye system are current carrying conductors and shall always be connected first and removed last during installation and removal. They shall always be connected to the transformer tank before the transformer is energized.

40.9 FUSING

In general, loop feed pad-mounted transformers have internal fusing as shown in Figure 1. The following criteria of fusing apply, unless otherwise specified by Distribution Design.

A. Overhead Supplied, Radial Feed, Pad-Mounted Transformers, without internal fusing shall be fused on the riser pole in accordance with Overhead Construction Standards Section 12 – Protection.

B. Overhead Supplied, Loop Feed, Pad-Mounted Transformers, with internal fusing shall be fused on the riser pole in accordance with fuse coordination table in Overhead Construction Standards Section 12 – Protection.

C. Underground Supplied, Radial and Loop Feed, Pad-Mounted Transformers shall be fused in accordance with fuse coordination tables in Section 39 – Fuses.

D. Dual ratio transformers, equipped with fusing, shall be refused in accordance with tables in Overhead Construction Standards Section 12 – Protection whenever the primary supply voltage is changed.

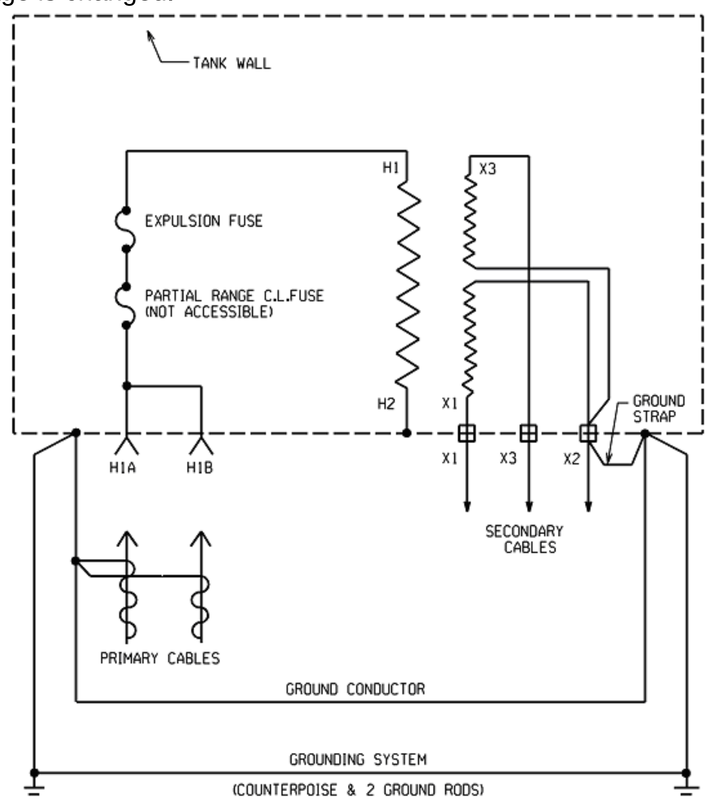


Figure 1
(Single Phase Unit Shown For Simplification)

40.10 METERING

Meter installations for single customers supplied by three phase pad-mounted transformers may be installed on the transformer.

40.11 THREE PHASE PAD-MOUNTED TRANSFORMER INSTALLATION

The size and type shall be determined by Distribution Design. Installation shall be in accordance with Section 44 – UCD.

40.12 LOOP FEED PAD-MOUNTED TRANSFORMER

Connection and grounding shown in Figure 2 are typical for a three phase open point loop feed transformer with surge arresters. Figure 2 may be adapted for radial deadfront or for live front transformers. See Section 44 – UCD for details of secondary cable terminations.

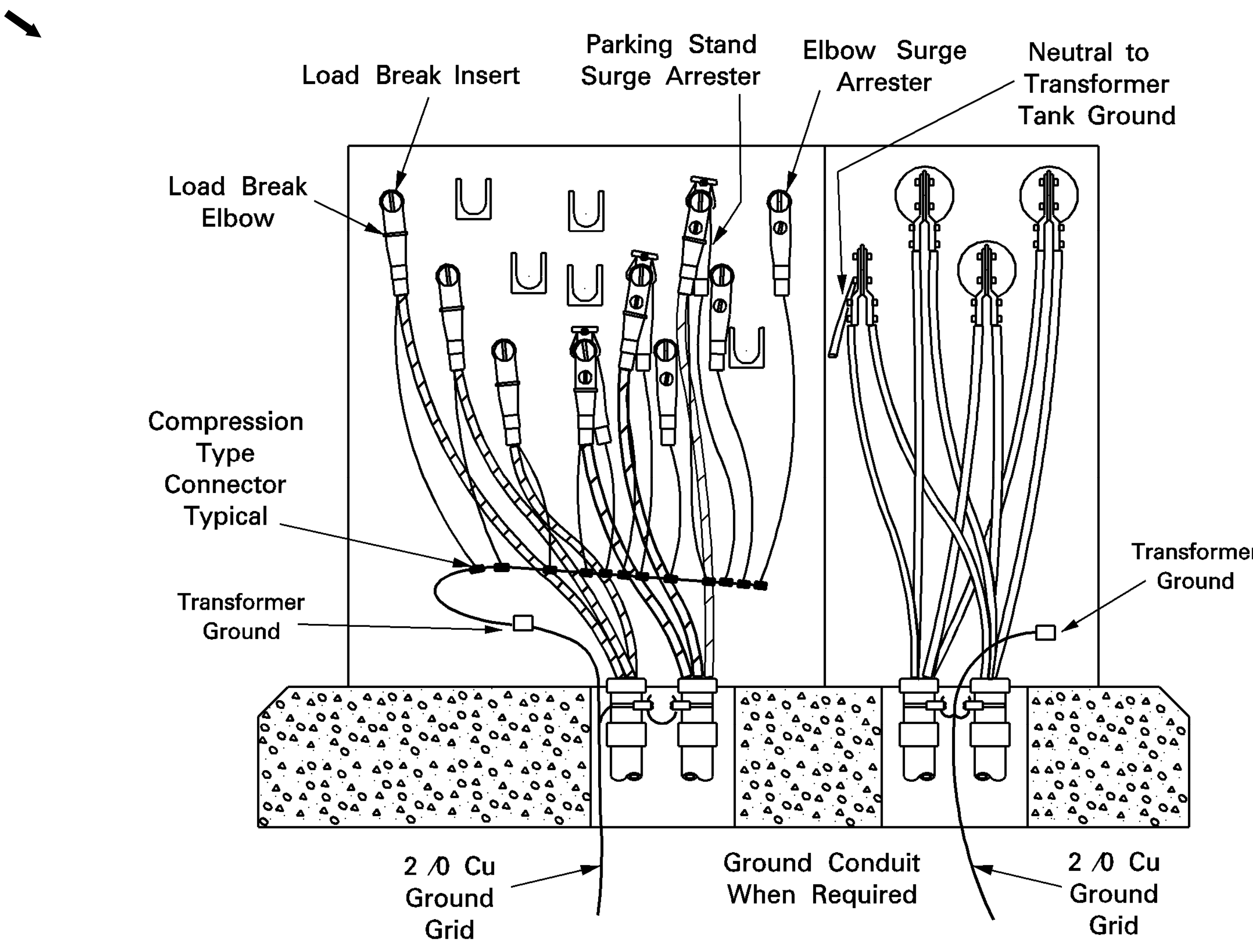


Figure 2
Loop Transformer With Parking Stand And Elbow Arresters

Figure 3 details proper tagging on transformers with tag holder and tag phrase (Std. Item UP21W and UP21P). All elbows must be tagged with Company approved tags to match the manufacturer's designation on the bushing where they would normally be installed to energize the transformer. Bushing identification tags are required in addition to cable tags.

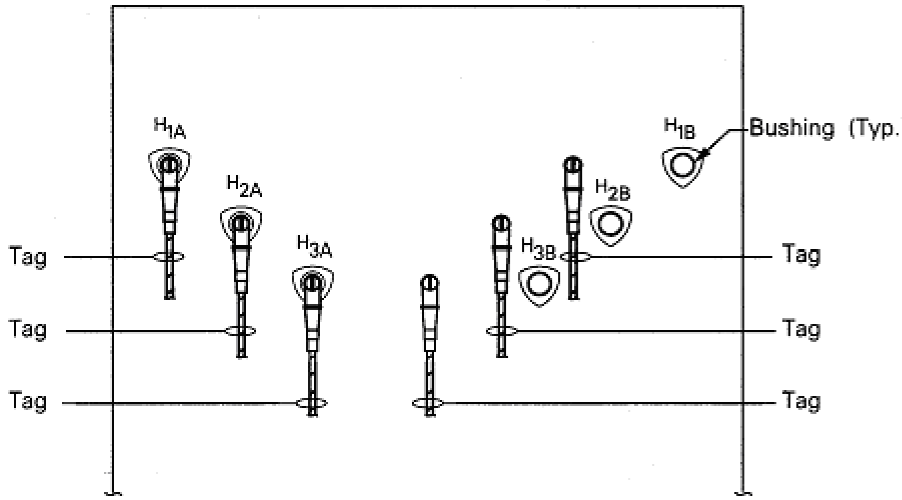
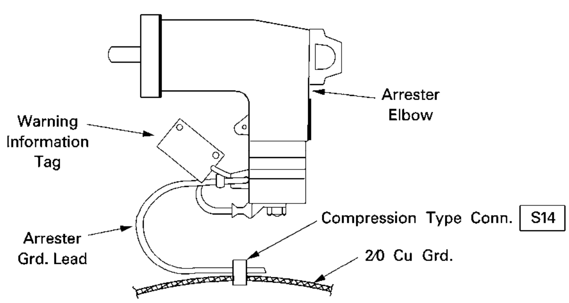


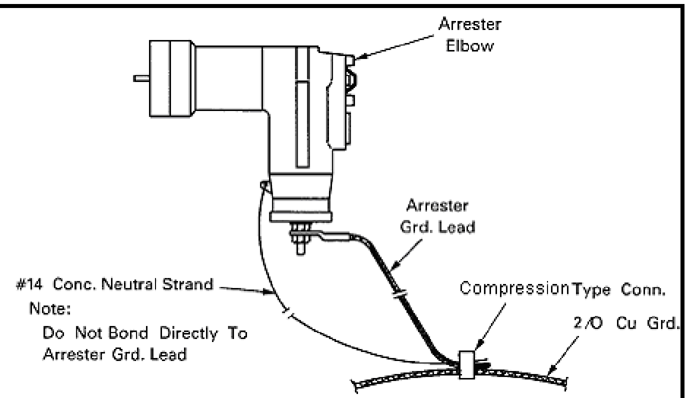
Figure 3
Primary Compartment

Supersedes 1/07 Issue. Modify Paragraph 40.13

40.13 SURGE PROTECTION

Surge arresters are required at riser poles, transformer locations and at all open points. Figure 4, 5 and 6 detail proper grounding detail for elbow arresters and parking stand arresters. Elbow arrester (Std. Item UR40), parking stand arrester (Std. Item UR40B3) and bushing well arrester (Std. Item. UR40C) may come with braided ground lead.





Elbow Arrester with braided ground attached to housing.	Elbow Arrester without ground attached to housing, install #14 concentric neutral or equivalent from housing to 2/0 Cu. system ground.

Figure 4
Arrester Elbow Grounding Detail with grounding lead (Std. Item UR40A)

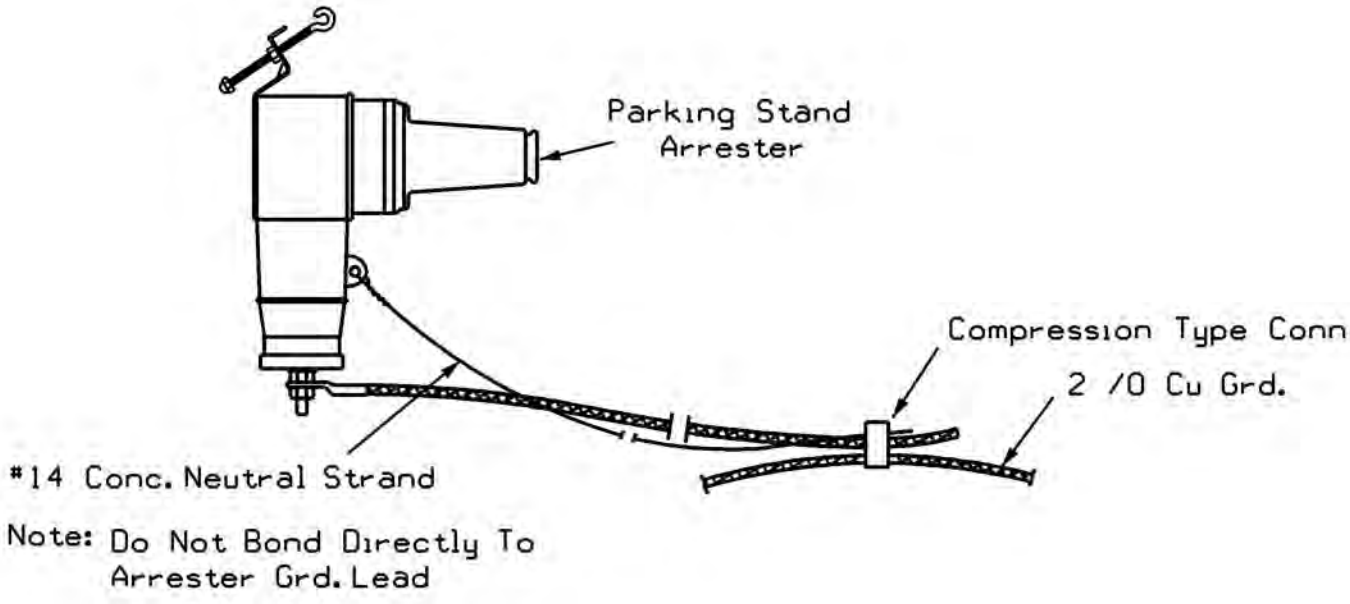


Figure 5
Arrester Parking Stand Grounding Detail (Std. Item UR40B3)

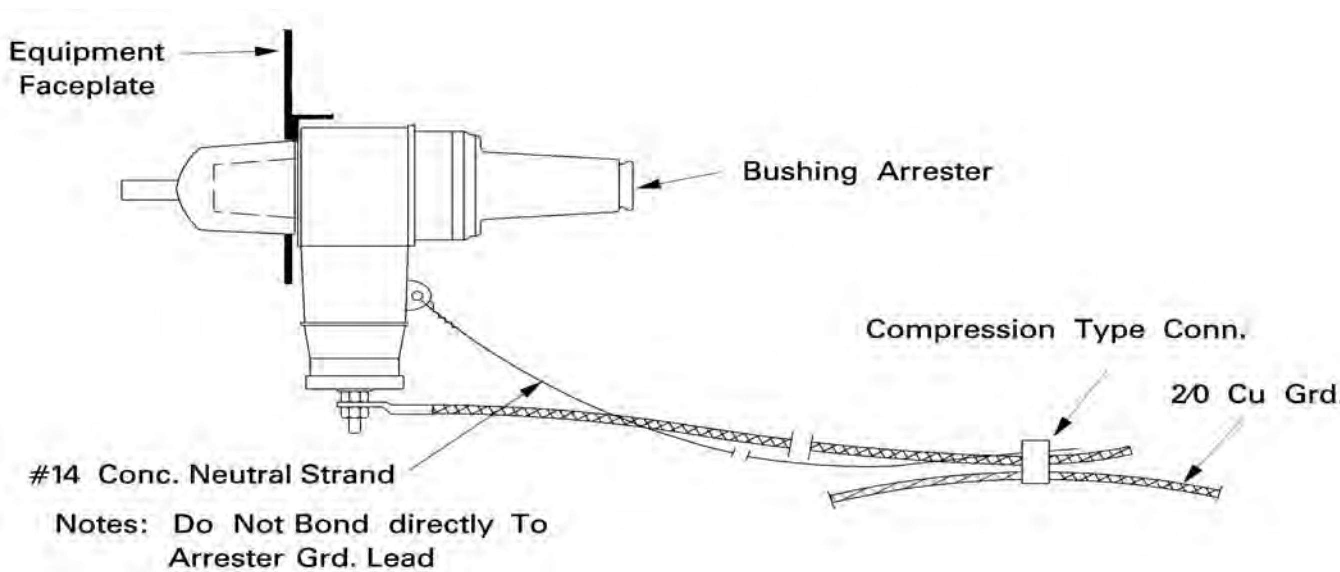


Figure 6
Bushing Arrester Grounding Detail (Std. Item UR40C)

Supersedes 7/08 Issue – Moved Section 40.14 Easements to page 40-7

Supersedes 2/06 Issue. Modify Formatting for Section 40.14. Added new Section 40.20

40.14 EASEMENTS

All Company owned equipment must be located within a permanent easement. Easements shall be in accordance with Section 44 – UCD and Section 45 – URD.

40.15 PAD-MOUNTED TRANSFORMER FOUNDATION

Location shall be designated or approved by the Company. In general, transformers shall be located in accordance with Sections 44 – UCD and Section 45 – URD.

40.16 SUBWAY TRANSFORMERS

Every effort should be made to use pad-mounted transformers for new installations. Only if pad-mounted transformer locations can not be obtained, subway transformers can be installed, provided they are installed in vaults and manholes. Low profile units are available for manholes with low headroom. These transformers must be located to allow pulling the loadbreak elbows from outside the vault or above the manhole. If it is not possible to locate the transformers with elbows being accessible, then an MVS (molded vacuum switch) must be installed. Subway transformers are available with or without internal fusing. If transformers without internal fusing are used, then an MVI (molded vacuum interrupter) shall be installed in the primary. The low profile units are all without internal fusing. Subway transformers for use on a delta primary system are not available in loop-feed configuration.

40.17 SUBSURFACE TRANSFORMERS

Subsurface transformers have been used in URD's. Subsurface transformers are for maintenance only. Subsurface transformers shall be per MS2590. If a subsurface transformer fails, it shall be replaced with a mini-pad. This shall be done by splicing the high and the low voltage cables, if necessary, in order to connect them to the mini-pad. To make these changes a pad-mounted conversion cover will be needed, choose from one of the following: Std. Items UR12P, UR12F, UR12G or UR12H. Dead-break elbows shall be changed to load-break elbows.

40.18 STEP-DOWN TRANSFORMERS

Three phase, pad-mounted step-down (or step-up) transformers are available where required to change primary voltage and where overhead transformers are not suitable.

40.19 NETWORK TRANSFORMERS

Distribution Design shall designate network transformer locations. Network transformer installation and maintenance shall be in accordance with Section 42 – Networks.

40.20 HANDLING RETURNED TRANSFORMERS

40.20.10 Procedures

The following guideline outlines procedures for handling returned distribution transformers, including overhead, pad-mounted, subsurface and subway types:

40.20.20 When To Junk Transformers

Transformers shall be junked under the following conditions:

A. Transformer rating 7.5 kVA and below.
B. Non-usable ratings – declare surplus before junking.
C. Cast iron tanks.
D. Non-standard mounting.
E. Repair parts not available.
F. Primary codes 013, 022, 035, 040, 085, 095 and 529.
G. Tap codes 77, 78, 83 and 89.
H. PCB transformers (500 ppm and above). **WARNING:** Transformers containing PCB fluid require special handling.
I. Transformers manufactured during or before 1970 unless the unit is required for assurance/back-up.

40.20.30 When To Return Transformers To Stock For Re-issue

Return transformers to stock for re-issue, without electrical testing, if all of the following apply:

A. Transformer has **non-PCB** label.
B. Transformer was removed on routine change-out or due to new construction.
C. Transformer bushings, terminals, protective coating, and other accessory equipment are in good condition.
D. Single phase transformer with secondary voltage rating of 120/240 or 240/480 (E/2E) with internal secondary connections set up for three wire operation. This applies to transformers with three low voltage terminals 100 kVA and below.

In addition:

A. Assign new physical data code to transformer if not already assigned.
B. Inspect condition of transformer markings and replace if necessary.
C. Remove bottom portion of “Transformer On Stock Status” tag.
D. Transfer transformer to stock.

New Process

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DESCRIPTION – Code numbers specify five basic items regarding transformers as follows:

00	000	00	00	00
Type Code (Table 1)	Primary Code (Table 2)	Secondary Code (Table 3)	Tap Code (Table 4)	Fuse & Switch Code (Table 5)

TABLE 1 – TYPE CODE

KEY	
OA – Mineral Oil-Filled, Air Cooled	**LF – Less Flammable-Filled, Air Cooled**
10	Overhead – OA
11	Overhead – OA w/Stainless Steel Tank
13	Overhead – LF
17	Overhead – CSP – OA – with Built In Overload Tripout
18	Pole type Pad Mounted Deadfront
20	Auto-Transformer – OA
30	Pad-mounted – Loop Feed – Dead Front – OA
31	Pad-mounted – Loop Feed – Dead Front – OA w/Stainless Steel Tank
32	Pad-mounted – Loop Feed – Live Front – OA
34	Pad-mounted – Loop Feed – Dead Front – LF
40	Subway – OA
41	Subway – OA – Low Profile
50	Pad-mounted – Radial Feed – Dead Front – OA
52	Pad-mounted – Radial Feed – Live Front – OA
54	Pad-mounted – Radial Feed – Dead Front – LF
56	Pad-mounted – Radial Feed – Dead Front – Dry
60	Network – OA
62	Network – LF
65	Network – Pad-mounted – LF
70	Subsurface – Radial Feed – OA
72	Subsurface – Loop Feed – OA
80	Self-Regulated – OA
90	Station Type
99	Other – Not Listed
Note:	Transformer types listed above may or may not have surge arresters.

Supersedes 2/06 Issue - Added Type Code 11 and 31 and revised Type Code 18 description

Supersedes 2/06 Issue – Corrected Type Code 108 voltage and added Code 116

TABLE 2 - PRIMARY CODE

KEY:

(-)		Voltage Nomenclature
E_1	=	$\sqrt{3}$ E
E_2	=	Any Value of E Other Than E, E_1, or 2E

* - One Primary Bushing - Single Phase Overhead Transformers
** - Two Primary Bushings - Single Phase Overhead
*** - Junk Codes

SINGLE PHASE TRANSFORMERS (001 – 500)

001 – 025	**E ****
005	480
007	600
010	11500
011	12000
012	13800
013	22000 ***
014	13200
015	22900
017	34400
018	34500
022	11000 ***
023	14400

026 – 050	**E/2E ****
035	2300/4600 ***
040	11000/22000 ***
042	11550/23100

076 – 088	**E X 2E ****
080	1200 X 2400
082	2400 X 4800
085	11000 X 22000***
086	11500 X 23000

089 – 100	**E X E_2 ****
095	22000 X 33000 ***

101 – 150	**E/E_1 Y ****
108	2160/3740Y
109	2400/4160Y
112	4160/7200Y
114	4800/8320Y
116	6930/12000Y
118	7200/12470Y
119	7620/13200Y
120	7970/13800Y
125	11500/19900Y
126	12000/20780Y
127	12470/21600Y
129	13200/22860Y
131	13800/23900Y
133	14400/24940Y
140	19920/34500Y

151 - 200	**E_1 Grounded Y/E ***
155	3740 Grounded Y/2160
157	4160 Grounded Y/2400
159	8320 Grounded Y/4800
165	12470 Grounded Y/7200
167	13200 Grounded Y/7620
169	13800 Grounded Y/7970
175	22860 Grounded Y/13200
177	24940 Grounded Y/14400
178	34400 Grounded Y/19860
180	34500 Grounded Y/19920

TABLE 2 – PRIMARY CODE (Continued)

SINGLE PHASE TRANSFORMERS (001 – 500) (Continued)

201 – 250	E/E Grounded Y **
217	13200/22860 Grounded Y
220	14400/24940 Grounded Y

251 – 300	E/E$_1$Y x E/E$_1$Y **
255	2160/3740Y x 7620/13200Y
257	2400/4160Y x 4800/8320Y
258	2400/4160Y x 7200/12470Y
259	2400/4160Y x 7620/13200Y
260	2400/4160Y x 7970/13800Y
263	2400/4160Y x 13800/23900Y
264	4160/7200Y x 7620/13200Y
265	4160/7200Y x 7970/13800Y
267	4160/7200Y x 12470/21600Y
269	4160/7200Y x 13800/23900Y
271	4160/7200Y x 14400/24900Y
272	4800/8320Y x 7200/12470Y
273	4800/8320Y x 7620/13200Y
275	4800/8320Y x 7970/13800Y
277	4800/8320Y x 14400/24940Y
280	7200/12470Y x 19920/34500Y
281	7620/13200Y x 19920/34500Y
282	7970/13800Y x 19920/34500Y

301 – 350	**E1 Grd Y/E x E1 Grd Y/E ***
310	3740 GrdY/2160 x 13200 GrdY/7620
315	4160 GrdY/2400 x 12470 GrdY/7200
316	4160 GrdY/2400 x 13200 GrdY/7620
317	4160 GrdY/2400 x 13800 GrdY/7970
325	8320 GrdY/4800 x 12470 GrdY/7200
326	8320 GrdY/4800 x 13200 GrdY/7620
327	8320 GrdY/4800 x 13800 GrdY/7970
330	12470 GrdY/7200 x 34500 GrdY/19920
331	13200 GrdY/7620 x 34500 GrdY/19920
332	13800 GrdY/7970 x 34500 GrdY/19920
333	13800 GrdY/7970 x 23900 GrdY/13800

401 – 425	(E/E$_1$ Y x E/E$_1$ Y x E/E$_1$ Y **
405	2400/4160Y x 7200/12470Y x 7620/13200Y
408	2400/4160Y x 7620/13200Y x 7970/13800Y
415	2400/4160Y x 7200/12470Y x 14400/24940Y
419	4800/8320Y x 7620/13200Y x 7970/13800Y
420	2400/4160Y x 7200/12470Y x 7970/13800Y

426 – 450	E$_1$ Grd. Y/E x E$_1$ Grd. Y/E x E$_1$ Grd. Y/E *
432	4160 GrdY/2400 x 13200 GrdY/7620 x 13800 GrdY/7970

451 – 460	E$_1$ Grd. Y/E x E$_1$ Grd. Y/E x E$_1$ Grd. Y/E x E$_1$ Grd. Y/E **

461 - 475	E$_1$ Grd Y/E x E$_1$ Grd Y/E x E$_1$ Grd Y/E x E$_1$ Grd Y/E *
465	3740 GrdY/2160 x 4160 GrdY/2400 x 13200 GrdY/7620 x 13800 GrdY/7970
500	Other

Supersedes 2/06 Issue – Deleted PDC 453 because this connection cannot be built

TABLE 2 – PRIMARY CODE (Continued)

THREE PHASE TRANSFORMERS (501 – 999) (Continued)

501 – 550	E	501 – 550	E
505	480	532	12470
507	600	533	13200
515	2400	534	13500
520	4160	535	13800
523	4800	537	14400
525	8320	540	22900
529	11000 ←	542	23900
530	11500	545	34500

551 – 575	E_1Y

576 – 600	E x 2E
580	2400 x 4800
592	11500 x 23000

601 – 635	E x E_2
605	2400 x 4160
610	2400 x 13200
612	2400 x 13800
614	3740 x 13200
616	4160 x 12470
617	4160 x 13200
619	4160 x 13800
621	4800 x 8320
622	4800 x 13200
623	4800 x 13800
624	8320 x 12470
630	13800 x 22860

636 – 650	E/E_1 Y
640	2400/4160Y

651 – 675	E_1 Y/E
652	4160Y/2400

676 – 725	E_1 Grd Y/E
682	4160 GrdY/2400
684	4330 GrdY/2500 ←
690	12470 GrdY/7200
691	13200 GrdY/7620
693	13800 GrdY/7970
700	24900 GrdY/14400
705	34500 GrdY/19920

726 – 740	E/E_1 Y/E
730	2400/4160Y/2400

750 - 755	E_2 x E_1 Grd Y/E
750	4800 x 13200 GrdY/7620

826 – 875	E_1 Grd Y/E x E_1 Grd Y/E
828	3740 GrdY/2160 x 13200 GrdY/7620
832	4160 GrdY/2400 x 12470 GrdY/7200
833	4160 GrdY/2400 x 13200 GrdY/7620
835	4160 GrdY/2400 x 13800 GrdY/7970
840	8320 GrdY/4800 x 12470 GrdY/7200
841	8320 GrdY/4800 x 13200GrdY/7620
843	8320 GrdY/4800 x 13800 GrdY/7970
860	12470 GrdY/7200 x 34500 GrdY/19920
861	13200 GrdY/7620 x 34500 GrdY/19920
862	13800 GrdY/7970 x 34500 GrdY/19920

876 – 900	E/E_1 Grd Y/E

901 – 925	E/E_1 Y x E x E_1 Y/E
905	2400/4160Y x 2400 x 13800Y/7970

926 – 950	E x E_2 x E_2
935	4160 x 4800 x 13200

951 – 970	T
951	4160T
955	12470T
957	13200T
959	13800T

971 – 990	T x T
971	4160T x 12470T
973	4160T x 13200T
975	4160T x 13800T
980	4800T x 13200T

990 – 999	Others
997	23000 x 34500
999	Other

Supersedes 1/07 Issue – Added Type Code 684 and removed *** from Type Code 529

 Doc. # ST. 40.00.001

TABLE 3 – SECONDARY CODE

KEY:

(-) Voltage Nomenclature
E_1 = √3 E
E_2 = Any Value of E Other Than E, E_1, or 2E

SINGLE PHASE TRANSFORMERS (01 – 50)

01 – 09	E
01	120
02	240
05	480
07	600
08	14400

21 – 24	E x 2E
21	120 x 240
22	240 x 480
23	292 x 584
24	300 x 600

31 – 40	E/E_1 Y
31	120/208Y
32	265/460Y
33	277/480Y
34	4160/7200Y
35	2400/4160Y
36	4800/8320Y
37	7200/12470Y
38	7620/13200Y
39	7970/13800Y
40	12000/20780Y

44 – 46	E/E_1 Y x E/E_1 Y
44	2400/4160Y x 4800/8320Y
45	2400/4160Y x 7200/12470Y
46	2400/4160Y x 7620/13200Y

10 – 15	E/2E
10	120/240
11	115/230
12	240/480
14	292/584

25 – 30	E x E_2
26	277 x 600
27	300 x 650
28	480 x 600
30	600 x 2400

41 – 43	E_1 Grd Y/E
41	13200 GrdY/7620
42	4160 GrdY/2400

47 – 50	Others
47	120/240/208
48	2400/4160Y x 4160/7200Y
49	120/240/480/600
50	Other

16 – 20	2E/E
16	240/120
17	480/240

THREE PHASE TRANSFORMERS (51 – 99)

51 – 57	E
52	480
53	600
54	2400
55	4800

69 – 71	E/E_1 Y
71	4360Y/2520

79 – 82	E_1 Grd Y/E
79	4160 GrdY/2400
80	12470 GrdY/7200
81	13200 GrdY/7620
82	13800 GrdY/7970

90 – 94	T
91	208T/120
92	480T/277
93	480T x 240T
94	600T

61 – 65	E x 2E
61	240 x 480
63	2400 x 4800

72 – 78	E_1 Y/E
72	216Y/125
73	208Y/120
74	480Y/277
75	4160Y/2400
76	13200Y/7620
77	13800Y/7970
78	600Y/346

83 – 85	E/E_1 Y/E
83	2400/4160Y/2400

95 – 99	OTHERS
95	120 x 240/208Y
96	480Y/277 x 208Y/120
97	600 x 2400 x 4800
98	480Y/277 x 600Y/346
99	600 x 2400

Supersedes 7/10 Issue – Correction to Code 77 (13800Y/7970)

TABLE 4 – TAP CODE

KEY:

A = Taps Above Primary Nameplate Rating
B = Taps Below Primary Nameplate Rating

* Codes 14, 21 and 22 replaced actual codes in GIS prior to 5/20/2011 and are only used to reference GIS records preceding that date. All codes are now valid for use in GIS.

** Junk Codes (see Section 40.20)

00	**None**
01	1 - 2½ A
02	2 - 2½ A
04	4 - 2½ A

11	1 - 2½ B
12	2 - 2½ B
13	3 - 2½ B
14	4 - 2½ B
15	5 - 2½ B

21	1 - 2½ A + 3 - 2½ B
22	2 - 2½ A + 2 - 2½ B
23	3 - 2½ A + 1 - 2½ B
27	2 - 2½ A + 4 - 2½ B
29	4 - 2½ A + 2 - 2½ B

31	1 - 5 A
32	2 - 5 A
34	4 - 5 A

41	1 - 5 B
42	2 - 5 B
43	3 - 5 B
44	4 - 5 B

51	1 - 5 A + 2 - 2½ B
53	1 - 5 A + 1 - 5 B

61	1 - 10 A
65	1 - 10 B

72	4160 Volt

75	2520/2460/2400/2340/2280 Volt (Code 22*)
76	4360/4260/4160/4055/3590 Volt (Code 22*)
77	5040/4920/4680/4560 Volt **
78	8720/8520/8100/7900 Volt **
79	11275/11000/10725/10450/10175 Volt (Code 21*)
80	11800/11500/11200/10900/10600 Volt (Code 21*)
82	13090/12780/12470/12160/11850 Volt (Code 22*)
83	13200/12480/11500 Volt **
84	14400/13800/13200/12870/12540 Volt (Code 21*)
85	13860/13530/13200/12870/12540 Volt (Code 22*)
86	14400/14100/13800/13500/13200 Volt (Code 14*)
87	14400/14100/13800/13500/13200 Volt (Code 22*)
88	15600/15000/14400/13800/13200 Volt (Code 22*)
89	17200/16770/15910/15480 Volt **
90	14100/13800/13500/13200/12900 Volt (Code 21*)
92	24100/23500/22900/22300/21700 Volt (Code 22*)
94	36200/35300/34400/33500/32600 Volt (Code 22*)
96	36225/35363/34500/33638/32775 Volt (Code 22*)
98	14400/14040/13680/13320/12960 Volt (Code 14*)
99	Others

Supersedes 2/06 Issue - * Codes Use, ** Junk Codes Reference, Code 84 Underlined Nominal Voltage

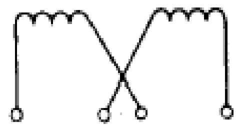
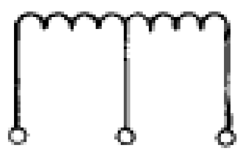
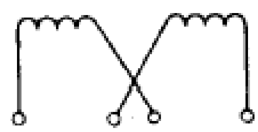
TABLE 5 – FUSE & SWITCH CODE (00 – 99)

00	None
01	Bayonet Fuse Holder (Loadbreak) With Expulsion Link Without Isolation Link Or Current Limiting Fuse
02	Bayonet Fuse Holder (Loadbreak) With Expulsion Link And With Isolation Link
04	Bayonet Fuse Holder (Loadbreak) With Current Limiting Fuse
05	Bayonet Fuse Holder (Loadbreak) With Expulsion Link And With Current Limiting Fuse Under Oil
07	Bayonet Fuse Holder (Loadbreak) With Expulsion Link Without Isolation Link Or Current Limiting Fuse And With Four Position Loadbreak Switch Under Oil
08	Bayonet Fuse Holder (Loadbreak) With Expulsion Link With Isolation Link And With Four Position Loadbreak Switch Under Oil
11	Drywell Canister (Loadbreak) With Current Limiting Fuse
12	Drywell Canister (Non-Loadbreak) With Current Limiting Fuse
21	Externally Mounted Hinge Type, Current Limiting Fuse
32	Current Limiting Fuse With Arc-Strangler Loadbreaking Device
33	Single Current Limiting Fuse (Clip Mounted) And Arc-Strangler Switchblade (Tandem-Unit Mounting)
34	Parallel Current Limiting Fuses (Clip Mounted) And Arc-Strangler Switchblade (Tandem-Unit Mounting)
35	Single Current Limiting Fuse (Hinge Mounted)
36	Parallel Current Limiting Fuse (Unitized-Hinge Mounted)
37	Single Current Limiting Fuse (Clip Mounted)
38	Parallel Current Limiting Fuse (Unitized-Clip Mounted)
51	Internal Weak Link Fuse Under Oil
53	Internal Weak Link Fuse Under Oil With Secondary Breaker
55	Secondary Breaker With No Internal Weak Link Fuse Under Oil
60	Two Position Loadbreak Switch Under Oil Without Fuse
61	Four Position Loadbreak Switch Under Oil Without Fuse
62	Four Position Loadbreak Switch Under Oil With Current Limiting Fuse
75	Three Position Deadbreak Switch With Two Electrical Interlocks Scheme
76	Three Position Mag Break Switch With Locked Energized Interlock Scheme
80	Network Protector
99	Other

EXPLANATION OF VOLTAGE RATINGS

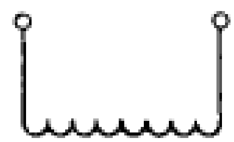
KEY:

$E_1 = \sqrt{3}\,E$
E_2 = Any Value Of E Other Than E, E_1 or 2E

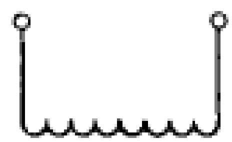
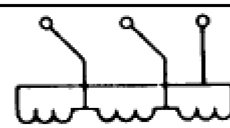
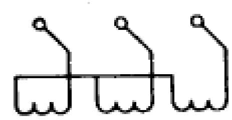
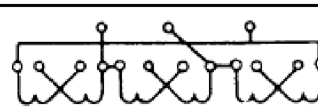
SINGLE PHASE TRANSFORMERS					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
001-025	01 - 09	E	34500		Indicates a winding for connection on an E volt system.
026-050	10 - 15	E/2E	120/240		Indicates a winding for multiple, series or three-wire service.
051-075	16 - 20	2E/E	240/120		Indicates a winding for 2E volts, two-wire full kVA, or for 2E/E volts three-wire service with one-half kVA available from mid-point to each outside terminal.
076-088	21 - 24	E x 2E	1200 x 2400		Indicates a winding for multiple or series operation only. (Not for three-wire service).
089-100	25 - 30	E x E_2	22000 x 33000		
101-150	31 - 40	E/E_1 Y	2400/4160 Y		Indicates a winding for connection on an E volt system or Y connection on an E_1 volt system.

EXPLANATION OF VOLTAGE RATINGS (Continued)

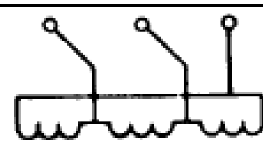
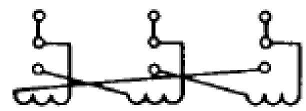
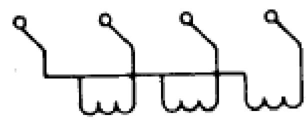
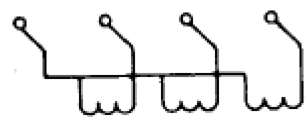
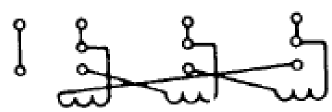
SINGLE PHASE TRANSFORMERS (Continued)

Primary Code Numbers	Secondary Code Numbers	Symbol (Voltage)	Typical Rating	Typical Winding	Explanation
151-200	41 - 43	E_1 GrdY/E	124700 GrdY/7200		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on an E_1 volt system with the neutral end of the winding effectively grounded.
201-250	--	E/E_1Grd Y	7620/13200 Grd Y		Indicates a winding with reduced insulation for Y connection on an E_1 volt system with the transformer neutral effectively grounded or for connection on an E volt system.
251-300	44 - 45	E/E_1 Y x E/E_1 Y	2400/4160 Y x 7200/12470 Y		Indicates a winding for connection on an E volt system of Y connection on an E_1 volt system.
301-350	--	E_1 Grd Y/E x E_1 Grd Y/E	4160 Grd Y/2400 x 12470 Grd Y/7200		Indicates a winding with reduced insulation of the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on an E_1 volt system with the neutral end of the winding effectively grounded.
401-425	--	E/E_1 Y x E/E_1 Y x E/E_1 Y	2400/4160 Y x 7200/12470 Y x 7620/13200 Y		Indicates a winding for connection on an E volt system or Y connection on an E_1 volt connection.

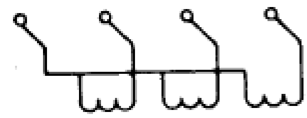
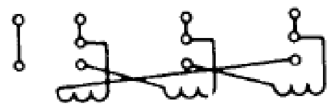
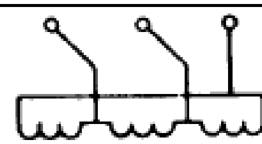
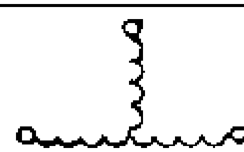
EXPLANATION OF VOLTAGE RATINGS (Continued)

SINGLE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
426-450	--	E_1 Grd Y/E x E_1 Grd Y/E x E_1 Grd Y/E	4160 Grd Y/2400 x 12470 Grd Y/7200 x 13800 Grd Y/7970		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on and E_1 volt system with the neutral end of the winding effectively grounded.
451-460	--	E/E_1 Y x E/E_1 Y x E/E_1 Y x E/E_1 Y	2400/4160 Y x 7200/12470 Y x 7620/13200 Y x 7970/13800 Y		Indicates a winding for connection on an E volt system or Y connection on an E_1 volt system.
461-475	--	E_1 Grd Y/E x E_1 Grd Y/E x E_1 Grd Y/E x E_1 Grd Y/E	3740 Grd Y/2160 x 4160 Grd Y/2400 x 13200 Grd Y/7620 x 13800 Grd Y/7970		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tnak for connection single phase or in Y on an E_1 volt system with the neutral end of the winding effectively grounded.
(i) THREE PHASE TRANSFORMERS					
501-550	51 - 57	E	11500		Indicates a winding permanently connected.
551-575	58 - 60	E_1 Y	4160 Y		Indicates a winding permanently Y connected with the neutral isolated.
576-600	61 - 65	E x 2E	2400 x 4800		Indicates a permanently connected winding for multiple or series operation.

EXPLANATION OF VOLTAGE RATINGS (Continued)

THREE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
601-635	66 - 68	E x E_2	2400 x 13200		Indicates a winding permanently connected.
636-650	69 - 71	E/E_1 Y	2400/4160 Y		Indicates a winding for connection E volts or E_1Y volts with the neutral isolated.
651-675	72 - 77	E_1 Y/E	4160 Y/2400		Indicates a winding permanently Y connected with fully insulated neutral available.
676-725	78 - 82	E_1 Grd Y/E	13800 Grd Y/7970		Indicates a winding having reduced insulation and permanently Y connected with the transformer neutral grounded.
726-740	83 - 85	E/E_1 Y/E	2400/4160 Y/2400		Indicates a winding for connection E volts or E_1Y volts with a fully insulated neutral available.
750	73 - 74	E_2 x E_1 Grd Y/E	4800 x 13200 GrdY/7620		Indicates a winding for connection E_2 volts or E_1Y volts having a reduced insulation and permanently connected with the transformer neutral grounded.

EXPLANATION OF VOLTAGE RATINGS (Continued)

THREE PHASE TRANSFORMERS (Continued)					
Primary Code Numbers	**Secondary Code Numbers**	**Symbol (Voltage)**	**Typical Rating**	**Typical Winding**	**Explanation**
826-875	--	E_1 Grd Y/E x E_1 Grd Y/E	4160 Grd Y/2400 x 13800 Grd Y/7970		Indicates a winding having reduced insulation and permanently Y connected with the transformer neutral grounded.
876-900	--	E/E_1 Grd Y/E	7970/13800 Grd Y/7970		Indicates a winding having reduced insulation for Y connection on an E_1 volt system with the transformer neutral grounded, or for connection on an E volt system.
901-925	--	E/E_1 Y/E x E_1 Y/E	2400/4160 Y/2400 x 13800 Y/7970		
926-950	--	E x E_2 x E_2	4160 x 4800 x 13200		Indicates a winding permanently connected.
951-970	90 - 94	T	13800 T		Indicates a primary winding consisting of two windings - the main and a teaser.
971-990	--	T x T	4160 T x 13800 T		Indicates a primary winding consisting of two windings - the main and a teaser.
991-999	95 - 99	Others -	Those Three Phase Transformers That Do Not Fall Into One Of The Classifications Above		

1. **NOTE VOLTAGE** marked on transformer nameplate and transformer tag. All changes to internal connections should be made in the shop.

2. **POLARITY DESIGNATION** - Additive has X1 on the right and H1 on the left as viewed from the secondary side. Subtractive has X1 and H1 on the left as viewed from the secondary side. Single phase transformers, 200 kVA and under having high voltage winding rated 8660 volts and below, have additive polarity. All other single phase transformers have subtractive polarity.

3. **SECONDARY CONNECTIONS**

   A. 120/240 (E/2E) and 240/480 (E/2E) can be connected for series, parallel or three wire operation. Transformers 100 kVA and below have three low voltage terminals and transformers 167 - 500 kVA have four low voltage terminals. See Figures 1 through 14.
   B. 240/120 (2E/E) can be connected for three wire or two wire operation, but not for parallel operation. Note - only one-half of the kVA rating available between center tap terminal and either extreme terminal. Three low voltage terminals are provided on all kVA sizes. See Figures 15 through 18.
   C. 292 x 584 (E x 2E) can be connected for series or parallel operation. Transformers will have four low voltage terminals on all kVA sizes. See Figures 8, 9, 11 and 12. This rating must be used with primary taps.
   D. 277/480 Y (E/E_1Y) and 600 (E) transformers have two low voltage terminals on all sizes. See Figures 19 through 21.

New single ratio overhead transformers for existing 600 V customers should be ordered 292 x 584 with primary taps so that 600 V can be obtained from the 584 volt connection. These transformers can also be used at 277 volts. Specify the 600 V rating for dual ratio transformers.

4. **100 kVA AND BELOW WITH E/2E VOLT SECONDARIES – PRIMARY 8660 VOLTS AND BELOW**

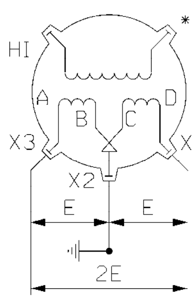


FIG. 1
(Three Wire)
Additive

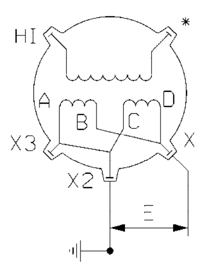


FIG. 2
(Parallel)
Additive

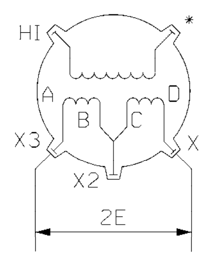


FIG. 3
(Series)
Additive

* Transformers with one primary bushing have other end of coil connected to the tank.

5. 100 kVA AND BELOW WITH E/2E VOLT SECONDARIES – PRIMARY ABOVE 8660 VOLTS

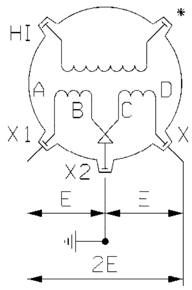


FIG. 4
(Three Wire)
Subtractive

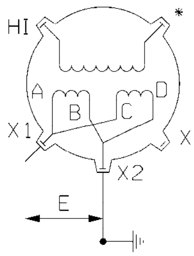


FIG. 5
(Parallel)
Subtractive

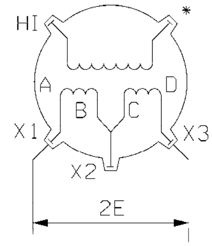


FIG. 6
(Series)
Subtractive

6. 167 kVA WITH E/2E AND 167 kVA AND BELOW WITH E X 2E VOLT SECONDARIES – PRIMARY 8660 VOLTS AND BELOW

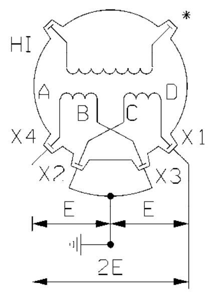


FIG. 7
(Three Wire)
Additive

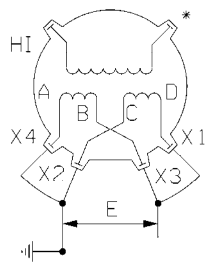


FIG. 8
(Parallel)
Additive

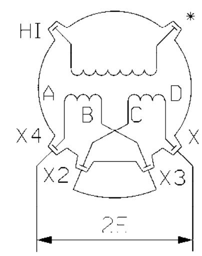


FIG. 9
(Series)
Additive

* Transformers with one primary bushing have other end of coil connected to the tank.

7. 167 kVA WITH E/2E AND 167 kVA AND BELOW WITH E X 2E VOLT SECONDARIES – PRIMARY ABOVE 8660 VOLTS

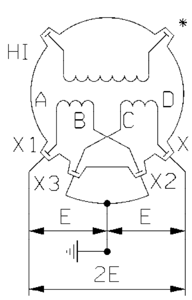


FIG. 10
(Three Wire)
Subtractive

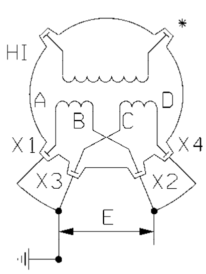


FIG. 11
(Parallel)
Subtractive

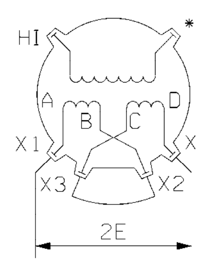


FIG. 12
(Series)
Subtractive

8. 250 – 500 kVA WITH E/2E AND E X 2E VOLT SECONDARIES – PRIMARY ABOVE AND BELOW 8660 VOLTS

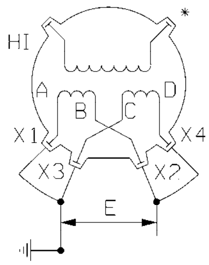


FIG. 13
(Parallel)
Subtractive

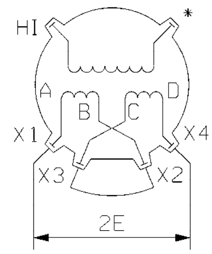


FIG. 14
(Series)
Subtractive

* Transformers with one primary bushing have other end of coil connected to the tank.

9. 167 kVA AND BELOW WITH 2E/E VOLT SECONDARIES

PRIMARY 8660 VOLTS AND BELOW

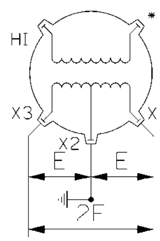


FIG. 15
(Three Wire)
Additive

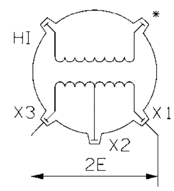


FIG. 16
(Two Wire)
Additive

PRIMARY ABOVE 8660 VOLTS

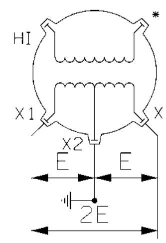


FIG. 17
(Three Wire)
Subtractive

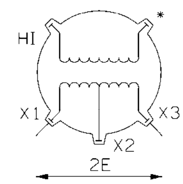


FIG. 18
(Two Wire)
Subtractive

10. 25 – 500 kVA WITH E OR E_1/Y VOLT SECONDARIES

**25 – 167 kVA
PRIMARY 8660 VOLTS
AND BELOW**

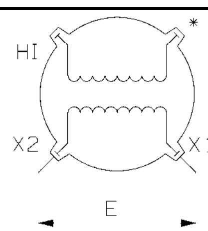


FIG. 19
Additive

**250 – 500 kVA
PRIMARY 8660 VOLTS
AND BELOW**

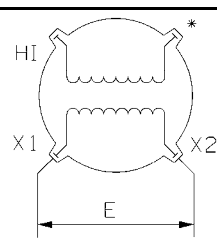


FIG. 20
Subtractive

**25 – 500 kVA
PRIMARY ABOVE
8660 VOLTS**

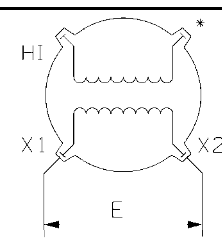
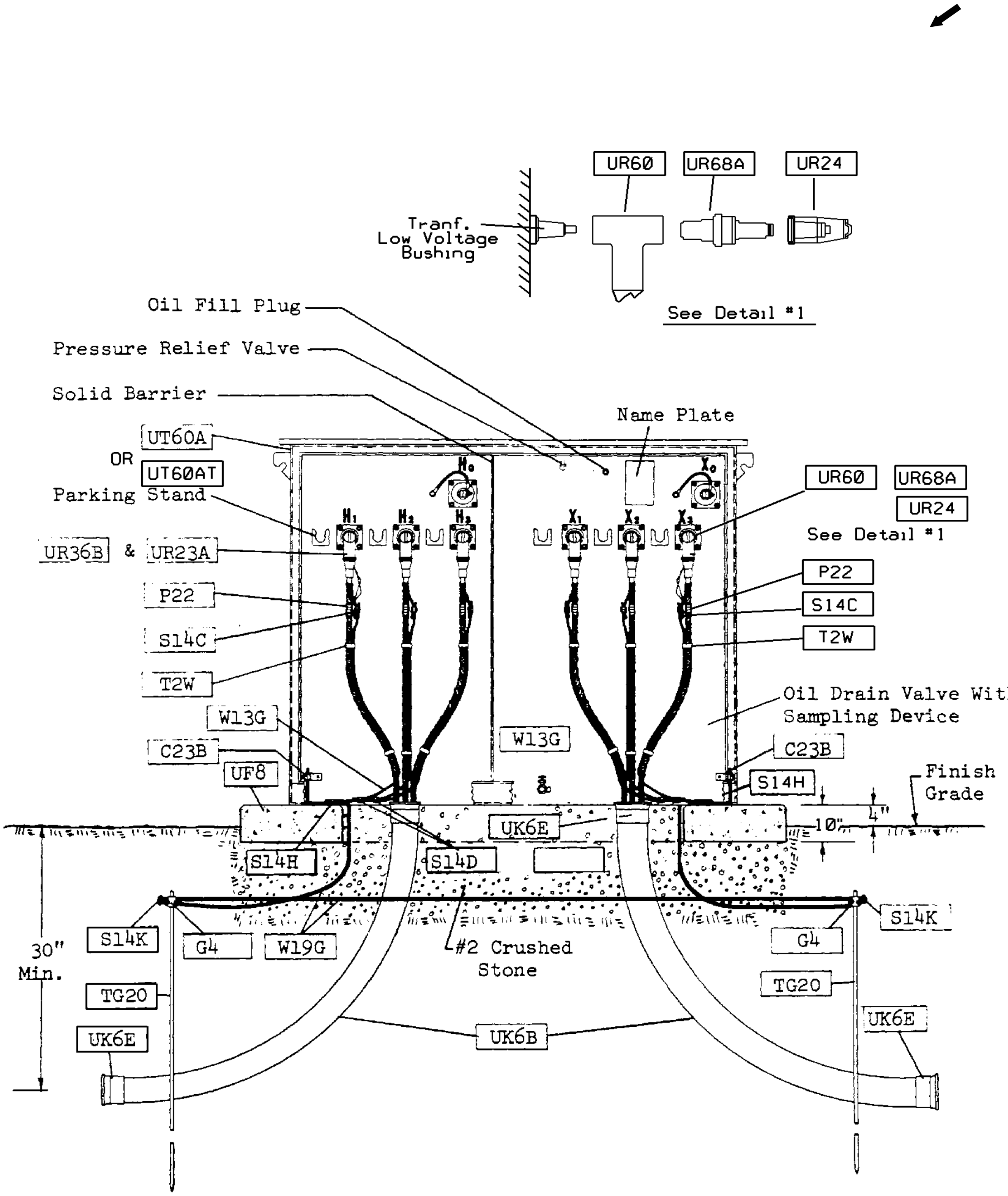


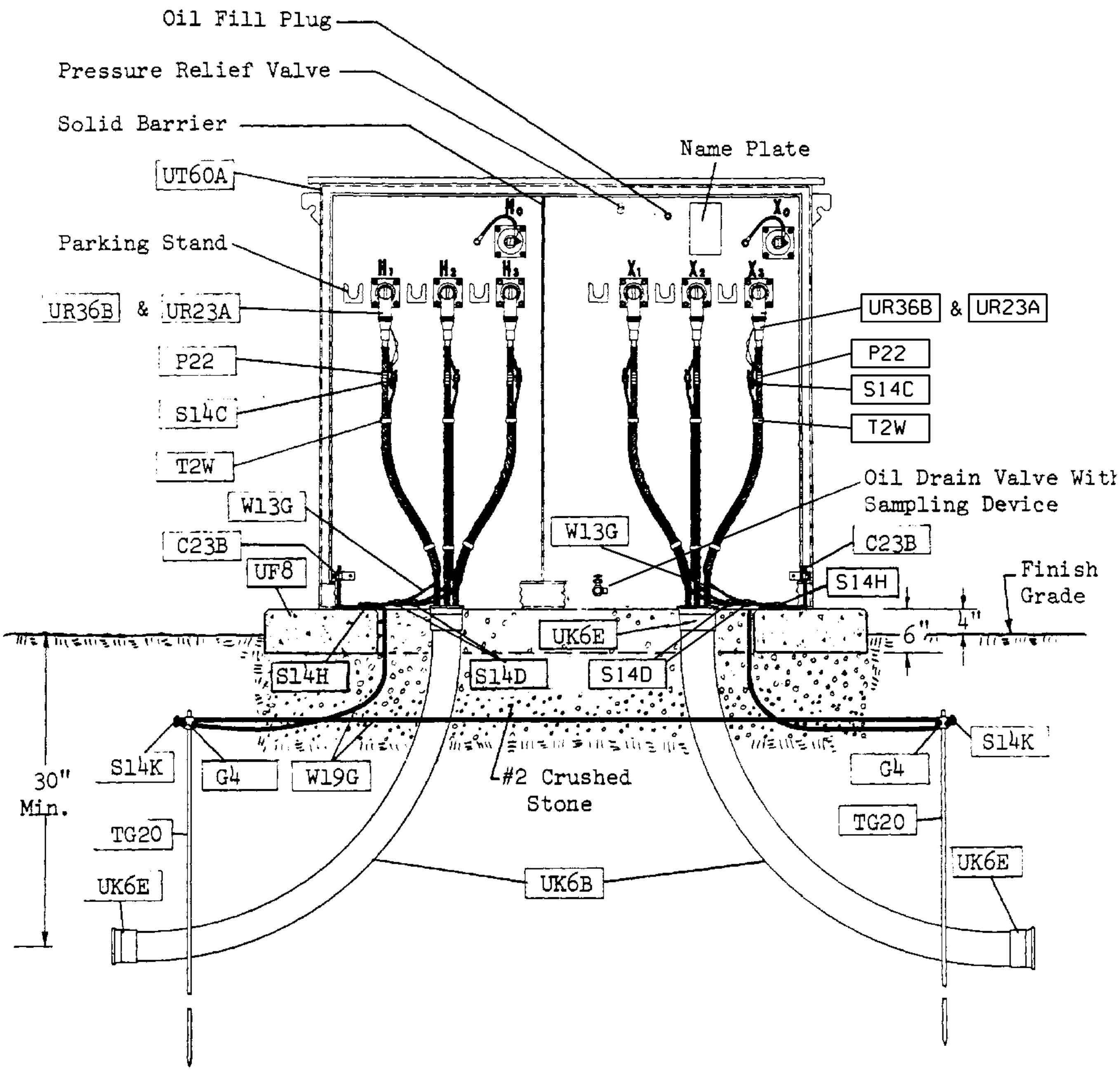
FIG. 21
Subtractive

Supersedes 1/07 Issue, Removed Cable Reference Lower Right



STEP-DOWN TRANSFORMER DETAIL 2,500kVA			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		40-101	7/08

Doc. # ST. 40.00.001



STEPDOWN TRANSFORMER DETAIL 500-1,000kVA

ISSUE	PAGE NUMBER		
1/07	40-102	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

Version	Date	Modification	Author(s)	Approval by (Name/Title)
3	07/12	• Added process - Handling returned transformers • Modified text in Std 40-55 for Use Codes	Hernan Yepez	Susan Fleck VP of Standards, Policies and Code
2	07/10	• Update PDC codes – Table 3 Page 40-54	Tim Hayden	Allen Chieco, Director of Distribution Standards and Work Methods
1	07/08	• Modified section 40.13. • Modified Figure 5 Title. • Added Type Code 11 and 31 and revised Type Code 18 description in Table 1. • Corrected Type Code 108 voltage and added Code 116 in Table 2. • Deleted PDC 453 because this connection cannot be built in Table 2. • Added Type Code 684 and removed *** from Type Code 529 in Table 2. • Added Type Code 78 in Table 3. • Removed cable reference in lower right on page 40-101.	Tim Hayden	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/08 Issue. Updates to 44-1, 44-5, 44-8, 44-12, 44-14, 44-20, 44.21, 44.24, 44-102, 44-108 and 44-111 & added 44.25 and 44.26

Supersedes 7/08 Issue – Update to 44-120 and 44-123

Supersedes 7/08 Issue – Text Update 44.1, 44.3 and 44.5

44.0 GENERAL

The following Standard is the practice to be followed when designing and installing Underground Commercial Developments (UCD). This Standard shall apply to primary and secondary systems installed by both the Company and/or the customer/developer.

44.1 CLEARANCE FROM BUILDINGS AND OBJECTS

Air insulated equipment shall have a 5 foot minimum clearance from buildings. In the absence of industry accepted or municipal requirements, oil insulated equipment shall be located in compliance with the minimum clearances indicated on Pages 44-101 and 44-102. For existing buildings, the transformer shall not block access to existing building systems, such as wall mounted fire sprinkler systems. The building owner's and/or tenant's fire insurance carrier or local inspection authority may restrict the proximity of the equipment to doors, windows or combustible materials. It is the customer/developer's responsibility to determine the acceptability of the proposed location of the equipment.

The clearances, line of sight, shall apply to doorways, windows, ventilation ducts and fire escapes. When line of sight distances cannot be met practically, refer to Distribution Design.

44.2 ACCESSIBILITY

Equipment shall be located within 10 feet of a way open to vehicular traffic and a minimum distance from any structure such as poles, fences, etc. as a means to permit accessibility for installation and maintenance. A minimum of 10 feet of clear space shall be maintained in front of the equipment doors to permit installation and removal of separable connectors and fuses with shotgun stick.

44.3 MECHANICAL PROTECTION

Whenever possible, equipment should be located so it is not subject to vehicular damage. If this is not feasible, adequate guards such as concrete filled pipes shall be installed in place to protect the equipment prior to delivery. Refer to Section 44.16 for details.

44.4 NOISE LEVEL

When locating transformers or other equipment, consideration should be given to the effect of noise on adjacent occupancies.

44.5 FINISHED GRADE

Finished grade shall gradually slope away from padmount transformer. Slope to be no more than 1" per foot. The slope limit shall extend 10 feet out in the front of the transformer and 5 feet out on the sides.

44.6 EASMENTS

Requirements for underground construction and associated pad-mounted equipment shall be determined for each site by Distribution Design. All Company owned equipment must be located within a permanent easement. The customer/developer shall grant such permanent easements, including rights of access to each easement, to the Company. Easements must be in place prior to installation of any Company owned equipment.

44.7 CLEAN FILL CERTIFICATION

The customer/developer shall certify, to the Company, that areas in which the Company is to perform installation or maintenance work are free of pre-existing contamination by hazardous wastes or materials and indemnify the Company for any claims, costs, expenses, suits, demands, citations, fines, or damages of any kind arising from the presence of any such contamination.

44.8 TRENCH AND DUCTLINE

Underground cable installations shall be installed in accordance with the latest edition of the Electric Service Bulletins 754 and 759B. State tariff policies vary with respect to installation method and the allocation of work responsibility between the customer and the company. Typical trench cross sections can be found on page 44-125.

44.9 RISER POLE

The Company shall designate conduit riser locations on the pole. Riser pole installation and maintenance shall be in accordance with Section 48 – Risers.

44.10 SWITCH / SWITCHGEAR

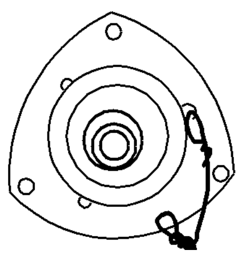
The Company shall designate switches and switchgear locations. Switchgear installation and maintenance shall be in accordance with Section 38 – Switches/Switchgear.

44.11 PAD-MOUNTED TRANSFORMER INSTALLATION

The type and size of pad-mounted transformers shall be determined by Distribution Design. Installation and grounding shall be in accordance with Pages 44-104 thru 44-107 and Section 44.22. The transformer in most instances is to be installed, owned and maintained by the Company. Special ownership arrangements shall be referred to Distribution Design.

44.12 PRIMARY CABLE AND TERMINATIONS

In general, jacketed cable per Section 35 - Cables, cold shrink terminators, and loadbreak elbows per Section 37 - Terminations, shall be specified. Distribution Design shall size and specify cable for special designs. The Company will furnish, install, own and maintain all primary cable and terminations. Ground all primary bushing inserts as shown in Figure 1.



Note: Use a minimum of #14 AWG Solid Copper or equivalent to bond bushing insert to mounting plate, the preferred wire is bare #12 AWG Solid Copper, tinned soft drawn Standard Item UC2V, Item ID 4015004.

Figure 1
Primary Bushing Grounding Detail
Only One Phase Shown For Clarity

44.13 SECONDARY CABLES

Secondary cables shall be installed underground in customer/developer furnished, installed, owned and maintained conduit system or raceway. Conditions requiring more secondary cables than the Company's transformer secondary terminals can accommodate may require the customer/developer to supply an intermediate secondary cable collecting bus to make a transition from National Electrical Code required cable capabilities (required to match main switch), to actual load cable capabilities. The need for any additional secondary connector bus pad-mounted compartment shall be determined by Distribution Design.

Supersedes 7/08 Issue – Text Updates 44.8 and 44.12

44.13.10 Three Phase Pads

Size and number of secondary cables shall be in accordance with the NEC and shall be approved by the wire inspector of the town or city involved. Maximum number of secondary cables to be physically connected to the Company's pad-mounted transformer is outlined below:

4 Hole Spades	6 sets 750 kcmil Max.
6 Hole Spades	8 sets 750 kcmil Max.
10 Hole Spades	10 sets 600 kcmil or 8 sets of 750 kcmil

Secondary requirements greater than this shall necessitate a separate compartment, handhole, or bus duct, and should be referred to Distribution Design.
All acceptable spade terminals are shown in Figures 2, 3 and 4. Minimum terminal thickness is to be ¼ inch, with $^{9}/_{16}$ inch holes.

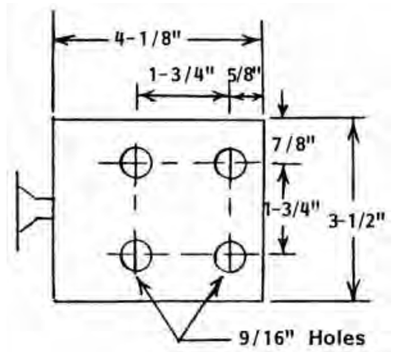


Figure 2

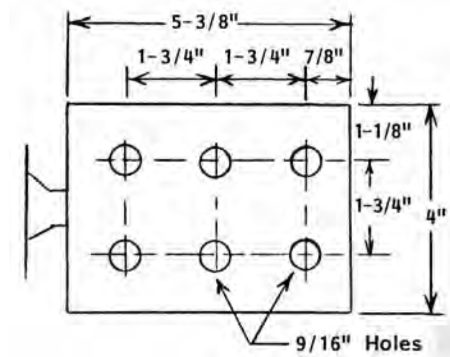


Figure 3

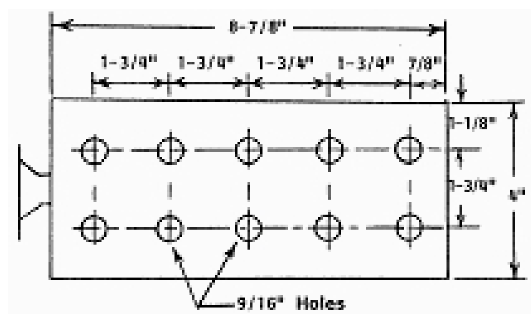


Figure 4

kVA Rating	L.V. Rating	kVA Rating	L.V. Rating	kVA Rating	L.V. Rating
75 – 300	208Y/120	500	208Y/120	750 – 1000	208Y/120
75 – 500	480Y/277	750 – 1500	480Y/277	2000 – 2500	480Y/277

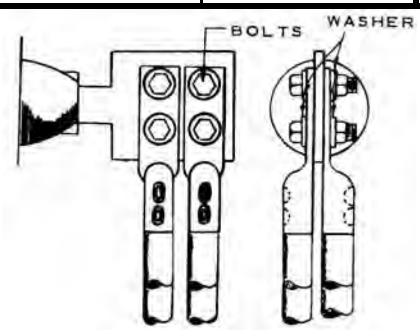


Figure 5
4 Cables – 500 kcmil & Below

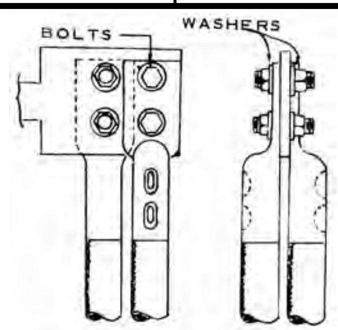


Figure 6

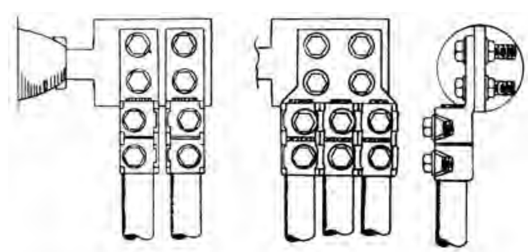


Figure 7

Notes:

1. Figure 5 – Compression connections will accommodate up to four cables with a maximum individual lug width of 1¼ inch.

2. Figure 6 – Compression connections will accommodate two cables with lug greater than 1¾ inch width.

3. Figure 7 – Typical example of bolted connections for two, four or six cables to maximum capacity of lug.

44.14 SECONDARY CONNECTIONS

All connectors and connector fasteners shall be furnished, installed, owned and maintained by the customer/developer. Connectors shall be approved by the Company prior to purchase. Final electrical connection to the transformer secondary terminals shall be inspected by the Company. The customer/developer shall make all final connections to the spades of the padmount transformer to a final torque of 40 foot pounds. Size and number of secondary cables shall be in accordance with the NEC and shall be approved by the wire inspector for the town or city involved.

The customer/developer shall supply aluminum connectors for use with aluminum cable or bronze connectors for use with copper cable. Tin plated connectors can also used be used as an alternate connector for aluminum and bronze connectors. Connector shall be a cable to flat clamp or compression type connector, with a minimum of two holes in the flat pad and two clamping elements or two compressions per cable, and must be approved by Standards Engineering.

Maintenance, adding or reconnecting secondary cables to the secondary compartment of the transformer once energized shall be coordinated through the local field office.

44.14.10 Bolted Connections

A. A flat washer is placed between the concave side of the belleville washer and the surface of the member being joined. The belleville is thus captured between the head of the bolt and the large flat washer. The flat washer should have an outside diameter greater than the flattened belleville's such that no overhand results. Select a flat washer that is twice as thick as the belleville for strength. (If not available, stack two or three thinner washers to achieve the same effect).

B. With the belleville washer captured between the flat washer and the bolt head, fit the assembly into its hole. When the washers are fitted in position, there should be no interference with washers of adjacent bolts and no overhang over surface edges.

C. Tighten the nut on the bolt (with a washer of its own) until a sudden, noticeable increase in torque is required to continue. The belleville washer is now flat. It is not necessary to "back off" the nut after tightening to this point.

D. Bolts and flat washers shall be grade 304 stainless steel. Belleville washers shall be grade 301 stainless steel. Nuts shall be waxed and be grade 316 stainless steel.

Supersedes 7/08 Issue – Text Updates to 44.14 and 44.14 D

Table 1
Stainless Steel Fasteners

Description	Std. Item
½" x 1½" Bolt & Nut	B8C15
½" x 2" Bolt & Nut	B8C20
Flat Round Washer	B8W3
Bellville Washer	B8W10

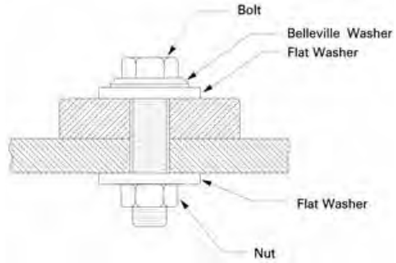


Figure 8

44.15 METERING

Meter location and type shall be determined by the Company. Meters shall be furnished and installed by the Company.

44.16 BOLLARDS

Bollards shall consist of 6 inch minimum diameter hot dip galvanized or painted steel pipes filled with concrete. Plastic bollard covers are available (Std Item C80) if bollard can not be painted at the time of installation. Bollards are to be 5 feet above the ground and a minimum of 4 feet below the ground. Concrete is to be crowned on top of all bollards. Bollards are to be set in a 12" minimum concrete footing from the base to within 6" from finished grade. See drawing details on page 44-111.

The number and locations of bollards shall be determined by Distribution Design, taking into account proximity to traffic and to buildings as well as other barriers to traffic. Suggested bollard locations and dimensions are shown on Page 44-110. Distribution Design will determine which bollards are required by marking Page 44-110 as described in Note 2. Delivery of equipment shall not take place until required bollards have been installed. The location of bollards shall not impede a door opening of 100 degrees.

Bollards shall be installed with due care to avoid interfering with ground grid and conduits. Refer to Section 44.20 for concrete pad dimensions.

44.17 CONCRETE PAD

Concrete shall conform to Section 31 – General (Mix M-4) for ready mix concrete. All exposed edges shall have a ¾ inch chamfer.

44.18 REINFORCING

Reinforcing to be #5 grade 60 bars and shall conform to ASTM STANDARD A-615 of latest date. Reinforcing rods are to be located in center of the slab, with a minimum of 2 inches of clearance from face of concrete.

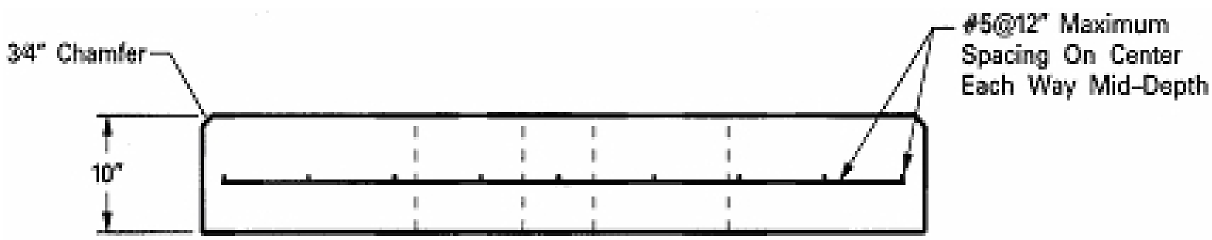


Figure 9

44.19 SAND AND GRAVEL

Place concrete slab on a base of 2 inches of sand and 12 inches of gravel as shown on Pages 44-113 thru 44-116. The gravel shall be thoroughly compacted and the sand thoroughly wetted immediately before placing the concrete.

44.20 PRECAST / POURED SLAB AND CONDUIT ENTRY

Conduit shall be installed as shown on Pages 44-113 thru 44-116 before slab is poured. Use 36 inch radius sweeps, with couplings, nipples and bushings as required. Sweeps for primary cables shall be galvanized steel or PVC rigid direct burial type. Conduits shall be raised a minimum of 1 inch over the concrete slab. The owner of the conduits shall install the bell ends onto the conduits. Expanding foam (Std. Item UF10) will be used to fill the conduits around the cables to prevent oil from entering the conduit in the event of a leak. Empty conduits shall be sealed using a conduit plugs (Std. Item UK34_). Sealing of conduits shall be done by the owner of the cables in the conduits. Additional information on installation and maintenance of conduit shall be in accordance with Section 32 – Conduit.

After the concrete is cured, the remainder of the conduit primary and secondary openings through pad will be sealed with grout. Fill the conduit primary and secondary openings with sand (no aggregate) to a grade of 4 inches below the top of the concrete pad. Place a layer of concrete grout (no aggregate) 1 to 2 inches thick on top of the sand layer to seal the conduit entrance. Do not cover the conduit ground clamps with grout. Expanding foam can also be used as an alternate to filling in the conduit area with sand and sealing the top with grout. Sealing of the openings shall be done by the installer of the pad and conduits.

44.21 GROUND GRID

The ground grid shall be 2/0, bare, soft drawn, 19 strand copper wire. The wire shall be installed 12 inches below grade and located around the transformer pad as shown on Page 44-117. Bond to all exposed metallic conduit and leave 3 feet of wire above pad for grounding transformer, one lead in the primary conduit opening and the other lead in the secondary conduit opening. The neutrals from the cables connecting to ground grid shall be a compression type connector. Up to three separate neutrals from the cables can be bundled together with a compression connector.

Two ⅝ inch diameter, 8 feet long copper weld ground rods (Std. Item TG20) and approved connectors shall be installed. The top of the ground rods shall be 12” below finish grade. Leave the ground rods and grid exposed until inspected by the Company. The ground grid is to be complete and backfilled prior to energizing the transformer.

Connections to ground grid to be made as shown on Page 44-117 Details A and B, except that exothermic welding ("cad weld") shall be an acceptable alternative to compression or bolted connections. Bolted connectors are only acceptable for the connections to the ground rods.

44.22 OIL CONTAINMENT

This is to be used where oil containment is required by local authorities or where otherwise justified. This liner system will significantly slow the migration of oil into the under laying sub grade, allowing additional time to initiate a cleanup response. The polypropylene geotextile allows the passage of water but absorbs small quantities of oil.

This design is intended to confine 100% of total transformer oil present, with a 20% reserve margin, for up to 36 hours. If additional confinement is desired consult Distribution Design.

Oil curb should be installed with concrete in accordance with Mix #4 per Section 31 – General. Reinforcement to be four #4, grade 60 rods, 6 inches on center as shown. Bend rods around corners. Fill area between slab and curb with 1½ inches uniformly graded crushed rock and line with 2 layers of geotextile liner as shown. Geotextile liners to be separated by a 6 inch layer of well compacted, silty sand and gravel mix. Geotextile liner shall be 16 oz. polypropylene geotextile - all seams to overlap a minimum of 12 inches. See Page 44-120 for construction detail.

Supersedes 7/08 Issue – Text update 44.20 and 44.21

44.23 CABLE TAGS

Primary cables shall be identified in each handhole, manhole, vault, enclosure, riser pole, transformer and switchgear and at every termination point. Identification shall be a minimum of the circuit number, next location and phase marking. For cables of one circuit that are bundled together, one tag can be used to indicate the circuit and location on the bundled set of cables. Individual tags are available with a variety of phrases (e.g. A Phase; To Riser; To MH; XMFR – Std. Item UP21P). Utilize the phrase tags to clarify the next location of the cable. The phase shall be included at terminations. In three phase loop feed transformers, the bushing (H1A, H2A, etc.) shall be included.

A complete selection of numbers and letters, 3 sizes of tag holders, various phrase tags and cable ties can be found in Section 50 – Materials Catalog.

Secondary cables to be labeled as follows:

A. Company Owned Cable

The letter N identifies Company owned 600 V secondary cable. The dash followed by a number, e.g. 15, identifies the transformer / manhole / handhole that the cable goes to.

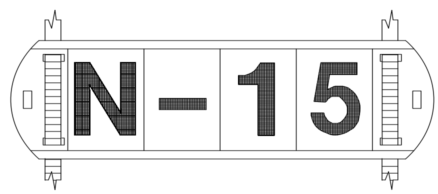


Figure 10

B. Customer Owned Service Cable

The letter C identifies the customer owned 600 V service cable. The number, e.g. 155, identifies the customer's building or apartment number.

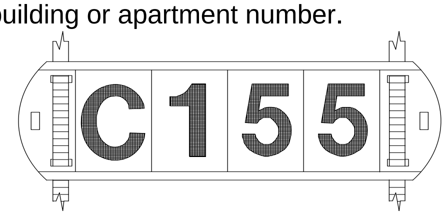


Figure 11

C. For parallel secondary services, install a parallel service tag in the tagholder along with the building or apartment number.

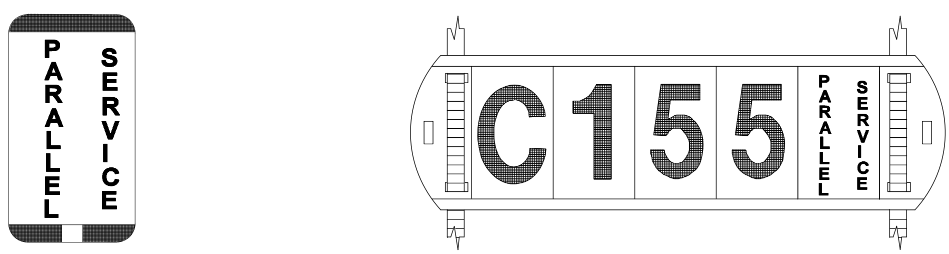


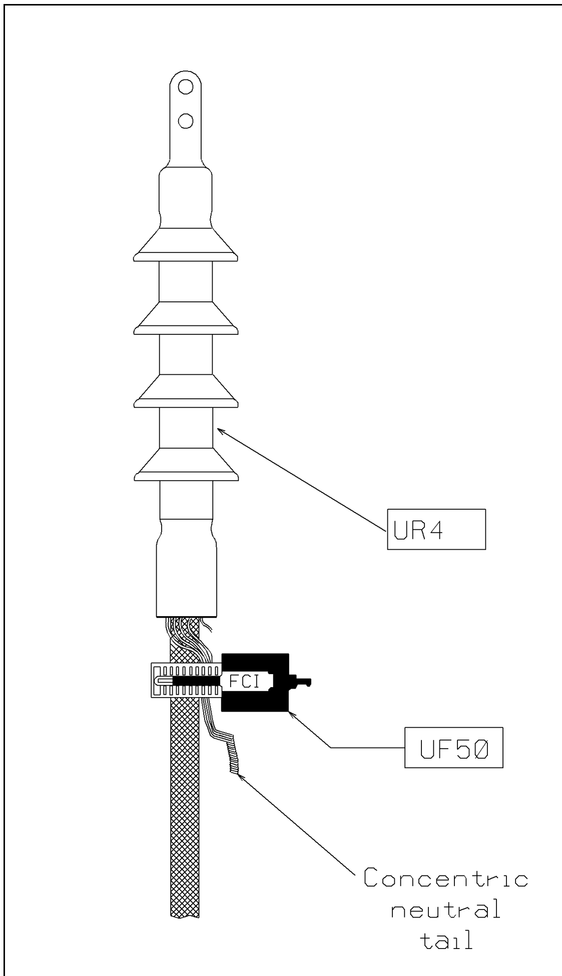
Figure 12

Supersedes 7/07 Issue – Text Update

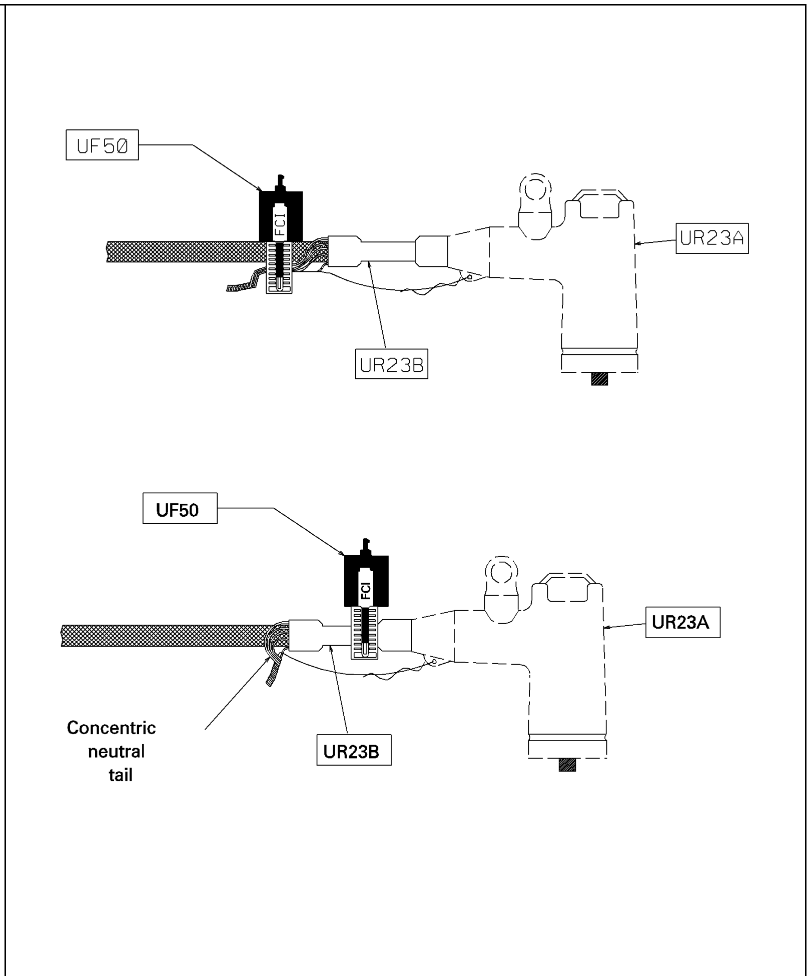
44.24 FAULT INDICATORS

Fault indicators can be used in underground commercial distribution. Fault indicators have an 8 hour reset. Two styles are available (see Std. Item UF50), time or time and current reset. The indicators can be installed in switchgears and padmounts at the cable termination points. Figure 13 shows how to install the indicator. To minimize outage restoration times fiber optic leads (Std Item UF50CC) can be installed to provide a visible external display of the indictor flashing. The fiber optic lead plugs in to the end of the indicator and the display light is mounted thru the switchgear or padmount. Distribution Field Engineering can provide recommendations on where the indicators shall be used.

Figure 13



Termination Installation
Install indicator over neutral tail



Elbow Installations
Install indicator over neutral tail or before neutral tail

Supersedes 7/07 Issue – Text update 44.24

44.25 TRANSFORMER INSTALLATION IDENTIFICATION

Padmounted transformers shall have an identification location installed to identify the number or name of the specific location of the transformer. Place 2 x 3 self adhesive decals (STD. Item P21) on the outside of the right side door of the padmount. See the drawing on page 44-123 for the transformer location number. Install decals so as to be easily visible from the street, parking area or driveway.

44.26 TRANSFORMER SIGNS

Padmounted Equipment shall have warning decal (STD. Item P25P) installed on the outside front door, see drawing on page 43-123 and danger decals (STD. Item P25PD) installed on the inside of the transformer compartment per the general section of the standards book.

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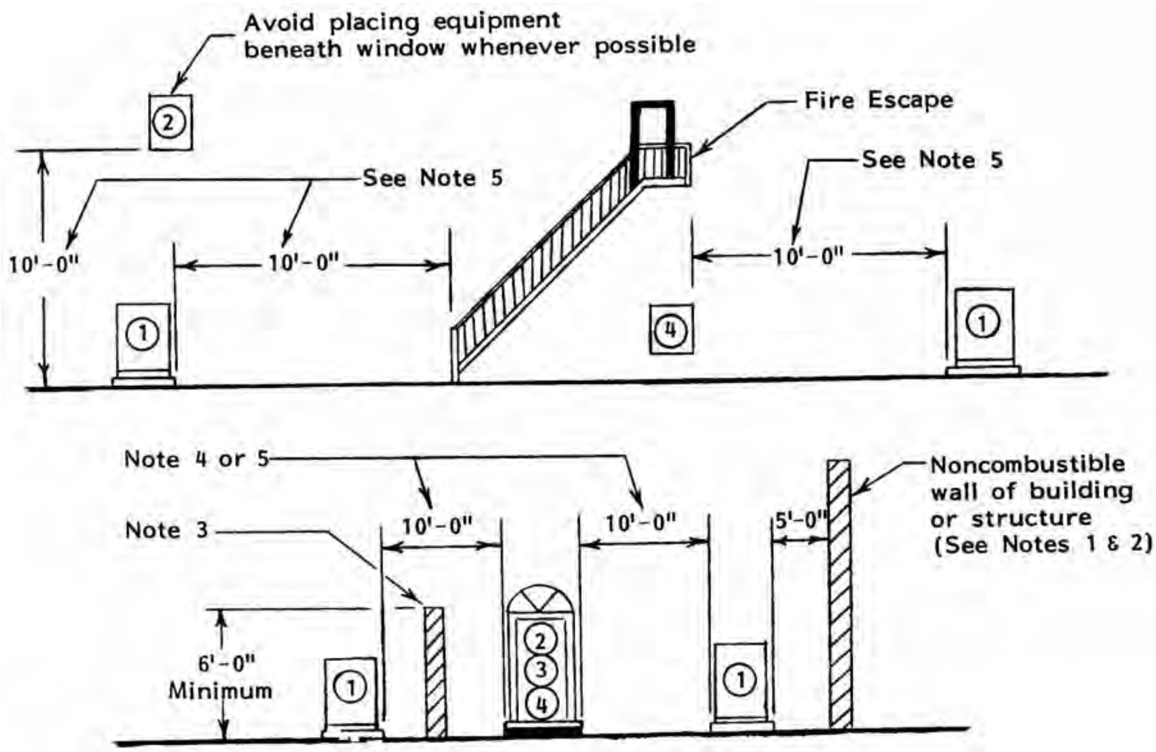
New page.



Legend	
①	Equipment, oil insulated
②	Window
③	Door
④	Ventilating Duct

Notes:

1. Noncombustible material is defined as a material that will not ignite, burn, support combustion or release flammable vapors, when subjected to fire or heat, or as described by the latest edition of the NFPA-220.

2. No portion of a building or building structure shall overhang any part of the pad-mounted equipment.

3. In cases where required distances cannot be met, a noncombustible barrier, 6 foot minimum height, shall be constructed. This barrier shall be designed to provide adequate fire protection to the existing structure. A design for this structure shall be prepared and sealed by the customer's Professional Engineer or Registered Architect and shall be further approved by the local authority having jurisdiction of building code enforcement.

4. For exits from a public assembly room, such as an auditorium, a 10 foot minimum clearance should be increased to 25 feet, unless there is a barrier.

5. This requirement may vary between individual states. Refer to the building code regulations for the state involved.

Clearances from objects:

A. An area measuring 10 feet from any point of the transformer pad shall be kept free of all:

- buried water lines, storm drain lines, gas lines, sewer lines and other electric lines;
- underground fuel storage tanks; and
- above grade fire hydrants, cell towers, self contained diesel or diesel byproduct fuel generators and outdoor enclosed generators.

NOTE: With the use of a noncombustible barrier (see note 3), the 10 foot clearance may be reduced to not less than five (5) feet from the edge of the transformer pad. The customer or their authorized representative shall obtain this clearance reduction approval from the company and the local AHJ (authority having jurisdiction) as necessary, prior to the noncombustible barrier installation.

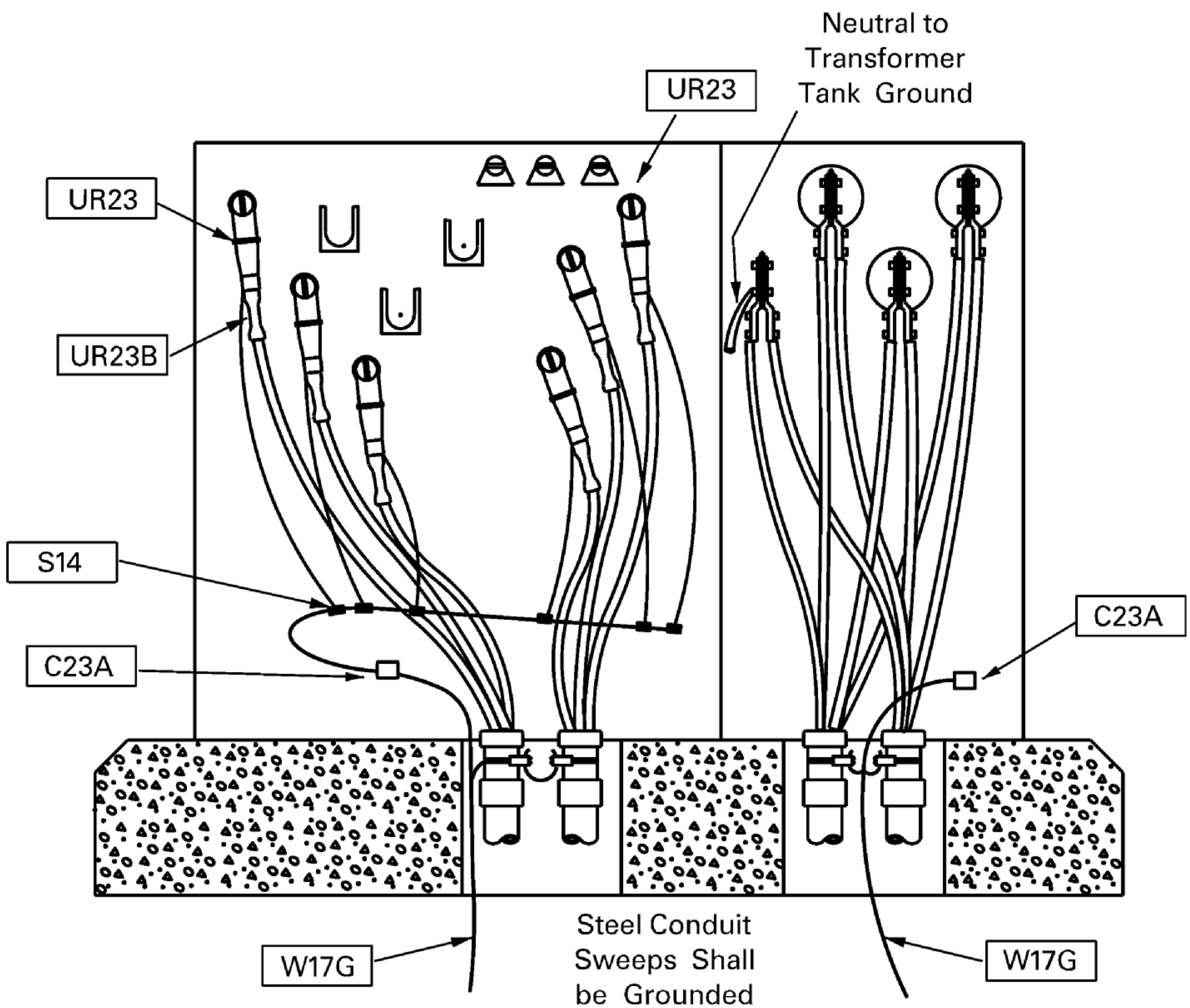
B. An area measuring 25 feet from any point of the transformer pad shall be kept free of all:

- exposed water lines, gas piping, sewer lines:
- open conductor electric lines; and
- above grade gas meters or regulator vents, fuel storage tanks or dispensing units, and non-enclosed gasoline/ propane/ LP or LNG gas fueled generators.

NOTE: The 25 ft. clearance may be reduced to 10 ft. with a noncombustible barrier (see note 3) and shall not be less than five (5) feet from the edge of the transformer pad. The customer or their authorized representative shall obtain this clearance reduction approval from the company and the local AHJ (authority having jusidiction) as necessary, prior to the noncombustible barrier installation.

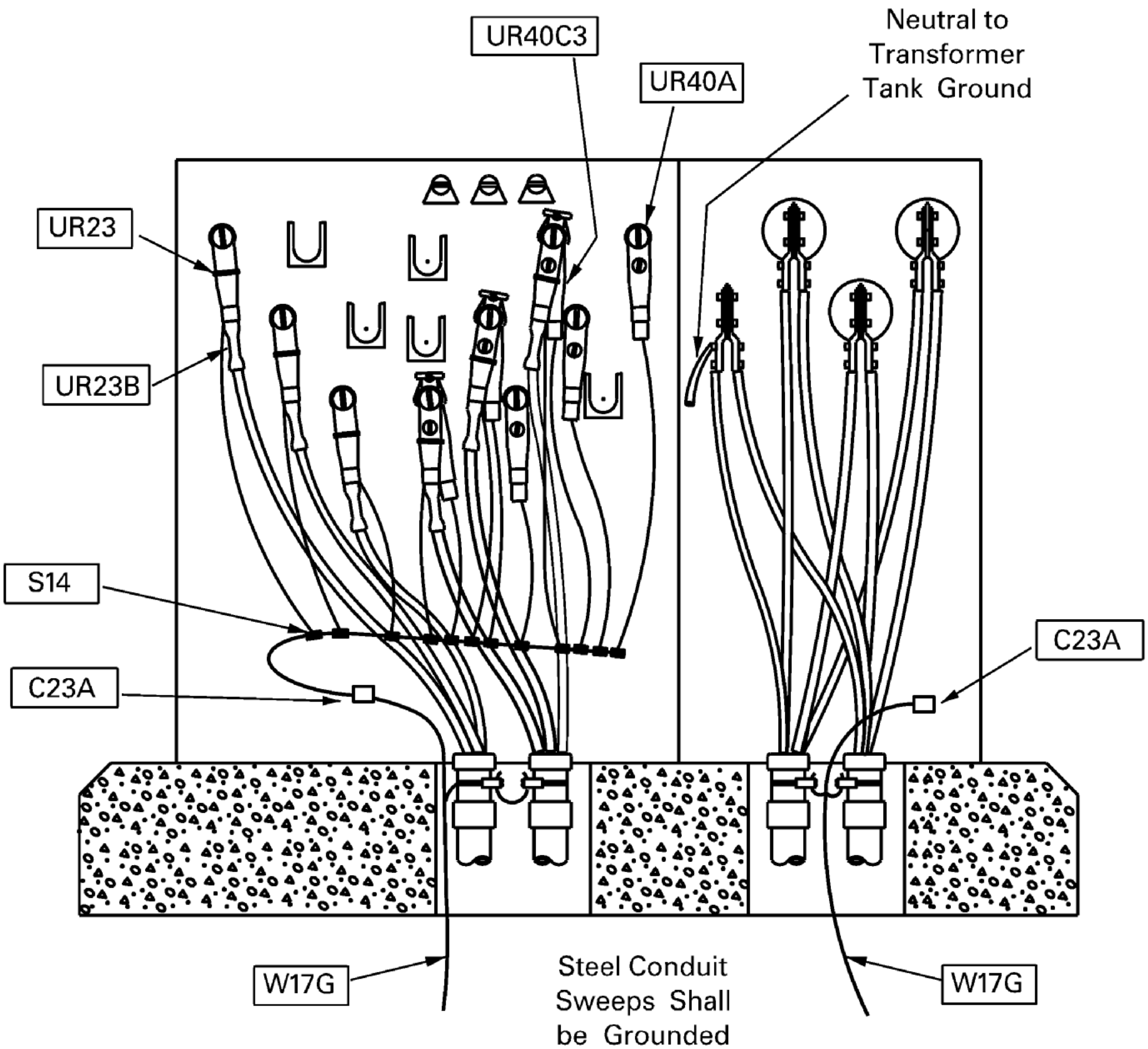
Supersedes 7/08 Issue – Text Update

Std. Item	UT42_, UT47_	(A) = Kva Size (B) = Primary Code (C) = Secondary Code (D) = Tap Code
CU	TPM30T(A)K(B)P(C)S(D)TLF	
MU	@TPM30T(A)K(B)P(C)S(D)TLF	



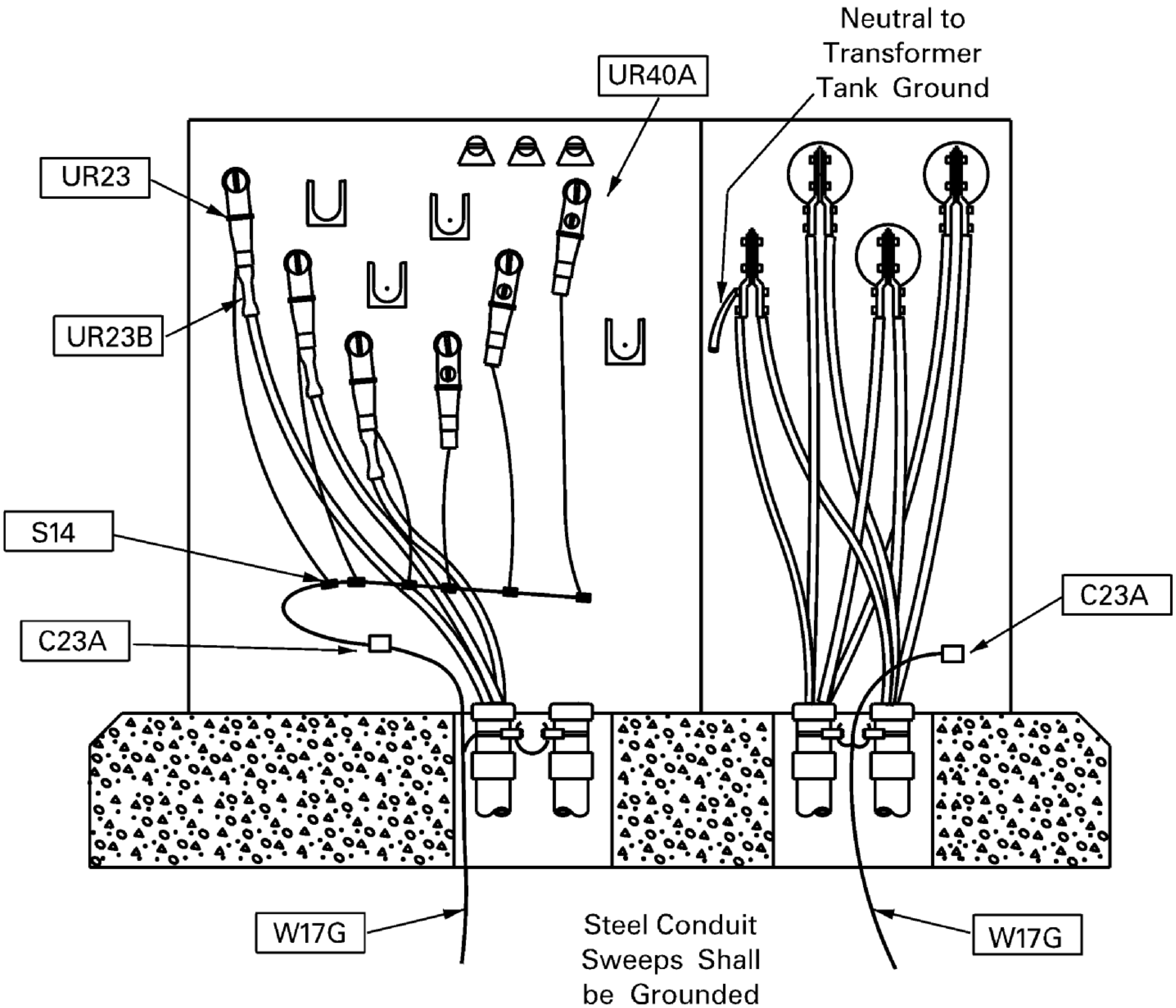
Supersedes 7/07 Issue - Added Std. Items

Std. Item	UT42_, UT47_	(A) = Kva Size (B) = Primary Code (C) = Secondary Code (D) = Tap Code
CU	TPM30T(A)K(B)P(C)S(D)TLF	
MU	@TPM30T(A)K(B)P(C)S(D)TOP	



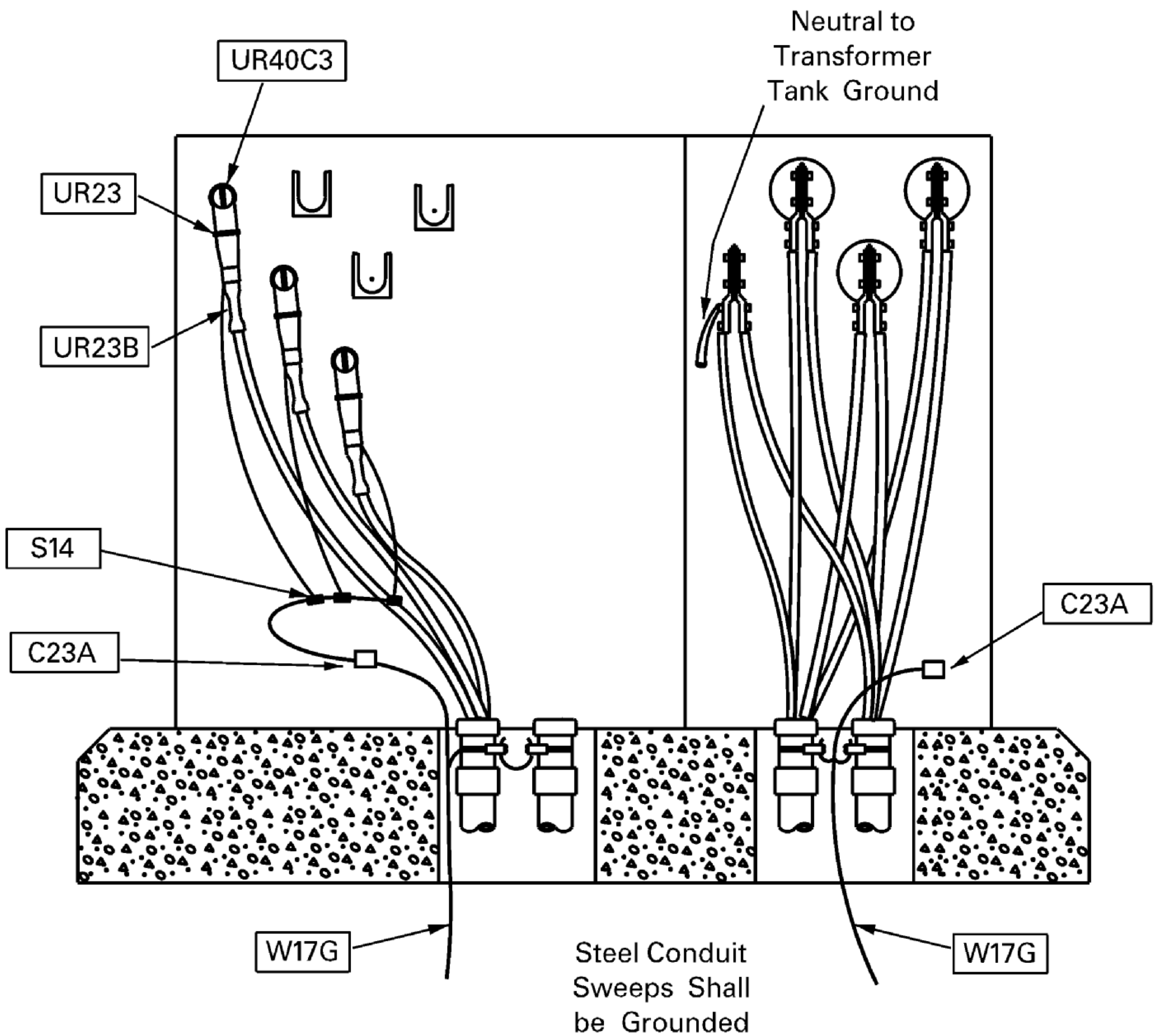
Supersedes 7/07 Issue – Added Std. Items

Std. Item	UT42_, UT47_	(A) = Kva Size (B) = Primary Code (C) = Secondary Code (D) = Tap Code
CU	TPM30T(A)K(B)P(C)S(D)TLF	
MU	@TPM30T(A)K(B)P(C)S(D)TRF	



Supersedes 7/07 Issue - Added Std. Items

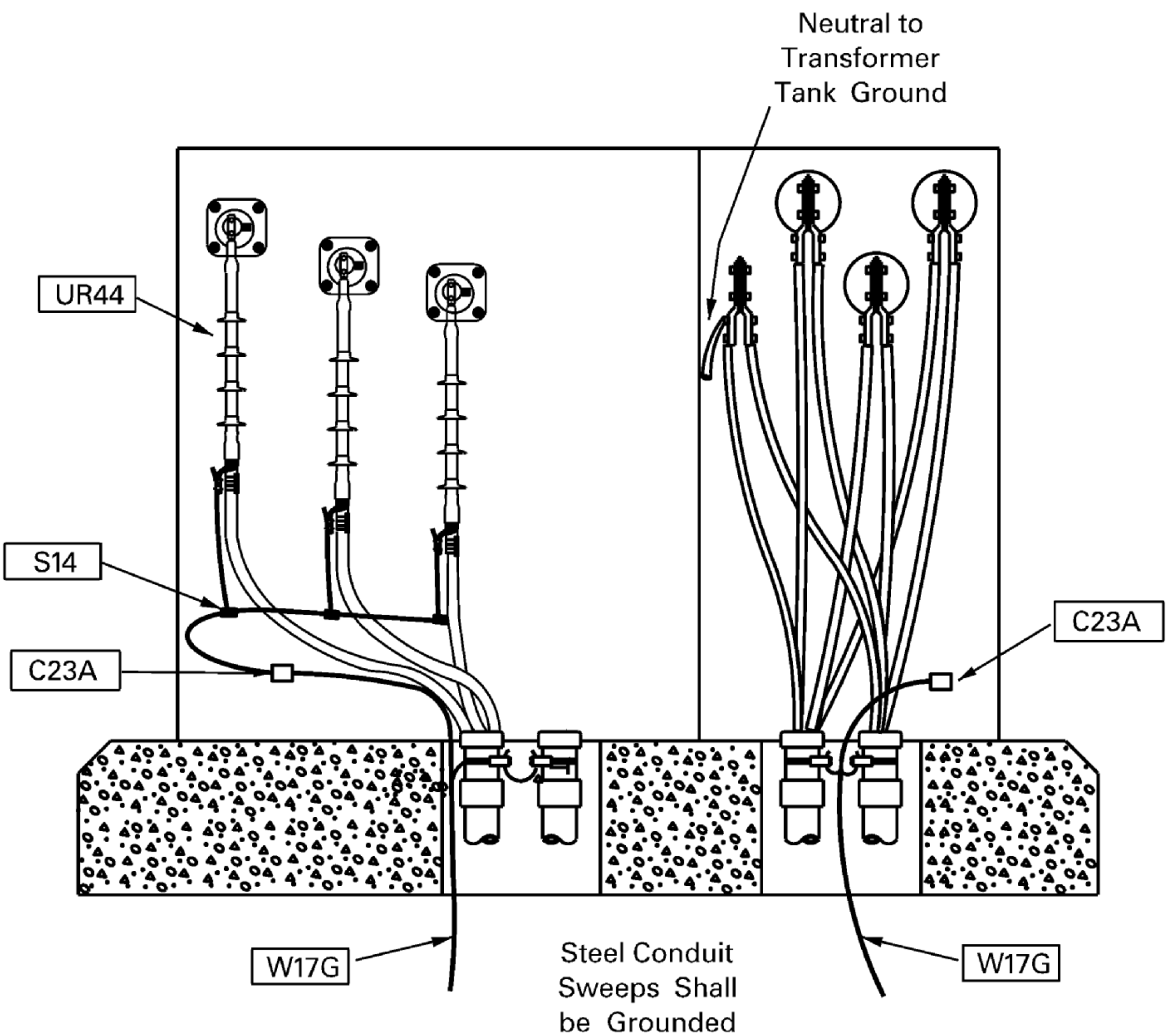
Std. Item	UT41_, UT46_	(A) = Kva Size (B) = Primary Code (C) = Secondary Code (D) = Tap Code
CU	TPM50T(A)K(B)P(C)S(D)TRF	
MU	@TPM50T(A)K(B)P(C)S(D)TRF	



Supersedes 1/07 Issue – Drawing Update

 Doc. # ST. 44.00.001

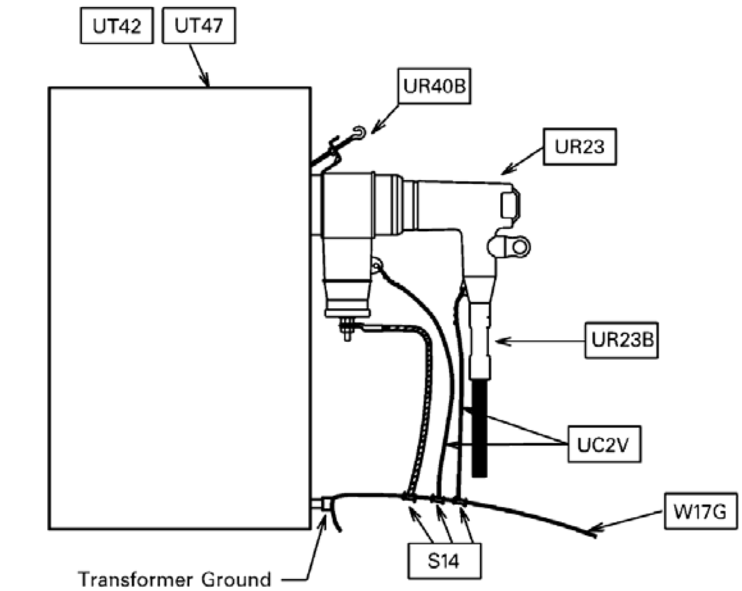
Std. Item	UT45_	(A) = Kva Size (B) = Primary Code (C) = Secondary Code (D) = Tap Code
CU	TPM52T(A)K(B)P(C)S(D)TRF	
MU	@TPM52T(A)K(B)P(C)S(D)TRF	



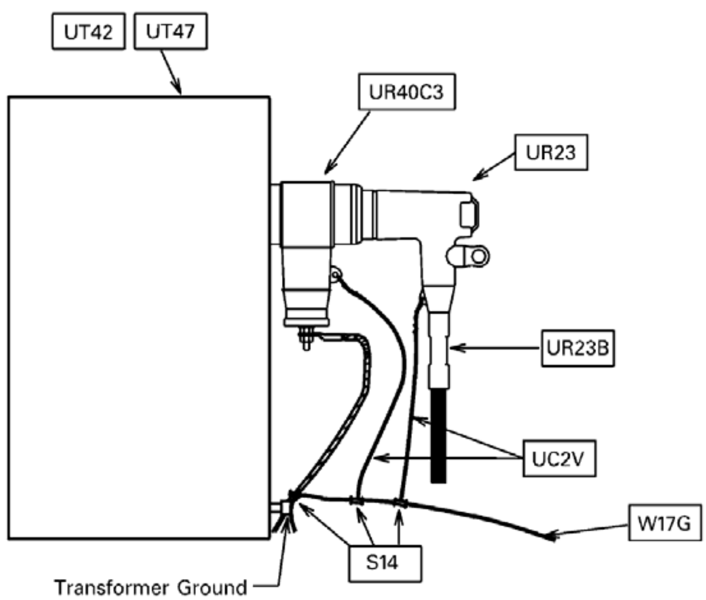
Supersedes 1/07 Issue – Added Std. Item.

 Doc. # ST. 44.00.001

Std. Item	CU
UR40B3	CLFA15KNE
UR23A	CLBE200
UR23A1	CLBE2001/0NE
UR23A2	CLBE2002/1NE
UR23A4	CLBE4/0
UR23B	INCL IN CLBE_
W17G	C20CSTBC
S14F OR G	INCL IN CLBE_



SIDE VIEW
PARKING STAND ARRESTER ON LOOP FEED TRANSFORMER



SIDE VIEW
BUSHING WELL ARRESTER ON LOOP FEED TRANSFORMER

Supersedes 7/07 Issue – Added Std. Items and Note.

Note: On all elbow style padmounted equipment, all housings arresters, elbows and insulating caps shall have a bond wire tied between these devices and ground. This will keep the potential of these devices at zero. Use a minimum of #14 AWG Solid Copper or equivalent to bond equipment housing to the ground, the preferred wire is bare #12 AWG Solid Copper, tinned soft drawn Standard Item UC2V, Item ID 4015004.

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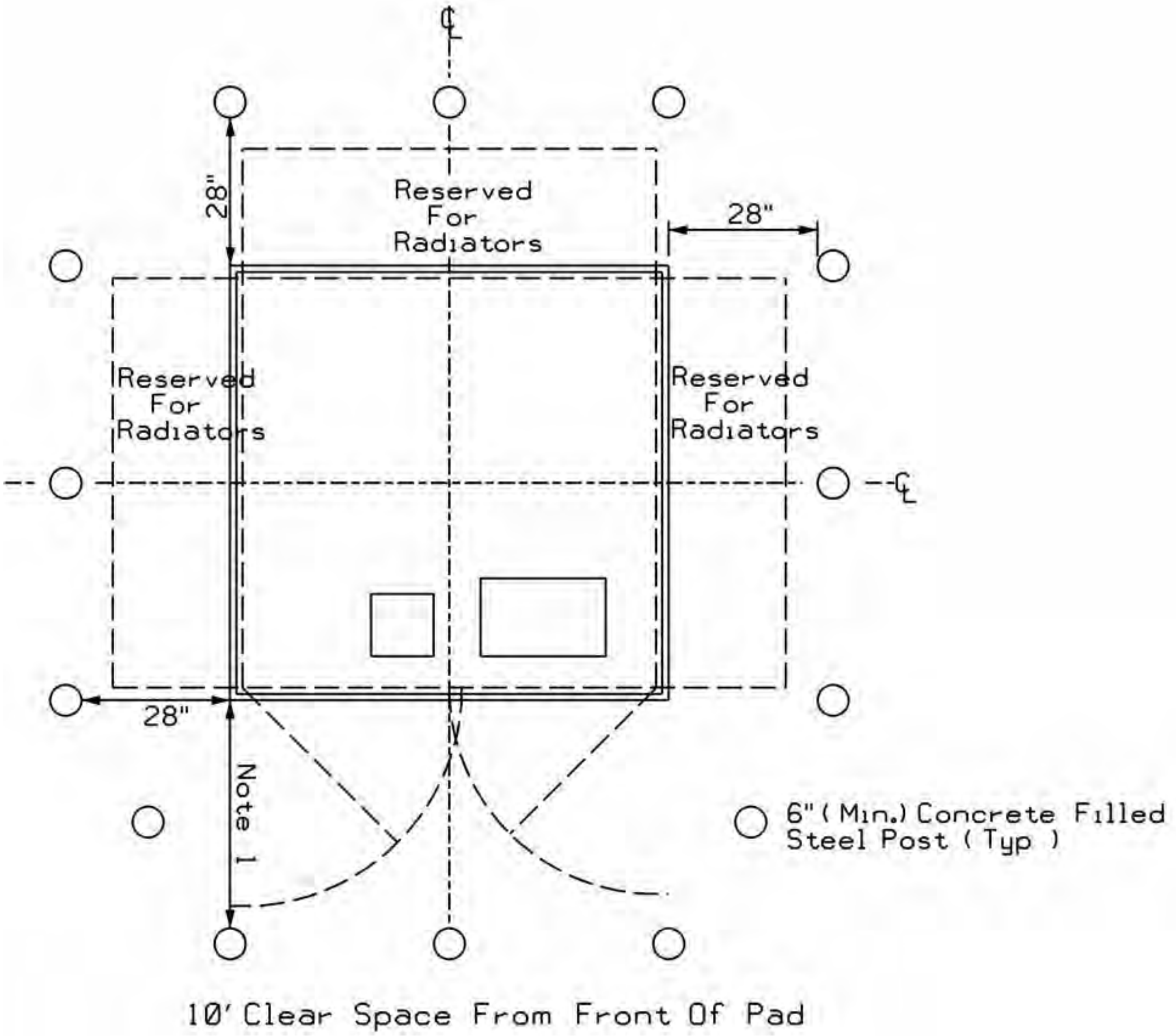
 Doc. # ST. 44.00.001



Notes:

1. 6 foot minimum clearance.

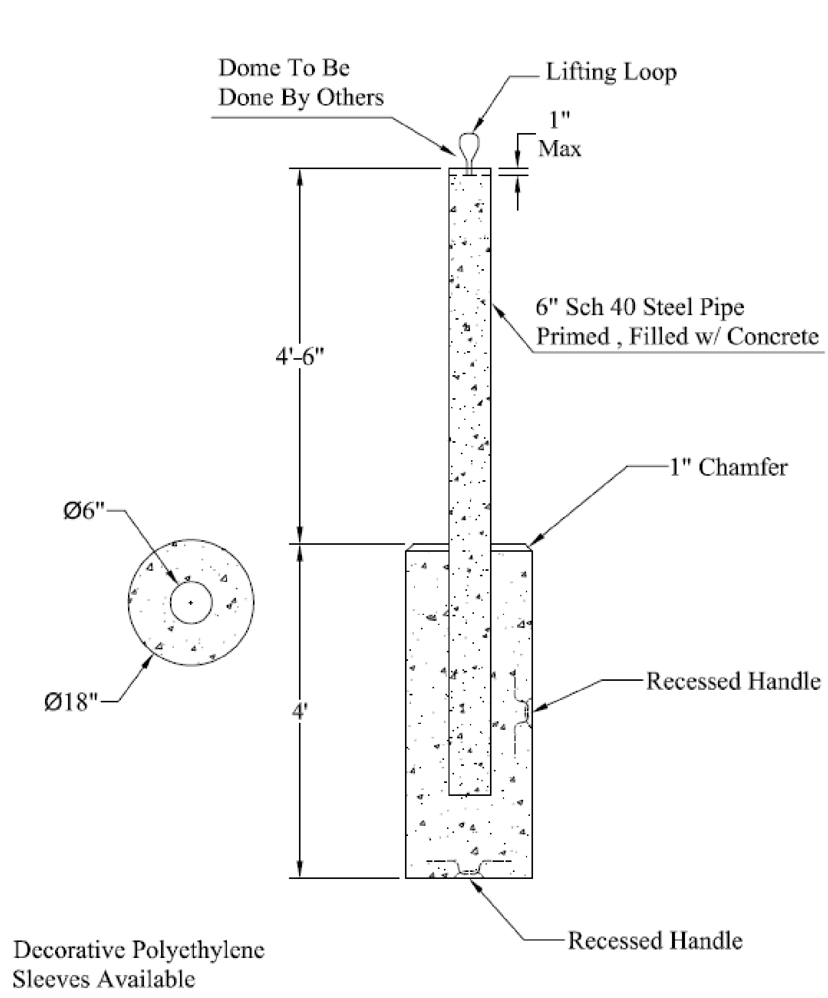
2. Distribution Design shall designate the number and location of Bollards by marking the Bollards of this drawing as follows:

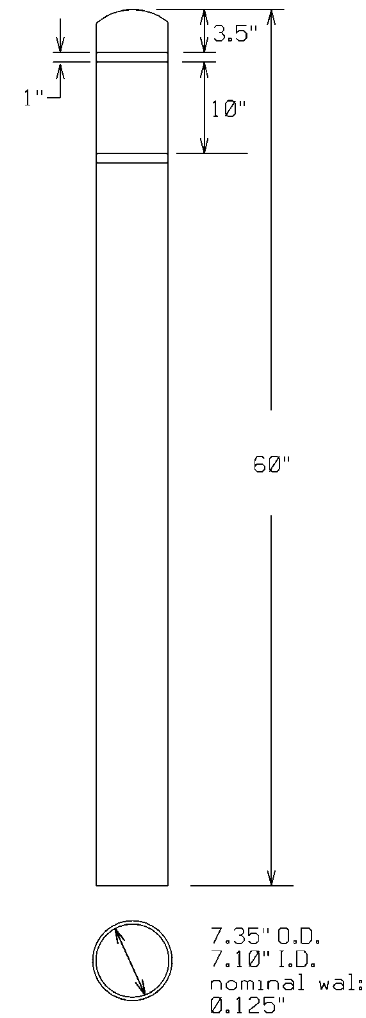
Bollards Required	●
Bollards Not Required	⊗

 Doc. # ST. 44.00.001

Std. Item

Std. Item	C80
CU	KCSSSCYFP



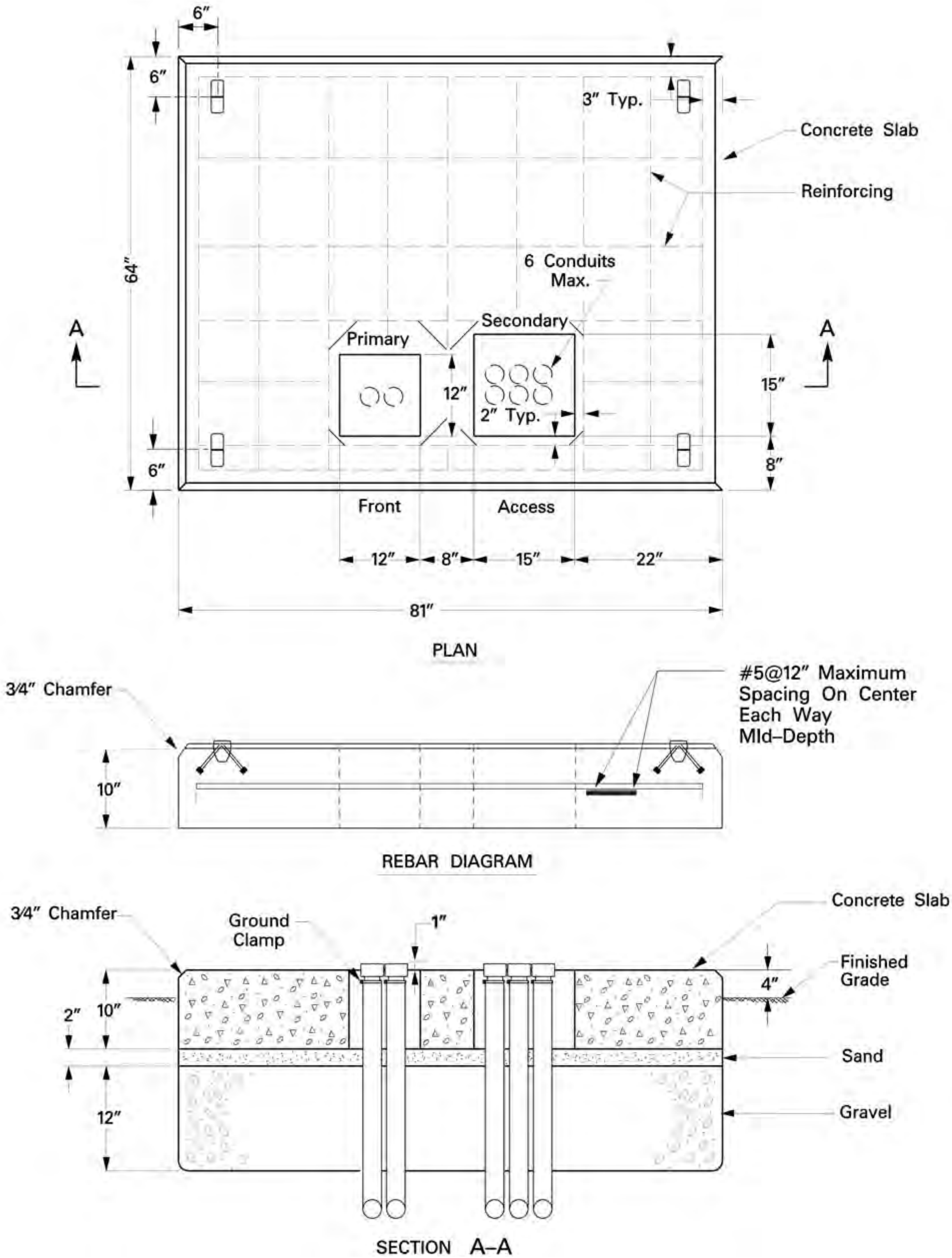


TYPICAL BOLLARD DETAIL

YELLOW PLASTIC COVER, USE FOR BOLLARDS THAT CAN NOT BE PAINTED DURING TIME OF INSTALLATION

 Doc. # ST. 44.00.001

Profile Item	
Std. Item	UF8A
CU	TTFPC2582

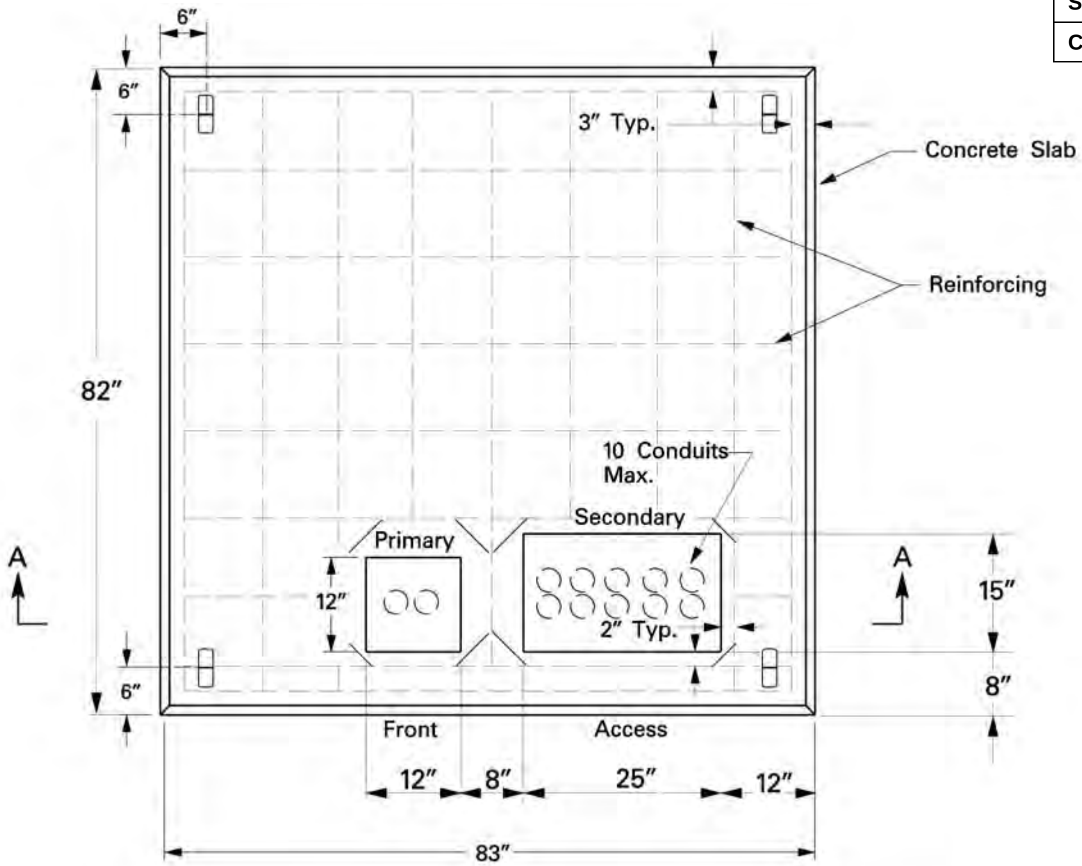


Supersedes 1/07 Issue – Added Std. Item.

CONCRETE SLAB FOR 75-500kVA THREE PHASE TRANSFORMERS 15kV CIRCUITS

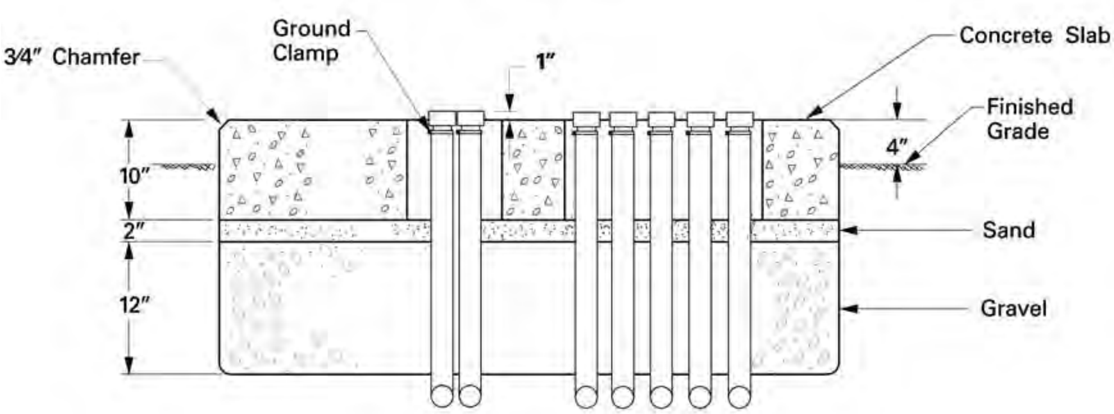
	PAGE NUMBER		
7/11	44-113	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

Store Room Item	
Std. Item	UF8B
CU	TTPC2583



PLAN

REBAR DIAGRAM

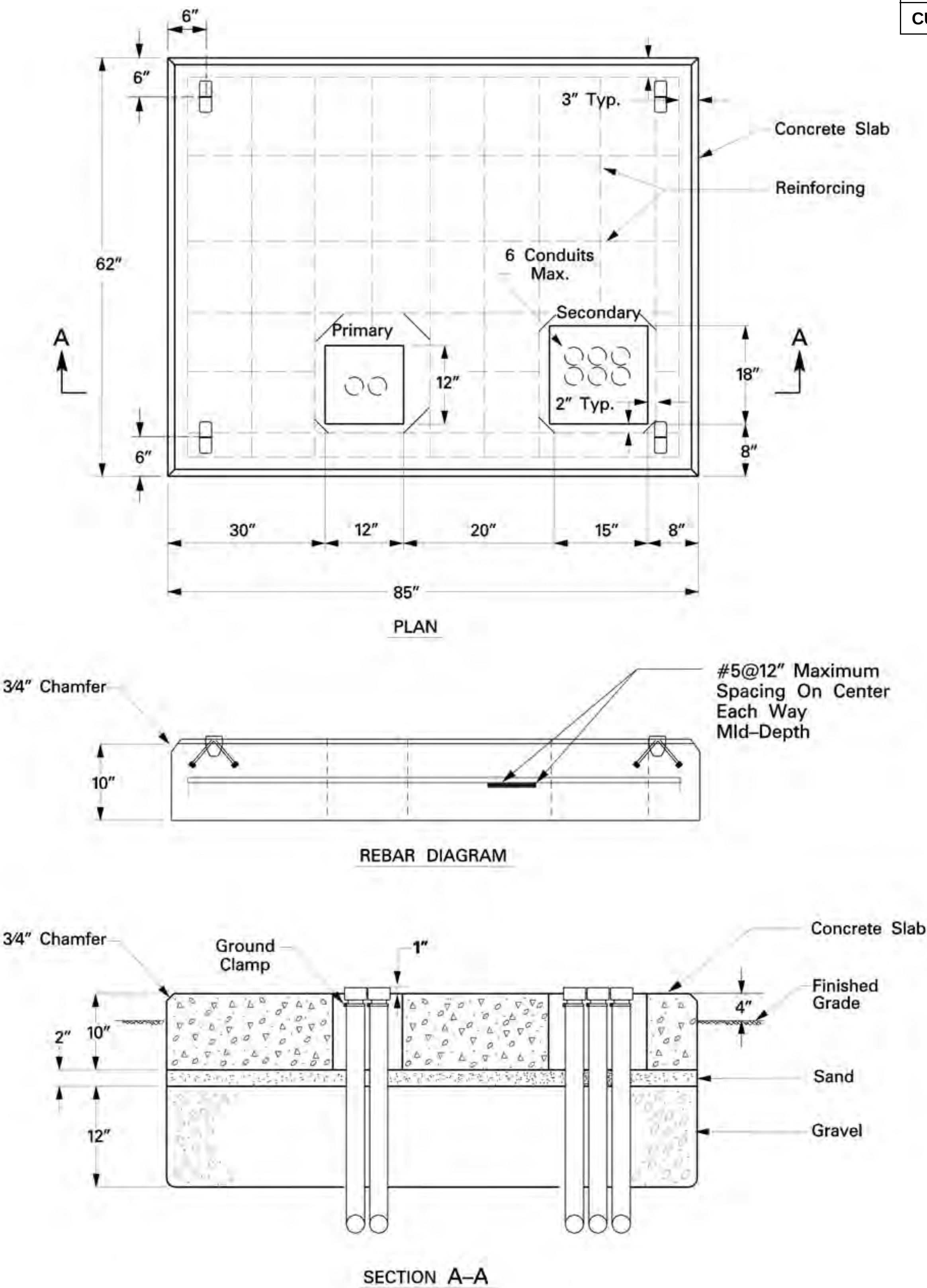


SECTION A–A

Supersedes 1/07 Issue – Added STD Item.

CONCRETE SLAB FOR 750-2500 kVA THREE PHASE TRANSFORMERS 15kV CIRCUITS			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		44-114	7/11

Profile Item	
Std. Item	UF8C
CU	TTFPC2584



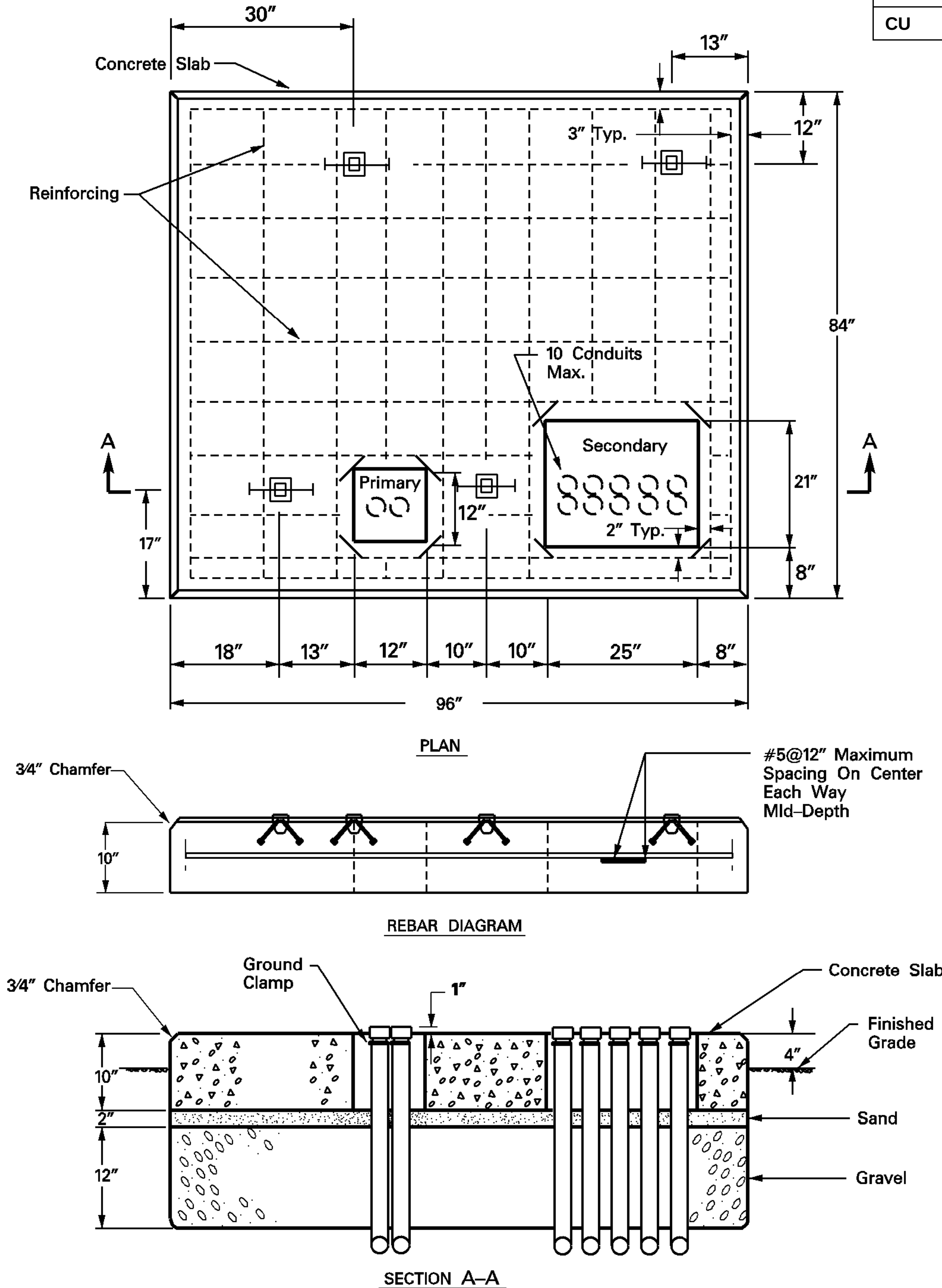
Supersedes 1/07 Issue – Added Std. Item.

CONCRETE SLAB FOR 75 – 300 kVA THREE PHASE TRANSFORMERS
25 - 35 kV CIRCUITS

ISSUE	PAGE NUMBER		
7/11	44-115	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

 Doc. # ST. 44.00.001

Profile Item	
Std. Item	UF8D
CU	TTFPC2585

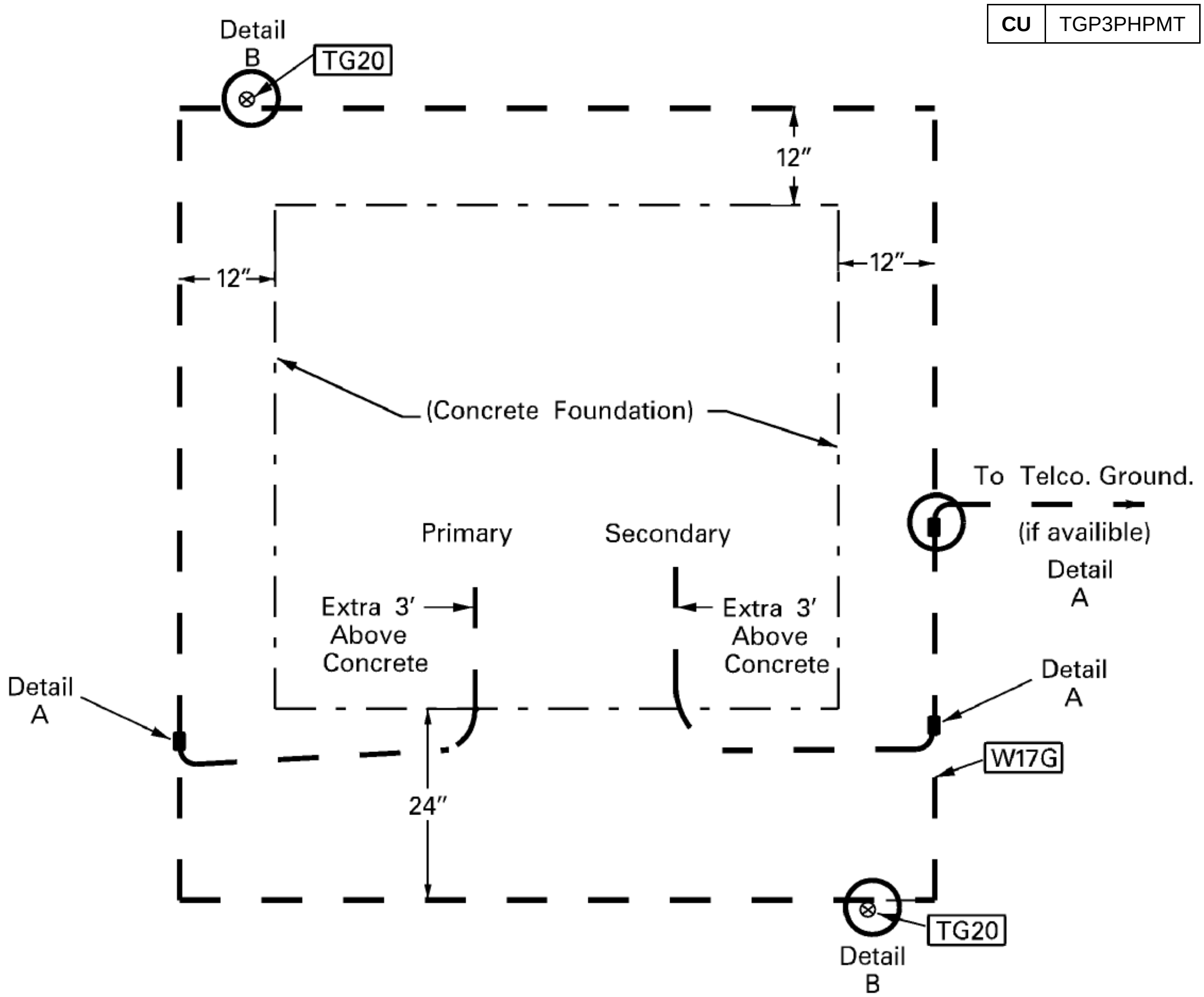


Supersedes 7/07 Issue – Added Std. Item.

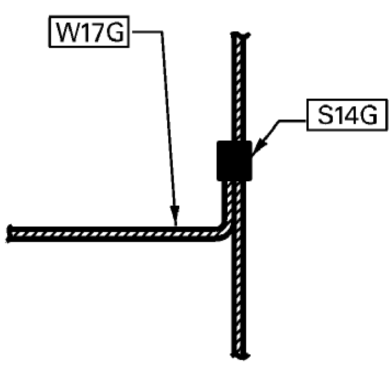
CONCRETE SLAB FOR 500 – 2500 kVA THREE PHASE TRANSFORMERS 25 – 35 kV CIRCUITS			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 44-116	ISSUE 7/11

Doc. # ST. 44.00.001

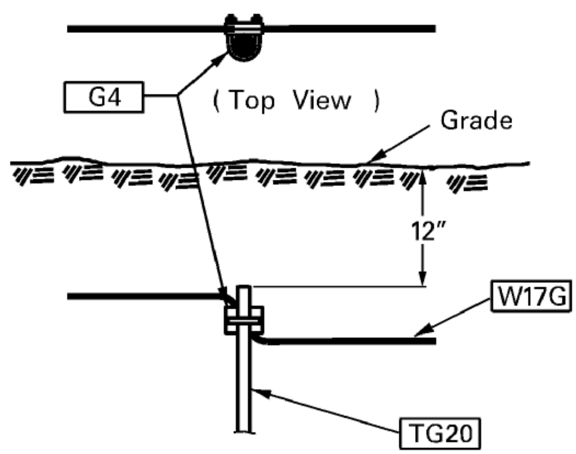
CU	TGP3PHPMT



Supersedes 7/08 Issue - Drawing Updated with Std Items.



Detail A



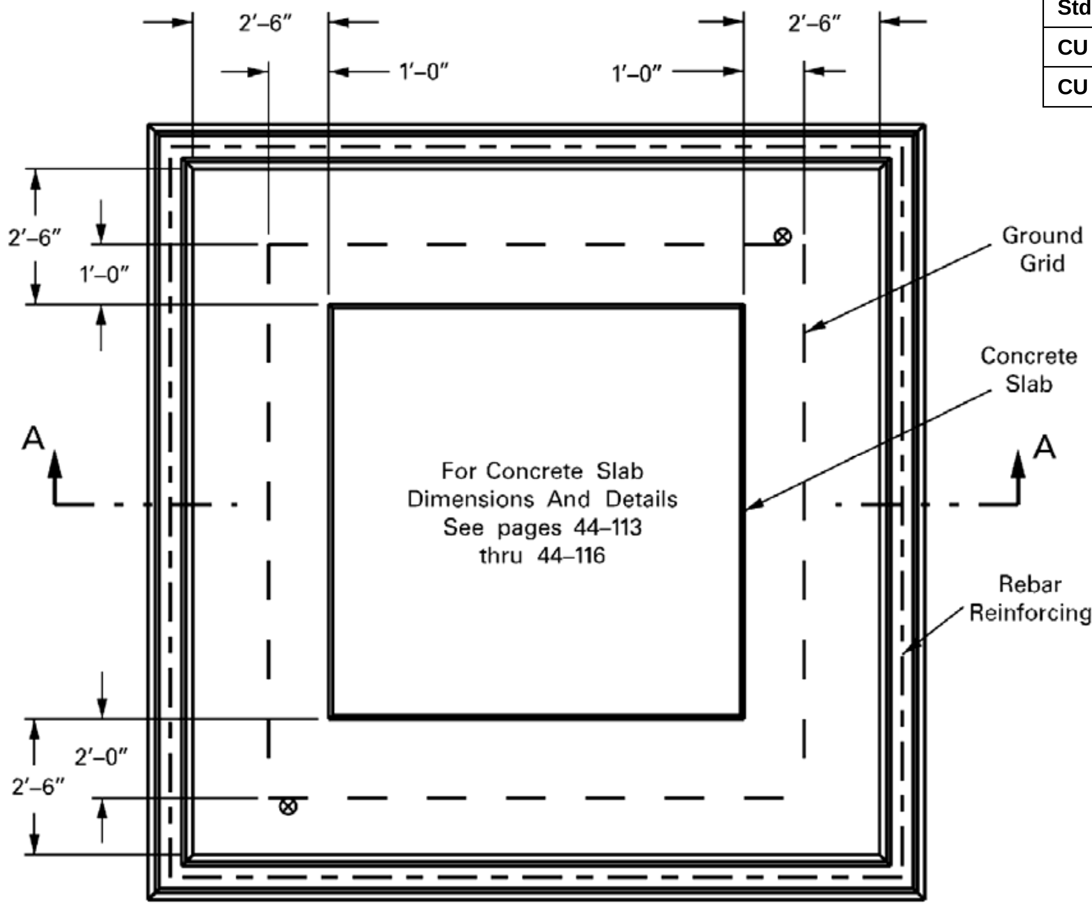
Detail B

GROUND GRID INSTALLATION DETAILS

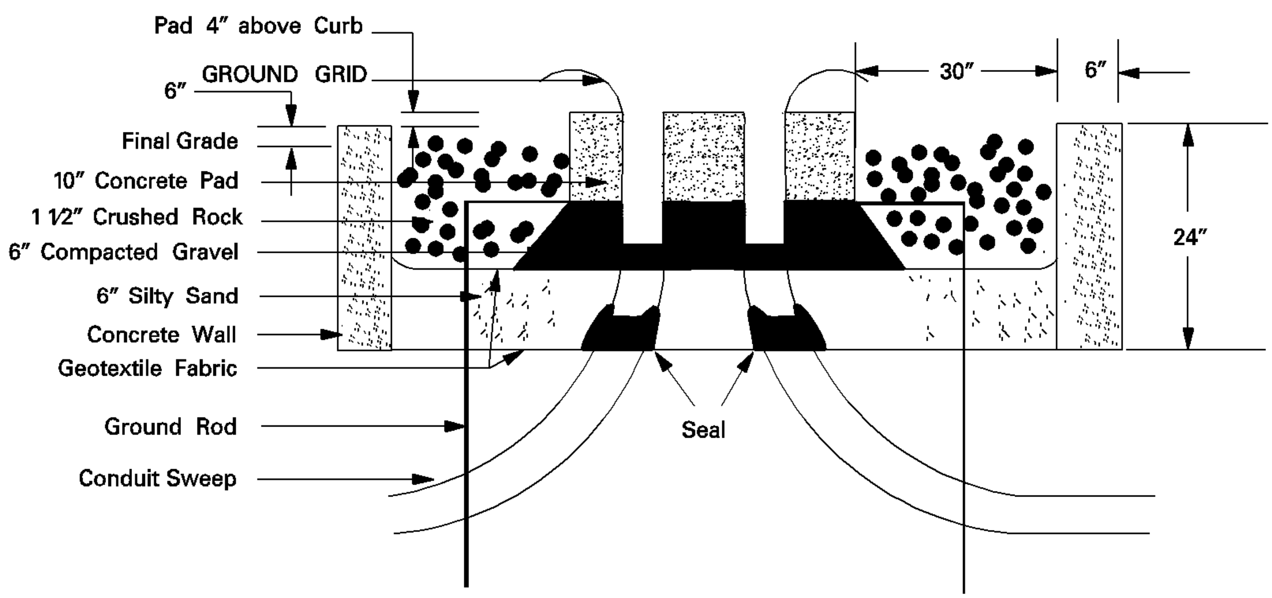
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/11	44-117		

 Doc. # ST. 44.00.001

Profile Item	
Std. Item	UF7_
CU	TCCUF7A
CU	TCCUF7B



Typical Cross Section of Containment Pad A-A



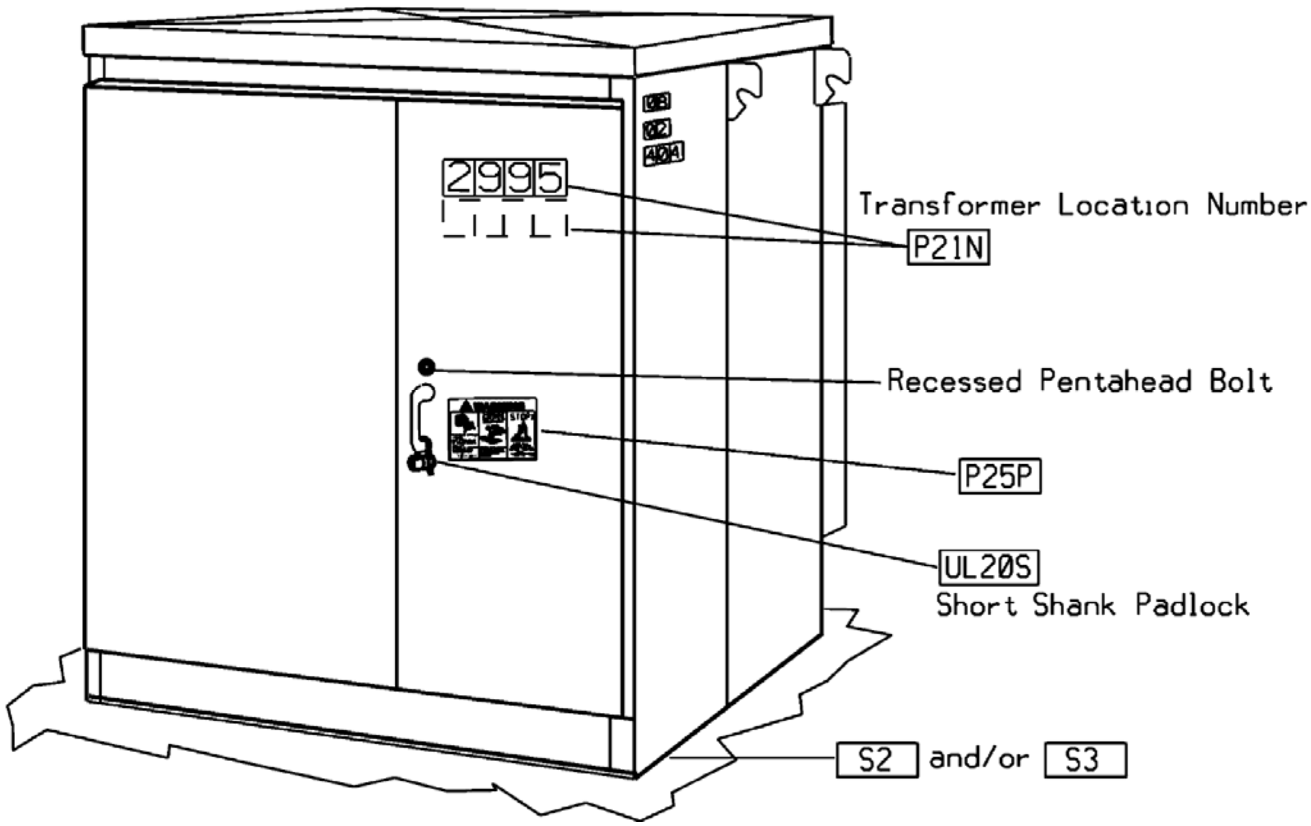
Supersedes 7/07 Issue – Drawing Update and added Std. Item.

OIL CONTAINMENT INSTALLATION DETAIL			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 44-120	ISSUE 7/11

 | Doc. # ST. 44.00.001

Std. Item	UT39_, UT41_, UT42_, UT45_, UT46_, UT47_

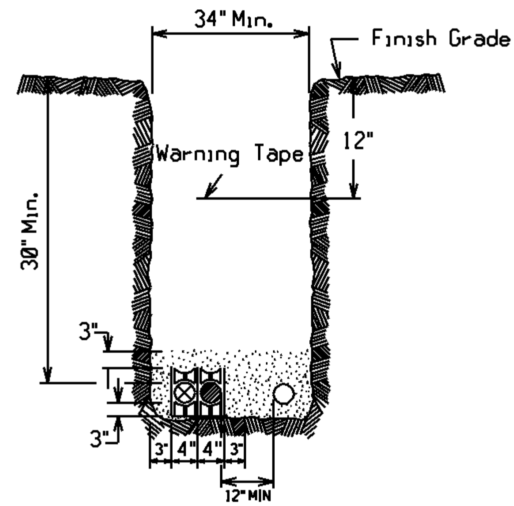
Std. Item	CU
P21N	TP21N_
P25P	TP25P
UL20S	TUL2OT
S2	CS2
S3	CS3



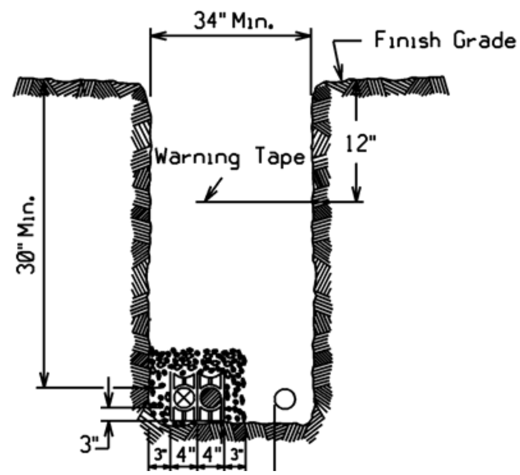
Supersedes 2/06 Issue - Drawing Update and Added Std. Item.

SECURITY AND INSTALLATION OF IDENTIFICATION INFORMATION

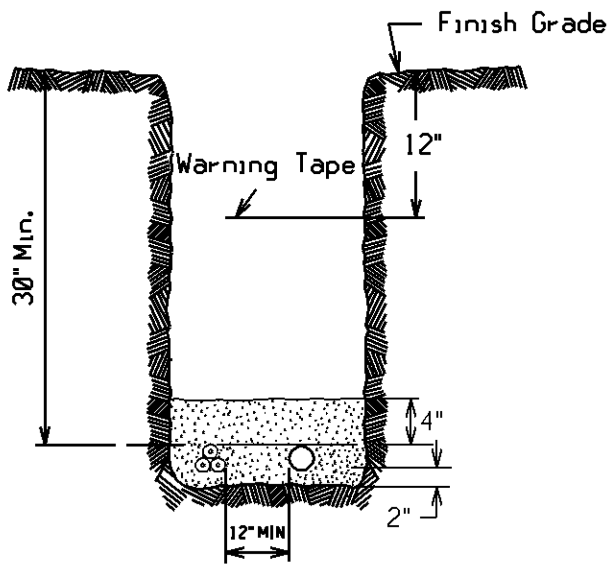
Conduit Trench



Conduit in Concrete Trench

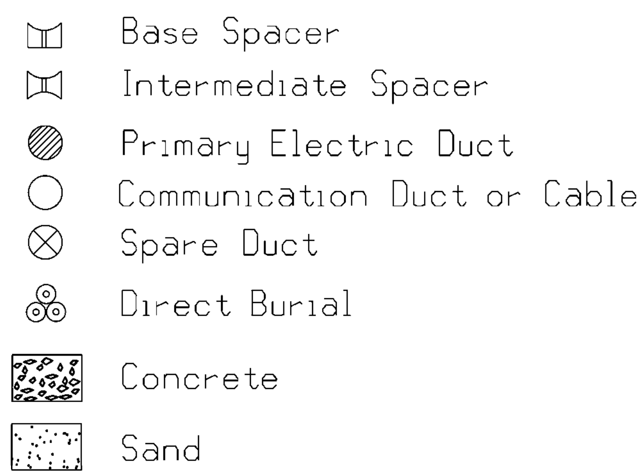


Direct Burial Trench



Note: If more than one set of primary is in trench, separate primary by 6" minimum.

Legend



Version	Date	Modification	Author(s)	Approval by (Name/Title)
2.1	12/13	• Convert to Liberty Utilities Document from National Grid	Robert Johnson	Robert Johnson Program Manager
2.0	7/11	• Updated text in sections 44.1, 44.3, 44.5 , 44.8, 44.12, 44.14, 44.14.10, 44.16, 44.20, 44.21, 44.24, 44-102, 44-1-8, 44-111 and 44-123. • New sections 44.25 and 44.26 • Drawing updates to 44-108, 44-44-120 and 44-123. • Added Std. Items to Drawings.	John Vartanian	Susan Fleck, VP of Standards, Policies, & Code
1.0	07/08	• Updated sections 44.1, 44.8, 44.14, 44.16, 44.20, 44.21, 44.23, • Inserted 44.42 (new section). • Updated page 44-111 - added bollard cover to drawing. • Updated drawing on page 44-117. • New drawing on page 44-125.	John Vartanian	Allen Chieco, Director of Distribution Standards and Work Methods

Supersedes 7/11 Issue – 45.19.35 aNew Standard

 Doc. # ST. 45.00.001

Supersedes 7/07 Issue – New Updated Standards

45.0 GENERAL

This Section outlines general construction practices for Underground Residential Developments (URD). In general, these practices shall apply to 15 kV, 200 A, single phase class of equipment.

It is intended to apply these practices to qualifying residential developments in accordance with Company Policy. The preferred primary system configuration is a loop with an open point at the one-half load point in the development.

For specific layout and design practices refer to the URD Design Guide available on the Distribution Standards Engineering website.

45.1 PRIMARY CABLE

Primary cables shall consist of a single jacketed #2 aluminum conductor, EPR insulated cable, with full size copper concentric neutral (Std. Item UC11BC).

Cable shall have a semi-conducting jacket and is to be used in all conduit and direct buried installations. This cable is suitable for random lay where other communications cables are present.

45.2 SECONDARY CABLE

Secondary cable shall consist of triplexed (three single conductors twisted together), 4/0 or 350 kcmil aluminum conductor (Std. Item UC8). Typical ampacities for the above secondary cables are detailed in Table 1. These ampacities are shown as a guide only. For specific installations, refer to Distribution Design.

Table 1
Typical Ampacity For URD Secondary Cable

Cable Size	Ampacity In Conduit (Amps)	Ampacity Direct Buried (Amps)
1/0 AL*	185	205
4/0 AL	265	300
350 AL	360	400

* For Reference Purposes Only

45.3 INSTALLATION

New Hampshire tariffs require a conduit and cable system to be installed.

Conduit systems shall consist of a primary conduit with cable in it and a spare conduit. Spare conduit shall be installed along the entire route of the primary cable and terminated at the base of the riser pole in a 90 degree sweep, with a coupling and conduit plug (Refer to Section 48 – Risers). A spare conduit is not required in a looped system.

45.4 JOINT TRENCHING

Joint trenching involves the utilization of the same trench by a combination of utilities including electric primary cable (60l V to 15,000 V), electric secondary / street light cable (600 V and below), buried communication cable including telephone and CATV, and/or natural gas lines. Direct buried electric cable shall not be installed in a joint trench with water lines, fuel lines, steam lines, or sewers, including both sanitary and storm type. Joint trenching with communication cable including telephone and CATV and/or natural gas lines shall be utilized when practical.

45.5 EQUIPMENT LOCATION

Requirements for underground construction and associated pad-mounted equipment shall be determined for each development by Distribution Design. All Company owned equipment must be located within a permanent easement. The customer / developer shall grant such permanent easements, including rights of access to each easement, to the Company. ***Easements must be in place prior to installation of any Company owned equipment.***

The location of the easement strip, the trench within the easement strip and the placement of the electric cable shall be such as to avoid above ground and underground structures and obstructions. To avoid interfering with future installation by other utilities, the trench should be run parallel with the centerline of the street.

Pad-mounted equipment and below-grade submersible equipment (e.g. transformer foundations), transformer enclosures, secondary service handholes, etc. shall be located in the easement strip and should be placed between the trench and the private property side of the easement strip. A minimum separation of 12 inches of well tamped and/or undisturbed earth should be maintained between the trench and any pad-mounted or below-grade utility structures (e.g. transformer foundations). The separation of the trench from the edge of the easement strip should be as large as necessary to permit maintenance of the buried facilities.

In those areas where water and/or sewer lateral stubs have been installed, future excavation for connection to the stubs must be anticipated. These stubs usually terminate at the property line or up to two feet on the private property side of the front lot (street) line. The stubs should be considered in locating the trench. Water and sewer laterals should be installed in advance of the electric distribution facilities.

The electric primary cable shall normally be placed on the private property side of the trench. Communication cables and gas lines shall normally be placed on the public way side of the trench.

45.6 EXCAVATION

The width and depth of the trench will vary dependent upon the number and type of utilities occupying the trench. The width of the trench should be kept to a minimum. The excavation shall conform on plan, depth and grade to those shown on the detailed construction drawings. The trench shall be uniformly graded and the bottom of the trench shall be well tamped and/or of undisturbed earth, free of rocks and any sharp projections. Before placement of direct buried cable, a 2 inch protective layer of sand or rock-free sandy loam shall be placed on the trench bottom. Typical trench cross sections are shown on Pages 46-100 thru 46-101.

45.7 BACKFILL

The Company shall inspect the cable installation prior to backfilling and shall also approve or reject the proposed backfill material. All backfill material shall be free of objects that may damage the cable / conduit installation. Trenches in streets or other areas that may pose an undue hazard or an inconvenience to the public shall be backfilled as soon as possible.

Selected backfill shall be carefully placed around the cable / conduit and to a point a minimum of 4 inches above the cable / conduit. The selected backfill shall consist of sand or rock-free sandy loam. This selected backfill shall be compacted by foot-walking and hand tamping.

The remainder of the backfill shall be in 6 inch layers and each layer shall be well tamped with a mechanical tamper after a 6 inch covering is in place. The backfill material shall be dense and compacted sufficiently to prevent further settling. This backfill shall consist of sand or earth or a mixture. This backfill may contain rocks provided the rocks do not exceed 2 inches in any direction or with sharp edges likely to cause damage. Rocks shall not comprise more than 50% of the backfill material by volume. Selected backfill shall not contain shell, ash, cinder or frozen material.

Trenches with gas mains installed are to be backfilled with soil free of rocks or other debris that may damage the pipe surfaces. Before installing a gas line in the joint trench, all other occupants shall have their respective facilities installed and backfilled with the required minimum cover of 12 inches.

CLEARANCES

45.8.10 General

The minimum burial depth between the top of the completed primary conduit or direct buried primary cable and finished grade is 30 inches. All conduits / cables entering equipment enclosures, such as, transformer foundations or pull / splice boxes, shall remain at the required 30 inch depth until protected by the enclosure.

If these minimum burial depths cannot be achieved due to excessive ledge or solid rock conditions, the following guidelines may be applied. Every attempt should be made to achieve the 30 inch minimal clearance prior to implementing these supplemental instructions.

A. Conduit Applications

Supplemental protection is required to prevent potential damage. The minimum excavation depth can be reduced to 21 inches and the conduit encased in concrete. The concrete envelope is to be a minimum of 3 inches thick in all directions around the conduit (Refer to Section 32 – Conduit). Minimum cover over the concrete encasement shall not be less than 12 inches.

B. Direct Buried Applications

If a 30 inch burial depth cannot be achieved, the cable must be placed in a 3 inch conduit encased in concrete. The minimum excavation depth can be reduced to 21 inches. The concrete envelope is to be a minimum of 3 inches thick in all directions around the conduit. Minimum cover over the concrete encasement shall not be less than 12 inches.

The minimum burial depth for secondary conduits / cables shall be 24 inches.

Greater depths than those indicated may be required dependent upon field conditions, other utilities occupying a joint trench, and other common factors.

45.8.20 Communication Cables

Direct buried communication cable, including telephone and CATV, may be buried at the same depth with the direct buried electric cable with no deliberate separation between facilities, provided all parties involved are in agreement and provided the primary electric cable has a semi-conducting jacket.

45.8.30 Natural Gas Lines

Direct buried electric cable shall be separated from gas lines by a minimum of 12 inches in any direction. Gas lines shall normally be located above the electric cable, provided a minimum of 12 inches of vertical separation is maintained. Gas lines shall not be located at the same depth as the electric cable.

45.9 MARKING TAPE

Marking tape shall be installed in the cable trench above all electric conduit / cable. The tape (Std. Item UT8) shall be installed approximately 12 to 18 inches below finish grade to prevent dig-ins of underground cable. The installation shall take place during the backfill of the cable trench.

45.10 TYPICAL TRENCH DETAILS

The trench cross sections shown on Pages 45-100 thru 45-101 illustrate typical combinations of joint facilities and the minimum clearance and separation required for areas where the finish grade has been established. For those areas where only rough grade (rough grade being grade within 6 inches of finish grade) has been established, an additional 6 inches should be added to the depths given to maintain the minimum depths required.

45.11 CABLE PULLING

Primary cables shall be installed utilizing the pulling eyes at the transformer foundation, and in instances requiring it, a primary cable pull/splice box having pulling eyes installed in them for this purpose.

Primary cable pulling tension shall be limited to 730 pounds. **ALL CABLE PULLS REGARDLESS OF THEIR LENGTHS SHALL USE PULLING LUBRICANT (Std. Item UC75) IN ACCORDANCE WITH RECOMMENDED PRACTICES.**

Additionally, cable "reel drag" shall be minimized by attending the cable reel and hand feeding the cable in at the feed point as it is pulled from the pulling end. Minimizing "reel drag" dramatically reduces cable pulling tensions.

Cable pulling sheaves of proper diameter shall be used during pulling to prevent cable damage from bends less than the minimum radius recommended. Refer to Section 35 – Cables for further information on recommended minimum bending radius for cable. Proper pulling techniques will insure normal life expectancies for cable and will also prevent damage to conduit ends inside transformer foundations and pull/splice boxes.

Cold shrink cable end seals (Std. Item UC90) shall be used on primary cables to keep moisture out of the cable during all phases of installation.

Secondary cables shall be pulled into the transformer foundation, utilizing the pulling eye in the transformer foundation installed for this purpose.

Where cable must be pulled between secondary handholes, these distances should be kept short (limited typically to road crossing widths) and the number of conduit bends should be minimized as pulling by hand will be necessary.

45.12 CABLE SPLICING

Splicing shall be in accordance with Section 36 – Connectors / Splices. Cold shrink splice jackets (Std. Item UR75) shall be employed to cover all pre-molded straight cable joints.

Supersedes 2/06 Issue – 45.10 Page Update

A primary pull / splice box (Std. Item UR6) shall be employed where specified by Distribution Design. Cable should be trained such that splices are installed along the long walls of splice boxes as shown in Figure 1.

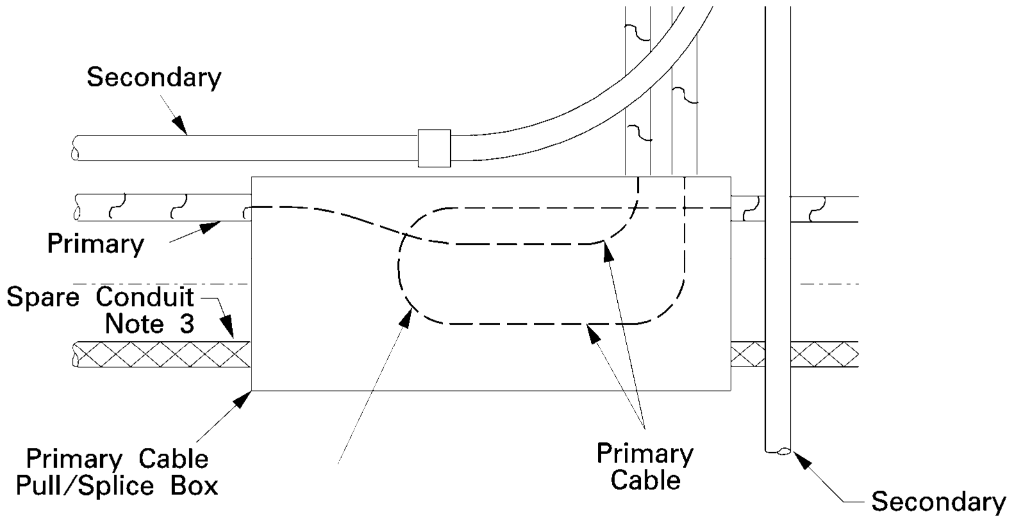


Figure 1
Primary Cable Training In Pull / Splice Box

When training primary cables in transformer foundations and pull/splice boxes, it is important to meet or exceed the cable's minimum bending radius, refer to Section 35 – Cables.

45.13 CABLE TERMINATING

Cable terminating shall be in accordance with Section 37 – Terminations.

45.13.10 Loadbreak Elbow Connectors

Loadbreak elbow connectors shall be installed on dead front pad-mounted transformers and similar equipment using universal bushing wells and loadbreak bushing inserts.

Jacket cutback sealing kits (Std. Item UR23B) are required to reseal the cable jacket.

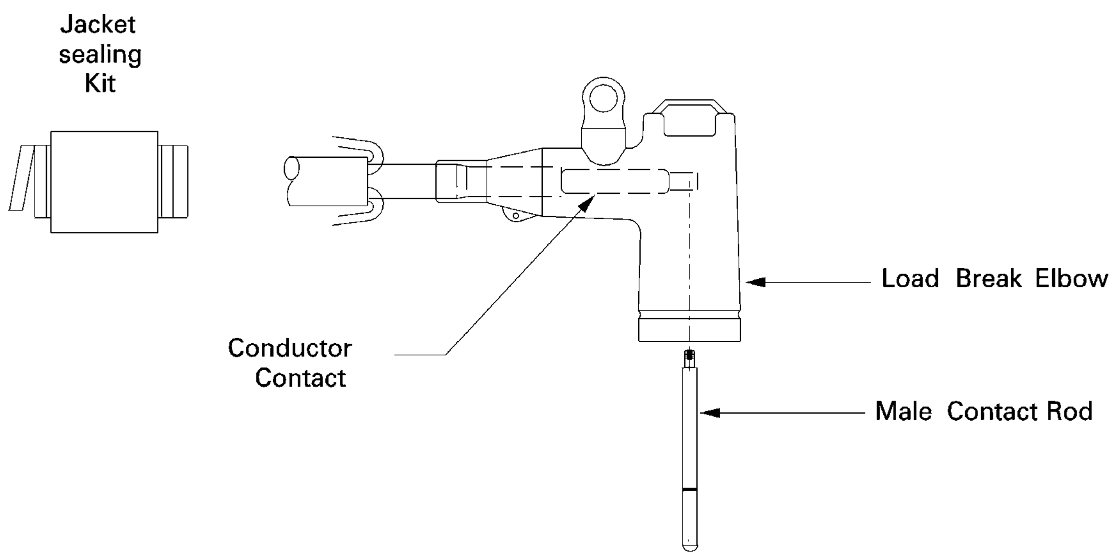


Figure 2

45.13.20 Cold Shrink Terminators

Cold shrink terminators shall be in accordance with Section 37 – Terminators and are to be used on riser poles and live front pad-mounted equipment (live front pad-mounted equipment to be used only when specified by Distribution Design). Terminator kits specified for jacketed concentric neutral cable provide a weatherproof seal at the jacket cutback.

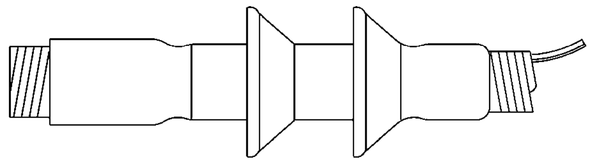


Figure 3

45.14 SURGE PROTECTION

Surge protection shall be in accordance with Section 40 – Transformers. Surge arresters must be applied at all riser poles and at all open points.

The importance of short surge arrester primary and ground leads in parallel with riser pole terminators cannot be overstated. This practice is depicted in Section 48 – Risers.

Before energizing primary cables, make sure surge arrester leads are connected properly at the riser pole, and at open points as required.

45.15 CABLE IDENTIFICATION AND TAGGING

45.15.10 Primary Cable Systems

A. Application

To provide identification system for primary URD cables so that the physical location of the terminal points of the cable can readily be determined.

B. Procedure

(Refer to Figure 4) – Each transformer manhole, pad-mounted transformer, primary pull/splice box, enclosure or primary handhole in each development will be initially numbered consecutively starting with #1. Additions to the system will be numbered with the next consecutive number. In some operating areas equipment has been labeled by house number, in these areas future numbering can remain the same to minimize confusion and keep consistency in the operating area. All cable tags shall represent where the cable is going to.

C. Identify Location

Identify location by stamping castings, covers, or by placing decals on tamper shields or on pad-mounted transformers.

D. Tags

Refer to Section 50 – Materials Catalog (Std. Item UP21). Select appropriate plastic tags, insert into tag holder, and attach it to cable.

Supersedes 7/07 Issue – Updated procedure

Supersedes 7/07 Issue –Replaced SWITCHING MODULE with FUSED SWITCH PAD in figure 4

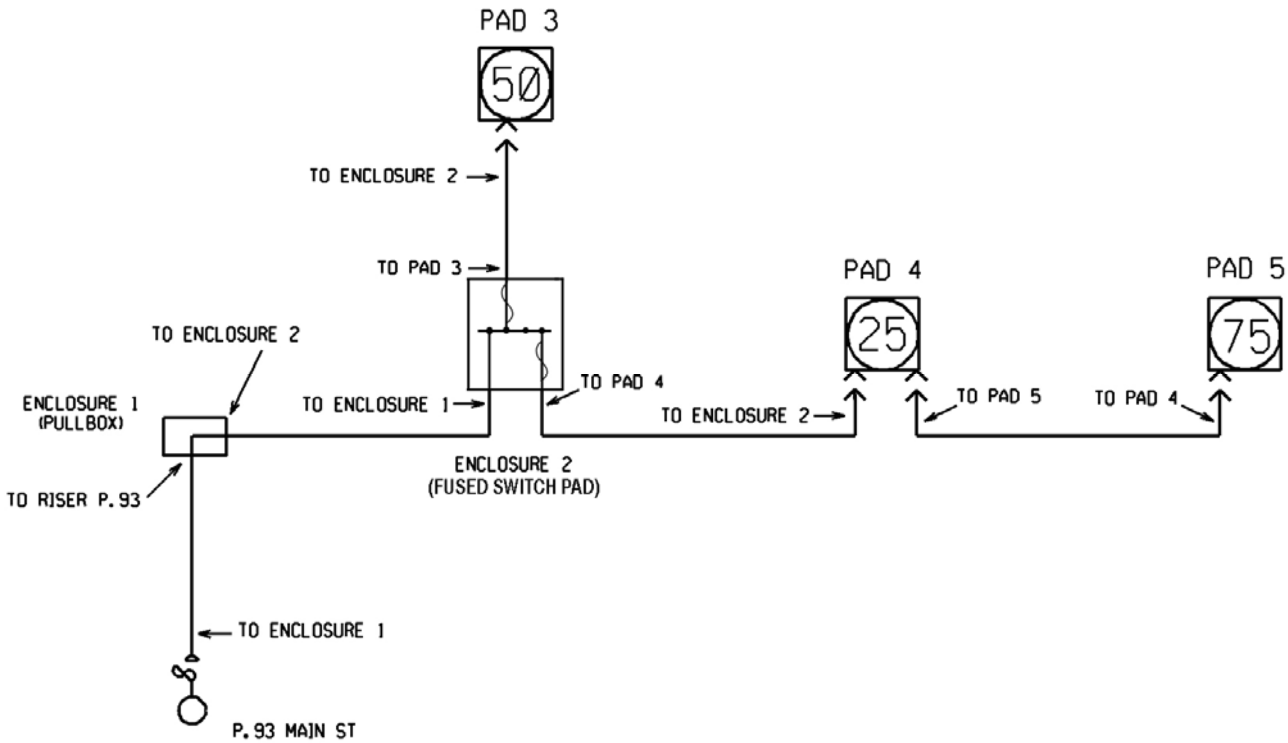


Figure 4
Primary Cable Tagging & Identification

45.15.20 Secondary Cable Tagging And Identification System

A. Application

To provide identification system for secondary URD cables so that the physical location of the terminal points of the cable can be readily determined.

B. Company Owned Cable to Transformer

The letter N identifies Company owned 600 V secondary cable. The dash followed by a number (e.g. 15) identifies the transformer that houses the other end of the cable.

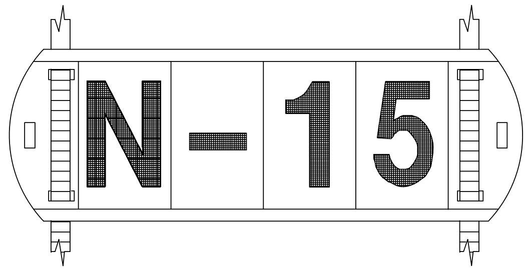


Figure 5

C. <u>Company Owned Secondary Cable to Handhole</u>

The letter N identifies the cable owned by the Company. The letter H followed by a number (e.g. 15-1) identifies the handhole location that houses the other end of the cable.

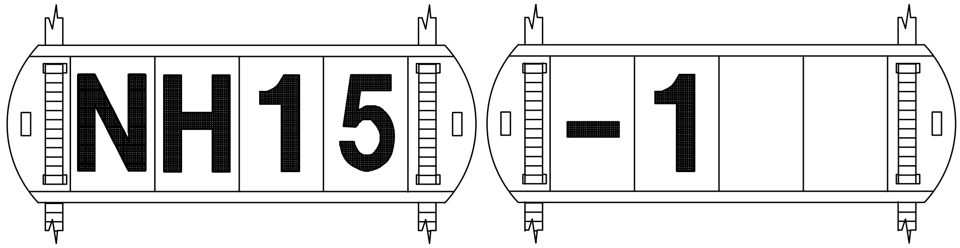


Figure 6

D. <u>Customer Owned Service Cable</u>

The letter C identifies the customer owned 600 V service cable. The number (e.g. 155) identifies the customer's building or apartment number. Customer service cable will terminate at either a handhole or padmount transformer.

Figure 7

E. <u>Parallel Secondary Service</u>

For parallel secondary services, install a parallel service tag (Std. Item UP21P) in the tagholder along with the building or apartment number.

Figure 8

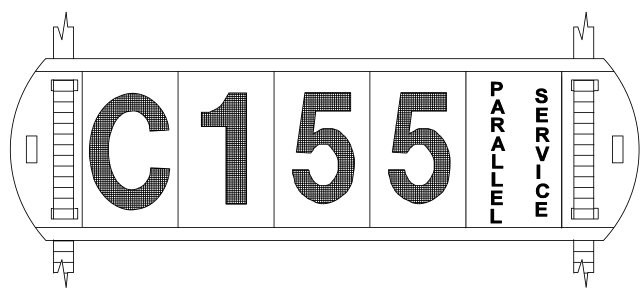


Figure 9

Supersedes 2/06 Issue – Added Text

45.16 SINGLE INSULATED SECONDARY BUSES – ALUMINUM 600V

45.16.10 Single Allen Set Screw (#10 – 500 kcmil)

The single Allen set screw insulated secondary connector is designed for connecting insulated copper and/or aluminum secondary, service lateral and street light cables with a cable range of #10 stranded through 500 kcmil stranded. The insulated secondary bus is available with 4, 6 or 8 positions.

The insulated secondary connector is suitable for service handhole, submersible transformer enclosure and direct burial applications when operated on 600 V or lower voltage class systems.

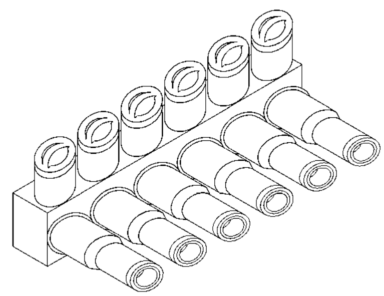


Figure 10
Single Allen Set Screw Insulated Secondary Bus

Table 2
Insulated Aluminum Bus

Std. Item	Number Of Terminals	Length (Inches ±)	Range
UR15A4	4	4.7	#10 – 500 kcmil
UR15A6	6	7.1	
UR15A8	8		

1. Remove the cable insulation down to the conductor 1⅛ inch from the end of the cable. Do NOT pencil the cable.

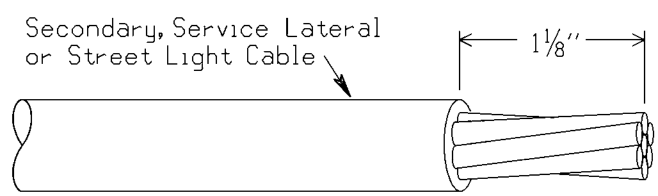


Figure 11

2. Select the cable port to be used and remove the cable adapter from the cable port. Ensure that the bus is pre-filled with oxide inhibitor. If the cable adapter is required, remove and discard the plastic dust cap and select the cut line that corresponds to the cable size being used. Cut the cable adapter at the proper cut line and slide the cable adapter onto the cable.

   Note: For 500 kcmil cable, discard the cable adapter and slide the cable directly into the cable port.

Supersedes 2/06 Issue – Added 45.23

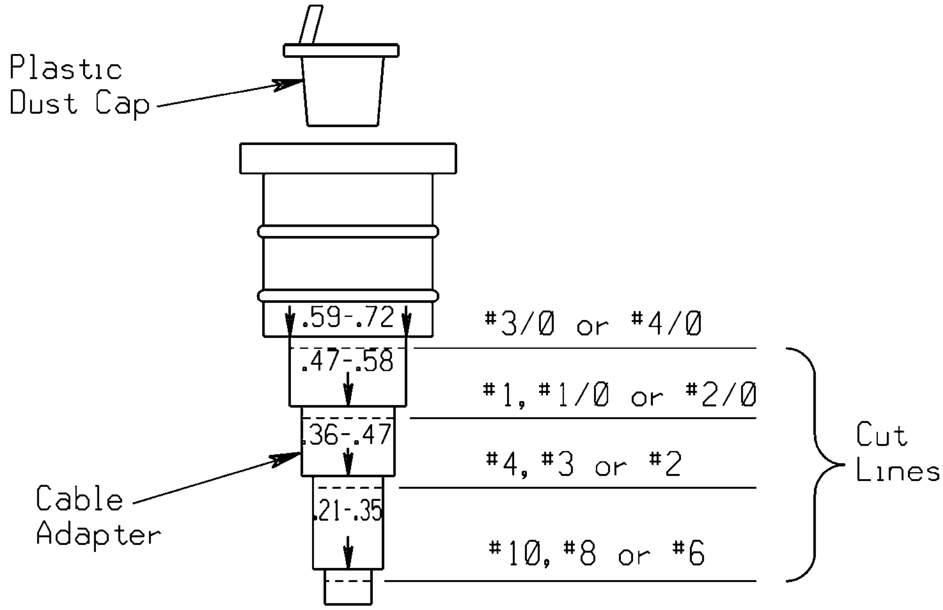


Figure 12

3. Remove the rubber plug from the respective set screw port and loosen the 5/16 inch Allen head set screw. Push the cable and cable adapter (if present) into the cable port of the connector until the conductor bottoms in the connector and the cable adapter (if present) is flush against the bottom edge of the cable port. Exposed bare conductor shall be wire brushed and cleaned immediately before insertion into the connector. While holding the cable and cable adapter (if present) in place tighten the Allen head set screw until the cable is secured in the connector. Replace the rubber plug into the set screw port. Install the proper cable identification numbers as instructed in Section 45.11.

4. Once the cable adapter seal has been cut or pierced and the cable removed, only the same size cable or larger size cable can be reinstalled in the cable adapter. NEVER USE A CUT OR PIERCED CABLE ADAPTER TO SEAL A CABLE PORT. ALL SET SCREW PORTS MUST BE SEALED WITH RUBBER PLUGS AND ALL UNOCCUPIED CABLE PORS MUST BE SEALED WITH UNCUT OR UNPIERCED CABLE ADAPTERS TO MAINTAIN A COMPLETE WATERTIGHT SEAL.

45.17 MAINTENANCE OF INSULATED "MULTI-PIECE" SECONDARY BUS

This section covers the maintenance of existing multi-piece insulated secondary busses. If it becomes necessary to replace any of the multi-piece busses in a secondary handhole, all three units should be replaced with the appropriate Allen set screw style insulated bus (Refer to Section 45.16 for details).

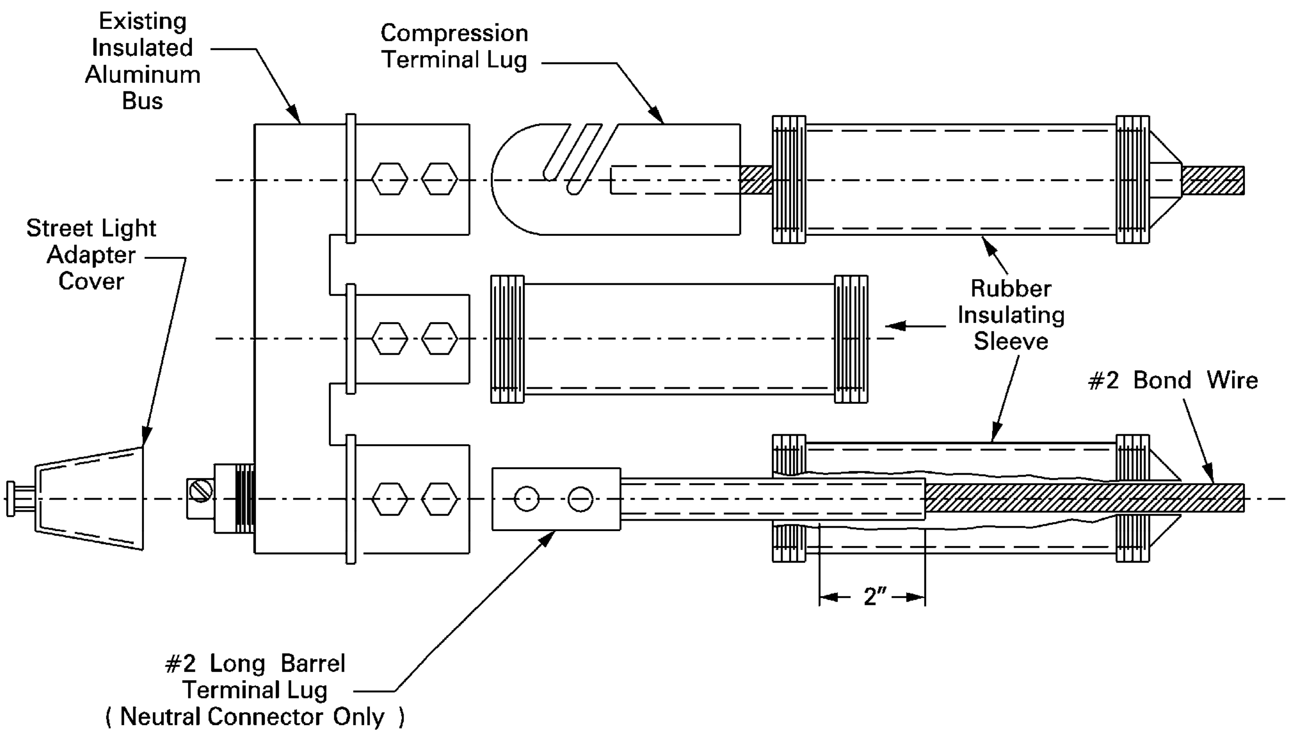


Figure 13
FOR MAINTENANCE PURPOSES ONLY

45.18 SECONDARY CABLE STRAIGHT SPLICE

45.18.10 Application

Use for repairing faulted, direct buried, aluminum conductors, or for piecing out cable where required. Connector should be used on straight sections of cable only and care should be taken to avoid bends near the splice.

1. Connector – Select appropriate connector from Table 3.

2. Thoroughly clean surface of cables to be spliced.

3. Make a smooth cut on each end of housing to match cable diameter.

4. Lubricate cables and splice housing with silicone grease. Slide housing parts over cable ends.

5. Using appropriate tools square cut ends of cable and skin insulation the depth of the connector plus ¼ inch. Cut insulation squarely being careful not to nick conductor.

6. Wire brush conductors and insert into connector. Compress connector, referring to Section 34 – Tools / Dies for tools and dies. File any sharp burrs and wipe off excess compound and filings on connector.

7. Slide housing over connector.

Table 3
Splice Housing And Connector

Secondary Cable Size	Cable O.D. Inches	Housing	Connector*
1/0	0.54	UR15C	UC61B
4/0	0.70		UC61C
350	0.88		UC61D

* Connector to be used on Aluminum conductors only.

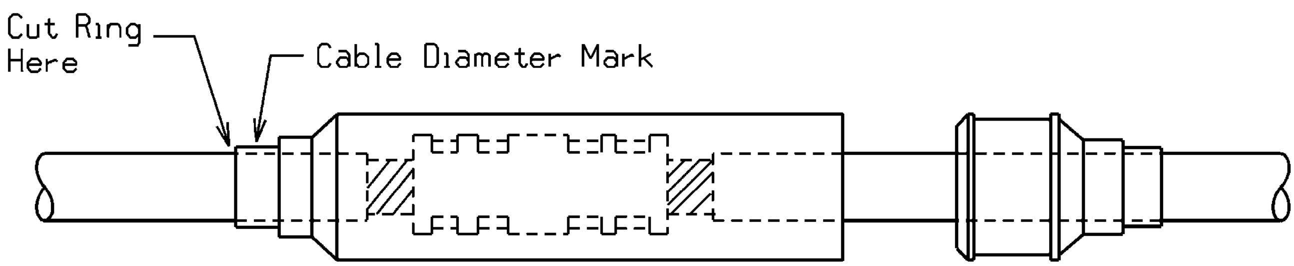


Figure 14
Secondary Cable Straight Splice

45.19 SINGLE PHASE PAD-MOUNTED TRANSFORMER INSTALLATION

45.19.10 Application

URD developments will utilize loop feed, dead-front, pad-mounted transformers (Std. Item UT31). Transformers will be 15 kV in the following standard sizes: 25 kVA, 50 kVA, 75 kVA, 100 kVA and 167 kVA. In residential developments, initial transformer sizes should be limited to 25 kVA, 50 kVA & 75 kVA sizes. Transformer sizes of 100 kVA and 167 kVA should be used to change out overloaded transformers.

45.19.20 Location

Transformers are to be located in the easement area as depicted on Pages 45-115 and 46-116. Transformers should be orientated such that the compartment cover faces the street. The easement area must be clear of obstructions that would interfere with the installation or removal of fuses or elbows when using a shotgun stick.

45.19.30 Transformer Foundation & Cover

A reinforced fiberglass box pad (Std. Item UR8) shall be used as the foundation for the transformer in all installations of conduit systems. UR9F shall be used in direct burial applications.

If there is a change in the final grade of an existing transformer installation, the 10 inch vault pad adapter (Std. Item UR9) may be used to raise the elevation of the transformer. The vault pad adapters are stackable; therefore if more than 10 inches is required the correct grade may be achieved by stacking the appropriate number of adapters. The box-pad cover shall be installed to protect cables prior to actual transformer installation.

45.19.35 Transformer Oil Containment

This is to be used where oil containment is required by local authorities or where otherwise justified. The liner system, made up of layers of fabric and silty sand, will significantly slow down the migration of oil into the underlying sub-grade allowing additional time to initiate clean up response. The 16 Oz polypropylene geo-textile fabric (Item ID# F70) allows the passage of water but absorbs small quantities of oil. This design is intended to confine 100% of total transformer oil present, with a 20% reserve margin for up to 36 hours. If additional confinement is desired consult Distribution Design. See pages 45-143 and 45-144 for construction details.

Supersedes 1/07 – Transformer Oil Containment

45.19.40 Handling Transformers

Removable lifting lugs are provided with the transformer and should be utilized in conjunction with spreader bars and/or non-metallic slings when moving the transformer to prevent damage to paint or other parts. Lift only by appropriate lifting lugs. After checking the nameplate for proper voltages and kVA size, install the transformer on the foundation and remove the lifting lugs. Secure the transformer to the foundation as depicted in section 45.23.

45.19.50 Primary Connection

Install loadbreak bushing inserts in bushing wells using torque limited tools and properly bond the bushing well to the ground (see Page 45-126). Train the primary cable, being careful to meet or exceed the allowable cable bending radius, see Section 35 – Cables. Install loadbreak connector elbow such that the cable is located in its final assembled position. This position should contain enough slack to provide adequate clearance for removing the elbow and preventing any strain. Since the cable jacket cutbacks are sealed at the elbows, it is important to pull-in enough cable to allow approximately 2 feet of twisted concentric neutral wire length between the elbow and the ground connection. Connect the ground grid to transformer tank and concentric neutral wires to ground before energizing the transformer.

Tag all primary cables in accordance with Section 45.15 to identify phase and destination of cables.

45.19.60 Secondary Connection

Train secondary cables and connect to the transformer as shown in Section 45.20. The secondary cables must not interfere with the primary cable movement when operating primary loadbreak elbows.

Tag all secondary cables in accordance with Section 45.15.

45.19.70 Fuse Check

Check position of dual voltage switch, if present. Verify accessible fuse size for correct current and voltage rating from Section 39 – Fuses and install fuse.

The single phase pad-mounted transformer is equipped with two fuses, an expulsion fuse and a partial range current limiting fuse, installed in series; see Pages 45-120 and 45-121. The partial range current limiting fuse is installed internal to the tank and is not accessible for replacement. The partial range current limiting fuse is sized to coordinate with the expulsion fuse and should only operate for internal winding faults.

45.19.80 Installation Identification

Identify transformer location by placing 2 × 3 self adhesive decals (Std. Item P21) on the cover of the padmount. Install decals so as to be easily visible from the street.

45.19.90 Transformer Security

After tightening the captive pentahead bolt provided with the unit, install a standard short shank padlock (Std. Item UL20S).

45.20 SINGLE-PHASE PAD-MOUNTED TRANSFORMER SECONDARY CONNECTIONS

45.20.10 General

Low voltage bushings (Std. Item UR21) for transformer sizes 25 – 75 kVA are ⅝ inch threaded studs, transformer sizes 100 – 167 kVA have 1 inch threaded studs. The lowest bushing (X2) is the neutral and has a ground strap connected to the transformer tank wall.

45.20.20 Connectors

Secondary connectors are the slip fit type containing 6 positions covering a range of conductor sizes from #2 stranded to 500 kcmil and are constructed from an aluminum alloy making them suitable for both copper and aluminum conductors. A connector kit contains three bus connectors, two with protective covers for use on the live leg connections, and one bare bus connector for the neutral connection.

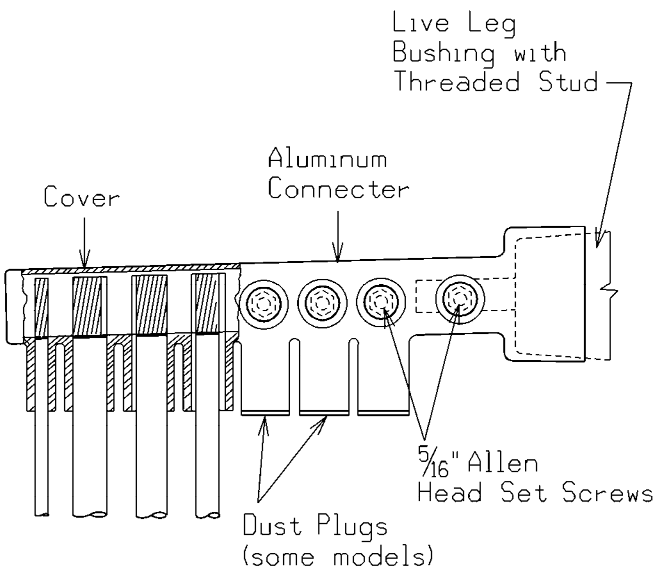


Figure 15
Live Leg Connection

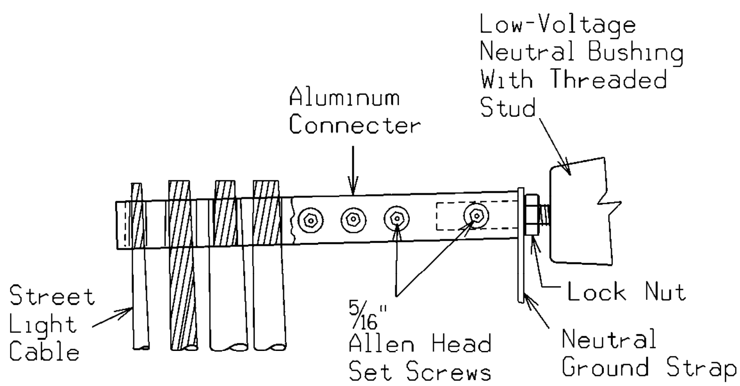


Figure 16
Neutral Connection

45.20.30 Connector Installation

A. Live Legs

Some transformers may be shipped with a nut screwed onto the threaded stud. This nut is not required and should be removed as it may inhibit the proper insertion of the secondary bus connector. With an insulated Allen wrench, loosen the stud mounting set screw and slip the bus connector over the threaded stud until it bottoms in the connector. Position the connector such that the cable ports are in a 7 o'clock orientation (to facilitated cable connections) and tighten the set screw securely. See Figure 15 for details. Note install all bus connectors with Allen connections on the left side facing toward the left exterior of the minpad.

Supersedes 2/06 Issue – Added text to 45.21 and 45.20.40

B. Neutral Leg

Transformers are shipped with a grounding strap attached to the neutral bushing sandwiched between two nuts on the threaded stud. It will be necessary to remove the outside nut to allow the bus connector to slip deep enough onto the threaded stud to properly engage the set screw. After removing this nut, install the neutral bus connector in the same manner as the live leg connectors. After the stud set screw has been tightened, tighten the nut on the back side of the ground strap against the bus connector to provide a solid ground strap contact, see Figure 16.

45.20.40 Cable Installation

Train cable to proper position. Loosen the cable port set screw using an insulated Allen wrench (remove port dust plug, if any exists). Carefully remove an amount of cable insulation equal to the width of the connector. Do not pencil. Wire brush the bare conductor and insert it fully into the inhibitor pre loaded port of the connector. Hold cable in place and tighten the set screw. No bare conductor shall be exposed below the port.

45.20.50 Streetlight Connection

The end position of the bus connector (furthest away from transformer) is reserved for the street light cable. To install #6 street light cable, remove an amount of cable insulation equal to twice the width of the bus connector. Double the conductor size by folding the exposed conductor in half. Wire brush the conductor and insert it fully into end position of the connector. Hold cable in place and tighten the set screw.

45.21 SUBSURFACE TO PADMOUNT CONVERSION ADAPTER

Subsurface and submersible equipment are no longer standard items for URD construction. When field conditions and/or problems warrant working on existing subsurface equipment, these installations should be converted to pad-mount installations.

The submersible to pad-mount conversion adapter assemblies (Std. Item UR12) allow conversion of existing submersible junction enclosures to pad-mounted junction enclosures and single phase submersible transformer enclosures to single phase pad-mounted transformers.

A universal adapter is available (Std Item UR11U) for installations where specific adapters will not work. The adapter is 48" x48" x 15" high. Flange of the base of the adapter to be buried 8 to 12" below finished grade.

45.21.10 Precast Concrete Transformer Vault Conversions

Attach converter pad to existing subsurface vault using either combination of 39 inch spaced holes. Use two ⅜ inch x 1¼ inch stainless steel pentahead bolts. Attach single phase pad-mount transformer using ⅜ inch x 1¼ inch stainless steel pentahead bolts.

45.21.20 36 Inch Submersible to Padmount Conversion Adapter Assembly

1. Prepare the existing junction or transformer enclosure for conversion, including removing the frame and cover from the enclosure.

2. Remove a sufficient amount of earth from around the upper portion of the enclosure to permit the installation of the conversion adapter and the installation of the ground rods and ground grid as required. For grounding plan refer to Pages 45-120 and 45-121 for a single phase pad-mounted transformer and Section 38 – Switches / Switchgear for a single phase pad-mounted junction enclosure.

3. Bolt the four angle brackets to the bottom of the top cap in the positions shown on Page 45-130. Do not completely tighten the bolts at this time.

4. Position the top cap onto the enclosure so that the angle brackets are located inside the enclosure as shown on Page 45-130.

5. Mark the location of the angle brackets; remove the top cap and notch out the top edge of the enclosure to accommodate the angle bracket so that the top cap will set flush with the top of the existing enclosure.

6. Replace the top cap on the enclosure and fasten the angle brackets flush to the inside of the enclosure.

7. After all brackets are fastened to the enclosure, tighten all the bolts to the top cap.

8. Backfill or grade around top cap, if required, to finish grade.

9. Place the cover onto the top cap and secure as shown on Page 45-131.

10. Install the pad-mounted junction enclosure or the single phase pad-mounted transformer, as required.

45.21.30 <u>48 Inch Submersible to Padmount Conversion Adapter Assembly</u>

1. Prepare the existing junction or transformer enclosure for conversion, including removing the frame and cover from the enclosure.

2. Remove a sufficient amount of earth from around the upper portion of the enclosure to permit the installation of the conversion adapter and the installation of the ground rods and ground grid as required. For grounding plan refer to Pages 45-120 and 45-121 for a single phase pad-mounted transformer and Section 38 – Switches / Switchgear for a single phase pad-mounted junction enclosure.

3. Bolt the four angle brackets to the bottom of the adapter ring in the positions shown on Page 45-132. Do not completely tighten the bolts at this time.

4. Position the adapter ring onto the enclosure so that the angle brackets are located inside the enclosure and in the position as shown on Page 45-132. Fasten the angle brackets flush to the inside of the enclosure as shown on Page 45-132. After all brackets are fastened to the enclosure, tighten all the bolts to the adapter ring.

5. With the adapter ring fastened in place, position the top cap on the adapter ring and line up the four bolt holes in the top cap with those in the adapter ring and secure the top cap as shown on Page 45-133.

6. Backfill or grade around top cap, if required, to finish grade.

7. Place the cover onto the top cap and secure as shown on Page 45-134.

8. Install the pad-mounted junction enclosure or the single phase pad-mounted transformer, as required.

Supersedes 7/07 Issue – Updated Std Item UF50

45.22 SINGLE PHASE SUBSURFACE TRANSFORMERS (FOR MAINTENANCE ONLY)

1. General

Single-phase subsurface transformers are no longer standard items for URD construction. When field conditions and/or problems warrant working on existing subsurface equipment, consideration should be given to converting these installations to pad-mount installations.

Single phase, submersible transformers (URD type, Std. Item UT20B) upon receipt should be visually inspected for any external damage that may have occurred during shipment and for parts that may have become loose in handling. Storage can be either indoors or outdoors provided care is used to insure against damage to the special corrosion preventive coating or the unit itself. Lifting lugs are provided with the transformer and should be used in conjunction with spreader bars and non-metallic slings as necessary to prevent any damage to the coating or other parts. Do not lift the unit by way of the cover or the radiators, if present; but only by the appropriate lifting lugs.

Every unit shall be visually inspected for any external damage and for parts that may have become loose in handling before placing the unit into service. In addition, the coating of every unit shall, where practical, be carefully checked with a high voltage “Jeep” tester. Any breaks or voids in the coating shall be repaired in accordance with the manufacturer’s recommendations to achieve a coating with uniform integrity.

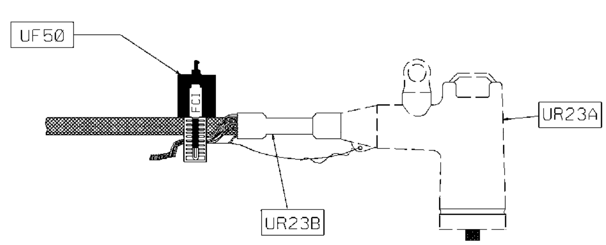
Install single phase submersible transformer (Std. Item UT20B) in the enclosure on the three 8 inch × 16 inch × 8 inch concrete blocks or equivalent footing. Use additional blocks, if required, to bring the transformer to the appropriate height.

Cable terminated in single-phase, submersible transformers should be of the same phase. If field conditions necessitate cables of different phases a “NOT IN PHASE” sign (Std. Item P22P) must be used in conjunction with the installation for identification purposes.

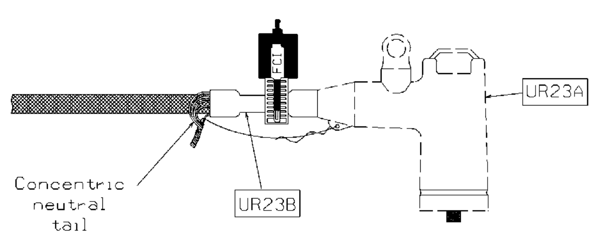
45.23 FAULT INDICATORS

Fault indicators can be used in underground residential distribution. The indicators can be installed in switching modules/enclosures and padmounts at the cable termination points. Figure 13 shows how to install the indicator on a loadbreak elbow. To minimize outage restoration times a fiber optic lead (Std Item UF50__) can be installed to provide a visible external display of the indictor flashing. The fiber optic lead plugs in to the end of the indicator and the display light is mounted thru the switching module/enclosure or padmount. Distribution Design Engineering can provide recommendations on where the indicators shall be used.

Figure 17



Indicator installed thru all neutrals over cable



Indicator installed thru cable only, no neutrals

45.24 SIDE TAP SECTIONALIZING

Large URD's with radial side taps can be sectionalized with a fused switch pad. The fused switch pad has one source input with three bay-o-net style fused taps. Typical installation of this would be at a street intersection. The switch pad shall be installed on the standard mini-pad foundation. Note: due to the dimensions of the switch pad, it must be installed sideways to properly fit over the opening. See figure 18 below for one line. All bushings are 200 amp style for Load Break Elbows.

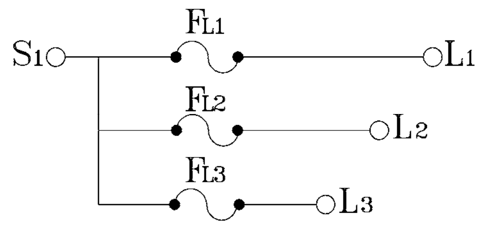


Figure 18

45.25 CUSTOMER LOAD AND VOLTAGE DROP CALCULATION

This section gives a step by step direction on how to properly size transformers as well as estimate voltage drop at any place on a secondary crib. It is important to design a URD as efficiently as possible so that maximum utilization of company assets and customer reliability is achieved.

1) Determine transformer size:

Use Table 2 below to determine the correct sized transformer for your particular application. Cross reference the '# of houses' column with the 'transformer needed' column to determine the appropriate transformer for each application. Table 1 below shows the approximate loading per dwelling for small, medium and large sized homes. This information is extrapolated and diversified in Table 2 from 2 to 15+ customers.

Table 1

Small House 0-1700 sq. ft.			
Base Load (kW)	AC Load (kW)	Total (kW)	Total (kVA)
4	3.5	7.5	7.89

Medium House 1800-2600 sq. ft.			
Base Load (kW)	AC Load (kW)	Total (kW)	Total (kVA)
4.5	5.5	10	10.53

Large House 2700-3000 sq. ft.			
Base Load (kW)	AC Load (kW)	Total (kW)	Total (kVA)
5	6.5	11.5	12.11

Supersedes 7/07 Issue – Added section 45.24 and Customer Load and Voltage Drop Calculation

Table 2

House Size		**Small 0-1700 sq. ft.**		**Medium 1800-2600 sq. ft.**		**Large 2700-3000 sq. ft.**	
Total AC							
# of houses	**Diversity Factors**	**Typical Diversified Load (kVA)**	**Transformer Needed (kVA)**	**Typical Diversified Load (kVA)**	**Transformer Needed (kVA)**	**Typical Diversified Load (kVA)**	**Transformer Needed (kVA)**
1	1	8	25	11	25	12	25
2	0.92	15	25	19	25	22	25
3	0.81	19	25	26	25	29	50
4	0.73	23	25	31	50	35	50
5	0.71	28	50	37	50	43	50
6	0.7	33	50	44	50	51	75
7	0.69	38	50	51	75	58	75
8	0.68	43	50	57	75	66	75
9	0.67	48	50	63	75	73	75
10	0.66	52	75	69	75	80	100
11	0.65	56	75	75	75	87	100
12	0.64	61	75	81	100	93	100
13	0.63	65	75	86	100	99	100
14	0.63	70	75	93	100	107	na
15	0.63	75	75	99	100	114	na

2) Voltage Drop

Once the correct transformer size has been determined for the job it is important to calculate the voltage drop that the customer may experience.

There are three voltage drop factors that need to be taken into account while determining the overall voltage drop at the customer's service entrance. They are as follows:

- **Diversity Factor:** The diversity factor (listed in Table 2) is a factor that can be applied to a connected transformer load to determine how much of the load is likely going to be active at one time.

Example - If there were 5 customers and 40kVA of connected load, according to Table 2 the diversity factor for 5 customers is .71. Therefore you would size the transformer for (.71)(40)=28kVA.

- **Transformer (T) Factor**: The T factor is the voltage drop that occurs naturally in the transformer itself depending on impedance and load. Table 3 below shows approximate T factors that are associated with certain transformers.

Table 3

Transformer size	**T Factor**
25kVA	0.0796
50kVA	0.0367
75kVA	0.0212
100kVA	0.0212

- **Cable (S) Factor**: The S factor is for calculating voltage drop that is a result of cable impedance alone. Each type of cable has a per foot S factor. Table 4 below shows S Factors for different types of cable.

Table 4

Cable Size	S Factor
4/0 Al	0.0332
350 Al	0.0219
2/0 Cu	0.0329
4/0 Cu	0.0225
250 Cu	0.0199

.

Voltage Drop Calculation (Three step process)

I) Calculate voltage drop through transformer.

Transformer Voltage Drop = (Diversity Factor)(T Factor)(Connected load on Transformer.)/100 = ☐%

Note – For connected load use entire load on transformer. Not just the load in the direction you are calculating voltage drop.

II) Calculate voltage drop through secondary

Secondary Voltage Drop = (Diversity Factor)(S Factor)(Cable Length)(Connected Load)/100=☐%

Note – Only use # of customers and load down stream of the leg of cable you are calculating for. Also, add 10 feet per hand hole to the cable length.

III) Calculate secondary service voltage drop

Secondary Voltage drop = (S factor)(Cable Length)(Customer Connected load)/100=☐%

Note – For calculating a single customer's service voltage drop use the connected load of their house because there is no diversity factor for a single customer. Also, note that the customer cable may be different from the Liberty Utilities secondary cable in the street in which case it would have a different S Factor.

IV) Calculate TOTAL voltage drop at customer's service entrance

Total Voltage Drop = (Transformer Voltage Drop)+(Secondary Cable Voltage Drop)+(Service Cable Voltage Drop)

Supersedes 7/07 Issue – Added Customer Load and Voltage Drop Calculation

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New Page

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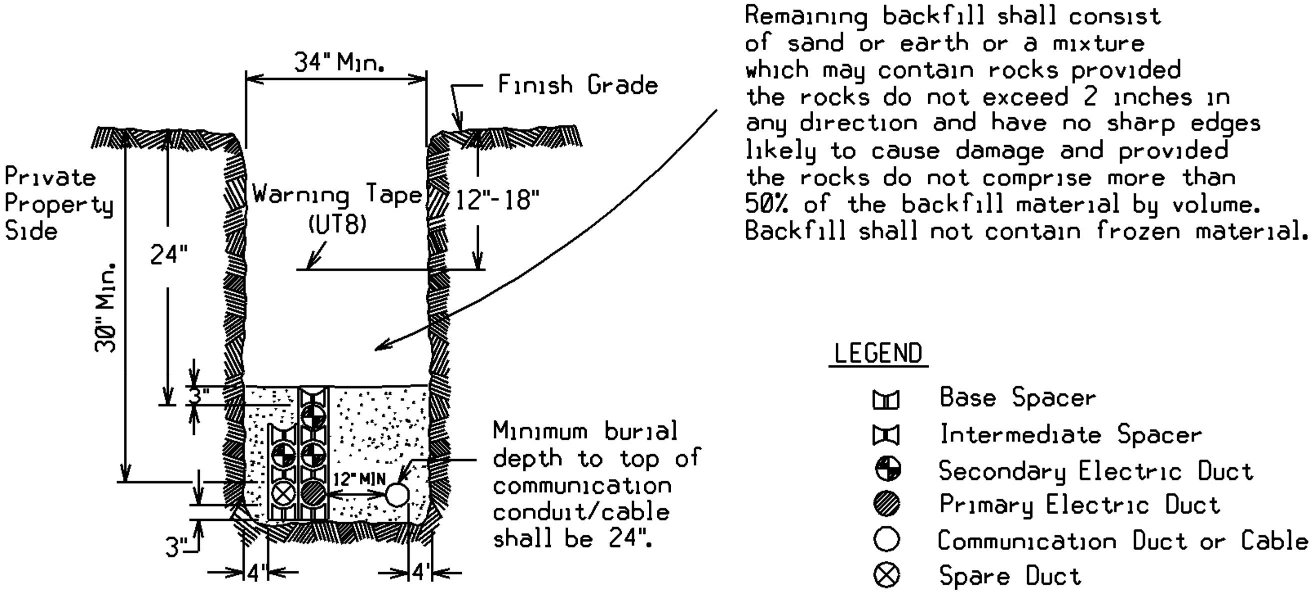
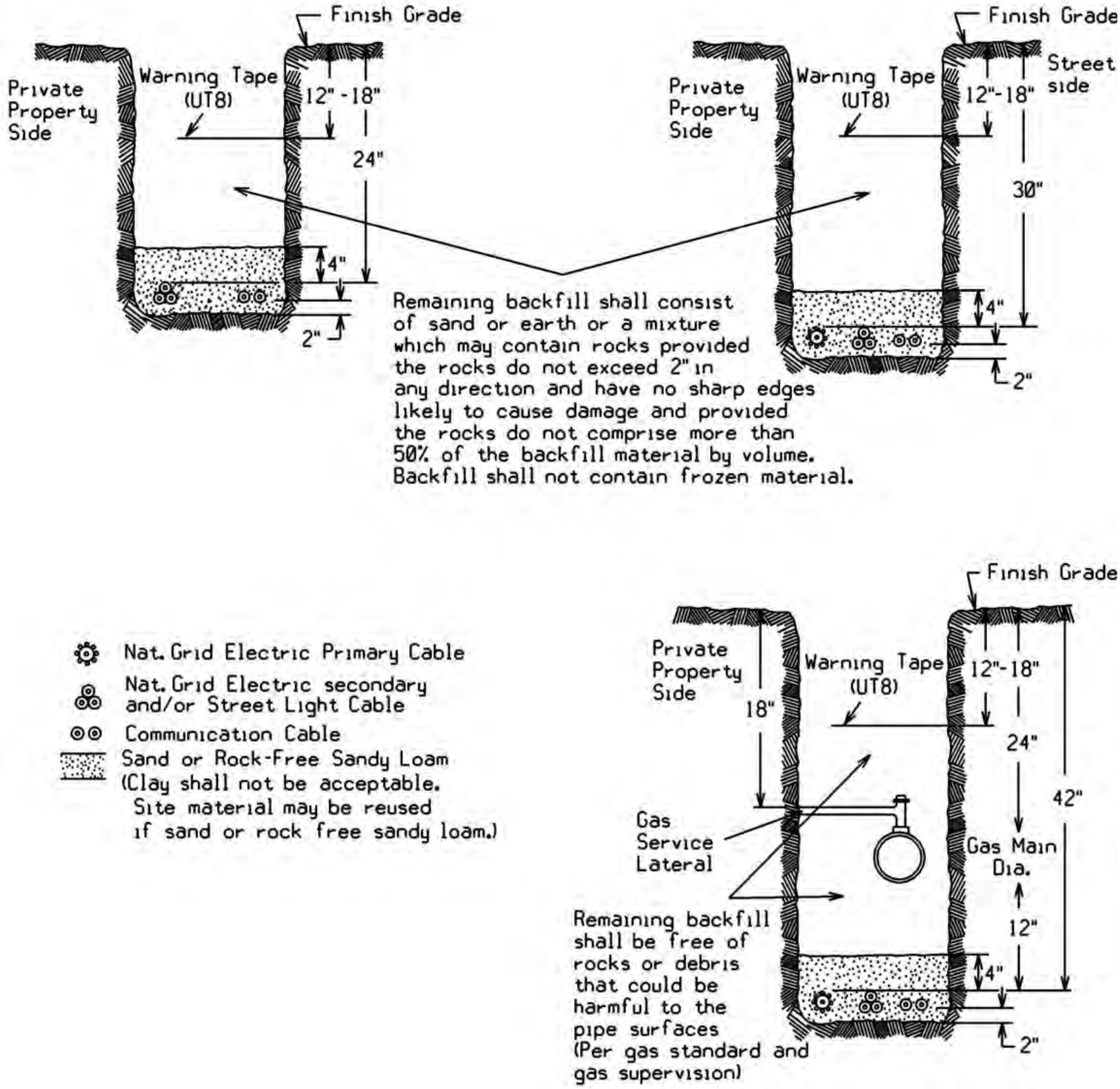
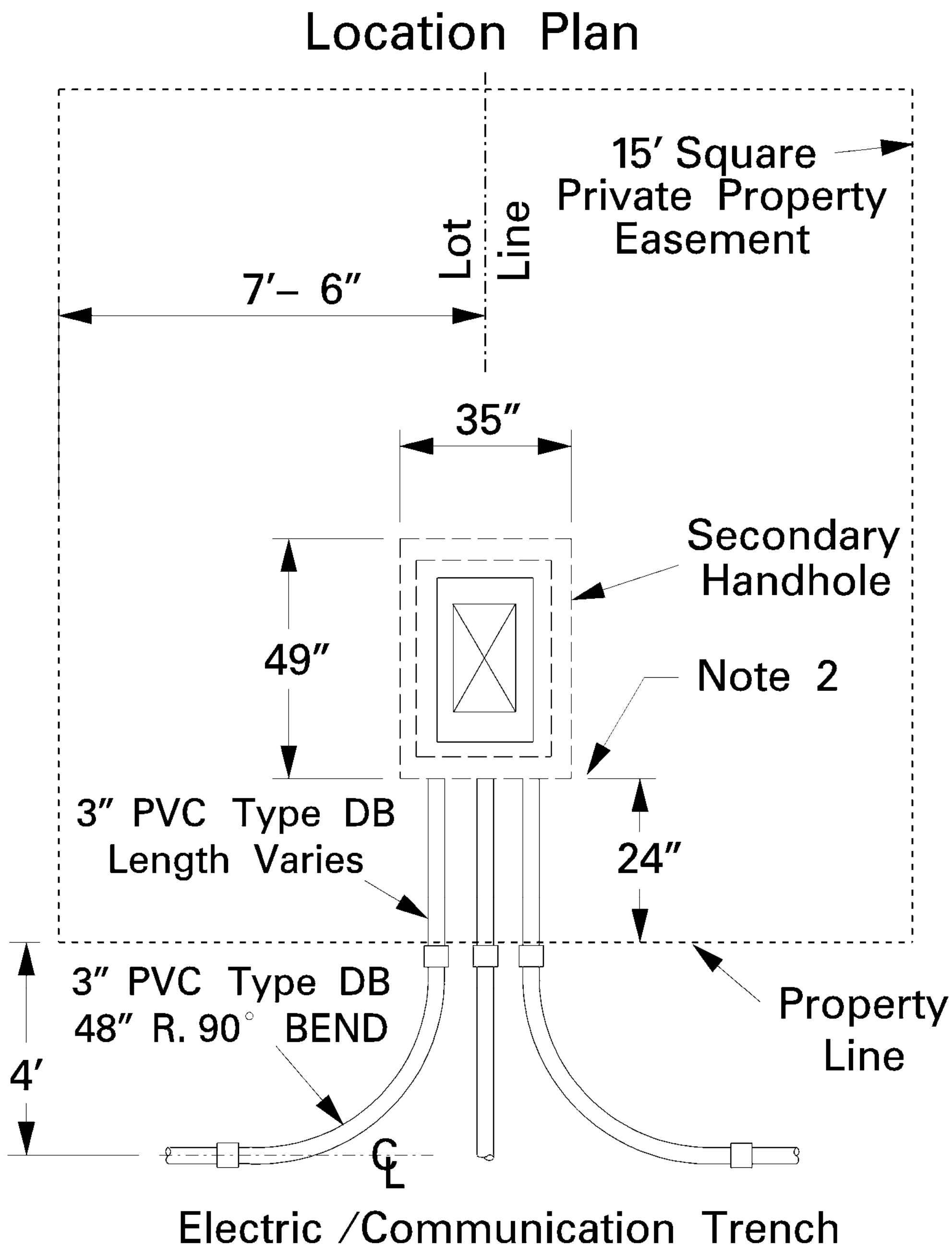


Supersedes 2/06 Issue – Added Text



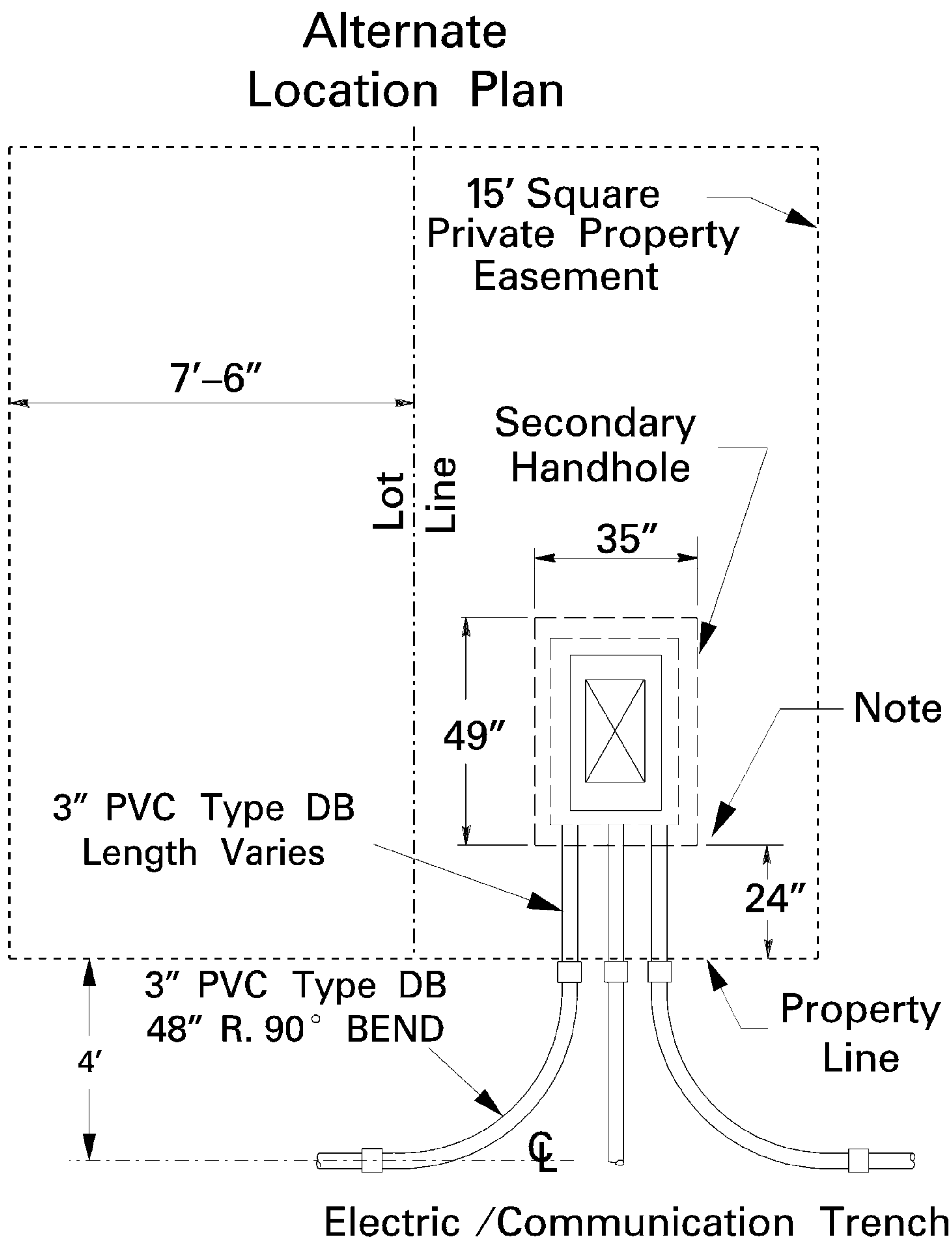
TYPICAL TRENCH DETAILS – DIRECT BURIED SYSTEM

Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER	ISSUE
		45-101	2/06



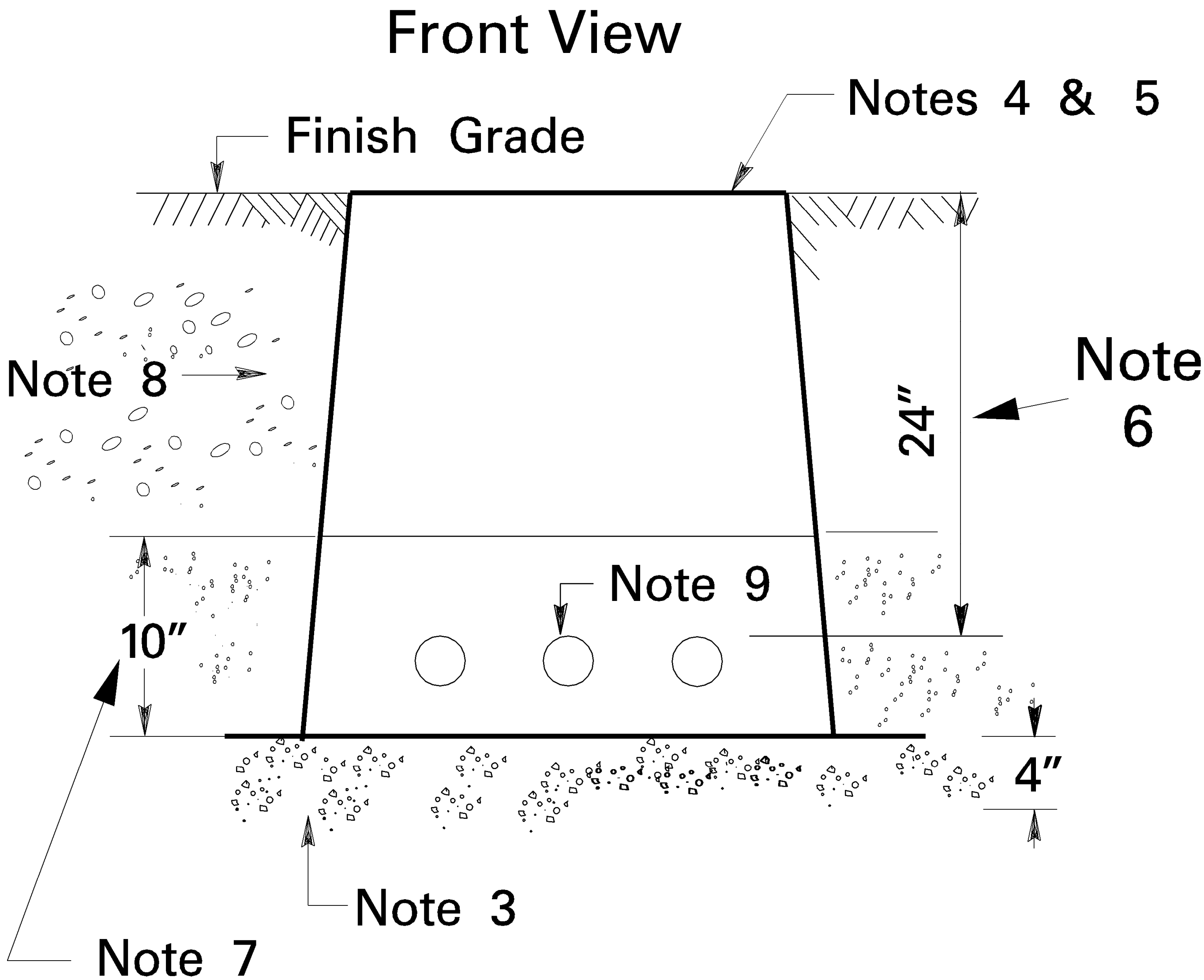
Notes:

1. Refer to URD Design Guide, for layout & design.
2. Secondary handhole to be placed as shown in location plan or alternate location plan with three conduit holes facing the electric/communication trench.
3. Secondary handhole to be placed on level undisturbed or well tamped solid earth covered with 4 inch minimum of crushed stone. Maximum stone size is ¾ inch.
4. All secondary handholes shall have their covers installed and secured after initial installation.
5. Secondary handhole cover shall be flush with finish grade.
6. Handhole shall be installed to maintain 24 inch burial depth from finish grade to top of conduit knockouts.
7. Use washed, screened sand.
8. Clean fill, free of stones greater than 2 inches and not containing shell, ash, cinder, or frozen material.
9. All unused conduit knockout holes shall be sealed with conduit plugs.



Notes:

1. Refer to URD Design Guide, for layout & design.
2. Secondary handhole to be placed as shown in location plan or alternate location plan with three conduit holes facing the electric/communication trench.
3. Secondary handhole to be placed on level undisturbed or well tamped solid earth covered with 4 inch minimum of crushed stone. Maximum stone size is ¾ inch.
4. All secondary handholes shall have their covers installed and secured after initial installation.
5. Secondary handhole cover shall be flush with finish grade.
6. Handhole shall be installed to maintain 24 inch burial depth from finish grade to top of conduit knockouts.
7. Use washed, screened sand.
8. Clean fill, free of stones greater than 2 inches and not containing shell, ash, cinder, or frozen material.
9. All unused conduit knockout holes shall be sealed with conduit plugs.



Notes:

1. Refer to URD Design Guide, for layout & design.
2. Secondary handhole to be placed as shown in location plan or alternate location plan with three conduit holes facing the electric/communication trench.
3. Secondary handhole to be placed on level undisturbed or well tamped solid earth covered with 4 inch minimum of crushed stone. Maximum stone size is ¾ inch.
4. All secondary handholes shall have their covers installed and secured after initial installation.
5. Secondary handhole cover shall be flush with finish grade.
6. Handhole shall be installed to maintain 24 inch burial depth from finish grade to top of conduit knockouts.
7. Use washed, screened sand.
8. Clean fill, free of stones greater than 2 inches and not containing shell, ash, cinder, or frozen material.
9. All unused conduit knockout holes shall be sealed with conduit plugs.

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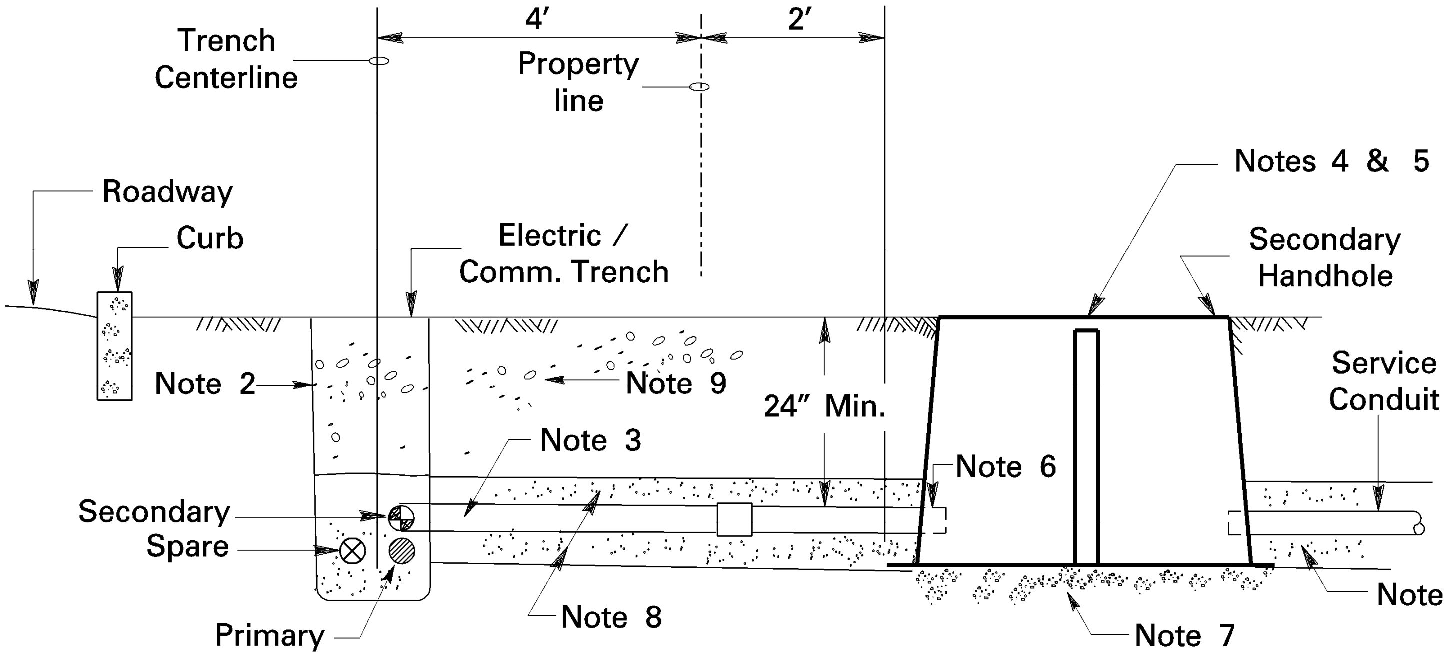
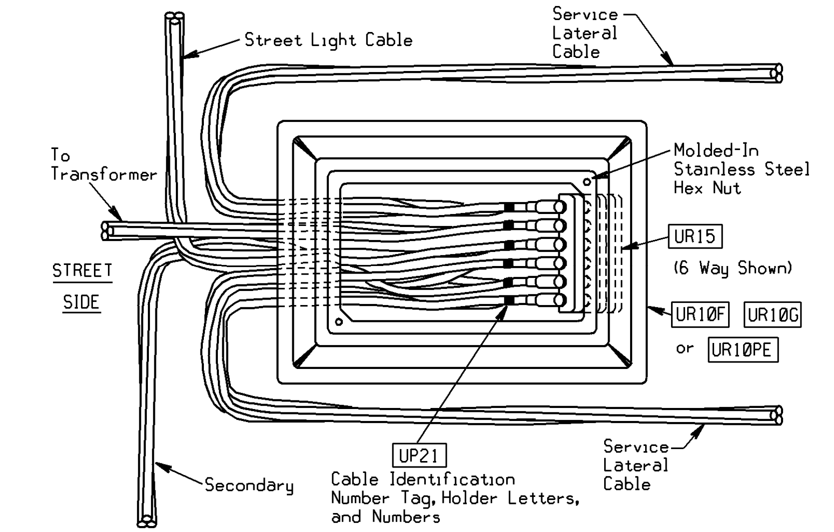
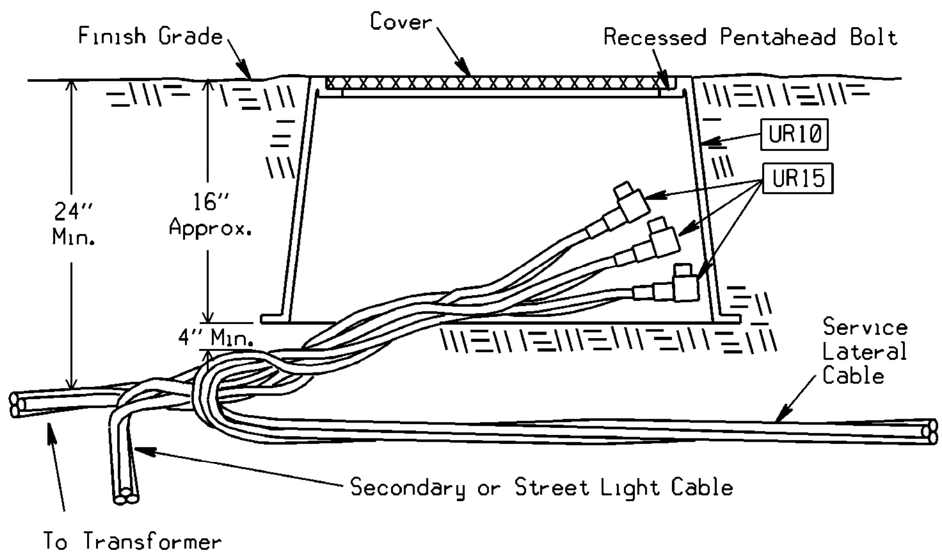


Notes:

1. Refer to URD Design Guide for layout & design.
2. Refer to Section 45.10 for trench specifications.
3. Refer to location plans for conduit details.
4. All secondary handholes shall have their covers installed and secured after initial installation.
5. Secondary handhole cover shall be flush with finished grade.
6. Extend PVC conduits into handhole by a maximum of 3 inches.
7. 4 inch minimum of crushed stone (maximum stone size ¾ inch) on solid earth.
8. Washed, screened sand, 4 inches above and below all conduits.
9. Clean fill, free of stones greater than 2 inches in diameter and not containing shell, ash cinder or frozen material.





Notes:

1. Refer to URD Design Guide, for layout & design.
2. Secondary handhole to be placed on level undisturbed or well tamped solid earth.
3. Secondary handhole cover shall be flush with finish grade.
4. All secondary handholes shall have their covers installed and secured after initial installation.
5. All secondary service cables, shall be brought into the handhole, allowing a minimum of 4 inches of clearance between the cable and the base of the handhole.
6. Washed, screened sand, 4 inches above and below all secondary cables.
7. Remaining fill to be free of stones greater than 2 inches in diameter and not containing shell, ash cinder or frozen material.

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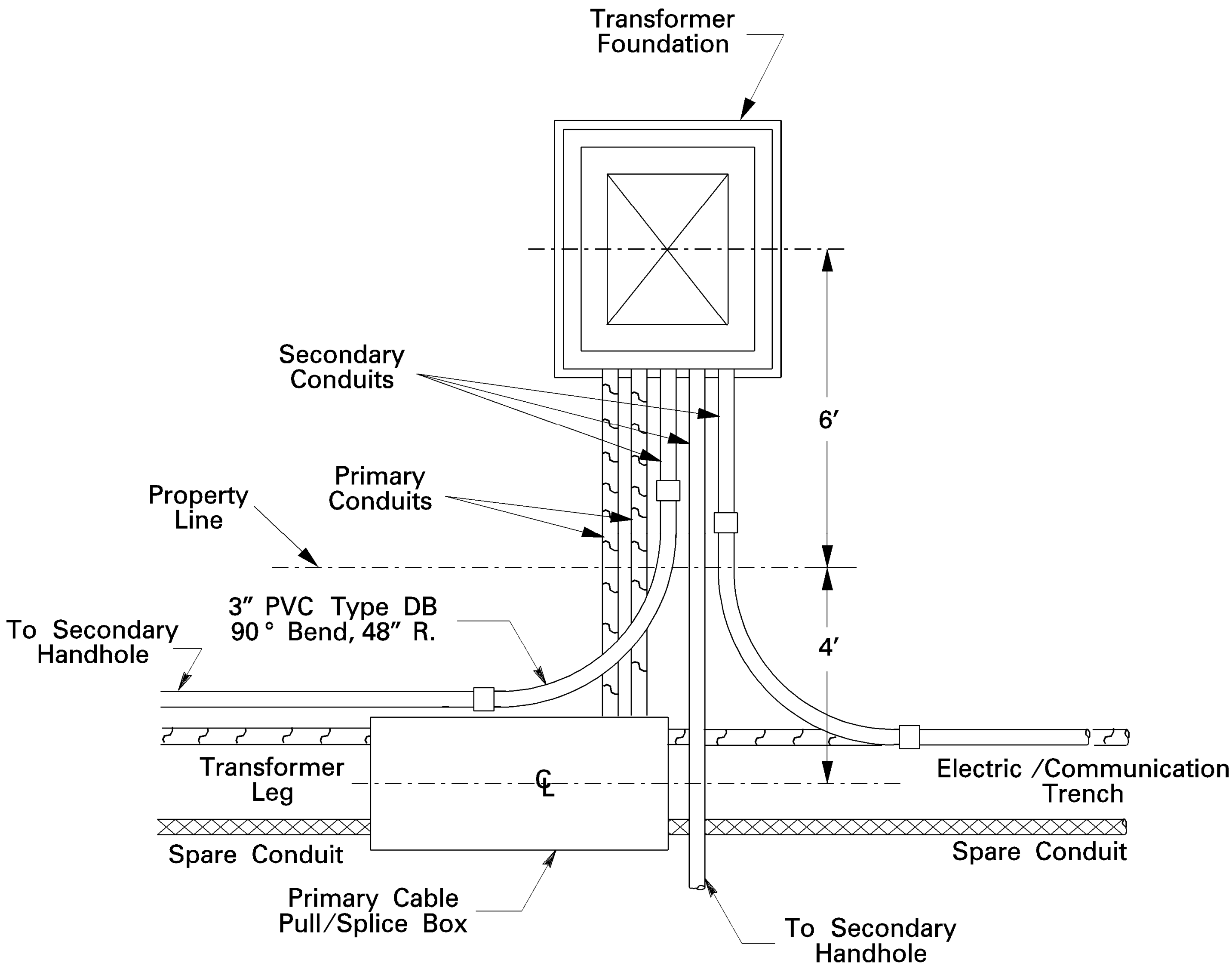
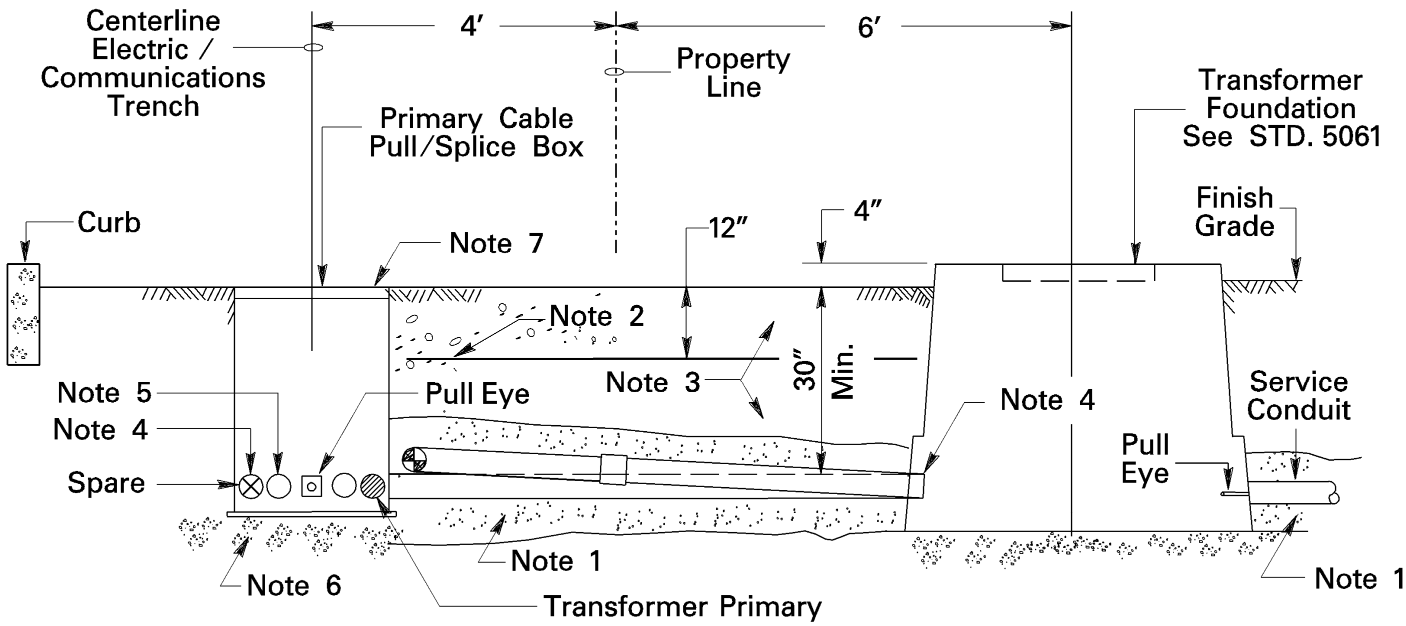


Notes:

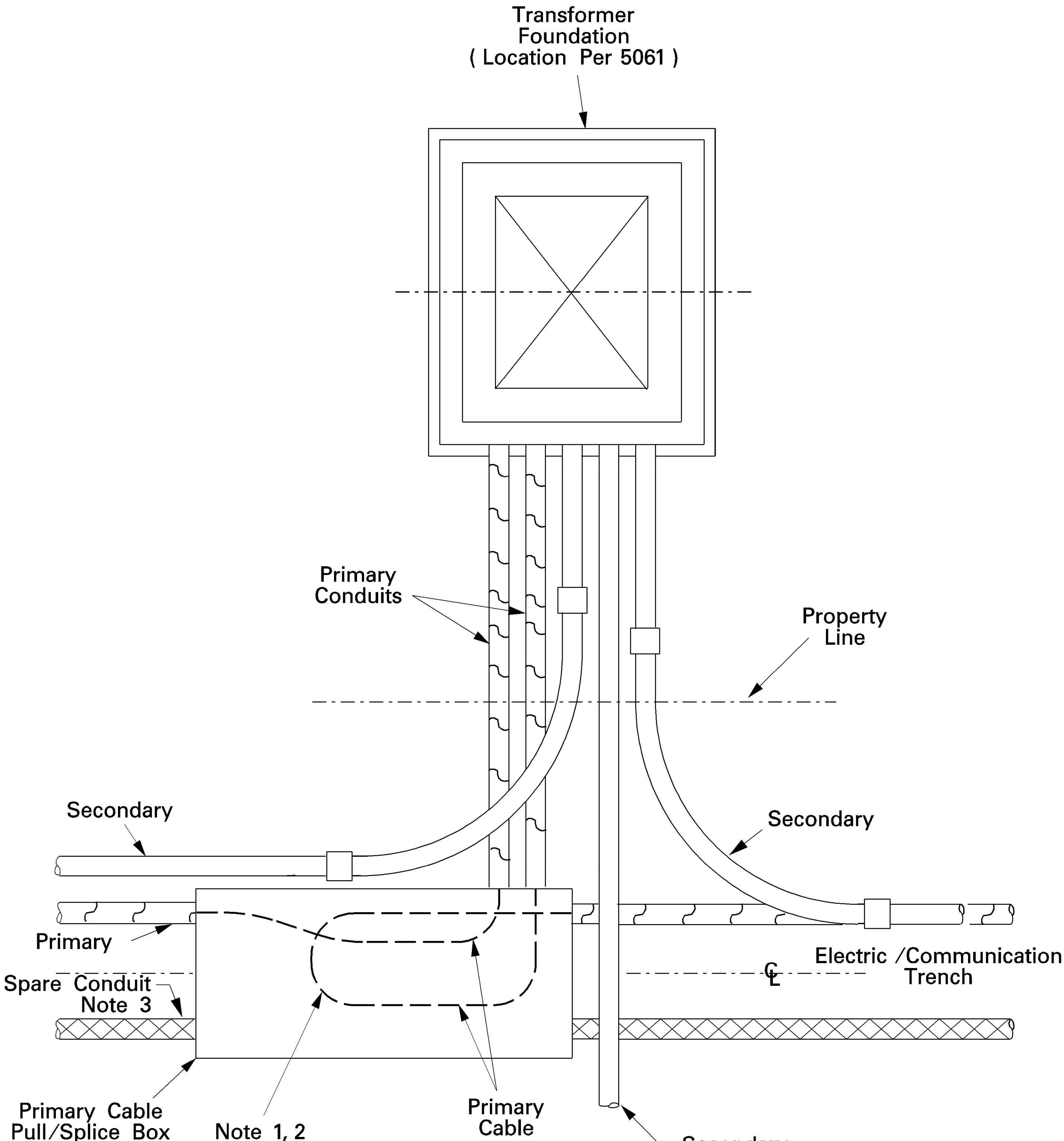
1. Maintain minimum cable bending radius on all primary cables.
2. Spare conduit not looped in and out of transformer foundation.

Doc. # ST. 45.00.001



Notes:

1. 4 inches of washed screened sand above and below all conduits.
2. Warning tape to be placed above conduits, approximately 12 – 18 inches below finish grade.
3. Clean fill, free of stones greater than 2 inches in diameter and not containing shell, ash, cinder or frozen material.
4. Conduit to penetrate inside walls of primary cable pull / splice box and transformer foundation by a maximum of 3 inches.
5. All unused conduit knockout holes shall be sealed with conduit plugs.
6. Primary cable pull / splice box shall be placed on level undisturbed or well tamped solid earth covered with 4 inches minimum of crushed stone. Maximum stone size is ¾ inch.
7. Top of primary cable pull / splice box to be flush with finished grade. Cover to be left secured to box when unattended.

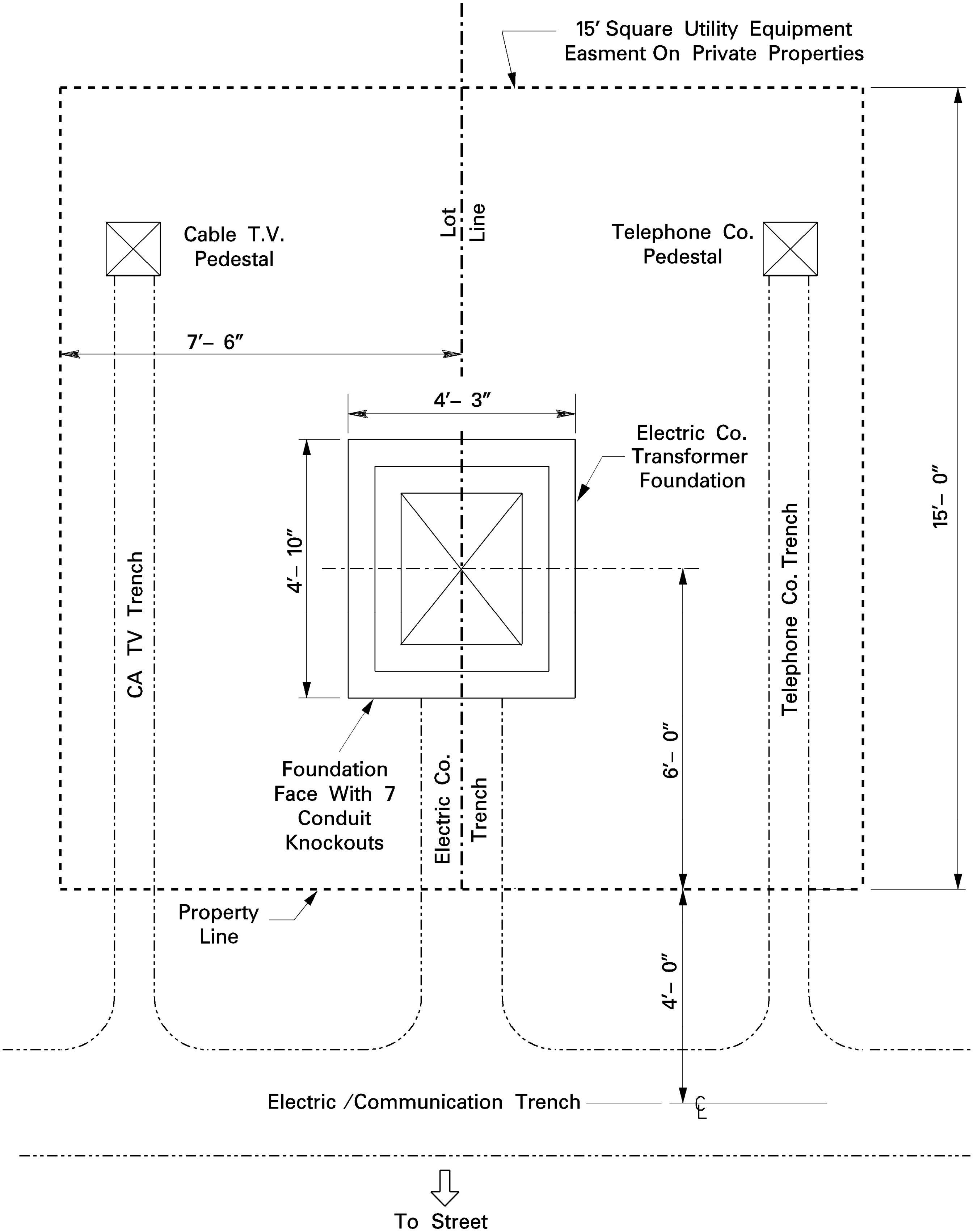


Notes:

1. Maintain minimum cable bending radius on all primary cables.
2. Modular splice shall be covered with cold shrink splice jacket per Standard Section 36.
3. Spare conduit not looped in and out of transformer foundation.

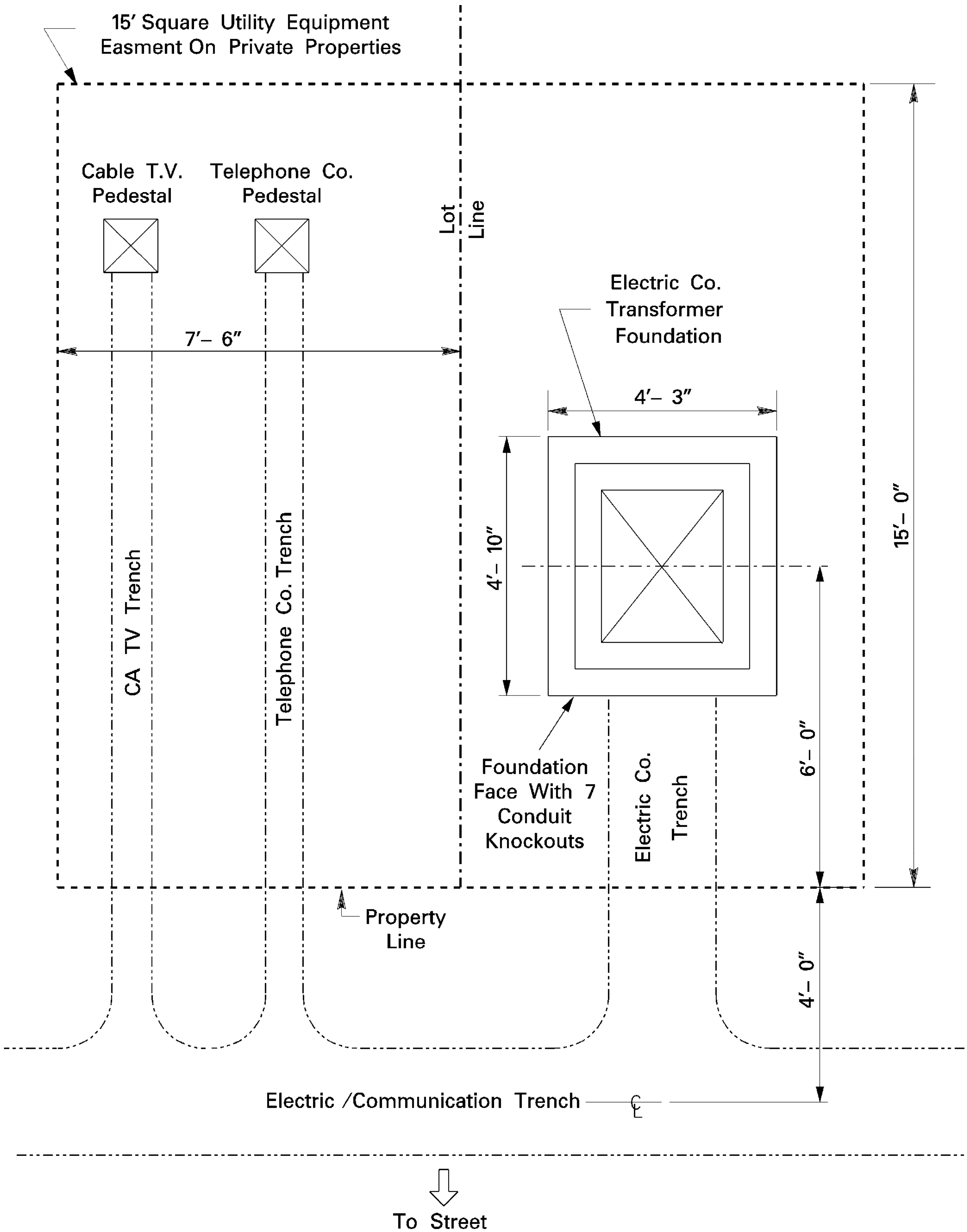
PRIMARY CABLE PULL / SPLICE BOX			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 45-111	ISSUE 2/06

 | Doc. # ST. 45.00.001



PREFERRED LOCATION OF EQUIPMENT IN EASEMENT AREA			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
2/06	45-114		

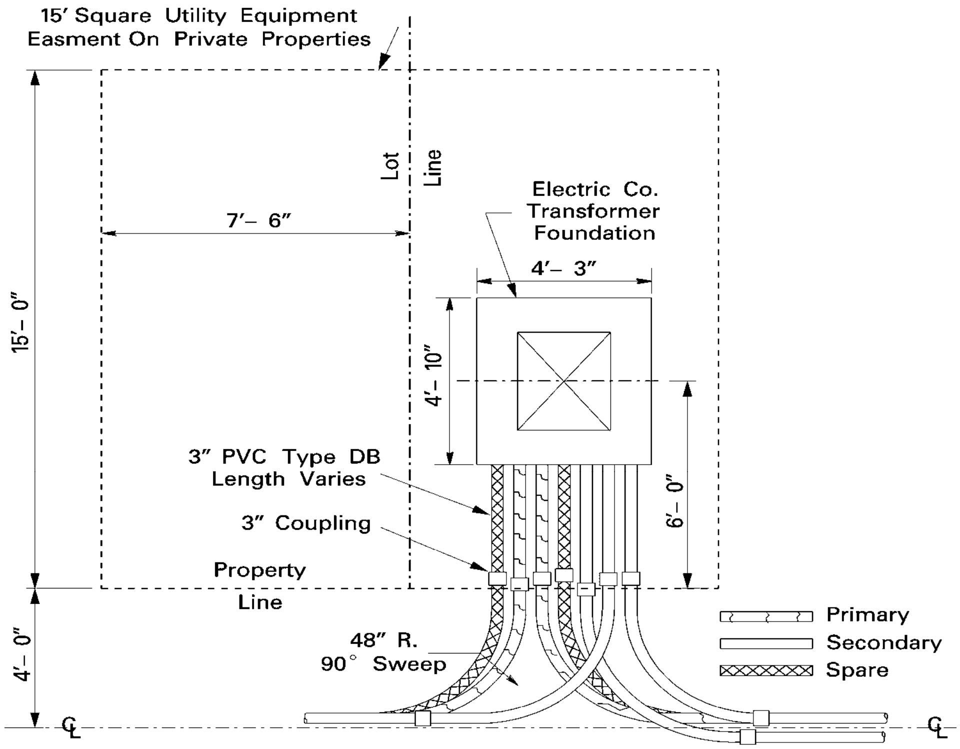
 Doc. # ST. 45.00.009



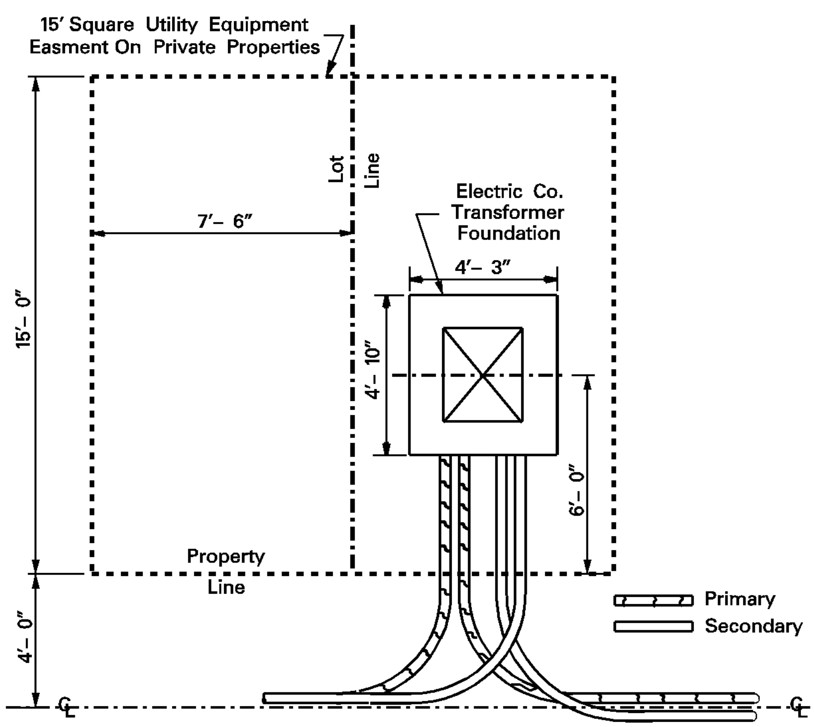
ALTERNATE LOCATION OF EQUIPMENT IN EASEMENT AREA			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 45-115	ISSUE 2/06

Doc. # ST. 45.00.001

Conduit Layout

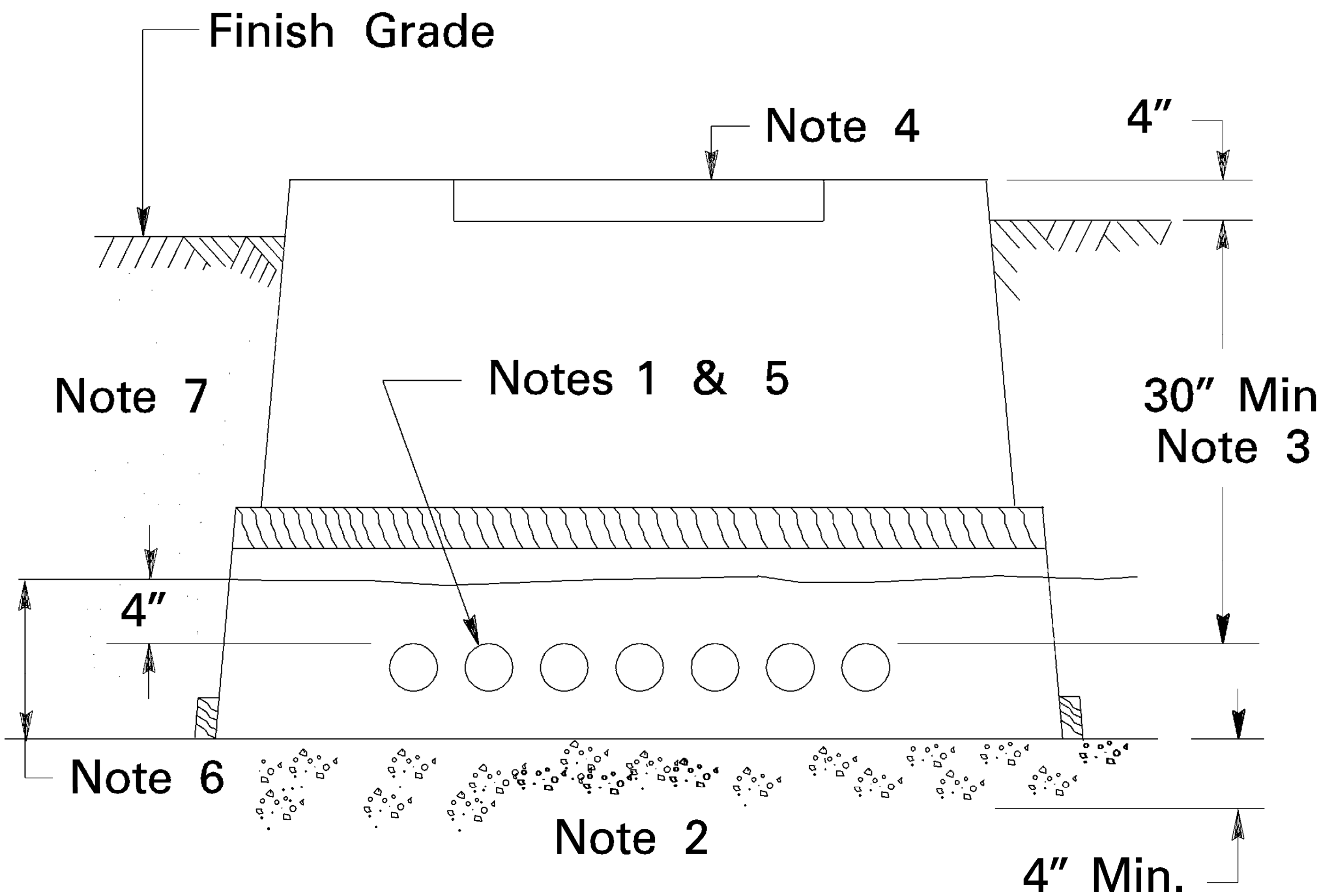


Direct Burial Layout



Supersedes 2/06 Issue – Add Direct Burial Layout

SINGLE PHASE PADMOUNT TRANSFORMER – TYPICAL LAYOUT			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
7/07	45-116		

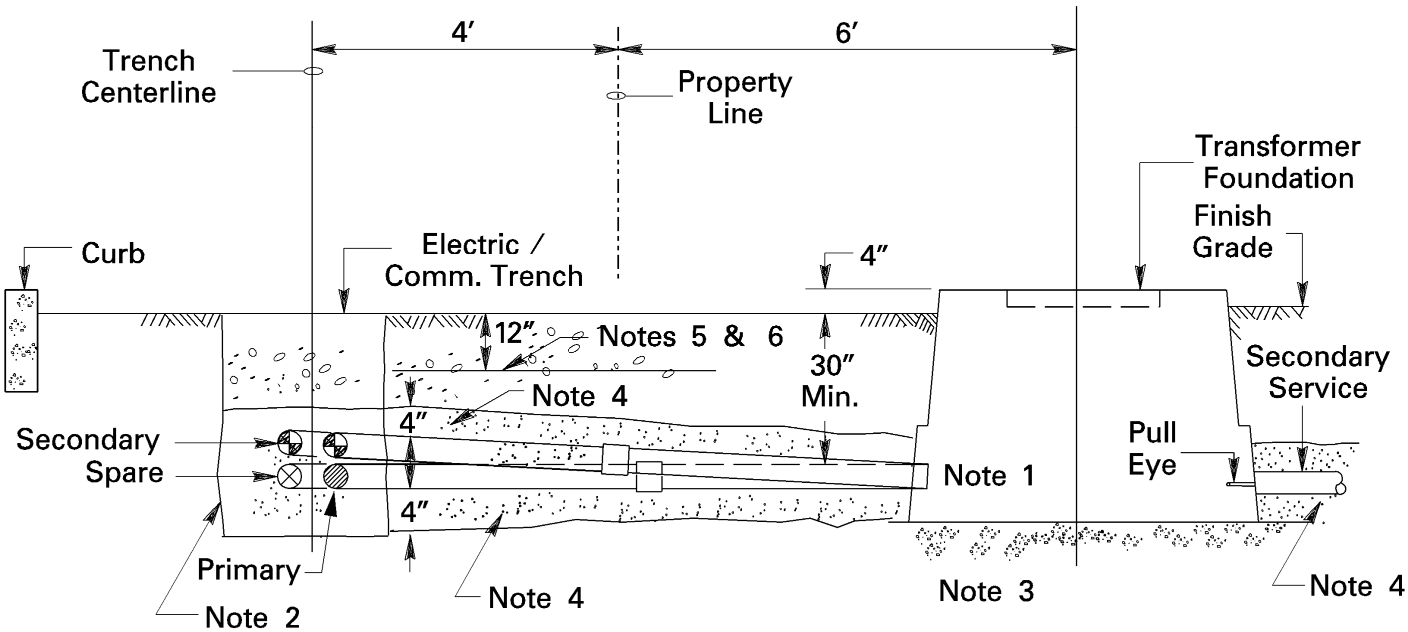


Supersedes 2/06 Issue – Page update

Notes:

1. Foundation to be placed as shown on pages 45-114 thru 45-116 with seven hole knockouts facing toward electric trench.
2. Foundation to be placed on level undisturbed or well tamped earth covered with 4 inches minimum well tamped crushed stone.
3. Top of conduit knockouts shall be 30 inches minimum below finish grade.
4. All foundations shall have covers installed and locked when transformer not in place.
5. All unused conduit knockout holes and conduits shall be plugged with conduit plugs.
6. Washed, screened sand.
7. Clean fill free of stones greater than 2 inches and not containing shell, ash, cinder or frozen material.

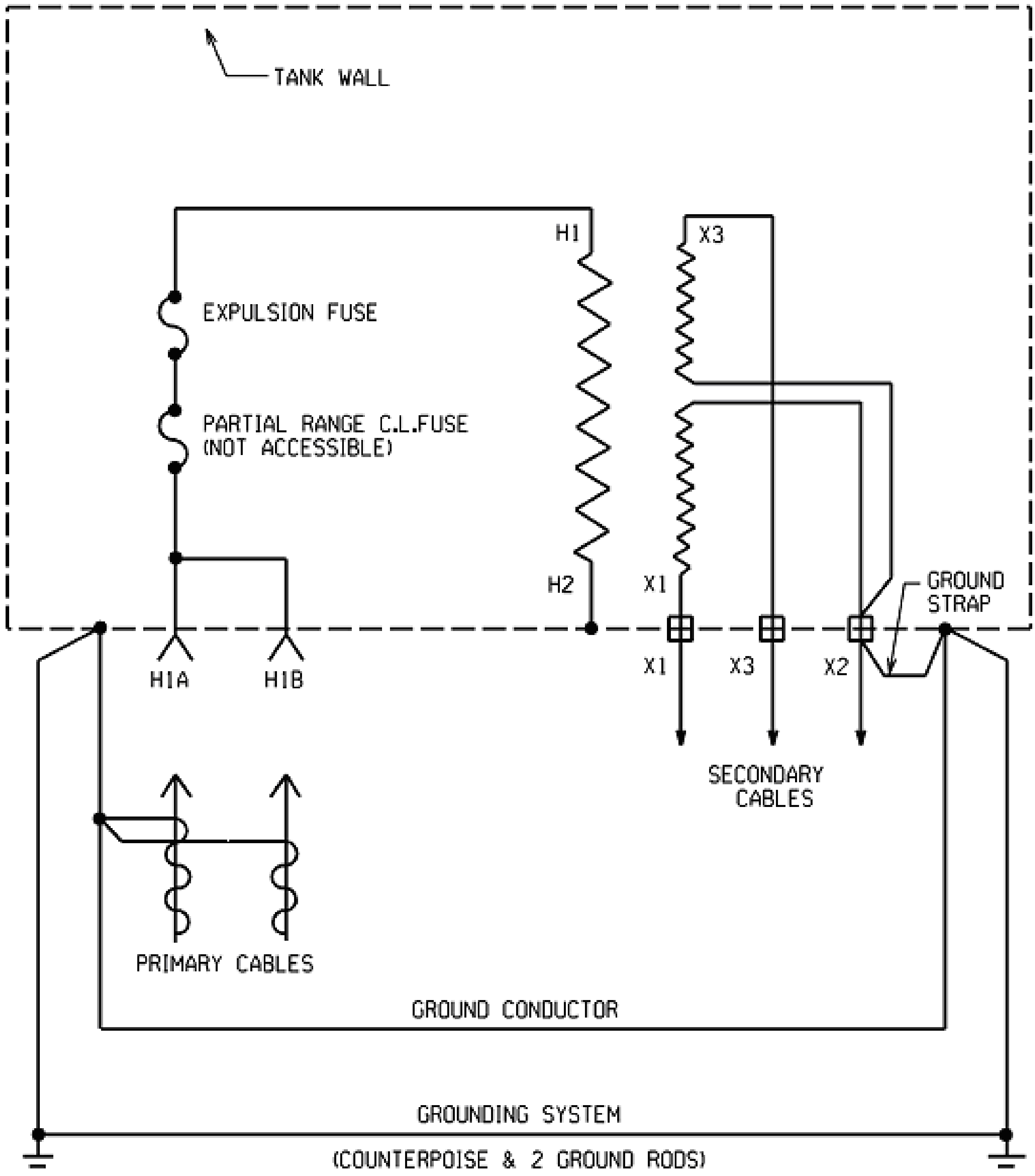
 Doc. # ST. 45.00.001



Notes:

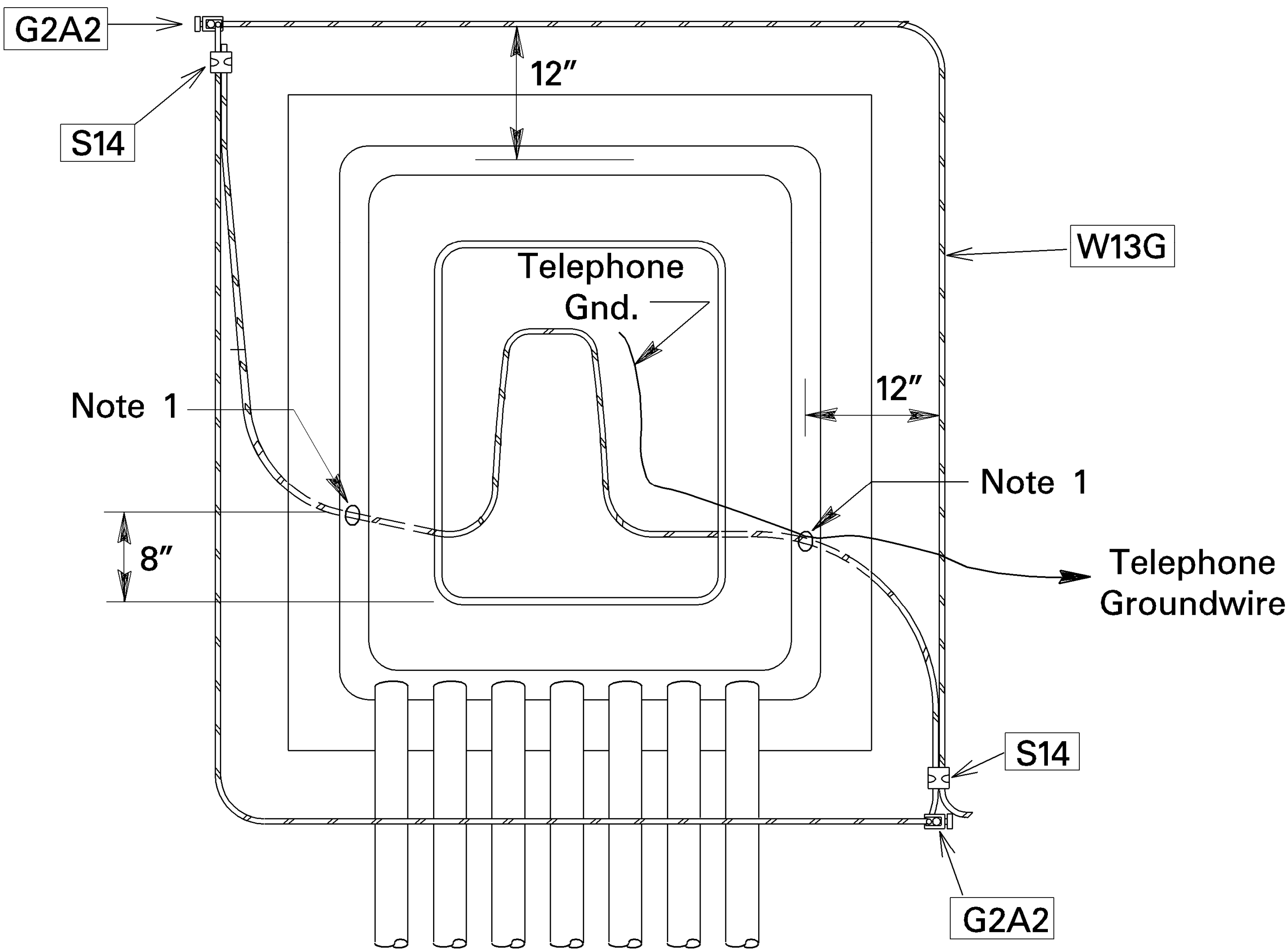
1. Extend PVC conduits through transformer foundation by 3 inch maximum.
2. Refer to Section 45.10 for trench specifications.
3. Foundation to be placed on level, undisturbed or well tamped earth covered with 4 inches minimum of crushed stone.
4. Washed, screened sand – 4 inches minimum above and below all conduit.
5. Clean fill, free of stones greater than 2 inches, and not containing shell, ash, cinder, or frozen material.
6. Install plastic warning tape above all conduit runs, approximately 12 – 18 inches below finish grade.

 Doc. # ST. 45.00.002



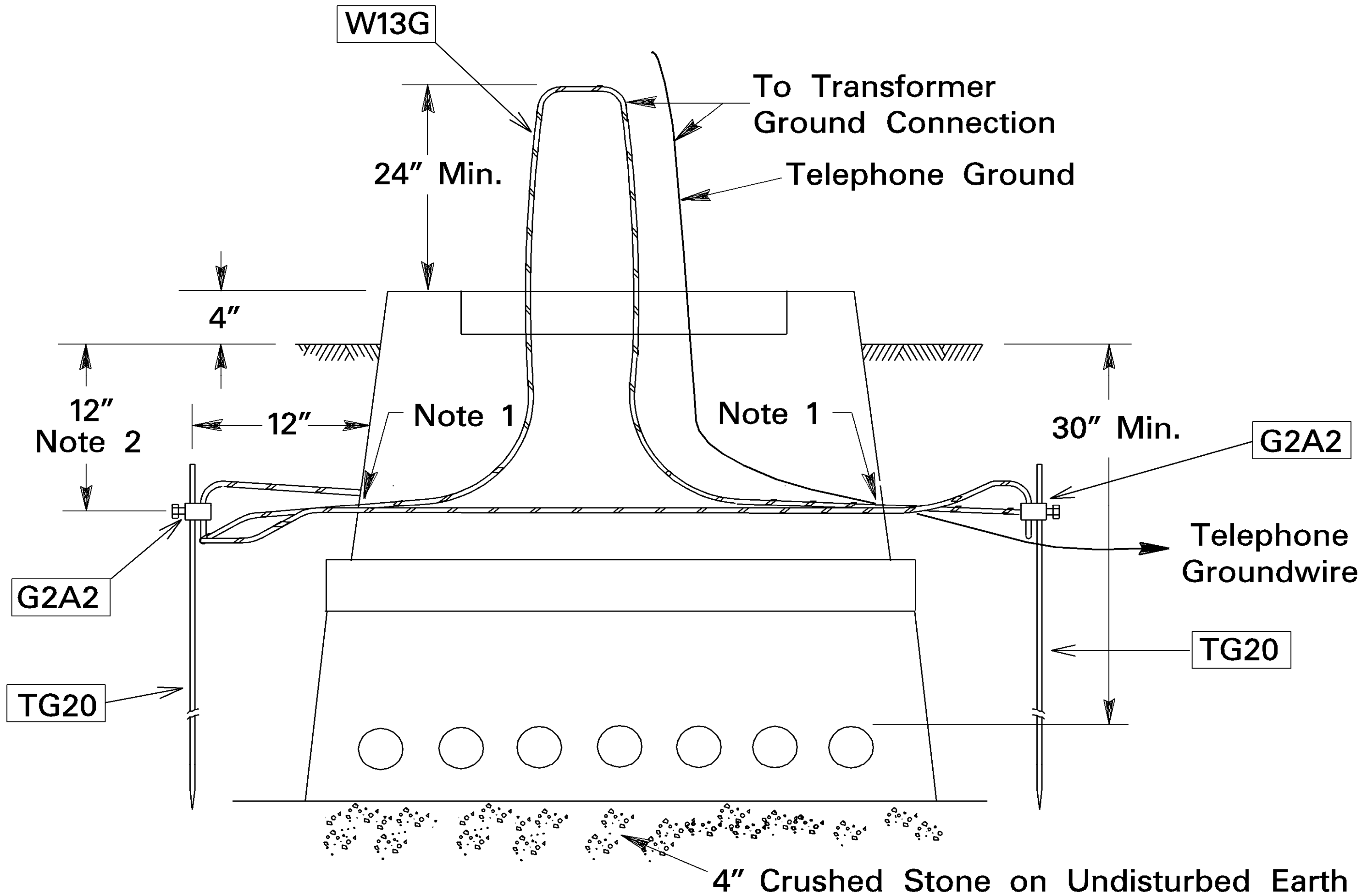
Notes:

1. Partial range current limiting fuse is not accessible for replacement.



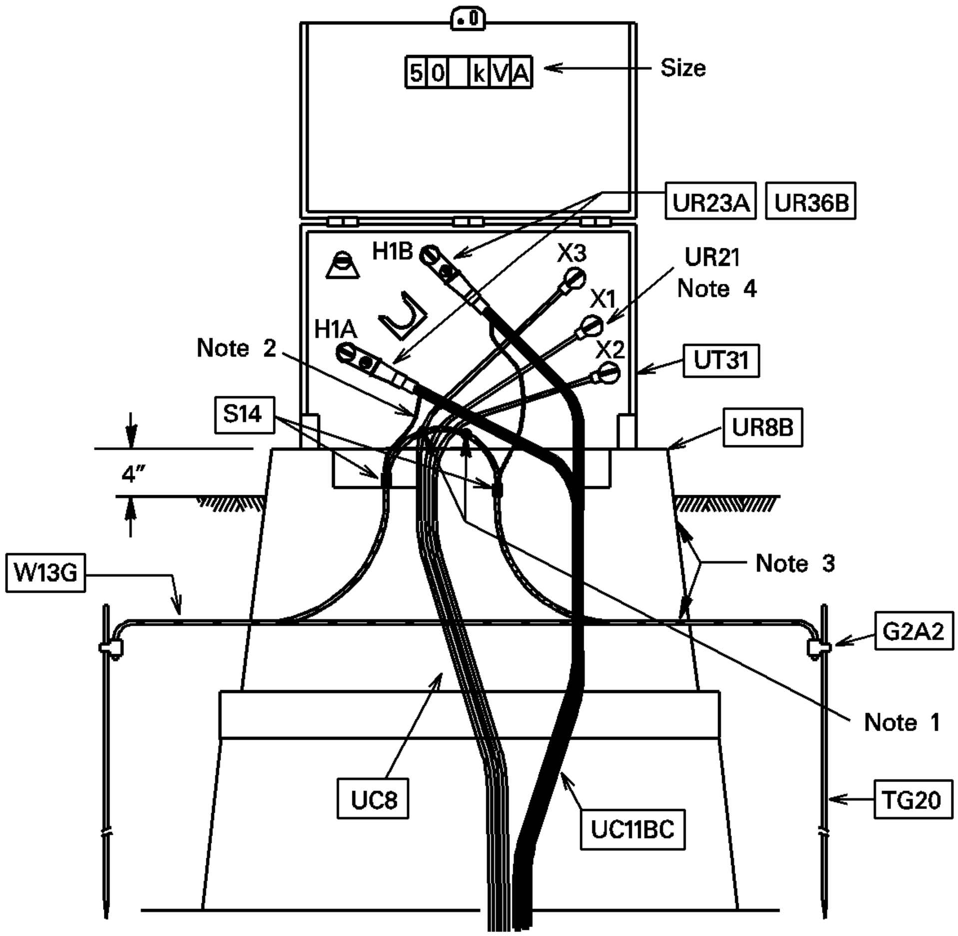
Notes:

1. Drill ⅝ inch diameter holes as shown in sides of foundation if not provided by foundation manufacturer.
2. Ground loop around foundation to be buried 12 inches below finish grade.
3. Although conduit system is shown, direct buried systems shall incorporate the same ground grid.



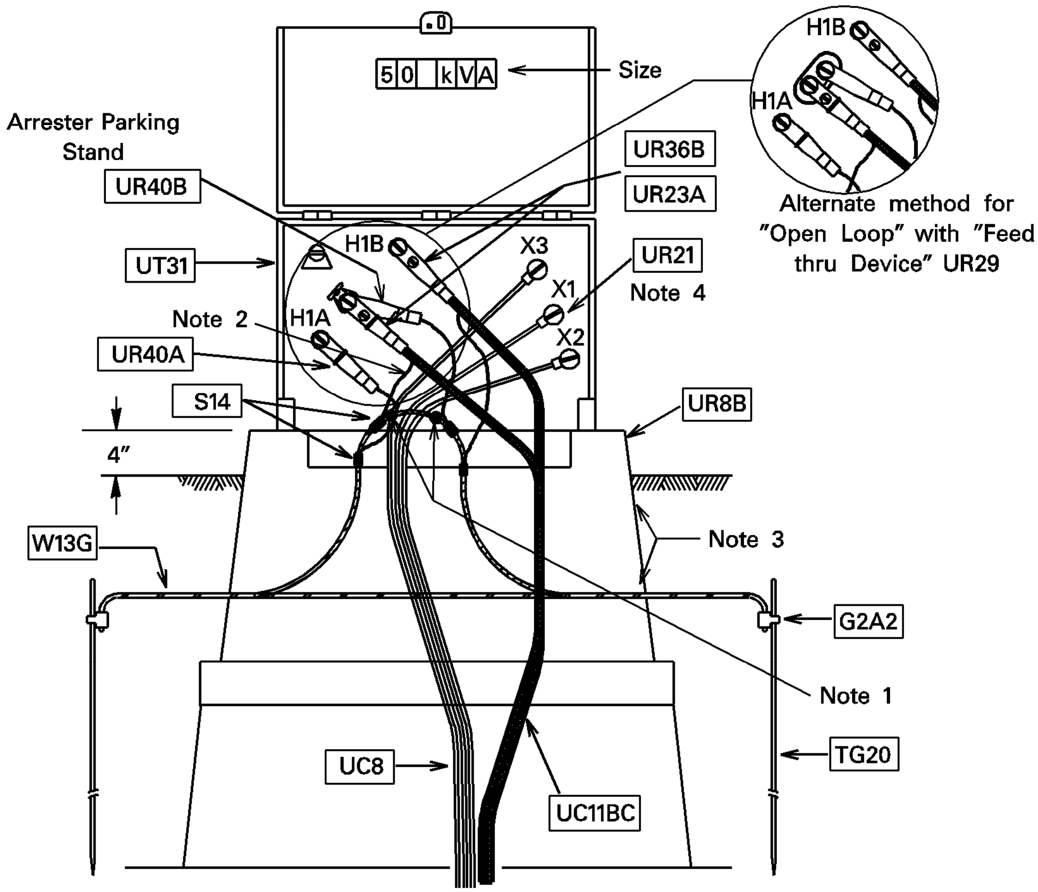
Notes:

1. Drill ⅝ inch diameter holes as shown in sides of foundation if not provided by foundation manufacturer.
2. Ground loop around foundation to be buried 12 inches below finish grade.
3. Although conduit system is shown, direct buried systems shall incorporate the same ground grid.



Notes:

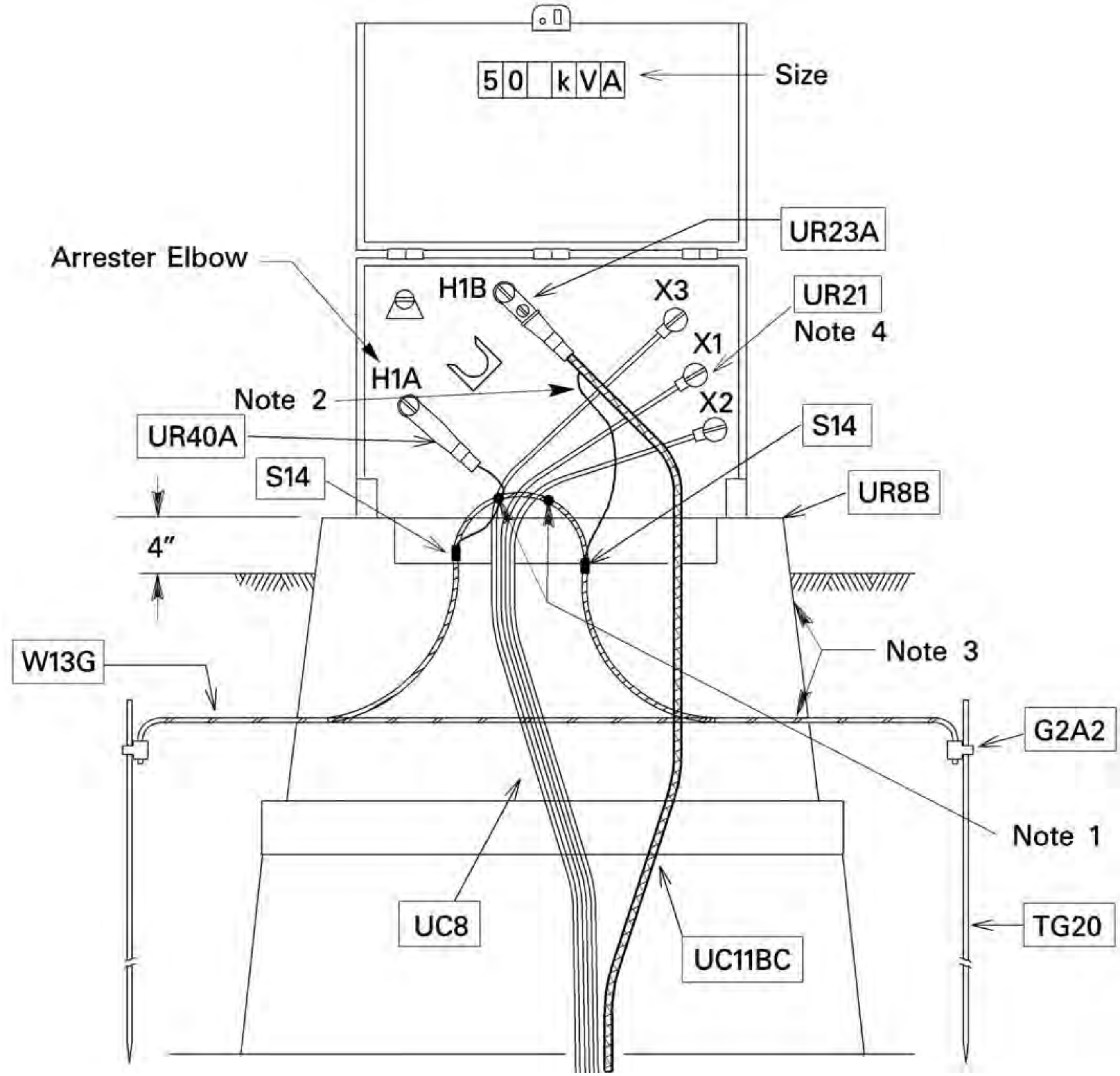
1. Install transformer tank ground split – bolt stud connectors to accept #2 copper ground wire loop.
2. Use 2 foot length of twisted concentric neutral wires from the primary cable for connection to #2 copper ground wire loop.
3. Install foundation and ground grid in accordance with Section 45.120 and Section 45.121.
4. Install secondary busses per Section 45.20.20.
5. Conduit system shown. For direct buried systems, loop cables around base of foundation before terminating.



Notes:

1. Install transformer tank ground split – bolt stud connectors to accept #2copper ground wire loop.
2. Use 2 foot length of twisted concentric neutral wires from the primary cable for connection to #2 copper ground wire loop.
3. Install foundation and ground grid in accordance with Section 45.120 and Section 45.121.
4. Install secondary busses per Section 45.20.20.
5. Conduit system shown. For direct buried systems, loop cables around base of foundation before terminating.

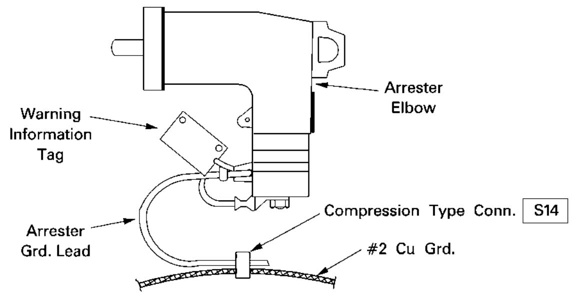
 Doc. # ST. 45.00.001

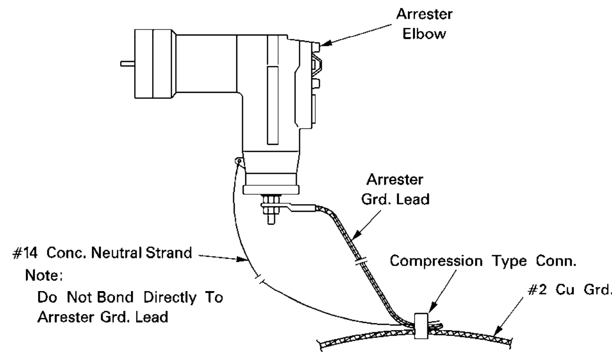


Notes:

1. Install transformer tank ground split – bolt stud connectors to accept #2 copper ground wire loop.
2. Use 2 foot length of twisted concentric neutral wires from the primary cable for connection to #2 copper ground wire loop.
3. Install foundation and ground grid in accordance with Section 45.120 and Section 45.121.
4. Install secondary busses per Section 45.20.20.
5. Conduit system shown. For direct buried systems, loop cables around base of foundation before terminating.

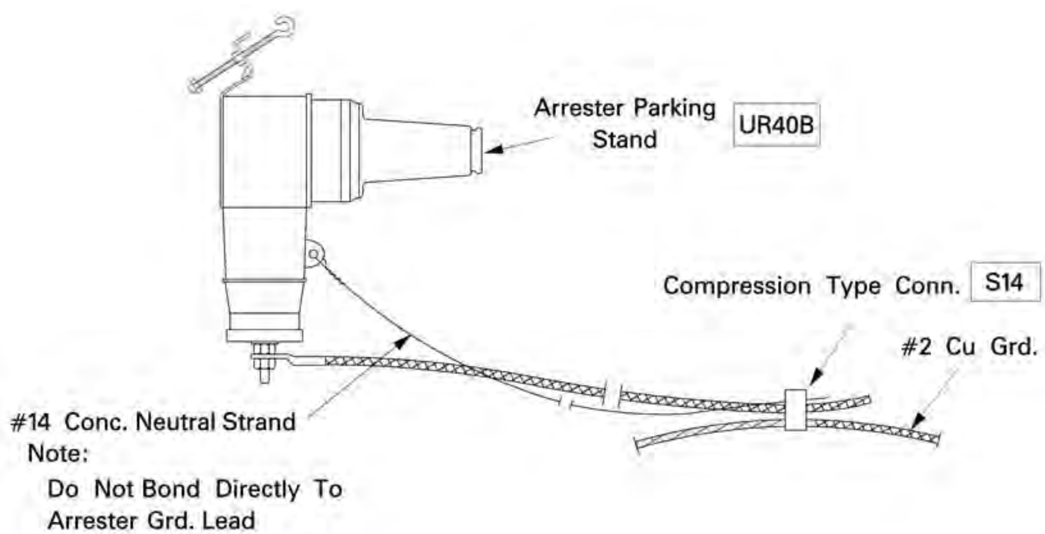
PADMOUNT TRANSFORMER INSTALLATION – FRONT VIEW TYPICAL ARRESTER ELBOWS END OF RADIAL CIRCUIT			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
1/07	45-124		



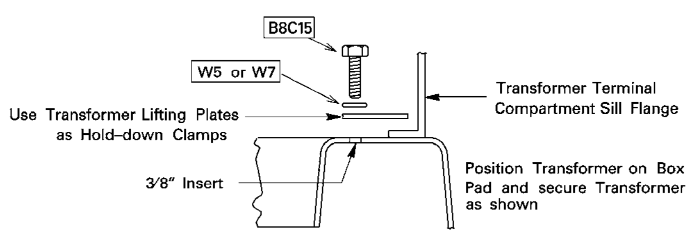


Elbow Arrester with braided ground attached to housing.	Elbow Arrester without ground attached to housing, install #14 concentric neutral or equivalent from housing to # 2 Cu. system ground in a URD.

Arrester Elbow Grounding Detail



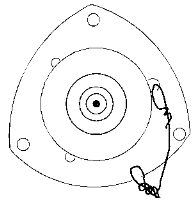
Arrester Parking Stand Grounding Detail



Transformer to Vault Pad Fastening Detail

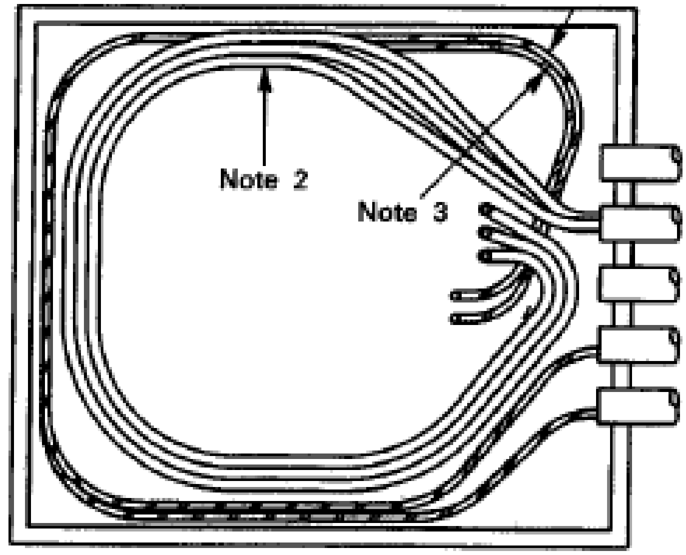
ARRESTER ELBOW AND PARKING STAND GROUNDING DETAIL TRANSFORMER TO VAULT PAD FASTENING DETAIL			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 45-125	ISSUE 1/07

 | Doc. # ST. 45.00.001

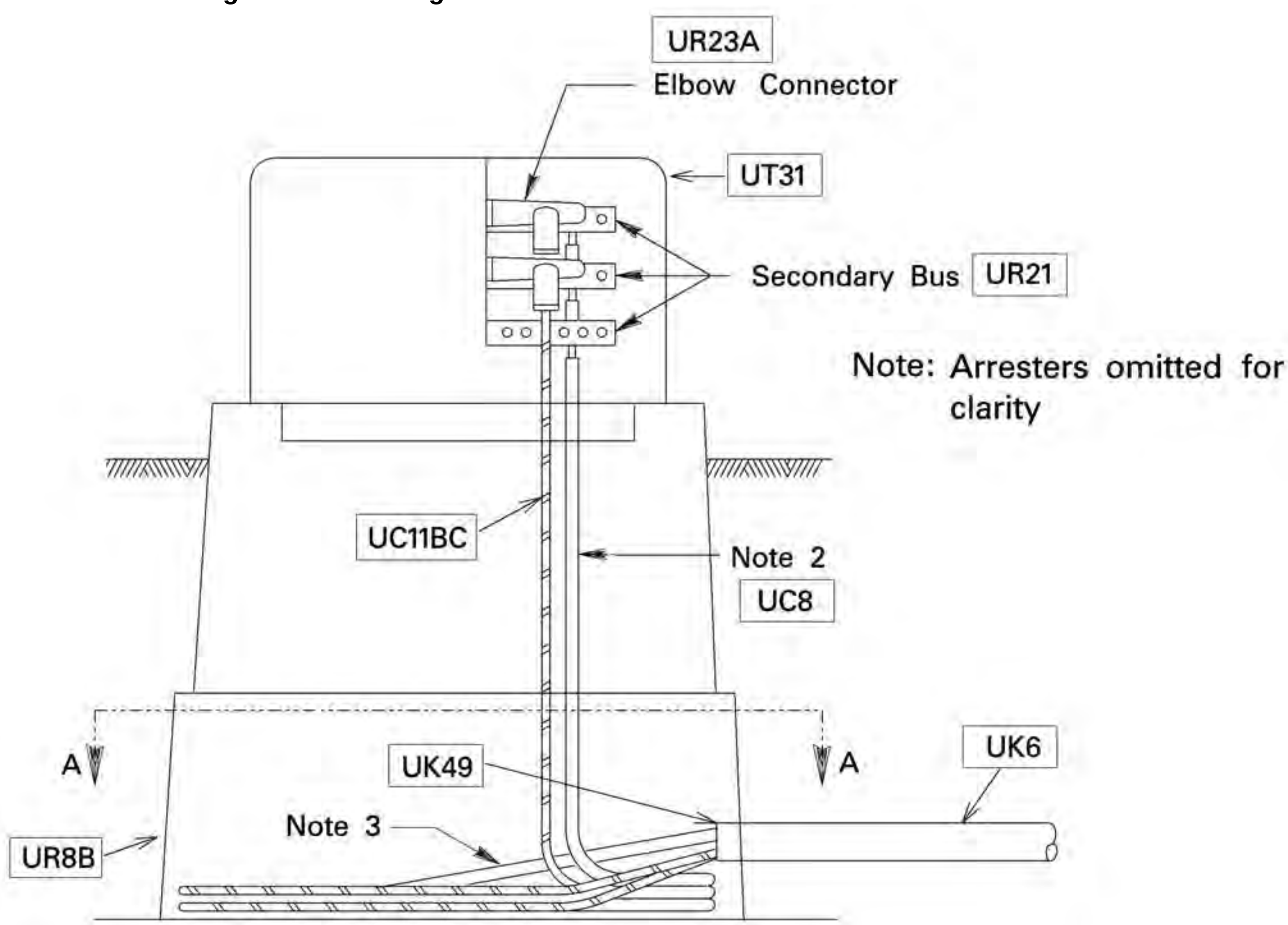


Note: Use a minimum of #14 solid copper or equivalent to bond bushing insert to mounting plate.

Transformer Bushing Well Grounding Connection



Section A – A



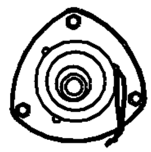
Single Phase Padmount Transformer – Installation

Notes:

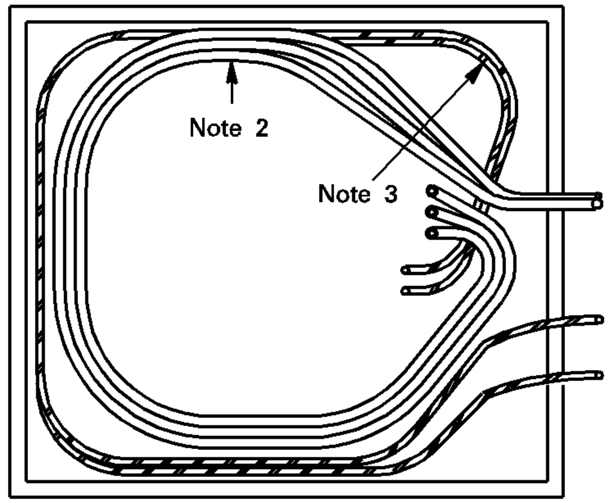
1. Grounding not shown.
2. Only one Triplexed Secondary Cable shown.
3. Do not exceed minimum cable bending radii when training cables.

Supersedes 1/07 Issue – Removed Note 4

New Standard

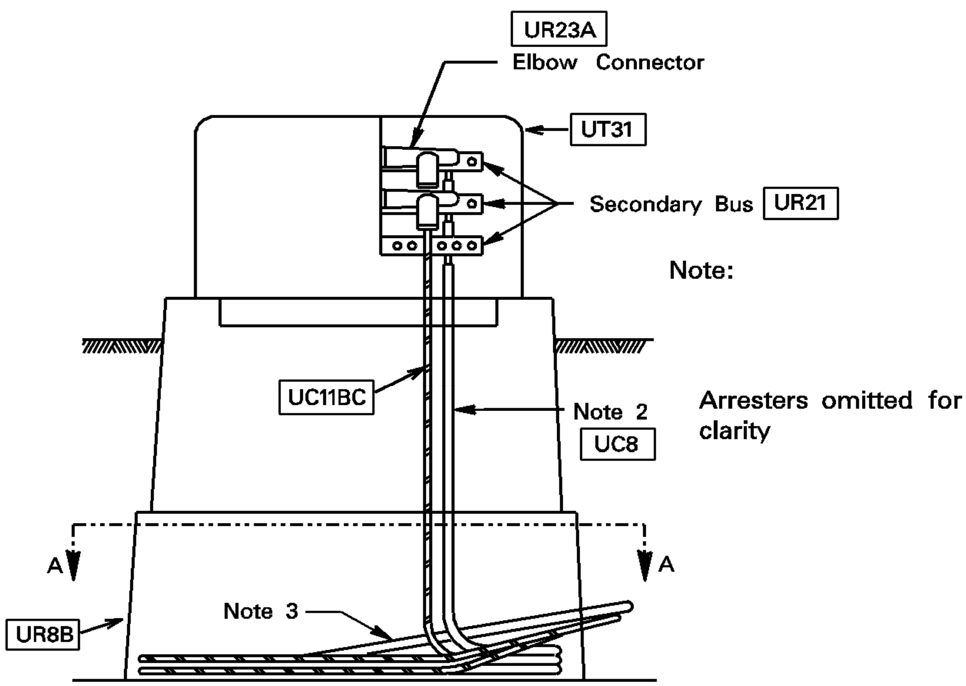


Note: Use a minimum of #14 solid copper or equivalent to bond bushing insert to mounting plate.



SECTION A–A

Transformer Bushing Well Grounding Connection



SINGLE PHASE PADMOUNT
TRANAFORMER–INSTALLATION

Notes:

1. Grounding not shown.
2. Only one Triplexed Secondary Cable shown.
3. Do not exceed minimum cable bending radii when training cables.

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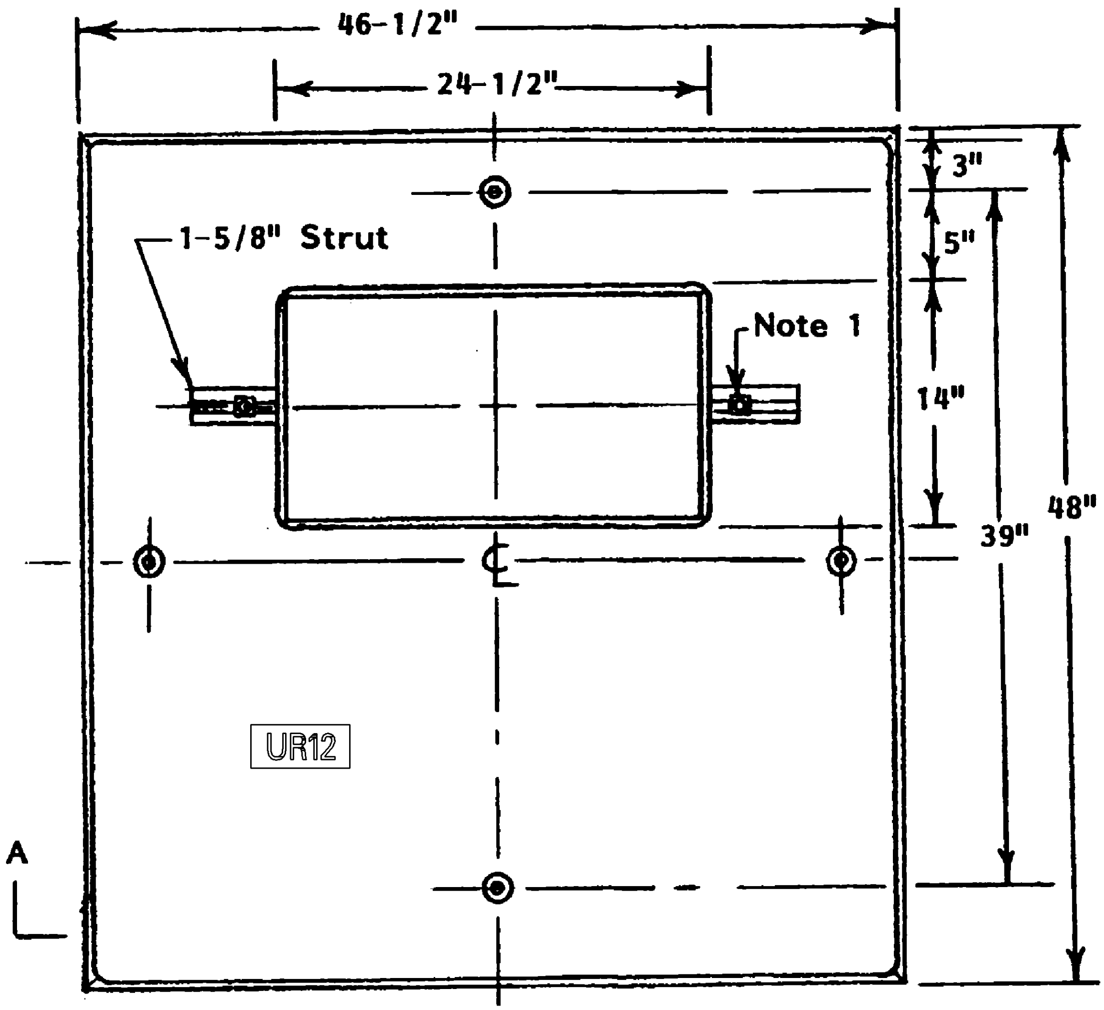


FIGURE 1
PLAN

Note 1 - Captive nut for 3/8" x 1-1/4" transformer mounting bolt.

B19

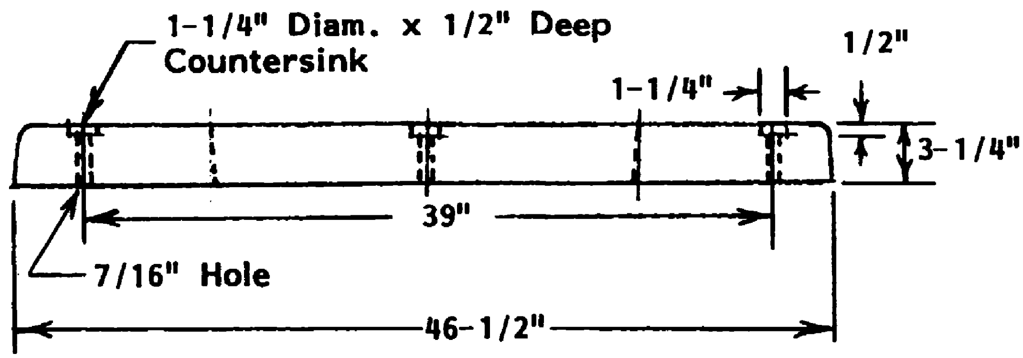
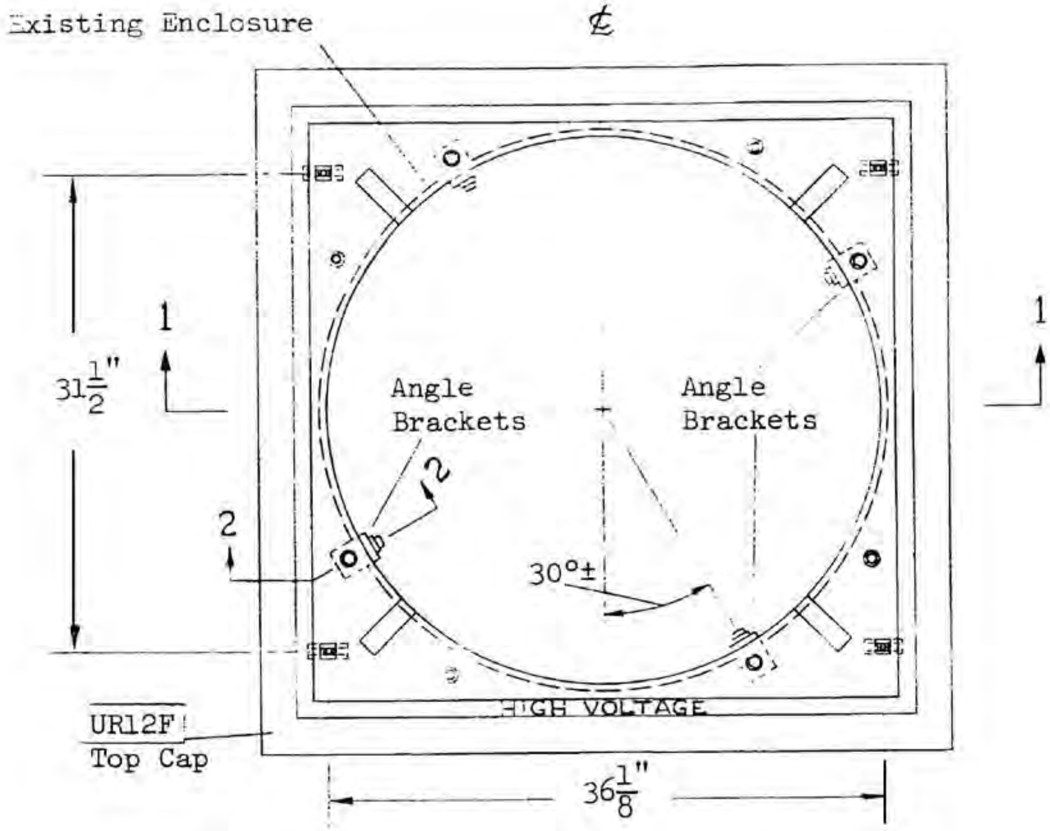


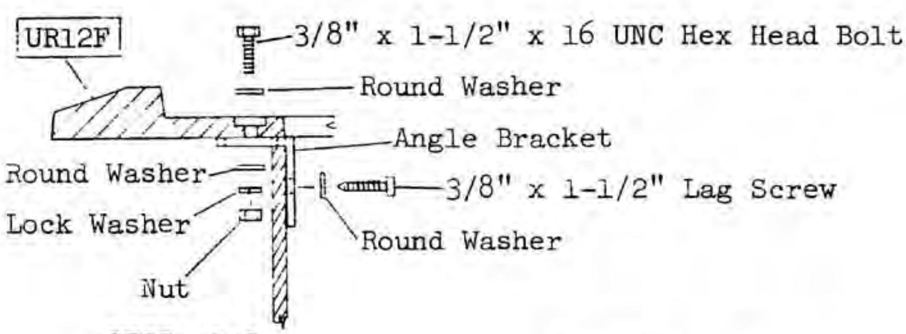
FIGURE 2
SECTION A-A

SUBSURFACE TO PADMOUNT CONVERTER PAD – NEW ENGLAND APPLICATONS			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 45-129	ISSUE 2/06

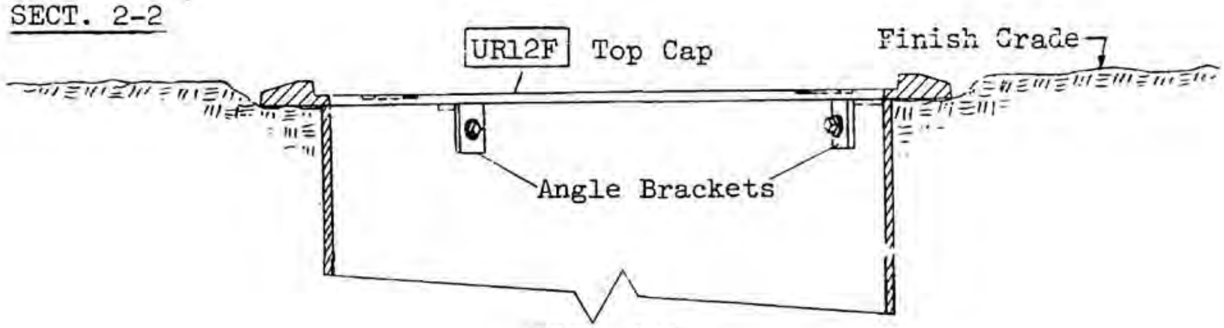
Doc. # ST. 45.00.001



STREET SIDE AND POSITION OF FRONT
OF PADMOUNTED JUNCTION OR TRANSFORMER



SECT. 2-2

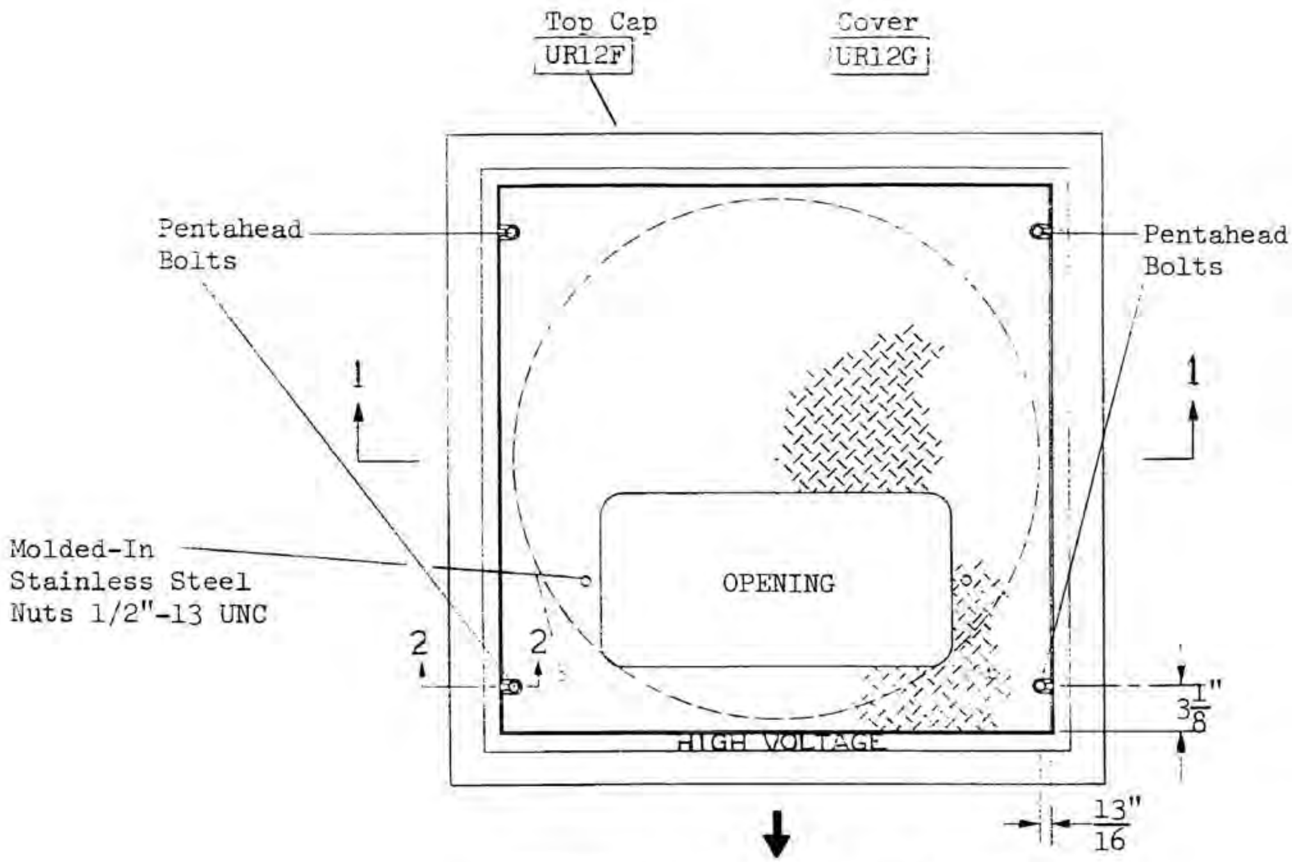


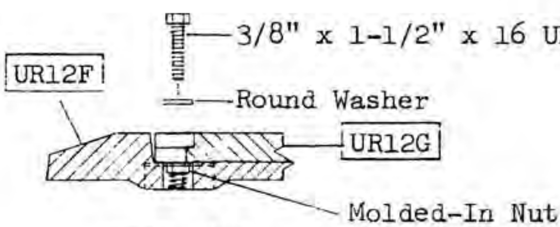
SECT. 1-1

SUBMERSIBLE TO PADMOUNT CONVERSION
36 INCH SUBMERSIBLE ENCLOSURES

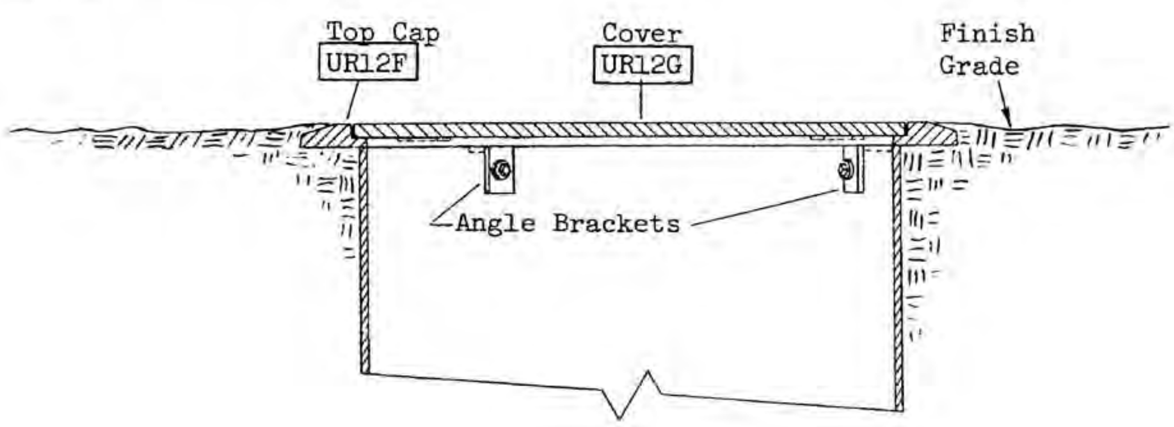
ISSUE	PAGE NUMBER		
2/06	45-130	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities

 | Doc. # ST. 45.00.001



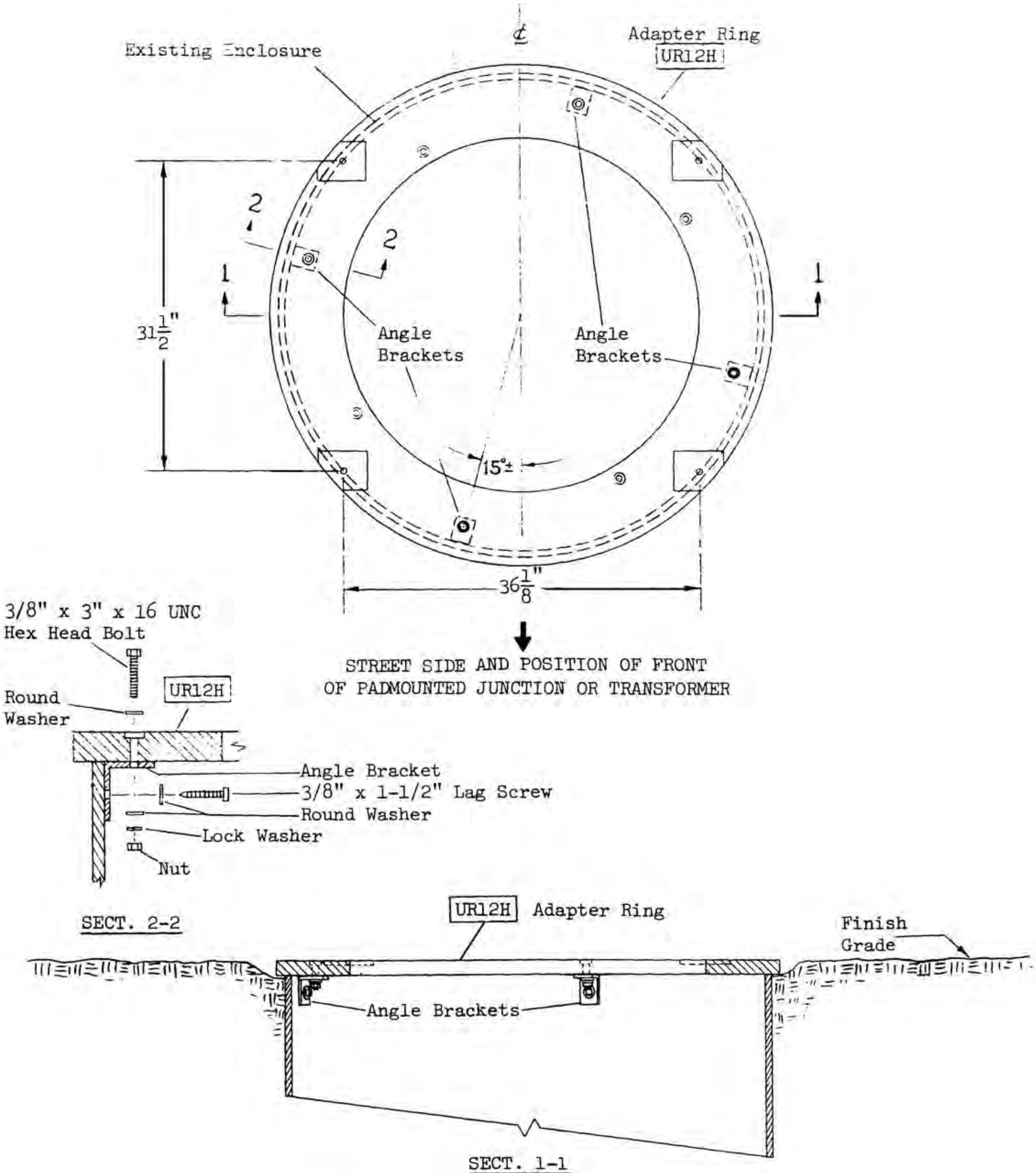


SECT. 2-2

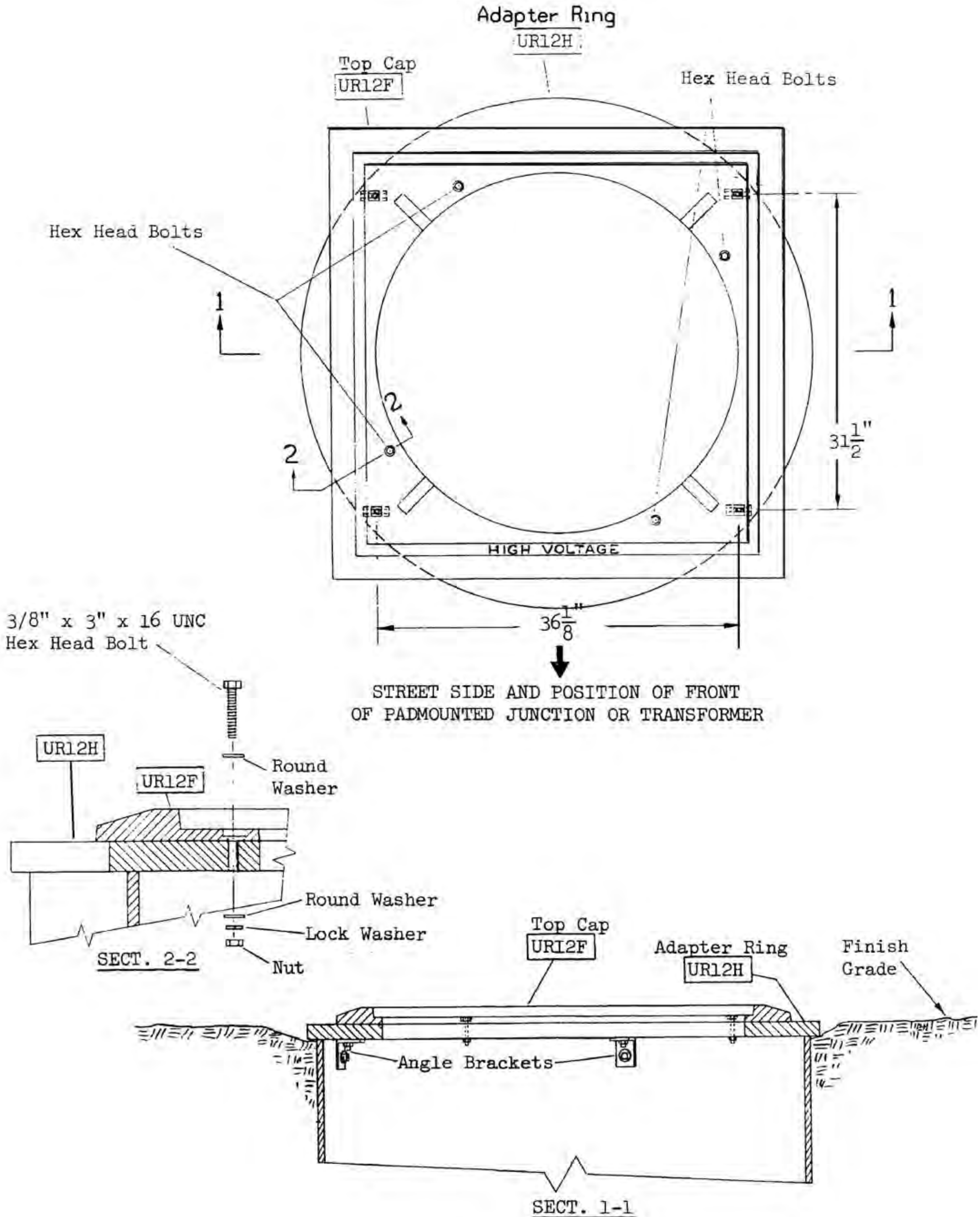


SECT. 1-1

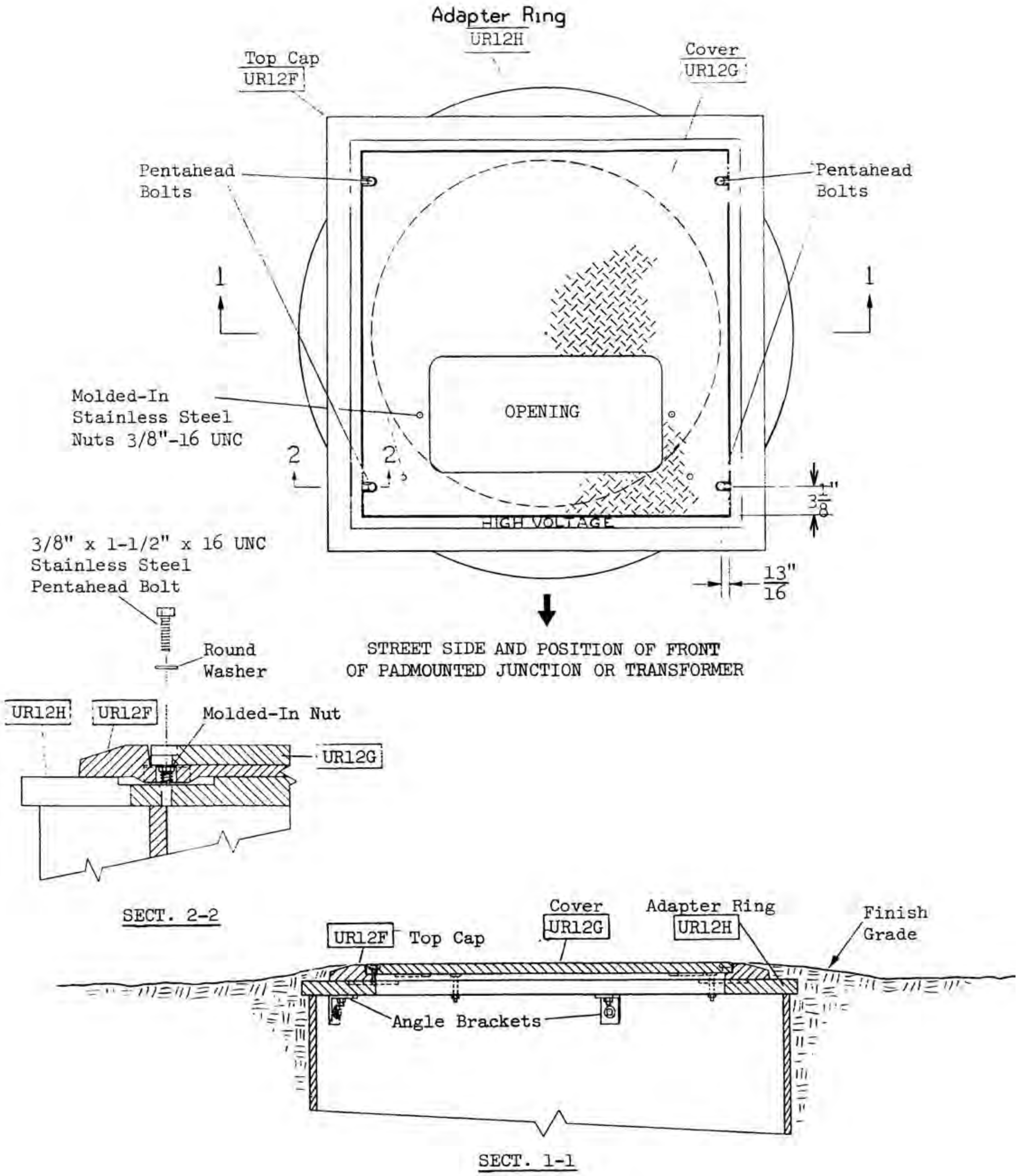
SUBSURFACE TO PADMOUNT CONVERSION 36 INCH SUBMERSIBLE ENCLOSURES			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 45-131	ISSUE 2/06



SUBMERSIBLE TO PADMOUNT CONVERSION 48 INCH SUBMERSIBLE ENCLOSURES			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
2/06	45-132		

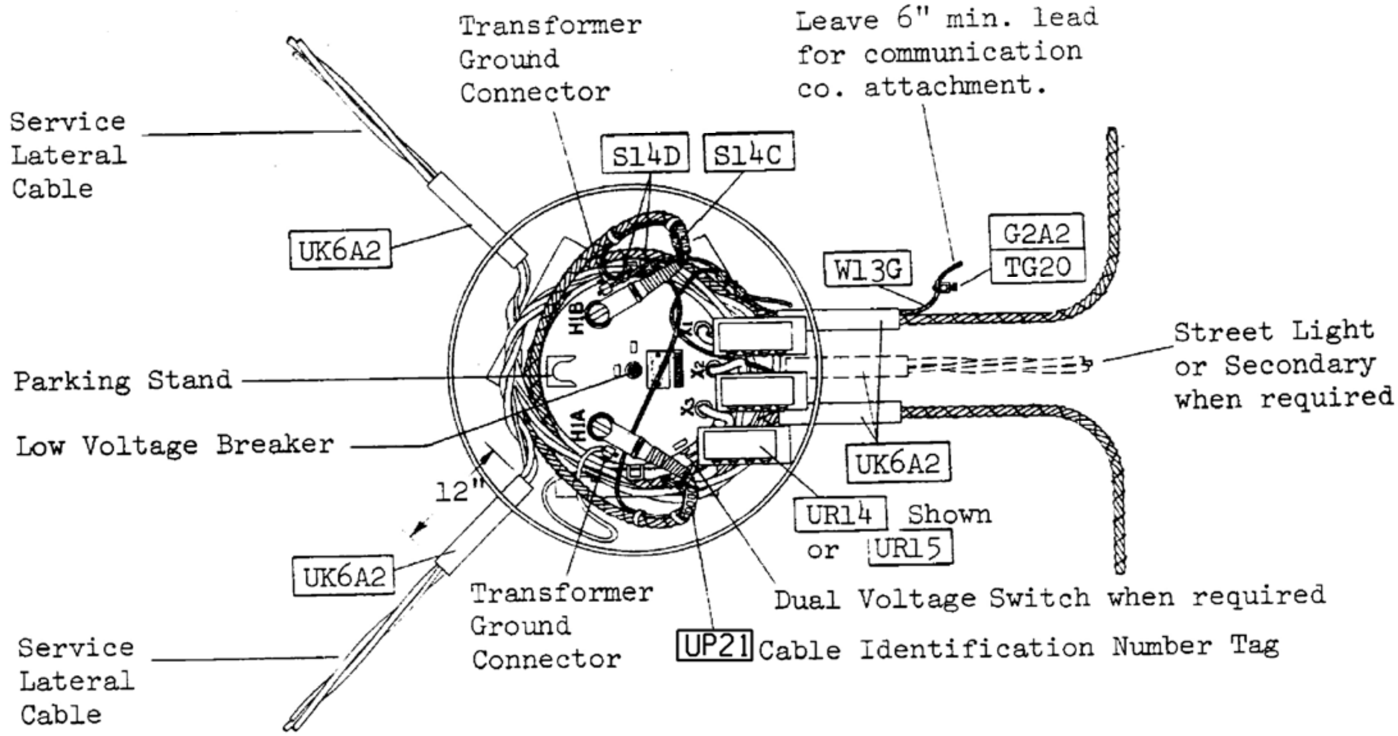


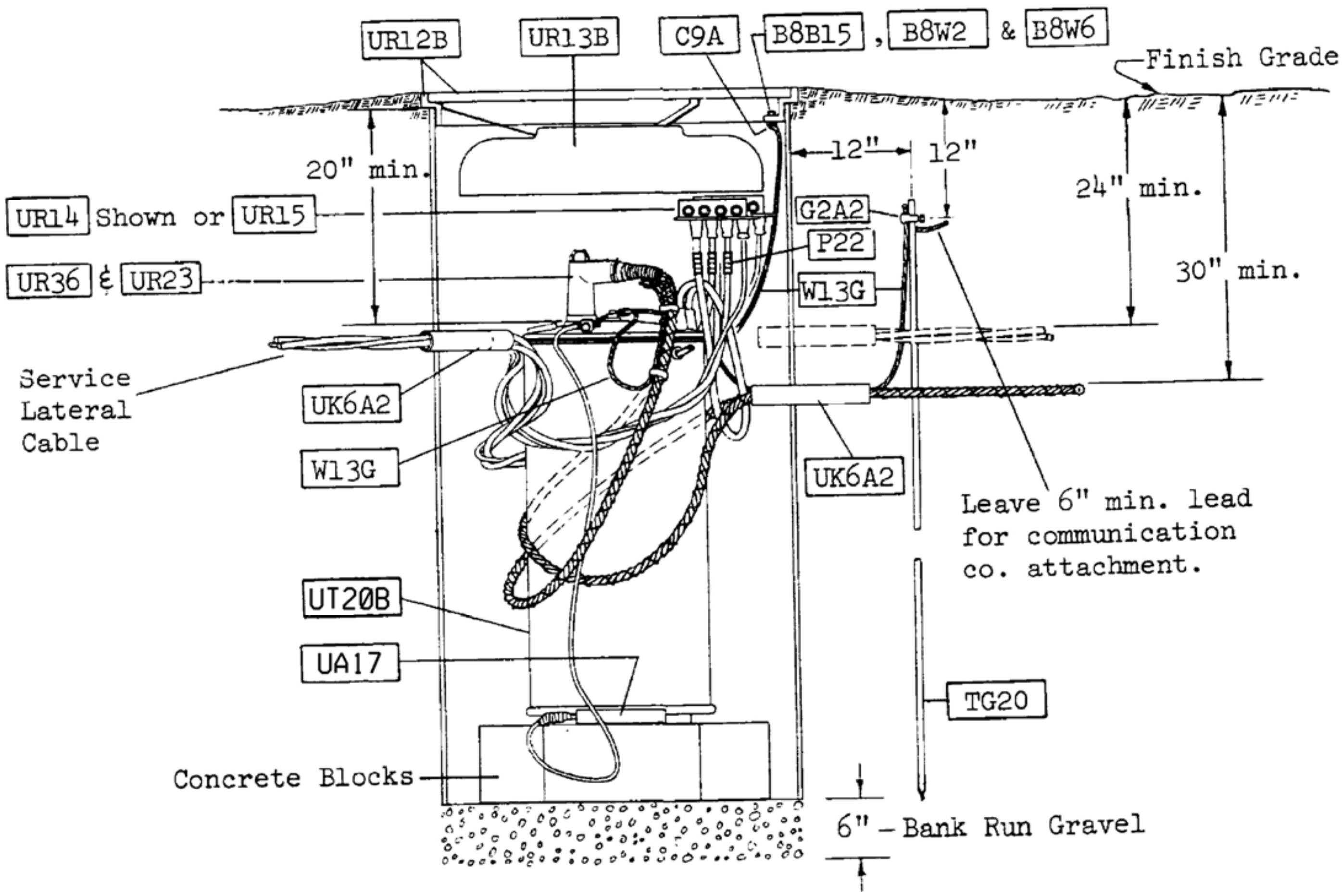
SUBMERSIBLE TO PADMOUNT CONVERSION 48 INCH SUBMERSIBLE ENCLOSURES			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER **45-133**	ISSUE **2/06**



SUBMERSIBLE TO PADMOUNT CONVERSION 48 INCH SUBMERSIBLE ENCLOSURES			
ISSUE	PAGE NUMBER	UNDERGROUND CONSTRUCTION STANDARD	Liberty Utilities
2/06	45-134		

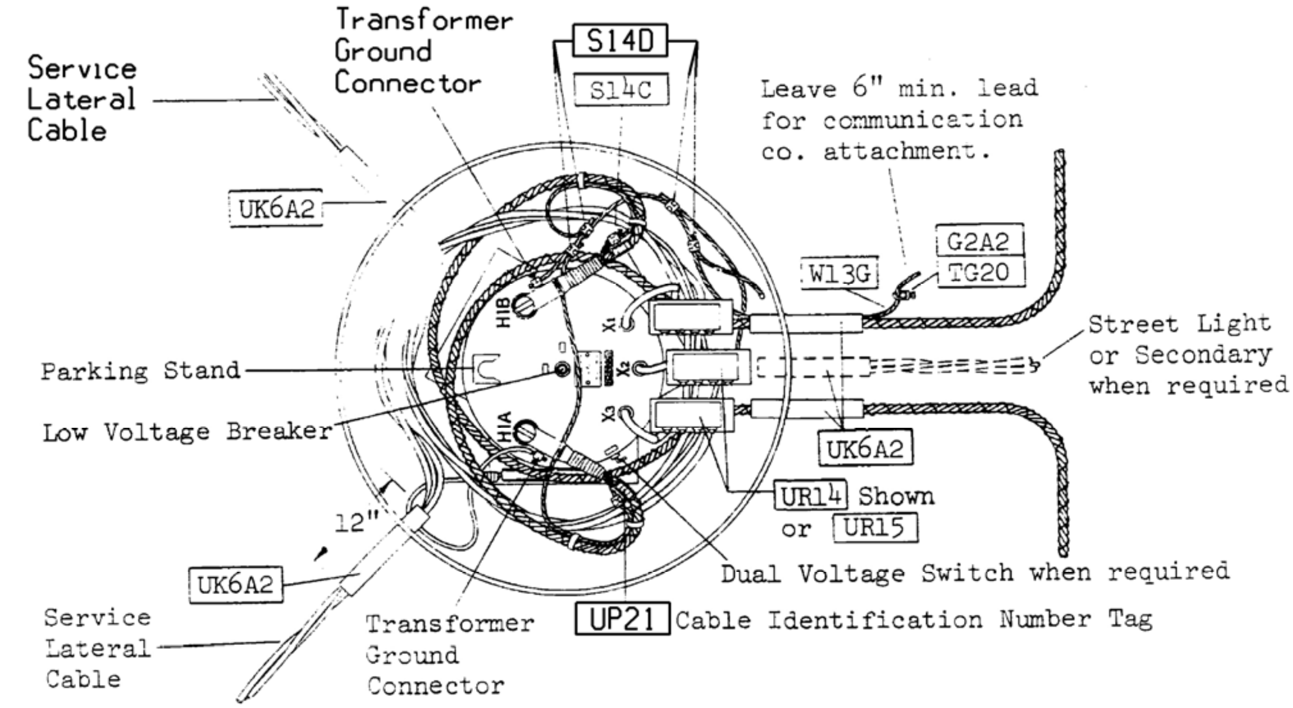
FOR MAINTENANCE PURPOSES ONLY

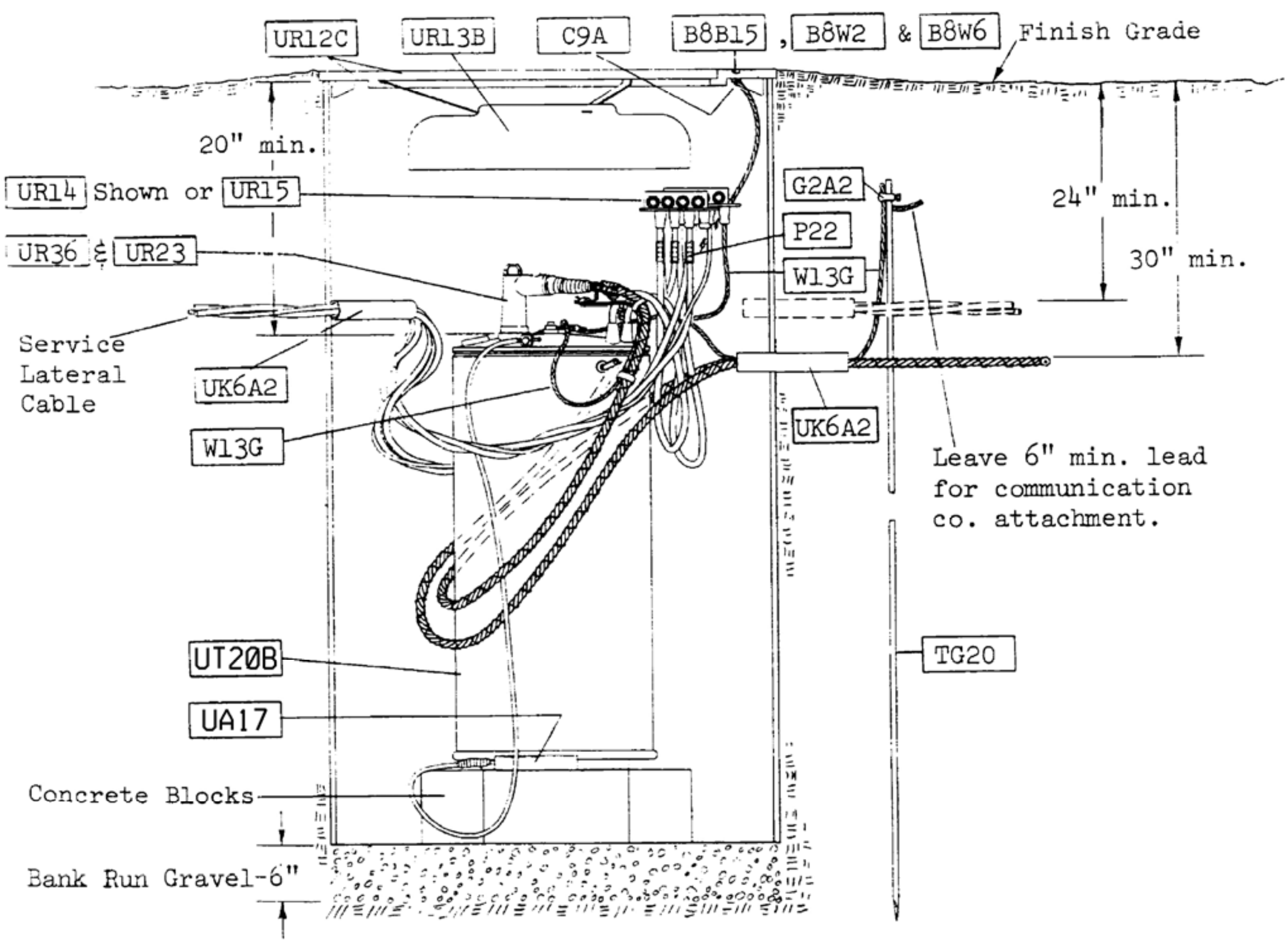




TOP AND FRONT ELEVATION – SINGLE PHASE SUBMERSIBLE TRANSFORMER 25 kVA IN A 36 INCH DIAMETER X 72 INCH DEEP ENCLOSURE			
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	PAGE NUMBER 45-137	ISSUE 2/06

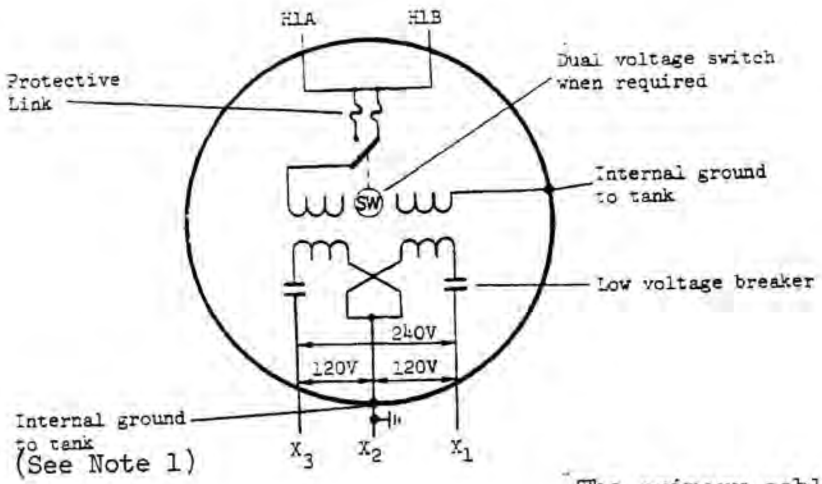
FOR MAINTENANCE PURPOSES ONLY



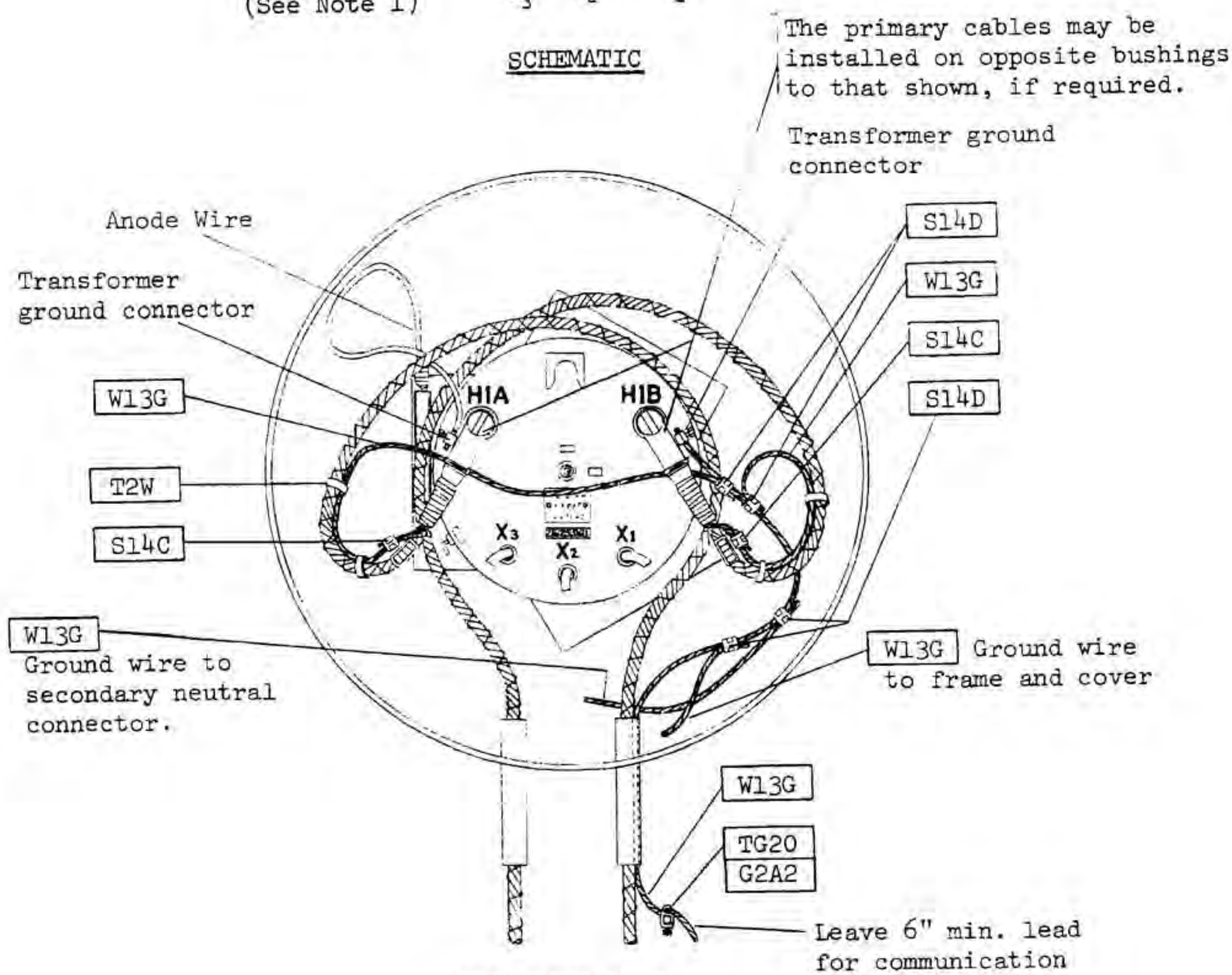


TOP AND FRONT ELEVATION – SINGLE PHASE SUBMERSIBLE TRANSFORMER 50, 75 OR 100 kVA IN A 48 INCH DIAMETER X 84 INCH DEEP ENCLOSURE			
ISSUE **2/06**	PAGE NUMBER **45-138**	**UNDERGROUND CONSTRUCTION STANDARD**	Liberty Utilities

FOR MAINTENANCE PURPOSES ONLY



SCHEMATIC



GROUNDING PLAN

Notes:

1. Some of the earlier single-phase submersible transformers on the system may not have had the secondary neutral internally grounded. Therefore, on all installations, the secondary neutral shall be externally grounded. The transformer shall be de-energized if this external secondary neutral ground connection is to be disconnected for any reason.
2. Secondary, service and street light cable and connectors not shown for clarity.

<table>
<tr><td colspan="4">SCHEMATIC AND GROUNDING PLAN
SINGLE PHASE SUBMERSIBLE TRANSFORMER</td></tr>
<tr><td rowspan="2">Liberty Utilities</td><td rowspan="2">UNDERGROUND
CONSTRUCTION STANDARD</td><td>PAGE NUMBER</td><td>ISSUE</td></tr>
<tr><td>45-139</td><td>2/06</td></tr>
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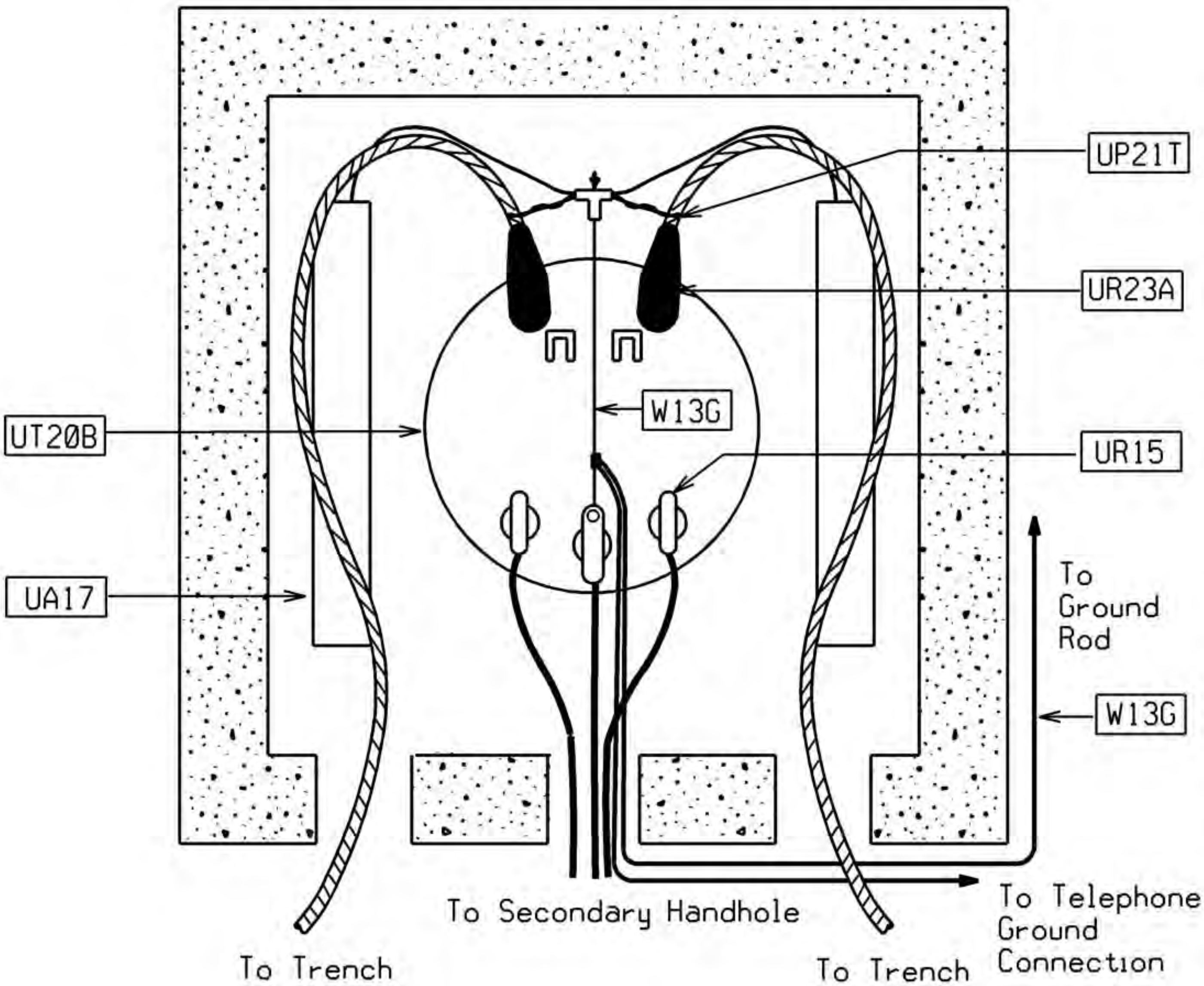
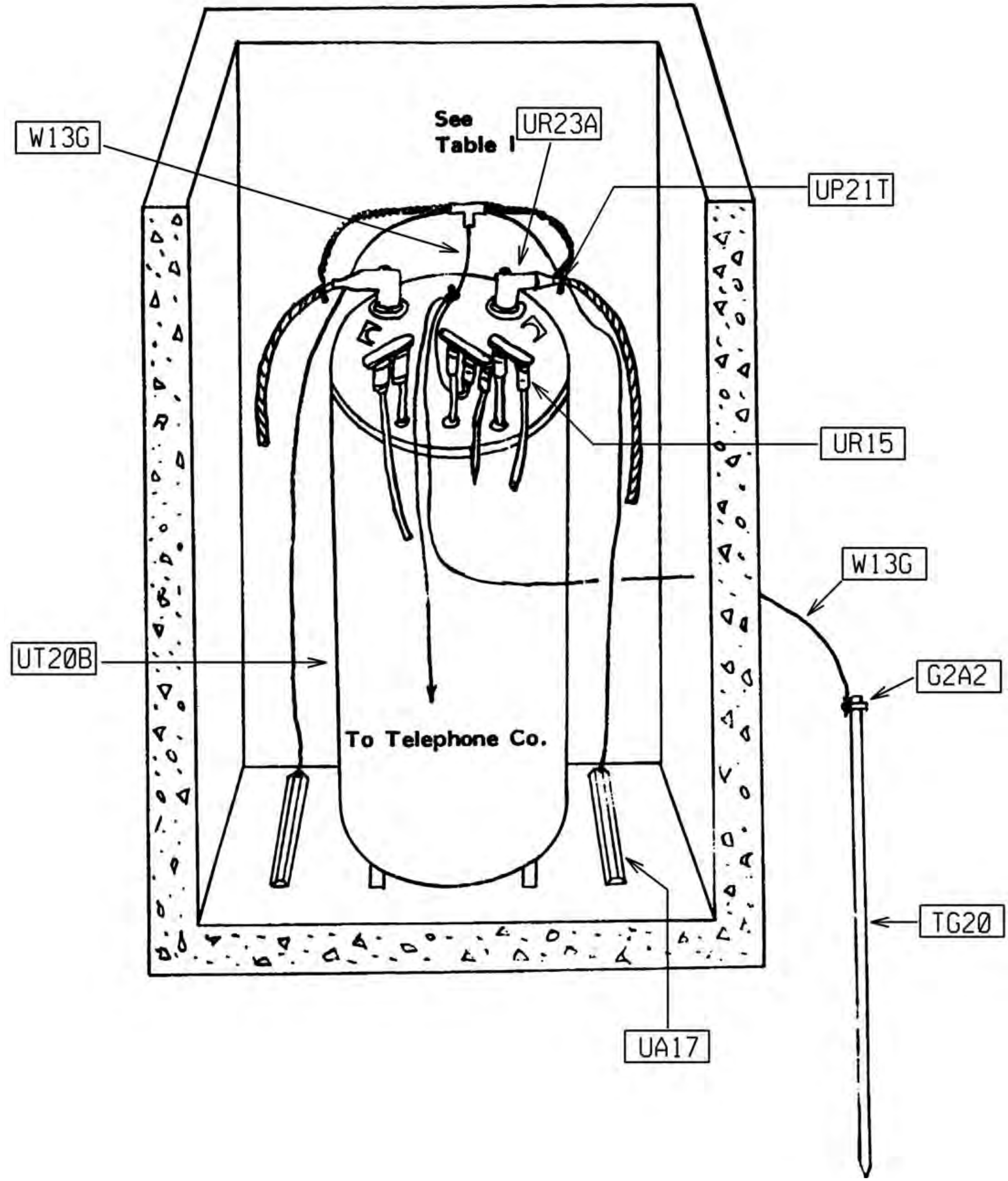


Transformer Size	Transformer Lead Size	Secondary To First Handhole	
		Size	Material Specification No.
15 & 25 kVA	2/0 Cu.	2-350 kcmil AL & 1-4/0 AL Neutral	5011
37.5 & 50 kVA	4/0 Cu.		
75 & 100 kVA	500 kcmil Cu.	2-500 kcmil AL & 1-4/0 AL Neutral	4154

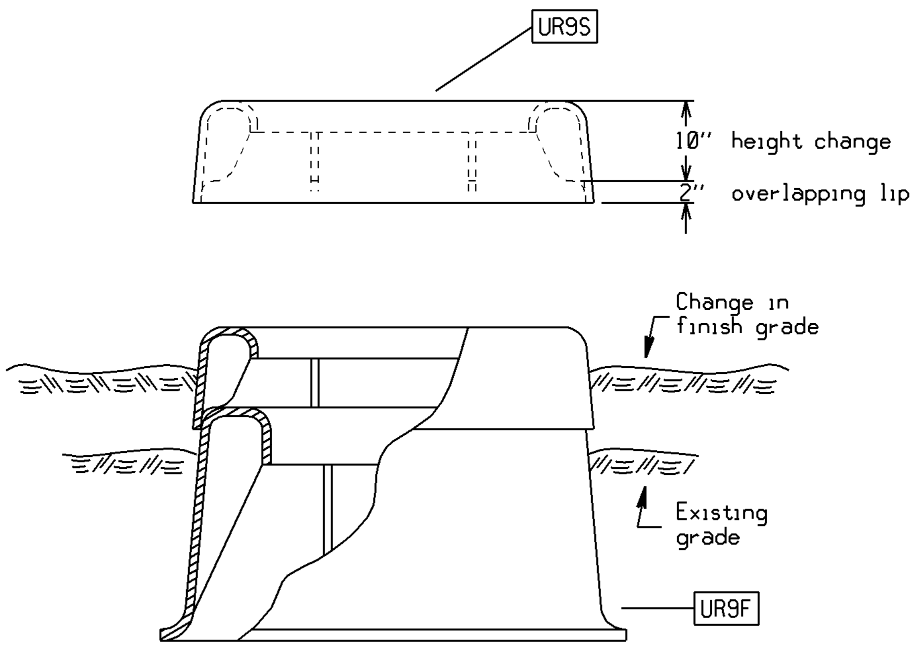
Allow adequate slack in all cables and neutrals to permit removal of transformer.



SCHEMATIC AND GROUNDING PLAN
SINGLE PHASE SUBMERSIBLE TRANSFORMER

		PAGE NUMBER	ISSUE
Liberty Utilities	UNDERGROUND CONSTRUCTION STANDARD	45-141	2/06

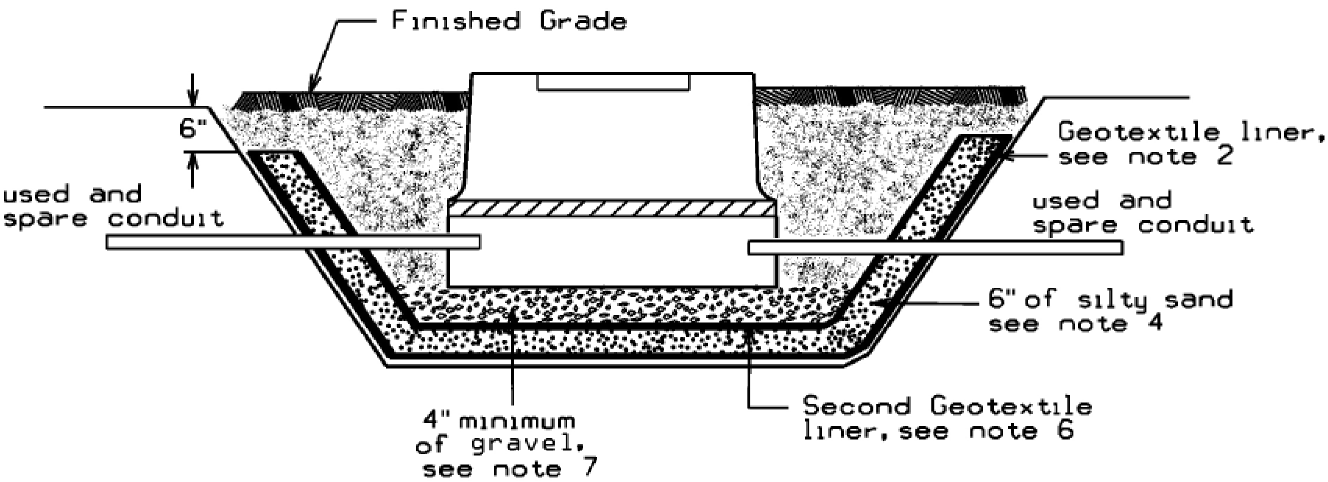
FOR MAINTENANCE PURPOSES ONLY

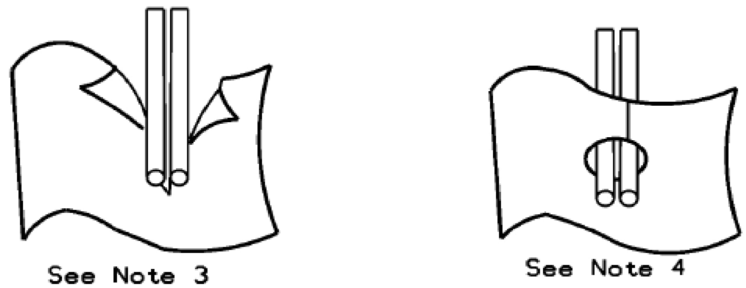


Notes:

1. When unexpected grade changes require a deeper vault pad, item UR9S will increase the height of the existing pad by 10 inches.

2. Item UR9S is designed to slip over the existing item UR9F and has a 2 inch overlapping lip to prevent slippage and assure a tight fit with the vault pad. No fasteners are required.



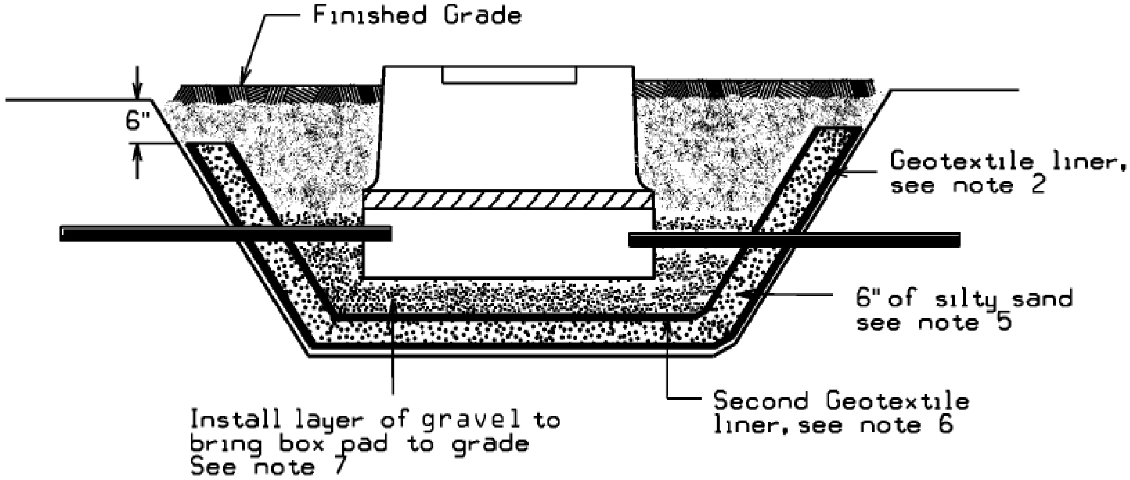


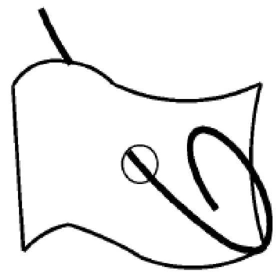
New Standard

Reference drawing taken from the Electric System Bulletin No 759A, page 24 (Figure 19.0-1)

<u>Notes:</u>

1. Dig out at least an additional foot on the bottom and sides of the boxpad area and stub out conduits out into the pit.
2. Install geo-textile liner (Item ID# F70) inside pit along the bottom and sides up to 6" from finish grade.
3. Make vertical cuts in the liner to accommodate conduits.
4. Overlap the liner flaps around the conduit and seal the liner seam and in between conduits with expanding foam (Item ID# UF10).
5. Fill in area with 6" of compacted silty sand.
6. Install second layer of geo-textile liner by repeating steps 2 and 3.
7. Install a minimum of 4" of gravel base for boxpad to be at proper grade.
8. Set boxpad and make up conduits into it.
9. Install secondary handhole (Item ID# UR10G) and connecting conduit(s) behind transformer boxpad, outside of oil containment.
10. Install ground grid and backfill after company inspection.





New Standard

Reference drawing taken from the Electric System Bulletin No 759A, page 25 (Figure 19.0-2)

Notes:

1. Dig out at least an additional foot on the bottom and sides of the boxpad area and stub out conduits out into the pit.
2. Install geo-textile liner (Item ID# F70) inside pit along the bottom and sides up to 6” from finish grade.
3. Make small holes in the liner and feed primary and secondary cables through holes into pit.
4. Once cables are pulled, seal the liner around the cables with expanding foam (Item ID# UF10).
5. Fill in area with 6” of compacted silty sand.
6. Install second layer of geo-textile liner and cut holes for cables as noted in step 3.
7. Install layer of gravel for cable routing and for boxpad base to be at proper grade.
8. Set boxpad, train cables into boxpad and backfill on top of cables with sand.
9. Install secondary handhole (Item ID# UR10G) and secondary cables behind transformer boxpad, outside of oil containment.
10. Install ground grid and backfill after company inspection.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
2.0	12/13	• Convert to Liberty Utilities Document from National Grid	Robert Johnson	
1.0	7/12	• Added Section 45-19.35 – Transformer Oil Containment • Added New Construction Standards 45-143, Single Phase Oil Containment – Conduit System • Added New Construction Standards 45-144, Single Phase Oil Containment – Direct Buried System	Hernan Yepez	Susan Fleck, VP of Standards, Policies, & Code
1	7/11	• Added Section 45.25 - CUSTOMER LOAD AND VOLTAGE DROP CALCULATION	Michael Brigandi	Susan Fleck, VP of Standards, Policies, & Code

 Doc. # ST. 46.00.001

46.0 GENERAL

This Section provides an overview of outdoor lighting utilized throughout the Company service territory. The State of New Hampshire has enacted "Dark Skies" legislation (House Bill 585-FN) which requires Liberty Utilities to use only luminaires which restrict the amount of light output allowed to go upward towards the sky.

To comply with this legislation, the following is effective immediately in New Hampshire:

1. We can no longer install any luminaires in New Hampshire with semi-cutoff optics.
2. Existing semi-cutoff luminaires in service can remain in service until failure or until removed for any reason.
3. All new and replacement horizontal roadway luminaire installations shall use luminaires with cutoff (flat glass) optics. See Section 46.3.100
4. All new and replacement "Traditional" post top luminaire installations shall use the new "Carriage" post top luminaire. See Section 46.5.50
5. All new and replacement floodlight luminaire installations shall include a visor. See Section 46.4.80
4. Semi-cutoff luminaires returned from the field shall be disposed of for scrap metal value. Do not return to inventory.

The intent is to provide the user with a basic knowledge of the limitations and capabilities of the luminaires offered by the Company that can be passed on to customers as an aid in selecting the luminaire that will best meet their lighting need. This is not intended to be a substitute for a formal lighting layout.

46.0.10 Light Sources

All of the Company's luminaires use the following high intensity discharge (HID) lamp sources.

Table 1
Lamp Sources

Light Source	Color Output	Comment
Mercury Vapor (MV)	Blue / White	Obsolete light source. Luminaires can no longer be purchased. Lamps are available for maintenance of existing installations. In New Hampshire MV lights will be removed and replaced.
High Pressure Sodium Vapor (HPS)	Orange	Most efficient light source used for all general illumination requirements.
Probe Start Metal Halide (MH)	White	Obsolete light source. Luminaires can no longer be purchased. Lamps are available for maintenance of existing installations.
Pulse Start Metal Halide (PSMH)	White	Used where light output color is a primary concern.

46.0.20 Lighting Control

Company luminaires are designed for dusk to dawn operation using photoelectric controls. Photoelectric controls are factory calibrated to "turn on" the luminaire when the natural light level falls to 1.5 foot-candles. This occurs at approximately 16 minutes after sunset and results in approximately 4,175 luminaire burning hours per year. A requirement of the New Hampshire "Dark Skies" legislation is to make available to a customer as an "option" a "part night" operation of street and area lighting luminaires. See Section 46.12.50.

46.0.30 Horizontal Roadway Luminaires

Horizontal roadway luminaires are designed for roadway illumination applications. A horizontal roadway luminaire will produce an oval shaped light pattern designed to throw the light output up and down the roadway a greater distance than across the roadway. The area a horizontal roadway luminaire can cover is directly dependent on the mounting height of the luminaire.

46.0.40 Floodlight Luminaires

Floodlight luminaires are designed to meet the needs of non-roadway illumination applications. They are designed to focus a high level of illumination on a specific area. Their primary application is commercial and industrial security lighting.

Private Area Luminaires

Private area luminaires are general purpose luminaires designed for non-roadway illumination applications. They produce a circular light pattern in a small concentrated area. These luminaires are primarily designed for residential security applications.

46.0.60 Post Top Luminaires

Post top luminaires are historic or contemporary style decorative luminaires designed to be mounted on metal or fiberglass posts, at a height of 14 feet. Most post top luminaires produce an oval shaped light pattern identical to horizontal roadway luminaires. Because of the lower mounting heights, luminaire spacing needs to be much closer than that of horizontal roadway luminaires to produce an equivalent illumination level. Specific posts are available to complement the decorative style of post top luminaire offerings.

46.0.70 Teardrop Luminaires

Teardrop luminaires are decorative luminaires designed for roadway illumination applications. They are mounted at a nominal 25 foot height and produce an oval shaped light pattern identical to horizontal roadway luminaires. Specific decorative poles are available to complement the historic teardrop luminaire style.

46.0.80 Architectural Luminaires

Architectural luminaires (also known as “shoebox” luminaires) are a contemporary style decorative luminaire used in general illumination applications. They are mounted only on square shaft, architectural style, poles.

46.1 DEFINITIONS

Table 2
Commonly Used Outdoor Lighting Terms Defined

TERM	DEFINITION
Air Lamp:	A failure mode for a high intensity discharge lamp where the vacuum is lost within the glass bulb and the lamp becomes filled with air.
Anchor Base:	A type of outdoor lighting pole base that is bolted to a precast concrete or other type foundation.
Anchor Bolt:	A galvanized steel bolt embedded in concrete that is used to secure an anchor base pole.
Anchor Bolt Projection:	The length of anchor bolt that projects above the top of a precast concrete lighting foundation.
Arc Tube:	A gas filled glass tube within a high intensity discharge lamp that gives off illumination when energized with an electric current.
Architectural Luminaire:	A contemporary style decorative luminaire with a rectangular shaped housing. Also commonly called a “shoebox” or “rectilinear” luminaire.
Architectural Pole:	A square shaft pole designed for use with an architectural luminaire.
Arm:	A device utilized on metal or fiberglass pole to extend and hold the luminaire out over a roadway surface.
Ballast Transformer:	An auxiliary device used with a high intensity discharge lamp to obtain necessary circuit conditions for starting and operating the lamp. Reactor Ballast = A single winding ballast transformer. CWA Ballast **=** **C**onstant-**W**attage **A**utotransformer. - A two winding ballast transformer.
Base:	A precast or poured concrete device used to mount an anchor base type pole. Also commonly called a “foundation”.
Bird Guard:	A device in a horizontal roadway luminaire used to prevent birds and squirrels from entering the luminaire housing.
Bolt Circle: (BC)	A measurement to describe the positioning of anchor bolts on a precast concrete lighting foundation.
Bracket:	A device installed on a wooden distribution pole which is used to extend and hold a luminaire out over a roadway surface.
Break-Away:	A safety device used to enable an anchor base pole to break away from its foundation in the event the pole is struck by a motor vehicle.
Bulb:	The glass envelope component of a lamp.
Button Control:	A photoelectric control used in a decorative luminaire where only the light sensing device is visible from the outside of the luminaire.
Cobra-Head:	Another name for a horizontal roadway luminaire.
Cutoff: • *(non-cutoff)* • *(semi-cutoff)* • *(cutoff)* • *(full cutoff)*	An IES term used to describe how much illumination an outdoor luminaire allows to go skyward.
Cycling:	A failure mode of a high pressure sodium vapor lamp where the lamp continuously cycles “on” and “off”.
Davit Pole:	A lighting pole whose arm forms a 90 degree sweep.
Effective Projected Area: (EPA)	A measurement in square feet to describe the area of a luminaire with respect to wind displacement.

TERM	DEFINITION
Embedded:	A term used to identify a lighting pole that is installed by direct burial of the bottom portion of the pole shaft in the ground.
Festoon Outlet:	An electrical receptacle located on an outdoor lighting pole.
Finial:	A decorative ornament affixed to the top of a luminaire.
Floodlight Luminaire:	An outdoor luminaire used to flood an area with a concentrated large quantity of illumination.
Foot-candle: (FC)	A standard measurement of illumination. One foot-candle = the light intensity on a 1 square foot surface located one foot away from a 1 lumen light source.
Foundation:	A supporting structure for an anchor base pole – usually precast concrete.
Getter Flash:	A device within a high intensity discharge lamp used to as a cleaning agent to maintain a pure vacuum within the lamp bulb.
Glare:	Light output that is offensive or blinding to the viewer.
Grounding Conductor:	An electrical conductor used to connect a metal pole or luminaire housing to earth potential.
High Intensity Discharge: (HID)	A method of producing illumination by passing an electric current through a gas filled arc tube.
High Pressure Sodium Vapor (HPS):	A type of high intensity discharge light source that emits an orange colored light output.
Horizontal Roadway Luminaire:	A type of outdoor luminaire used for roadway illumination where the lamp is operated in a horizontal position.
IES:	Illuminating Engineering Society
Igniter:	An auxiliary device used to start a high intensity discharge lamp.
Incandescent:	A type of light source where an electric current is passed through a filament wire.
Lamp:	A device that transforms electrical energy into light usually consisting of a base, bulb and light emitting device.
Lens:	A glass or plastic device in a luminaire that redirects and controls the distribution of light by refraction.
Light Trespass:	The distribution of illumination output into unwanted areas.
Lumen:	A measure of illumination output.
Luminaire:	A complete lighting unit consisting of a housing, terminal board, auxiliary electrical components, reflector/refractor and lamp socket. The luminaire is designed to distribute the illumination output and to position and protect the lamp.
Mercury Vapor: (MV)	A type of high intensity discharge light source that emits a blue/white colored light output.
Metal Halide: (MH)	A type of high intensity discharge light source that emits a white colored light output.
Mounting Height: (MH)	The vertical distance measured from ground level to a luminaire.
Multiple Circuit:	A street lighting circuit where multiple luminaires are connected in parallel and operate on a nominal secondary voltage.
Multiple Control Relay:	A device used to group control a multiple number of luminaires

TERM	DEFINITION
NEMA:	**N**ational **E**lectrical **M**anufacturers **A**ssociation.
NEMA Luminaire:	A type of luminaire commonly used in rural or residential security lighting installations.
Optical Assembly:	The refractor and reflector components of a luminaire that control the illumination output.
PECR:	**P**hoto-**E**lectric **C**ontrol **R**eceptacle
Photoelectric control: (PEC)	A device that switches luminaires on or off in response to natural light levels.
Photometrics:	A description of illumination output qualities and characteristics of a luminaire.
Pole Access Handhole:	An opening near the base of an outdoor lighting pole to provide access to the electrical wiring connections.
Post Top Luminaire:	A type of decorative luminaire that is installed directly on the top of a pole.
Powerbracket:	A type of luminaire commonly used in rural or residential security lighting installations
Rectilinear Luminaire:	A contemporary style decorative luminaire with a rectangular shaped housing. Also commonly called a “shoebox” or “architectural” luminaire.
Red Cap:	A device used in place of a twistlock photoelectric control to leave the lamp load permanently “off”.
Reflector:	A surface of polished or painted metal, mirrored glass, or plastic, shaped to control and re-direct the illumination output.
Restrike Time:	The amount of time needed for an HID lamp source to restart after a momentary interruption in electrical power.
Series Circuit:	A street lighting circuit where the luminaires are connected in series to one another.
Shoebox Luminaire:	A contemporary style decorative luminaire with a rectangular shaped housing. Also commonly called a “rectilinear” or “architectural” luminaire.
Shorting Receptacle Cap:	A device used in place of a twistlock photoelectric control to leave the lamp load permanently “on”.
Shroud:	A device used at the base on an anchor base pole to cover the anchor bolts.
Lipfitter:	The portion of a luminaire whose purpose is to attach the luminaire to an arm or bracket.
Starter:	An electronic device utilized to provide voltage and current for initial illumination of an HID lamp.
Teardrop Luminaire:	A decorative style pendant luminaire that is shaped like a teardrop.
Tenon:	A device on a pole designed to accept the luminaire slipfitter.
Transformer Base: (T-Base)	An enclosure installed at the base of an anchor base pole that is used to house the luminaires ballast transformer or other electrical equipment.
Underpass Luminaire:	A specialty luminaire that is designed to provide illumination under a highway bridge or in a tunnel.
Vandal Shield:	An accessory device used on an outdoor luminaire to provide protection from vandalism.
Visor:	An accessory device used on an outdoor luminaire to restrict and limit the outer limits of the illumination output.

46.2 IES LIGHT DISTRIBUTION PATTERNS

The Illuminating Engineering Society (IES) has a three part system to define the light output pattern of horizontal roadway, post top, and other luminaires commonly used in roadway lighting service.

46.2.10 Spacing Classification

This defines how far up and down the length of the roadway the luminaire can cover. This distance is expressed as a factor of the mounting height (MH) of the luminaire.

Table 3

Spacing Classification	Length of Main Beam	Maximum Pole Spacing
SHORT	1.0 to 2.25 MH	4.5 MH
MEDIUM	2.25 to 3.75 MH	7.5 MH
LONG	3.75 to 6.0 MH	12.0 MH

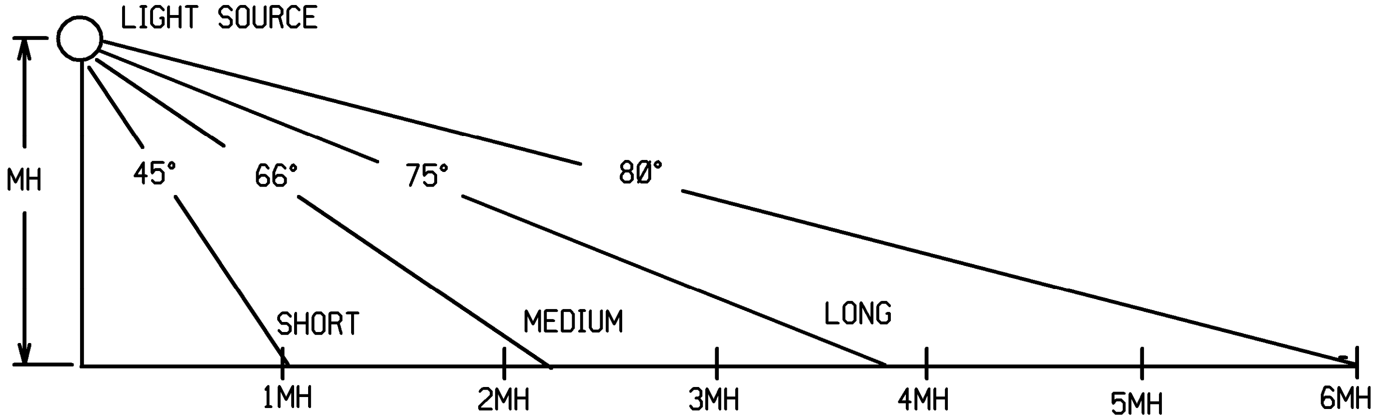


Figure 1
IES Spacing Classification

46.2.20 Glare Control Classification

The glare control classification defines how much of the light output is allowed to go above the 80 degree and 90 degree horizontal plane (skyward) of the luminaire.

Table 4

Glare Classification	Allowable Illumination Between The 80° and 90° Plane	Allowable Illumination Above the 90° Plane
FULL CUTOFF	< = 10 %	0 %
CUTOFF	< = 10 %	< = 2.5 %
SEMI-CUTOFF	< = 20 %	< = 5.0 %
NON-CUTOFF	no limitation	no limitation

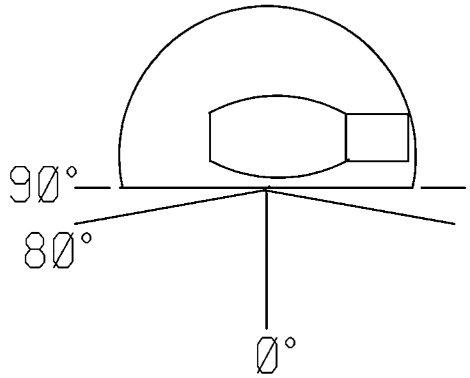


Figure 2
Glare Control Classification

46.2.30 **Width Classification**

This defines how far across the width of the roadway the main beam will shine. This distance is expressed as a factor of the mounting height (MH) of the luminaire.

Table 5

Width Classification	Definition
Type I	Intended to be located over the center of relatively narrow residential roadways.
Type II	Intended to be located near the side of a roadway not exceeding 1.75 MH in width.
Type III	Intended to be located near the side of a roadway not exceeding 2.75 MH in width.
Type IV	Intended to be located near the side of a roadway greater than 2.75 MH in width.
Type V	Provides a circular light pattern of equal intensity in all directions.

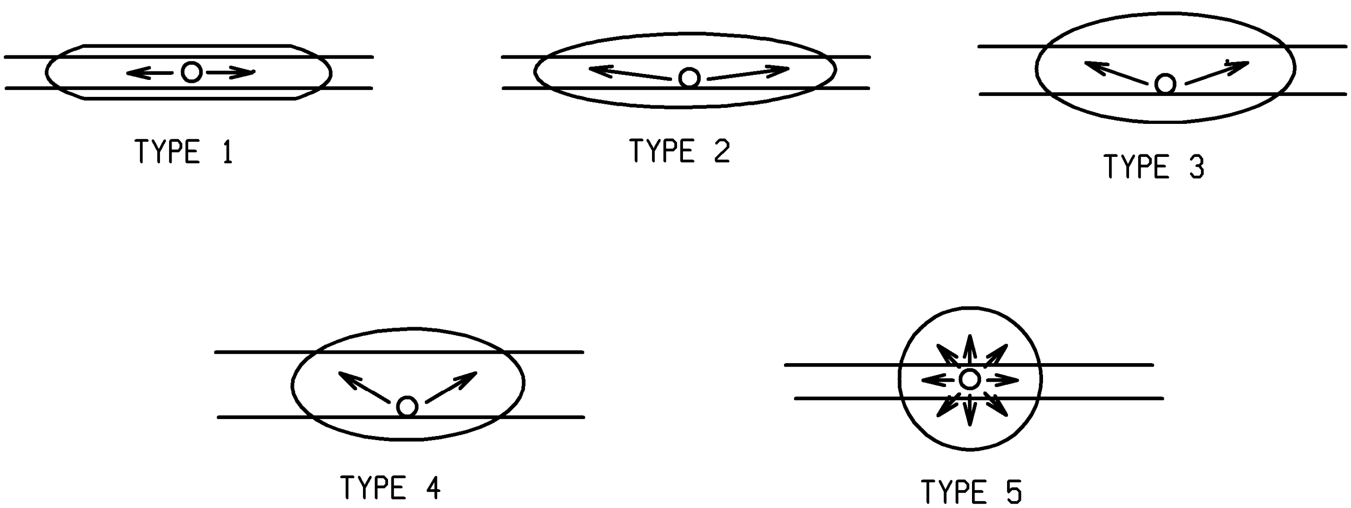


Figure 3
Width Classification

46.2.40 **Company Luminaires**

The IES Classification information for all luminaires used by the Company is found in STANDARDS Section 49 – Materials Index – Outdoor Lighting.

46.3 ROADWAY LUMINAIRES

This Section provides information for the proper application of horizontal roadway luminaires and other decorative pendant style luminaires with an IES type II or III distribution.

46.3.10 Mounting Height

Roadway luminaires must be installed at a sufficient height to minimize the glare to approaching traffic and at the same time provide an acceptable level of illumination at the roadway surface. The mounting height of a light source will affect the intensity of illumination, uniformity of brightness, area covered, and relative glare produced by the luminaire. Higher mounting heights will provide greater area coverage, more uniformity, and a reduction of glare, but a lower overall illumination level.

46.3.20 Overhead Supplied Installations

For lighting installations on wood distribution poles, the actual luminaire mounting height will be affected by other distribution equipment on the pole. In every case, adequate clearances, as specified in the Overhead Construction Standards Manual - Page 19, must be maintained. The roadway bracket rise will typically add 30 inches (±) to the luminaire mounting height as measured from the bracket through bolt height.

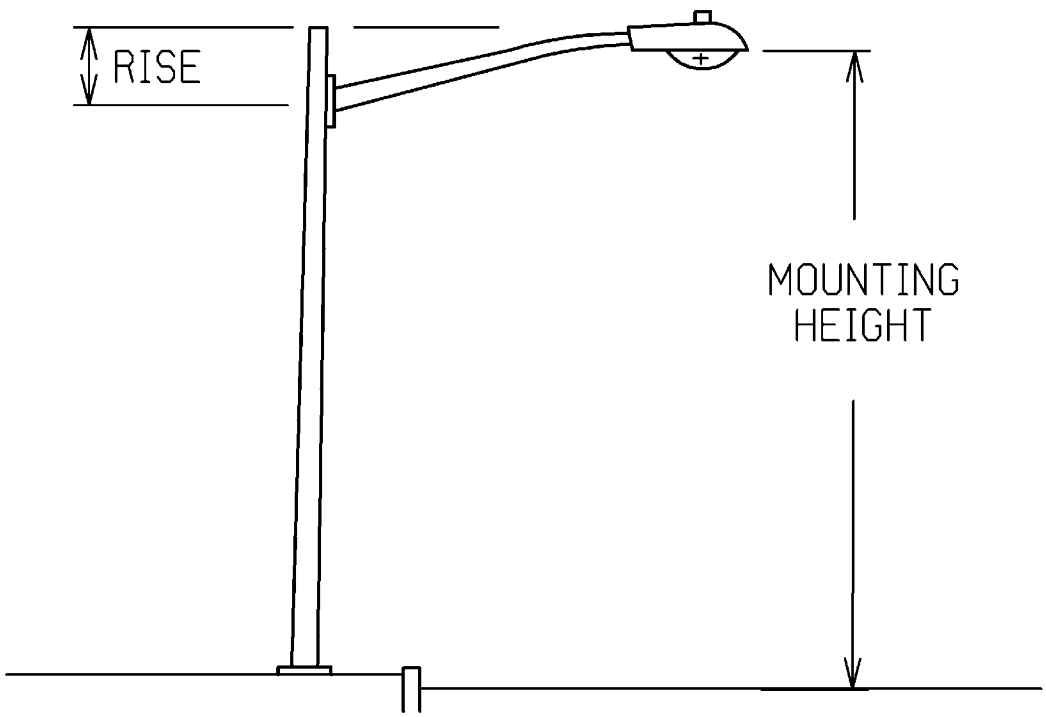


Figure 4
Luminaire Mounting Height

46.3.30 Recommended Minimum Roadway Luminaire Mounting Heights

Table 6

Luminaire Wattage	Minimum Mounting Height
50 Watt – 250 Watt	20 Feet
400 Watt	30 Feet
1,000 Watt	35 Feet

46.3.40 Arm / Bracket Length

The luminaire arm / bracket must have sufficient length to properly place the luminaire over the roadway surface in order to take best advantage of the luminaire light distribution pattern. Roadway luminaries with IES type II or III light distribution are designed to be mounted over the roadway surface near one side and still project useful light output across the entire roadway width. Common practice is to have the luminaire's refractor overhang the roadway surface by four feet.

46.3.50 To Determine Arm / Bracket Length

Add setback distance (determined by field measurement) to arm / bracket overhang distance (always 3 feet). The result will be the minimum arm / bracket length required. Installation of the luminaire will provide the additional distance needed to create a four foot overhang.

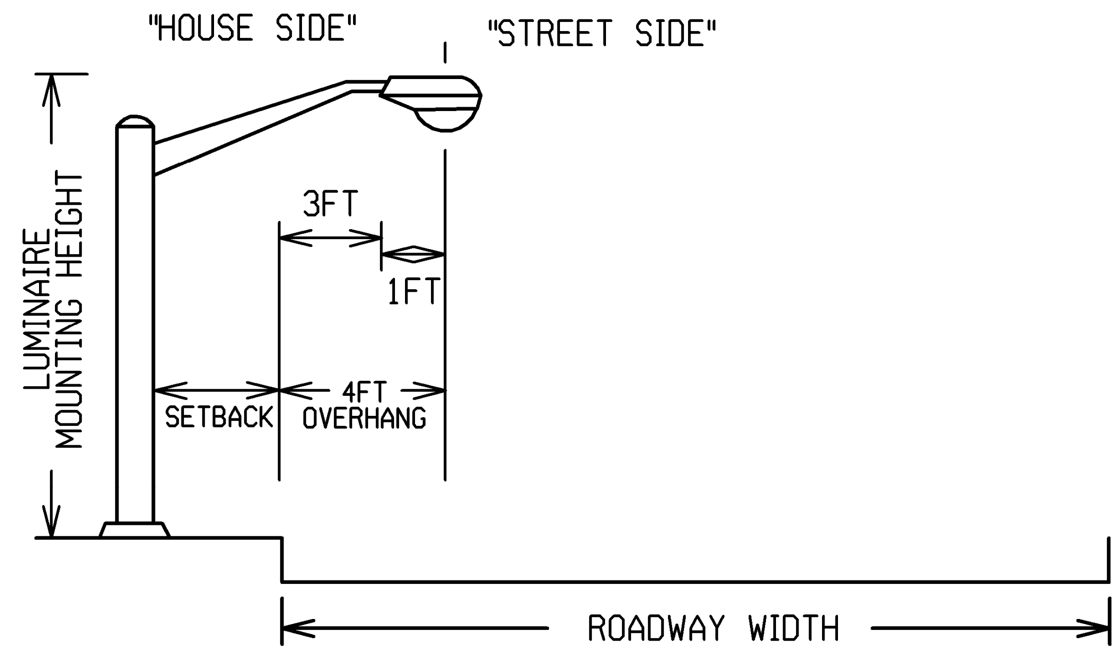


Figure 5
Arm / Bracket Length

46.3.60 Roadway Width

Roadway luminaries with an IES type II light distribution pattern are designed for roadways where the width does not exceed 1.75 times the luminaire mounting height. IES type III roadway luminaries are designed for roadway widths up to 2.75 times the luminaire mounting height.

If the roadway has multiple travel lanes or is divided, a roadway luminaire with Type II or Type III distribution will not be able to adequately illuminate the entire roadway width. A possible solution is to install luminaries on both sides of the roadway opposite one another.

46.3.70 Luminaire Adjustment

Tilting the luminaire five degrees upward will increase the "street side" illumination (and decrease the "house side" illumination). This may be a solution when a shorter arm / bracket must be used because of insufficient pole space or clearances.

46.3.80 Exceptions

Field conditions, such as trees, may necessitate using a different arm / bracket length than would normally be called for.

46.3.90 Luminaire Spacing

Luminaires should be spaced to allow the light output between adjacent luminaires to overlap. This will eliminate dark spots midway between two luminaires and contribute uniformity to the overall lighting installation.

46.3.100 Roadway Luminaire Selection

The State of New Hampshire has enacted "Dark Skies" legislation (House Bill 585-FN) which requires Liberty Utilities to use only luminaires which restrict the amount of light output allowed to go upward towards the sky.

To comply with this legislation, the following is effective immediately in New Hampshire:

1. We can no longer install any roadway luminaires in New Hampshire with semi-cutoff optics.
2. Existing semi-cutoff luminaires in service can remain in service until failure or until removed for any reason.
3. All new and replacement horizontal roadway luminaire installations shall use luminaires with cutoff (flat glass) optics. See Table 1 below
4. Semi-cutoff luminaires returned from the field shall be disposed of for scrap metal value. Do not return to inventory.

Table 1

Cutoff Roadway Luminaire

STD Item #	Item ID #	Description
SK03A1	8830-5821440	50w HPS Cutoff
SK03B1	8830-0810168	70w HPS Cutoff
SK03C1	8830-0811065	100w HPS Cutoff
SK03D1	8830-0811066	150w HPS Cutoff
SK03G1	8830-0811067	250w HPS Cutoff
SK03H1	8830-0811074	400w HPS Cutoff

46.4 FLOODLIGHT LUMINAIRES

This Section provides information for proper application of floodlight luminaries.

46.4.10 Mounting Height

Floodlight luminaires must be installed at a sufficient height in order to maximize the efficiency of the illumination output and at the same time control glare. The recommended mounting height for a floodlight luminaire is one half the distance across the area to be illuminated.

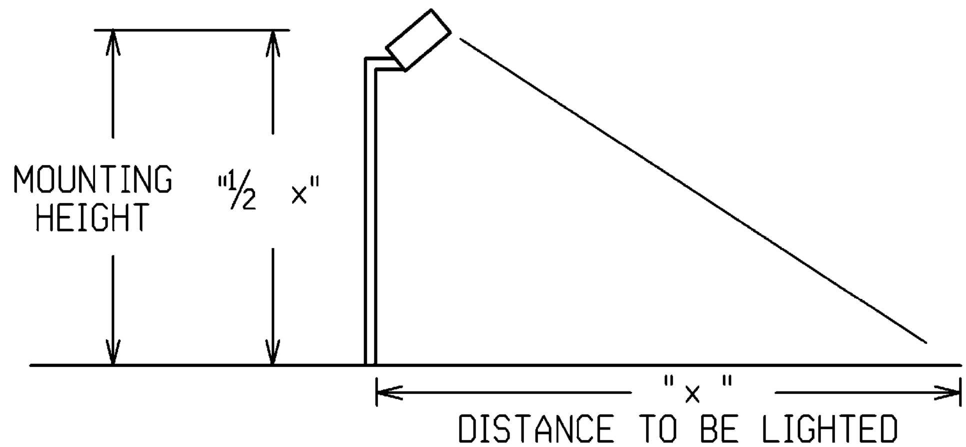


Figure 6
Floodlight Mounting Height

46.4.20 Clearance To Overhead Conductors

For floodlight installations mounted on wood distribution poles, the actual floodlight mounting height may be limited by other distribution equipment on the pole. In every case, adequate clearances, as specified in the Overhead Construction Standards Manual - Page 19-1, must be maintained.

46.4.30 Aluminum Pendant Pole Installations

Aluminum pendant poles are rated capable of supporting one floodlight luminaire along with one arm and roadway luminaire or two floodlight luminaires with no roadway luminaire. Ratings are based on a sustained 90 mph wind. Consult Standards Engineering if additional loading is required.

46.4.40 Floodlight Aiming

Floodlight luminaires must be properly aimed in order to obtain the desired illumination. Some floodlight luminaires have a sight aiming guide molded into the top of the housing. Follow the manufacturer's instructions.

46.4.50 Vertical Aiming

Vertical floodlight aiming affects the distance a floodlight luminaire can cover. To maximize the useful light output, the floodlight should be aimed ⅔ across the distance to be lighted, or approximately two times the mounting height, whichever value is lower. To minimize glare, a floodlight's vertical aiming point distance should never exceed twice the mounting height. See Figure 7 for details.

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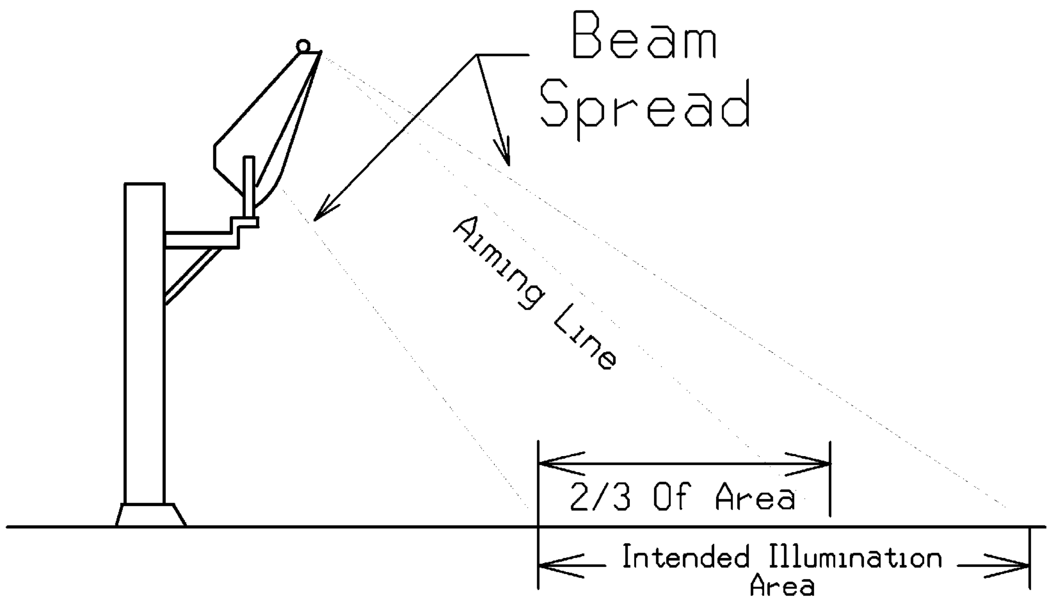


Figure 7
Floodlight Aiming – Vertical

46.4.60 **Horizontal Aiming**

Horizontal aiming must be considered when more than one floodlight is contributing to the illumination output. A floodlight's horizontal beam spread will extend 45 degrees on either side of the aiming line. Floodlight luminaires should be horizontally aimed to allow the light output between adjacent luminaires to overlap. This will contribute to overall uniformity to the overall lighting installation.

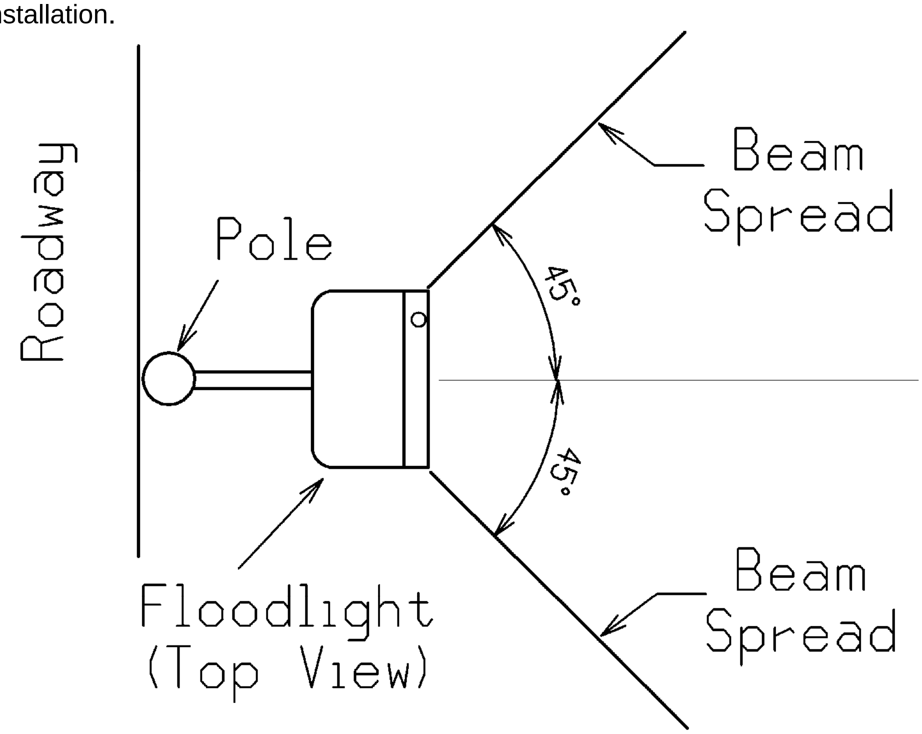


Figure 8
Floodlight Aiming – Horizontal

46.4.70 Pole Spacing

When a floodlighting installation consists of multiple luminaires mounted on different poles, pole spacing needs to be considered. In general, the spacing between adjacent floodlight poles should equal 4 times the luminaire mounting height.

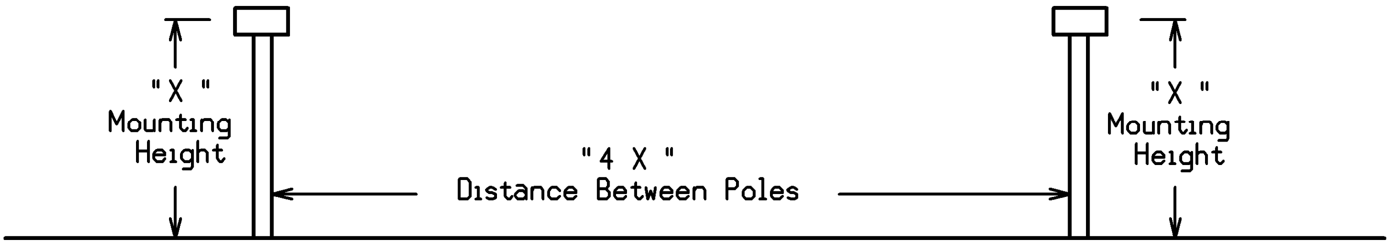


Figure 9
Floodlight Pole Spacing

46.4.80 Light Pollution

The State of New Hampshire has enacted "Dark Skies" legislation (House Bill 585-FN) which requires Liberty Utilities to use only luminaires which restrict the amount of light output allowed to go upward towards the sky.

To comply with this legislation, the following is effective immediately in New Hampshire:

1. All new and replacement floodlight luminaire installations shall include a visor. See Table 1 below.

Use care in the aiming of floodlights. Never allow a floodlight's light output to extend onto an adjacent roadway into the face of oncoming traffic. Never install a floodlight across a roadway from the intended illumination area. Always be sensitive to the spilling of unwanted light onto adjacent properties.

Table 1

Floodlight Luminaire		
STD Item #	**Item ID #**	**Description**
SJ03G	8830-0811060	250w HPS Floodlight
SJ03H	8830-0811061	400w HPS Floodlight
Visor		
SJ12D	8830-5825814	Visor for GE Floodlight
SJ20D	8830-9201362	Visor for Cooper Floodlight

46.5 POST TOP LUMINAIRES

This Section provides information for proper application of post top style luminaries.

46.5.10 Mounting Height

Post top luminaires must be mounted at a sufficient height to take best advantage of the luminaire's light output and at the same time minimize glare to approaching traffic. In New Hampshire all post top luminaires are mounted at a height of 14 feet.

46.5.20 Luminaire Orientation

Most post top luminaires that are commonly used By Liberty Utilities produce an IES Type III light distribution pattern (oval shaped light output pattern) and are provided with "street side" and "house side" orientation markings to facilitate proper installation. Follow the manufacturer's instructions, supplied with every luminaire, to properly direct the light output pattern.

46.5.30 Luminaire Spacing

Because of their lower mounting height, post top luminaires require a relatively close spacing between adjacent luminaires in order to produce a uniform illumination pattern without dark spots between luminaires. As a general rule, the spacing between adjacent post top luminaires should not exceed 5 times the luminaire mounting height.

46.5.40 Pole Application

Post top style poles are available in aluminum, galvanized steel, cast iron, and fiberglass. As a general rule, metal poles are preferred in "downtown" type applications typically subject to physical abuse from motor vehicle doors, snow plowing, etc. Fiberglass poles are preferred in underground residential developments, town parks, and other areas somewhat protected from such physical abuse.

46.5.50 Luminaire Selection

The State of New Hampshire has enacted "Dark Skies" legislation (House Bill 585-FN) which requires Liberty Utilities to use only post top luminaires which restrict the amount of light output allowed to go upward towards the sky.

To comply with this legislation, the following is effective immediately in New Hampshire:

1. We can no longer install any post top luminaires in New Hampshire with semi-cutoff optics.
2. Existing semi-cutoff post top luminaires in service can remain in service until failure or until removed for any reason.
3. All new and replacement post top luminaire installations shall use luminaires with cutoff (flat glass) optics. See Table below
4. Semi- cutoff post top luminaires returned from field shall be disposed of for scrap metal value. Do not return to inventory.

"Carriage" Post Top Luminaire

STD Item #	Item ID #	Description
SL75A	8830-9202744	50w HPS "Carriage"
SL75C	8830-9202745	100w HPS "Carriage"

46.6 ELECTRICAL DESIGN

This Section provides information to aid in the design of underground circuits supplying outdoor luminaries.

46.6.10 Series Circuits

No new series street lighting circuits shall be installed. Existing series circuits shall be converted to multiple operation any time there is a major component failure, additional load to be added, or substantial maintenance is required.

46.6.20 Multiple Circuits

All new underground lighting circuits shall be a multiple design where each individual luminaire is operating on a standard system secondary voltage (120 Volts preferred) and each individual luminaire is controlled by its own individual photoelectric control.

46.6.30 Preferred Underground Supply

The preferred underground supply design is to tap existing secondary mains with an individual radial feed supply to each single street light pole location.

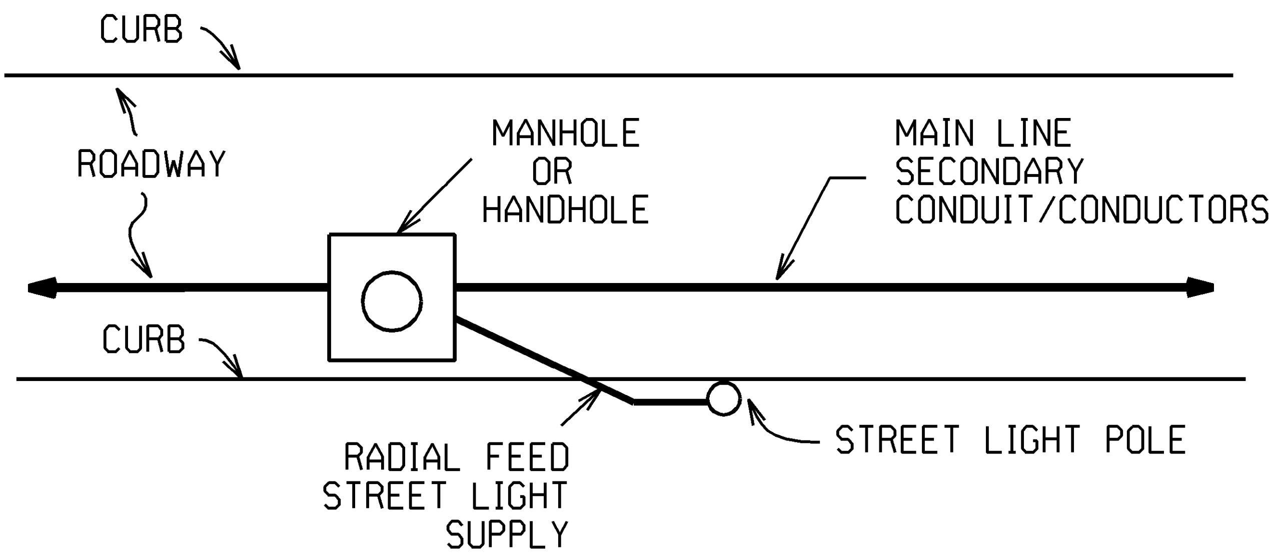


Figure 10
Street Light Supply from Existing Secondary Mains

46.6.40 Alternate Underground Supply

An alternate underground supply design is to provide a dedicated secondary main exclusively for outdoor lighting use and tap multiple luminaires onto this supply circuit at multiple locations.

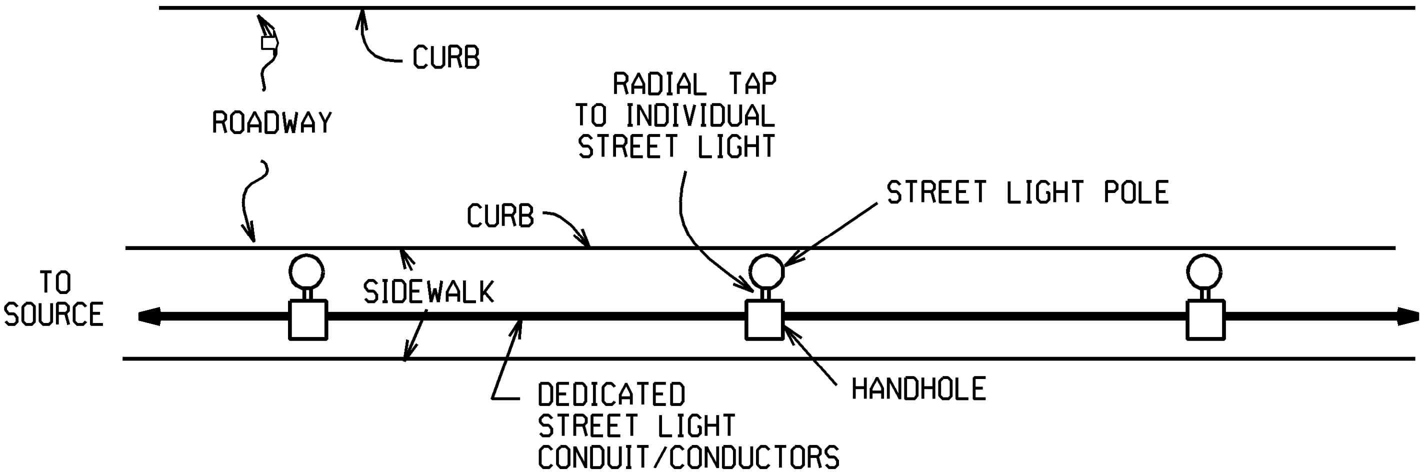


Figure 11
Street Light Supply from Dedicated Secondary Mains

46.6.50 Underground Supply Conductors

The standard underground conductor supplying a single radial fed street light pole location shall be #6 copper (STD Item W27). This conductor is available as (2) conductor - (BLACK-WHITE), or (3) conductor - (BLACK-WHITE-RED) and is suitable for both direct burial and conduit applications.

Conductor assignment shall conform to the following color code:
BLACK = Hot Lead
RED = 2nd Hot Lead
WHITE = Neutral

The underground supply conductors for a dedicated street light supply circuit shall be sized to supply the lighting load with respect to voltage drop. The standard copper conductors available for customer secondary mains are available for applications where #6 is not adequate. Underground taps to individual street light pole locations shall use #6 copper (minimum).

46.6.60 Luminaire Supply Conductors

Use #10 AWG stranded copper conductors (STD Item W29) in all outdoor lighting installations to connect the luminaire. In underground supplied installations, (on aluminum or fiberglass poles) use #10 conductors from the pole access handhole – up the pole - to the luminaire. Use #10 conductors on all wood pole, overhead supplied installations to connect the luminaire to the secondary supply.

Conductor assignment shall conform to the following color code:
BLACK = Hot Lead
WHITE = Neutral
GREEN = Luminaire Housing Ground

Supersedes 1/07 Issue – Revised paragraphs 46.6.50 and 46.6.60.

46.6.70 Electrical Connections

A. Black Lead (hot) **–** Use an in-line fuse holder (STD. Item SX31) to connect the underground supply conductors to the luminaire supply conductors. The in-line fuse holder is supplied with a solid copper link. A cartridge type fuse can be substituted when fusing is desired. The in-line fuse holder is designed to pull apart, in the event of a pole knockdown, and leave no exposed energized wires.

B. Neutral Lead – Use a gel-wrap connector (STD. Item SX30) to connect the underground supply conductors to the luminaire supply conductors.

46.6.80 Fusing

A. Radial Supplied Pole Locations **–** A 10 A midget cartridge fuse (STD. Item F10A10), installed in the in-line fuse holder, is recommended to provide elevated voltage protection in the event of a short circuit in the luminaire supply conductors.

B. Dedicated Underground Supply Circuits **–** Cartridge style fuses in watertight housings shall be installed at strategic circuit locations in dedicated underground lighting supply circuits as a sectionalizing device to add in finding underground faults. Fuses shall be sized with respect to the conductor size.

Supersedes 1/07 Issue – Removed Table 8

46.7 LUMINAIRES

This Section provides general requirements for all luminaires used throughout the Company service territory.

46.7.10 Utility Grade

All luminaires shall be designed for long term reliable use in street and area lighting applications.

46.7.20 Voltage Rating

The standard Company luminaire is designed to operate from a 120 VAC, 2 wire source. Luminaires with other voltage ratings are available as non-standard luminaires to meet specific application needs.

46.7.30 Ballast Selection

All Company luminaires use high intensity discharge lamp sources that require an internally mounted ballast transformer. Two types of ballast transformers are available for use.

Table 7
Ballast Selection

Ballast Type	Ballast Features
Reactor Ballast	● Single coil ballast wired in series with the lamp. ● Non-regulating – normal power factor ballast. ● Lowest ballast losses = least wasted energy. ● Tolerates line voltage variations to within + or – 5%. ● Standard ballast used in HPS luminaires below 250 Watts. ● Most economical purchase cost.
Regulated (CWA) Ballast	● Two coil ballast. – Constant Wattage Autotransformer ● Regulating – high power factor ballast ● Higher ballast losses than reactor ballast. ● Tolerates line voltage variations to within + or – 10%. ● Standard ballast used in HPS luminaires 250 Watts & above. ● Standard ballast used in all mercury vapor and metal halide luminaires. ● Higher purchase cost than reactor ballast.

Note: The lamp wattage and light source of any HID lamp must match the lamp wattage and light source rating of the HID luminaire it is to be used in. Lamps and luminaires with different wattage ratings or different light sources are not interchangeable.

46.7.40 Starting Aids

All high pressure sodium vapor luminaires require a separate starter to ignite the lamp. The Company Standard is to require a field replaceable plug-in starting aid whenever possible.

46.7.50 Terminal Block

Whenever possible, all Company luminaires shall have a terminal connection block for attachment of the source wiring.

Standard 2 wire, 120 Volt luminaires shall have a three terminal block with the middle terminal connected to the luminaire metal housing with a green housing ground wire.

Non-standard voltage luminaires shall have a two terminal connection block or three terminal connection block as needed.

46.7.60 Luminaire Electrical Load Data

Table 8
Luminaire Data

Luminaire Description			Luminaire Component Loads				
Wattage & Light Source	**Ballast Type**	**Source Voltage**	**Rated Lamp Wattage**	**Ballast Wattage**	**Photo Control Wattage**	**Total Wattage Load**	**Maximum Input * Amperage**
100 Watt – MV *ANSI H-38*	Regulated	120 VAC	100 Watts	29 Watts	1 Watt	130 Watts	1.1 A
175 Watt – MV *ANSI H-39*	Regulated	120 VAC	175 Watts	35 Watts	1 Watt	211 Watts	1.7 A
250 Watt – MV *ANSI H-37*	Regulated	120 VAC	250 Watts	56 Watts	1 Watt	307 Watts	2.8 A
400 Watt – MV *ANSI H-33*	Regulated	120 VAC	400 Watts	76 Watts	1 Watt	477 Watts	4.0 A
1,000 Watt – MV *ANSI H-36*	Regulated	120 VAC	1,000 Watts	94 Watts	1 Watt	1,095 Watts	2.5 A
50 Watt - HPS *ANSI S-68*	Reactor	120 VAC	50 Watts	10 Watts	1 Watt	61 Watts	1.5 A
70 Watt - HPS *ANSI S-62*	Reactor	120 VAC	70 Watts	15 Watts	1 Watt	86 Watts	2.0 A
70 Watt - HPS *ANSI S-62*	Regulated	120 VAC	70 Watts	19 Watts	1 Watt	90 Watts	0.8 A
100 Watt - HPS *ANSI S-54*	Reactor	120 VAC	100 Watts	17 Watts	1 Watt	118 Watts	3.2 A
100 Watt - HPS *ANSI S-54*	Regulated	120 VAC	100 Watts	23 Watts	1 Watt	124 Watts	1.2 A
150 Watt - HPS *ANSI S-55*	Reactor	120 VAC	150 Watts	22 Watts	1 Watt	173 Watts	4.4 A
150 Watt - HPS *ANSI S-55*	Regulated	120 VAC	150 Watts	36 Watts	1 Watt	187 Watts	1.6 A
250 Watt - HPS *ANSI S-50*	Regulated	120 VAC	250 Watts	53 Watts	1 Watt	304 Watts	2.5 A
400 Watt - HPS *ANSI S-51*	Regulated	120 VAC	400 Watts	69 Watts	1 Watt	470 Watts	3.9 A
1,000 Watt - HPS *ANSI S-52*	Regulated	120 VAC	1,000 Watts	105 Watts	1 Watt	1,106 Watts	9.7 A
175 Watt – MH *ANSI M-57*	Regulated	120 VAC	175 Watts	31 Watts	1 Watt	207 Watts	1.8 A
250 Watt – MH *ANSI M-58*	Regulated	120 VAC	250 Watts	44 Watts	1 Watt	295 Watts	2.6 A
400 Watt – MH *ANSI M-59*	Regulated	120 VAC	400 Watts	50 Watts	1 Watt	451 Watts	4.0 A
1,000 Watt – MH *ANSI M-47*	Regulated	120 VAC	1,000 Watts	77 Watts	1 Watt	1,078 Watts	9.0 A
175 Watt – PSMH *ANSI M-152E*	Regulated	120 VAC	175 Watts	23 Watts	1 Watt	199 Watts	1.78 A
250 Watt – PSMH *ANSI M-153E*	Regulated	120 VAC	250 Watts	30 Watts	1 Watt	281 Watts	2.5 A
400 Watt – PSMH *ANSI M-155E*	Regulated	120 VAC	400 Watts	48 Watts	1 Watt	449 Watts	4.0 A

* = Maximum input amperage = Starting amperage. Operating amperage will be lower.

Supersedes 1/07 Issue – Revised Table 8. Added Pulse Start Metal Halide.

46.8 LUMINAIRE LAMP IDENTIFICATION

This Section covers the labeling system used on all mercury vapor, high pressure sodium vapor, and metal halide luminaires for field identification of the lamp wattage and light source.

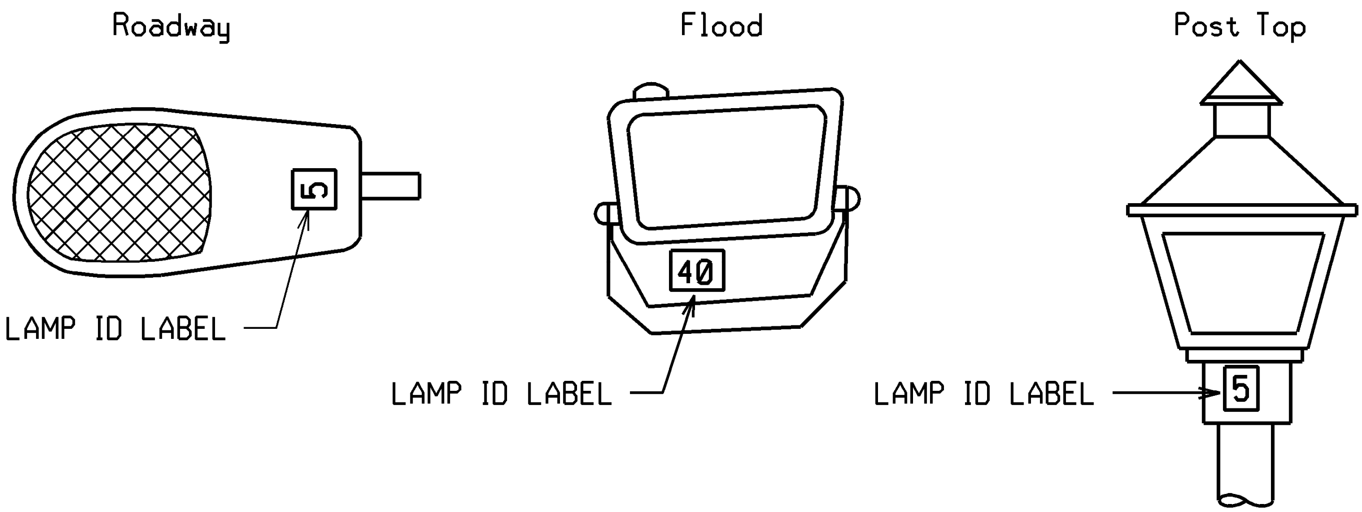


Figure 12
Typical Label Placement on Common Luminaires

46.8.10 Lamp Identification

A number / color code label system is used to identify the wattage and light source of all luminaires. All roadway and floodlight luminaires use a 3 inch square label. All post top luminaires use a 1 inch square label. New luminaires come with factory installed labels. Replacement labels are available from Stores for maintenance. See Figure 12 for typical label locations on commonly used luminaries.

Table 9
Wattage Code Numbers

Wattage	Wattage Code Number
50	“5”
70	“7”
100	“10”
150	“15”
175	“17”
250	“25”
400	“40”
1,000	“X1”

Table 10
Light Source Color Code

Light Source	Label Background Color
Mercury Vapor	Blue
High Pressure Sodium Vapor	Yellow
Metal Halide – Probe Start	Red
Metal Halide – Pulse Start	Red / White

Supersedes 07/09 Issue – Revised Table 10. Deleted green retrofit label.

46.9 LUMINAIRE OWNERSHIP IDENTIFICATION

This Section covers the labeling system used on all luminaires to identify the luminaire owner and / or party responsible for maintenance.

46.9.10 Customer Owned & Maintained Luminaires

Customer owned and maintained luminaires that are installed on Company poles are identified by two customer supplied labels detailed as follows:

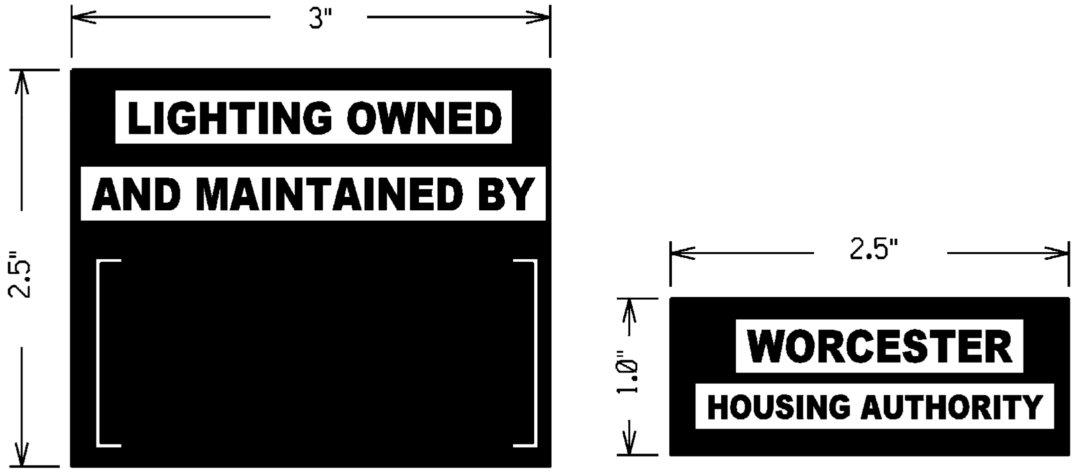


Figure 13
Customer Owned & Maintained Luminaire Label Example

Both labels shall have a black background and reflective silver legend. The label identifying the owner shall be applied within the brackets of the larger label.

Supersedes 1/07 Issue – Revised paragraph 46.10.20 – Mercury lamp usage.

46.10 LAMPS

This Section provides technical information on incandescent and high intensity discharge (HID) lamps available for use in all Company outdoor lighting installations.

46.10.10 Incandescent Discharge Lamps

Incandescent lamps are available for maintenance of existing multiple incandescent street lighting installations only.

46.10.20 High Intensity Discharge Lamps

High pressure sodium vapor and pulse start metal halide, high intensity discharge lamps are the standard lamps available for use in all new outdoor lighting installations. Mercury vapor lamps are available until January 1, 2016 for maintenance of existing mercury vapor installations only.

46.10.30 Theory Of Operation

All high intensity discharge (HID) lamps have a sealed, gas filled, arc tube with electrodes at each end. Once energized, an electric arc is created between these two electrodes. This caused gasses and metals within the arc tube to vaporize, giving off energy as illumination.

Because HID lamps have negative resistance characteristics, they must be used with a ballast transformer rated for the specific lamp type and lamp wattage.

Note: The lamp wattage and light source of any HID lamp must match the lamp wattage and light source rating of the HID luminaire it is to be used in. Lamps and luminaires with different wattage ratings or different light sources are not interchangeable.

Table 11
HID Lamp Characteristics

Lamp Type	Color Output	Efficiency (Initial Lumens/Watt)	Restrike Time	Most Common Failure Mode
Mercury Vapor	Blue / White	34 - 63	3 – 6 minutes	Gradually Dims
High Pressure Sodium Vapor	Orange	51 - 140	1 minute	Cycles
Metal Halide	White	68 - 120	10 – 15 minutes	Extinguishes

46.10.40 Lamp Safety

All HID lamps run very ***HOT***. Use Extreme Caution!

WARNING: An HID lamp with a broken outer glass bulb will give off ultraviolet radiation. Always de-energize lamp before attempting replacement.

46.11 MULTIPLE CONTROL RELAYS

This Section covers application details for multiple control relays. A multiple control relay allows group control of a quantity of luminaires. This type of control is most often used when the circuit is designed exclusively for outdoor lighting and individual photoelectric controls cannot achieve desired operational results. Examples would be underpass lighting where adequate daylight may never reach the photocontrol, or areas where artificial light sources prevent the photoelectric control from operating. The number of luminaires a multiple control relay can control is limited by voltage drop and relay capacity.

46.11.10 Multiple Control Relay Operation

A standard twistlock photocontrol is used as the daylight sensing device and controls the multiple control relay, which in turn, energizes or de-energizes the dedicated lighting circuit.

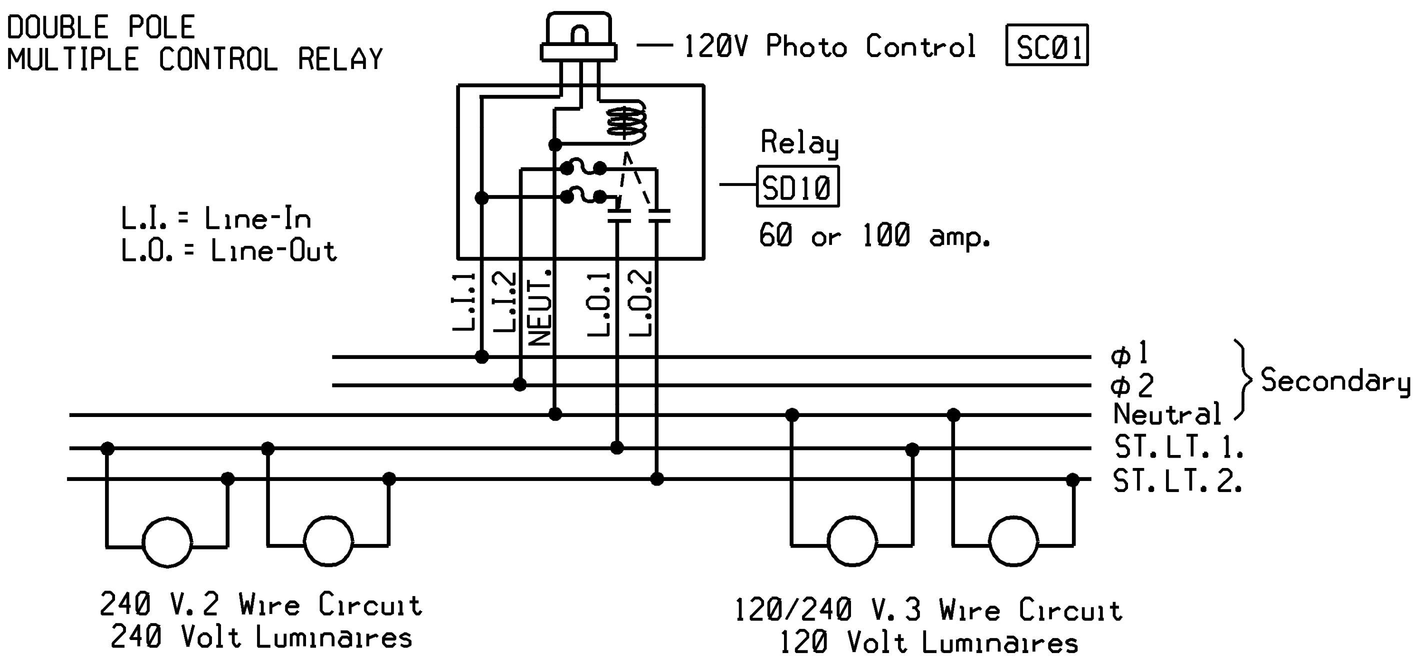


Figure 15
Multiple Control Relay Wiring Diagram

Notes:

1. Bond all neutrals, circuit grounds and pole or bracket grounds to secondary neutral.
2. Internal relay contacts shown are normally open (coil de-energized).

Supersedes 1/07 Issue – Revised Table 12. Redefined use of BLUE and GREEN photocontrols.

46.12 TWISTLOCK PHOTOELECTRIC CONTROLS

This Section provides instructions for installation and field testing twistlock photoelectric outdoor lighting controls (photocontrols).

Twistlock photocontrols are used for dusk to dawn control of nearly all outdoor lighting installations. Select the proper photocontrol to use based on the operating voltage of the luminaire. The operating voltage of the photocontrol is identified on the base of the photocontrol and can also be determined by the color of the photocontrol housing.

Table 12
Housing Color Code for Twistlock Photocontrols

Housing Color	Voltage Rating	Use
GRAY	105-130 VAC	Use on all new and existing 120 Volt luminaires.
BLUE	105-300 VAC	May be used on 120 Volt luminaires. ***MUST*** be used on 2 wire 240 Volt and 277 Volt luminaires ***MUST*** be used on all LED luminaires
GREEN	105-130 VAC	Part Night Control – Allows partial night operation of luminaire. Use only upon specific request.

46.12.10 Installation

Install photocontrol with the control window facing NORTH, however, reposition as necessary to avoid pointing the window towards artificial light which could cause unwanted photocontrol operation. See luminaire instruction sheet for information on adjusting the photocontrol receptacle. Upon installation, twist the photocontrol clockwise to lock it in position.

46.12.20 Field Testing

Cover and uncover the photocontrol window and check for luminaire “turn on” and “turn off”. If the photocontrol exhibits any chatter noise when switching, DO NOT USE. Turn in the photocontrol as defective and replace with another photocontrol. At night, test operation by aiming a flashlight into the photocontrol window.

Note: Some photocontrols have a short time delay on “turn on” and/or “turn off”. Allow time for the control to operate.

46.12.30 Warranty Information

All photocontrols are under warranty for 6 years from the date of manufacture. Twistlock photocontrols have the year of manufacture molded into the top of the housing. Photocontrols which fail in service within the 6 year warranty shall be saved for return to the manufacturer for warranty replacement.

46.12.40 Photocontrol Maintenance

A. Electro-Mechanical Photocontrols – Twistlock photocontrols purchased prior to 1996 are electro-mechanical units. These controls can be identified by the date code on the top of the housing. As this type of control ages, its light level setting will drift, causing an undesirable increase in the number of luminaire burning hours. When performing any type of maintenance on a luminaire with this type of photocontrol, replace the photocontrol if it is greater than 5 years old.

B. <u>Electronic Photocontrols</u> – Twistlock photocontrols purchased by the Company since 1996 are electronic controls. This type of photocontrol will hold the proper light level setting throughout its life and will not drift the way an electro-mechanical control will. When performing any type of maintenance on a luminaire with an electronic photocontrol, replace the photocontrol only if it has failed, or is greater than 10 years old.

Table 13
Twistlock Photocontrol Accessories

Description	Housing Color	Use
"OPEN" Receptacle Cap	RED	Used in place of a twistlock photocontrol to leave the lamp load permanently "OFF".
"SHORTING" Receptacle Cap	BLACK	Used in place of a twistlock photocontrol to leave the lamp load permanently "ON".
Twistlock Photocontrol Receptacle with Mounting Bracket.	N/A	Use when a twistlock photocontrol must be pole or crossarm mounted. The mounting bracket may be adapted for ½ inch conduit or knockout mounting.

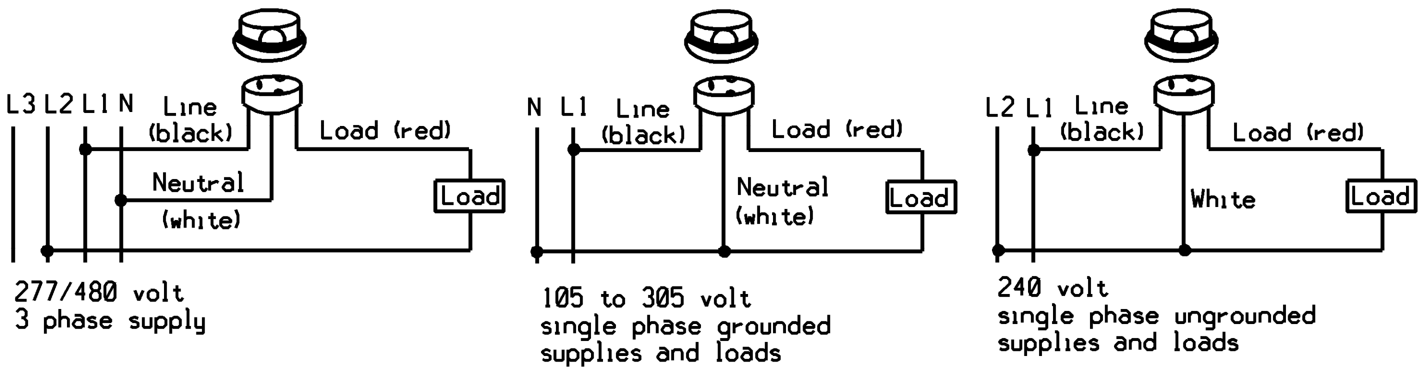


Figure 16
Wiring Diagrams for Photocontrol Receptacle Mounting Bracket

46.12.50 <u>"Part Night" Luminaire Operation</u>

The State of New Hampshire has enacted "Dark Skies" legislation (House Bill 585-FN) which requires Liberty Utilities to offer "part night" operation of street and area lighting luminaires as an ***option*** that customers can choose to save energy. This option is available **<u>ONLY</u>** upon specific request from a customer.

To comply with this legislation, Liberty Utilities has introduced a new photoelectric control specifically designed for part night operation. This new photoelectric control will operate as follows:

The new control will turn the luminaire: "ON" at dusk. "OFF" ½ way through the night (*approx. 12:00AM*) "ON" 5-1/2 hours later. (*Next morning's commute*) "OFF" at dawn.	 Part Night Control STD Item "SC04 Item ID # 8830-9202661 Photocontrol will have a GREEN housing

46.13 BUTTON PHOTOELECTRIC CONTROLS

This Section provides instructions for installation and field testing button style photoelectric outdoor lighting controls (photocontrols).

Button photocontrols are available for dusk to dawn control of certain decorative luminaires. They are used only when space on the luminaire is not available for a standard twistlock photocontrol or when use of a twistlock photocontrol would detract from the luminaires appearance.

46.13.10 Installation

Mount the button photocontrol inside the luminaire housing using the plastic locknuts provided. Mount the rubber “O-ring” to the outside of the luminaire housing under the plastic locknut to provide a weatherproof seal. See Figure 17 for details.

Note: Only the window and threaded nipple are rain tight. The body of the button photocontrol is not rain tight. Orient the photocontrol body with the leads facing downward and form a drip loop with the wiring to direct water away from the photocontrol.

Adjust the luminaire housing if the button photocontrol window is pointing towards artificial light which could cause an unwanted photocontrol operation. Be aware that this adjustment may require a subsequent adjustment of the luminaire’s optical assembly to maintain the proper roadway light distribution pattern. See instructions supplied with the luminaire.

Electrically connect the button photocontrol using wire nuts.

BLACK wire = Source wire (hot) – **WHITE** wire = Neutral wire. – **RED** wire = Load wire (hot)

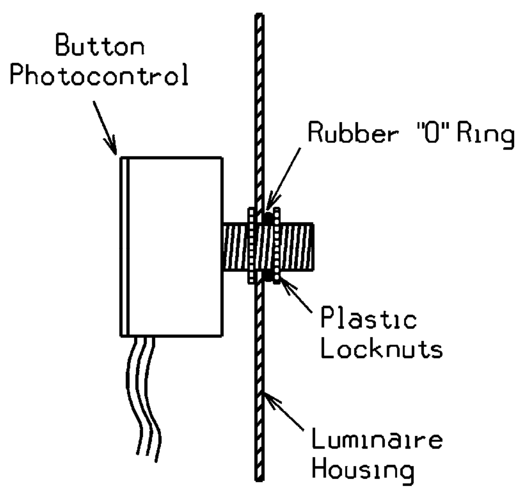


Figure 17
Button Photocontrol Mounting

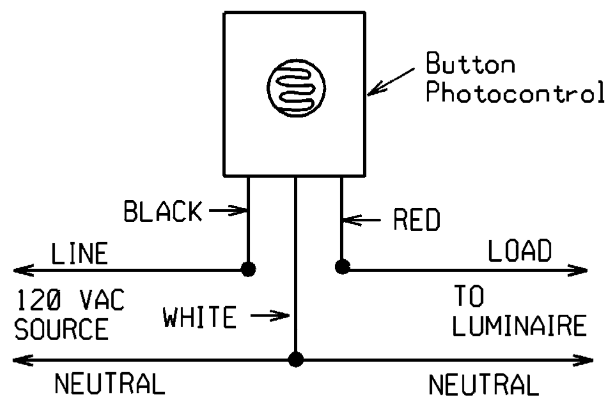


Figure 18
Button Photocontrol Wiring Diagram

46.13.20 Field Testing Button Photocontrols

Cover and uncover the photocontrol window and check for luminaire “turn on” and “turn off”. If the photocontrol exhibits any chatter noise when switching, DO NOT USE. Turn in the photocontrol as defective and replace with another photocontrol. At night, test operation by aiming a flashlight into the photocontrol window.

Note: Button photocontrols have a 1 minute (±) time delay on “turn on” and/or “turn off”. Allow time for the control to operate.

46.13.30 Warranty Information

All photocontrols are under warranty for 4 years from the date of manufacture. Button photocontrols have the date of manufacture identified on the side of the housing. Photocontrols which fail in service within the 4 year warranty shall be saved for return to the manufacturer for warranty replacement.

46.13.40 Photocontrol Maintenance

Button photocontrols should be replaced only when the unit has failed.

46.14 POLES

This Section provides general requirements and application information for all anchor base and embedded poles used for street lighting service.

46.14.10 Loading

In general, all poles have been engineered to support the expected loading imposed by the luminaire(s) and supporting arm(s). Loading details specific to any particular pole style are included in the construction standard for that pole style. All ratings are based on a sustained 90 mph wind.

MUNICIPAL ATTACHMENTS – BANNERS, FLOWERPOTS, SIGNS, ETC. – In general, poles do not have sufficient spare strength to support the additional loading imposed by municipal attachments. These attachments, particularly banners, can often far exceed the pole's wind loading capacity. In some cases, however, limited additional loading may be possible. Each request must be evaluated on a case-by-case basis. In every case, the customer must furnish the following information:

A. Effective Projected Area, (EPA) of the proposed attachment (this is a square foot measurement describing the wind displacement requirements of the attachment).

B. Weight of the proposed attachment.

C. Exact attachment location on the pole.

D. Pole height and pole manufacturer.

E. Proposed method of attachment to the pole. (In no cases shall any pole ever be field drilled to accommodate any municipal attachment).

With this information, Distribution Standards Engineering will then consult the pole manufacturer to determine if the municipal attachment can be safely supported.

46.14.20 Installation Notes

Poles shall never be installed without the luminaire(s). The luminaire(s) contribute to dampen wind induced vibration forces which could lead to pole failure.

46.14.30 Embedded Poles

In general, embedded poles are designed to be used with direct buried supply conductors. In cases where an embedded pole must be installed with conduit enclosed supply conductors, install a handhole (Std. Item SG10) adjacent to the pole. See STANDARDS Section 46.17 for handhole installation details. Direct buried conductors can then be installed between the handhole and the embedded pole.

46.14.40 Anchor Base Poles

Anchor base poles are designed to be used with precast concrete foundations. Although conduit enclosed supply conductors are preferred, direct buried supply conductors can be installed directly into the conduit slot in precast concrete foundations. See STANDARDS Section 46.18 for information on the bolt circle patterns required by the Company's standard pole offerings.

46.14.50 Festoon Outlets

See STANDARDS Section 46.36.

46.15 POLE NUMBER AND REFLECTOR INSTALLATION

This Section covers requirements for installing pole number decals and pole reflectors on all metal and fiberglass lighting poles.

46.15.10 Pole Numbers

Every pole shall be numbered in accordance with Figure 19. Pole surface must be clean and dry. Install pole number decals on the roadway side of pole 6 feet above finished grade.

Always use 13/4 inch x 3 inch, high intensity WHITE, reflective pole number decals. (STD Item Sx20) ***Do not use yellow reflective number decals.***

Always install pole number decals HORIZONTAL to each other as shown in Figure 19. – ***not vertical*****.**

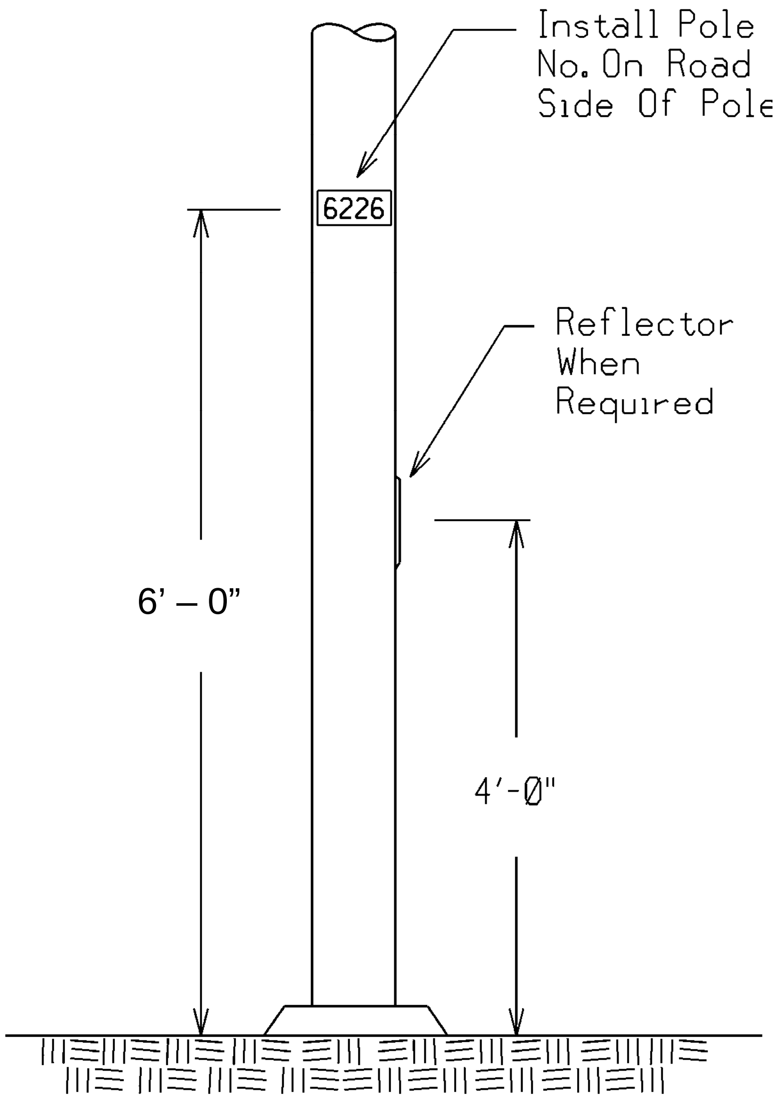


Figure 19
Pole Number Installation

46.15.20 Pole Reflectors

In New Hampshire, pole reflectors (STD Item # Z12B White, Z12D Yellow) are not required on poles. Pole reflectors could be installed on company poles if requested by a state or municipal authority or may be used where deemed appropriate. For installation of reflectors see as follows:

The pole surface shall be clean and dry. Install 3 inch x 10 inch adhesive high intensity pole reflectors, vertically, facing traffic, centered 4 feet above grade.

A. Reflector Color

On ramps, freeways, divided highways, and one way streets, reflective material shall face oncoming traffic and shall be colored white on the right side of the roadway and yellow on the left side of the roadway. On two way undivided roadways, reflective material shall be colored white and shall be placed on poles to the right of, and facing, oncoming traffic on each side of the road.

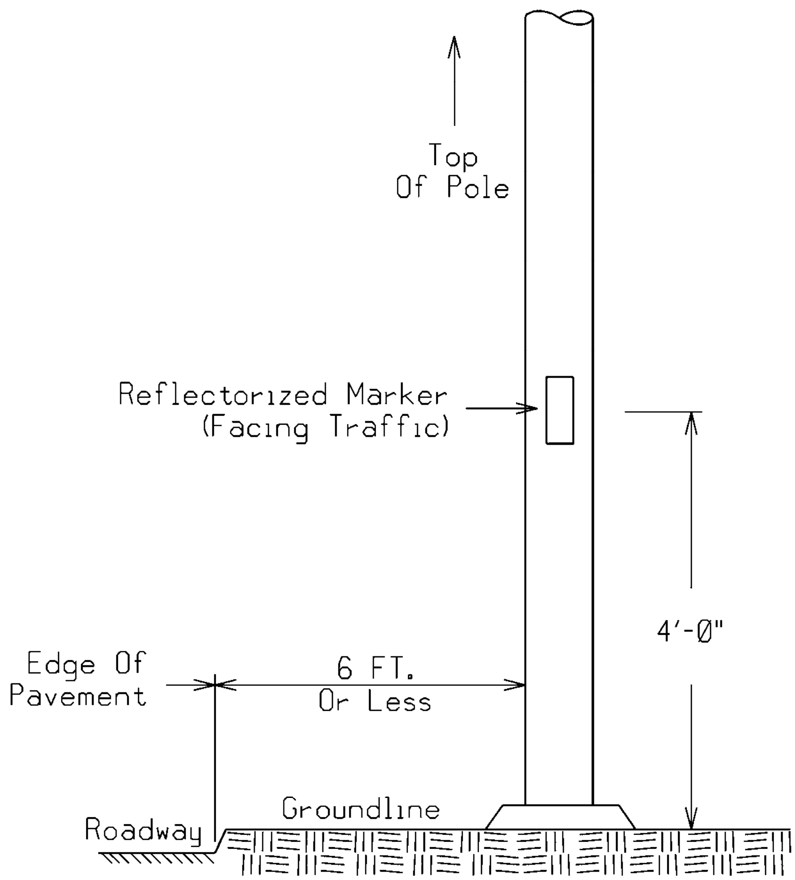


Figure 20
Pole Reflector Installation

Supersedes 1/07 Issue – Deleted Table 16. Revised paragraph 46.15.20.

46.16 PRECAST CONCRETE STREET LIGHTING FOUNDATION

This Section provides details for installation of a precast concrete lighting foundation.

46.16.10 Foundation Design

All precast concrete lighting foundations have a built-in slotted opening to facilitate conduit or direct buried supply conductors.

46.16.20 Anchor Bolt Size

Precast concrete foundations with ¾ inch diameter anchor bolts are designed for use with post top poles 16 feet and under in height. They shall not be used to support taller poles.

Precast concrete foundations with 1 inch diameter anchor bolts are available for use with 25 foot and taller poles.

46.16.30 Foundation Location

The precast foundation should be placed within the area between the sidewalk and edge of the roadway. Utilize the utility corridor or grass strip when available. When possible, place pole 6 to 12 inches away from the roadway edge to provide protection from vehicles and snowplows, etc. When installed within the sidewalk area, be sensitive to wheelchair access.

46.16.40 Bollards

Poles installed adjacent to parking lots or other locations with direct exposure to backing motor vehicles shall be protected by bollard(s). Use a 3 inch galvanized steel pipe filled with concrete and painted yellow.

46.16.50 Excavation

Excavate hole to required depth. Foundation should rest on undisturbed earth.

46.16.60 Backfill

Backfill material should consist of good compactable materials such as approved native soils, sand or select backfill material. Backfill in 6 inch segments and tamp thoroughly. Avoid large rocks.

46.16.70 Conduit System

Foundations are supplied with a 2 – 2" PVC conduit coupling flush openings are designed to accept (2) two inch diameter conduits oriented 180 degrees apart. This allows the underground supply to be extended to the next pole location without the need of a handhole adjacent to the foundation (Maintenance Only). If a handhole installation system is used refer to Std. 46.17.

46.16.80 Grounding

Install ground rod and grounding conductor at each pole location. Always connect grounding conductor to all metal conduits.

46.16.90 Protection

Install temporary foundation cover (Std. Item SF40) if pole is to be installed at a later date.

 Doc. # ST. 46.00.017

Table 14
Precast Concrete Foundations

Std. Item	Description	
SF01	**Precast Concrete Foundation - 8½" Bolt Circle with (4) ¾" anchor bolts** 24" x 24" x 48" depth - conduit opening 2 PVC conduit coupling flush - weight = 2,225 # Refer to Liberty Utilities Material Spec. # LU-MS6640	
	For use with Std. Item poles:	
	SW01C1	14' "Suburban" fiberglass post top pole – 8830- 5100003
SF10	**Precast Concrete Foundation - 11½" Bolt Circle with (4)-1" anchor bolts** 24" x 24" x 60" depth - conduit opening 2 PVC conduit coupling flush - weight = 2,500 # Refer to Liberty Utilities Material Spec. # LU-MS6650	
	For use with Std. Item poles:	
	ST01	30' "Pendant" aluminum roadway poles – 8830-5821833 30' "Pendant" style with festoon outlet box & cover – 8830-9202005 35' "Pendant" aluminum roadway poles – 8830-5821834
	For use with Std. Item poles:	
SW03	Embedded Square Fiberglass (**Maintenance Only**) replace wood embedded pole	
	Std. Item poles:	
	SW03C	18 Foot Suburban Embedded Square Fiberglass Lighting Pole Item ID # 8830-5106561
	For use with Std. Item poles:	

Supersedes 7/09 Issue – Revised Table 14.

46.16.100 **<u>All Precast Foundations</u>**

Anchor bolt projection above the top of the concrete = 2¾ inches.

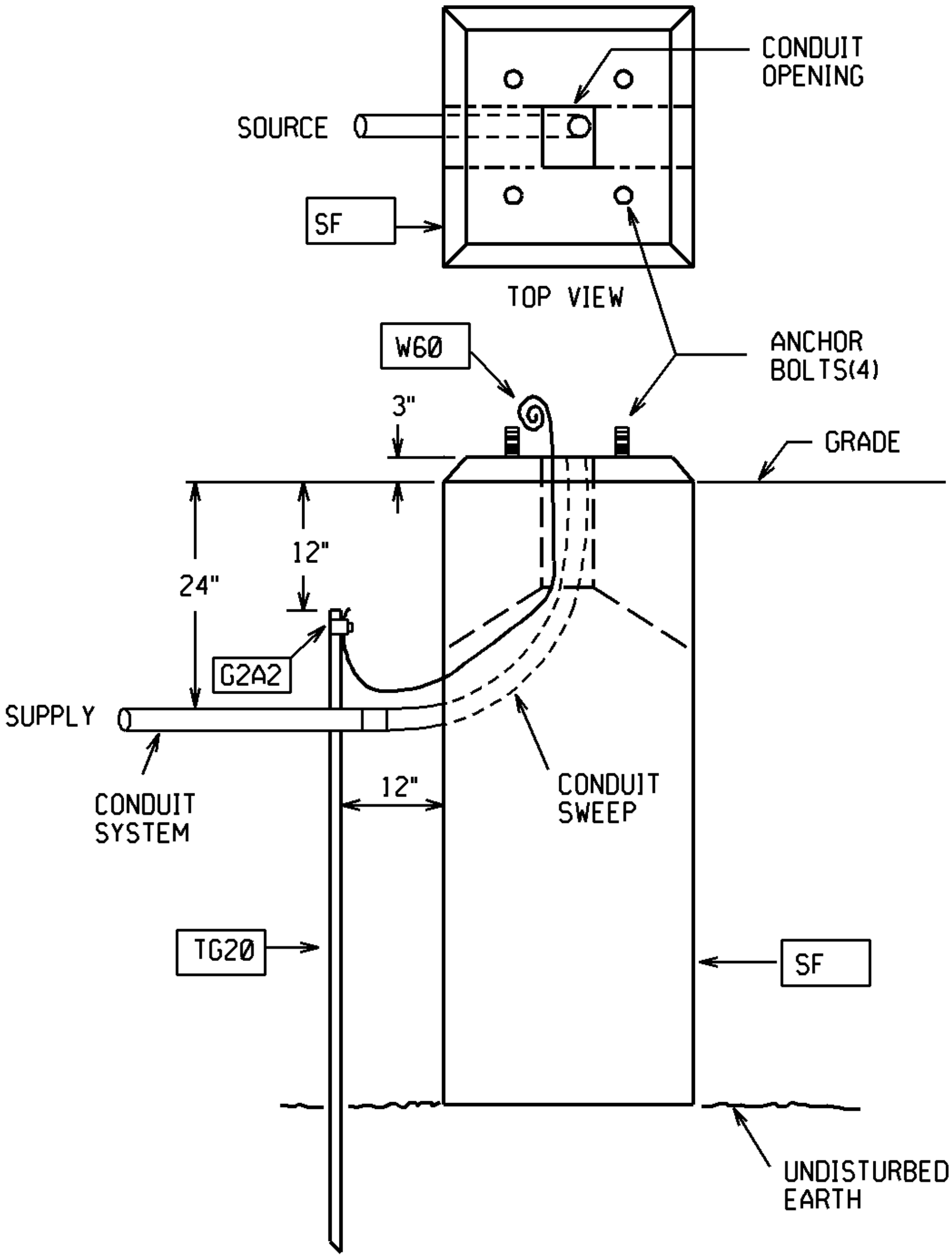


Figure 21
Precast Concrete Foundation – Single Source

 Doc. # ST. 46.00.017

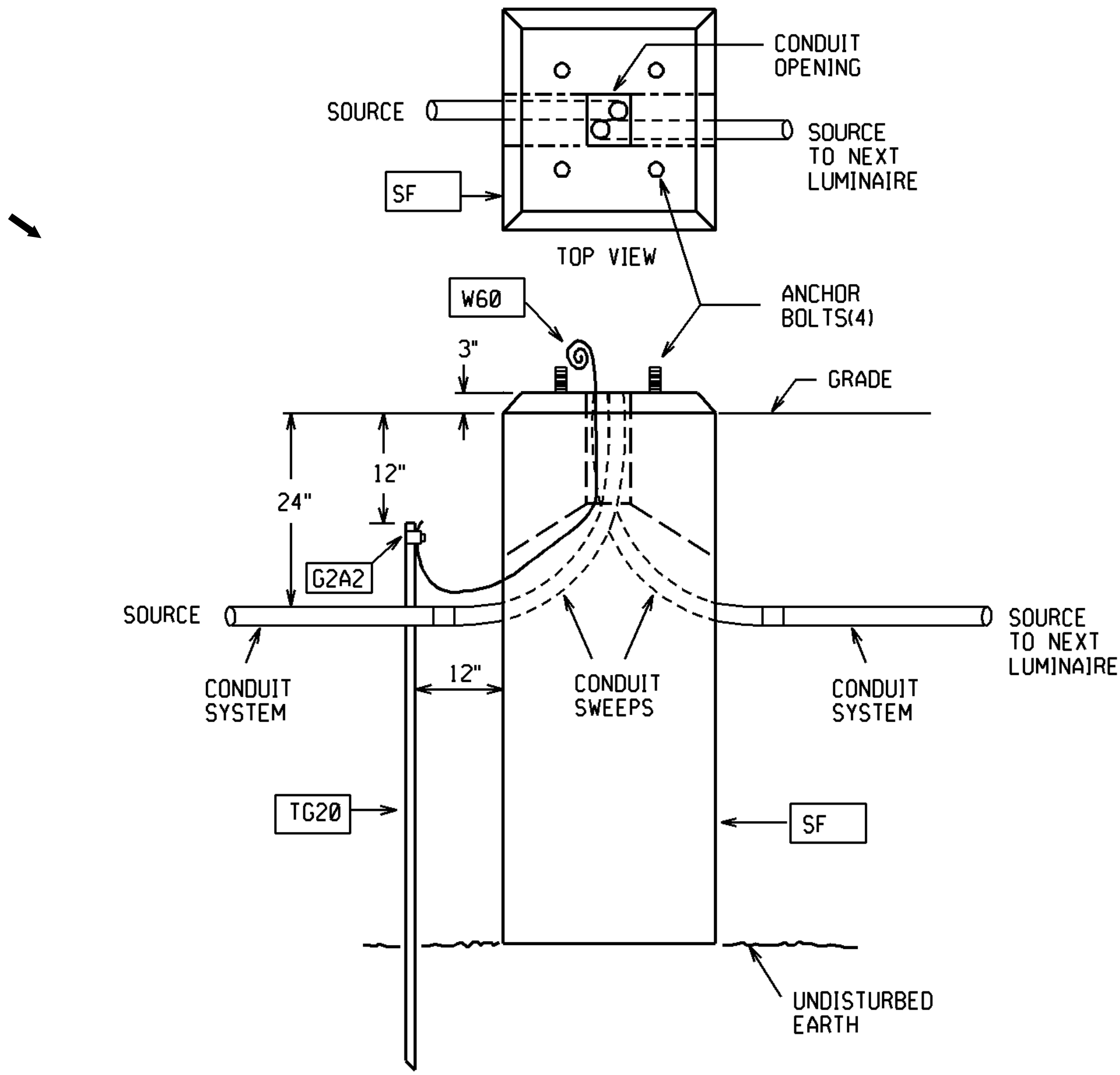


Figure 22
Precast Concrete Foundation – Twin Source

Supersedes 1/07 Issue – Deleted Table 18. Revised paragraph 46.17.10.

46.17 HANDHOLE INSTALLATION ADJACENT TO PRECAST STREET LIGHTING FOUNDATION

This Section provides details for installation of a polymer concrete handhole adjacent to a precast concrete lighting foundation.

46.17.10 Application

Install a polymer concrete handhole (STD Item SG10) any time it is necessary to have more than one conduit at a precast concrete foundation. Terminate all conduits in the in ground handhole and install one conduit to the precast foundation.

46.17.20 Location

A typical installation would place the polymer concrete handhole adjacent to or behind a precast lighting foundation such that the conduit system can sweep directly into the conduit slot in the foundation.

46.17.30 Installation

A typical installation would place the polymer concrete handhole adjacent to or behind a precast lighting foundation such that the conduit system can sweep directly into the conduit slot in the foundation.

46.17.40 Restrictions

Polymer concrete handholes are rated for use in grass areas, sidewalks, driveways, and parking lots. They are not rated for use in roadways or in any location subject to heavy traffic.

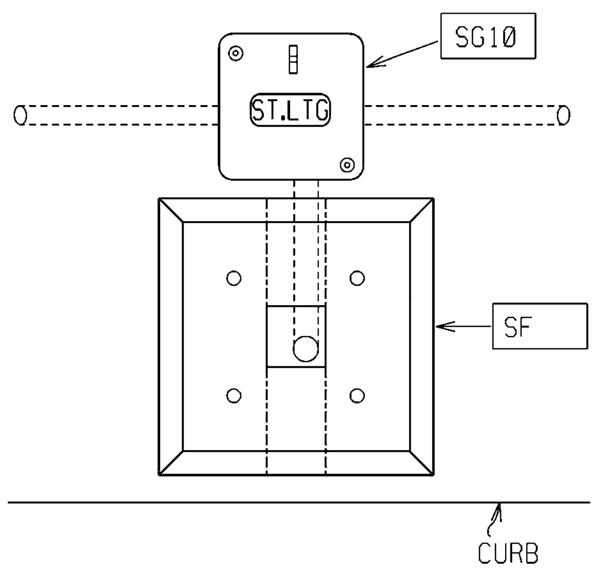


Figure 23
Handhole Installation Adjacent to Precast Concrete Lighting Foundation – Top View

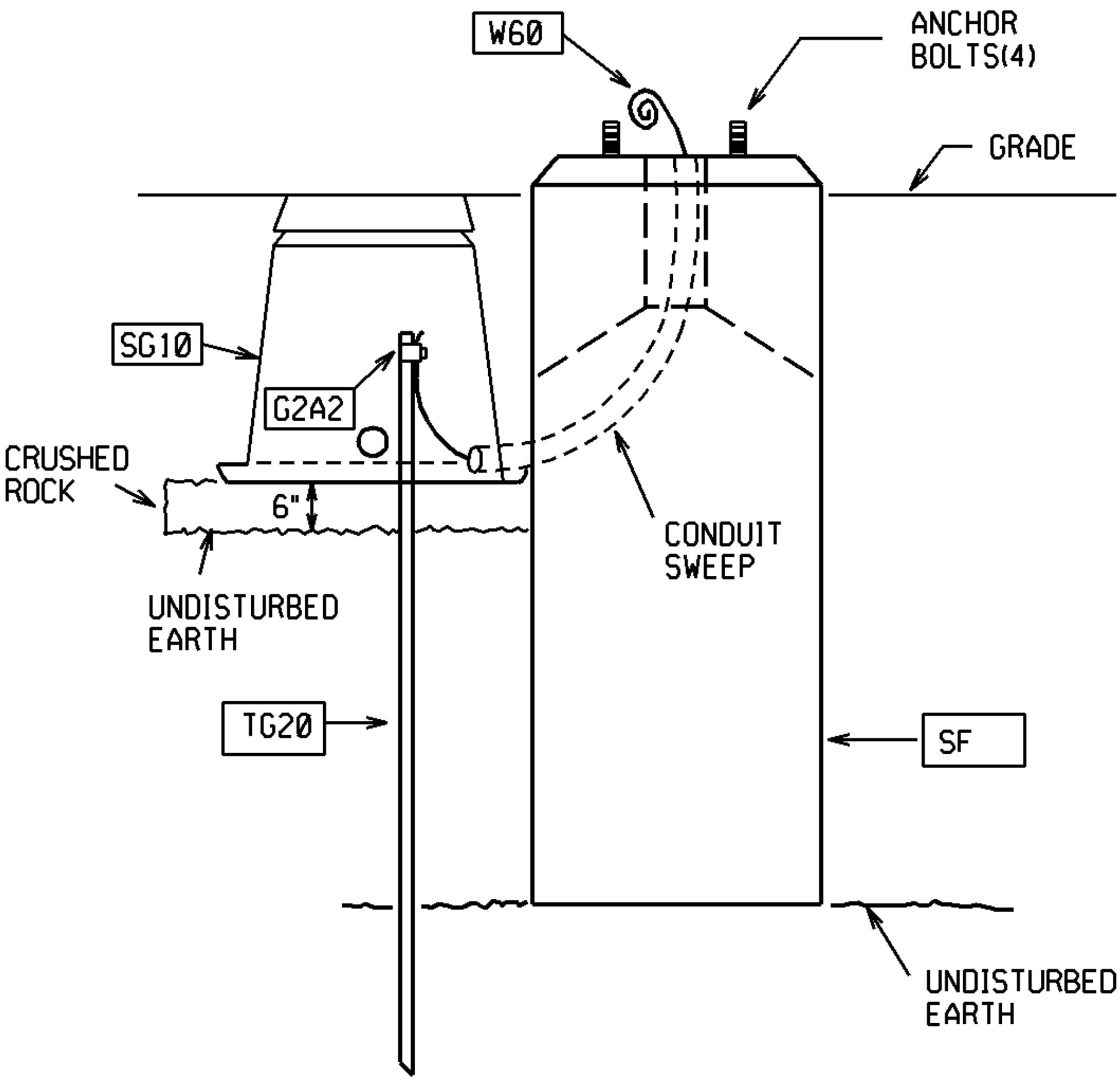


Figure 24
Handhole Installation Adjacent to Precast Concrete Lighting Foundation – Side View

46.18 POURED CONCRETE FOUNDATIONS – ANCHOR BOLT CIRCLE REQUIREMENTS

The Company Standard is to use precast concrete foundations for all underground supplied outdoor lighting applications. In those rare cases where field conditions prohibit the use of a precast concrete foundation, a poured in place concrete foundation may be used. This Section provides general guidance to aid in foundation design and anchor bolt circle requirements for standard Company lighting poles.

46.18.10 Poured In Place Concrete Foundations

Poured in place concrete foundations shall be field designed so as to duplicate the equivalent precast concrete foundation with respect to physical size and materials. Each foundation requires (4) anchor bolts (STD Item SF30 or SF31). Foundation conduit sweeps shall be a minimum 24 inch radius using 2 inch conduit. See STANDARDS Section 46.16 for precast concrete foundation dimensions and Company Material Specification Standards for detailed drawings.

Figure 25
Anchor Bolt for Poured-In-Place Concrete Foundations

46.18.20 Anchor Bolt Circle Requirements

All anchor base poles require a concrete foundation with four galvanized steel anchor bolts arranged in accordance with Figure 26 and Tables 15 or 16, as applicable.

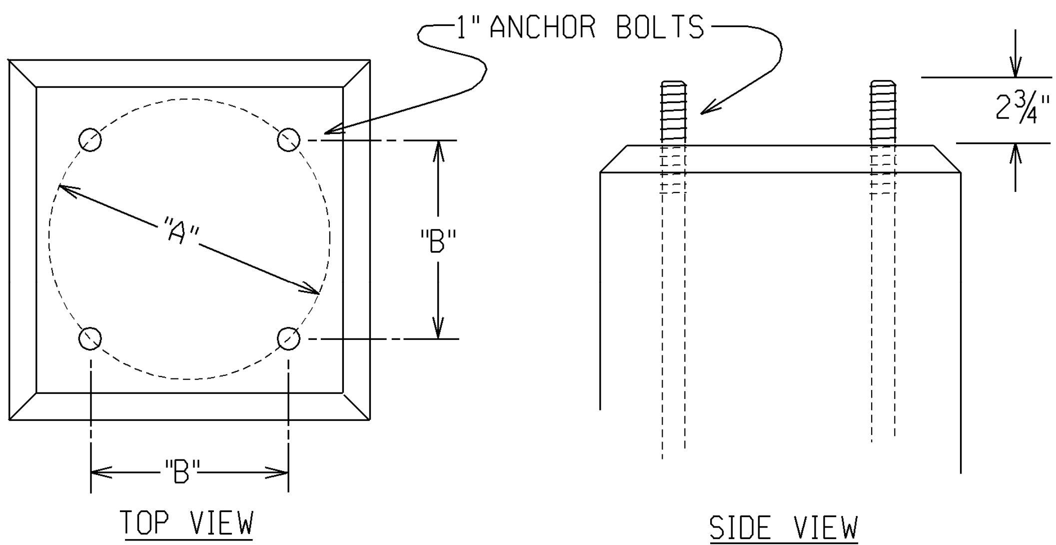


Figure 26
Anchor Bolt Circle Requirements

Supersedes 1/07 Issue – Deleted Table 19. Revised paragraph 46.18.10

Table 15
Roadway Poles

Std. Item	Description	Anchor Bolt Circle Diameter (Dimension "A")	Anchor Bolt Distance (Dimension "B")	Anchor Bolt Diameter
ST01	*"Pendant"* Pole - Aluminum	11½ Inch	8⅛ Inch	1"
ST02	*"Pendant"* Pole - Fiberglass	11½ Inch	8⅛ Inch	1"
ST03	*"Pendant"* Pole - Steel	11½ Inch	8⅛ Inch	1"
ST04	*"Davit"* Pole - Aluminum	11½ Inch	8⅛ Inch	1"
ST05	*"Davit"* Pole - Steel	11½ Inch	8⅛ Inch	1"
ST06	*"Manchester"* Pole - Aluminum	11½ Inch	8⅛ Inch	1"
ST08	*"Niagara"* Pole - Aluminum	11½ Inch	8⅛ Inch	1"
SU01D	*"Architectural"* Pole – Aluminum 16 Foot	11½ Inch	8⅛ Inch	¾"
SU01F	*"Architectural"* Pole – Aluminum 25 Foot	15-Inch	10⅝ Inch	1"
SX80	Transformer Base	15-Inch	10⅝ Inch	1"

Table 16
Post Top Poles

Std. Item	Description	Anchor Bolt Circle Diameter (Dimension "A")	Anchor Bolt Distance (Dimension "B")	Anchor Bolt Diameter
SW01	*"Suburban"* Post Top Pole Fiberglass	11½ Inch	8⅛ Inch	¾"
SW01C1	*"Suburban"* Post Top Pole Fiberglass	8½ Inch	6 Inch	¾"
SW05	*"Armory Square"* Post Top Pole Aluminum	15 Inch	10⅝ Inch	¾"
SW06	*"Essex"* Post Top Pole Aluminum	8½ Inch	6 Inch	¾"
SW07	*"Villager"* Post Top Pole Aluminum	8½ Inch	6 Inch	¾"
SW08	*"Presidential"* Post Top Pole Fiberglass	15 Inch	10⅝ Inch	¾"
SW09	*"Washington"* Post Top Pole Aluminum	8½ Inch	6 Inch	¾"

Supersedes 1/07 Issue – Revised Tables 15 and 16.

46.19 CONNECTIONS AND GROUNDING FOR UNDERGROUND SUPPLIED LIGHTING

This Section provides connections and grounding details for all underground supplied lighting installations where connections are made inside the pole access handhole.

46.19.10 Connection Rules

Figures 27 – 32 provide details on the most common connection and grounding combinations. The following connection and grounding rules apply to all pole installations, and shall be applied in cases where the connection combination required is not shown in Figures 27 – 32.

A. Ground Rod: Every pole installation requires a driven ground rod and # 6 AWG grounding connection. The #6 AWG grounding conductor shall always be connected to the system neutral conductor inside the pole access handhole.

B. Metal Poles: Every metal pole shall be grounded by connecting the #6 AWG grounding conductor to the metal pole shaft. This connection shall be made inside the pole access handhole, or inside the transformer base, as applicable.

C. Non-Metallic Poles: The metal housing on every luminaire installed on a non-metallic pole shall be grounded. Always install a separate # 10, GREEN conductor inside the pole shaft for each luminaire. Whenever possible, luminaires are supplied with a three terminal connection block with the middle terminal factory connected to the luminaire housing by a green grounding conductor. Use this middle terminal for the housing grounding connection when available. Otherwise, connect the #10 Green conductor directly to the luminaire housing. Follow manufacturers instructions supplied with every luminaire.

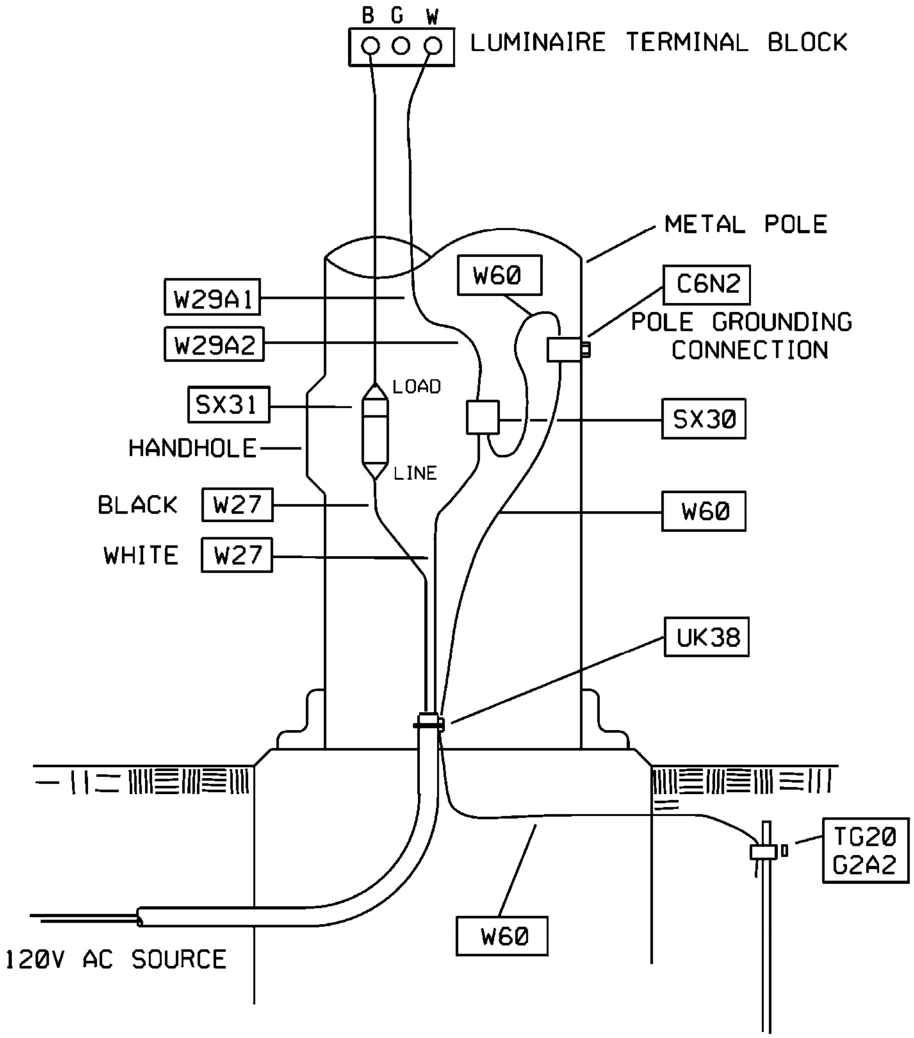


Figure 27

Supersedes 1/07 Issue – Revised STD Item #s in Figure 27.

Notes:

1. Always use an in-line fuse holder as the connection between the #6 source wiring and the #10 luminaire wiring. In-line fuse holders are designed to separate when the pole is broken by a motor vehicle and leave no exposed energize wiring. The in-line fuse holder housing must be installed properly with respect to “Line End” and Load End” as marked on the rubber housing. Follow manufacturers instructions packaged with every fuse holder.

2. Always pull conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Push completed connections and slack conductors back inside handhole and secure cover with tamper resistant hardware.

3. Connect equipment grounding conductor to metal conduit sweep, when available, and then to a driven ground rod. For direct buried cable installations or when conduit sweep is non-metallic, install grounding conductor direct to the driven ground rod.

Supersedes 1/07 Issue – Revised STD Item # in Figure 28.

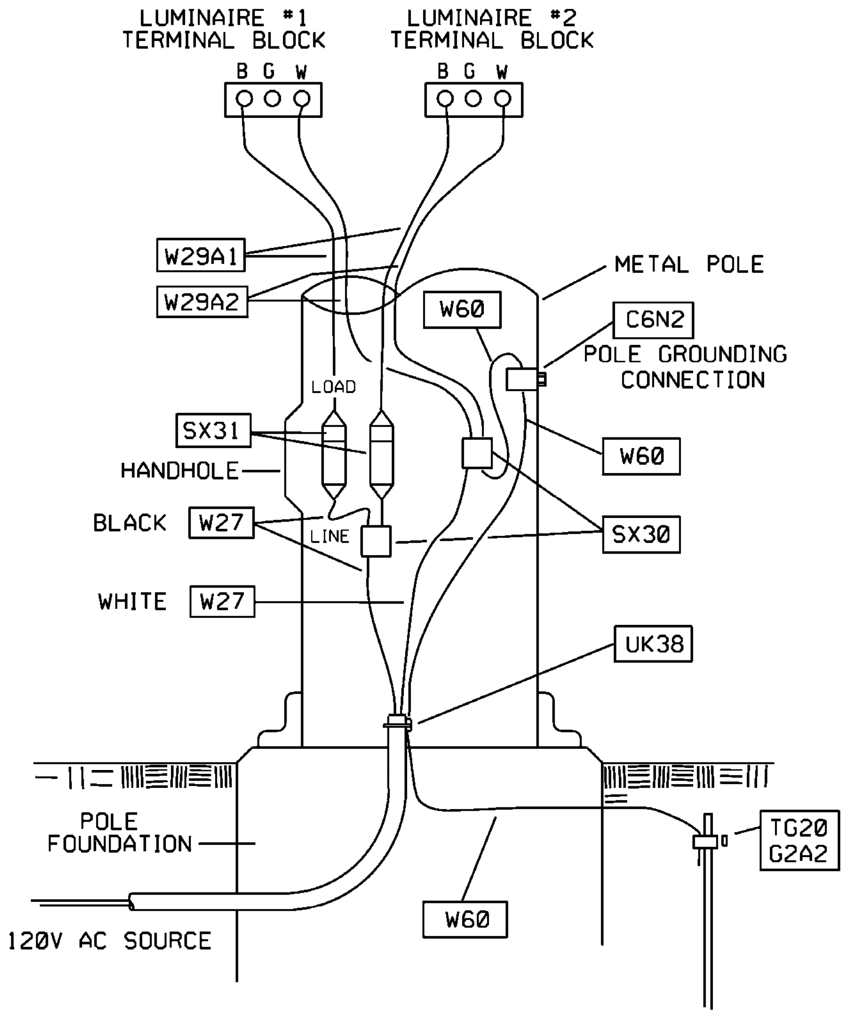


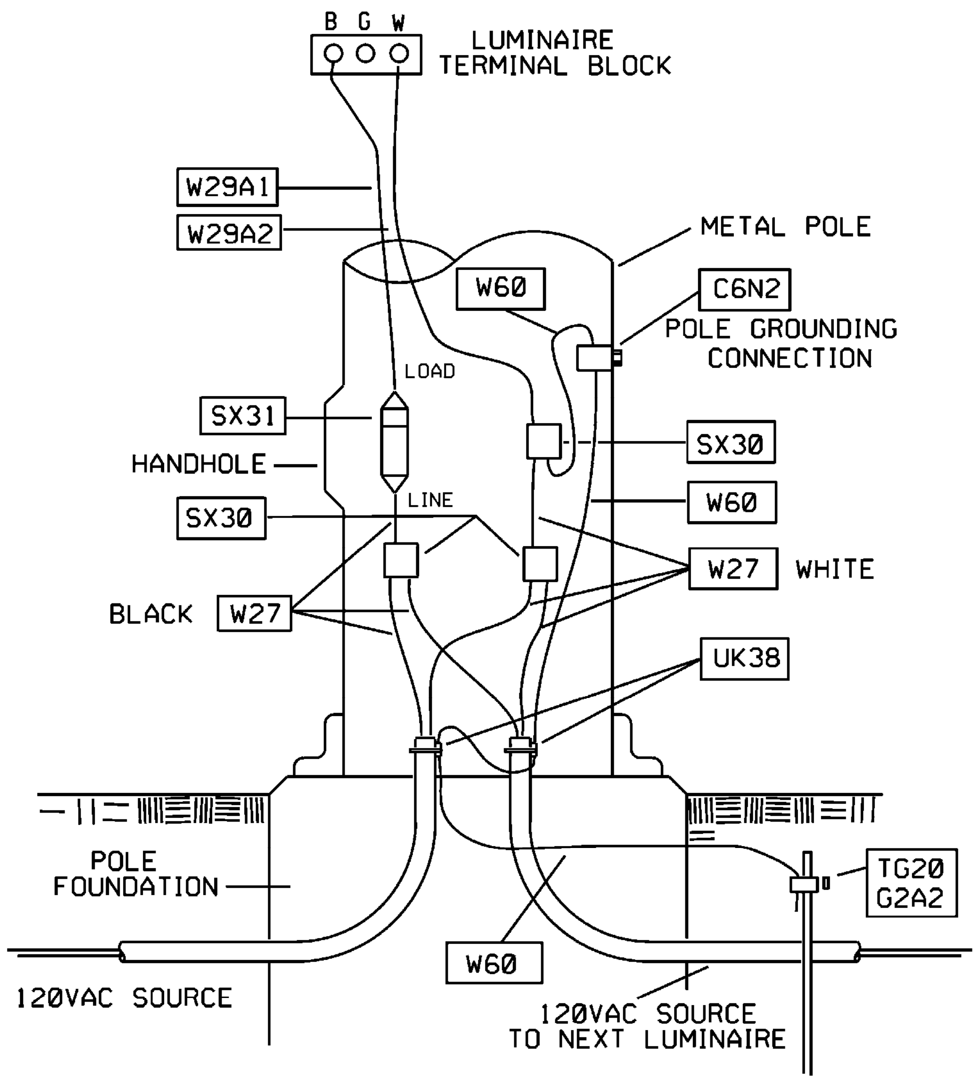
Figure 28

Notes:

1. Always use an in-line fuse holder as the connection between the #6 source wiring and the #10 luminaire wiring. In-line fuse holders are designed to separate when the pole is broken by a motor vehicle and leave no exposed energize wiring. The in-line fuse holder housing must be installed properly with respect to “Line End” and Load End” as marked on the rubber housing. Follow manufacturers instructions packaged with every fuse holder.

2. Always pull conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Push completed connections and slack conductors back inside handhole and secure cover with tamper resistant hardware.

3. Connect equipment grounding conductor to metal conduit sweep, when available, and then to a driven ground rod. For direct buried cable installations or when conduit sweep is non-metallic, install grounding conductor direct to the driven ground rod.



Supersedes 1/07 Issue – Revised STD Item # in Figure 29.

Figure 29

Notes:

1. Always use an in-line fuse holder as the connection between the #6 source wiring and the #10 luminaire wiring. Separable connectors are designed to separate when the pole is broken by a motor vehicle and leave no exposed energize wiring. The in-line fuse holder housing must be installed properly with respect to “Line End” and Load End” as marked on the rubber housing. Follow manufacturers instructions packaged with every fuse holder.

2. Always pull conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Push completed connections and slack conductors back inside handhole and secure cover with tamper resistant hardware.

3. Connect equipment grounding conductor to metal conduit sweep, when available, and then to a driven ground rod. For direct buried cable installations or when conduit sweep is non-metallic, install grounding conductor direct to the driven ground rod.

Supersedes 1/07 Issue – Revised STD Item # in Figure 30.

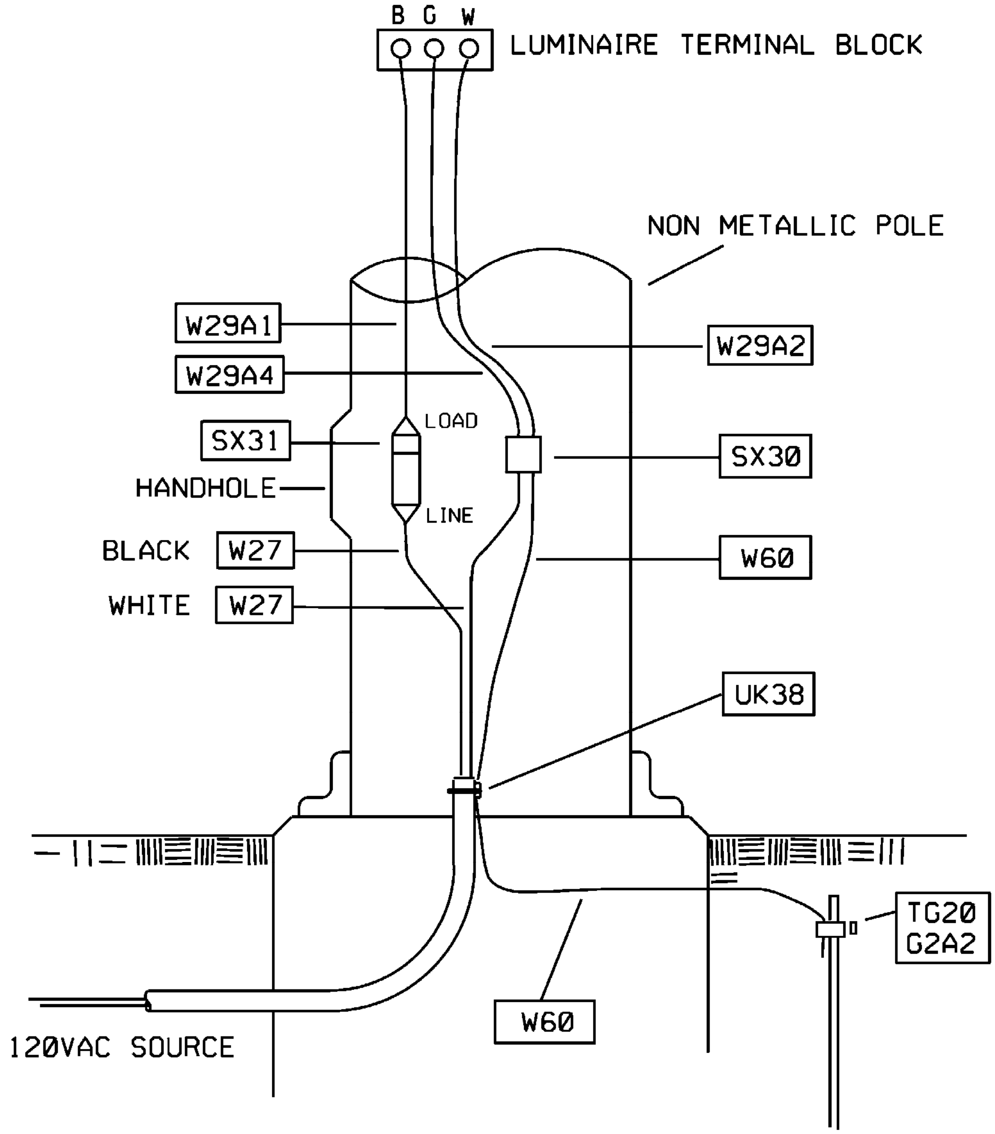


Figure 30

Notes:

1. Always use an in-line fuse holder as the connection between the #6 source wiring and the #10 luminaire wiring. In-line fuse holders are designed to separate when the pole is broken by a motor vehicle and leave no exposed energize wiring. The in-line fuse holder housing must be installed properly with respect to "Line End" and Load End" as marked on the rubber housing. Follow manufacturers instructions packaged with every fuse holder.

2. Always pull conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Push completed connections and slack conductors back inside handhole and secure cover with tamper resistant hardware.

3. Connect equipment grounding conductor to metal conduit sweep, when available, and then to a driven ground rod. For direct buried cable installations or when conduit sweep is non-metallic, install grounding conductor direct to the driven ground rod.

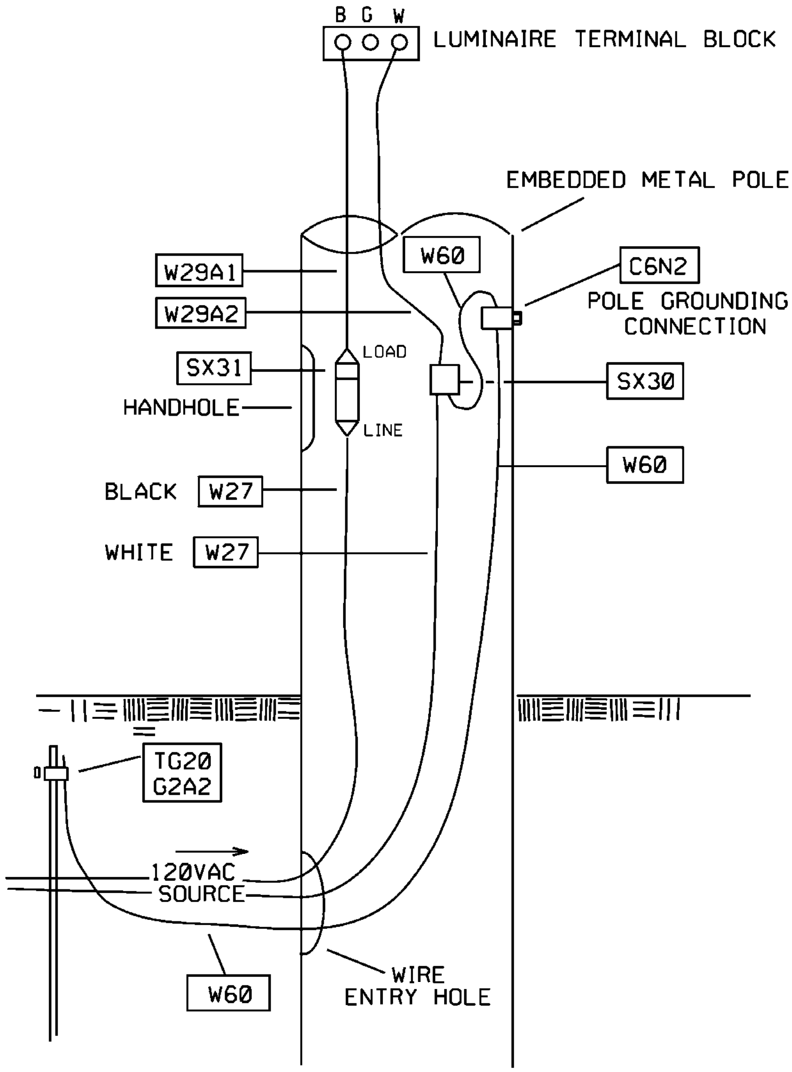


Figure 31

Supersedes 1/07 Issue – Revised STD Item # in Figure 31.

Notes:

1. Always use an in-line fuse holder as the connection between the #6 source wiring and the #10 luminaire wiring. In-line fuse holders are designed to separate when the pole is broken by a motor vehicle and leave no exposed energize wiring. The in-line fuse holder housing must be installed properly with respect to “Line End” and Load End” as marked on the rubber housing. Follow manufacturers instructions packaged with every fuse holder.

2. Always pull conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Push completed connections and slack conductors back inside handhole and secure cover with tamper resistant hardware.

3. Connect equipment grounding conductor to metal conduit sweep, when available, and then to a driven ground rod. For direct buried cable installations or when conduit sweep is non-metallic, install grounding conductor direct to the driven ground rod.

Supersedes 1/07 Issue – Revised STD Item # in Figure 32.

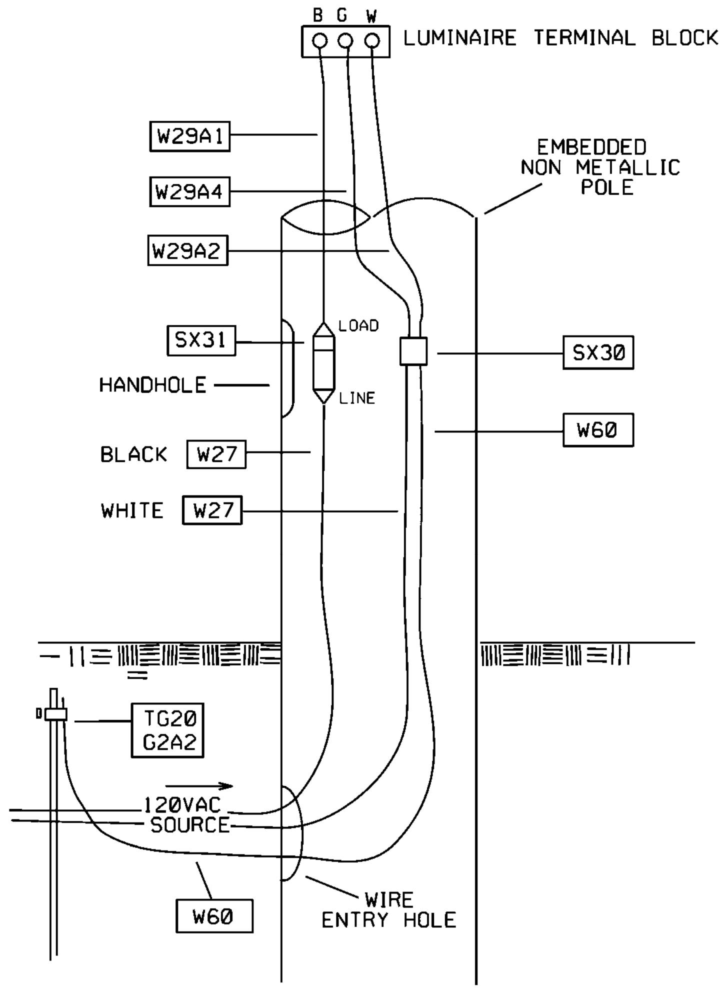


Figure 32

Notes:

1. Always use an in-line fuse holder as the connection between the #6 source wiring and the #10 luminaire wiring. In-line fuse holders are designed to separate when the pole is broken by a motor vehicle and leave no exposed energize wiring. The in-line fuse holder housing must be installed properly with respect to “Line End” and Load End” as marked on the rubber housing. Follow manufacturers instructions packaged with every fuse holder.

2. Always pull conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Push completed connections and slack conductors back inside handhole and secure cover with tamper resistant hardware.

3. Connect equipment grounding conductor to metal conduit sweep, when available, and then to a driven ground rod. For direct buried cable installations or when conduit sweep is non-metallic, install grounding conductor direct to the driven ground rod.

Supersedes 1/07 Issue – Deleted Table 22. Added paragraph 46.20.40.

46.20 "PENDANT" STREET LIGHTING POLE – INSTALLATION

This Section provides details for installation of an aluminum pendant street lighting pole.

46.20.10 Loading

Pendant street lighting poles are rated capable of supporting one or two supporting arms with horizontal roadway luminaire(s) or one horizontal roadway luminaire / arm and one floodlight luminaire with arm. Ratings are based on a sustained 90 mph wind. Consult Standards Engineering if additional luminaire loading is required.

MUNICIPAL ATTACHMENTS – BANNERS, FLOWERPOTS, ETC. – In general, pendant poles have been engineered to support the arm and luminaire loading only and not the additional loading imposed by municipal attachments. In some cases, however, limited additional loading may be possible. See STANDARDS Section 46.14 for details.

46.20.20 Wiring Details

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack conductors back inside pole access handhole and secure cover with tamper resistant hardware.

46.20.30 Twin Luminaire Wiring Details

Install a separate set of #10 conductors for each luminaire and terminate inside the pole access handhole. Wrap each set of luminaire conductors with three layers of PVC tape to aid in conductor identification.

46.20.40 Pendant Pole & Arm Selection

See STANDARDS Section 49-ST01 for available aluminum pendant poles and arms.

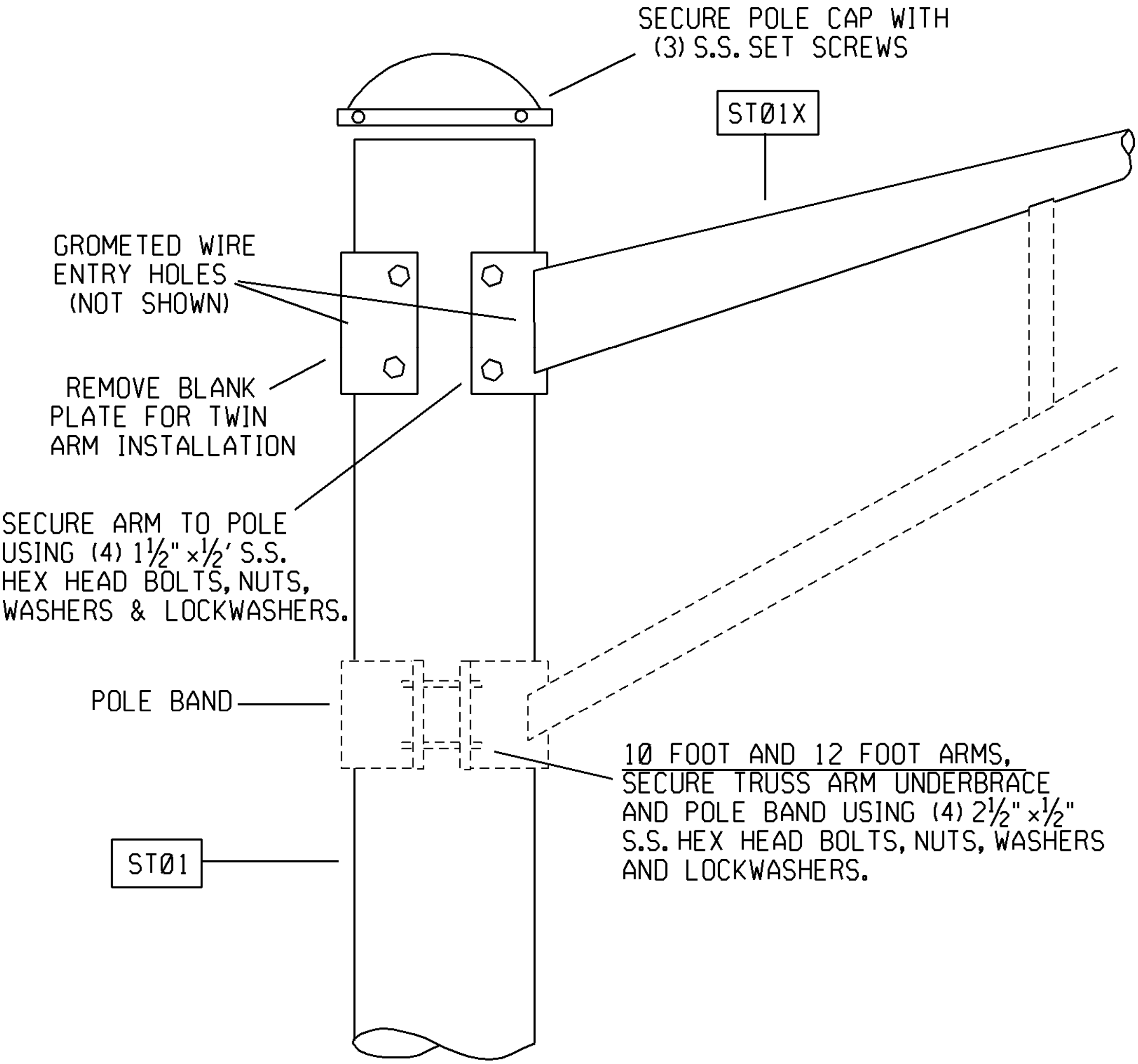


Figure 33
Arm Installation on Aluminum Pendant Pole

 Doc. # ST. 46.00.021

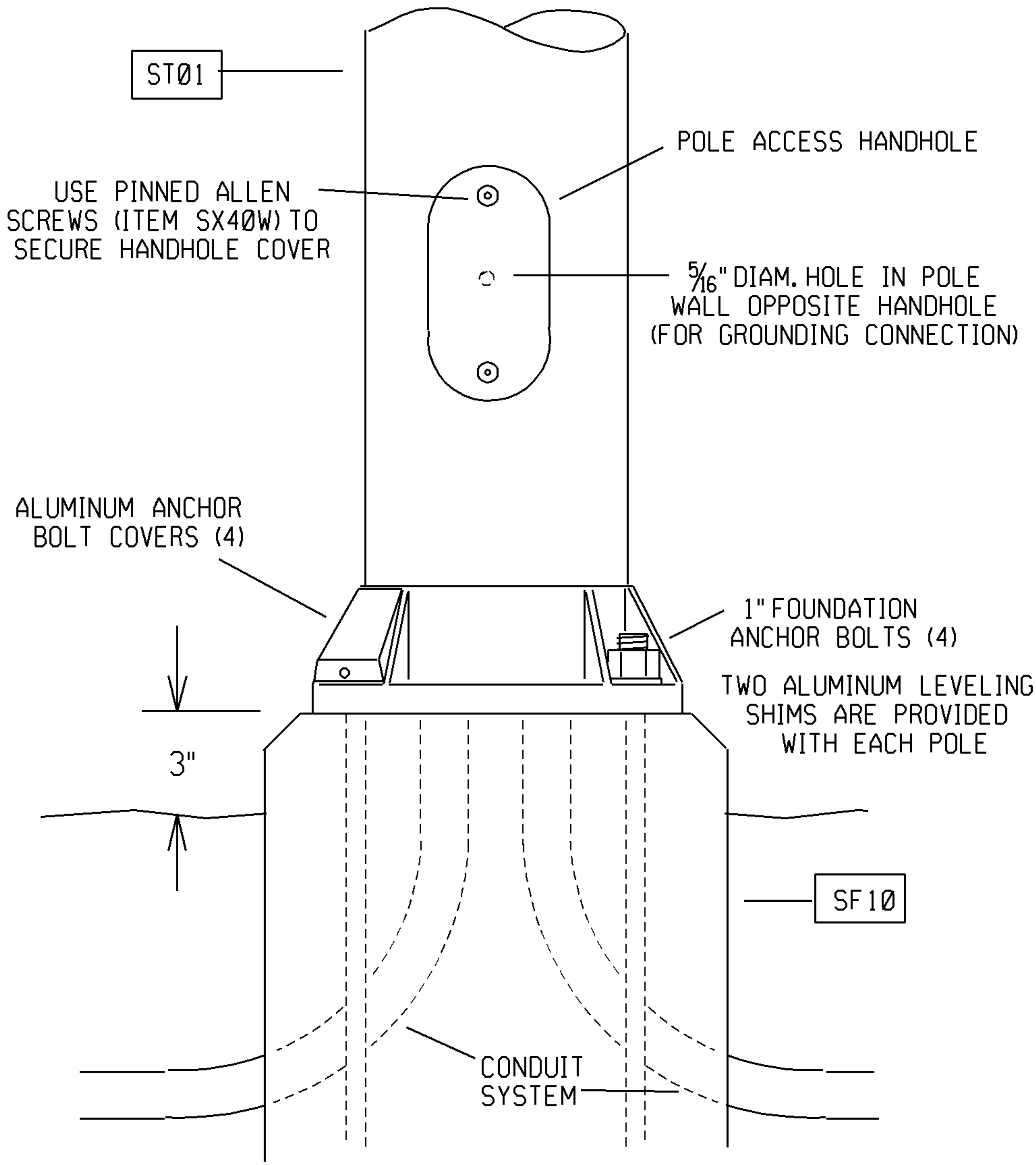


Figure 34
Aluminum Pendant Pole – Installation

CAUTION: Never install pole without arm and luminaire. The arm / luminaire combination contribute to dampen wind induced vibration forces which could lead to pole failure.

46.21 FLOODLIGHT INSTALLATION ON ALUMINUM PENDANT POLE

This Section provides instructions for installation of a floodlight luminaire on an aluminum pendant street lighting pole.

46.21.10 Loading

Aluminum pendant street lighting poles are rated capable of supporting one or two supporting arms with floodlight luminaire(s) or one floodlight arm / luminaire with one horizontal roadway luminaire with arm. Ratings are based on a sustained 90 mph wind. Consult Standards Engineering if additional loading is required.

46.21.20 Floodlight Aiming

See STANDARDS Section 46.4 for specific details on aiming floodlights.

46.21.30 Wiring Details

Install a separate set of #10 conductors for each luminaire and terminate inside the pole access handhole. Wrap each set of luminaire conductors with three layers of PVC tape to aid in conductor identification. Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19 as applicable. Push completed connections and slack conductors back inside pole access handhole and secure cover with tamper resistant hardware.

46.21.40 Floodlight Selection

See STANDARDS section 49-SJ for available floodlight luminaires and section 49-ST01 for floodlight arms.

Supersedes 1/07 Issue – Deleted Table 23. Added paragraph 46.21.40.

 Doc. # ST. 46.00.021

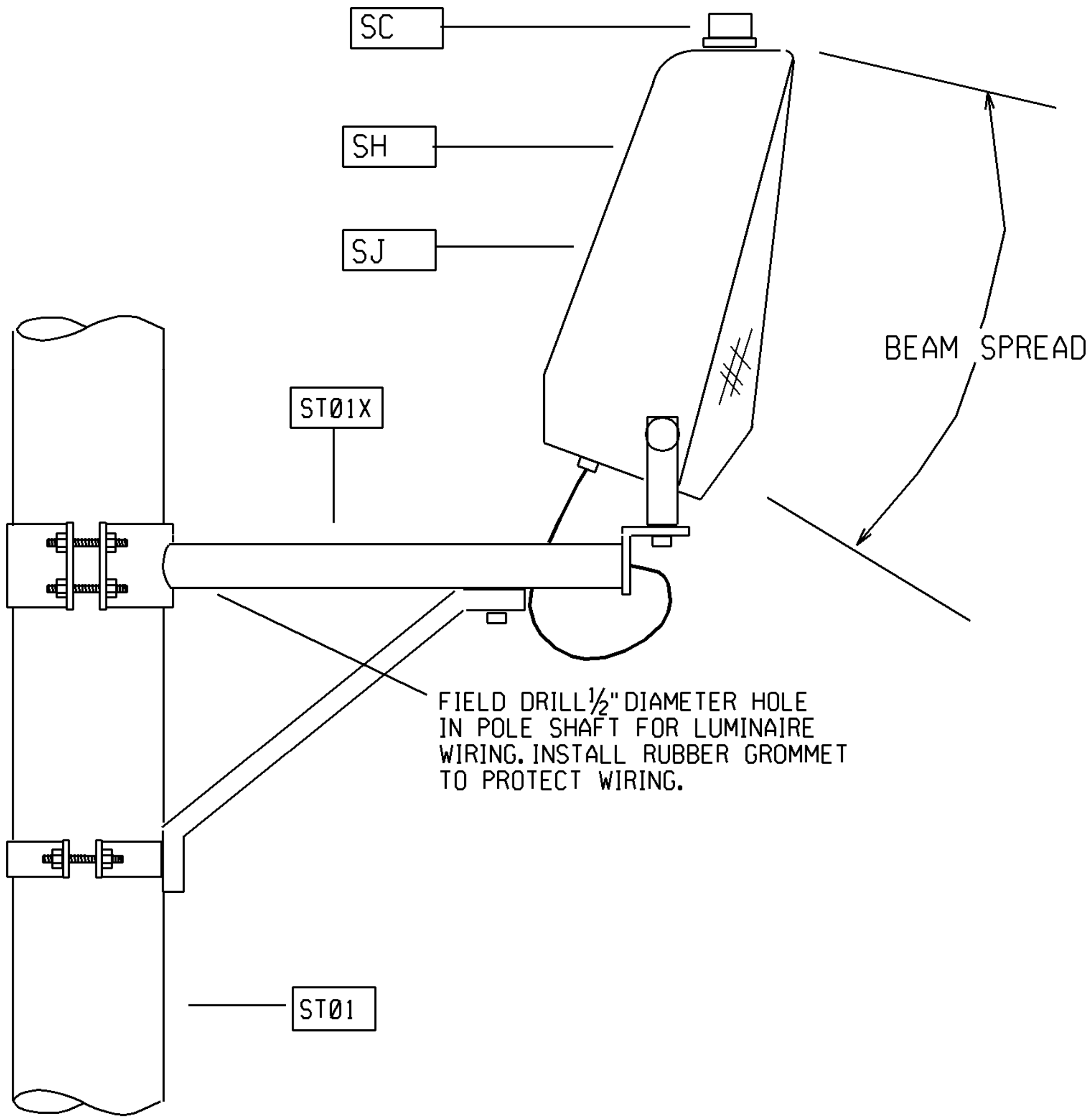


Figure 35
Floodlight Installation on Aluminum Pendant Pole

Note: For twin floodlight installations, mount two floodlight arms back-to-back and omit the back pole plates.

46.22 <u>"DAVIT" STREET LIGHTING POLE – INSTALLATION</u>

This Section provides details for installation of an aluminum davit style street lighting pole.

46.22.10 <u>Loading</u>

Aluminum davit poles are rated capable of supporting a single or twin supporting arm with horizontal roadway luminaire(s). Floodlight luminaire installations are not allowed on davit poles. Ratings are based on a sustained 90 mph wind.

MUNICIPAL ATTACHMENTS – BANNERS, FLOWERPOTS, ETC. – In general, aluminum davit poles have been engineered to support the arm and luminaire loading only and not the additional loading imposed by municipal attachments. In some cases, however, limited additional loading may be possible. See STANDARDS Section 46.14 for details.

46.22.20 <u>Wiring Detail</u>

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19 as applicable. Push completed connections and slack conductors back inside pole access handhole and secure cover with tamper resistant hardware.

46.22.30 <u>Twin Luminaire Wiring Detail</u>

Install a separate set of #10 conductors for each luminaire and terminate inside the pole access handhole or transformer base. Wrap each set of luminaire conductors with three layers of PVC tape to aid in conductor identification.

46.22.40 <u>Davit Pole & Arm Selection</u>

See STANDARDS Section 49-ST04 for available aluminum davit poles and arms.

Supersedes 1/07 Issue – Deleted Table 24. Added paragraph 46.22.40.

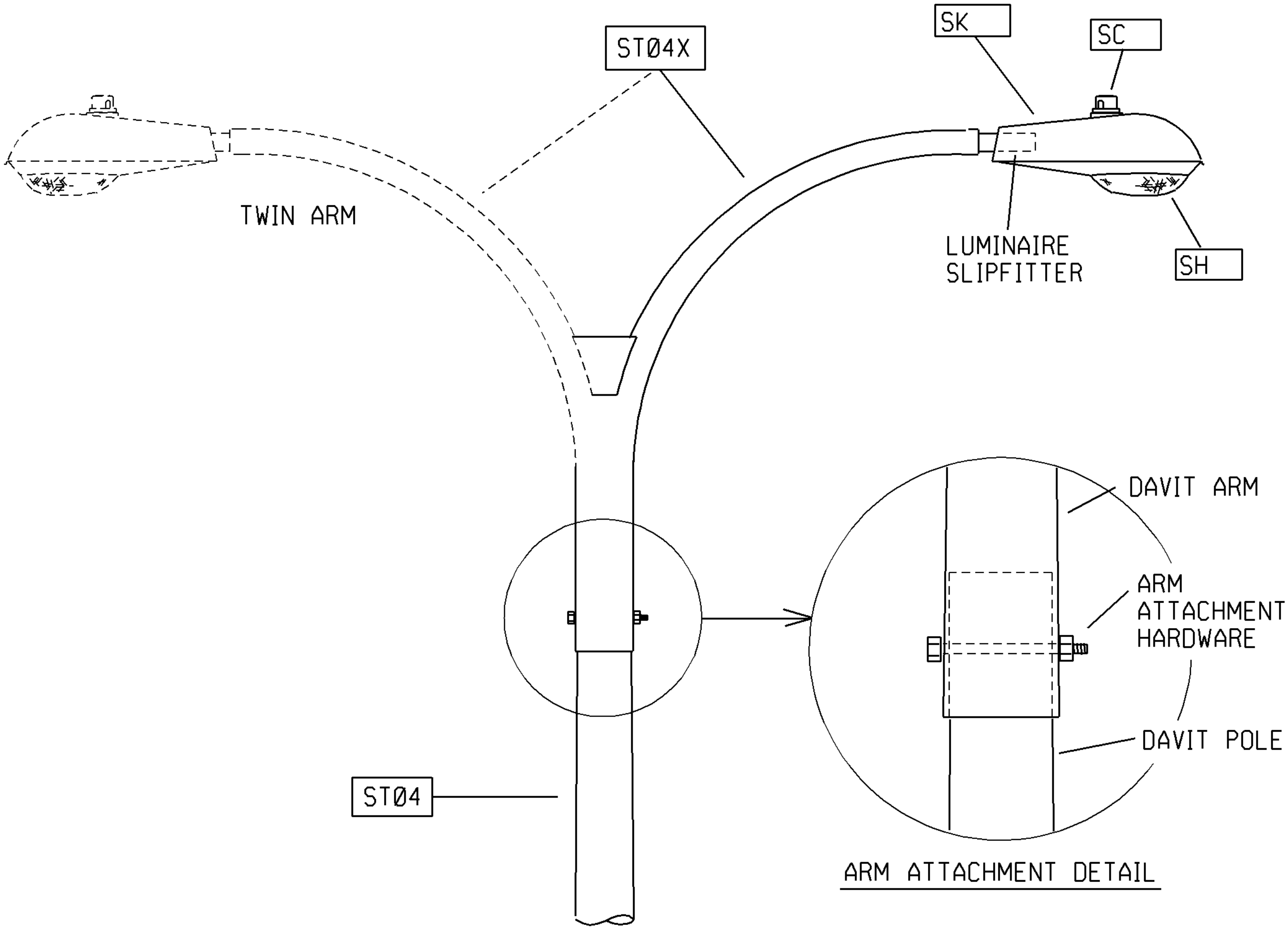


Figure 36
Arm Installation on Aluminum Davit Pole

Note: Davit arm attachment hardware consists of (1)-⅝ inch x 8 inch long aluminum studbolt, (2)-⅝” lock washers, and (2)-⅝” nuts. Attachment hardware is furnished with the davit arm.

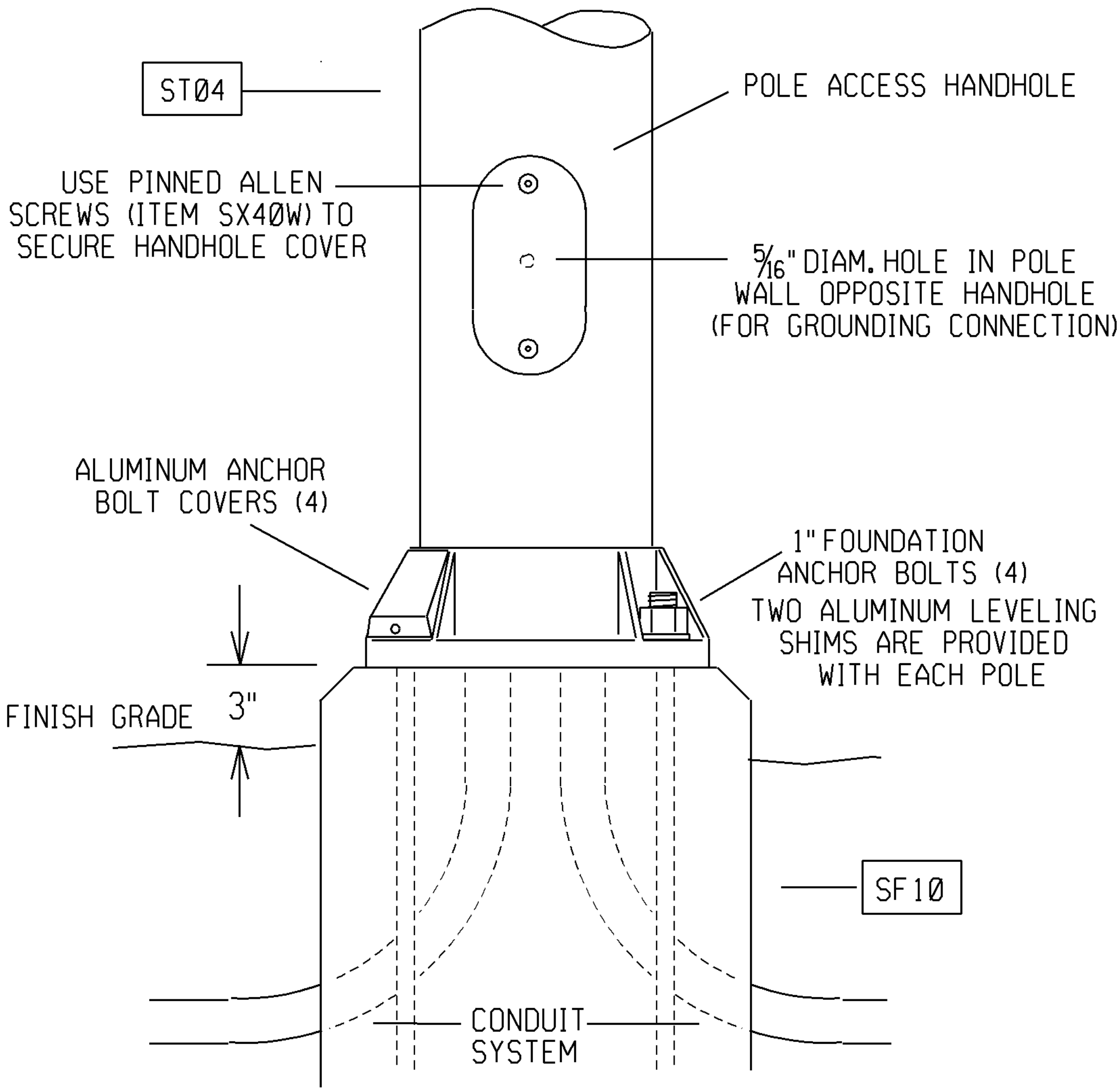


Figure 37
Aluminum Davit Pole – Installation on Precast Concrete Foundation

CAUTION: Never install pole without arm and luminaire. The arm / luminaire combination contribute to dampen wind induced vibration forces which could lead to pole failure.

Supersedes 1/07 Issue – Revised STD Item # in Figure 38.

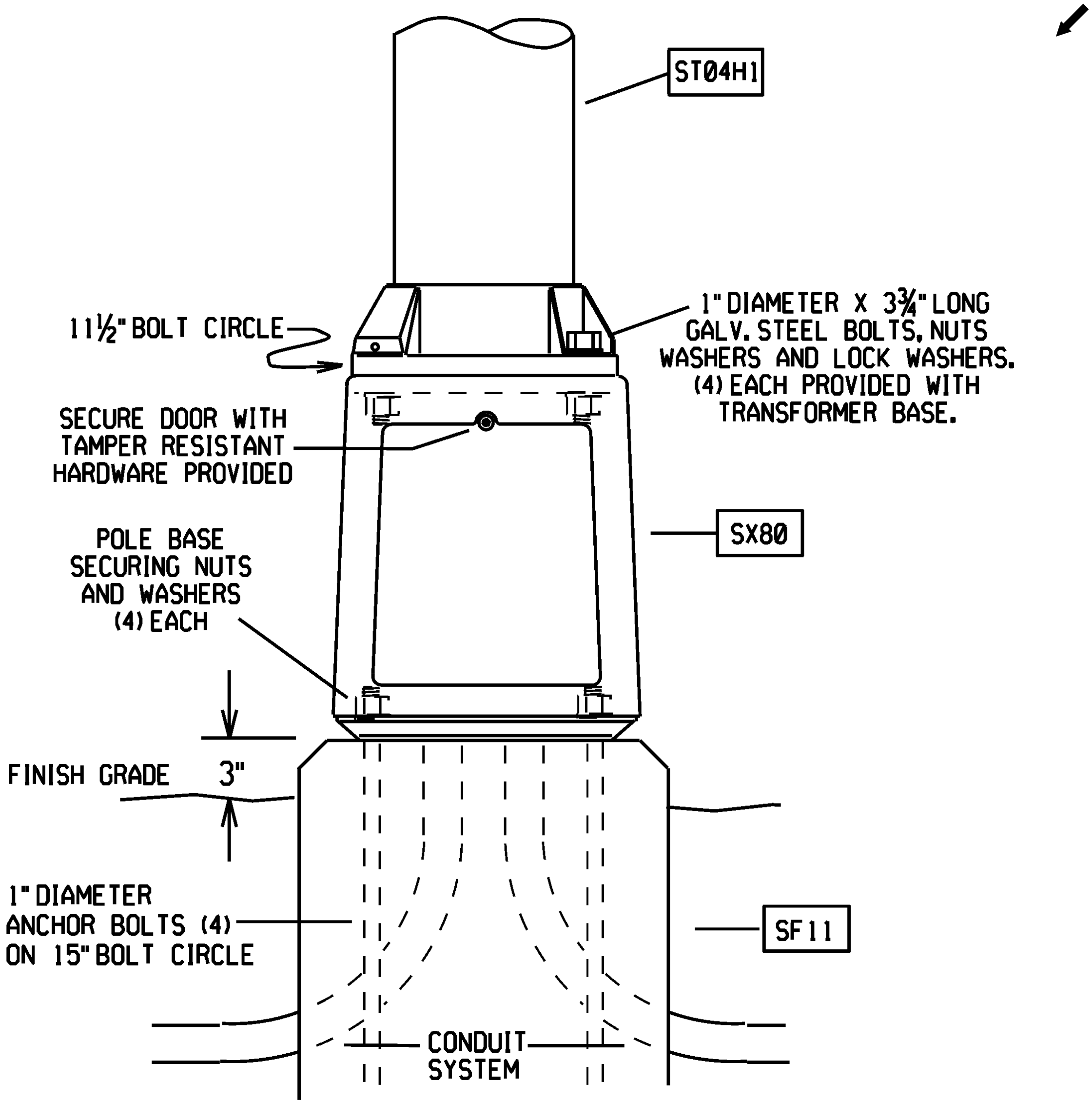


Figure 38
Aluminum Davit Pole – Installation on Aluminum Transformer Base

46.23 “ARCHITECTURAL” STREET LIGHTING POLE – ALUMINUM - INSTALLATION

This Section provides details for installation of an aluminum, square shaft, architectural style street lighting pole.

46.23.10 Loading

Aluminum architectural poles are rated capable of supporting up to four shoebox style luminaires only. Ratings are based on a sustained 90 mph wind.

46.23.20 Foundation Selection

Aluminum architectural poles are installed on precast concrete foundations. See STANDARDS Section 46.16 for precast concrete foundation selection.

46.23.30 Wiring Details

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19 as applicable. Push completed connections and slack conductors back inside pole access handhole and secure cover with tamper resistant hardware.

46.23.40 Multiple Luminaire Wiring Details

Install a separate set of #10 conductors for each luminaire and terminate inside the pole access handhole. Wrap each set of luminaire conductors with three layers of PVC tape to aid in conductor identification.

46.23.50 Luminaire Installation

Pole must be field drilled to accept mounting arm and luminaire. See manufacturer’s instructions (packaged with every luminaire) for drilling template. Follow manufacturer’s instructions for arm and luminaire installation.

Luminaires may be single, double, triple, or quadruple mounted as required.

46.23.60 Architectural Pole & Shoebox Luminaire Selection

See STANDARDS section 49-SU01 for Architectural pole selection and section 49-SM03 for Shoebox luminaire selection.

Supersedes 1/07 Issue – Revised paragraph 46.23.20. Added paragraph 46.23.60.

Supersedes 1/07 Issue – Deleted Table 26.

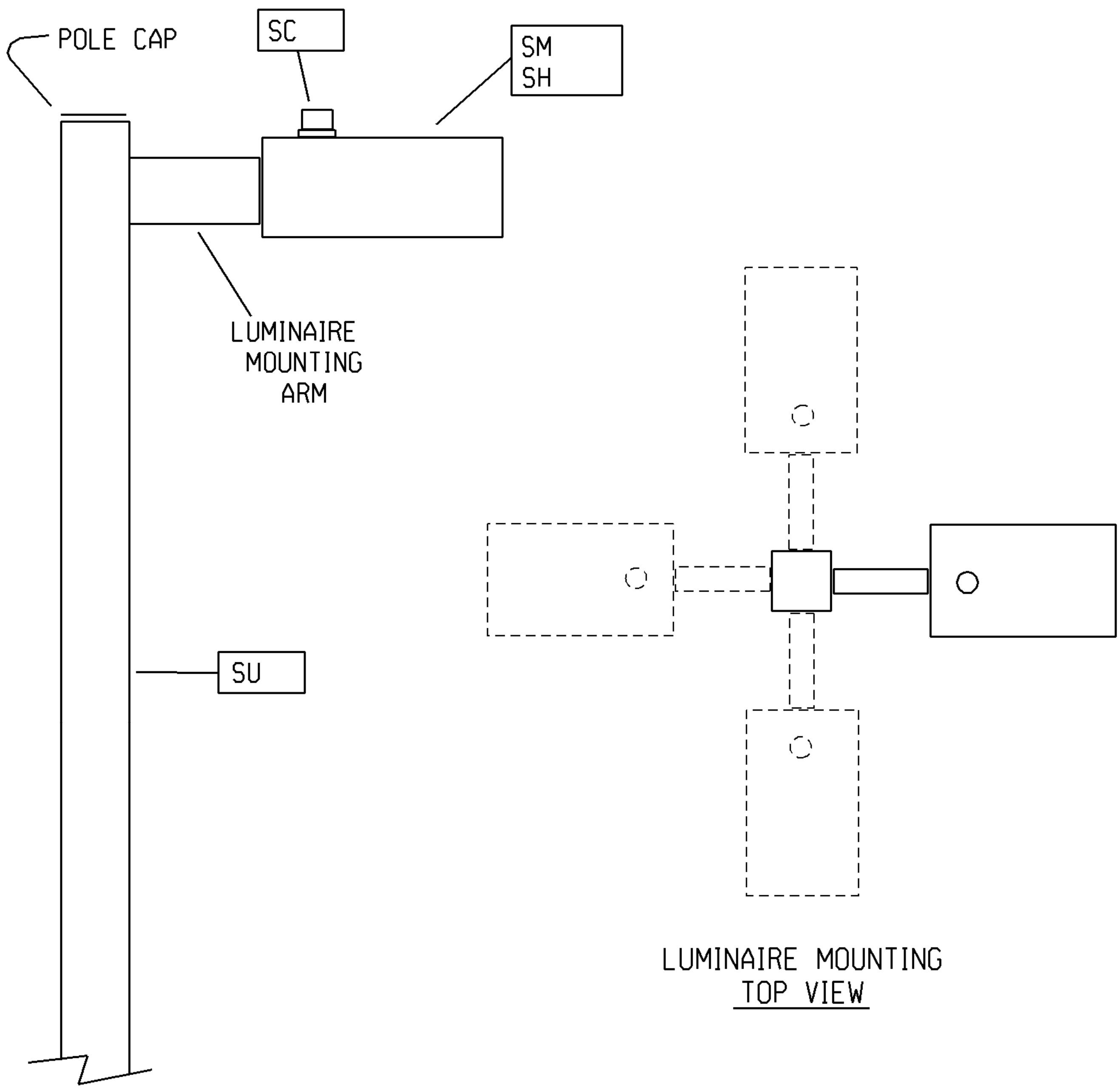


Figure 39
Shoebox Luminaire Installation on Aluminum Architectural Pole

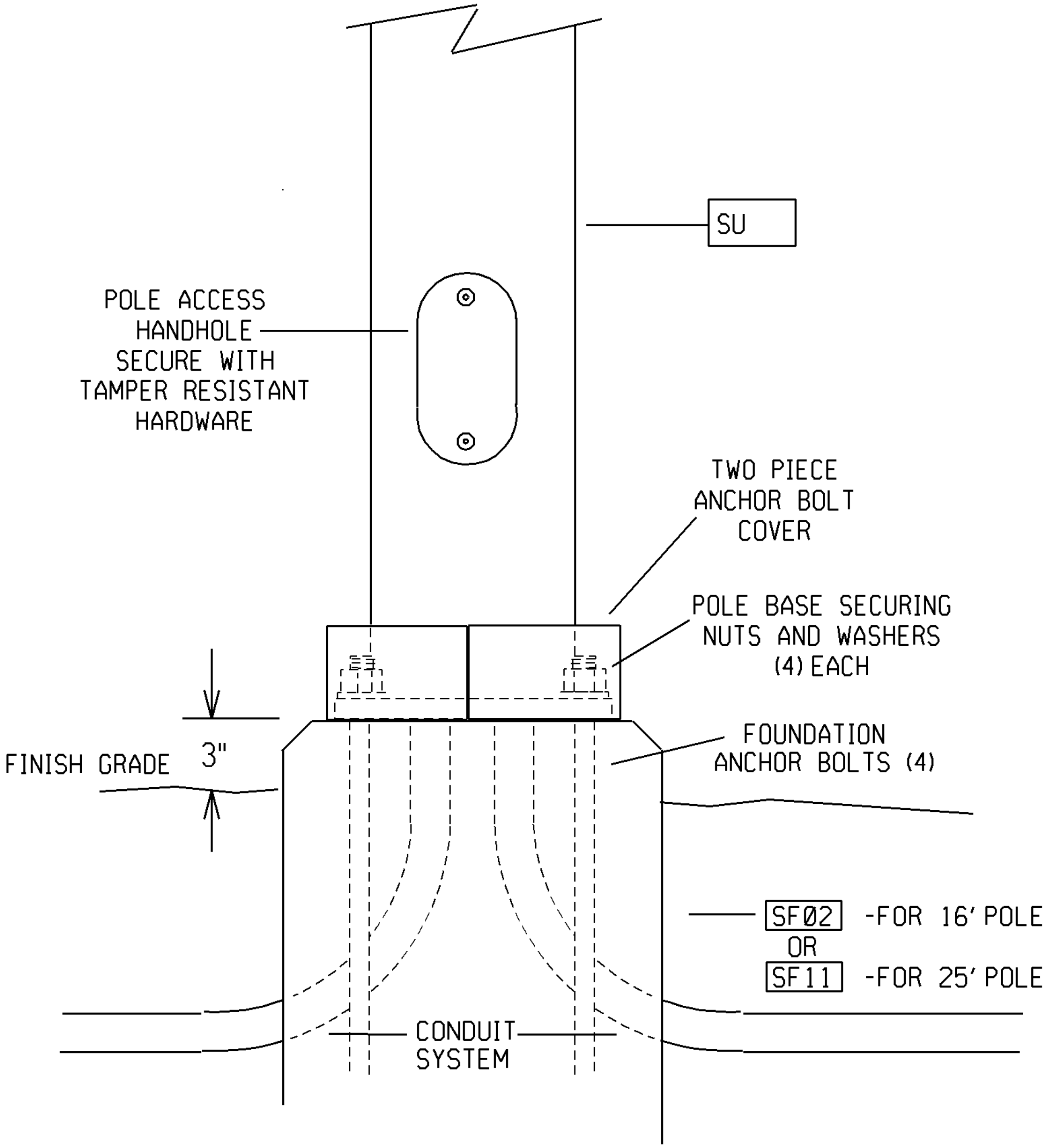


Figure 40
Architectural Pole Installation on Precast Concrete Foundation

CAUTION: Never install pole without luminaire(s). The luminaire(s) contribute to dampen wind induced vibration forces which could lead to pole failure.

46.24 “PENDANT” STREET LIGHTING POLE – FIBERGLASS – EMBEDDED - INSTALLATION

This Section provides details for installation of an embedded, fiberglass, pendant, street lighting pole. (STD Item ST02F1) Embedded, fiberglass, pendant, street lighting poles are available for use in the New England service territory only and are to be used strictly for maintenance of existing installations. They are intended for use with horizontal roadway luminaires in underground residential developments using direct buried supply conductors. New installations shall use anchor base style poles.

46.24.10 Loading

Embedded, fiberglass, pendant, poles are rated capable of supporting a single arm and horizontal roadway luminaire only. Ratings are based on a sustained 90 mph wind.

MUNICIPAL ATTACHMENTS – BANNERS, FLOWERPOTS, ETC. – Embedded, fiberglass, pendant street lighting poles have been engineered to support the arm and luminaire loading only and not the additional loading imposed by any type of municipal attachment.

46.24.20 Wiring Details

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack conductors back inside pole access handhole and secure cover with tamper resistant hardware.

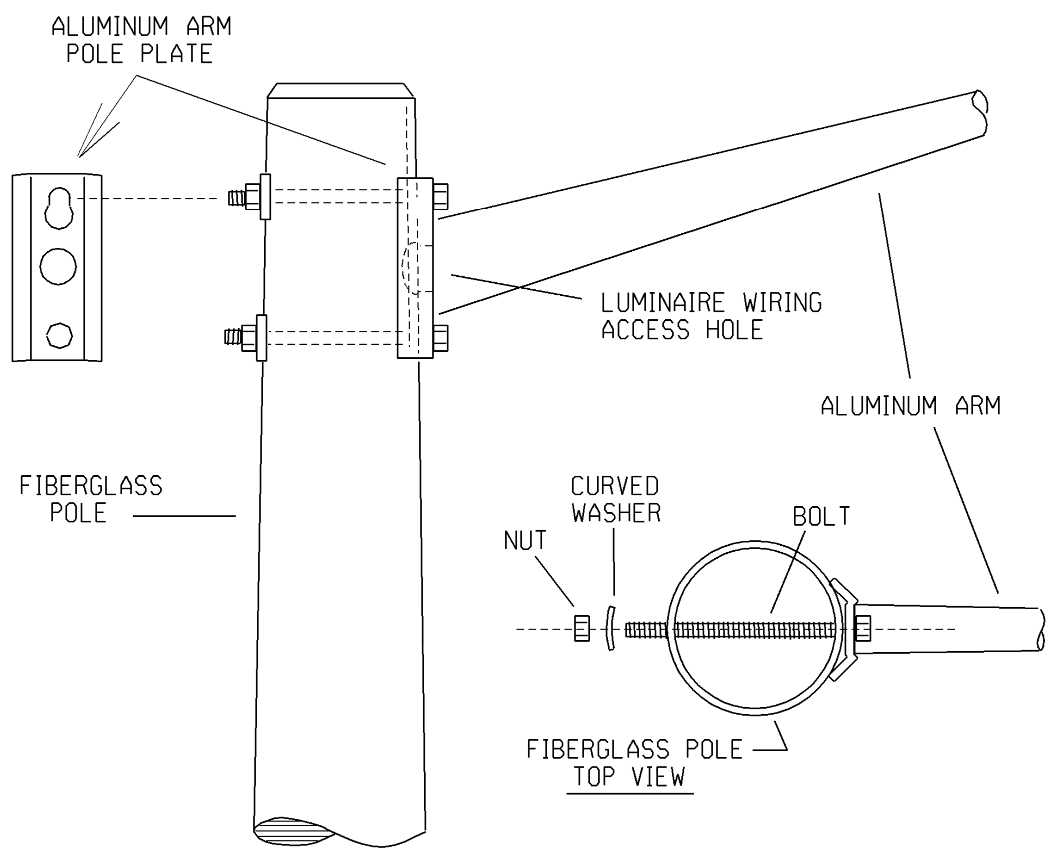


Figure 41
Arm Installation on a Pendant Fiberglass Pole

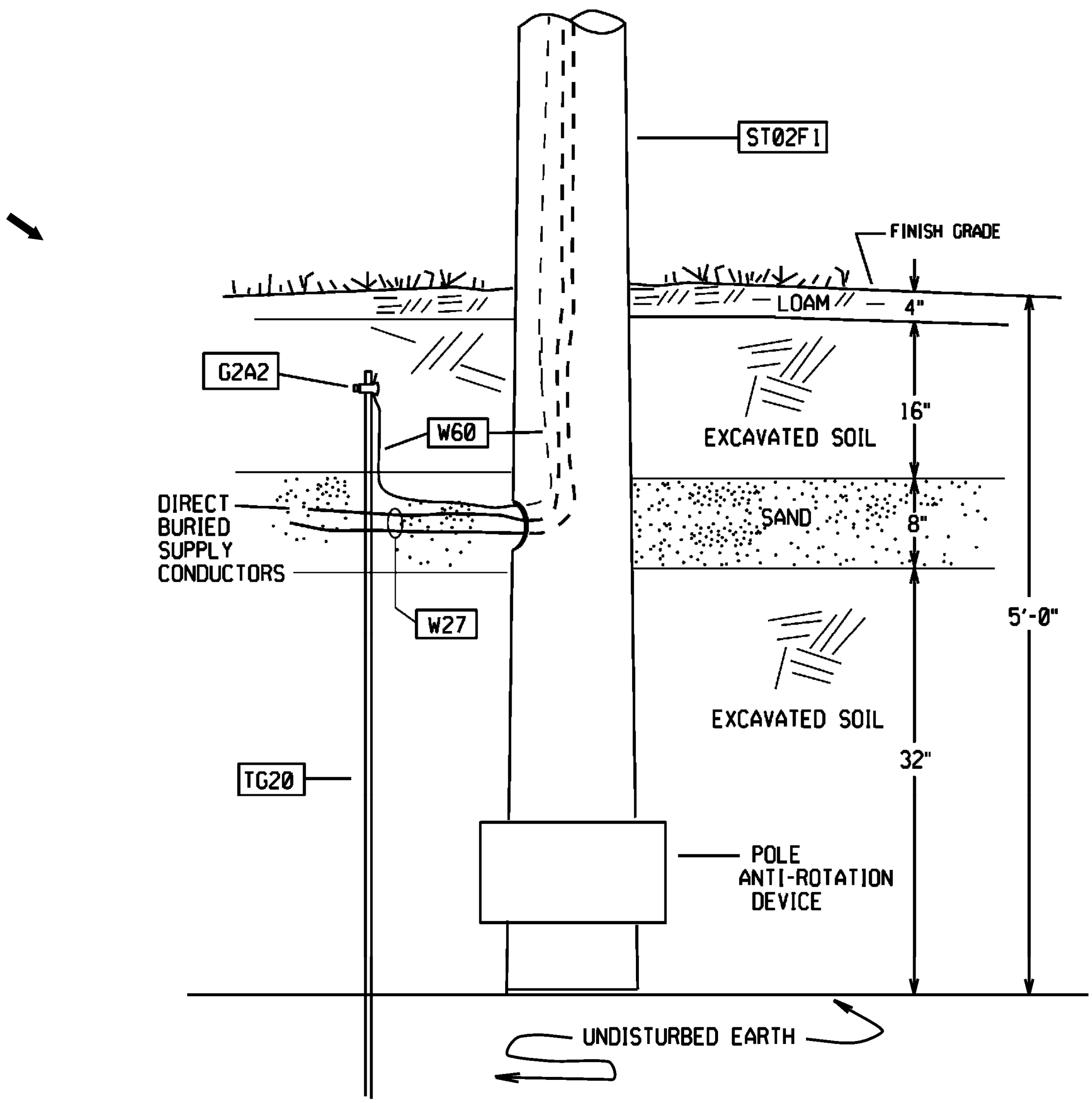
Supersedes 1/07 Issue – Deleted Table 27. Revised paragraph 46.24. Revised paragraph 46.24.

46.24.30 Pole Installation

Auger hole to required depth. Using belt slings or rope (no chain or cable), set pole plumb and hold in position on undisturbed earth. Do not remove protective pole covering during installation.

46.24.40 Backfill

Add backfill in 6 inch layers and tamp firmly. Complete filling of the hole with excavated soil to within 4 inches below grommoted wire hole and tamp firmly to eliminate voids. Avoid using stones larger than 2 inches in diameter. Next, add 8 inches of tamped sand (covering direct buried supply conductors), followed by 16 inches of tamped, excavated backfill to within 4 inches of final grade. The final 4 inches of fill shall be tamped loam.



Supersedes 1/07 Issue – Revised STD Item # in Figure 42.

Figure 42
Embedded, Fiberglass Pendant Pole – Installation

46.25 “PENDANT” STREET LIGHTING POLE – ANCHOR BASE FIBERGLASS - INSTALLATION

This Section provides details for installation of an anchor base, fiberglass, pendant, street lighting pole. (STD Item ST02F). Anchor base, fiberglass, pendant, street lighting poles are intended for use with horizontal roadway luminaires in new underground residential developments using conduit installed supply conductors.

46.25.10 Loading

Anchor base, fiberglass, pendant, poles are rated capable of supporting a single arm and horizontal roadway luminaire only. Ratings are based on a sustained 90 mph wind.

MUNICIPAL ATTACHMENTS – BANNERS, FLOWERPOTS, ETC. – Anchor base, fiberglass, pendant street lighting poles have been engineered to support the arm and luminaire loading only and not the additional loading imposed by any type of municipal attachment.

46.25.20 Wiring Details

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack conductors back inside pole access handhole and secure cover with tamper resistant hardware.

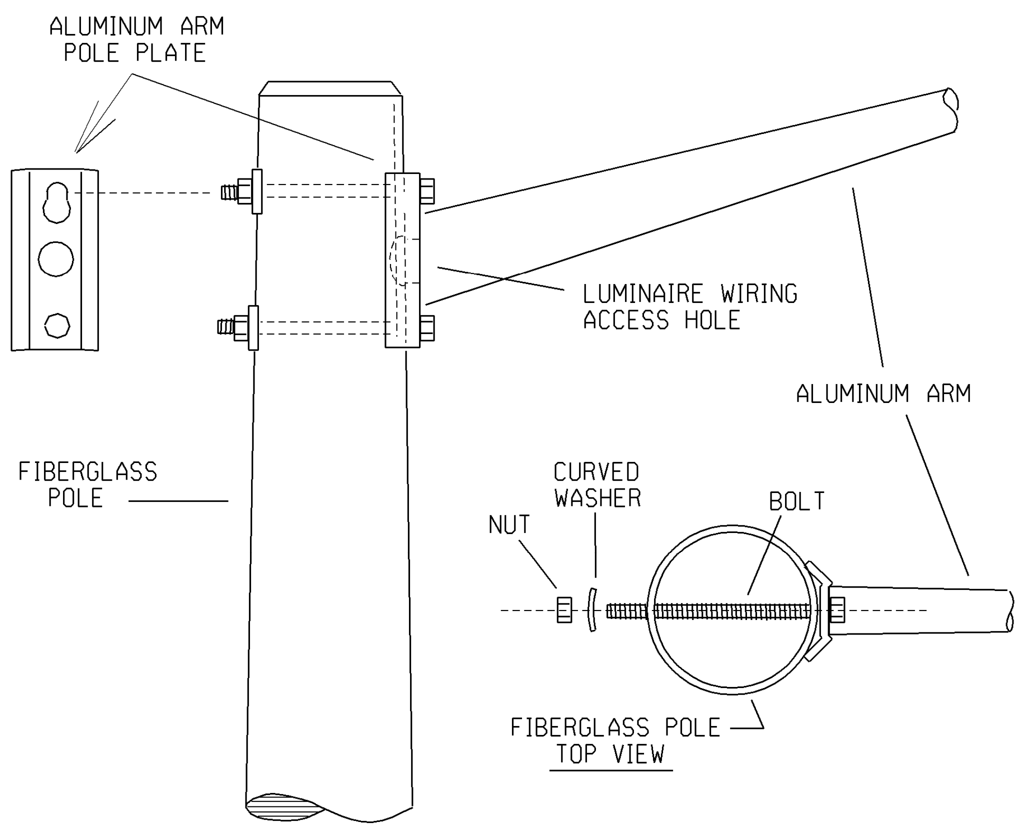


Figure 43
Arm Installation on a Pendant Fiberglass Pole

Supersedes 1/07 Issue – Deleted Table 28. Added Figure 43.

 Doc. # ST. 46.00.023

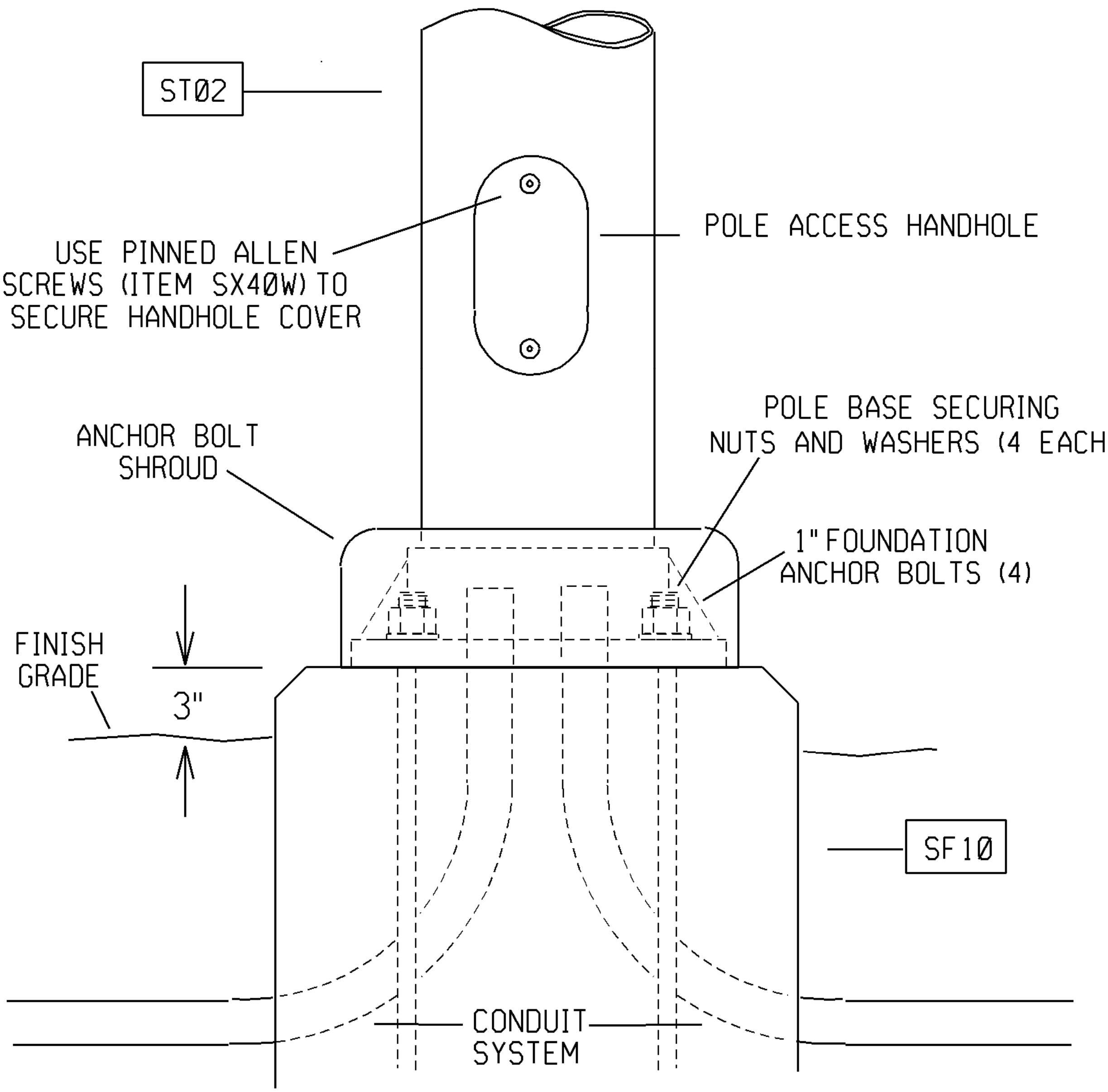


Figure 44
Anchor Base, Fiberglass, Pendant, Pole – Installation

CAUTION: Never install pole without arm and luminaire.
The arm / luminaire combination contribute to dampen wind induced vibration forces which could lead to pole failure

46.26 “SUBURBAN” POST TOP POLE - ANCHOR BASE, ROUND, FIBERGLASS – INSTALLATION

This Section provides details for installation of an anchor base, fiberglass, Suburban post top pole.

46.26.10 Foundation Installation

Anchor base, fiberglass Suburban post top poles are installed on precast concrete foundations. See STANDARDS Section 46.16 for precast concrete foundation selection and precast concrete foundation installation details.

46.26.20 Pole Installation

Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation. Install anchor bolt shroud onto pole shaft before installing post top luminaire.

46.26.30 Wiring Diagram

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

Supersedes 1/07 Issue – Deleted Table 29. Revised paragraph 46.26.10.

 Doc. # ST. 46.00.024

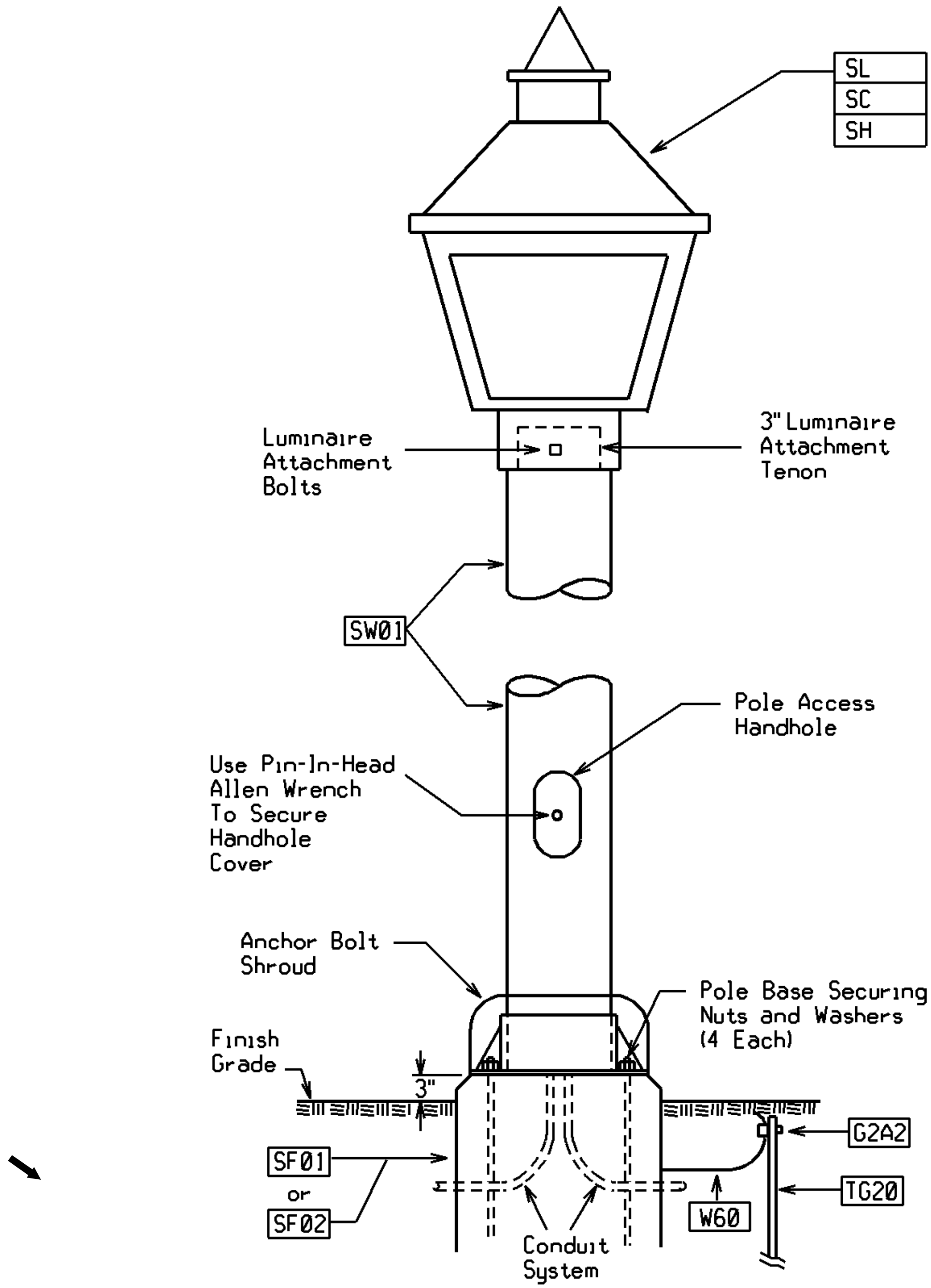


Figure 45
Suburban Post Top Pole - Anchor Base, Fiberglass, – Installation

46.27 “SUBURBAN” POST TOP POLE – EMBEDDED, ROUND, FIBERGLASS – INSTALLATION

This Section provides details for installation of an Suburban embedded, round, fiberglass, post top style pole. (STD Item SW02). Suburban, embedded, round fiberglass poles are intended for use with direct buried supply conductors.

46.27.10 Pole Loading

Suburban, embedded, round, fiberglass poles are rated capable of supporting one post top style luminaire. No other attachments are allowed.

46.27.20 Pole Installation

Auger hole to the required depth. Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation. Set pole plumb and hold in position on undisturbed earth. As pole is set, feed underground supply cable through the conductor entrance hole up toward the pole access handhole.

46.27.30 Backfill

Add backfill in 6 inch layers and tamp firmly. Complete filling of the hole with excavated soil to within 4 inches below grommeted wire hole. Avoid stones larger than 2 inches in diameter. Next, add 8 inches of tamped sand, (covering direct buried secondary conductors), followed by 16 inches of tamped, backfill to within 4 inches of final grade. The final 4 inches of fill shall be tamped loam.

46.27.40 Luminaire Installation

Orient luminaire with respect to “street side” and “house side” markings to properly direct the light output. Securely attach the luminaire to the pole top tenon with the three attachment bolts. Lamp and photoelectric control should be the last items installed.

46.27.50 Wiring Details

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

Supersedes 1/07 Issue – Deleted Table 30. Revised paragraph 46.27.

 Doc. # ST. 46.00.024

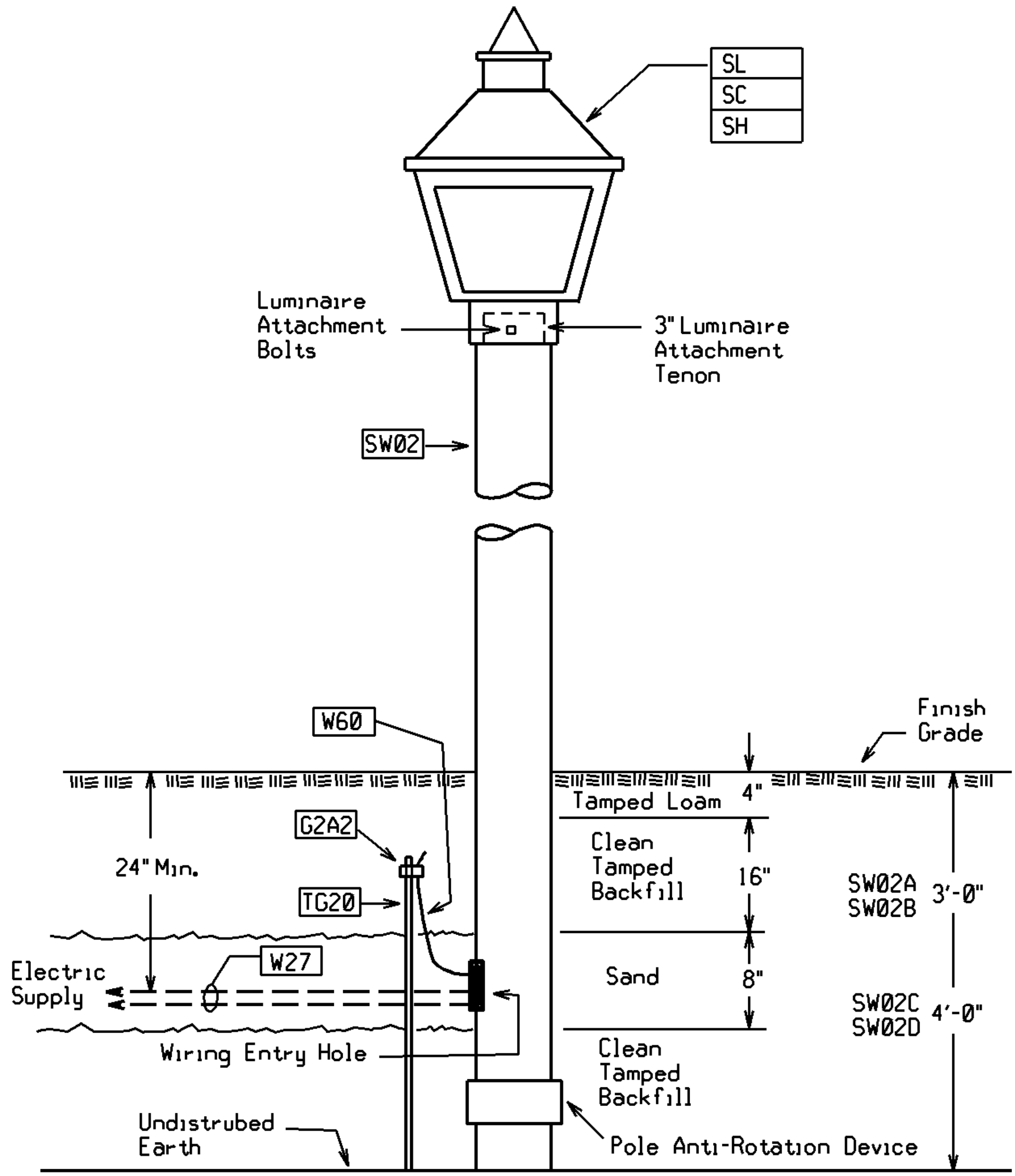


Figure 46
Suburban Post Top Pole – Embedded, Round, Fiberglass – Installation

46.28 “SUBURBAN” EMBEDDED, SQUARE, FIBERGLASS POLES – INSTALLATION

This Section provides details for installation of a Suburban embedded, square, fiberglass, post top style pole. Suburban embedded square fiberglass poles are intended for use with direct buried supply conductors.

46.28.10 Pole Loading

Suburban embedded, square, fiberglass poles are rated capable of supporting one luminaire. No other attachments are allowed.

46.28.20 Pole Installation

Auger hole to the required depth. Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation. Set pole plumb and hold in position on undisturbed earth. As pole is set, feed underground supply cable through the conductor entrance hole up toward the pole access handhole.

46.28.30 Backfill

Add backfill in 6 inch layers and tamp firmly. Complete filling of the hole with excavated soil to within 4 inches below grommeted wire hole. Avoid stones larger than 2 inches in diameter. Next, add 8 inches of tamped sand, (covering direct buried secondary conductors), followed by 16 inches of tamped, backfill to within 4 inches of final grade. The final 4 inches of fill shall be tamped loam.

46.28.40 Luminaire Installation – 18 Foot Pole

This pole is designed for use with post top luminaires. Orient luminaire with respect to “street side” and “house side” markings to properly direct the light output. Securely attach the luminaire to the pole top tenon with the three attachment bolts. Lamp and photoelectric control should be the last items installed. See Figure 47.

46.28.50 Luminaire Installation – 24 Foot Pole

This pole is designed for use with shoebox style luminaires (Std. Items SM03B1 or SM03C1 only). A tenon adapter (Std. Item SU02X) is required to mount the shoebox luminaire to the pole top tenon. Lamp and photoelectric control should be the last items installed. See Figure 48.

46.28.60 Wiring Details

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

46.28.70 Suburban Square Fiberglass Pole Selection

See STANDARDS sections 49-SU02 and 49-SW03 for available Suburban square fiberglass poles.

Supersedes 1/07 Issue – Deleted Table 31. Added paragraph 46.28.70.

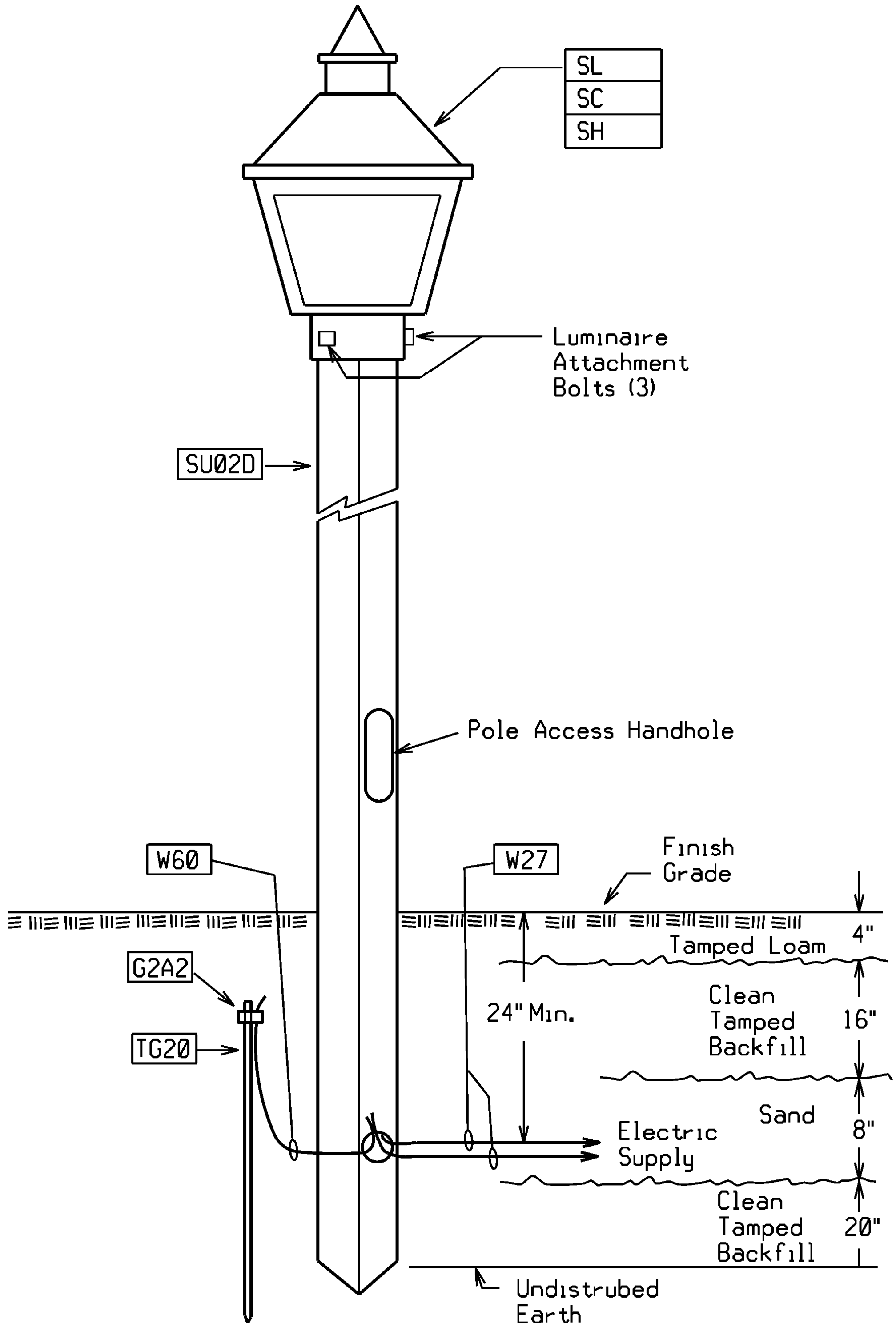


Figure 47
18-Foot Embedded "Suburban" Square Fiberglass Pole – Installation

Supersedes 1/07 Issue – Updated STD Item # in Figure 47.

Supersedes 1/07 Issue – Revised STD Item # in Figure 48.

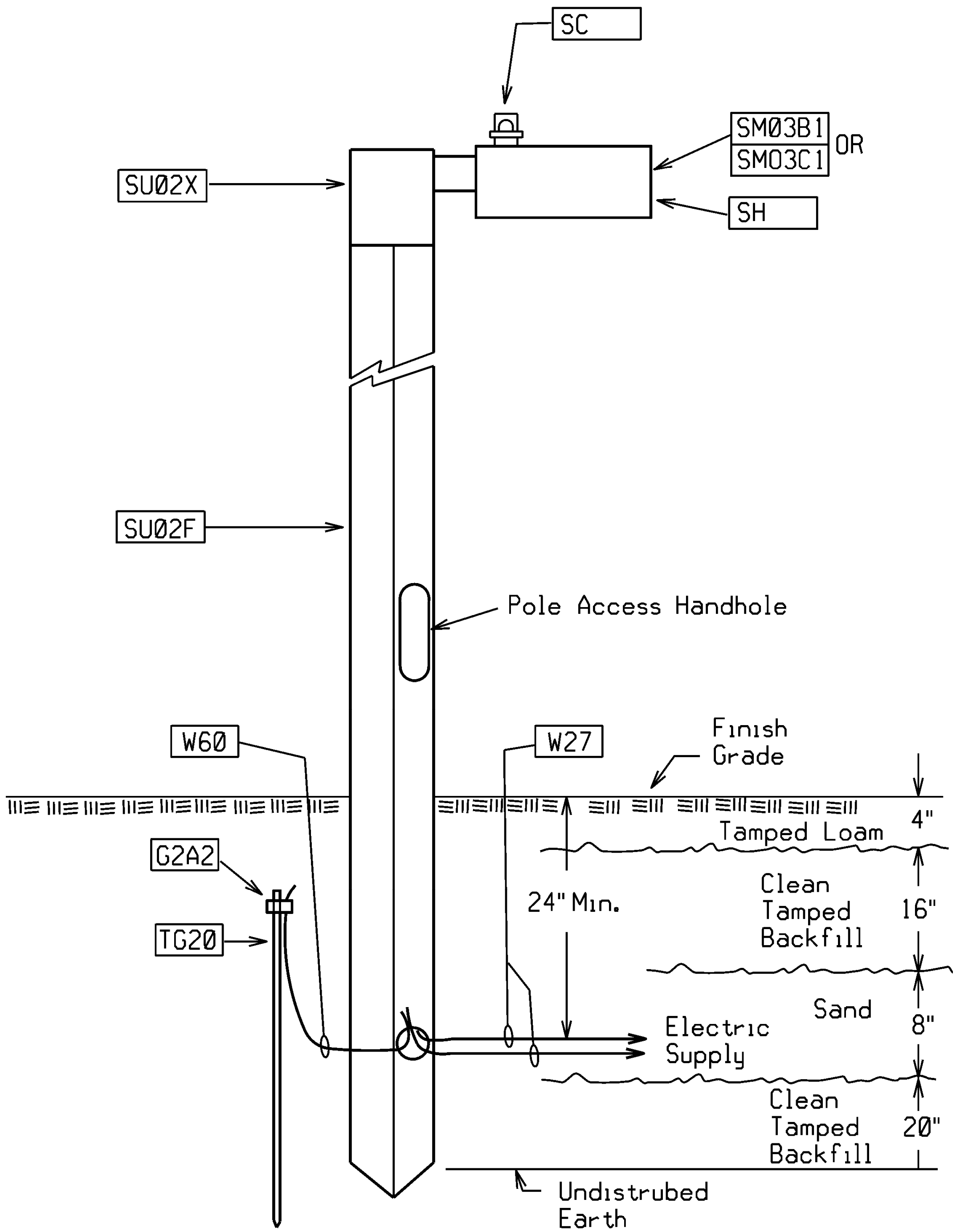


Figure 48
24-Foot "Suburban" Square Embedded Fiberglass Pole – Installation

46.29 “VILLAGER” POST TOP POLE – INSTALLATION

This Section provides details for installation of a “Villager” anchor base, aluminum, post top style pole.

46.29.10 Foundation Installation

Villager post top poles are installed on precast concrete foundations.
See STANDARDS Section 46.16 for precast concrete foundation selection and precast concrete foundation installation details.

46.29.20 Pole Installation

Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation.

46.29.30 Wiring Diagram

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

46.29.40 Villager Pole Selection

See STANDARDS Section 49-SW07 for available Villager poles.

Supersedes 1/07 Issue – General revision. Added “Villager” marketing name.

Supersedes 1/07 Issue – Revised STD Item # in Figure 49.

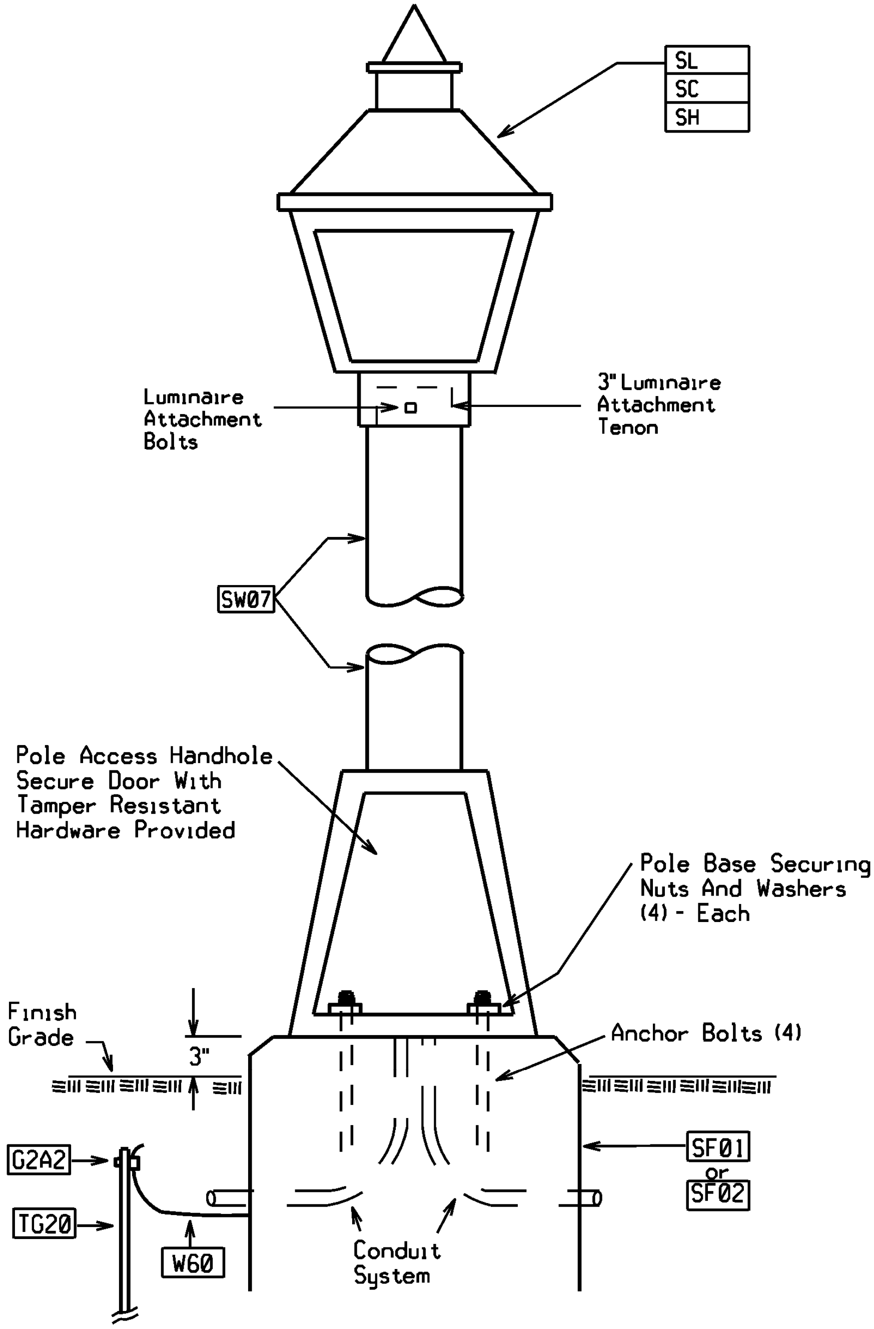


Figure 49
"Villager" Post Top Pole – Installation

46.30 TWIN POST TOPLUMINAIRE – INSTALLATION

This Section provides details for installing two post top style luminaires on the same pole using a twin arm.

46.30.10 Wiring Details

Install a separate set of #10 conductors for each luminaire and terminate inside the pole access handhole. Wrap each set of conductors with three layers of PVC tape to aid in conductor identification. Pull all conductors outside of the pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections back inside the pole access handhole and secure cover with tamper resistant hardware.

46.30.20 Twin Arms

See STANDARDS Section 49-SW50 for available selection of twin arms.

Supersedes 1/07 Issue – Deleted Table 34. Added paragraph 46.30.20.

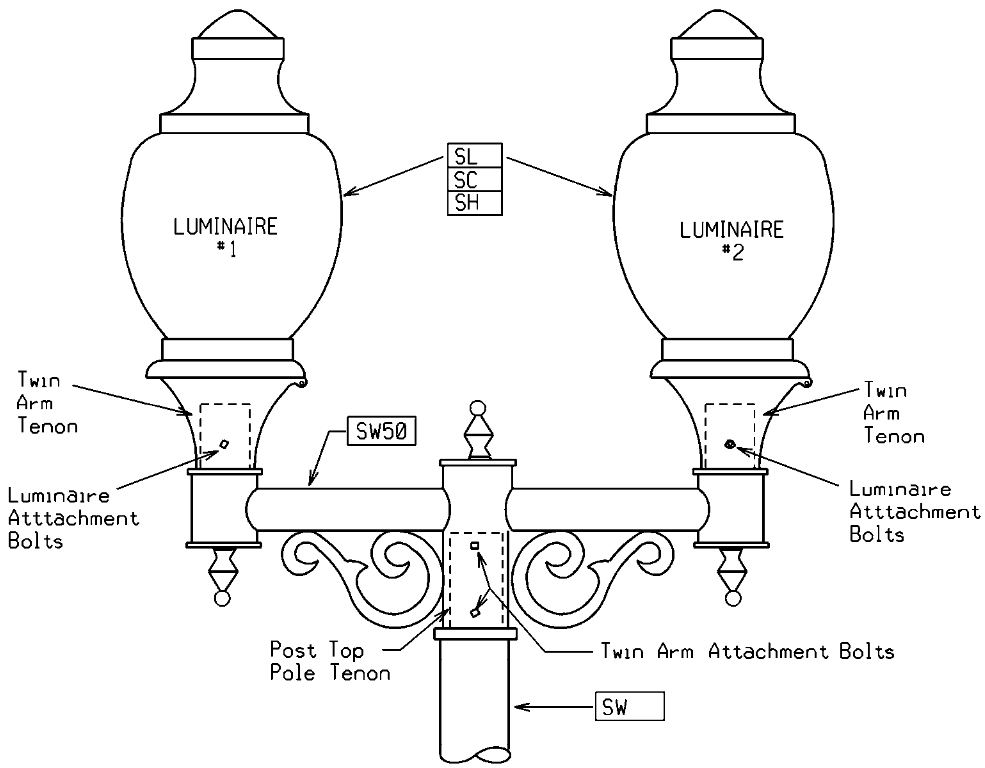


Figure 50
Twin Luminaire Arm Installation

46.32 “ESSEX” POST TOP POLE – INSTALLATION

This Section provides details for installation of an “Essex” anchor base, aluminum, post top pole.
Might not be offered in New Hampshire, check with Liberty Utilities Business Services Group.

46.31.10 Foundation Installation

Anchor base, aluminum post top poles are installed on precast concrete foundations.
See STANDARDS Section 46.16 for precast concrete foundation selection and precast concrete foundation installation details.

46.31.20 Pole Installation

Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation.

46.31.30 Wiring Diagram

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

46.31.40 Essex Pole Selection

See STANDARDS page 49-SW06 for available Essex poles.

Supersedes 1/07 Issue – Deleted Table 35. Revised paragraph 46.31.10. Added paragraph 46.31.40.

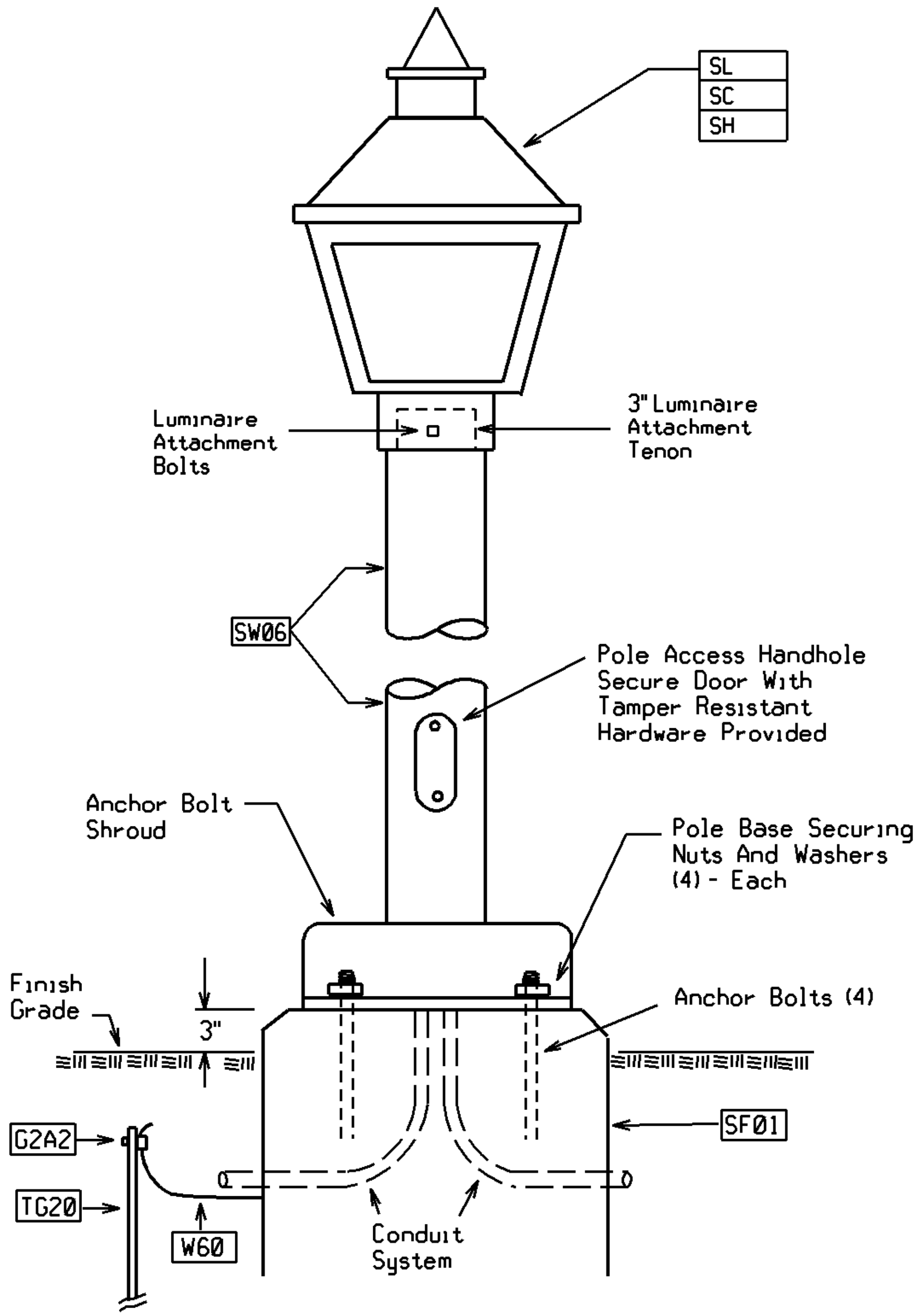


Figure 51
"Essex" Anchor Base Aluminum Post Top Pole – Installation

Supersedes 1/07 Issue – Deleted Table 36. Revised paragraph 46.32.10. Added paragraph 46.32.40.

46.32 <u>"WASHINGTON" POST TOP POLE – INSTALLATION</u>

This Section provides details for installation of an "Washington" anchor base, aluminum, post top pole. *Might not be offered in New Hampshire check, with Liberty Utilities Business Services Group.*

46.32.10 <u>Foundation Installation</u>

Washington anchor base, aluminum post top poles are installed on precast concrete foundations. See STANDARDS Section 46.16 for precast concrete foundation selection and precast concrete foundation installation details.

46.32.20 <u>Pole Installation</u>

Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation.

46.32.30 <u>Wiring Diagram</u>

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

46.32.40 <u>Washington Pole Selection</u>

See STANDARDS Section 49-SW09 for available Washington poles.

 Doc. # ST. 46.00.026

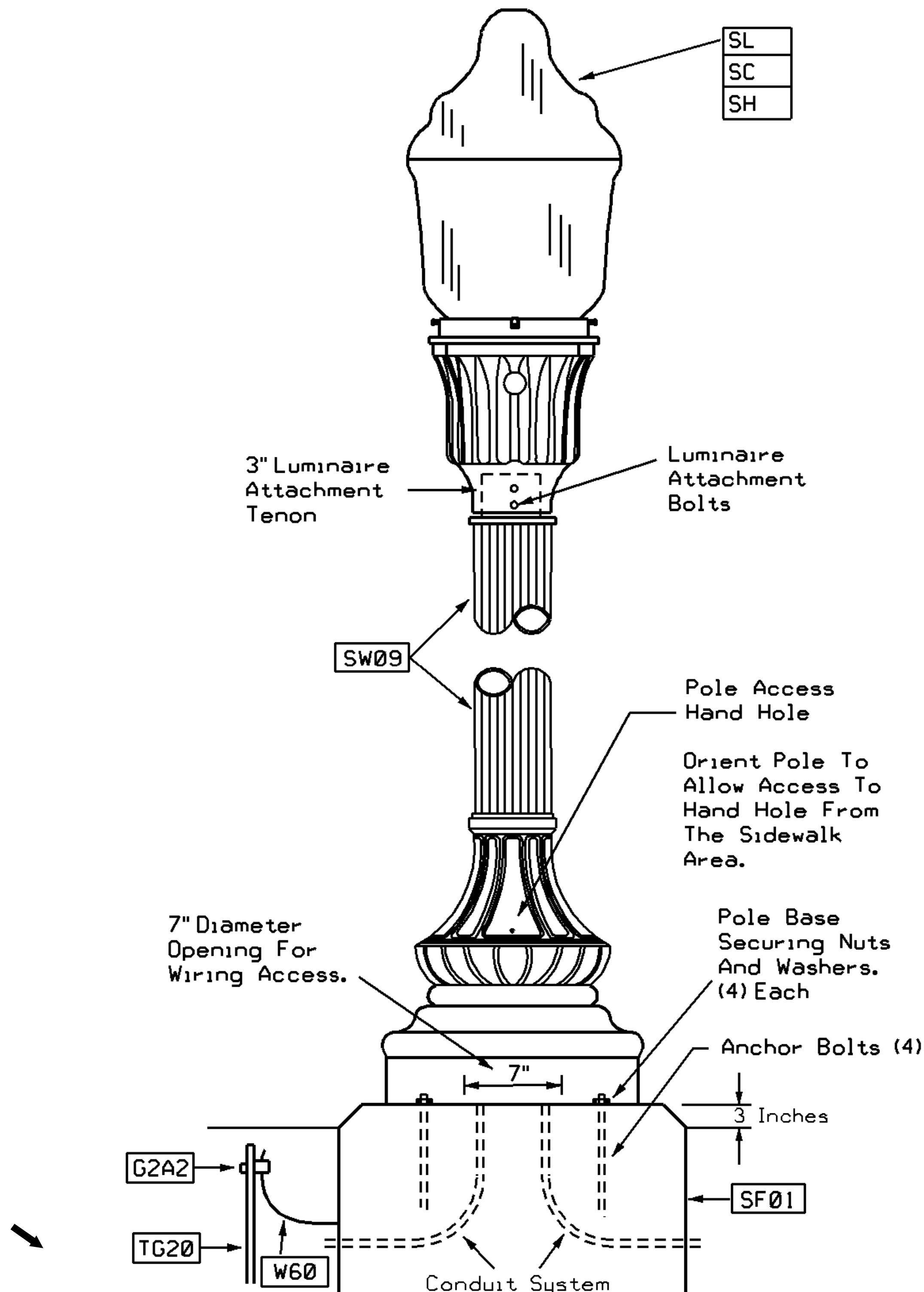


Figure 52
"Washington" Pole – Installation Details

"WASHINGTON" POST TOP POLE – INSTALLATION			
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46.34 “PRESIDENTIAL” POST TOP POLE – INSTALLATION

This Section provides details for installation of a “Presidential” anchor base, fiberglass, lighting pole. *Might not be offered in New Hampshire, check with Liberty Utilities Business Services Group.*

46.33.10 Foundation Installation

Presidential anchor base, fiberglass post top poles are installed on precast concrete foundations. See STANDARDS Section 46.16 for precast concrete foundation selection and. precast concrete foundation installation details.

46.33.20 Pole Installation

Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation.

46.33.30 Wiring Diagram

Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Modify as applicable for twin source or twin luminaire requirements. Push completed connections and slack back inside pole access handhole and secure cover with tamper resistant hardware.

46.33.40 Presidential Pole Selection

See STANDARDS Section 49-SW08 for available Presidential poles.

Supersedes 1/07 Issue – Deleted Table 37. Revised paragraph 46.33.10. Added paragraph 46.33.40.

 Doc. # ST. 46.00.027

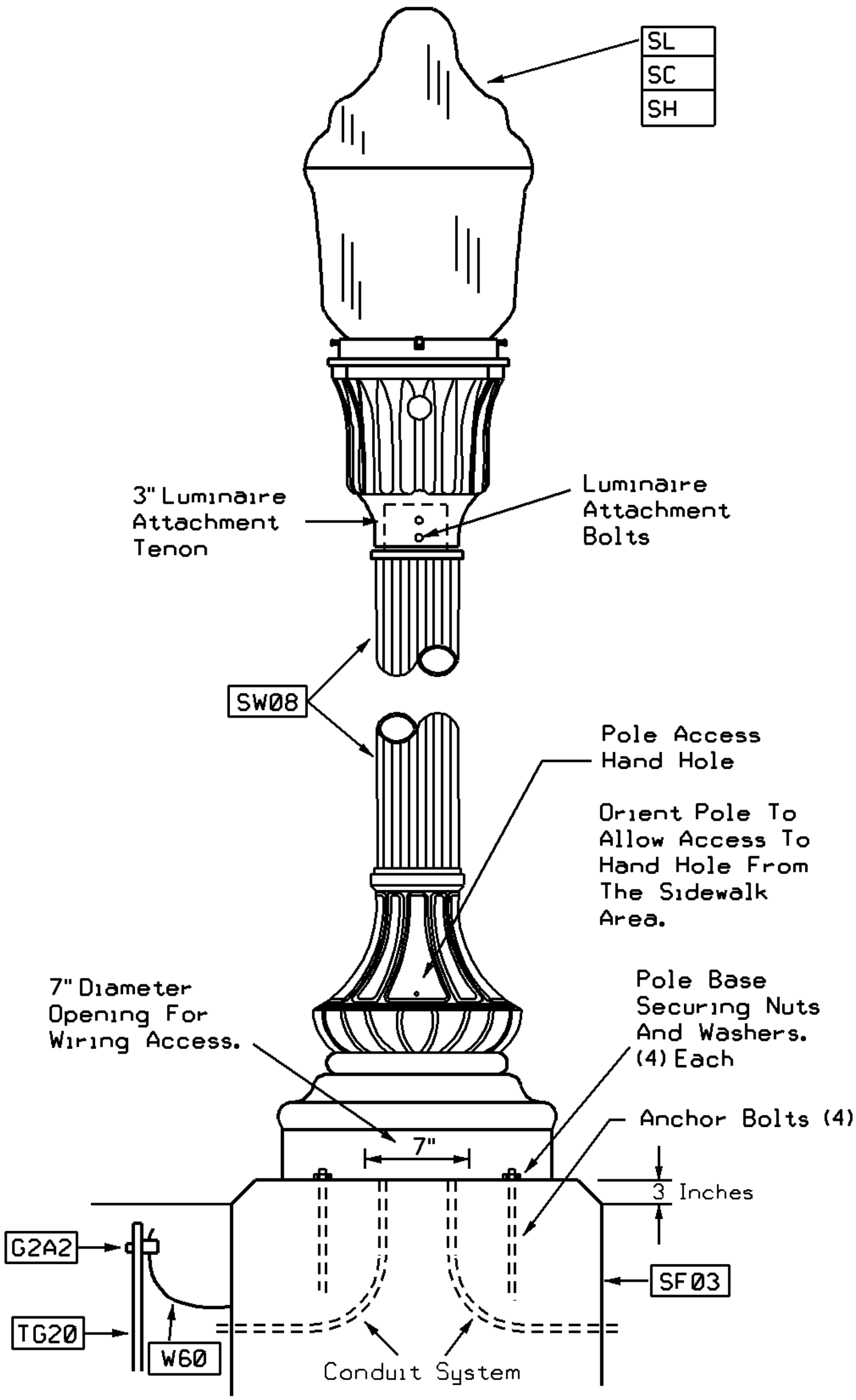


Figure 53
"Presidential" Post Top Pole – Installation Details

46.34 "ARMORY SQUARE" POST TOP POLE – INSTALLATION

This Section provides details for installation of an "Armory Square" aluminum, anchor base, post top lighting pole. *Might not be offered in New Hampshire, check with Liberty Utilities Business Services Group.*

46.34.10 Foundation Installation

Armory Square, anchor base, aluminum, post top poles are installed on precast concrete foundations. See STANDARDS Section 46.16 for precast concrete foundation selection and precast concrete foundation installation details.

46.34.20 Pole Installation

Attach nylon sling at a point approximately 1/3 down from pole top. Never use chain or cable. Be careful not to cut or scratch the pole surface during installation.

46.34.30 Wiring Diagram

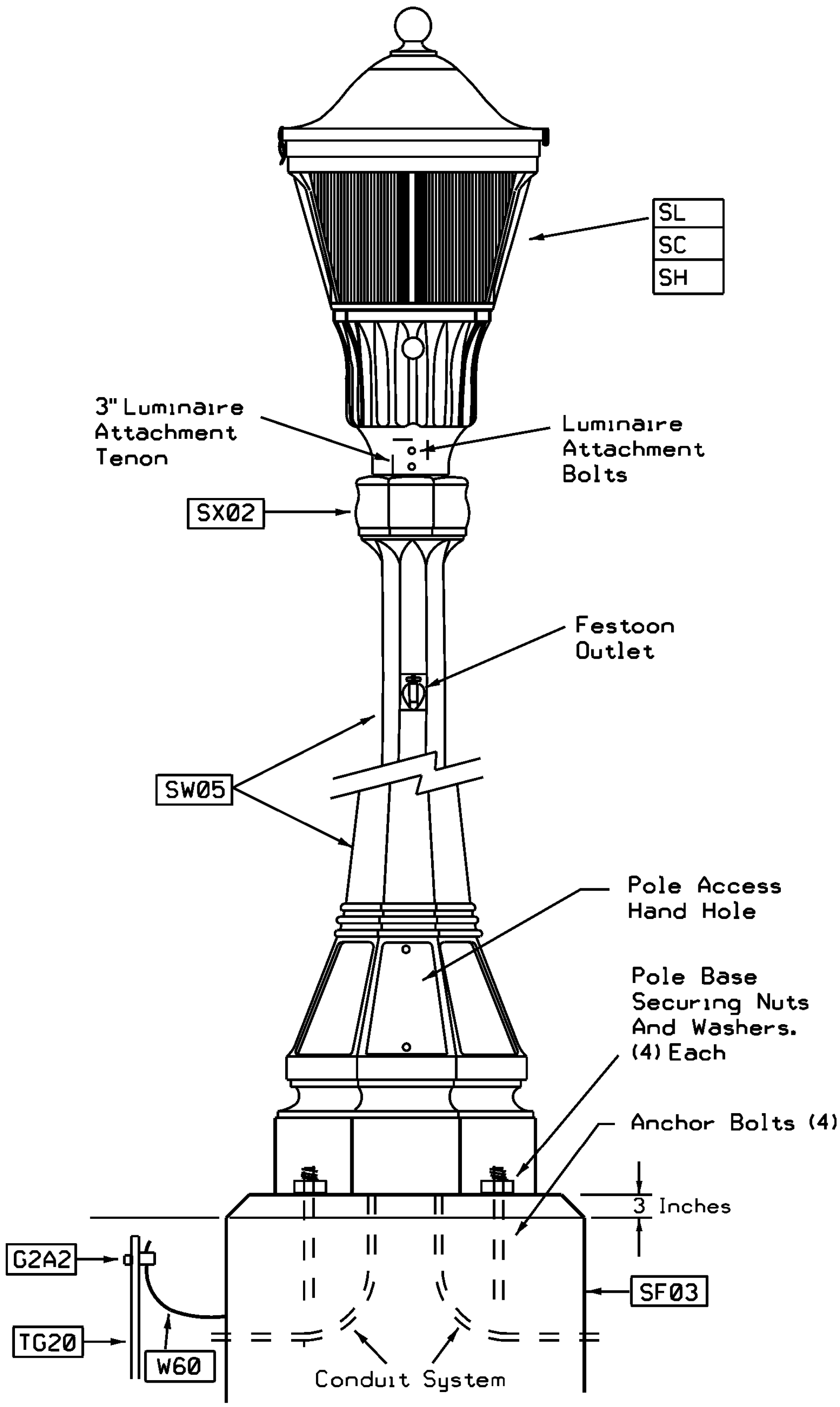
Pull all conductors outside of pole access handhole to make connections. Allow sufficient slack for future maintenance. Complete connections in accordance with STANDARDS Section 46.19. Push completed connections back inside pole access handhole and secure cover with tamper resistant hardware.

46.34.40 Armory Square Pole Selection

See STANDARDS Section 49-SW05 for available Armory Square poles.

Supersedes 1/07 Issue – Deleted Table 38. Revised paragraph 46.34.10. Added paragraph 46.34.40.

 Doc. # ST. 46.00.027



Supersedes 1/07 Issue – Revised STD Item # in Figure 54. Added Note 1.

Figure 54
"Armory Square" Post Top Pole - Installation Details

NOTE 1: STD Item SX02 (Tenon Adapter) is needed only on older style Armory Square poles with a 7" tenon.
New Armory Square poles are provided with a standard 3" tenon.

46.37 CONNECTION DETAILS – CUSTOMER OWNED STREET LIGHTING EQUIPMENT

This Section covers requirements for installation and connection of customer owned street light equipment to company owned secondary conductors.

46.37.10 Standards

All customer owned construction shall be in compliance with the applicable provisions of the National Electric Safety Code, latest edition.

46.37.20 Final Connections

The Company shall connect / disconnect all connections to the Company owned secondary conductors.

46.37.30 Customer Owned Equipment

The customer shall own, operate, and maintain all equipment beyond the street light service taps. – See Figures 60, 61, and 62.

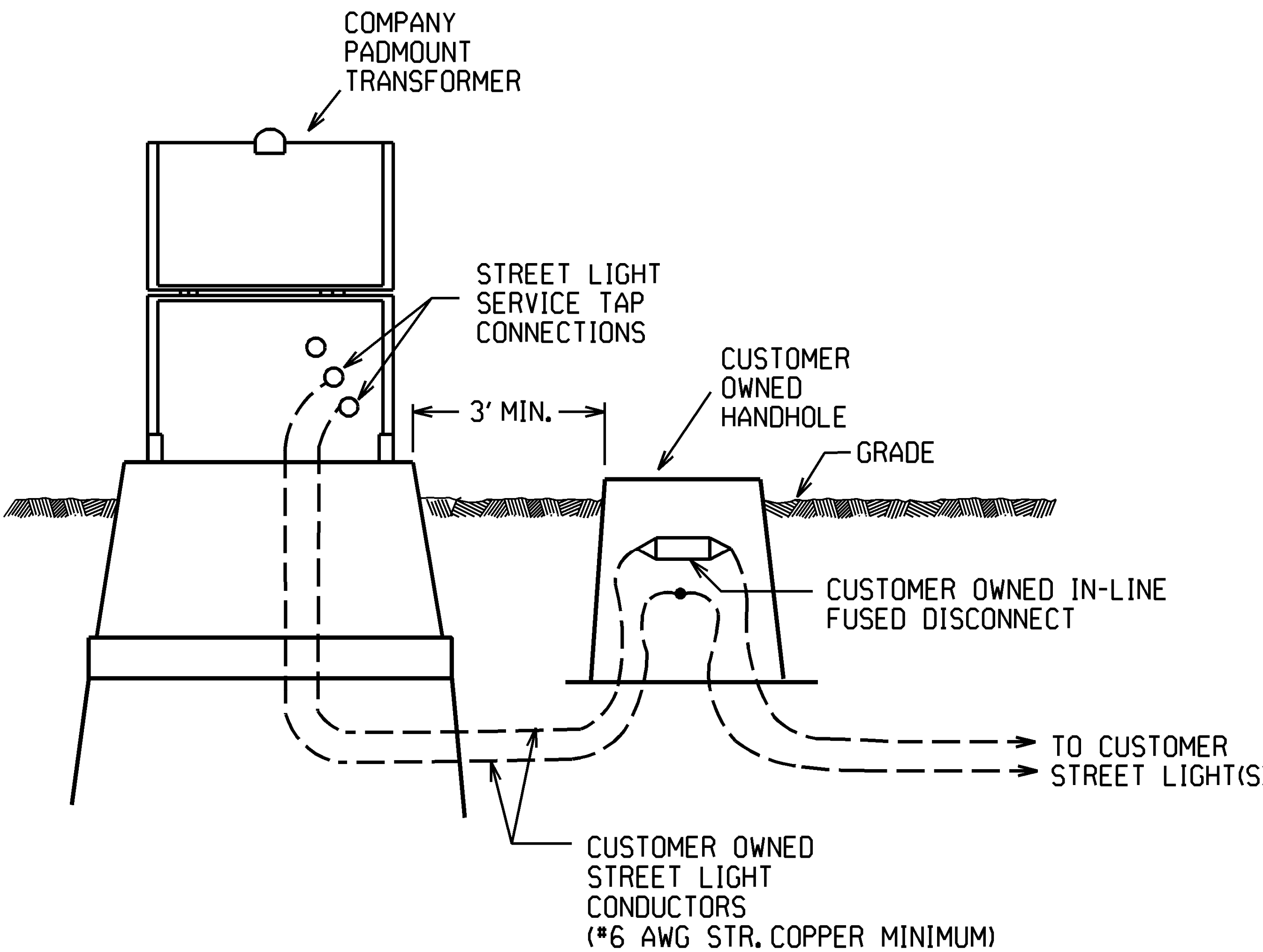


Figure 60
Connection of Customer Owned Streetlight(s) Supplied From URD Pad-mount Transformer

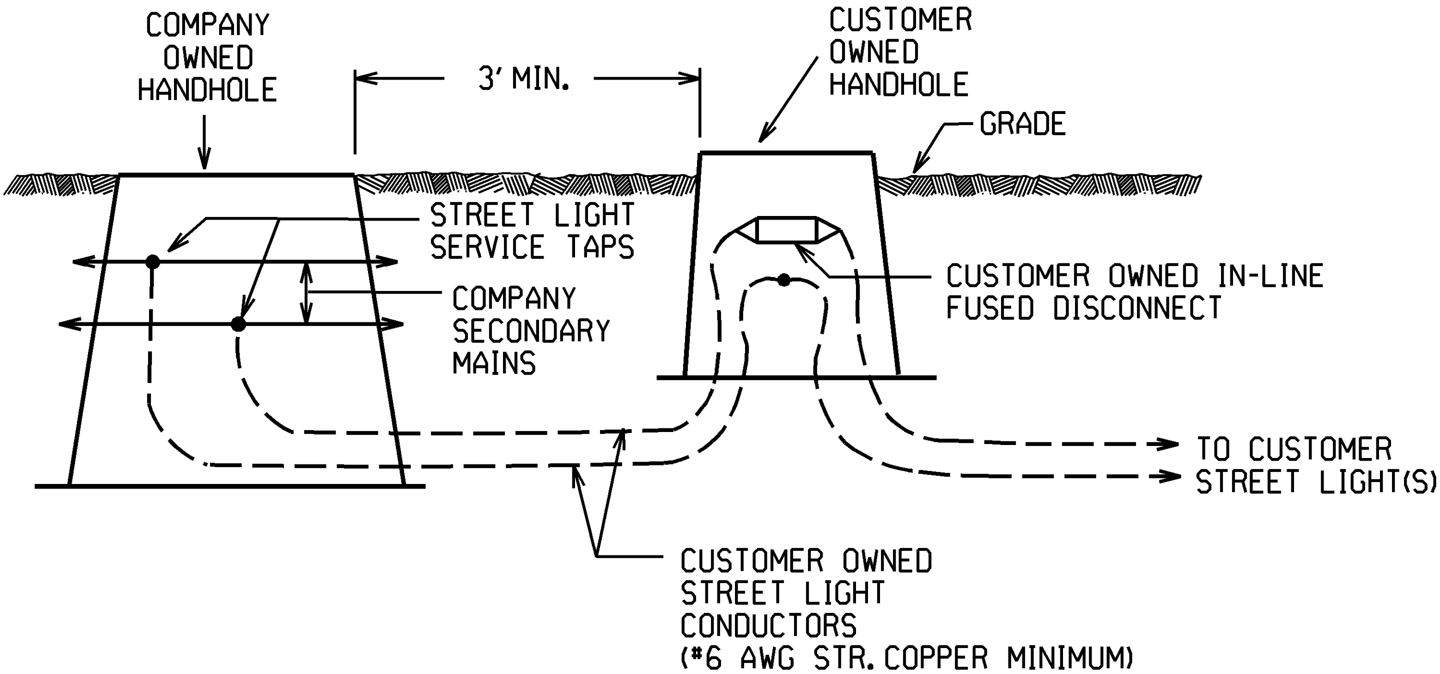


Figure 61
Connection of Customer Owned Streetlight(s) Supplied From URD Secondary Handhole

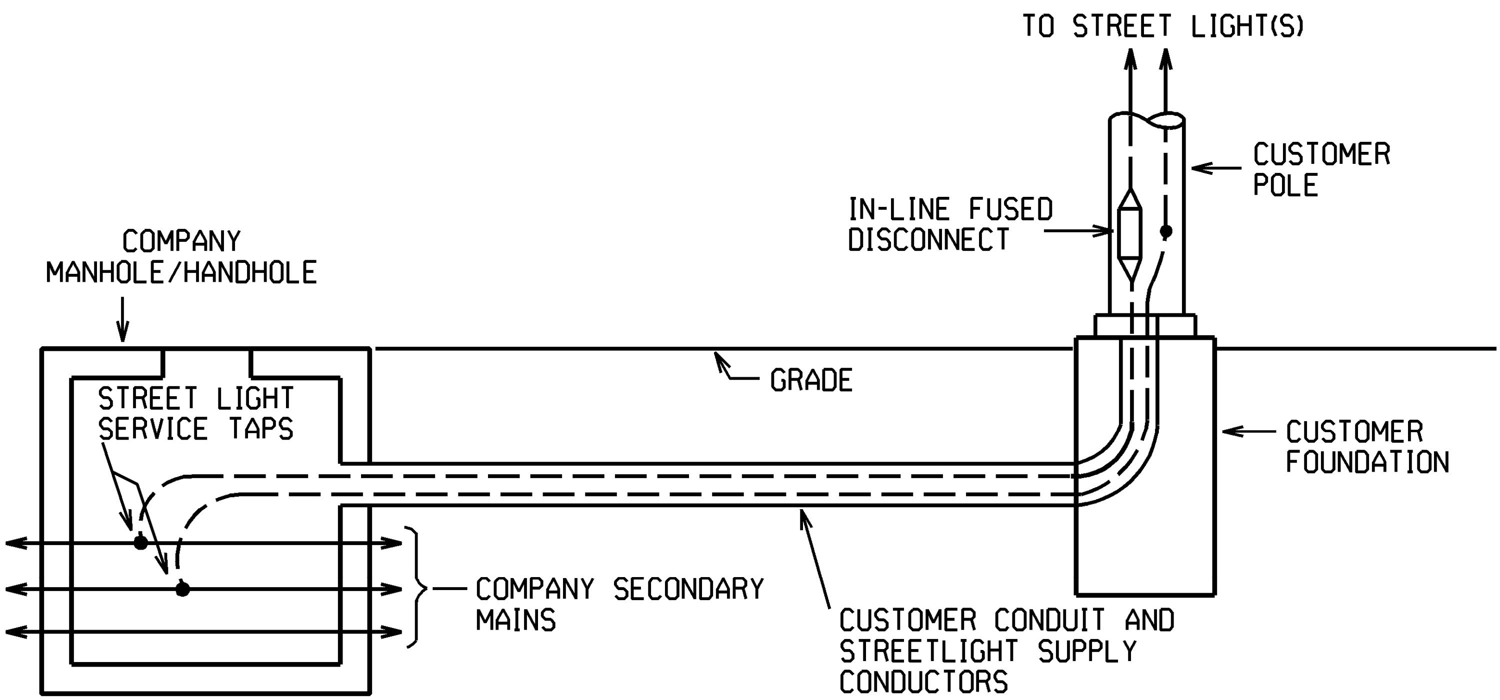


Figure 62
Connection of Customer Owned Streetlight(s) Supplied From Distribution Manhole

46.37.40 <u>In-Line Fused Disconnect</u>

All customer owned street lighting equipment shall be fused using a watertight in-line fuse holder and cartridge style fuse. This fuse, in addition to providing electrical protection, shall serve as a disconnection point for the customer owned streetlight equipment. The in-line fused disconnect shall be a Homac “Floodseal” model SDK-M or equivalent. The cartridge fuse shall be 600 volt, 13/32” diameter, 1½” length, non-glass type or equivalent. When separated, the cartridge fuse shall be held in the load end. Provide sufficient slack in wiring to facilitate fuse replacement.

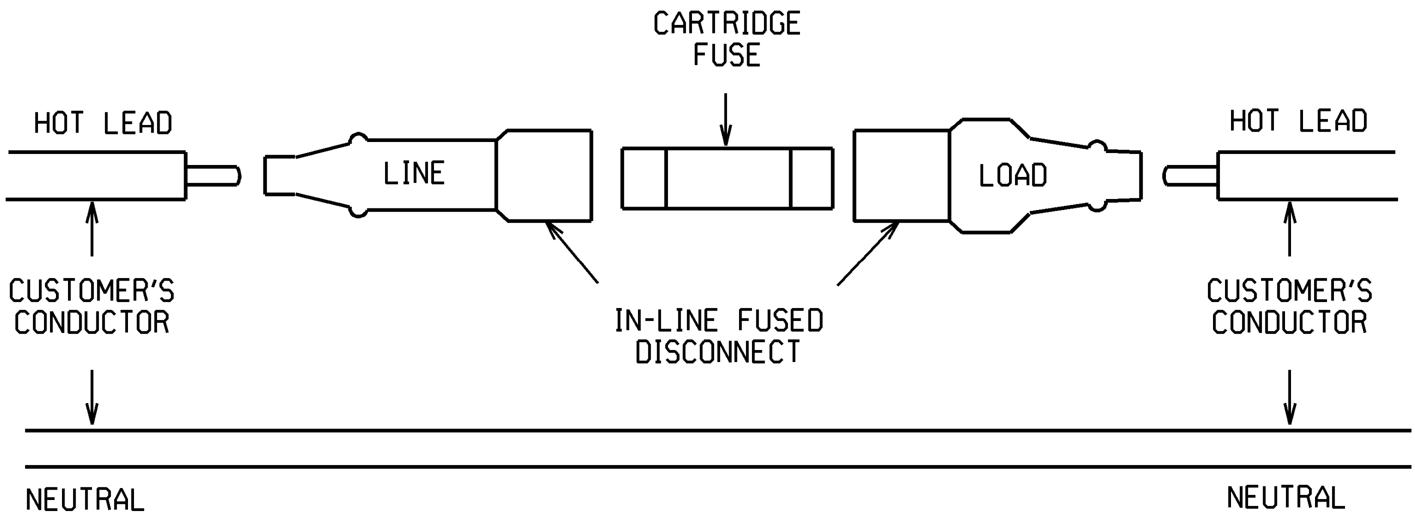


Figure 63
In-Line Fused Disconnect

46.38 FIELD MAINTENANCE OF HPS OUTDOOR LIGHTING EQUIPMENT

This Section provides technical instructions to diagnose common failure modes of all types of high pressure sodium vapor outdoor lighting equipment.

Refer to the Company Electric Operating Procedure # G007 for additional required maintenance activities to be preformed any time a crew has a need to perform any repairs on an outdoor lighting installation.

46.38.10 Luminaires Which Will Not Turn "On" At Night

Table 17

Step #	Action	Comment
1	Check connections at pole for signs of corrosion and replace if necessary.	Especially important in coastal areas.
2	Test photo control operation.	This will confirm an energized circuit at least to the line side of the photo control.
3A	If photo control is not working, replace unit and retest or troubleshoot for an open circuit.	Source voltage can be checked at the terminal block inside the luminaire and in the pole's handhole (if supplied by underground distribution).
3B	If photo control is working, remove photo control	De-energizes load side of circuit.
4	Check luminaire labeling for lamp wattage and type and replace lamp with proper unit.	See Note 1 below for visible signs of lamp failure.
5	Reinstall photo control and test to see if lamp strikes.	Reenergizes load side of circuit.
6	If lamp fails to strike, replace plug-in starter with a properly rated unit.	Replacement starter may have to be modified before installation. See instructions supplied with every starter.
7	If lamp still fails to strike, check inside of luminaire for loose or broken connection and check for proper supply voltage and lamp type.	
8	If lamp still fails to strike, replace luminaire	Most luminaries have a five year warranty. Date of manufacture is found on the luminaire nameplate.

Note 1:

Visible signs of lamp failure:

A. Normal end of life:

Arc tube will be blackened.

B. Arc Tube Leaker:

This occurs when sodium leaks out of the ends of the arc tube. Look for the outer glass bulb to be discolored with a transparent amber color, if a small leak, or a dark silver-black color if a large leak.

C. Air Lamp:

A crack in the outer bulb will allow air to enter the lamp and contaminate the vacuum. The "getter flash" (dark-silver-black coating on the outer glass bulb just above the lamp base) will be white and flaky pieces may be floating loose within the outer bulb. The lamp base may have a tarnished look. The "getter flash" acts as a cleaning agent to maintain the lamp's vacuum. Without a good getter, the lamp would expire in about a week.

46.38.20 Luminaires Which Cycle “On” And “Off”

Cycling is a condition common to high pressure sodium vapor lamps where the lamp cycles “on“and “off” for no apparent reason. This condition may occur only once in a while or may be continuous until corrected. The most common causes of cycling and their solutions are listed below:

A. End of Life Cycling:

The most common cause of cycling is when the lamp reaches the end of its life. After the arc is established, the voltage (measured at the lamp socket) is drawn down to as little as 12 volts. As the lamp warms up, this voltage increases to the “New Lamp Voltage Range” as shown in the table below. As the sodium vapor lamp ages, this voltage gradually increases above this value. Eventually the voltage needed by the lamp will exceed what the ballast can supply. (See “End of Life Lamp Voltage” in table below.) When this happens, the arc inside the lamp can no longer be supported, so the lamp extinguishes and must cool down before the arc will reestablish itself.

A lamp which has just reached end of life may cycle only one or two times a night. The frequency of cycling will increase as the lamp ages, and it will eventually cycle all night long.

THE SOLUTION IS TO REPLACE THE LAMP

A cycling lamp should be replaced promptly to avoid long term damage to the igniter and the ballast.

Note: If the lamp strikes, the plug-in igniter is working properly and need not be replaced.

Table 18

Lamp Wattage (Watts)	Rated Lamp Voltage (Volts)	New Lamp Voltage Range (Volts)	End of Life Lamp Voltage (Volts)
50	52	46 – 60	84
70	52	45 – 60	84
100	55	44 – 62	84
150	55	48 – 62	88
250	100	90 – 120	160
400	100	84 – 115	140
1,000	250	210 – 275	350

B. Photo control Caused Cycling:

In rare instances, artificial light from illuminated signs or headlights may cause the photocontrol to turn the lamp load “off”. This unwanted “turn off” may appear as cycling hut actually is not. The solution is to adjust the luminary’s photocontrol receptacle so the control window will “look” in a different direction.

C. Equipment Mismatch:

A mismatch between the lamp and the luminaire (e.g. 50 Watt lamp installed in a 250 Watt luminaire) will often cause cycling. Check the ANSI code on the lamp and the luminaire nameplate to make sure they match.

D. Broken Arc Tube Support:

A broken frame weld on the arc tube support inside the lamp may cause rapid cycling. This condition is usually caused by vibration and can damage the ballast if not promptly corrected.

E. Redirected Energy:

A condition where the lamp's energy is reflected back through the arc tube. This causes excessive heating of the arc tube and induces cycling. This condition can occur when aluminum foil is used inside the refractor to block and redirect the luminaries light output.

F. Manufacturing Defect:

The way the arc tube is manufactured may cause a rapid voltage rise and cycling. This will happen early in the lamp life and will continue for thousands of hours. Lamps with this condition should be returned to the lamp manufacturer as defective.

G. Voltage:

Low or high supply voltage to the luminaire may cause cycling or erratic lamp operation.

H. Feeder Operation

A momentary interruption in voltage or a sudden voltage drop may extinguish the arc in a sodium vapor lamp. The lamp must cool sufficiently before the arc will restrike. This condition may appear to be cycling but actually is not. No corrective action is needed.

46.38.30 Luminaires Which Stay "On" All Of The Time

Check the voltage rating of the luminaire and replace the photo electric control with a properly rated unit. Check new photocontrol for proper operation. Note that the sodium vapor lamp must cool sufficiently before the arc will restrike.

If this fails to correct the problem, check for a disconnected or broken neutral (white wire) connection inside the luminaire at the photocontrol receptacle.

46.38.40 Luminaires Which Burn Dim

A mismatch between the lamp and the luminaire may cause low light output. Check lamp wattage and compare with the wattage rating of the luminaire.

Check for low supply voltage. Measure supply voltage and compare with the voltage rating on the luminaire nameplate.

If the luminaire has a capacitor, check for signs of leaking, a bulged tank, broken connections, or a broken bleed resistor across the capacitor terminals.

Version	Date	Modification	Author(s)	Approval by (Name/Title)
1	07/13	• General Revision of entire section to convert to Liberty Utilities and New Hampshire specific. • Added pulse start metal halide information in multiple locations. • Added conductor color code assignments of page 46.16. • Added marketing names for poles in multiple locations. • Deleted CU Tables in multiple locations. • Corrected STD Item #s on multiple drawings.	Robert Johnson	Robert Johnson Program Manager