Merrimack Outages For 2008

Merrimack-1

The following outages occurred at Merrimack-1 during 2008. The major project for this unit was the replacement of the HP and LP rotors during the annual overhaul.

A - (Outage Report OR-2008-02)
1/7 – 2.9 days
The unit was taken off line for this planned outage on a Monday due to the low cost of power as projected by bidding and scheduling. The unit was on line for 105 days and required an air heater wash. This is a common outage for this unit after approximately 3 months of continued operation. If the unit is out of service for other reasons, the air heaters are washed at that time so that a special unit outage is not required.

PSNH planned to install new enamel cold end air heater baskets in the fall overhaul (Outage E below) to lengthen the time between wash cycles. The enamel coating retards the buildup of ash on the air heaters.

B - (Outage Report OR-2008-08)
4/25 – 3.6 days
This was a planned maintenance outage taken to wash the air heaters from continued operation since the January 10th air heater wash.

C - (Outage Report OR-2008-10)
6/6 – 3.1days
The unit was taken off line to repair 4 reheater tube leaks. The leaks were repaired and the unit returned to service. PSNH noted that non-destructive examination of this area of the boiler found no issues in 2006. However, non-destructive examination during the fall 2008 outage (Outage E below) indicated thinning of reheater tubes requiring replacement in 2010.

D – (Outage Report OR-2008-12)
8/20 – 2.1 days
The unit was taken off line due to a screen tube leak. A large clinker (buildup of solidified ash) hanging from the secondary super heater fell and damaged the tube screen clip. The clip cracked and the crack propagated to the screen tube causing the tube to fail. PSNH noted that replacement of some of the screen tubes has been scheduled over the next two overhauls.

E
9.9 – 49.6 days
This planned outage was taken to perform the 2008 overhaul for the unit. The outage schedule critical path was dictated by the removal, repair, and re-installation of the HP and LP rotors. The outage had an ISO outage window of 56 days. The PSNH outage schedule which is set on the aggressive side was scheduled for 49 days with the actual outage coming in at 51 days or 49 hours behind PSNH schedule.

Siemens entered into a contractual arrangement with PSNH to have the rotor returned by 10/18, essentially locking in the critical path to that point in time. After 10/18, the schedule became exposed to delays and gains based on daily progress during the outage. Siemens was able to ship the HP rotor one day earlier than contractually obligated to do so but the LP rotor was shipped 8 hours later than planned due to difficulty in Siemens receiving travel permits for the permit loads (Specific travel restrictions which may vary from state to state).

Once the HP and LP rotors were on site, items such as the grinding of the generator collector rings which requires the turbine to be in place and rotating on turning gear and other items that emerged as emergent work in the close out work sequence caused the outage to exceed schedule by about 2 days. The bulk of the outage extension was due to the grinding of the generator collector rings (19 hours).

F - (Outage Report OR-2008-14)
10/31 – 2.1 days
The unit tripped when the P-12 breaker opened during the start up of the main fire pump motor. The P-12 breaker feeds the circulating water pumps. The P-12 breaker was replaced as part of the switchgear replacement of two 4.16 kV load centers during the annual overhaul in Outage E above. Investigation found that the relay setting to the screen house and fire pumps was set too low by the vendor who used an incorrect current transformer ratio in setting the relay.

This problem was a vendor quality control problem as PSNH supplied the correct information to the vendor. PSNH had all relay settings made by the vendor checked again by the vendor and all were found to be correct. The vendor has also included current injection to each breaker to confirm correct current transformer ratios as part of its new equipment start up procedures.

Prior to coming off line for this outage, a boiler leak was evident. The outage was extended to repair 2 boiler wall tube leaks. Upon startup, the condensate pump mechanical seal failed requiring replacement and extended the outage further. After the seal was replaced, the unit returned to service.

G – (Outage Report OR-2008-16)
11/25 – 4.0 days
The unit was taken off line to repair a screen tube leak in the floor of the boiler. The failed tube was not in the section of screen tubes that were replaced during the overhaul

in Outage E above, rather was located behind refractory and was not identified during the non-destructive examination performed during the overhaul. The screen tube was repaired and the unit returned to service.

H
12/5 – 0.7 days
This outage was required because of a noisy 1B air heater drive. During the annual overhaul (Outage E above), both air heaters were replaced. The spare air heater drive was installed in heater 1A based on maintenance records and the 1A drive was sent out to be rebuilt. PSNH monitored the noise in the 1B drive, expedited the rebuilding of the 1A drive, and took this outage to replace the 1B gear box. The gear box was replaced with the rebuilt drive and the unit returned to service.

I
12/15 – 0.3 days
The cyclone 1A and 1C cyclone blast gates were replaced during the annual overhaul. The blast gates are located above the cyclone burners and are designed to prevent the fires in the cyclones from backing up into the coal feeders. When cleaning coal pluggage, the 1A blast gate would not operate in either the manual or automatic mode, requiring the unit to come off line. Modifications were made to the 1A cyclone blast gate and the unit returned to service. During a subsequent outage, modifications were made to the 1C cyclone blast gate.

Merrimack-2

The following outages occurred at Merrimack-2 during 2008. The major projects for this unit were the replacement of the generator rotor, upgrade of the HP/IP turbine, air heater tube replacements, secondary superheater inlet bank replacement, and the replacement of the boiler floor.

A - (Outage Report OR-2008-03)
1/30 – 5.3 days
The unit was taken off line due to a secondary superheater leak in the inlet bank that damaged two adjacent tubes. The damage was such that 124' of tube needed replacement and scaffolding was required, thereby lengthening the outage. Two water tube leaks in the 2B and 2C cyclones and a furnace wall tube leak were also repaired. The unit returned to service without incident. Note: the secondary superheater inlet bank was replaced during the annual overhaul in Outage C below.

B – (Outage Report OR-2008-06)
3/2 – 4.5 days
The unit was taken off line due to a secondary superheater leak in the inlet bank. Investigation revealed that the failed tube had damaged 4 tube U-bends in the secondary superheater inlet pendent requiring their replacement. In addition, the failed tube damaged three adjacent tubes with steam cuts. Two water tube leaks in the 2C cyclone

and four furnace wall tube leaks were also repaired. The unit returned to service without incident. Note: The secondary superheater inlet bank was replaced during the annual overhaul in Outage C below.

C
4/1 – 50.8 days
This planned outage was taken to perform the annual over-haul of the unit, extensive generator stator inspection, air heater tube replacement, boiler floor replacement, secondary superheater inlet bank replacement, and the installation the new more efficient HP/IP turbine. The outage was scheduled with an ISO window of 63 days, but was aggressively internally scheduled to last 50 days. The actual outage ran duration of 52 days. The critical path throughout the majority of the outage was the replacement of the hot side air heater tube replacement project consisting of approximately 28,000 tubes consisting of multiple sections each. Only two significant schedule changes occurred during the outage. The first was a 23 hour delay to tighten the generator stator core, however, that time was made up by changes made to the generator stator program. The other areas of delay were attributed to high winds impeding boiler sealing (10 hours) and the boiler hydro test and delays due to boiler leaks which were not known until the boiler hydro test was performed (33 hours). These items accounted for virtually all of the schedule delay for the overhaul.

Liberty made some suggestions of potential for improvement during the outage such as listing crane departure dates on the update reports and having weekend updates conducted during the outage. PSNH quickly reviewed the suggestions and has included crane departure dates in its update report and has increased the frequency of outage updates during the last two weeks of a major outage when the dynamics of the outage increase.

D
5/22 – 0.8 days
The unit had just returned to service from its annual overhaul in Outage C above. An operator noticed that one of the disconnect switches (G-201) for the generator main breaker was red hot and removed the unit from service. The NU transmission department performs thermographic inspection of this equipment twice a year and additional inspections upon request. The G-201 disconnect was replaced in 2006 and last thermographed in 2/08 with no anomalies noted. The switch was found to have poor contact, was replaced, and the unit returned to service.

E – (Outage Report OR-2008-11)
6/20 – 23.9 days
This outage was required to inspect the new HP/IP turbine to determine reasons why the unit failed to even achieve prior existing full load capability when returning from the annual overhaul in Outage C above. The installation of a new more efficient HP/IP turbine was supposed to increase output in the order of 10 MW.

During startup from the annual overhaul, full load was not reached. Siemens was called in and found no noise problems, no vibrations, no overheat problems, no oil problems, good chemistry, proper temperatures, and proper pressure differentials. PSNH believed that with no abnormal indicators, that a design problem existed with the new HP/IP turbine. Siemens determined that the best approach would be to leave the unit at 300 MW and not attempt to obtain a higher load level out of the unit until it could be inspected.

The unit ran at 300 MW until taken out of service for inspection during this outage. In the time between returning from service and this inspection outage, Siemens thoroughly checked all designs, materials, analyses performed, pedigree of materials, and their records to find a clue as to why the unit was not performing as it was designed to do so. No design or material deficiencies were found.

Inspection revealed foreign material was in and had passed through the turbine and had damaged the turbine blades. PSNH checked and inspected approximately 100 locations with a boroscope for foreign materials including the LP-1 turbine, LP-2 turbine, condensate and feedwater systems, boiler headers and tubes, and turbine piping. The inspection was broadened to include valves, pumps and heaters. Foreign material was found in the condenser hotwell, main boiler feed pump, condensate pumps, and deaerator. No foreign material was found in the boiler.

A vast array of vendors and specialists were brought in to perform inspections, cleaning, and corrective action for identified repairs.

In the investigation process, PSNH identified chrome throughout the foreign material and determined that the chrome was not plated off of the turbine. The foreign material was identified as shot blast material. There is no record or personnel knowledge of shot blast material ever being used at Merrimack Station indicating that the foreign material was introduced from vendor supplied material. Three possible sources were identified. The vendor of the HP/IP piping, BendTec, did shot blast their product and then applied a protective coating. The vendor for the 23 secondary superheater inlet bank pendants, B&W Mexico, did not use shot blast on either the inside or outside of the tubing, however, shot blast is used for other purposes in their facility. The tubing vendor to B&W Mexico, Bentler, does not blast tubes at all. The furnace floor was manufactured by B&W Miss., and was shot blasted externally. The tubing was supplied by MST who does not blast tubes at all. All vendors who used shot blast material supplied samples for analysis. Extensive and multiple analyses showed that all samples were consistent with the foreign material found in the HP/IP turbine. All piping received from all vendors was

either inspected with a boroscope or blown out/vacuumed prior to installation, a long standing Merrimack Station requirement.

During its review, Liberty noticed that plywood is nailed to staging planks at most work locations. Liberty requested that the nails (called duplex nails because they have a double head for extraction) used for this purpose be analyzed for material content. PSNH analyzed the staging nails and found that they are made of low carbon steel, contain no chrome, and are very soft. There are two harness scales used in the industry, which are the Rockwell and Brinell hardness scales. A zero on the Rockwell scale is a 152 on the Brinell scale. The nails tested to a Brinell hardness of 100 while the shot blast tested to a Rockwell hardness of 44. Simply stated the hardness of the staging nails is below the Rockwell scale and could not be the foreign material.

In summary, no root cause for the path of the foreign material reentrance into the boiler has been identified, yet none have been ruled out including sabotage. Results are totally inconclusive.

The unit was cleaned and reconditioned or repaired as required. The unit returned to service and achieved a 320 MW load level at full load, its previous full load level. The 320 MW load was achieved with lower than full load steam flow indicating that the turbine was more efficient but that the remaining turbine damage prevented achieving a higher load.

A repair and replace option was considered. A new turbine would cost well in excess of $10 million and would take 2 ½ years to procure. In that time period, increased MW would not be available from the turbine. The repair option would replace all turbine blades in the HP/IP turbine so that the entire steam path was new. The decision was made to go with the repair option. The repair option would commence on 8/1/09 and last for 18 weeks. Note: If the upgrade was to produce a 10 MW upgrade, each dollar per MW that the Merrimack delivery price was lower than the market price would be about a $200,000 penalty to customers. Therefore, if Merrimack beat the market at $10/MWh, customers would be penalized approximately $20 million during the wait for a new turbine.

PSNH is pursuing insurance claims with its insurance carrier and performance issue with the vendor. These efforts are expected to continue into 2010. In addition, PSNH has strengthened and completely formalized its internal foreign material exclusion practice and reinforced foreign material exclusion requirements on contractors such as Siemens.

F – (Outage Report OR-2008-13)
9/19 – 4.6 days
The unit was removed from service due to high water usage resulting from tube leaks in the horizontal reheat section of the boiler. The primary leak damaged two other wall tubes. 14 other leaks and damaged tubes were found throughout the boiler. Repairs were made and the unit returned to service.

G
9/24 – 0.4 days
While returning to service from Outage F above, the unit tripped due to inadequate pressure in the 1st stage HP steam pressure sensing line. During the phasing of the unit, there is a short time period where the HP turbine needs to see transfer steam flow for minimum operation otherwise the unit will trip. The HP steam pressure sensing line is used as a proxy for HP turbine steam flow. Investigation revealed that the pressure switch sensing unit was faulty (would not trip with applied pressure), was replaced, and the unit was turned over to operations.

H – (Outage Report #14)
9/24 – 0.7 days
While returning to service from Outage G above, the unit again tripped due to inadequate pressure in the 1st stage HP turbine steam pressure sensing line. The sensing line was found to be plugged and would require a major outage to address. The location of the sensing line requires that the HP/IP turbine needs to be disassembled in order to either clean or replace it. Siemens approved using the HP/IP cylinder drain line as a proxy for the pressure of the HP turbine steam pressure sensing line. This line is in the same location as the plugged 1st stage HP steam pressure sensing line, so the same pressure reading is obtained. The unit returned to service without incident. The plugged 1st stage HP steam pressure sensing line will be replaced during the 2009 annual overhaul.

I
11/3 – 3.6 days
The unit was removed from service due to a tube leak in the horizontal reheat superheat section of the boiler. The primary leak occurred over time due to the failed tube rubbing and wearing against the economizer riser tube (Normal separation approximately 1/8 inch). PSNH states that this section of the boiler was visually inspected during the annual overhaul in Outage C above, no clip damage was noted, and the rubbing condition was not noted. PSNH further states that their review indicates an adequate amount of clip support for the tubes in this area.

Evaluation (Except for MK-2 – C and MK-2-E)

Liberty reviewed the outages above and found them either to be reasonable and not unexpected for these units and their vintage, or necessary for proper operation of the unit. Liberty concluded that PSNH conducted proper management oversight.

Evaluation for Outage MK-2 – C

There are two parts to the evaluation of the installation of the HP/IP turbine at Merrimack-2. The first evaluation answers the question if the conduct and management oversight of the outage itself was proper and the second is if it was in the customer's best economic interests to proceed with the replacement of the HP/IP turbine. This is Outage MK-2-C.

With regard to the question if proceeding with the HP/IP turbine was in customer's best interests, Liberty answers the question by performing its own economic analysis based on very conservative assumptions for information that was available at the time that a decision had to be made to proceed or not with the replacement of the HP/IP turbine for Unit 2. Those results are presented in Exhibit MDC-3A.

Merrimack 2 performed its last major and overhaul of the HP/IP turbine in 2003 and was scheduled perform the next inspection/overhaul in 2008 as the turbine was on a 5-year overhaul schedule. Siemens had determined in its 2003 blade condition report that the nozzle blocks (stationary blades) and first two rotating blade stages needed replacement in 2008.

In 2004, Siemens notified PSNH that it had developed a new HP/IP replacement turbine for its BB-43 frame machines (Merrimack 2 has a BB-43 frame). Siemens stated that the new turbine could go 10 years between inspection/overhaul eliminating a major unit outage and was markedly more efficient resulting in greater energy output. PSNH received budget grade estimates, determined that the project had about a 2-year payback, and bid out the project in early 2006 to ensure availability for the 2008 overhaul.

As noted above, Liberty performed its own economic evaluation on HP/IP turbine replacement economics. Liberty used much more conservative assumptions and found that under worst case conditions, that the project had an economic payback in the 12 to 13 year range. Such payback time periods demonstrate under the very conservative overlapping assumptions used suggest very strong project economics. In fact, the project economics are so in favor of the customer; Liberty would be raising questions of prudence if PSNH had not committed to pursue replacement in the 2008 outage window (earliest opportunity to do so) subjecting customers to added millions of added cost by their inaction. Liberty recommends recovery of replacement power costs for this outage.

Evaluation for Outage MK-2 – E

This outage would not have been required but for the performance issues related to the replacement of the HP/IP turbine at Merrimack-2. As noted above, PSNH is pursuing insurance claims with its insurance carrier and performance issue with the vendor. These efforts are expected to continue into 2010. Liberty recommends that replacement power costs for Outage MK-2-E be recovered by PSNH in this proceeding, but that the Commission provide an after the fact opportunity for review of PSNH's efforts to mitigate costs to customers in this outage.