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Rebuilding IP Feedwater Heaters Improves Performance and Saves Money

Nicholas Samford
Limestone Engineering Supervisor
NRG Texas
Nicholas.Samford@nrgenergy.com
Work: 903-626-1003
Cell: 979-221-4033

Daniel D. Bina
President & CEO
American Power Services Inc.
Work: 800-535-6649
Cell: 859-512-0040

Abstract:

Two (2) HP feedwater heaters with stainless steel U-tubes in service for over 20 years were beginning to be unreliable and needed to be replaced or rebuilt. Tube failures were more frequent primarily in the de-superheating zone. Through root cause analysis evaluation the tube failures were caused by wet wall from an oversized de-superheating zone, steam impingement entering the zone and excessive steam velocity causing vibration damage.

This paper describe the specific causes of tube failure, the redesign of the de-superheating zone to reduce it's size and reduced steam velocity by half, and the process of rebuilding the two (2) HP feedwater heaters within a short 26 day outage window. Rebuilding the two rebuilt HP feedwater heaters resulted in an improved heater performance and long term reliability, as well as extending the heaters life an additional 20+ years while solving and eliminating causes of past tube failures. Through rebuilding, we created value for the company by significantly reducing the cost of the outage and the duration compared to the cost and time of purchasing and installing two new manufactured heaters.

The paper will discuss the decisions made by NRG's Limestone Generating Station Management during the evaluation process prior. during and after the rebuilding process. The performance and operation of the heaters since the rebuilding in February of 2009 will also be discussed.

Figure 1. NRG Limestone Generating Station located in Jewett Texas.

Located between Houston and Dallas, NRG's Limestone station is a lignite/coal-fueled plant with two units—one 836 MW unit and one 864 MW unit. Both of the original feedwater heaters had been in service for more than 20 years. The two IP feedwater heaters were located in the 836 MW Unit #1.

Figure 2. One of Two IP FWH's with (1,134) ¾"OD x .035" SA-688 304 SS U-tubes.

Root Causes of tube failure:

The de-superheating (DSH) zone was originally designed too large. This resulted in saturated water exiting the DSH zone at excessive velocities causing tube erosion and tube vibration in the zone. The eddy current test report documented this OD tube erosion and vibration damage from localized excessive steam velocity and steam impingement.
One of the two IP feedwater heaters had tube failures from flashing condensate in the sub-cooling zone close to the SCZ end plate. The end plates for both heaters were replaced with 3" thick end plates with tight tube hole tolerance.

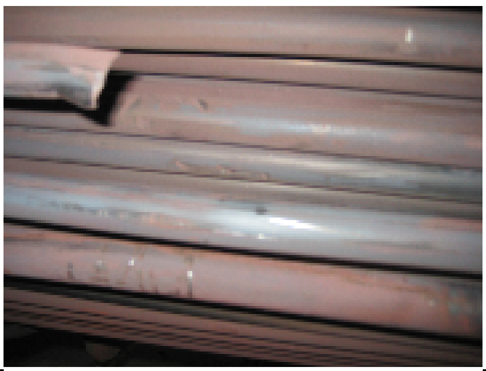


Figure 3. DSH Tube Vibration Damage

Figure 4. Severed tubes in shell dome.

Figure 5. Condensate flashing in SCZ at End Plate

Rebuilding cost-savings:

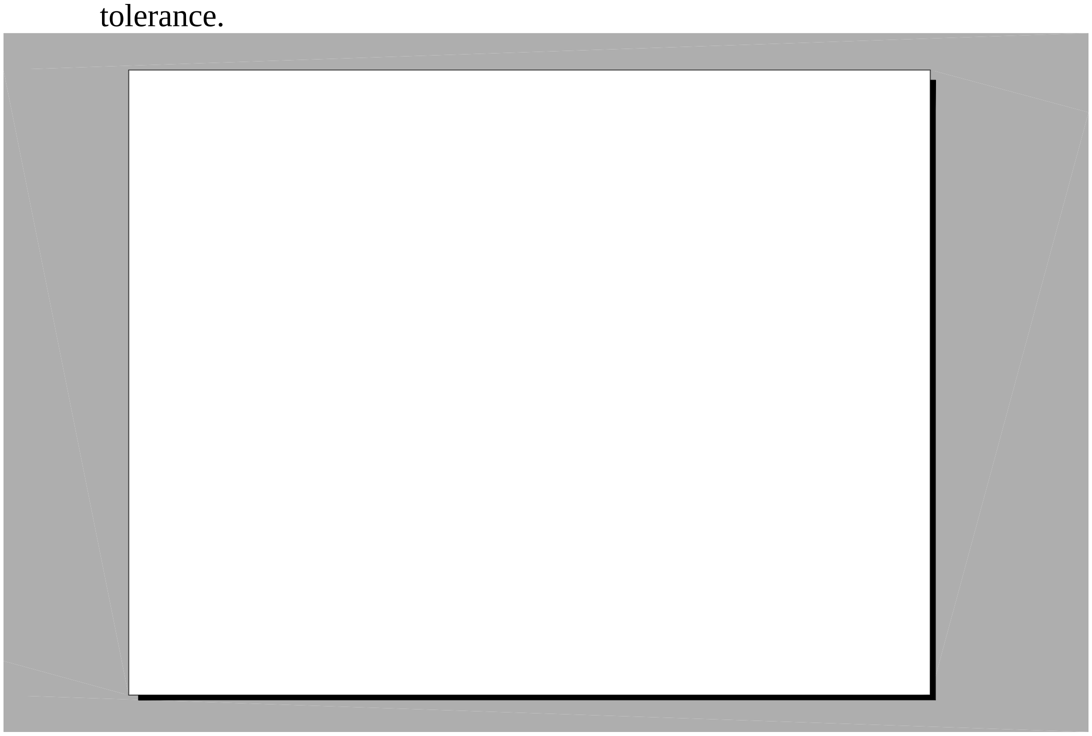
Limestone initially considered buying completely new heaters, but ultimately decided not to because of the additional cost and because the rebuilding included a re-design to eliminate the original design problem and correct all of the root causes of tube failures. The time to rebuild both heaters on site (26 days) was achievable within the outage window. The savings to the plant turned out to be 30% of the cost to fabricate and install two new replacement heaters.

Project objective:

Re-design two feedwater heaters to eliminate the root causes of tube failure and rebuild the (12A and 12B) IP Feedwater Heaters on site within a 26 day outage window.

Key changes in the re-designed 12A and 12B IP Feedwater Heaters:

1. Relocated steam inlet to the bypass nozzle to allow steam flow reduction in DSH.
2. DSH Re-designed steam flow to reduce steam flow velocity to eliminate tube vibration.
3. Reduced the overall size of the DSH to eliminate condensing and Wet Walls
4. Replace damaged SCZ end plates using 3” thick plates with tight tube hole tolerance.



Scope of work:

1. Redesign steam flow entering and flowing through the de-superheating zone.
2. Order new tubes, baffles and other internal parts based on the redesign.
3. Complete a detailed plan and schedule for the rebuilding project.
4. Conduct an on site review of the plan and schedule to the satisfaction of NRG and off load the new tubes, baffles, tie rods and spacers, zone shrouds and other parts to be replaces during the rebuilding.
5. Mobilize specialized tools and equipment and travel to Limestone Station.
6. Arrive on-site, unload and set up tools at each heater.
7. Cut shell at shell cut line with track cutter and all shell connecting piping. Rig shell and set bundle horizontally on cribbing.
8. Remove channel hemi-head to gain full access to the tube sheets with internal rotary torch cutter. Unbolt and remove pass partition plate cover to provide access to the tube sheet.
9. Remove about 430 mechanical tube plugs form each heater. Visually examine the heater components and gasket surfaces for cracks, erosion and defects to determine their overall condition.
10. Cut (2268) tube ends in each of the two heaters internally 1” behind the tube sheets.
11. Machine the tube to tube sheet weld from (2268) tube ends in each heater.
12. Hydraulically extract (2268) tube stubs from each heater’s tube sheet.
13. Cut and pull (1134) U-tubes through the support plate holes. Provide sections of removed tubing for laboratory analysis. Visually inspect random sections of removed tubing for signs of tube vibration, corrosion and pitting. Chop tubes and dispose of scrap tubing.
14. Remove all the internal parts from the heater including all zone shrouds, support plates, baffles, tie rods, spacers and divider plates.
15. Move the location on the N3 steam inlet nozzle to reduce the velocity in the de-superheating zone. The new N3 steam inlet nozzle was used as a by-pass in the old heater and the old N3 nozzle was capped.
16. Clean, examine and dry tube sheet and tube sheet holes to ensure they are free from grease, oil or other contaminants thus ensuring proper tube joint integrity. Randomly inspect tube sheet holes for roundness. Take random measurements of tube sheet holes to establish a mean hole diameter and ensure holes are within Heat Exchange Institute (HEI) specified tolerances.
17. Install new de-superheating and sub-cooling zone shrouds in each heater.
18. Build the new de-superheating zone and drains cooler zone cages.
19. Build the new condensing zone using new support plates, tie rods and spacers.
20. Align all the zones and install a new 3” thick endplate in each heater.

Scope of work (continued):

21. Install (1134) new U-tubes in each heater after cleaning each tube end and inspecting them for burrs.
22. Tack and then seal weld each of the new tube ends to the reconditioned tubesheets.
23. Inspect the shells interior and repair spots of the shell showing erosion.
24. Install the shell back onto the new bundles.
25. Weld the shell back to the skirt and weld all of the piping connections to the shell.
26. Perform an air test and dye penatrent (PT) test to verify the tightness and quality of the seal welds.
27. Mechanically expand tube ends to within 1/8" of the backside of the tube sheet utilizing an expander and the automatic torque control method to ensure expansion uniformity. Shoot acetone soaked felt plugs through the tubes after expansion to remove any residual expander lubricant. Perform QC inspection to check for and document proper tube end expansion.
28. Install and re-bolt pass partition plate cover and channel closure with new gaskets.
29. Weld hemi-head on channel while maintaining pre-heat. Provide post weld stress relieving of the head to channel weld. Test all welds and document test results.
30. Perform a shell side air test of the heater to verify no tube joint leaks and review the weld test results with the ASME Code Authorized Inspector.
31. Install, torque channel cover and gasket. Attach nameplate and sign off "R-1"
32. Clean up work area and move off job site.

Figure 7. Only 5' of insulation removed for shell cut.

Figure 8. Removed head insulation.

Figure 9.Cutting shell with track cutter

Figure 10.Cut head with rotary torch cutter

Figure 11. Shell cut prepped for re-welding.

Figure 12. Head Cut provides weld prep.

Figure 13. Hydraulic tube stub removal.

Figure 14. Pulling stubs from back face.

Figure 15. New tubes in rebuilt cage

Figure 16. New bundle ready for shell

Conclusion

Two 20 year old IP feedwater heaters containing 1,134 U-tubes each, with vibration problems, eroded tubes with zone shroud, end plate, support plates damage; were redesigned and rebuilt in place, on-site within a 26 day outage window. The redesigned heater eliminated all identified root causes of failure. The de-superheating zone was resized and the steam velocity was reduced to avoid erosion and vibration. Damaged internal components were replaced with new when needed. All zone shrouds and internal welds were PT tested and visually inspected and certified. The hemi-head to channel, new steam inlet nozzle and other shell welds were UT tested and inspected by the ASME Code Authorized Inspector and passed all requirements.

Since March 9th , 2009, the heaters have been performing above the original design with no need to open either of the heaters. The plant expects the rebuilt heaters to continue this reliable operation for at least an additional 20 years.

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