Boiler Inspection Report

VALMET REFERENCE No. M40001

May 2017

Gainesville Renewable Energy Center
Gainesville, Florida

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Boiler service and inspection

Date of Report
August 2017

Project # M40001
ProArc ID: P00506222

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INSPECTION REPORT
GREC
GAINESVILLE, FL

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From

Tony Gravel

Valmet, Inc. Field Service Engineer

Subject

BFB Boiler Inspection Report
May, 2017

Action/Notes

1. INTRODUCTION

Mr. Tony Gravel from Valmet, Inc. was at the GREC Gainesville, FL plant from May 22 - 25, 2017. The purpose of the visit was to assist with inspection of the BFB boiler during its scheduled maintenance outage. The main customer contacts while on site were Mr. Michael Buonsignore and Mr. Tom Gardner.

When Valmet arrived on site the outage was already well along and nearing completion. All accessible areas of the boiler were inspected. Contained in this report are the results of this cursory inspection with respect to general condition of the areas inspected, any problems noted and recommendations made. Also, contained are recommendations for the next outage.

The criterion used in this report with respect to boiler nomenclature is as follows: The boiler is viewed in the direction of flue gas flow and this is considered the front wall. The numbering of wall tubes is from left to right as viewing the respective wall from inside the combustor. Superheater elements, boiler bank elements and economizer elements are numbered from left to right. Individual tubes within these elements are numbered from top down. This designation system will not be deviated from unless otherwise noted.

2. SUMMARY

The last scheduled maintenance outage was May 2015. Since this time the boiler has not seen many hours of operation and has been in stand-by mode most of the time.

Overall the boiler is in very good condition with no significant issues noted.

Valmet arrived on site the afternoon of May 22 and the boiler outage was in progress and nearing completion. The customer had already inspected many areas and access doors to these areas were bolted close. The evening of May 24, the boiler was closed-up in preparation to blow in new sand bed. During course of the inspection, two times the unit had to be evacuated due to thunderstorms. Valmet only did a cursory inspection of the boiler.

All the bed material was removed from the lower furnace. Scaffold was erected on both side walls to the height of the fuel feed openings. Plywood sheets were provided to assist in walking across the tuyeres. A cursory visual inspection of the lower furnace waterwalls was made from the scaffold provided and from standing on top of the tuyeres.

At the nose arch elevation, the maintenance deck was installed. No scaffold tiers were erected in the superheater section sootblower lanes.

No erosion noted to any of the boiler pressure parts.

Lower furnace tuyeres are in good condition with no plugged nozzle holes. No problems noted with the fireside of the hydro beams.

In the four corners of the boiler floor there are sets of three TCs that are staged at different heights. For three of these sets, the tallest TC had failed. For these failed TCs, there was no appreciable heat damage or mechanical damage to the thermowell. The customer was unable to remove the damaged thermoelement from out of the thermowell to replace it with a new thermoelement. This necessitated replacing the whole group of 3 TCs. The customer is sending one of these failed group of 3 TCs back to the vendor for failure analysis.

Lower furnace refractory is in very good condition with no touch up repairs required.

Biomass fuel feed openings and start-up burner openings are in very good condition.

A limited visual inspection was made of the superheaters from the maintenance deck.

For almost all secondary superheater elements, from the middle hand cuff elevation down, in the outer tube loop bundle the lower loops are bowing to the side direction from ½ to 3 tube diameters. The bowing starts at the middle hand cuff row (3 hand cuff elevations) and tapers outward in the side direction as the tubes run downward. The outer tubes stay fairly straight (vertical), but the inner tubes are bowing sideward with each one having more sideward deformation. This was noted during the previous inspection in May 2015 but the magnitude of the bowing has slightly increased. This condition was reported to Valmet Engineering for review and comment. It was reported back that this type tube bowing is common in this superheater design. The degree of bowing usually reaches a certain magnitude and then stops. Tube bowing of this magnitude does not pose a problem. The recommendation was to monitor it during future outages.

Slight amount of hardened ash deposit buildup on superheater tubes which is normal.

Back pass superheater enclosure in very good condition with no significant issues noted.

In the back pass catalyst section, one basket was removed and sent out for analysis.

The expansion joints in the primary air supply duct to the windbox (ground floor) were replaced this outage. Several secondary air ductwork expansion joints were also replaced.

A failed steam drum TC was replaced.

3. RECOMMENDATIONS

3.1 RECOMMENDATIONS FOR NEXT OUTAGE

1. For boiler bank section sootblowers, there are support bracket /roller guides used to support the sootblower lances. These guides are made from angle iron welded together into a frame with the rollers mounted in this frame. These guides are bolted to the tubes above them. On some of these guides, the ends of the mounting legs could possibly rub on the tube surface. Install a short piece of tube shield in this area (Section 5.2).

2. To gain access to the top face of the economizer requires a ladder to be dropped down from the access door opening. Normal size ladders will not fit through the access door openings. Have the appropriate size scaffold ladder available that will allow entry. Better option is to build a custom ladder for entry to this area and secure it to the deck/handrail in general area of the access door opening so that it can be used again during future outages (Section 5.3).

3. For primary 1 superheater elements, the top tube has 3ft long tube shields installed at the sootblower lanes. At the front sootblower lane about 20 tube shields are slightly rolled and not orientated correctly to the flue gas flow. This was noted in the last inspection. At the next outage, tap these tube shields back into the correct position (Section 5.5.4).

4. On the secondary SH elements, the lower section of the outer loop has slight bowing to the side direction. Monitor this bowing (Section 5.5.6).

5. At every annual outage, the bed should be removed to below the hybex beams to allow inspection of the tuyeres with respect to condition and for plugged nozzle holes from sintered bed material (Section 6.1).

6. Inspect the bed thermocouples. Any damaged or in marginal condition TC’s should be replaced. Spare TCs, thermowells and protective pipe sleeves should be stocked in plant spares. Because of the importance of the bed TCs in operating the boiler, the inspection of the bed TCs is a task that should be scheduled for every annual outage (Section 6.3).

7. At every annual outage, inspect the condition of the biomass fuel feed openings. Damage in this area could cause the fuel to hang up causing chute plugging or uneven distribution into the furnace (Section 6.4).

8. At every annual outage, inspect the PA windbox and hybex beams for back sifted bed material. Vacuum out any back sifted bed material from inside the hydro beams (Section 7.1).

9. Replace the three broken (U) bolts that are used to attach nose arch dead air space seal plates to screen tubes (Section 11.2).

4. BOILER DATA

Boiler	Bubbling Fluidized Bed Boiler
Supplier	Valmet Inc. (Metso)
Initial Start-Up	2013
Fuel	Biomass
Steam Capacity	930,000 lbs./hour
Steam Pressure	1620 Psig
Design Pressure	1945 Psig
Steam Temperature	1005 °F

5. PRESSURE PARTS

5.1 STEAM DRUM

The customer had already made a visual inspection of the drum prior to Valmet arriving on site. No issues were reported.

5.2 BOILER BANK

The boiler bank sections were entered and visual inspection was made with no issues noted. Inspection observations are listed below:

- There is no downward sagging in the tube elements **(Photos 1 & 2)**.
- Element alignment is good. For the most part, no individual tube bowing in elements and tubes are sitting flat in their support lugs off the stringer tubes. At the lower sootblower elevation, on some elements the bottom two tubes have a slight upward bow which has them slightly out of contact with the support lugs off the stringer tubes. This is not an issue **(Photos 3 – 5)**.
- Front and rear wall element supports are in good condition **(Photos 6 & 7)**.
- There is a slight amount of hardened ash deposits on tube surfaces and tube shields. No appreciable ash buildup in the flue gas lanes between elements.
- No visible signs of fly ash erosion or sootblower erosion to the tube surfaces.
- Tube shields at the sootblower lanes are in good condition, firmly attached to the tubes and positioned correctly to the flue gas flow. Erosion baffle plates along the SH enclosure walls are all in very good condition and

show no heat warping. These baffle plates are firmly attached to the SH enclosure walls **(Photos 8 & 9).**

Photo 1 – View is of sootblower lane between P1 superheater and boiler bank. No sagging in boiler bank elements.

Photo 2 – View of lower face of boiler bank. No sagging in boiler bank elements.

Photo 3 – Top face of boiler bank, elements are straight. No ash deposit build up on tubes or between elements. Tube shields in good condition.

Photo 4 – Boiler bank tubes sitting flat in support lugs on the stringer tubes.

Photo 5 – Boiler bank elements; lower tubes not sitting flat in support lugs on the stringer tubes.

Photo 6 – Front wall supports for boiler bank elements are in good condition.

Photo 7 – Rear wall supports for boiler bank elements are in good condition.

Photo 8– On top face of boiler bank below sootblower lance, tube shields are in good condition, firmly attached and correctly positioned.

Photo 9 – On top face of boiler bank, front wall erosion baffles in very good condition.

In the boiler bank section, there are support bracket /roller guides used to support the sootblower lances. These guides are made from angle iron welded together into a frame with the rollers mounted in this frame. Two sections of angle iron are welded perpendicularly at the top two corners of the frame and these are “U” bolted to the tubes above them. Where bolted, the tube shield is between the guide and the tube **(Photo 10)**. For one of the lower elevation of sootblowers, the end of the guide mounting angle iron extends over to the centerline of the bottom tube on the next element. On this tube the existing tube shield does not extend that far over. There is a slight gap between the end of the angle iron and the tube (gap is thickness of tube shield). At this interface, there is no erosion to the tube surface **(Photos 11 & 12)**. If in the future this tube should deform/sag slightly, erosion to the tube from rubbing contact with the end of the angle iron could occur. At the next annual outage, it is recommended to install a small section of tube shield to the tube to protect it from any rub contact with the end of the angle iron. Another option is to reposition the guide roller (mounting angle iron has slots for “U” bolts), but there is a good chance nuts are frozen on and will be wrung off requiring new “U” bolts. Trimming the end of the angle iron can also be done but since the cut point would be in the “U” bolt slot, a small section of plate has to be welded across the cut point to maintain the integrity of the angle iron. The quickest option is to install a small section of tube shield.

Photo 10 – In boiler bank section, roller guide support for sootblower lance.

Photo 11 – In boiler bank section; roller guide support for sootblower lance is attached to tubes by "U" bolts.

Photo 12 – Roller guide support for sootblower lance; end of mounting angle iron extends over to below tube. Slight gap there. No tube shield there.

5.3 ECONOMIZER

Description:
This is a finned tube economizer.

Economizer section access doors were all bolted shut therefore this area was not inspected by Valmet.

As noted in the previous outage inspection, to gain entry to the top face of the economizer requires a ladder to be dropped down from the access door opening. Normal size ladders will not fit through the access door opening. Certain scaffold ladders will fit through the opening. For the next outage have an appropriate size ladder available to allow entry to the top face of the economizer. A custom ladder can be built and secured to deck/hand rails near access door opening for use during future outages.

5.4 FURNACE WATERWALLS

5.4.1 Hybex Beams / Floor Tubes

The floor tubes are configured to make air plenums (Hybex beams) that supply air to the tuyeres. All bed material was removed from the lower furnace. From furnace side inspection, no problems noted with these tubes with respect to warping, erosion or mechanical damage **(Photo 13)**.

Photo 13 – View of Hybex beam floor tubes.

5.4.2 Lower Furnace (Floor to Maintenance Deck)

Scaffold was erected on both side walls to the height of the fuel feed openings. Plywood sheets were provided to assist in walking across the tuyeres. A cursory visual inspection of the lower furnace waterwalls was made from the scaffold provided and from standing on top of the tuyeres. From this view point, the furnace tube wall panels are straight. Where visible, no erosion noted to tube surface areas directly above the lower furnace refractory line. Spot areas on tube surfaces have slight ash deposits. This is normal and not an issue **(Photos 14 & 15)**.

Photo 14 – Lower furnace front wall tube panels are straight with spot areas having slight ash deposits.

Photo 15 – Lower furnace front wall tube panels are straight with spot areas having slight ash deposits.

5.4.3 Upper Furnace (Maintenance Deck to Roof)

The maintenance deck was installed this outage. No scaffold towers were built off this deck. A cursory visual inspection of the upper furnace waterwall tubes was made from the maintenance deck. Tube wall panels are straight **(Photo 16).** Tubes surfaces had a light ash deposit which is normal. From this limited view point, no issues noted.

Photo 16 – Upper furnace waterwall tube panels are straight.

5.4.4 Nose Arch Tubes

No issues noted with the nose arch tubes. Nose arch tubes are all running straight with no deformation in the tube panels. No erosion noted to tube surfaces at the tip of the nose arch. **(Photos 17 & 18)**.

Photo 17 – View looking across tip of nose arch.

Photo 18 – View of upper slope of nose arch.

5.4.5 Rear Wall Screen Tubes

At the top of the nose arch, the tubes transition to a vertical run and become part of the rear wall screen section. There was no scaffold on the front side of these tubes so inspection was done from the superheater enclosure.

For the rear wall screen section, the tube rows are all straight and in plane with each other. No bowing to individual tubes with in the screen tube rows. On the front tube of every screen tube row, the lower 8ft of the tube is covered with a tube shield. These tube shields are all in good condition, firmly attached to the tubes and correctly orientated towards the flue gas flow. Tube and tube shield surfaces have a slight ash deposits. No erosion noted to tube surfaces. No issues noted with this section of pressure parts. **(Photos 19 – 22)**.

Photo 19 – As viewed from rear side, front to rear alignment of rear wall screen tube rows is good.

Photo 20 – Side-to-side alignment of screen tube rows is good.

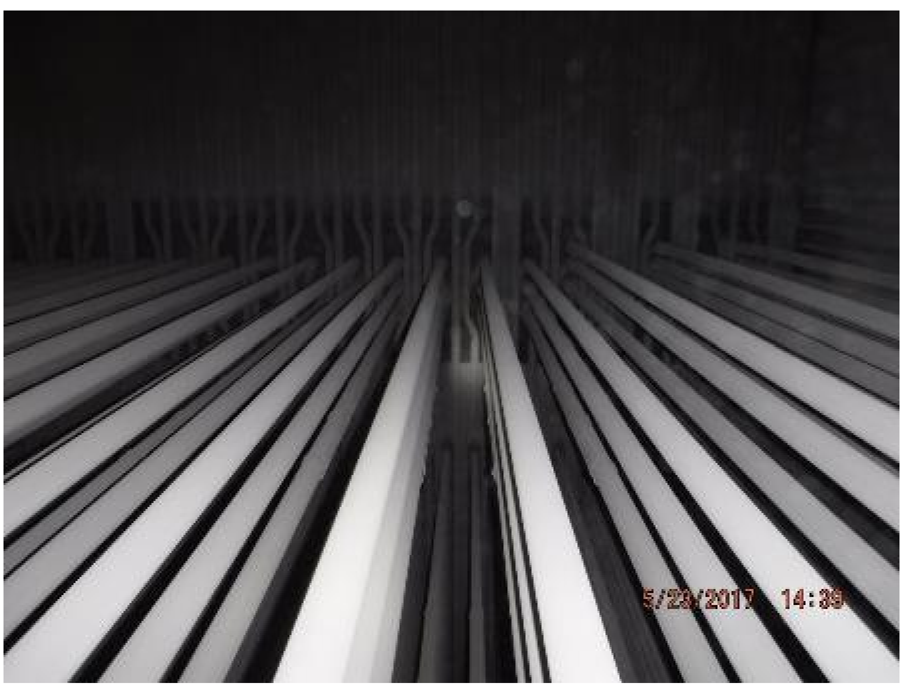

Photo 21 – No bowing to individual tubes within screen tube rows.

Photo 22 – On screen tubes, tube shields show no heat degradation or erosion thinning and are firmly attached.

5.5 *SUPERHEATER*

5.5.1 Roof Tubes

Due to lack of access (no scaffold) only a cursory visual inspection could be made of the superheater roof tubes. The tubes all appear to be in plane with no downward sagging. Tube surfaces have slight ash deposits but this is normal **(Photos 23 & 24)**.

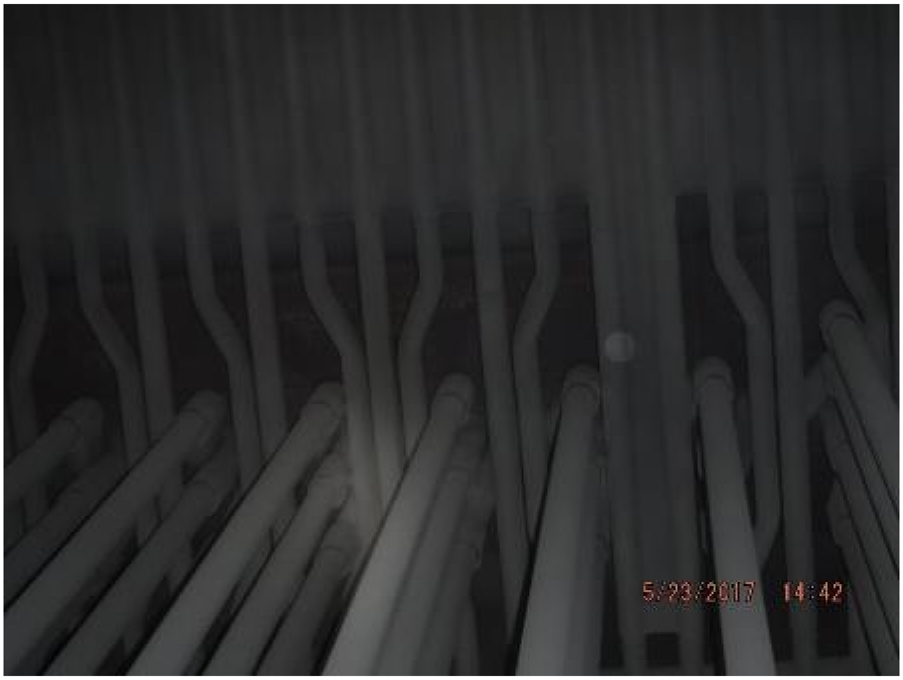

Photo 23 – View of roof tubes above rear wall screen tubes.

Photo 24 – View of back pass roof tubes.

5.5.2 Back Pass Superheater Enclosure

Both side walls and rear wall tube panels are straight. No erosion noted to tube surfaces. At just above the primary superheater bank, for the side wall tubes next to the rear wall screen, the lower 4ft of these tubes are covered with tube shields. These tube shields are in good condition and firmly attached to the tubes. Tube surfaces have a slight coating of ash deposits which is normal **(Photos 25 – 28)**.

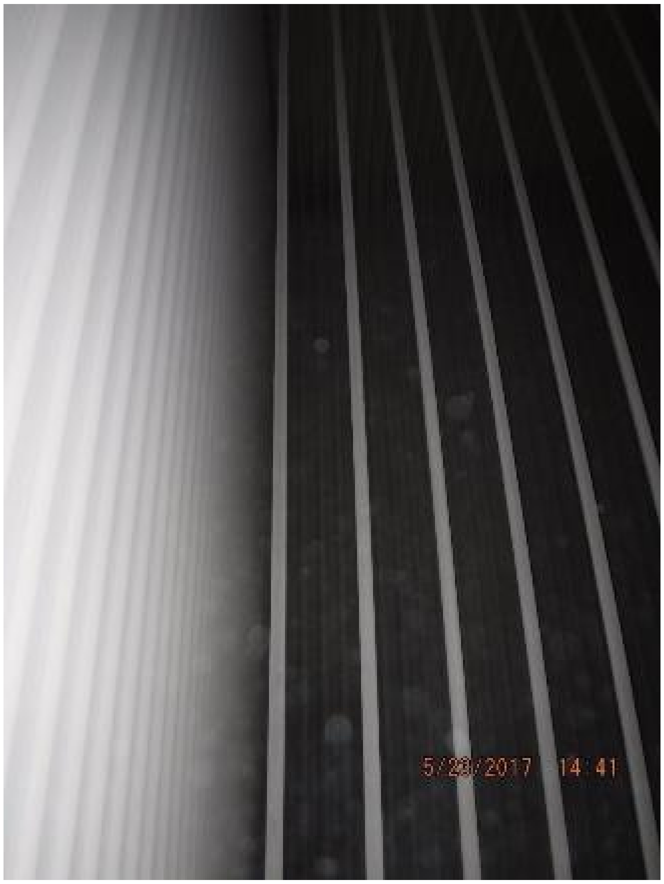

Photo 25 – View of left side wall of back pass superheater enclosure. Tube wall panels are straight.

Photo 26 – View of rear wall of back pass superheater enclosure. Tube wall panels are straight. Above P1SH, erosion baffle plates in very good condition.

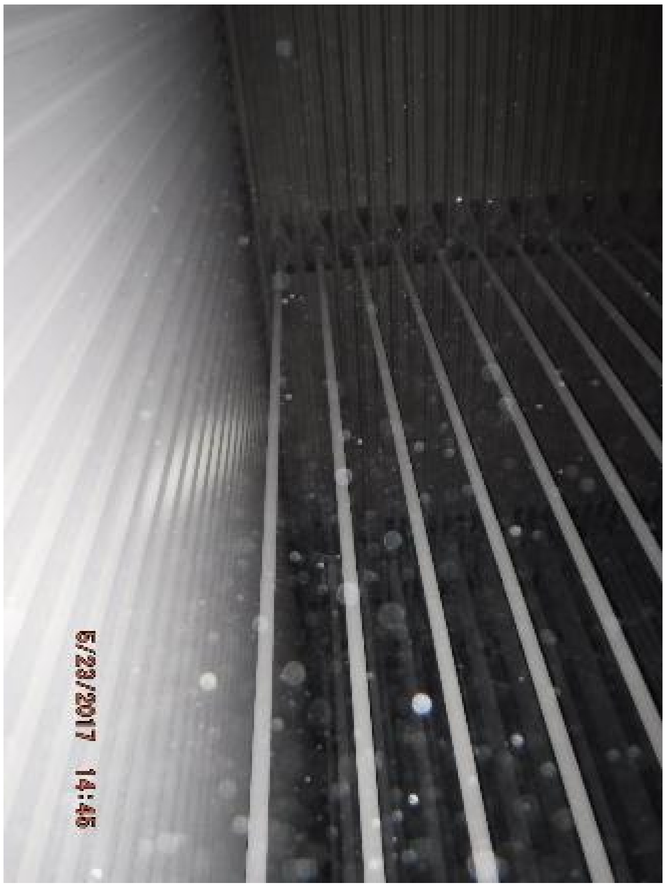

Photo 27 – View of right side wall of back pass superheater enclosure. Tube wall panels are straight.

Photo 28 – Tube shields are in good condition on back pass superheater enclosure side wall tubes near rear wall screen.

Directly above the primary superheater, baffle plates are installed across all four walls of the superheater enclosure. These baffle plates protect the tube surfaces from erosion. The baffle plates are in good shape with no heat bowing or heat degradation to the metal. No problems noted with baffle plate section attachment welds **(Photos 29 & 30)**.

Photo 29 – Directly above P1SH on front wall of back pass superheater enclosure, erosion baffle plates are in very good condition.

Photo 30 – Directly above P1SH on left wall of back pass superheater enclosure, erosion baffle plates are in very good condition.

5.5.3 Superheater Stringer Tubes

These stringer tubes are straight and in plane with each other. Tube surfaces have slight ash deposit buildup. On the vertical run of these tubes, all the tube shield sections are correctly orientated to the flue gas flow. Below the generating bank the stringer tubes run horizontally (before transitioning to a vertical run) and have tube shields. These tube runs are straight and the tube shields are in good condition. No sign of erosion seen to tubes or tube shield surfaces **(Photos 31 – & 33)**.

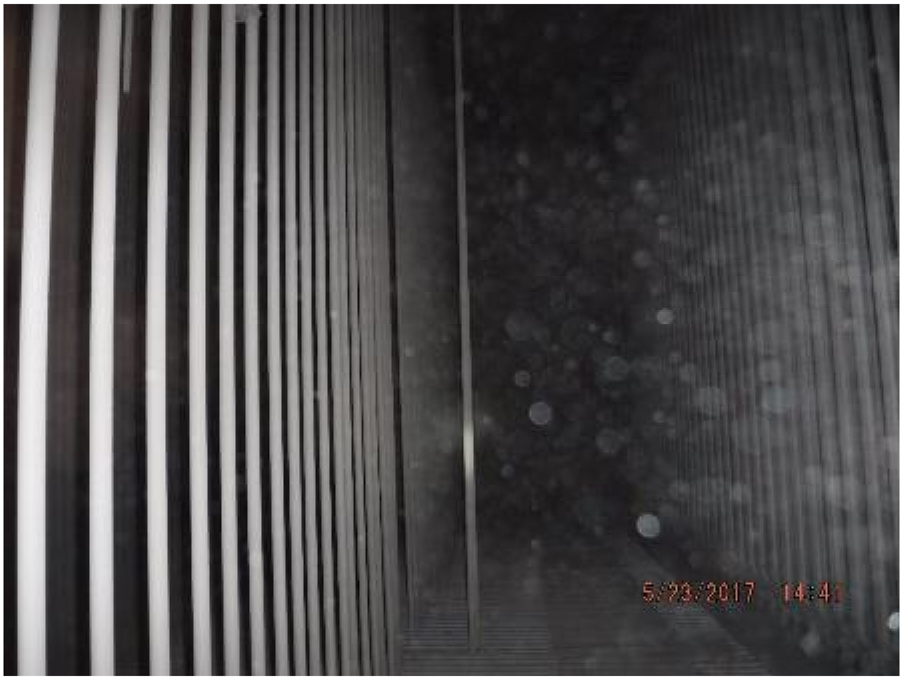

Photo 31 – Front row of SH stringer tubes are straight and in plane.

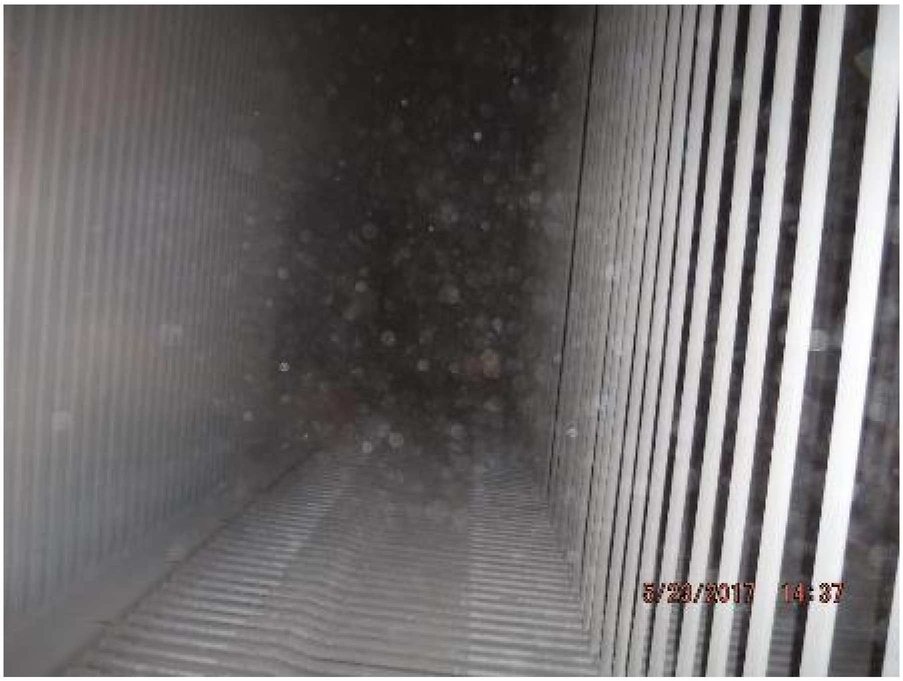

Photo 32 – Rear row of SH stringer tubes are straight and in plane.

Photo 33 – On horizontal run of SH stringer tubes, tubes are straight and tube shields are in good condition.

5.5.4 Primary 1 Superheater

The primary 1 superheater is a horizontal type superheater located in the back pass. No downward sag across the elements. Element-to-element alignment is good. No individual tube bowing within the elements with the exception of element #11 which has 1 tube (in middle of element) bowed out about 1 tube diameter towards element #10. This was noted in the previous inspection. Tubes are sitting flat in their support lugs off the stringer tubes. Front and rear wall element supports are in good condition. There is no appreciable ash buildup in the flue gas lanes between the elements. Tube surfaces have just a slight amount of hardened ash deposit which is normal. No erosion noted on tube surfaces. **(Photo 34 – 39)**.

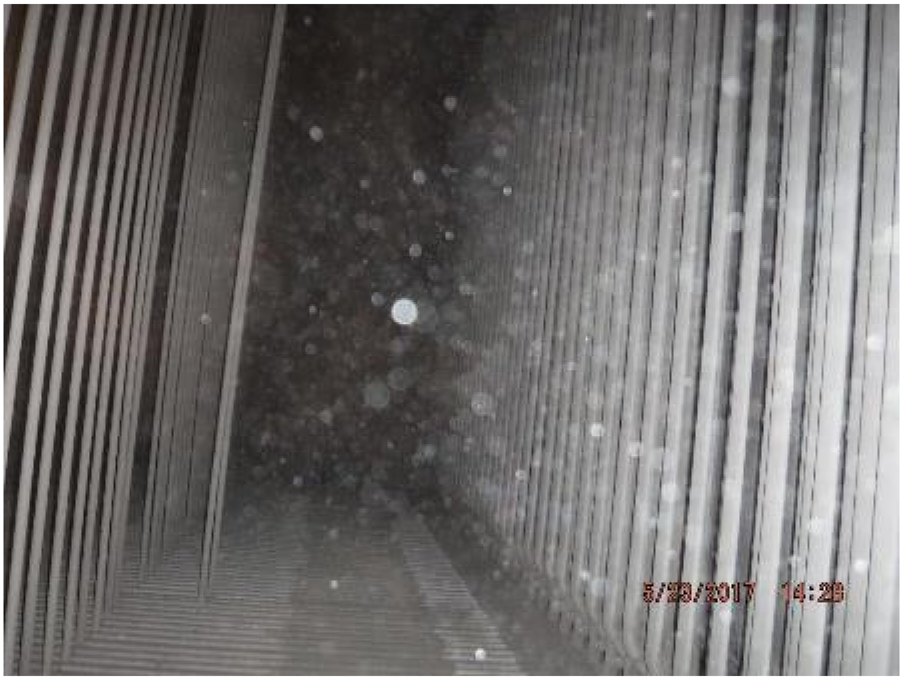

Photo 34 – View across top face of primary 1 SH. No downward sag in elements.

Photo 35 – View across bottom face of primary 1 SH. No downward sag in elements.

Photo 36 – Primary 1 SH element-to-element alignment is good. No ash buildup between elements.

Photo 37 – Primary 1 SH tubes are sitting flat in their support lugs off the stringer tubes.

Photo 38 – On front wall of back pass, primary 1 SH element supports are in good condition.

Photo 39 – On rear wall of back pass, primary 1 SH element supports are in good condition.

At the sootblower lanes, there are 3ft long tube shields installed on both the top and bottom tubes of the elements. Tube shields are in good condition. On the top face of the of this tube bank, at the front sootblower lane about 20 tube shields were slightly rolled and not orientated correctly to the flue gas flow. This was noted in the last inspection. At the next outage, tap these tube shields back into the correct position **(Photos 40)**.

Photo 40 – Primary 1 SH element top tubes, some tube shields rolled out of position.

5.5.5 Primary 2 Superheater

No scaffold was erected at this superheater section. A cursory visual inspection was made from the back pass superheater enclosure looking through the screen tubes. From this limited view, no issues noted with these superheater elements. In the front to rear plane, alignment of the elements is good. Element-to-element alignment spacing is good. There is no individual tube bowing within the elements. There are no tube ties between the individual tubes within the elements. Handcuff clamps are used instead to secure/align the individual tubes within the elements. The handcuff clamps are in good condition and show no signs of heat degradation. These clamps are securely attached to the tubes. At the sootblower elevations, the front and rear tubes of the elements have tube shields installed on them. Only able to view the rear side and these tube shields are in good condition and securely attached to the tubes. No erosion noted to tube surfaces. Tube and tube shield surfaces have slight ash deposits adhered to them. **(Photos 41 – 43)**.

Photo 41 – As viewed looking through the back pass rear wall screen tubes, primary 2 SH element spacing is good. Tube shields are in good condition.

Photo 42 – As viewed looking through the back pass rear wall screen tubes, primary 2 SH element spacing is good. Tube shields are in good condition.

Photo 43 – As viewed looking through the back pass rear wall screen tubes, primary 2 SH element hand cuff clamps are in good condition.

5.5.6 Secondary Superheater

The maintenance deck was installed. No scaffold tiers were erected off the maintenance deck. A cursory visual inspection of this superheater section was made from the maintenance deck and observations with respect to alignment and hand cuff clamps are listed below:

- The front to rear plane alignment of the elements is good. Element-to-element alignment spacing is good **(Photo 44)**.

Photo 44 – Looking across rear side of secondary superheater, elements are all in line.

- There are no tube ties between the individual tubes within the elements. Three elevations of handcuff clamps are used instead to secure/align the individual tubes within the elements. The handcuff clamps are securely attached to the tubes, are in good condition and show no signs of heat degradation.
- For almost all secondary superheater elements, from the middle hand cuff elevation down, in the outer tube loop bundle the lower loops are bowing to the side direction from ½ to 3 tube diameters. The bowing starts at the middle hand cuff row (3 hand cuff elevations) and tapers outward in the side direction as the tubes run downward. The outer tube stays fairly straight (vertical), but the inner tubes are bowing sideward with each one having more sideward deformation. This was noted during the previous inspection in May 2015 but the magnitude of the bowing has slightly increased. This condition was reported to Valmet Engineering for review and comment. It was reported back that this type tube bowing is common in this superheater design. The degree of bowing usually reaches a certain magnitude and then stops. Tube bowing of this magnitude does not pose a problem. The recommendation was to monitor it during future outages **(Photo 45 – 50)**.

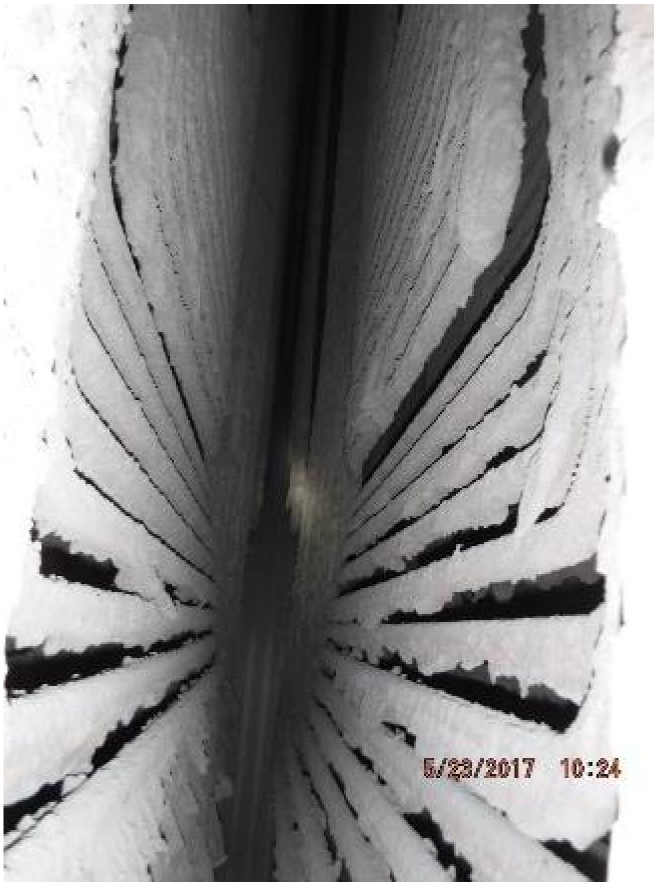

Photo 45 – Secondary superheater; side direction bowing to lower tube loops in outer tube bundle. View is from front to rear.

Photo 46 – Secondary superheater element; side direction bowing to lower tube loops in outer tube bundle. View is from front to rear.

Photo 47 – Secondary superheater element; side direction bowing to lower tube loops in outer tube bundle. View is from front to rear.

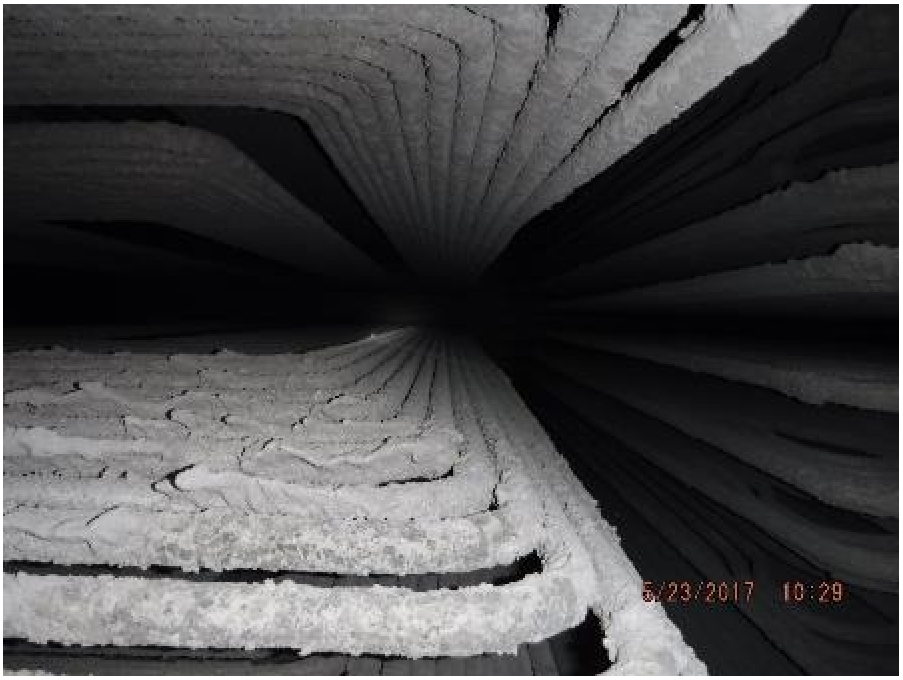

Photo 48 – Secondary superheater element; side direction bowing to lower tube loops in outer tube bundle. View is looking up.

Photo 49 – Secondary superheater element; side direction bowing to lower tube loops in outer tube bundle. View is looking up.

Photo 50 – Secondary superheater element; side direction bowing to lower tube loops in outer tube bundle. View is from rear to front.

- For all elements, the inner tube loop bundle does not have any of this side direction bowing as occurring in the outer tube loop bundle.
- Elements #10, 22 & 23 – The front section of the inner tube loop bundle has an individual tube with side direction bowing. For element #10 it is tubes 4 and 8 within this tube loop bundle. For element #22 it is tube 4 in this tube loop bundle. The bow is between the top and center hand cuff elevations. The bow is towards the right with a magnitude of 1 tube diameter. For element #23, it is the 3rd tube in this tube loop bundle. This tube bows in a serpentine fashion from the top tube tie elevation to the lower tube tie elevation and the maximum amount of deflection is about 2 tube diameters. This tube bowing is not an issue but should be monitored during future outages **(Photos 51 & 52)**.

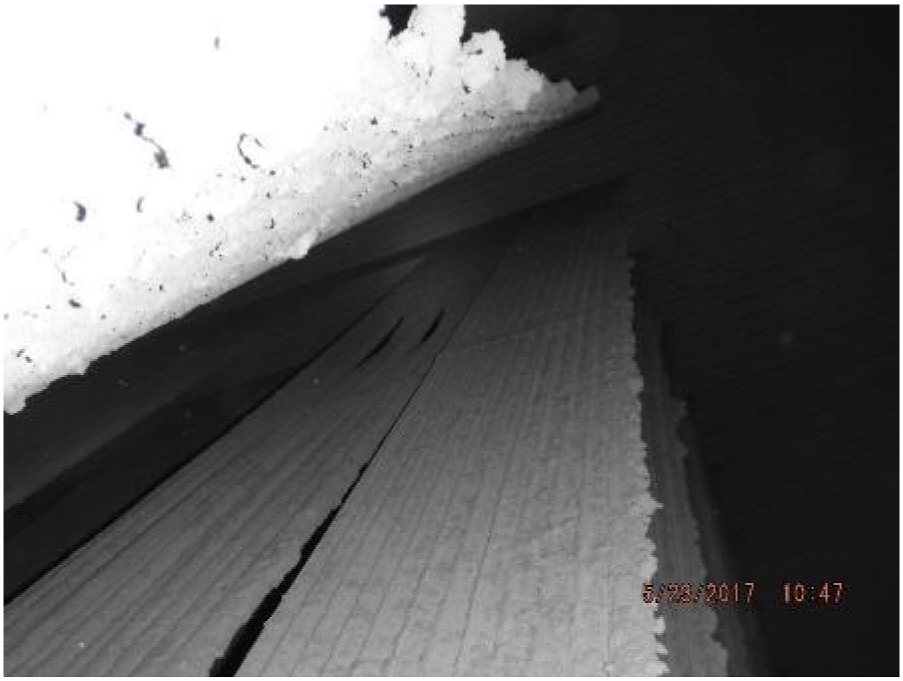

Photo 51 – Secondary superheater element #10; bowed individual tubes in front section of inner tube loop bundle.

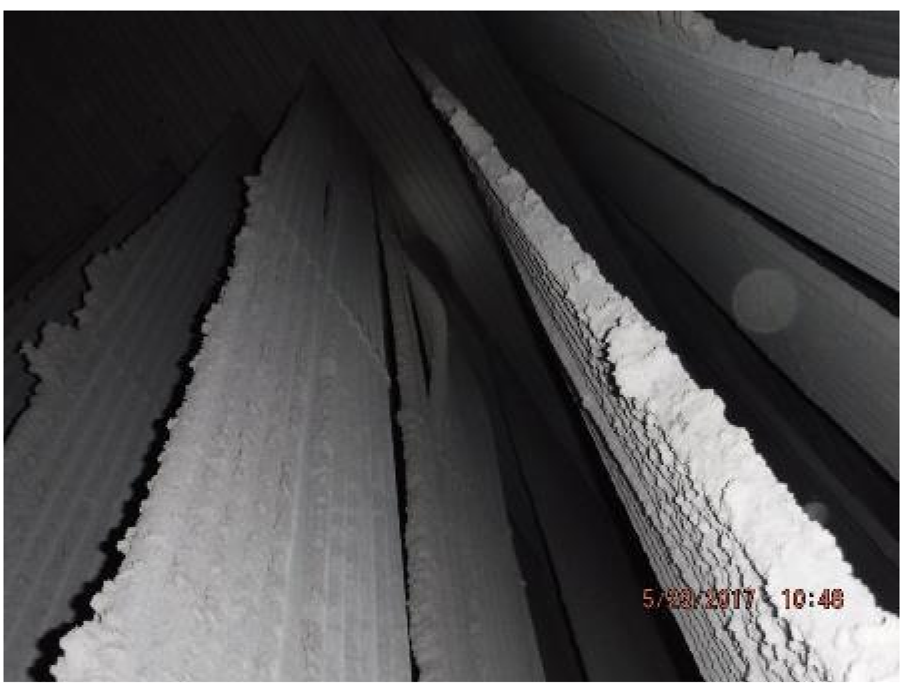

Photo 52 – Secondary superheater element #23; bowed individual tube in front section of inner tube loop bundle.

The rear tube of the elements has tube shields. These tube shields are in good condition, securely attached to the tubes and orientated in the correct direction.

No sign of erosion seen on the tube surfaces. No bridging of ash deposits between the tube elements. For the most part there is 1” to 2” of hardened ash deposit buildup on the tube surfaces (see Photos 45 – 52). This is normal.

5.5.7 Finishing Superheater

Background History:

> *Cracking had been an issue at tube stubs to the finishing superheater outlet header. During the May 2015 outage, the finishing superheater outlet header was replaced. The replacement header came with tube stub legs already welded to the header. Crossover terminal tubes from the header to the element were installed to give more flexibility.*

This superheater section could only be inspected from the maintenance deck. As viewed from this vantage point, front-to-rear alignment of the superheater elements is good. Within the elements there is no individual tube bowing. No bridging of ash deposits between the elements. Tube surfaces have 1/2” to 2” of hardened ash deposits. Some elements have bigger nodules of deposits of 4” to 8” on the front lower tube loop. These will probably break off when the unit is re-fired **(Photos 53 – 56)**.

Photo 53 – Front to rear alignment of finishing SH elements is good. View is right to left with finishing superheater on right side of photo.

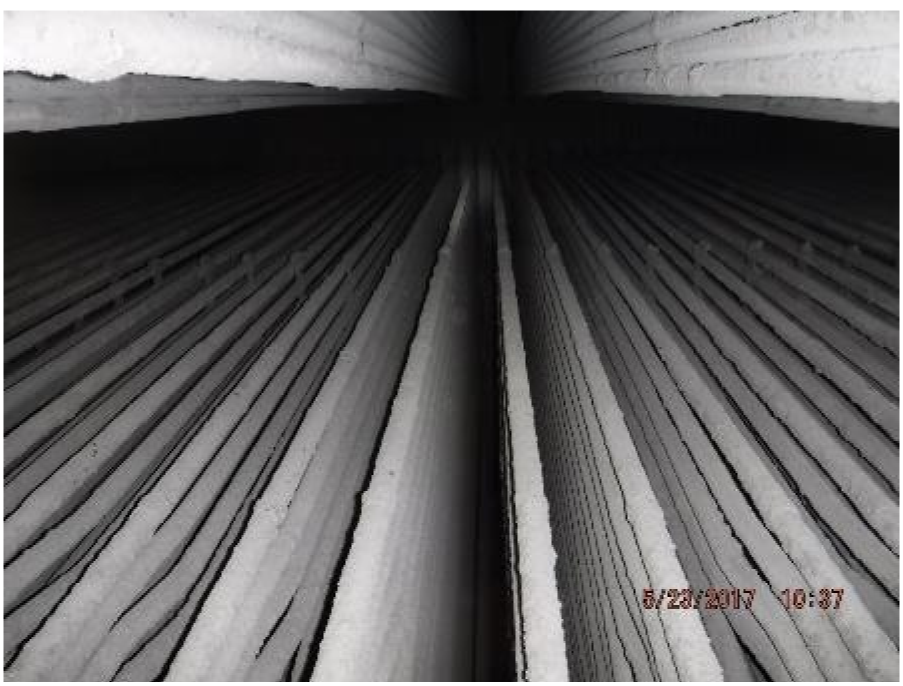

Photo 54 – Side to side alignment between the finishing SH elements is good. Handcuff clamps are in good condition.

Photo 55 – Finishing SH; view of lower tube loops.

Photo 56 – Finishing SH; some elements have 4” to 8” of ash deposits on front side outer tube loop.

6. LOWER FURNACE

The bed material was completely removed. Scaffold was erected on both side walls to the height of the fuel feed openings. Plywood sheets were provided to assist in walking across the tuyeres.

6.1 TUYERES

The bed material was completely removed and thus the tuyeres were visible for inspection. Tuyeres all in good condition. No appreciable heat degradation to the top or head of the tuyeres. Tuyeres were spot checked for plugged nozzle holes with no nozzle holes found plugged. Tuyere nozzle holes show no significant wear from erosion. At every annual outage, the bed should be removed to below the hydro beams to allow inspection of the tuyeres with respect to condition and for plugged nozzle holes from sintered bed material **(Photos 57 – 59)**.

Photo 57 – View of lower furnace tuyeres. The tuyeres are in very good condition.

Photo 58 – View of lower furnace tuyeres. The tuyeres are in very good condition.

Photo 59 – View of lower furnace tuyeres. The tuyeres are in very good condition.

6.2 LOWER FURNACE REFRACTORY

The lower furnace refractory is in good condition and firmly attached to the walls. The refractory has a few expansion cracks which is normal and not a problem. The upper edge of this refractory is square and still intact. Where accessible for inspection, no erosion noted to tube surfaces directly above refractory edge. The customer reported that on the lower 2ft to 3ft of the furnace walls and at start-up burner and biomass fuel feed openings, there were spot areas with 2” to 8” of sintered bed material adhered to the refractory face. These agglomerations were knocked off prior to Valmet inspection of the lower furnace. This type agglomeration is common with BFB boilers and is not an issue **(Photos 60 & 61)**.

Photos 60 – Lower furnace refractory is in good condition with no repair work required.

Photo 61 – Lower furnace refractory is in good condition with no repair work required.

6.3 BED THERMOCOUPLES

All the single bed thermocouples (TCs) were reported to be working. For these TCs, the thermowell and the protective pipe sleeve were in good condition and should last another year of operation **(Photo 62)**.

In the four corners of the boiler floor there are sets of three bed TCs that are staged at different heights. For three of these sets, the tallest TC had failed. For these failed TCs, there was no appreciable heat damage or mechanical damage to the thermowell. The customer was unable to remove the damaged thermoelement from out of the thermowell to replace it with a new thermoelement. This necessitated replacing the whole group of 3 TCs. The customer is sending one of these failed group of 3 TCs back to the vendor for failure analysis **(Photos 63 & 64)**.

The bed TC’s are so important for operating this boiler. At every annual outage, the bed should be lowered past the hydro beams to allow inspection of the bed TC’s. Any damaged or in marginal condition TC’s should be replaced. Spare TCs, thermowells and protective pipe sleeves should be stocked in plant spares.

Boiler service and inspection

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Photo 62 – Lower furnace single TC are in good condition.

Photo 63 – Lower furnace, three staged TC replaced.

Photo 64 – The cluster of 3 TC removed from furnace. Thermowells do not show heat or mechanical damage.

6.4 BIOMASS FUEL FEED OPENINGS

The fuel feed openings are constructed of Avesta 253MA material.

For all six of the fuel feed openings, the refractory at the openings is in good shape. At the fuel impact areas, the plate work did not show any signs of significant erosion. All the plate work in the opening is in good condition with no heat warping or visible signs of appreciable erosion. At all the fuel feed openings, the upper sweep air opening was partial blocked by hardened ash deposits which were cleaned out. Overall the fuel feed openings are in very good condition **(Photos 65 – 68)**.

At every annual outage, the condition of the fuel feed openings should be inspected. The metal plate work in the biomass fuel feed opening is subject to erosion from impact by the fuel. Damage in this area could cause the fuel to hang up causing chute plugging or not be distributed evenly.

Photo 65 – Depicts general condition of refractory at biomass fuel feed openings. Refractory is in very good condition at all feed openings.

Photo 66 – Depicts very good condition of metal plate work at biomass fuel feed openings.

Photo 67 – Depicts very good condition of metal plate work at biomass fuel feed openings.

Photo 68 – Biomass fuel feed openings; hardened ash deposits partially blocking off upper sweep air opening slot.

6.5 START-UP BURNER OPENINGS

No issues noted with burner throat refractory or burner diffusers. Refractory and burner components are all in very good condition **(Photo 69)**.

Photo 69 – View of start-up burner opening. Burner throat refractory and diffuser are in good condition.

6.6 SECONDARY AIR NOZZLES

As viewed from the scaffold along the furnace side walls and from standing on top of the tuyeres, the secondary air nozzles where rectangular and did not show any signs of heat warping to the nozzle plates. There was some hardened ash deposit build up adhered around these openings but this is common and not an issue **(Photo 70)**.

Photo 70 – Secondary air nozzles show no signs of heat warping. Some ash agglomeration built up around opening.

7. AIR SYSTEMS

7.1 Primary Air Windbox & Hybex Beams

These areas were inspected by the customer prior to Valmet's arrival on site. The customer reported that there was no excessive back sifting of bed material into the hybex beams.

Having a few inches of back sifted bed material into the hybex beams is common. During a given operating period, the more the unit has been removed from service the more potential there is for back sifting bed material into the hydro beams. At every annual outage, the PA windbox and hybex beams should be inspected for back sifted bed material. Vacuum out any back sifted bed material from inside the hybex beams.

7.2 Primary & Secondary Air Ductwork & Expansion Joints

The primary and secondary air ductwork was inspected by the customer with no problems reported. The expansion joints in the primary air supply duct to the windbox (ground floor) were replaced this outage. Several secondary air ductwork expansion joints were also replaced. Some of the replaced expansion joints were known to have small burn holes through them which occurred during from welding slagging during construction of the boiler. Others were replaced by the customer as a proactive measure versus waiting for one to fail. Expansion joints usually have only so much life depending on conditions. The customer reported that the replacement expansion joints were made with a more durable material then the original ones **(Photo 71)**.

Photo 71 – Expansion joints replaced on PA supply duct.

7.3 TUBULAR AIR HEATERS

The tubular air heaters were inspected by the customer with no issues reported. While Valmet was on site, the access doors to these air heaters were bolted close.

8. BACK PASS CATALYST SECTION

The catalyst section was inspected from the top face. No issues noted with the enclosure casing and supports in this area. Basket surfaces are clean and in very good condition. Next to right side wall, in first catalyst compartment directly to the rear of the access door opening, a ½" wide section was broken off the edge of one catalyst basket. This was noted in the previous outage inspections. One catalyst basket was removed and sent out for analysis. This basket was just to the right of sootblower #42 (14th from front and 2nd to right of divider plate) **(Photos 72 – 74)**.

Photo 72 – View across top side of catalyst section.

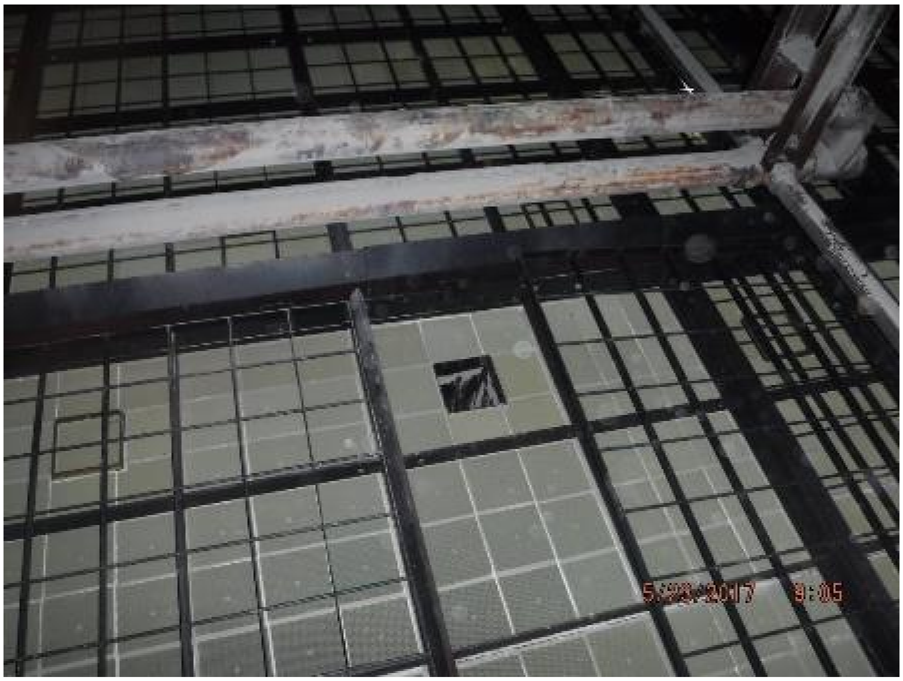

Photo 73 – Top face of catalyst baskets are in good condition. On catalyst basket removed to be sent out for analysis.

Photo 74 – Small section broke off catalyst basket.

9. BACK PASS FLUE GAS DUCTING

Not inspected by Valmet.

The back-pass flue gas ducting has an expansion joint at the inlet to the economizer. The customer reported that during boiler operation, from side wall to side wall the expansion joint mounting flanges bow downward along its length. As the unit is removed from service and cools off these mounting flanges return almost back to normal position. In exterior inspection during this outage, near the center on the rear side of the expansion joint some deformation to the top mounting flange is visible **(Photos 75 & 76)**. It is possible that this bowing is due to thermal expansion along the length of the expansion joint. By this inspection report, this issue is being reported to Valmet Engineering for review and comment.

Photo 75 – At flue gas inlet duct to economizer, deformation to the flanges of the expansion joint.

Photo 76 – At flue gas inlet duct to economizer, deformation to the flanges of the expansion joint.

10. BAG HOUSE INLET DUCTs

Not inspected by Valmet.

11. DEAD AIR SPACES

11.1 PENTHOUSE

The front side of the penthouse which is over the furnace was entered and inspected. There was slight fly ash dusting across the whole area. Where roof tubes meet with front wall tubes, at the interface with both side walls there was fly ash piled up several inches deep. For the seal plates in this area, apparently 100% seal welding wasn't done. This is a difficult area to access to this welding. These two areas along the side walls are most likely the source of the fly ash leaks into the front side of the penthouse. This is not a major issue however if you desire to stop these fly ash leaks, vacuum out the area, determine source of leaks and complete/repair seal welds **(Photos 77 – 81)**.

One failed steam drum thermocouple was replaced.

Photo 77 – View across front section of penthouse. Slight dusting of fly ash.

Photo 78 – Front section of penthouse. Fly ash accumulation where roof tubes interface with right side wall tubes.

Photo 79 – Front section of penthouse. Next to right side wall, fly ash accumulation in space between roof header and front wall header.

Photo 80 – Front section of penthouse. Fly ash accumulation where roof tubes interface with left side wall tubes.

Photo 81 – Front section of penthouse. Next to left side wall, fly ash accumulation in space between roof header and front wall header.

The center section of the penthouse where the superheater headers are located was not entered for inspection. Since these headers are insulated there is not much to see.

The rear half of the penthouse was entered and inspected. There was 1/8” to ¼” of fly ash accumulation on the penthouse floor. At the rear wall of the penthouse, a few sections of calsil insulation block had broken off from boiler bank riser pipes. Since it is inside the penthouse, replacement of these broken off insulation blocks is not required. No other issues noted in this cavity **(Photos 82 & 83)**.

Photo 82 – Slight amount of fly ash accumulation in rear section of penthouse.

Photo 83 – In rear section of penthouse, sections of calsil insulation block broken off boiler bank riser pipes.

11.2 *NOSE ARCH DEAD AIR SPACE*

In this cavity, there was a slight dusting of fly ash (up to 1/8" thick) on the lower slope of the nose tubes. The fly ash infiltration into this cavity could be coming from "U" bolt holes that secure the stainless steel seal plates to the rear wall screen tubes. Three of these "U" bolts were noted to have failed. This is not an issue that required repair at this time. During the next annual outage, replace these failed "U" bolts. The "U" bolts have to be inserted from the back-pass side and nutted from the nose arch dead air space. Use some type of high temperature gasket material to seal at the "U" bolt penetrations through the plate. As minimum a ladder is required to access these "U" bolts from within the nose arch dead air space **(Photos 84 – 86)**.

The nose arch dead air space seal plates appear to be in good condition with no appreciable heat warping.

Photo 84 – View of nose arch dead air space. The seal plates are in good condition with no appreciable heat warping.

Photo 85 – In nose arch dead air space, broken "U" bolts that is used to secure seal plates to tube in back pass.

Photo 86 – Front wall of back pass in boiler bank section, broken "U" bolt used to secure nose arch dead air space cavity seal plate to back pass tube.

12. SOOTBLOWERS

During walk-down inspection of the boiler, the sootblower lances were visually inspected. No issues noted. During back pass inspection, the lance nozzle tips were checked and none of them were cracked.

13. BIOMASS FUEL FEED SYSTEM

The fuel feed system was inspected by the customer during this outage. With respect to this equipment, no problems were reported by the customer. Spot visual checks were made to some of the fuel feed components by Valmet with no issues noted. During the May 2016 annual outage, extensive repairs and replacement were done to the fuel feed equipment (ref. Valmet inspection report). Since there has not been much run time of the boiler since the previous annual outage, this equipment should not have experienced a lot of erosion wear.

14. ASH REMOVAL SYSTEMS

Ash removal system equipment was inspected by the customer during this outage. With respect to this equipment, no problems were reported by the customer. Spot visual checks were made to some of the ash removal equipment by Valmet with no issues noted.

Attachment 1

General Arrangement Drawing

Attachment 2
CD with Report and Site Photos