“3D” Inspection Report

Unit 2 Airheaters
Outage May 7, 20XX

XXXXXXXX Co.
XXXXXXXX Station
Plant Contact: _________

By: XXXXXXXX XXXXXX
Field Services

Project Information

Date of inspection:	**05/07/20XX**
Location:	**XXXXXXXXXX Co.**
Unit Number:	**2**
OEM Contract Number:	AP#XXXX (Heater 2A #XXXX) (Heater 2B #XXXX)
Facility Contact:	____________ (Boiler Engineer)
Contact Phone:	(XXX) XXX-XXXX

1 SCOPE OF WORK:

We were tasked to perform a standard inspection of unit 2's two rotary airheaters, and supervise the overhaul of the 2B Support Bearing as outlined from our previous inspection. Prior to leaving the site, we will provide a list of immediate repairs that need to be completed prior to the close of the current repair cycle, as well as technical supervision pursuant to the completion of those repairs. Additionally, we will provide a detailed inspection report outlining specific repairs, general unit condition, and an overview of necessary future repairs/modifications accompanied by digital photographs detailing those repairs/conditions. This report will be furnished within 30 days of departing the facility.

NOTE: A word about the "*3D*" format. This report is written as part of our "3D" process (**Document**, **Define**, **Digitize**) and is formatted to be much more electronically accessible than standard reports. It's a fully integrated PDF format that is bookmarked and hyperlinked to get you where you need to go. It is also designed to be user friendly, concise, and informational to everyone from executive level managers to maintenance personnel. Simply click on the links in the Table of Contents, Executive Summary, or the Navigation pane on the left and you will go straight to the section of interest.

2 EQUIPMENT:

(2) Two 29-1/2 VI Ljungström type Primary regenerative air preheaters

(2) Two 25-1/2 VI Ljungström type Secondary regenerative air preheaters

Rotations:
2A (PRI): HTR# 3494; CW (Hot end view)
2B (PRI): HTR# 3496; CW (Hot end view)

2A (SEC): HTR# 3495; CW (Hot end view)
2B (SEC): HTR#: 3497; CW (Hot end view)

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3 Executive Summary:

3.1 Overview:

The biggest problem facing these units at present is the structural instability of the primary rotors. Repairs have been affected during the present visit due to the urgent nature of the problem. The movement of the rotor faces at their mating surface has caused damage to several other key components of the airheaters.

Cold end and intermediate layer baskets are also in need of replacement. At such time as this is accomplished, the cold end grating should be replaced as well. Further deterioration of the cold end support grating also destabilizes the rotor structurally since it is primarily this grating that transmits the motive force of the Rotor Drive Unit to the Rotor Post.

3.2 Discussion:

Gap between mating faces at the Rotor Post split on primary rotors:
This condition allows the two halve of the Rotor Post to move laterally with respect to each other. This movement will is greatest when the post split is parallel with the Sector Plates. In this position the Air-to-Gas differential pressure has the greatest mechanical advantage to tilt the post halves with respect to the Trunnion post end flanges

With the Rotor Post no longer performing its role as the key structural element in the Rotor, the forces at work will bias the Rotor until limited by the next weakest link in the system. In this case, either the trunnion bolts, or the pinrack to Pinion Gear engagement.

Primary Pinracks:
The pinrack on both primaries has Pinion Gear impingement wear on both the hot and cold end side rails within the same pinrack section. (See Photos in section 4.1.1.1, page 4) Normally when there is wear on both siderails in one section of pinrack it's a good indicator that the pinrack has been flipped, or removed and turned over to take advantage of the opposing wear surfaces. This will produce wear on both side rails, but the wear will be on the opposite sides of the pin. In both primaries, hot and cold side rail wear is on the same side of the pin indicating that the load has been in the same direction when the Pinion Gear contacted the rail. This precludes the flipping theory.

2B secondary gearbox:
This gearbox exhibited drastically large axial runouts. This alone was sufficient to merit the replacement of that gearbox during this outage. New gearbox was installed and clearances set to OEM specifications.

2B Support Bearing:
While the damage to the bearing has been repaired, the condition of the contact surfaces on this bearing merits a discussion about the continued use of this viscosity of lubricant.

4 OBSERVATIONS:

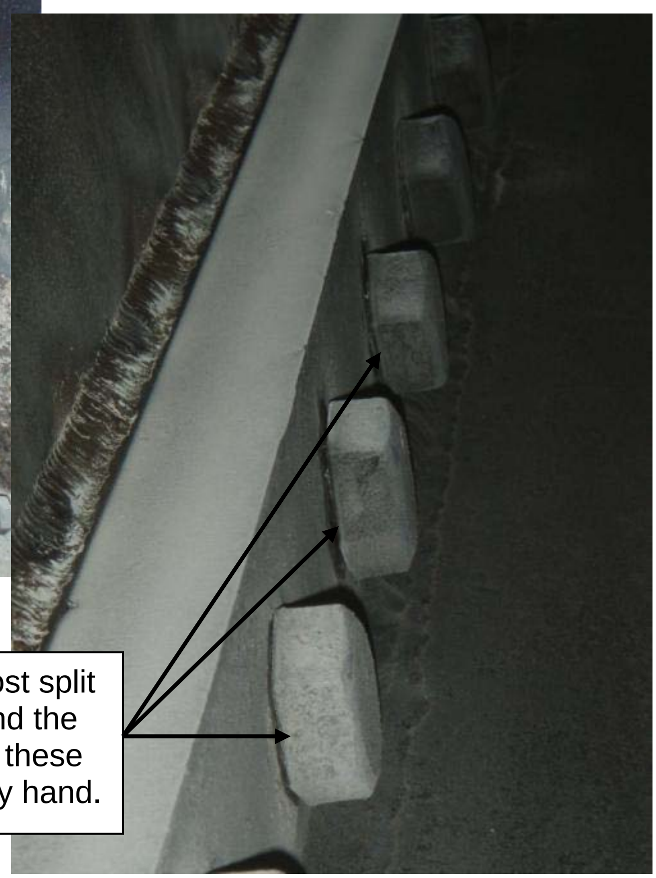
4.1 Air Preheater Rotor:

4.1.1 Diaphragms, stay plates, Rotor Post, and Shell welds

4.1.1.1 Primaries

Found numerous Stay Plate-to Diaphragm welds cracked on the hot end of both primary Rotors. The predominance of these cracks was toward the inboard end of the Diaphragms in the vicinity of the “A” baskets.

The Rotor Posts on both primaries had a .030-.060” gap between the Rotor Post halves. This was not a crack, but a gap between the mating surfaces of the post halves. Subsequent investigations found the gap to be uniform all the way up the length of the Rotor Posts. Additionally, the majority of the Rotor Post flange bolts were loose. (See Photos)



Note missing taper pin. Pin has not been sheared. It has worked loose.

Note gap between post split flange bolt heads and the flange. Nearly all of these bolts could be spun by hand.

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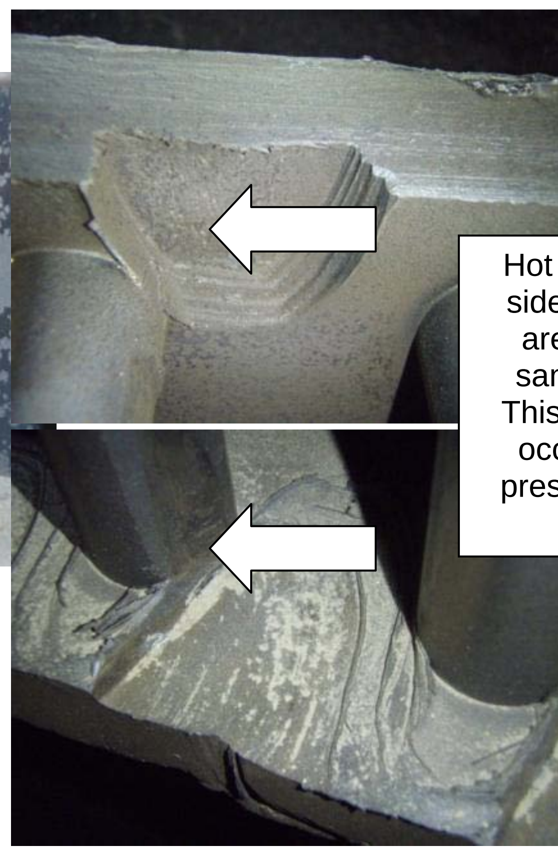
This condition allows the two halve of the Rotor Post to move laterally with respect to each other. This movement will is greatest when the post split is parallel with the Sector Plates. In this position the Air-to-Gas differential pressure has the greatest mechanical advantage to tilt the post halves with respect to the Trunnion post end flanges

With the Rotor Post no longer performing its role as the key structural element in the Rotor, the forces at work will bias the Rotor until limited by the next weakest link in the system. In this case, either the trunnion bolts, or the pinrack to Pinion Gear engagement.

We found no evidence that any of the trunnion bolts had broken or loosened, but the pinrack on both primaries has Pinion Gear impingement wear on both the hot and cold end side rails within the same pinrack section. (See Photo) Normally when I see wear on both siderails in one section of pinrack it's a good indicator that the pinrack has been flipped, or removed and turned over to take advantage of the opposing wear surfaces. This will produce wear on both side rails, but the wear will be on the opposite sides of the pin. In both primaries, hot and cold side rail wear is on the same side of the pin indicating that the load has been in the same direction when the Pinion Gear contacted the rail. This precludes the flipping theory.



Hot and cold end side rail damage are both in the same direction. This damage has occurred in the present mounting

4.1.1.2 Secondaries:

Found numerous Stay Plate-to Diaphragm welds cracked on the hot end of both secondary Rotors. Some cracked Stay Plate welds were noted on the cold end of 2A secondary. This Rotor was undergoing a cold end basket changeout during the inspection so we were able to inspect the cold end Stay Plates and staybars.

The majority of the Stay Plate cracked welds were in 2A secondary. At this point, neither the quantity nor severity of the cracks in the secondary Rotors is of particular concern. It is consistent with normal wear and usage.

<u>It should be noted that in all 4 Rotors the Diaphragm-to-Shell welds and the Diaphragm-to-Rotor Post welds were all in good condition. Through the hot and cold inspection of both the primaries and secondaries I did not find a single cracked or otherwise failed weld. This is exceptional.</u>

4.1.1.3 Baskets & Support Grating:

- <u>Hot end baskets:</u> **Primaries:** DU type element. Baskets were tight, with no appreciable pluggage. <u>Hot end baskets on both primaries are in excellent condition.</u> **Secondaries:** DL loosepack type element. The element itself is reasonably intact, but the size of the “rattle space” within the individual baskets leads me to believe that significant amounts of element are missing.

- <u>Intermediate baskets:</u> **Primaries:** Not inspected.
  Secondaries: The 2A secondary intermediates were the only baskets available for inspection. Noted significant element drop and thinning/cracking in the intermediate element. Given consistent operating characteristics, it would be reasonable to assume that the 2B secondary intermediate baskets are in similar condition. (See Photos next page)

- <u>Cold end Baskets and support grating:</u> **Primaries:** Cold end baskets and support grating on both primaries were in excellent condition. Grating was full thickness and free from significant erosion damage and cracks. Baskets were NF-6 type element 18 Ga. The element is clean and free thinning/spiking. **Secondaries:** Cold end grating is very thin. Cold end element of the DL loose pack type is severely thinned and spiking. (See Photos next page)

2A secondary intermediate layer element loss and thinning/cracking.

2B Secondary cold end DL element severely thinned and spiking.

2A Secondary cold end support grating thinned and cracking.

4.2 Rotor Drive Unit and Pin Rack Measurements:

ROTOR AND PINRACK MEASUREMENTS (PRIMARIES)		
UNIT 2A Pri	RUNOUTS	
	RADIAL	AXIAL
Pin Rack	3/8”	5/16”
Pinion Gear	Not Measured	.045”
Pinion Gear to Pin Rack root clearance	5/8”	
Pinion-to-Pinrack cold end side clearance	1/2”	
Pin wear	.055-.090” avg.*	
Pinrack siderail wear	¼” Hot end, 1/16-1/8” Cold end wear	
Inside-to-inside Pinrack height	4.188	
Unit 2B Pri	RUNOUTS	
	RADIAL	AXIAL
Pin Rack	5/16”	1/4”
Pinion Gear	Not Measured	.020
Pinion Gear to Pin Rack root clearance	11/16”	
Pinion-to-Pinrack cold end side clearance	0”*	
Pin wear	.060-.090	
Pinrack siderail wear	¼” Hot end, 1/16-1/8” Cold end wear	
Inside-to-inside Pinrack height	4.188	

- Both primary pinracks show sign of both hot and cold siderail impingement with the Pinion Gear.
- Nominal root clearance for a unit this size should be 19-21/32. This should be verified with the OEM prints.
- 2A Pri pinrack pins showed evidence of weld repair. For obvious reasons this is unacceptable except as an emergency measure.
- Pinion Gear axial runouts for both primary units were acceptable.
- Radial and axial pinrack runouts are excessive. The mfr’s spec for this measurement is 1/8” T.I.R

ROTOR AND PINRACK MEASUREMENTS (SECONDARIES)		
UNIT 2A Sec	RUNOUTS	
	RADIAL	AXIAL
Pin Rack	**7/16”**	**¼”**
Pinion Gear	**Not Measured**	**.035**
Pinion Gear to Pin Rack root clearance	**3/4”**	
Pinion-to-Pinrack cold end side clearance	**13/16”**	
Pin wear	**.025-.040” avg.**	
Pinrack wear	**¼” Hot end, spotty 1/16” Cold end wear**	
Inside-to-inside Pinrack height	**5.500”**	
Unit 2B Sec	RUNOUTS	
	RADIAL	AXIAL
Pin Rack	**1/8”**	**1/2”**
Pinion Gear	**Not Measured**	**1.060***
Pinion Gear to Pin Rack root clearance	**7/8”**	
Pinion-to-Pinrack cold end side clearance	**.200-1.250**	
Pin wear	**.020-.030 avg.**	
Pinrack wear	**3/16” Hot end, 1/8-3/16” Cold end wear**	
Inside-to-inside Pinrack height	**5.500”**	

- Radial and axial pinrack runouts are excessive. The mfr’s spec for this measurement is 1/8” T.I.R.
- 2A Sec CE side clearance is excessive. (should be 3/16-1/4”)
- **2B Sec Pinion Gear axial runout and CE side clearance indicate a failure within the gearbox. This condition represents an imminent risk of online failure.**
- Recommended root clearance for a unit this size is usually 25/32” measured from the pinrack section with the largest radial runout.

4.3 Seals (Radial, Bypass, Rotor Post, and Trunnion):

4.3.1 Radial Seals:

Localized failure of individual cold end Radial Seals was noted throughout all 4 rotors. Specific locations are delineated in the various Work Order sections for each Rotor.

4.3.2 Bypass Seals & T-Bars:

Noted characteristic contact wear in the bypass seals directly perpendicular to the Sector Plates and center section. Typical erosion damage to the bypass seals adjacent to the Axial Seal Plates was also noted. Note: many of the Rotors' T-Bars are welded to the T-Bar mounting angle. This is an old way of installing them. The current and proper method of installation has the T-Bars pad welded to each other and the faces seal welded and ground smooth. The mounting bolts are tightened to 20 ft/lbs. This allows them to "float" with respect to the Rotor and reduces the effect of "chording" that occurs in the Rotor as it comes up to operating temperature. T-Bars for the most part are in good condition on all rotors, with the exception of the cold end T-Bars on unit 2B Primary Cold end. T-Bars on the cold end of this Rotor are thinned to a face thickness of less than 1/8". Specific recommendations for replacement will be addressed in the Work Order section for that Rotor.

4.3.3 Hot & Cold end Rotor Post seals:

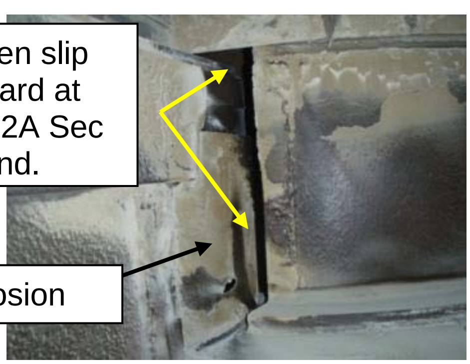
Hot and cold end Rotor Post seals were intact and functioning properly on both Rotors with the exception of unit 2A Secondary cold end. This problem was being addressed during the current outage in conjunction with changing the cold end Radial Seals

4.3.4 Static & Spool seals:

Static seals on the hot and cold end gas side of both the Sector Plates and Axial Seal Plates of all Rotors have both cracks and erosion damage. (See Photo) This is normal, but should be addressed promptly to prevent damage to the underlying Sector Plate and center section structure, as well as to limit the accumulation of debris between the Sector Plates and the center section.

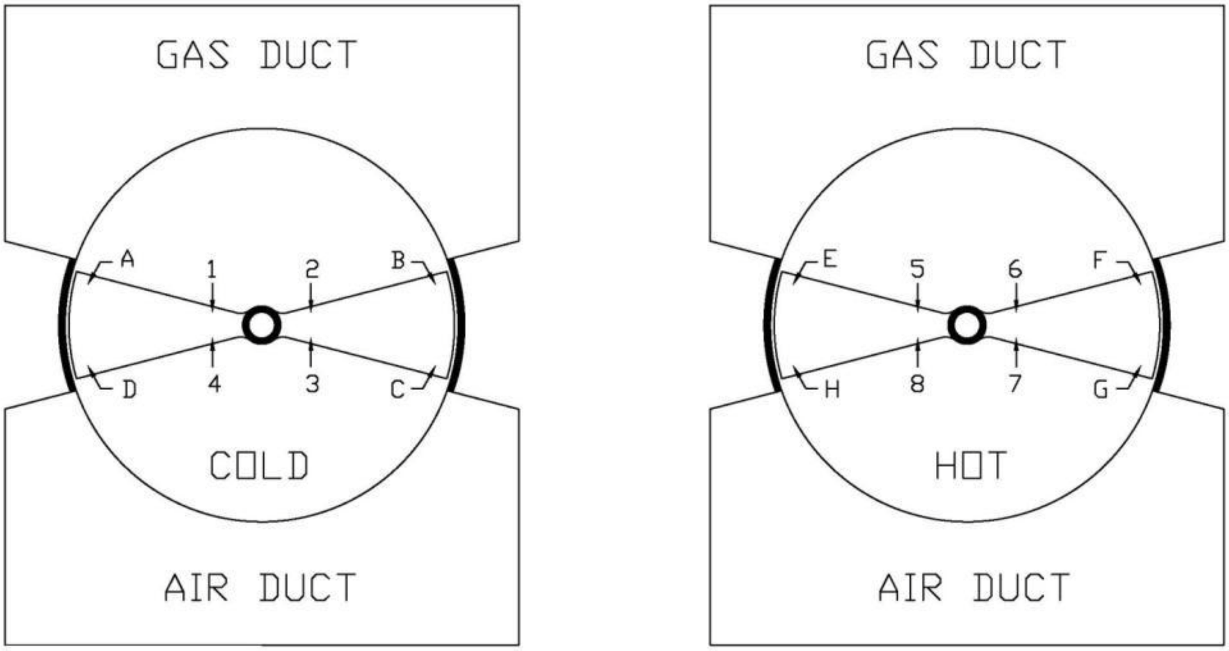
4.3.5 Trunnion Seals:

For the most part, the Primary hot end trunnion seals appear to be in acceptable condition. This is evidenced by a lack of accumulated debris below the hot end Guide bearing. The secondary units do have this accumulation and all should be checked during operation to determine the presence or absence of leakage. (See Photo) As a good engineering practice, it is a low cost preventative maintenance to repack the trunnion seals and Sector Plate tracking rods periodically.



4.4 Air Preheater Housing:

The above diagram indicates the measurement points taken during the Sector Plate



runout portion of the inspection. The rotation of all 4 Rotors is Clockwise as viewed from above the hot end. For the cold end measurements to make sense they will be recorded as though viewed looking downward through the Rotor.

After each Rotor's measurements are given, I will briefly describe the noteworthy conditions.

4.4.1 Sector Plate runout measurements:

Unit 2A Pri Hot end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
5	**3/8”**	**E**	**5/8”**
6	**3/8”**	**F**	**1/2”**
7	**7/16”**	**G**	**1/2”**
8	**5/16”**	**H**	**7/16”**
Inbd Runout	**1/8”**	**Outbd Runout**	**3/16”**
Unit 2A Pri Cold end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
1	**7/16”***	**A**	**11/16”***
2	**7/16”**	**B**	**1/2"**
3	**1/2”**	**C**	**13/16”***
4	**7/16”***	**D**	**3/4"**
Inbd Runout	**1/16”**	**Outbd Runout**	**5/16”**

Comments:

- “*” Indicates that the Sector Plate adjusting bolt below this area was found to be loose. The inboard adjusting bolt will have an effect on both inboard measurements for a given Sector Plate since it is the only mounting point for the nose of the plate.

- Hot and cold end Sector Plates were in good condition with relatively minimal signs of heavy contact wear or erosion.

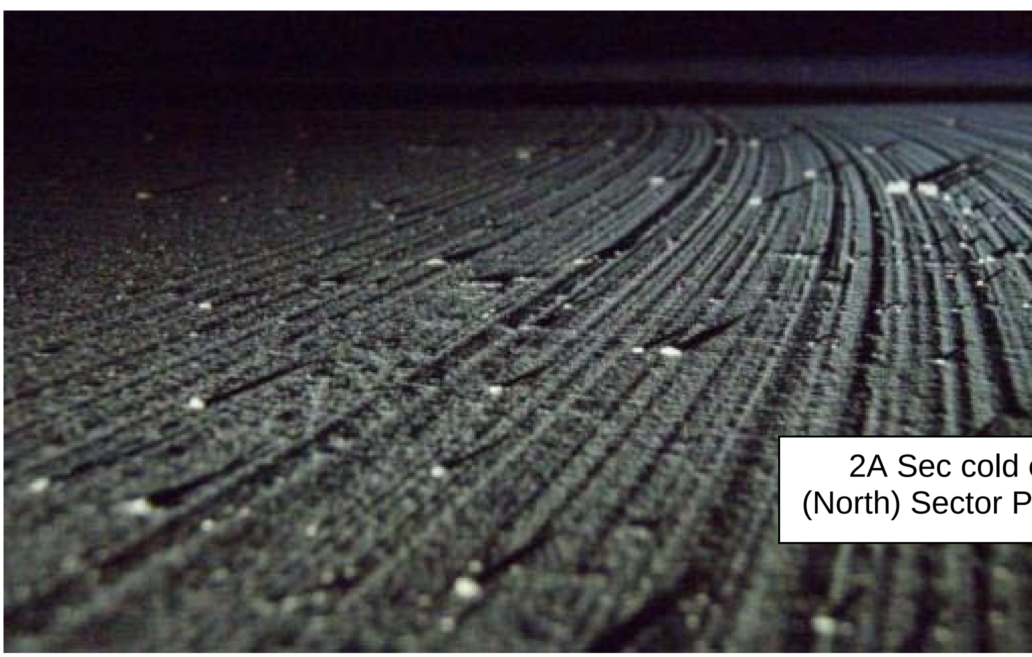
Unit 2A Sec Hot end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
5	**3/16”**	**E**	**1/2”**
6	**1/8”**	**F**	**5/8”**
7	**3/32”**	**G**	**5/8”**
8	**1/16”**	**H**	**1/2”**
Inbd Runout	**1/8”**	**Outbd Runout**	**1/8”**
Unit 2A Sec Cold end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
1	**3/8”**	**A**	**1-1/8”***
2	**7/16”**	**B**	**1-1/4”**
3	**5/16”**	**C**	**1”**
4	**3/8”**	**D**	**1-1/8”**
Inbd Runout	**1/8”**	**Outbd Runout**	**1/4”**

Comments

- “*” Indicates that the Sector Plate adjusting bolt below this area was found to be loose. The inboard adjusting bolt will have an effect on both inboard measurements for a given Sector Plate since it is the only mounting point for the nose of the plate.

- Hot and cold end Sector Plates were in good condition with relatively minimal signs of heavy contact wear or erosion with the exception of the following:

- Cold end Gas-to-Air Sector Plate shows signs of moderate contact wear. It is not localized and is not of significant depth to be a major concern. (See Photo)



2A Sec cold end Gas-to-Air (North) Sector Plate contact wear.

Unit 2B Pri Hot end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
5	**5/16”**	**E**	**7/16”**
6	**5/16”**	**F**	**5/16”**
7	**5/16”**	**G**	**3/8”**
8	**1/4"**	**H**	**7/16”**
Inbd Runout	**1/16”**	**Outbd Runout**	**1/8”**
Unit 2B Pri Cold end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
1	**1/8”**	**A**	**7/8”**
2	**1/8”***	**B**	**11/16”**
3	**1/4"***	**C**	**3/4"**
4	**1/8”**	**D**	**7/8”**
Inbd Runout	**1/8”**	**Outbd Runout**	**3/16”**

Comments

- “*” Indicates that the Sector Plate adjusting bolt below this area was found to be loose. The inboard adjusting bolt will have an effect on both inboard measurements for a given Sector Plate since it is the only mounting point for the nose of the plate.

- Hot and cold end Sector Plates were in good condition with relatively minimal signs of heavy contact wear or erosion with the exception of the following:

- 2B Pri Air-to-Gas Sector Plate moderate to severe contact wear. (See Photo) Notice the lack of identical damage to the Radial Seal in the photo. This would indicate that this wear has not occurred during the service life of these seals.

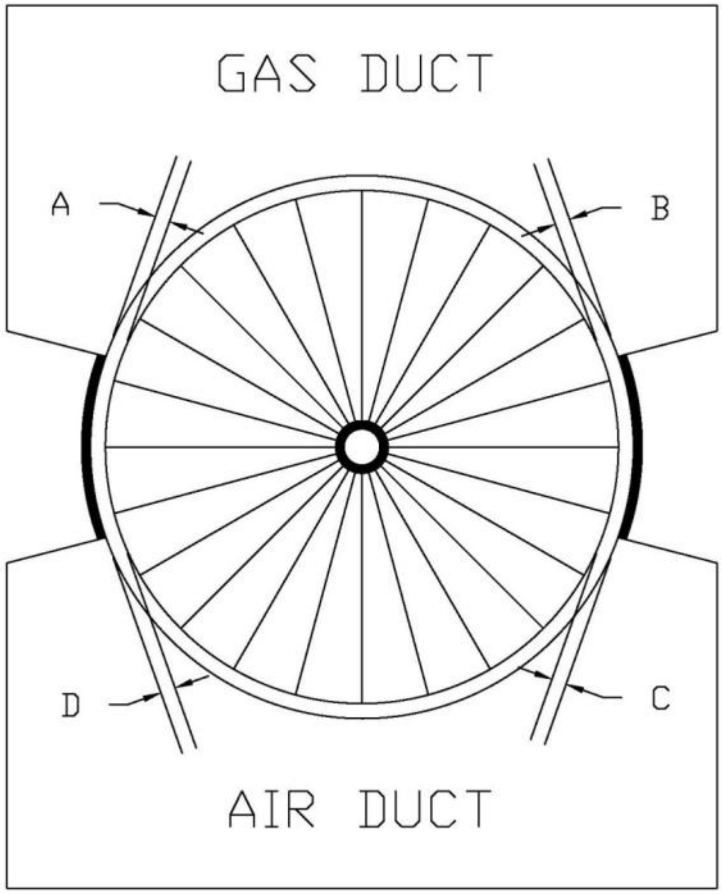
Unit 2B Sec Hot end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
5	**3/8”**	**E**	**1/4"**
6	**3/16”**	**F**	**1/8”**
7	**3/16”**	**G**	**3/16”**
8	**5/16”**	**H**	**1/4"**
Inbd Runout	**3/16”**	**Outbd Runout**	**1/8”**
Unit 2B Sec Cold end (CW rotation Hot End View)			
Inboard Measurement		**Outboard Measurement**	
Location	**Measurement**	**Location**	**Measurement**
1	**7/16”**	**A**	**1-1/8”**
2	**1/4"**	**B**	**1-5/16”**
3	**3/16”**	**C**	**1-1/4”**
4	**1/4"**	**D**	**1”**
Inbd Runout	**1/4"**	**Outbd Runout**	**5/16”**

Comments

- “*” Indicates that the Sector Plate adjusting bolt below this area was found to be loose. The inboard adjusting bolt will have an effect on both inboard measurements for a given Sector Plate since it is the only mounting point for the nose of the plate.

- Hot and cold end Sector Plates were in good condition with relatively minimal signs of heavy contact wear or erosion.

4.4.3 Axial Seal Plate runout measurements:



The above diagram indicates the measurement points taken during the Axial Seal Plate runout portion of the inspection. The rotation of all 4 Rotors is Clockwise as viewed from above the hot end. After each Rotor's measurements are given, I will briefly describe the noteworthy conditions.

Unit 2A Primary Axial Seal Plate Runout Measurements			
Location	Top	Middle	Bottom
A	7/16”	7/16”	11/16”
B	1/2"	7/16”	11/16”
C	7/16”	1/2"	3/4"
D	7/16”	3/8”	5/8”
Runout	1/16”	1/8”	1/8”

Unit 2A Secondary Axial Seal Plate Runout Measurements			
Location	Top	Middle	Bottom
A	7/8”	11/16”	9/16”
B	13/16	3/4"	5/8”
C	7/8”	3/4”	5/8”
D	7/8”	13/16”	3/4"
Runout	1/16”	1/8”	3/16”

Comments:

- All Axial Seal Plate mounting brackets/pivots and internal structure appears to be in acceptable condition.
- Axial Seal Plate static seals are in various degrees of disrepair. Individual repairs are delineated in the Work Order section for each unit.
- Sealing surfaces and Axial Seal Plate to Sector Plate seals were all in good condition. Both secondary and primary units have significant grooves immediately outboard of the pinrack suggesting that they may have been set too close at one time, or a pinrack section may have come loose. In either case, the runouts are not significant enough to warrant immediate attention. At such time as the axial seals are replaced, the plates can be brought into concentricity with the Rotor.

Unit 2B Primary Axial Seal Plate Runout Measurements			
Location	Top	Middle	Bottom
A	9/16"	7/16"	7/16"
B	3/4"	3/4"	5/8"
C	5/8"	5/8"	5/8"
D	7/8"	3/4"	13/16"
Runout	5/16"	5/16"	3/8"

Unit 2B Secondary Axial Seal Plate Runout Measurements			
Location	Top	Middle	Bottom
A	5/8"	1/2"	1/2"
B	5/8"	5/8"	1/2"
C	3/4"	1/2"	1/2"
D	5/8"	7/16"	1/2"
Runout	1/8"	3/16"	0"

Comments:

- All Axial Seal Plate mounting brackets/pivots and internal structure appears to be in acceptable condition.
- Axial Seal Plate static seals are in various degrees of disrepair. Individual repairs are delineated in the Work Order section for each unit.
- Sealing surfaces and Axial Seal Plate to Sector Plate seals were all in good condition. Both secondary and primary units have significant grooves immediately outboard of the pinrack suggesting that they may have been set too close at one time, or a pinrack section may have come loose. In either case, the runouts are not significant enough to warrant immediate attention. At such time as the axial seals are replaced, the plates can be brought into concentricity with the Rotor.

4.4.4 Ducting and Bracing:

All <u>accessible</u> ducting, bracing, and expansion joints were inspected for cracks, erosion, and bowing.

Hot end inboard pipe brace mounting pads on both 2A Secondary Hot end air side, and 2B Secondary Hot end gas side had cracked welds. (See Photo) Work orders have been initiated in the Work Order section for each unit.

4.5 Guide Bearings:

SKF 23000 series double spherical roller type: All Guide Bearings covers were removed for inspection. Radial clearances were not consistent with this size bearing. It is assumed that the races are loaded from the Sector Plate tracking rod yoke. In any case, readings obtained with the bearing in this position are unreliable. Bearing internal inspections yielded nothing out of the ordinary. Rollers were free from cracks, galling or other deformity. Races had the normal burnished annular rings of contact but no palpable wear or defects. Roller cages were intact and did not have excessive play. 2B Primary guide bearing was the worst in terms of debris and "coking". (See Photo) Bearing was solvent cleaned/flushed, then flushed with 32wt hydraulic oil, drained and refilled with the proper lubricant. All other Guide Bearings were drained and refilled pursuant to the inspection.

All Rotors were checked for level with a machinists' level accurate to .002"/ft. The factory build specification for leveling the Rotor is < .005"/ft. None of the Rotors were far enough outside that number to be of concern.

- 2A Primary: .005"/ft. toward Gas Duct.
- 2A Secondary: slightly greater than .005"/ft. toward Air Duct
- 2B Primary: slightly greater than .005"/ft. toward Gas Duct
- 2B Secondary: .010"/ft. toward South (2ASec)

2B Primary hot end Guide Bearing debris and hard carbon deposits

4.6 Support Bearings:

Kingsbury 6 shoe, flooded, equalized thrust bearing. Note: The Kingsbury type thrust bearing has to be nearly disassembled completely to conduct a proper inspection of the load and wear surfaces. The amount of time and expense necessary to do so make it unfeasible to do without cause. Unit 2B Secondary Support Bearing is being overhauled this outage per our recommendations from previous inspections. The remaining Support Bearings were given an external visual inspection that entailed the following:

- Inspection of trunnion seal for obvious leakage and centering.
- Verification that the rotor stoppage alarm components are intact and in position. Electrical operation is not verified.
- Checking for oil leaks.
- This is an external Support Bearing, meaning that it is held in place from beneath by mounting bolts rather than sitting internal to the center section frame. Consequently, those fasteners bear all the vertical/tensile load of the entire rotating mass of the Rotor. For this reason the Support Bearing mounting bolts and shim packs were checked for tightness.
- Checking oil level and condition.

All four bearings were inspected per the above list. There was significant oil leakage on and around all of them. Without a thorough cleaning of the bearing and surrounding area, it would be impossible to accurately determine the source of the leak.

All Support Bearing mounting bolts were in place, and their shim packs were in position and tight.

The condition and level of the oil were not monitored, as the oil in all 4 units was being changed during the present outage.

4.7 Soot Blowers:

- Hot end soot blowers are Copes-Vulcan linear travel lance type. The following deficiencies were noted:
  - 2A Primary:
    - External.
      - Missing poppet valve contact head.
      - Lance-to-housing air seal is missing. It has been disassembled, so the assumption was made that it is in the process of repair.
    - Internal:
      - Nozzles OK
      - Soot blower to element distance: 12-13-1/2" (slightly close)
  - 2A Secondary:
    - External:
      - Lance-to-housing air seal is missing. It has been disassembled, so the assumption was made that it is in the process of repair.
    - Internal:
      - Outboard and middle nozzles severely worn. The divergent nozzle is almost entirely eroded away.
      - Soot blower to element distance is closer than OEM recommends at 11-1/2". There does not appear to be any adverse effect from this.
  - 2B Primary:
    - External:
      - Carriage sliding feet slightly worn.
    - Internal
      - Outboard and middle nozzles severely worn. The divergent nozzle is almost entirely eroded away.
      - Soot blower to element distance: 12-1/2" is closer than OEM recommends, but only by 1/2". There does not appear to be any adverse effect from this.
  - 2B Secondary:
    - External:
      - Carriage sliding feet slightly worn.
      - Drive chain loose.
      - Lance/Housing air seal same as above.
    - Internal
      - Outboard and middle nozzles severely worn. The divergent nozzle is almost entirely eroded away.
      - Soot blower to element distance: 13-1/2"

5 SUPPORT BEARING WORK ON ROTOR 2B:

5.1 Introduction and background:

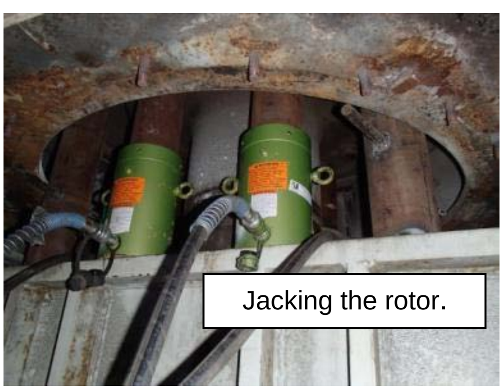
This work is pursuant to recommendations made by us during the last inspection. Extremely heavy starting loads, as well as failure of the bearing to maintain an oil wedge shortly after stopping indicated that the bearing surfaces were in need of inspection and replacement. The effort necessary to access the load bearing components of the Kingsbury type bearing are quite significant, and this process should never be undertaken solely for the purpose of inspection. It is recommended that the plant either have the necessary internal parts on hand prior to the outage, or have a repair facility lined up to resurface the thrust shoes so they can be reinstalled during the same outage. If the latter, it needs to be understood that this preparation will be to no avail if there are severely broken or damage internal components.

The details surrounding the operation of this unit are as follows:

- The forced lubrication system is out of commission, and has not functioned for many years.
- The plant has elected to use an ISO460 grade oil instead of the more viscous ISO 680 recommended by the OEM. They are using this oil in all of their thrust bearings company-wide, and have not had any significant problems with it.

5.2 Bearing Disassembly and Analysis:

The rotor was isolated from all forms of energy (electric, thermal, pneumatic, Hydraulic, potential, etc.) and the rotor load removed from the thrust shoes. The lower bearing housing (Tub) was then lowered on 3 pairs of Gr. B2 all-thread to gain access to the thrust shoes, thrust runner, and upper/lower leveling plates (See photos below)



Jacking the rotor.

Lowering the “Tub”

The thrust runner was removed and the internal components removed for inspection. Conditions of the internal components and housing were as follows:

1. Thrust shoes were finely galled over 100% of their contact area. (See Photos below).
2. Thrust runner was in good condition, with no immediate signs of damage to the wear surface. It is to be sent out for resurfacing with the shoes.
3. Upper/lower leveling plates and pivot rods appear to be in acceptable condition. The hardened steel rocking/pivoting inserts on all 3 layers will be check/replaced as necessary by the company performing the repairs during their overhaul.
4. The lower housing (Tub) was nearly full to the thrust runner with “sludge” consisting of Babbitt material and other solid particulate matter that has gained entry to the bearing over time. (See photos below)

Note fine galling over entire contact surface area. This is most likely a chronic effect of lack of filtration combined with the use of thinner lubricating oil.

Accumulation of sludge and Babbitt material due to lack of circulation/filtration. Bear in mind that the bottom of the bearing tub is about 8-9” below the level shown.

5.3 Support Bearing reassembly:

The Support Bearing components were reworked and shipped back to the plant. After a thorough cleaning of the tub and a radial clearance measurement of the lower radial bearing, the internal components of the thrust bearing were reassembled. The tub was then raised and secured with new bolts torqued to manufacturer's specs. The rotor was then leveled in the housing, and appropriate adjustments made to the hot and cold end trunnion seals to accommodate the new rotor position. (See photos below)

Counter clockwise from top right: Lower leveling plates and pivot rods in place, installation of the upper leveling plates, placement of the thrust shoes, rigging in the newly resurfaced thrust runner, and the fully assembled lower half of the Support Bearing (absent the thrust runner for visibility)

5.4 Discussion and Final Analysis:

While it's true that this bearing was caught in time, before catastrophic failure, it appears to have been riding very close to the line mechanically. The use of thinner oil was recommended by the Air Preheater OEM to reduce the starting torque necessary to get the rotor turning after extended periods of inactivity. This condition may have accommodated its intended goals indefinitely if the unit was being circulated/filtered on a regular basis. As it stands, the fact that the bearing had not yet failed is little cause for rejoicing when there are three similar bearings adjacent to this one that have been under identical operating conditions.

The use of thinner oils for these reasons is relatively common practice in the industry. The rationale seems to be that the bearings aren't failing catastrophically, so it must be OK. In calculating the minimum oil film thickness for this bearing we take into account RPM, load bearing surface area, radial dimension of the load surface, oil viscosity, ambient and operating temperatures, as well as some of the manufacturers index numbers for the specific oil used. In this example, the reduction in viscosity correlates to an almost 30% reduction in oil film thickness at operating speed and temperature. Fortunately, the minimum oil film thickness is still somewhat larger than the micron rating of the *in situ* filter. Had the filtration system been in use, it is possible that the solid particulates culpable for this damage would have been eliminated.

When all the numbers have been crunched, one is brought the long way around the mountain to a fuller understanding of just why the bearings' OEM recommended the lubricant that they did. Higher static breakaway torque is a small and relatively innocuous consequence of the thicker oil. The temperature rise across the bearing is easily handled by the installed fan cooling system, and the increase in oil film thickness greatly increases the overall life of the thrust shoes and bearing as a whole.

It is our recommendation that the bearing be filled with ISO 680 or equivalent lubricant and circulated/filtered for a set amount of time daily, regardless of temperature. We have installed filtration units that come equipped with heating elements that can be used as necessary to maintain a minimum oil temperature regardless of ambient external temperatures. This practice alone can be the single biggest determining factor with regard to longevity of the bearing.

6 WORK ORDERS:

The following section delineates specific recommended repairs. They are segregated by unit into Priority 1, 2, and 3 work orders.

- Priority 1 – Items have a high probability of causing a forced outage, significant performance degradation, financial loss, equipment damage, or safety hazard before the next scheduled outage.
- Priority 2 – Items which pose a possibility of failure or performance degradation.
- Priority 3 – Items that under normal operations would not cause a forced outage, or significantly degraded performance. These items are typically planned for future work.

They are accompanied with pictures and relative spatial reference drawings to give some idea as to their location in the unit.

For illustrative purposes, a representative example of each priority of work order is included below. Depending on the condition of the unit inspected, the work order section can be very large, or relatively small. This is particularly the case if much of the emergent work is completed during the inspection visit.

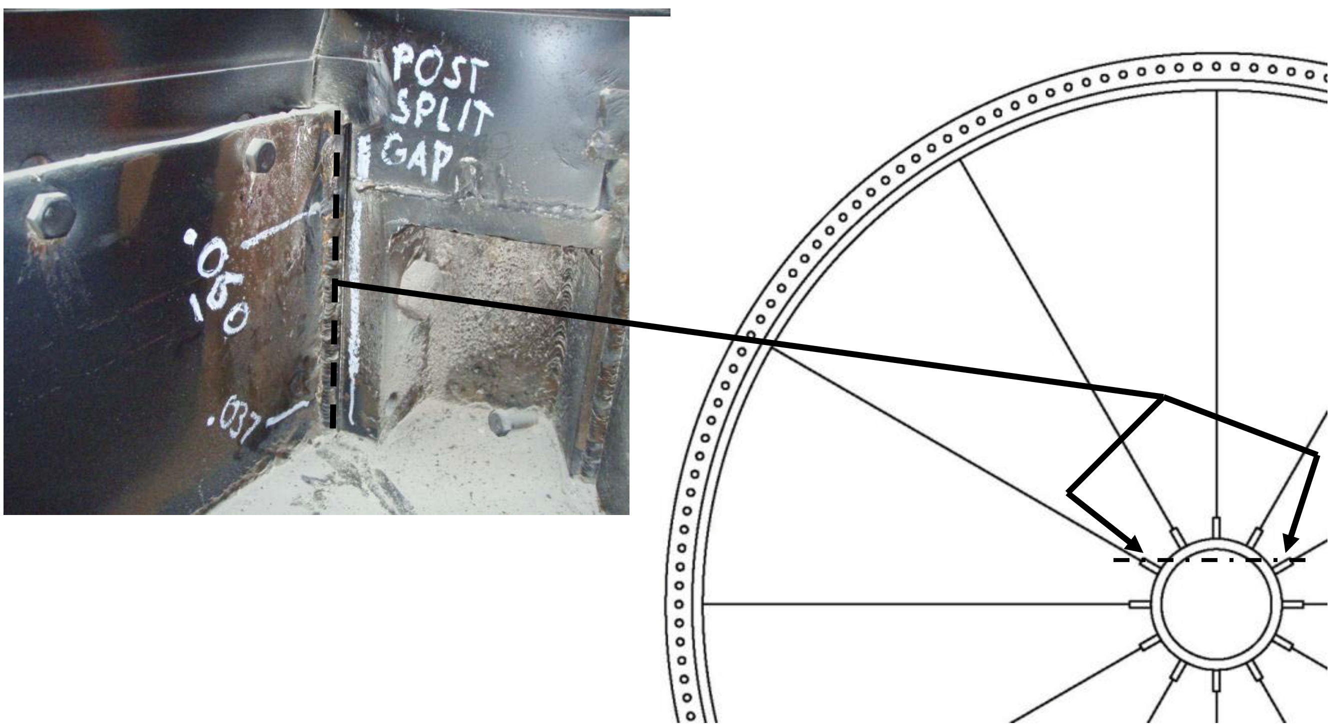
I would like to thank you for this opportunity to partner with you in your ongoing efforts to ensure the proper operation and reliability of your air preheaters. Please call me if you have any questions or concerns about any of the items mentioned in this report.

Best Regards,
XXXXXXXX XXXXXXXX
Field Services

Priority 1 Corrective Work Order

- **Unit 2A (Primary)**
  - **Area:** 2A Primary Rotor Post split.
  - **Action:** Replace Bolts, retorque.
  - **Cause:** Unknown
  - **Repair**: Replace and retorque Rotor Post flange bolts with A325 or equivalent 1.25 x 7 UNC bolts. Torque to 1120 Ft/Lbs in three incremental steps. (700, 900, 1120 ft/lbs) Alternate torquing sequence on last 2 steps. Once torqued, it is advised that the Rotor Post mating flanges be seal welded using 7018 or 8018 welding electrode with the proper preheat for parent material of this thickness.

When this operation is complete, the trunnion bolts on both hot and cold ends should be removed, replaced with new bolts, and re-torqued to OEM specified values. **(<u>This is a precautionary measure</u>. There was no damage noted during the inspection, but the movement of the rotor halves would have exerted considerable lateral force on the trunnion bolts themselves.)**



WORK REQUEST #:			STATUS:	

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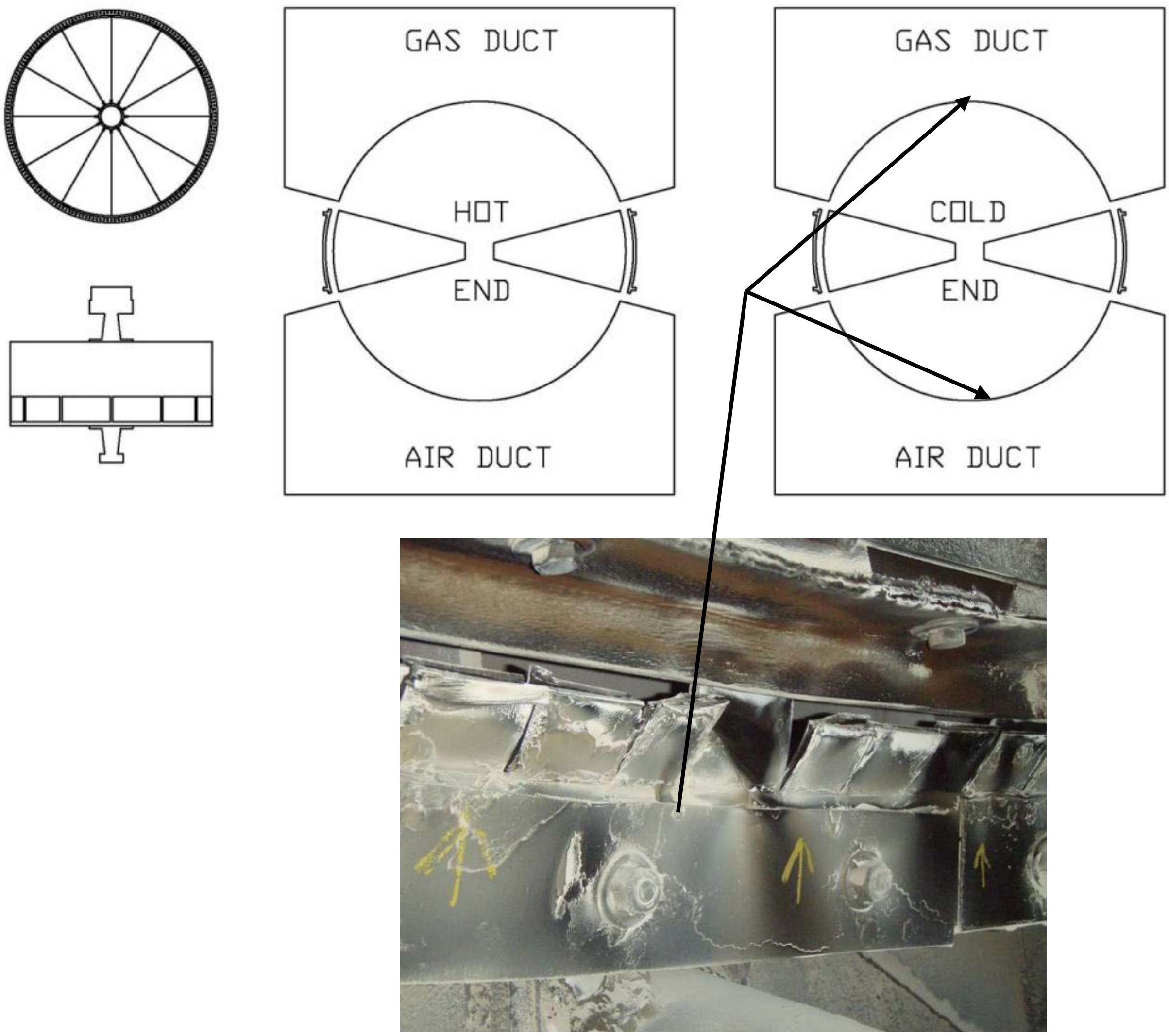
Priority 2 Corrective Work Order

- **Unit 2A (Primary)**
  - **Area**: 2A Primary cold end both air and gas sides.
  - **Action:** Replace Cold End Bypass seals.
  - **Cause:** Erosion/Abrasion/ Contact wear
  - **Repair:**
    - Replace cold end bypass seals. Seals are at the end of their effective service life.
    - Failing to replace these and other noted seals during this outage will most likely result in unsatisfactory leakage prior to the next scheduled outage.



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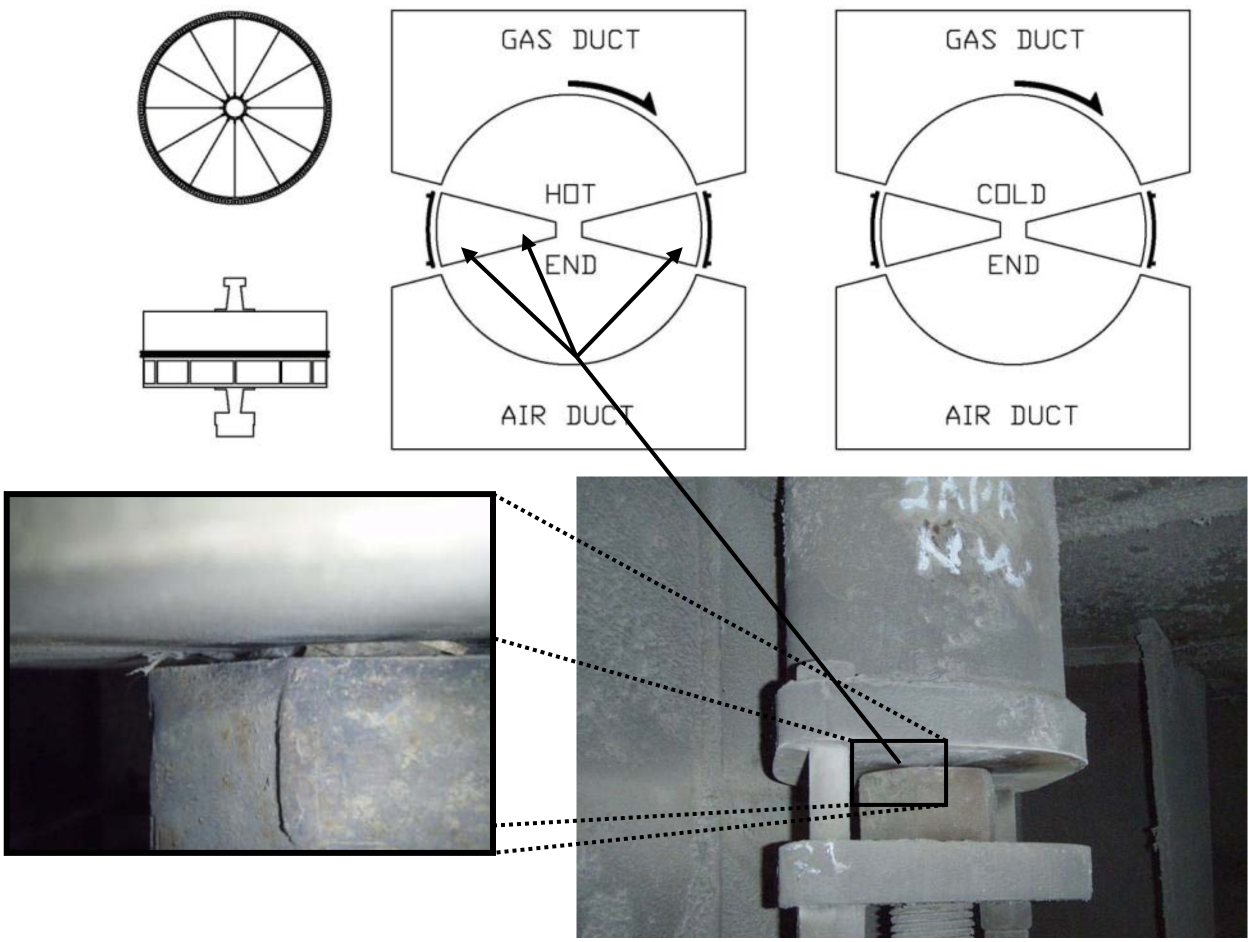
Priority 3 Corrective Work Order

- **Unit 2A (Primary)**
  - **Area**: 2A Primary Sector Plate adjusting bolts.
  - **Action:** Gaps between Keeper and Locknut. Tighten Keeper nuts to eliminate gap.
  - **Cause:** Unknown.
  - **Repair**: Gaps between Keeper and Locknut. Tighten Keeper nuts to eliminate gap. Do not change position of large locknut with respect to the adjusting bolt shank.

    Locations: South side: Inboard, Outboard West. North side: Outboard West. Adjusting bolt "cans" that needed tightening were labeled with grease marker and tightened during the present outage. All adjusters should be checked periodically for tightness during operation.



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