# BLRBAC ESP Subcommittee Published Incident Learnings 2005 – Fall 2022

Compiled by Dean Clay, ESP Subcommittee Secretary, from the published BLRBAC minutes for the ESP Subcommittee. These BLRBAC meeting minutes are posted on the www.blrbac.net site; Learnings started with the April 2005 Minutes. The learnings are arbitrarily organized in four General Topics, combining similar, repeated, learnings (meeting code is [S05] = Spring 2005; [F05] = Fall 2005).

The following BLRBAC Disclaimer also applies to the published ESP Subcommittee Learnings.



**General Topics (Ctrl + Click to go to a topic)**



## 1. Operations, Training, Procedures and Management

1.1. Mills need to emphasize training and empowerment of operators to identify and react to tube leaks in critical areas of the boiler by timely initiation of an ESP. [F05]

1.1.1. There were at least three incidents reported that were very close calls and it was fortunate that a smelt water explosion did not result. There were two screen tube leaks reported. It is interesting that in both cases, the leak detection systems provided the first indication of the leak although in one case it took three days to confirm the leak. It is human nature to try to find other explanations for problems such as leaks. It is important to continue to emphasize leak detection and leak identification in operator training. [S07]

1.1.2. It has been discussed before, but mills should not be in denial when looking for tube leaks. Shutting the boiler down with an ESP is a tough call to make and there can be a tendency to "wish away" or ignore symptoms of a leak. Mills should maintain diligence to recognize any potential symptoms that indicate a leak may be present. [F10]

1.1.2.1. A summary of many of the recovery boiler leak indications can be found in the TAPPI Technical Information Paper "Explanation of Recovery Boiler Leak Indications", TIP 0416-23 (2014) [F15]

1.1.3. We continue to hear of incidents that the time to identify leaks and initiate an ESP is excessive and, in many cases, mills require definitive proof that a leak is present as shown by the four incidents that did not initiate an ESP until water was observed in the furnace. It is human nature to discount the indications that a leak is present and to come up with alternate explanations of the cause for the tell-tale signs they are seeing. Training must emphasize leak identification and must caution operators to not to be too quick to explain away the signs that a leak is present. [S12]

1.1.4. First Assume the Worst – better to assume a worse case and then prove it is wrong than always assuming the best case. Confirmation Bias is the situation where people tend to look for information that supports their ideas and opinions (no leak) and ignore information that is contrary to that idea or opinion. [S18, F18, F20]

1.1.4.1. If a mill has continued problems with feedwater quality and has a history of 5 leaks in the lower furnace in the last 4 years should not need 4 hrs. to decide to ESP. [F18]

1.1.4.2. Don't go down "Rabbit Holes" just because something has been a problem in the past don't ignore indications that there may be a different bigger problem. [F20]

1.1.4.3. If multiple past leaks have been occurring on a unit in a certain section, do not become complacent and assume the present leak is in the same area. A leak may have occurred in a different area that may be critical, such as the upper section of an economizer exposed to the rear section of a 2 drum generating section or the top section of a Single drum boiler generation section. [F22]

1.1.5. Recognition of leaks and operator authority to initiate an ESP should be emphasized in training. There have been too many cases that operators either did not recognize the telltale signs of a leak or too easily explained them away for other causes. When a leak is discovered, the operator should not feel like he has to notify management before pushing the buttons. [F07, S08, F11]

1.1.5.1. Include scenario/table top drills for ESP situations in operator training. [F20]

1.1.6. Management must also emphasize that operators have the authority and responsibility to initiate an ESP without having to seek approval from supervision. In addition, they need to "walk the talk". Even though the official policy may be that operators have the authority, if management undermines that authority by subtly indicating that they must be in the loop of all major operational changes, the operators will be reluctant to perform an ESP without approval from supervision. There have been some indications that mills may be reluctant to perform an ESP because of concern for damaging the boiler in the process. [S12]

1.1.7. Who's in Charge? When extra supervision and operators are scheduled during an outage, it would be a good idea to make sure everyone understands who has the responsibility for the various areas of operation so that in an emergency, everyone is not expecting someone else to address the problem. [S10]

1.1.8. This last situation shows that we must remain vigilant to proper operating procedures and cannot put complete faith in the interlocks and protection systems. Sometimes, the systems may have shortcomings that do not provide the expected level of protection in all possible situations. We must not let the interlocks do our thinking for us! [F06]

1.1.9. There were two reports where the operators initiated the ESP from indications in the control room, including the leak detection systems, and did not have to visually confirm the leak. This action is to be commended. [F08]

1.1.10. Sometimes it's hard to tell the difference between drum level shrink and low drum level from a tube leak. After a boiler trip, as the steam bubbles collapse in the boiler water circuit, the drum level will drop quickly and as you add feedwater, the cooler water will further cause the bubbles to collapse, driving the drum level down. It is important to look for other indicators of a tube leak such as high furnace pressure or increase in ID fan speed to confirm the leak. [S11]

1.1.10.1. Determine normal time to restore drum level after a trip and include in training so operators recognize that extended time to recover drum level may indicate bigger problems. This can be determined from historical data. [F20]

1.1.11. Dean Clay provided a couple of slides that related to information from a presentation made by Dr. Tom Grace at the AF&PA Recovery Boiler conference in February 2006. Dr. Grace reviewed the explosion data that was available from BLRBAC and from other sources and made the following observations concerning identification of leaks.

•Operators fail to recognize tube leaks, even when they are large leaks.

• Failure to promptly detect the leak was a factor in 2/3 of the explosions involving pressure part failures since 1980

o Shortest time lag before the ESP was initiated was 9 minutes

o In some cases, an ESP was never initiated

o This is still a problem and affects the amount of water entering the furnace

A review of the incidents from the current meeting that had indications of high furnace pressure and/or low drum trip indicated that in half of the reports, an operator was sent out to confirm the presence of the leak and that the time to shut off the feedwater took up to 10 minutes. [S06]

| No. | Control Room Indications | Operators Sent Out | Min. to FW Stop/ESP |
|---|---|---|---|
| 4 | Hi Furn trip, level lost | To inspect | 10m, no |
| 11 | Low drum trip | To inspect | ? no ESP |
| 12 | drum level, furn pres | No | 0, ESP |
| 15 | level, furn pres | No | 1, ESP |
| 20 | Low drum trip | ?? | ?? |
| 21 | Low drum trip | To inspect | 8, ESP |
| 29 | Hi Furn trip, level lost | No | 1, ESP |
| 31 | Low drum trip, furn pr | Already out | 3, ESP |

1.2. Critical Leak Locations, Create boiler side view diagram that clearly indicates sections of the boiler where leaks would be potential Critical Incidents that should result in an ESP and where leaks would be considered Noncritical. Post the diagram in the control room for the benefit of the operators to make decisions on when to initiate the ESP. [F17]

1.2.1. Include the location of economizer and generating bank baffles in operator training so that operators are aware of the potential for leaks to enter the furnace cavity. Normally two drum units will allow water to enter the furnace from a leak in the upper hot economizer but in single drum units with a baffled generating bank, leaks in the upper economizer cannot get to the furnace. [S17]

1.2.2. Train operators on the criticality of leaks in all sections of the boiler, internal and external, membrane construction and refractory imbedded tube locations, baffle locations, etc. to aid with the decision as to if water has the potential to enter the furnace or not, and to ESP or Not ESP. Show these areas on a boiler side view drawing that is posted in the control room. [F20]

1.2.3. Do not run with an economizer leak unless you know for certain (and can see) the leak is in a non-critical area. It may be in a critical area. It may be in the economizer area exposed to the furnace with no baffles in between. [F22]

1.2.4. Do not assume sound in a boiler SH section is a noncritical SH leak. Even if it is, it can be impinging on a Critical wall tube, roof tube or screen tube. “If you can’t see it ESP it”. “When in doubt, punch it out”. Assume the worst situation is happening and then convince yourself it is not vs. assuming you are dealing with a non- critical situation only to find out it is critical. [F22]

1.2.5. Do not assume the sound of a leak in the SH section is an SH leak. Steam/FW differential can help determine the source as well as boiler chemical possible loss. (Is the differential caused by FW flow rise or Steam flow drop?) “If you can’t see it – ESP it!”. [S22]

1.3. Decision to ESP - It is <u>OK to turn on evacuation alarm</u> while investigating potential leak but once decision has been made to ESP it should not wait for evacuation. [F15]

1.3.1. In the event of an inadvertent ESP, follow the post-ESP procedures to ensure no unsafe conditions are created. [S16]

1.4. It is <u>not advised to run extended periods with a known leak even if it is in the economizer</u>. [S06]

1.4.1. As has been discussed in the past, small unit leaks can quickly become large leaks so it is not recommended to operate with known economizer leaks and personnel should be cautious when being near leaks. If there is water coming from the casing and there is little chance that it can be coming from anything but a leak, <u>it is not recommended to put personnel at risk by removing the casing to expose the leak</u>. [F10, F09, S10]

1.4.2. Several mills have reported operating with economizer leaks or handhole leaks for extended periods. Even though it would not result in the chance for a smelt water reaction, continued operation of leaks can spray on other tubes or the header and create a much larger problem. It was seen in one incident where the unit operated with a handhole leak that there was obvious washing of the header. This could potentially result in extended downtime for header repairs. [S11, S09]

1.4.3. As we have said before, it is not recommended to expose leaks with pressure still on the boiler. There have been several incidents over the years where small leaks have turned into big leaks and it is not a good idea to have personnel exposed to that risk. [S12, F12]

1.4.4. It is not recommended for operators to observe leaks through open mandoors to see if they are getting worse. Tube ruptures or even fan problems can cause blowback. [S16]

1.5. The report of the superheater leak at Thilmany (Incident 12) provided excellent information on <u>issues with clearing superheater tubes and the importance of using graphs of the individual superheater tube outlet temperatures</u>. Even though the mill had a temperature limit of several degrees above saturation to show the tubes were clear, reviewing graphs of those temperatures showed that several tubes were above the minimum limit but they did not show the characteristic spike in temperature that occurs when the tube actually clears. The mill has since implemented standard graphs to review all temperatures before putting the unit back on liquor. [S08, F08, F09]

1.5.1. The importance of clearing superheater tubes before increasing the load on the recovery boiler was highlighted again this meeting. One tool is to look for temperature spikes in the individual superheater tube thermocouples when clearing superheater tubes. The spike in temperature indicates that some of the steam that has been trapped in the tube has been released by the flow through the element causing the spike. After the hotter steam has been purged from the tube, the temperature will settle back down. [F10, F17] A research project being considered would review superheater failure incidents to try to correlate time to failure of uncleared loops vs. time required for safe loop clearing.

1.5.2. The importance of clearing superheater tubes even after a short shutdown was shown in one incident. It does not take long to accumulate condensate in the bottom of superheater loops after a trip, especially if there is some leakage in an attemperator spray water valve or if there has been a high drum level during the trip. We continue to see the importance of monitoring superheater tube thermocouples during the start-up. It was also reported that the superheater thermocouples should be mounted on the tube at least 12” below the outlet header to minimize the influence of the header metal temperature. [S11, F19]

1.5.3. Clearing condensate from superheater tubes during a start-up, especially after a trip, continues to be an issue. Temperatures in the upper furnace should be limited to 900°F until all tubes have been verified to be clear. Thermocouples on the outlet leg of superheater elements should be located at least 18” below the outlet header and covered with insulation to prevent inaccurate readings. [F12]

1.5.4. Start-up curves may need to be extended if boilers are experiencing tubes pulling out from the sidewalls, especially in the corners and also if there are problems with superheater leaks due to not sufficiently clearing the condensate out of the superheater loops before coming on line. [S09]

1.6. The report from one of the two dissolving tank explosions highlighted that it is difficult to determine the amount of smelt that accumulates behind the smelt spouts when they are all plugged. It is suggested to take a look at the boiler during the outage and establish a benchmark level from references inside the boiler that can be used during operation to better indicate to the operator when a critical level of molten smelt has accumulated so they can stop attempting to open a spout and start to shut down the boiler. References such as some level below the primary air port elevations could be useful for this. [F08]

1.6.1. Operating procedures for the condition of “All Spouts Plugged” should include taking the fire out of the boiler to minimize the potential of building up a large pool of smelt behind the spouts. There have been several incidents where boiler deposits have melted into the smelt pool and resulted in a heavy smelt run when a spout is eventually opened. [S09]

1.6.1.1. Develop procedures for operating with plugged spouts and in accordance with Chap 10 SFBL to include minimum spouts open to fire black liquor and when to stop all firing. Follow the procedure in spite of production pressures. [S17] [F22]

1.6.2. It is known that low level in the dissolving tank is a problem, but there was a report this meeting of a high level in the tank that contributed to a smelt reaction. Several years ago, there was another dissolving tank explosion when the overflow plugged and the tank level got just below the end of the spouts. [S09]

1.6.3. If operating two dissolving tanks in series, review system to assure dilution is going to proper tank at all times – including emergency dilution. [F15]

1.6.4. Use “Guard Goose” to watch furnace conditions during spout pluggage episodes to watch inside the furnace for smelt pools and saltcake dams. [F15]

1.6.5. Molten salt cake from boiler deposits has a different appearance than normal smelt and may look clear or light blue rather than the normal red smelt color. [F19]

1.6.6. Salt sheds from the SH and or Screen can add enough material to the floor area that it can flow to the DT and cause violence. It is typically Sulfate rich, highly viscous and will tend to dam and jelly roll. This material must be watched for accumulation and must be controlled and be considered bed material. [F22]

1.6.7. Smelting out a bed should start at the spout wall to minimize potential for smelt pool forming behind a salt cake dam. [F16]

1.6.8. Spout torches are good tool for opening plugged spouts. [S17]

1.6.9. The senior most knowledgeable management personnel must be involved in overseeing the situation when spouts are having plugging issues. [F22]

1.7. Shatter jets should remain in service while the boiler is on aux fuel after burning out the bed in case boiler deposits that fall from the upper furnace melt and discharge through the spouts. [F19]

1.8. Smelt flowing over refractory and on to tubes may cause localized corrosion – the “waterfall effect”. Maintaining a bed is very important to keep these tubes protected. [F19]

1.9. Because of the possibility for a superheater leak that either did not show up before the unit was shut down or possibly was caused by the shutdown, you should wait until bed is cool before starting hydrostatic test. [S06, F17, F20]

1.9.1. The smelt water reaction during a waterwash at Evadale (S08 Incident 25) provided several learnings. The mill discovered that the insulation for the thermocouples was not rated for the high temperatures that are present in the furnace during cooldown and were giving false indications. It was clear that the mill should not rely on the assessment of a bed cooling contractor to determine when the bed is sufficiently cooled to begin the waterwash. All areas of the bed should be probed with thermocouples and not just those areas that are more easily accessible. The use of a thermal imaging camera can be helpful to locate hot areas of the bed but the temperature readings from the camera should not be used in place of actual thermocouple readings. Additional information on cooling the bed for waterwash can be found in Chapter 8 of the Post ESP Procedure document and Section 2.7 of the Recommended Guidelines for Personnel Safety. The Subcommittee will be reviewing the Post ESP Procedure to see if there needs to be any revisions based on these learnings. [S08, F08]

1.9.2. Infrared Imaging guns may be useful to identify hot spots in the bed for further probing and temperature measurement but the indicated temp from IR should not be the final criteria. You are measuring the surface temperature and there may be molten pockets of smelt below the frozen surface. [S16, F16]

1.10. Smelt Spouts - Do not turn water back on to an isolated smelt spout! Once it has been isolated, it has most likely been further damaged and restoring water flow can result in a smelt water reaction. [S15]

1.10.1. If a spout water cooling leak is discovered, the recommended action is to cut off the cooling water and plug the spout. It is not recommended to continue operation of the unit with a known spout leak. [S16]

1.10.2. A discussion of what happens during upset conditions for vacuum spout systems should be included in operator training to make sure operators recognize the conditions that spout water flow may be interrupted. [S19]

1.10.3. Review spout cooling water piping that goes through spout hoods to see if shielding or protection from smelt leaks may be needed to prevent overheating or boiling the cooling water flowing through the piping and blocking cooling to the spouts. [S19]

1.10.4. When plugging a spout, Consider the dry solids loading on the remaining spouts. (1MM – 1.2MM max. typical). [S22]

1.11. Make sure Dissolving Tank emergency dilution is going to the correct tank at all times (for series dual tank systems). Need to confirm flow periodically rather than just testing valve. [S15]

1.12. Miscellaneous

1.12.1. The continuous use of igniters to maintain boiler purge credit if the black liquor system trips is not advised. (editor's note: SFBL later revised logic to not allow this) [S06]

1.12.2. Sootblower pressures should be checked periodically to make sure they are not above the recommended operating pressure, especially for sootblowers with the high efficiency nozzles, to prevent accelerated thinning and the possibility for fatigue cracks in tubes. Mills should also review their stuck sootblower procedures to make sure that sootblowers do not stay in the boilers and damage tubes. [S09]

1.12.3. If fans trip during an ESP, they should not be restarted until it is safe to re-enter the boiler area and inspect that there is no water on the bed. Prior reported explosions indicated that restarting a fan may have dislodged some upper furnace deposits that disturbed the bed and allowed water sitting on the bed to contact molten smelt under the frozen bed surface. [F09]

1.12.4. A review of an incident with a leak in the floor tubes suggested that an unexplained TRS spike may be another clue in detection of lower furnace leaks. The spike in itself would not necessarily indicate the leak, but combined with other symptoms may reinforce that there is a leak present. [F10]

1.12.5. Any changes in the recovery boiler either component changes, material changes or control system changes should be thoroughly reviewed before implementation or installation to make sure that they will perform adequately and no unintended consequences will result. [F11]

1.12.5.1. Implement Management of Change process for Soot Blowers (SB) to include: changes to SB nozzle and lance suppliers to provide proper quality of fabrication and are appropriate for the application; changes in nozzle type to make sure they provide proper cleaning but do not contribute to tube damage; changes in blowing pressure – involve both SB supplier and boiler OEM. [S18]

1.12.6. There were at least four incidents reported that were very close calls and <u>we consider it luck that a smelt water explosion did not result</u>. In one incident, a significant screen tube leak continued for about 40 minutes until the ESP was initiated. A review of explosion history by Tom Grace has shown that screen tube leaks have the highest probability of all leak locations for causing explosions. There were two floor tube leaks reported during the meeting that always are cause for concern. In the fourth incident, a significant amount of water entered the furnace from a liquor gun that was partially removed from the furnace so that the gun gate could be closed but it allowed wash water to spray into the furnace through the mesh of the gun gate. There was some indication of activity in the bed as a result of the water entering the furnace but no damage was found. [F06, F07]

1.12.7. There were <u>several incidents reported that were very close calls and five reports indicated that a smelt water reaction occurred but there was no damage</u> reported. The reports of the two floor tube leaks and the one leak in the lower furnace wall all mentioned a smelt water reaction had occurred. There were two reports that mentioned a smelt water reaction during the waterwash. Two incidents had large generating bank leaks that put a large amount of water into the furnace but fortunately, no smelt water reaction occurred. [S08]

1.12.8. Steam cooled wall panels (on some 1-drum RB designs) should be drained during startup to assure all tubes are clear and not blocked with water. [S14, S16, F19]

1.13. All operators and management should be trained on Large Leak Logic and proper actions to take before opening FW valve. [F20]

1.14. Consider having checklist for the operator to confirm the status of potential leak indicators prior to opening the FW valve after large leak logic activates. i.e., leak detection status, Steam/FW differential status, boiler water chemical status and feedrate status as well as operator reports of unusual sounds. [F20]

1.15. Train operators on leak detection system and alarms and proper actions when alarms are received, alarms must be recurring alarms. [F20]

1.16. Critical trends (i.e., leak detection, Steam FW differential, Boiler cycles chemical concentration and feedrate, etc.) should be reviewed every 4 hours and logged. [F20]

1.17. An ESP has not been found by BLRBAC to cause a defect or damage a boiler. An ESP may cause a previously existing defect to propagate to failure. The defect is there prior to ESP and the root cause of the defect should be determined and similar areas examined for similar defects. [F22]

1.18. Smelt bed temperatures must be determined through probing the bed through the surface crust with a rod and thermocouples. Surface temperature measurements are not sufficient. [F22]

1.19. Do not leave hoses around an RB unattended where they may spray into a RB or confuse operations as to the source of the water. [F22]

## 2. Design, Maintenance and Inspection

2.1. There were several reports that had similar leak locations and causes that indicate areas for emphasis during future inspections. One area for inspection on older, two-drum B&W units is the riser tube between the steam drum and the end plate of the sidewall header closest to the drum to see if cracking is occurring. [S05]

2.1.1. There were several reports that had similar leak locations and causes that indicate areas for emphasis during future inspections. One area for inspection on older B&W units is the side wall riser tubes from the upper headers to the drum, especially those that are closest to the drum and those risers with a close connected, tight bend by the header that leaves little room for expansion, to see if cracking on the ID of the riser is occurring. [F05, S09, S15, S16]

2.1.2. Riser tubes that do not completely vent to the drum (rise up from the header and go back down to enter the drum) may have internal thinning issues from steam blanketing. [F15, S16]

2.2. In boilers where the rear wall tubes at the top of the nose baffle form a screen between the generating bank and superheater, this area has been prone to cracking at the top of the nose where the screen begins. This should be inspected periodically, especially if the vibration restraints have failed or if there are incidents of stuck sootblowers in the area. Review the B&W Service Bulletin on this issue. [S05, S10, F17, F20, F21]

2.3. A reported floor tube failure and two reported floor tube leaks last meeting suggest that it is a good idea to check for possible thinning at welds in the floor, especially on flat floors. "Push Through" of the weld into the ID of the tube can be causing steam blanketing and thinning of the tube near the weld. [F05, S05]

2.4. There was one report of a floor tube leak that again highlights the concern with dents, depressions and weld push through that may cause a flow disturbance and steam blanketing in the tube. Any areas found need to be addressed. [F07]

2.5. Large slag falls ("Volkswagens") can cause floor tube damage including crimping tubes at floor beams. Be mindful of any negative slopes that may trap steam bubbles.

2.6. Tubes should be plugged as close to header as possible in order to reduce the possibility of failure from accumulation of sludge at upper header or steam blanketing at lower header. [S06, F09, S10, F12, F15, S16, S18, F20]

2.7. Mills that have "flat bar" vibration restraints located between generating bank tubes should inspect for erosion under the edges of the flat bars and may want to periodically move the bars up or down the tube. [F09, F21]

2.8. Several incidents highlighted the need to maintain the integrity of vibration restraints in the generating bank. Also need to watch for chaffing where vibration bars may cut into tubes. [S12, F12, F18]

2.8.1. Inspect and maintain vibration restraints in Economizer to prevent fatigue failures at the tube to header connections. [S17]

2.9. It is important to inspect and repair damaged and missing ties in the superheater to prevent tube failures. [S21, S22]

2.10. Before installing high efficiency sootblower nozzles, review the design and condition of the vibration restraints in critical areas such as furnace screen, superheater and generating bank. [S06]

2.10.1. SB Supplier needs to provide a chart with maximum pressure / flow for each section of the boiler – superheater, gen bank, economizer. [S18]

2.10.2. Consider installing steam cooled spacer for side-to-side restraint when using leading edge sootblowers in superheater. [S14]

2.10.2.1. Inspect and repair ties and straps in superheater to limit movement and prevent fatigue failures. [S19]

2.10.3. Work with sootblower supplier to establish blowing pressures for each area of the boiler and check periodically. Follow management of change process before exceeding established pressures to minimize risk of fatigue failures. [F15, F16, F21]

2.10.4. Mills should know the manufacturer recommended Sootblower pressure settings for the nozzle type installed at each location of the unit and have a system to ensure they are checked regularly (i.e., twice a year). Distance from the tubes being cleaned must be known to ensure peak impact pressures are not exceeded. [F20]

2.10.5. Use of Leading Edge angled sootblower nozzles may contribute to superheater failures due to fatigue cracking from swaying pendants. [S19, F19, F21, S22]

2.10.6. Involve Purchasing and Stores in Management of Change process to assure correct parts are available such as the correct replacement sootblower nozzles. [F17]

2.10.7. Mills should consider increasing sootblowing frequency rather than increasing sootblower pressure when dealing with boiler pluggage to limit potential for tube damage. Sometimes the steam you save may not be worth the pain. [S21]

2.11. Consider orifice for <u>sootblower condensate drains</u> rather traps due to reliability concerns with traps. Need to get the condensate out! [F14, S15, S18, S22]

2.11.1. <u>Keep condensate out of sootblowers</u>; Utilize thermal drains or orifice plates to drain condensate; Make sure steam lines to blowers are sloped back to the steam supply header; Maintain poppet valves; Maintain pipe insulation. [F17, S18, F19, S22]

2.11.2. Condensate removal system traps and check valves for Sootblowers should be checked regularly. Consider orifice to provide continuous removal. [F21]

2.12. We saw that <u>leaking sootblower poppet valves can create tube leaks</u>. Mills should <u>consider developing a method to indicate leaking poppet valves</u>. A steam flow alarm that indicates continued flow when all blowers are at rest was one suggested idea. The use of a “heat gun” to check the tube temperatures to see lance tube stays hot after it has been idle for a while was another idea. [S11, F19, F21]

2.12.1. Inspect large seal plates at sootblower openings for cracks. Consider replacing with refractory. [F14]

2.12.2. Condensate dripping from at rest sootblowers can drip on membrane and tubes below causing thermal fatigue. Consider extending the wall box sleeve a little way into the furnace cavity so condensate will drip into the furnace rather than on the wall tubes. [F15, S18, F18, S19]

2.12.3. Weld wall box sleeves to external wall box and not to boiler tubes to eliminate stresses on the wall tubes. [S19]

2.13. <u>Check alignment of sootblowers</u> in superheater section during outages to make sure they are not rubbing on tubes. [F17]

2.14. Develop criteria for determining end of life for blowers and lances rather than running to failure. [S18]

2.15. Take active role in understanding welding QA/AC for lance and feed tubes to make sure welds are made correctly and inspected. [S18]

2.16. Check poppet valve pressure on a regular basis and compare to target pressure. [S18, S19, F19]

2.17. Witness operation of each Soot Blower on a regular basis [S18]:

• Check that lance tubes are riding on rollers – if lifting off rollers, poppet valve set pressure may be too high
• Listen for superheater elements banging into lances – reduce poppet valve pressure if occurring
• Inspect for superheater elements banging into each other side to side
• Check alignment of sootblowers in superheater section during outages to make sure they are

not rubbing on tubes.

2.18. Inspect dissolving tank overflow for pluggage to assure that if a high-level condition occurs, the overflow will maintain the dissolving tank at a safe level. [S06]

2.19. There have been a couple of reports of some areas of accelerated corrosion in isolated areas in boilers that have seen an increase in loading or have had air system modifications. For units such as these, it is important to look closely for indications of thinning or discoloration from overheat that may result from internal deposits at bends around air ports and also in the upper furnace just above the tertiary ports, especially in units with composite tubes. [F06, S11]

2.19.1. May need to increase the elevation of protection from composite tubes by applying stainless weld overlay or replacement with composite tubes. [F19]

2.20. Clean saltcake buildup from economizer headers to reduce corrosion from wet saltcake during outages. [S16]

2.21. The third close call was a floor tube leak that occurred after partially covering the floor with refractory. The refractory was installed because of problems with dents and depressions in the floor. This incident also highlights that dents or depressions in floors can cause steam blanketing and rapid corrosion. [S07]

2.22. Flowing liquid smelt on studded carbon steel tubes with no frozen smelt layer may result in accelerated wastage of studs and tubes. [F19]

2.23. Implement inspection plan for SAC on older boilers (>15 years). TAPPI TIP 0402-38 Guidelines for detecting and mitigating waterside cracking (SAC) provides a good reference document for inspection methods and locations to inspect. [S17, S18]

2.23.1. There were four reported leaks in wall tubes in the lower furnace. In two of those reports, stress corrosion cracking at a swaged tube caused the leak. If you have a unit with swaged tubes in the furnace, it is very important to inspect those areas for possible cracking. Localized heavy waterside deposits continue to be reported as a cause for leaks so this, too, is an area of continued concern. [F07]

2.23.2. Dye penetrant testing only indicates surface cracks. Radiography or shear wave required to show internal cracking when looking for SAC. [S18]

2.23.3. Stress Assisted Corrosion (SAC) usually produces multiple internal cracks. Welding a crack that penetrates to the OD may result in later cracks that extend past the weld repair. [S19]

2.23.4. Welding over cracks and pin holes may not eliminate all the internal cracking. It is best to remove the tube section but if not, consider x-ray or shear wave inspection to determine the extent of internal cracking before welding. [S21, S22]

2.23.5. Consider replacement of pad welded tubes on future outages. Especially if the tube had indication of possible SAC (stress assisted corrosion), which is almost always waterside initiated, and may have produced other waterside cracks that have not reached the OD surface yet. [F22]

2.24. Several of the economizer leaks show that handhole repair procedures continue to be a problem. Section 2.1 of the draft "Recommended Guidelines for Materials & Welding in Black Liquor Recovery Boilers" contains information on suggested handhole cap repair procedures. [F08]

2.24.1. Cracking in handhole caps and at tube to header welds at the economizer inlet header may be caused by thermal cycling from swings in feedwater flow during startups and boiler upsets. Reference B&W Plant Service Bulletin "Economizer Inlet Header Cracking" for more information on the subject. [S19]

2.24.2. Consider Nipples and Caps for handhole caps in lieu of traditional plug type caps. [S22]

2.25. Units that have feedwater pipes that go through hopper walls with "slip joints" should be inspected for proper freedom of movement. [F09, S14, S17].

2.25.1. Consider indicator scale to check movement of header during start up. [S14, S15]

2.25.2. Where tubes or headers penetrate hopper walls check for proper operation slip joints to prevent fatigue failures – If the tubes or headers are welded to the hopper, it may be a location to check for SAC. [S18, F18]

2.26. Mills should inspect feedwater piping and link piping for Flow Accelerated Corrosion. Typical recovery boiler feedwater quality is in the range for FAC but higher chromium content of piping will provide protection from SAC. [F09]

2.27. When modifying casing or skirts around the dissolving tanks and smelt spouts, mills should be cautious not to create stress points that may result in tube cracking. [F09]

2.28. Spout attachment boxes are prone to cracking, especially if they are welded directly to the tubes. This should be an area for periodic inspection to see if Stress Assisted Corrosion or other cracking may be present. [S10]

2.29. Mills need to be mindful that changes in boiler combustion air systems my cause unintended problems such as deposit buildups such as lumps at the roof corners. These lumps can fall and cause significant tube damage. Installation of “breaker bars” on top of the leading screen tube may protect the tubes from some of this fallen material. [S09]

2.29.1. An incident was reported where the floor beam detached at the side wall, probably due to a large slag fall from the upper furnace. This may be an area for inspection during outages, especially if there has been a large slag fall. [S10]

2.29.2. After upgrades to increase boiler capacity, minimize other changes in boiler operation until there has been some operating experience with the new arrangement. [S19]

2.30. An incident report indicated that there is the potential for near drum corrosion under refractory at roof tubes that go into the steam drum. This area should be included in periodic inspections for near drum corrosion. [F10]. Inspect roof tubes that enter steam drum for corrosion due to wet refractory and wet salt cake from water washing during outages. [S19]

2.31. We again heard of the potential for cracks at floor tube membranes in sloped floor units where the floor tubes bend at the interface with the front wall. This is another area that should be inspected periodically. [F10]

2.32. Even though it is not a normal practice in North America, we saw from an international incident that you don’t clean boilers from the inside! Large accumulations of salt cake in the furnace can be dangerous to personnel if they fall from the upper furnace. Make sure the unit is sufficiently clean before allowing personnel access inside the boiler. [S11]

2.33. Better investigation of the true root cause mechanisms causing leaks is needed to work toward future prevention. It can be a challenge to take the time to remove a tube sample when repairing a tube leak but if there is not a good understanding of the cause, it is likely that a similar leak may occur later. In any event, it would be good to let other mills know what to look for to prevent a similar problem. [F11]

2.34. Mills should check for tube thinning above the composite tube line. There have been reports of localized deposits in this area as well as the potential for higher corrosion rates due to gas phase reactions. [F11]

2.35. Mills with B&W units that have a hopper support welded to the side walls at the top of the nose should check the area for stress assisted corrosion cracking. Problems have been found in at least two units. [S12]

2.35.1. When leaks occur, inspect similar areas for the same issue. If there is a leak on one side wall caused by stress it will probably be a problem on the other side as well. [F17]

2.36. Corrosion of tubes and headers under the smelt spouts from contact with weak wash from leaks around the spout hoods continues to be a problem. This area should be inspected routinely to identify any problems. [S12, S17, F18]

2.36.1. Watch for weak wash leaks onto tubes and headers behind spout hoods, especially the extended hoods. Consider stainless steel split pipe to cover lower water wall header. [S14, F14]

2.36.2. Weak wash from smelt hoods can cause rapid corrosion of boiler pressure parts. Inspect skirts during outages and test with water hoses during outages to assure there are no leaks. [S21]

2.37. Contractors that are working on the boilers during outages should be strongly urged to notify mill personnel if they cause or observe any damage in the boiler so it can be corrected. [F12, F21]

2.37.1. Review procedures for refractory removal with contractors to minimize potential damage to tubes. Consider hydroblasting rather than using air hammers. [S15]

2.37.2. If you find issues with craftsman's work such as bad welds or tube damage, inspect their previous work for similar damage. [S15]

2.38. Non-Destructive Examination contractors should be instructed to report unusual findings or observations. If they are inspecting a weld and see a Linear Indication (crack) in the shot but not at the weld, it should be reported. [S21]

2.39. Roof tubes should be routinely checked for thinning where the upper superheater sootblowers are located close to the roof, especially if the blowers are closer than 3 ft to roof [F12, F17]

2.40. Make sure to remove alignment bracket when installing tongue and groove ties in superheater [F14]

2.40.1. Buy groove ties that have precut alignment bracket or make cut before installation

2.40.2. Consider using weld material for attaching superheater links that will fail at the link rather than pulling out base tube metal (7018 weld rod) [S14]

2.40.3. Make sure start / stop of weld is on tie rather than on tube

2.40.4. Model or mock-up of proper installation may be helpful for installation contractors.

2.40.5. When repairing leaks at superheater clips, replace clip at a different spot away from repair weld to eliminate the possibility for additional stress on the repair from the clip. [S17]

2.41. There were two incidents reviewed that had leaks due to Copper Contamination Cracking. Both were from automated welding machines where the welding head struck the tube and melted the copper head into the tube metal. [S16, S18, F18]

2.41.1. It is recommended that any damage of this type should be cut out and the tube replaced. The Materials and Welding Subcommittee is working on recommendations concerning Liquid Metal Embrittlement. [F18]

2.42. Squared off membrane terminations can be source of cracking. Consider cutting to a V notch. [F14, S22] Consider stress relieving 2' beyond the end of the fin.(during original manufacture of the component – added comment for clarity). [S22]

2.43. When repairing cracks in finned tube economizers or generating banks, do not replace the fin section over the repair weld. [F18]

2.44. Look for cold side corrosion inside seal boxes where screen tubes go through the rear or front walls and behind mandoors and access ports. [S18, F18]

2.45. Quality Control is critical for the manufacture of any spout, especially any locally assembled spout. [S19]

2.46. Consider adding economizers 25 -30 years old to strategic plans for replacement. [F20]

2.47. Review economizer header feed tubes for proper flexibility and potential binding. [F20]

2.48. Hydrostatic test of boiler should not be conducted until bed is sufficiently cooled, even for economizer leaks, because there may be unknown leaks in the superheater or furnace cavity. [F20]

2.49. Be mindful of pressure curve on hydrostatic test. Consider small valve or external pump to pressurized boiler. [F21]

2.50. Superheaters should be backfilled with demin water for hydro rather than flooding the drum, especially if the boiler contains boiler water chemicals. [F21]

2.51. Minimize welding on tube bends and have spare tube bends on hand. [S22]

2.52. Using tube shields long term can cause corrosion behind the tube shield. [S22]

2.53. Ensure tube material installed is appropriate for the section of the unit. Have a boiler diagram showing material required and verify tube material certs from suppliers. [S22]

2.54. Consider increasing Spout cooling water flow to 40-45 gpm if spouts are suffering with Thermal cycle fatigue. [S22]

2.55. Ensure all spouts are level (Laser level) to ensure equal smelt flow and acceptable cooling per spout. [S22]

## 3. Controls

3.1. Two mills reported problems with "smart" actuators for Rapid Drain Valves such as the Rotork IQ Mk. 1 and Mk. 2. Mills with those actuators installed need to confirm proper configuration and wiring to assure proper operation in Rapid Drain Valve service and also need to periodically replace the backup battery. [S05]

3.2. Proper maintenance and support of leak detection systems is critical to their reliability so that operators will trust the indications they are receiving from the systems. The required resources should be dedicated to the leak detection system maintenance and calibration. [F05]

3.2.1. A central leak indicator screen should be developed in order to allow the operator to go to one screen to see all of his indicators of a possible leak. (Leak detection, Boiler chemical concentration and feedrate, ID fan speed, Stack temp., Steam FW differential, etc.). The screen should be reviewed at least every 4 hours. [F20]

3.2.2. FW steam differential alarms should be approximately 15% of MCR or 15-20K lb/hr above normal differential. Operators and management should be trained on proper actions to take. Alarm must be recurring so it will come back on if acknowledged but the differential alarm condition does not go away. [F20]

3.2.3. Ensure Leak detection systems/Alarm are being checked on a regular basis. Some were reported to be in alarm for an extended period and not reacted to, some reported to not have active alarms. [F22]

3.2.4. Consider testing the sensitivity of your leak detection system by cracking a drain and simulating a leak. Do not desensitize your system to avoid nuisance alarms such that an actual leak would not be detected. Utilize an MOC process to approve adjustment to any critical alarm settings. [F22]

3.3. In one of these incidents, the mill discovered that the furnace draft transmitter had excessive dampening in the draft signal so that it reduced the effectiveness of furnace draft changes as an indicator of tube leaks. Mills should review their furnace draft instrumentation to make sure that while damping may be needed for ID fan draft control, the indication of draft for the operators should not have excessive dampening. [S07]

3.4. We have been mentioning the possibility of installing an interlock in the control system that will close the automatic feedwater control valve and set it on "Manual" if a high furnace pressure and low drum level trip occur at the same time. This will prevent putting excessive amounts of feedwater into the drum if a leak is present and the operator can put the control back on "Auto" when he has determined that conditions are safe to do that. It was reported that a time interval needs to be included because sometimes the high furnace pressure trip and low drum level trip conditions may occur at slightly different times; but you need to make sure that the logic does not "latch in" so that a low drum level trip one day will not close the valve if a high furnace pressure trip occurs the next day. The Safe Firing of Black Liquor Subcommittee is developing some language for their document that contains a recommended time range. [F08, S08, S14, S15]. See Safe Firing of Black Liquor Guidelines ***3.5 Sudden, Large Tube Leak Indication*** for the recommended design of the interlock.

3.4.1. Consider redundant furnace pressure trips. [S14]

3.4.2. Review “Large Leak Logic” that closes feedwater control valve after a trip to make sure timing between low drum level and high furnace pressure trips are sufficient. High-capacity feedwater systems may be able to supply large quantities of feedwater that would delay the time before a low drum trip level is actuated even with a large leak. [F20, F22]

3.4.3. Consider activating Leak Logic on either High Furnace Pressure or Low Drum Level. [F20]

3.5. It is a good idea to monitor or confirm the status of the rapid drain valves prior to start up to assure that the ESP system has power and the rapid drain valves are in automatic. [S09]

3.6. Mills that have installed the necessary wiring to “bypass” the local selector switch on Rapid Drain Valves so that they will open automatically during an ESP if the switch has been inadvertently left in the “Local” position should run a test to verify that the wiring has been installed properly. [S10]

3.6.1. One incident reported problems with several of the Rapid Drain Valves during an ESP. They had made some changes to the valves and had not fully tested them. This shows the importance of fully testing the system after any change is made! [F12]

3.7. Consider bypassing the torque limits of any motorized valve that is part of ESP – not just the Rapid Drain Valves. The ESP guidelines do not specify any other valves other than the Rapid Drain Valves for bypass of the limits but is important to consider especially for the feedwater stop valve where there are multiple boilers being fed by the same feedwater pumps. [F17]

3.8. The importance of maintaining dilution flow to the Direct Contact Evaporator after an upset condition, especially an ESP was shown. It is critical to have a system that can keep the DCE solids under control during the evacuation period after the ESP. A high drive amp alarm is also very important to indicate the possibility for a DCE drive trip. Mills should review how the DCE drive could be reset if it trips during an ESP evacuation period. [S11, F12]

3.9. Check installation details for ESP system in PLC or DCS to make sure it is set up for “energize to initiate” so that a loss of interrogation power or broken wire will not initiate an ESP. [S15, S16]

3.10. Redundant inputs and outputs for PLC should go to different I/O modules, especially if they are used to initiate an ESP. [F21]

3.11. Critical alarms should be set up to come back on if they are acknowledged but the problem continues. In the middle of a crisis, it is easy to forget about an acknowledged alarm. [S16]

3.11.1. All critical alarm settings should be known and documented. F20]

3.12. Alarm setting changes, process control changes should go through an MOC process. Alarm disabling should require a jumper tag. Jumper tag logs must be reviewed by the control room operator prior to all start-ups. [F20]

3.13. Mills should develop standard operating procedures for loss of DCS display to include when and how to put boiler is a safe state. [S21]

3.14. Mills should review the Dissolving Tank level and density instrumentation to make sure low dissolving tank level does not interfere with the density measurement. Consider redundant level measurements. [S21]

3.15. Steam quality monitoring is useful to indicate boiler water carryover to the superheater. Continuous sodium monitors would be the best practice. [F21]

3.16. Ensure low drum level trip points do not allow exposure of upper level generating section and phase separation. [F22]

## 4. Water Treatment

4.1. We are continuing to see problems with localized heavy internal tube deposits, especially at the air port openings. Localized corrosion or discoloration of the composite surface may indicate that internal deposits are present. Dents, depressions and weld push through on floor tubes are a concern because of the potential for steam blanketing downstream of that area. [S08]

4.1.1. Localized deposits can cause tube thinning either external from overheat or internal from under deposit corrosion. We have had several incidents reported where the boiler was thought to be clean based on DWD readings from what was thought to be the high heat areas of the unit. Many of these deposits have been found at tube bends at airports and burner openings. [S16]

4.1.2. Boroscope or video probe is a good tool to look for localized deposits in wall tubes. [S14]

4.1.3. Deposit Weight Density (DWD) readings are nice but how do you know that you found the worst tube? Deposits tend to be very localized. [F19]

4.1.4. Evaluate the frequency of acid cleanings. Waterside deposits become more tenacious over time and harder to remove. Deposits raise the tube metal surface temperature thereby accelerating corrosion rate. [S22, F22]

4.1.5. Ensure waterside deposits are tested for composition so that acid cleaning steps are appropriate for removing the type of deposit existing on the tube. [S22]

4.2. Copper tubing or coils in heat exchangers can be a source of copper contamination in the boiler feedwater. Copper can result in localized heavy deposits that build up over a relatively short period of time and result in tube thinning or overheat failure. [F11]

4.2.1. Mills with hot air dryers or pulp dryers that have copper heating coils should be mindful of possible copper deposits in boilers. [F19]

4.3. Mills should establish definitive shutdown criteria for low boiler water pH excursions in order to minimize any second guessing or delays in shutting down with low pH. [S12]

4.4. It doesn't need a lot of elaboration, but it is never a good idea to use untreated raw water as feedwater makeup to a boiler! [F10]

4.5. Consider installing an ORP (oxidizing, reducing potential) meter to monitor feedwater quality – dissolved oxygen, pH, conductivity. [F16]

4.5.1. Periodically shut off oxygen scavenger to check deaerator performance (<10 ppb). [F16]

4.5.2. Feedwater O2 control is especially important in the useful life of economizers to prevent oxygen pitting. [F20]

4.6. Consider chemically cleaning economizer w/ balance of the boiler to remove internal deposits, eliminate under-deposit corrosion, and passivate any O2 corrosion cells. [F14, F16]

4.7. Consider using x-ray of tubes at the cold economizer inlet to detect possible oxygen pitting on older units. [F18]

4.8. Make sure condensate contamination protection systems are adequate and functional – including check valves for direct steam injection. [F15]