Exhibit F

Report on Comanche Unit 3 High Pressure Turbine Blade Damage

Prepared by [redacted], Fleet Engineering

Non-Public Confidential

Executive Summary

Damage from contact (rubbing) between the last three stages of rotating blades and the seal strips was found on the Comanche 3 High Pressure (HP) Turbine during inspection in February, 2020. The damage was significant enough to require blade and seal strip replacement.

Operating data was reviewed from the one year warranty inspection in the fall of 2011 to January 13, 2020 to determine the cause. The evidence suggests that the HP Turbine shaft and turbine casing was bowed from water induction into the turbine during two events in 2018. Damage likely occurred when the bowed shaft was rotated on turning gear and when rolled up during unit startup. Subsequent damage may have occurred during a third event which resulted in high shaft vibration during startup due to high eccentricity.

Overview

Comanche 3 was removed from service on January 13, 2020 to investigate a step change in Low Pressure Turbine B vibration. The full train inspection planned for the fall of 2020, was started on January 24, 2020, due to the length of the outage required to repair the Low Pressure Turbine.

Inspection of the HP Turbine revealed rubbing on the rotating blade shrouds of stages 2 through 9 with work hardening of the shrouds from heating on stages 7, 8, and 9. A corner section of the shroud was missing on the stage 9 blades. Stationary seal damage was significant in the lower portion of the casing.

Hardness of the rotating blade shrouds ranged from 47.7 HRC to 50.6 HRC compared to the standard blade hardness of 30 HRC to 35 HRC. After removal of 0.010 inches of blade material, hardness increased by as much as 10%. Since the hardness could not be removed by machining, the rotating blades for stages 7, 8, and 9 required replacement, along with the seal strips. Replacement blades were sourced through the Ethos Energy Group.

The pictures below show the altered shapes of the stage 9 rotating blade shrouds.

Data / Event Analysis

Data was reviewed from the one year warranty inspection in the fall of 2011 to January 13, 2020. The data indicates that the HP Turbine rotating blade shroud and seal damage likely occurred in 2018.

Operational data reviewed:

- Shaft vibration at Bearings 1 and 2, including overall, 1X, 2X, phase angle, and shaft position
- Turning gear operation, eccentricity, differential expansion, and thrust position
- Bearing temperatures
- Casing temperatures. Top and bottom differential, flange and bolt differential, inlet steam and metal temperature differential
- Feedwater heater extraction flows, levels, and temperatures.
- Turbine drain valve actuator positions
- Auxiliary steam system
- Gland steam sealing system

Vibration Data, Eccentricity, and Turning Gear Review

Bearing 1 and 2 vibration and phase trends were reviewed for step changes. As seen in the example below, in 2019, there were no large amplitude nor phase step changes that would indicate balance shifts. Temporary high amplitude excursions, as could occur while the rotor was rubbing, were also not found while the machine was online. High amplitude vibration occurred on Bearings 1 and 2 during several startups in 2018. The significant startup vibration events will be discussed further in Contributing Events.

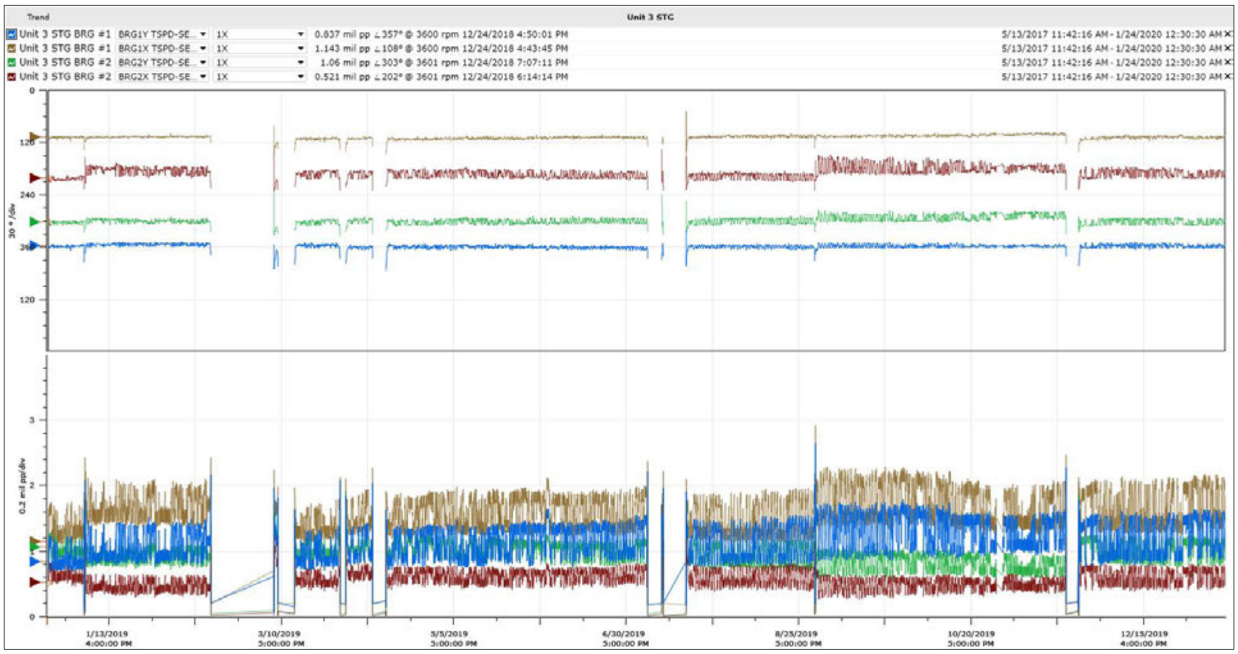

Figure 1: 1X running speed vibration amplitude and phase through 2019

High eccentricity will cause high HP/IP Turbine vibration during turbine roll up. As the example in Figure 2 shows, high eccentricity was present for several startups when the high eccentricity alarm did not initiate.

Vibration when the turbine was on turning gear in 2018 is also notable. The high eccentricity and the turning gear events are considered likely contributing factors to blade and seal damage and will be discussed further in the Contributing Events.

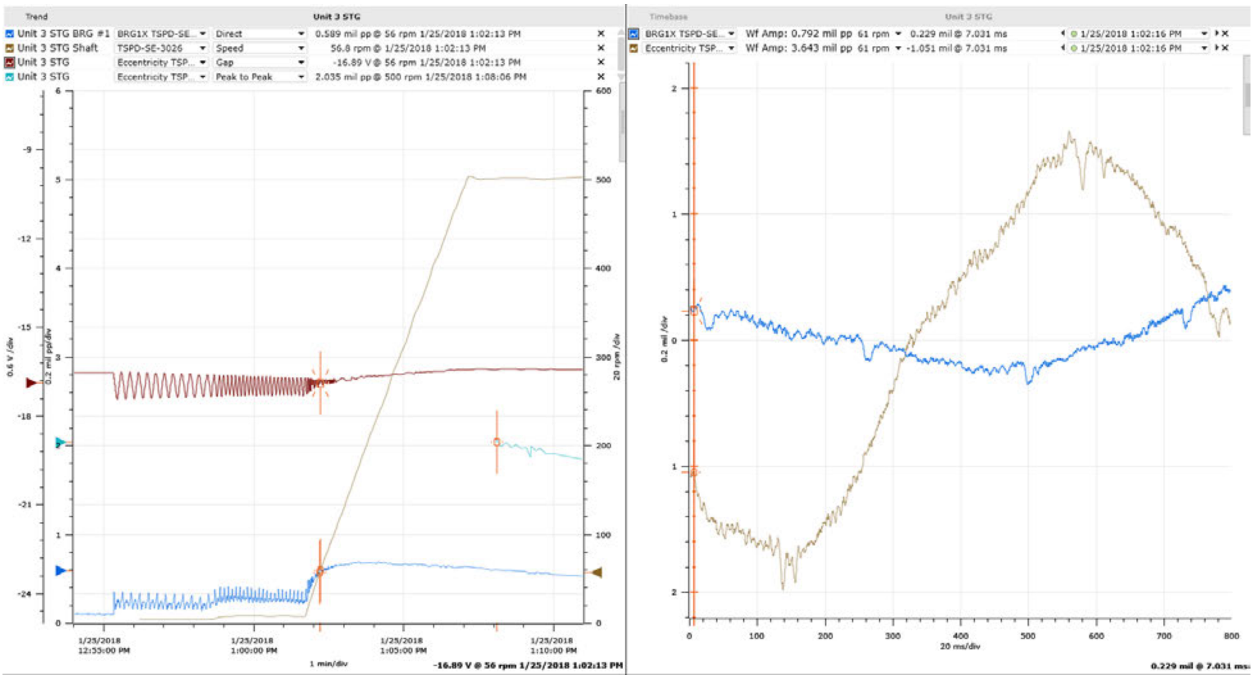

Figure 2: January 25, 2018 rotor eccentricity waveform (right) can be used to verify that eccentricity was over 3.5 mils, alarm 2.95 mils, while out of range for calculated value that initiates the high eccentricity alarm.

Differential Expansion and Thrust Position.

Differential expansion and thrust position data did not contain concerning evidence. Thrust position remained constant when the machine was under load and differential expansion remained consistent and within limits.

Turbine Bearing Temperature

Bearing 1 and 2 did not experience a significant temperature change in operation.

Feedwater Heater Extraction

High Pressure Feedwater Heaters 7 and 8 draw steam from the 6th and 9th stage of the HP Turbine, respectively. There were several occasions of limited extraction flow and brief heater level alarms, however, there were no corresponding increases in vibration or turbine casing differential temperatures during those events.

Auxiliary Steam

The auxiliary steam system was reviewed to identify potential flow paths to the HP Turbine when the unit was out of service. Low pressure auxiliary steam was observed at the leaking non-return check valve described above, however the two additional non-return valves protect the HP Turbine from auxiliary steam backflow.

HP/IP Turbine Casing Insulation

Turbine casing calcium silicate insulation thickness was measured and found close to the turbine manufacture's specification of 210 mm and 170 mm for the lower and upper casing, respectively. Additional insulation blankets are installed on the upper casing which are not specified by turbine manufacturer. This additional insulation may contribute to the casing differential measured around 80 °F during turbine shutdown but does not cause the turbine case to exceed the manufacturer's differential temperature limit of 75°F during normal operation.

Gland Sealing Steam

The gland steam system was reviewed as a potential source of casing temperature differential. The HP/IP Turbine gland steam maintained normal temperature and pressure and a gland steam exhauster was running during both events high casing temperature differential events.

Turbine Drain and Non-Return Valve Functionality

Turbine drain valves leaked in service and were isolated with the manual isolation valves. Actuated turbine drain valves did not operate in 2018 after unit trips. The lack of a drain path for condensation corresponds with two high turbine casing differential temperature events. A turbine drain valve checklist was developed by plant Operations in April of 2019, for use after the unit is removed from service to ensure turbine drain paths. A high turbine casing differential temperature event has not occurred since the turbine drain valve check list was employed.

During the spring 2020 outage, a non-return check valve was found with an assembly error preventing the valve from completely closing against return flow. The valve is in the HP Turbine exhaust piping, however, no evidence was found that its failure to seal contributed to a water induction event.

Contributing Events

The evidence suggests that the HP Turbine shaft and turbine casing was bowed from water induction into the turbine during two events in January and September of 2018. Damage occurred when the bowed shaft was rotated on turning gear and when rolled up during unit startup. Damage also likely occurred during a third event in December of 2018, a startup with excessive vibration from high eccentricity.

1/20/2018 Water Induction

After the turbine was removed from service and had been on turning gear for 18 hours, there was a sudden drop in lower casing temperature which caused a differential temperature of 396 °F between the top and bottom of the HP Turbine casing. As the casing differential temperature increased, the vibration increased, up to 10 mils at Bearing 1 and Bearing 2. The turbine stayed on turning gear through this event. Vibration of this magnitude on turning gear is an indication of a significant rub

An automatic HP Turbine exhaust piping drain valve, that opens on unit shutdown to remove condensation in the piping remained closed during this outage.

The turbine started up several days later after the turbine casing differential temperature was normal, on 1/25/2018, after sitting off of turning gear for 1 hour. The rotor ran between 500 – 1000 RPM for 1.25 hours. At low speeds it is difficult to detect potentially destructive rubs because vibration amplitude measured at the journals is very low.

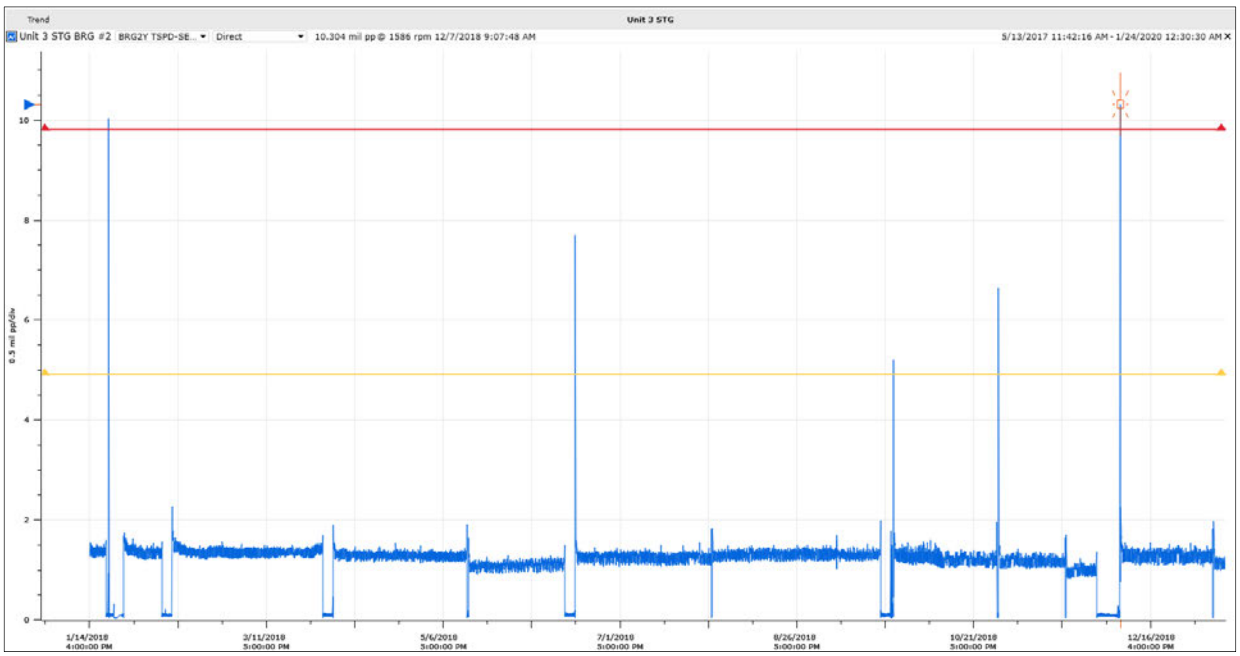

Figure 3: This 2018 Bearing 2 vibration trend shows several startup vibration events and one turning gear vibration event in January.

9/25/2018 Water Induction

In September of 2018, the HP Turbine developed a 266 °F casing temperature differential after a unit shutdown in which an automatic turbine drain valve did not operate. The shaft centerline rose 36 mils at Bearing 1 during the casing temperature differential. The turbine rotor showed a significant bow as it rotated until the turning gear motor tripped on overload.

A 120 °F casing temperature differential was still measurable when the turbine was rolled during startup. During the turbine roll the HP/IP Turbine first critical speed reached 6 mils. Unlike the other turbine rolls with high vibration, this turbine roll was not preceded by time off of turning gear. This suggests that the high vibration during the turbine roll was more likely the result of a rub, rather than just high eccentricity. Bearing metal temperatures also slightly rose at Bearing 1 and 2 by 4-5 °F when online.

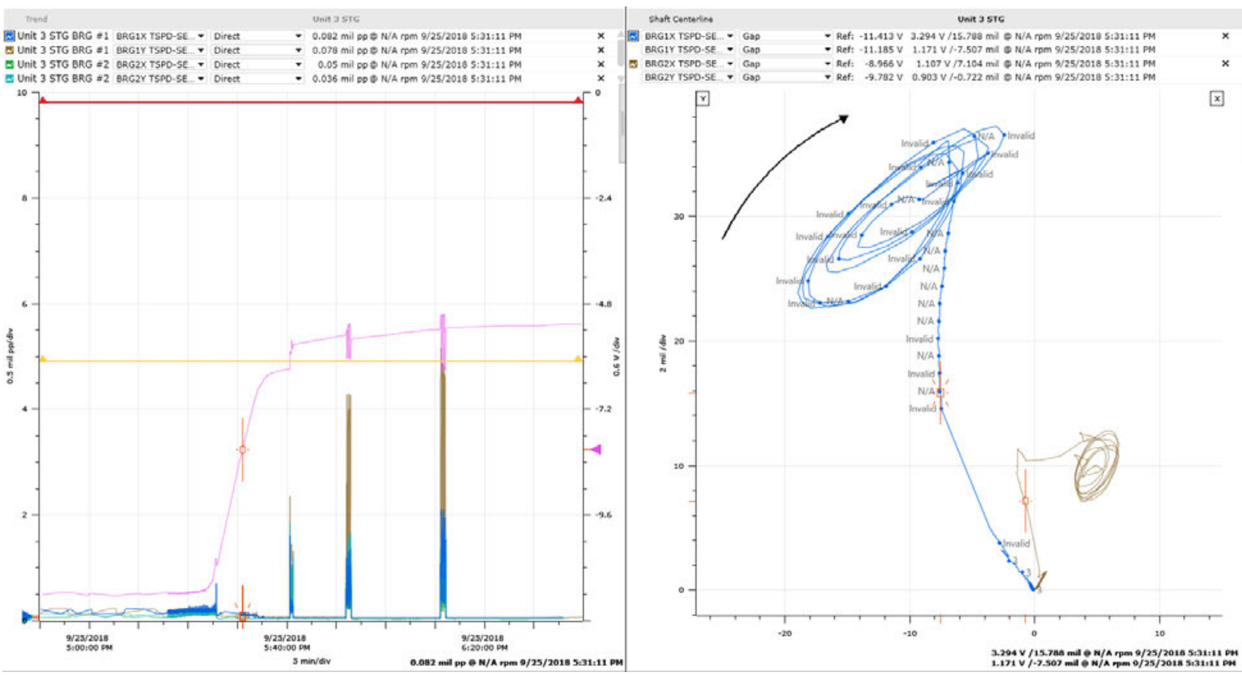

Figure 2: This shaft centerline plot(right) from 9/25/2018 shows shaft position rising from (0,0) point at bottom of bearing to +36 mils at BRG1 and +14 at BRG2. The "orbits" at the top of bearing 1 are 1X turning gear speed, essentially measuring 12 mils of rotor bow.

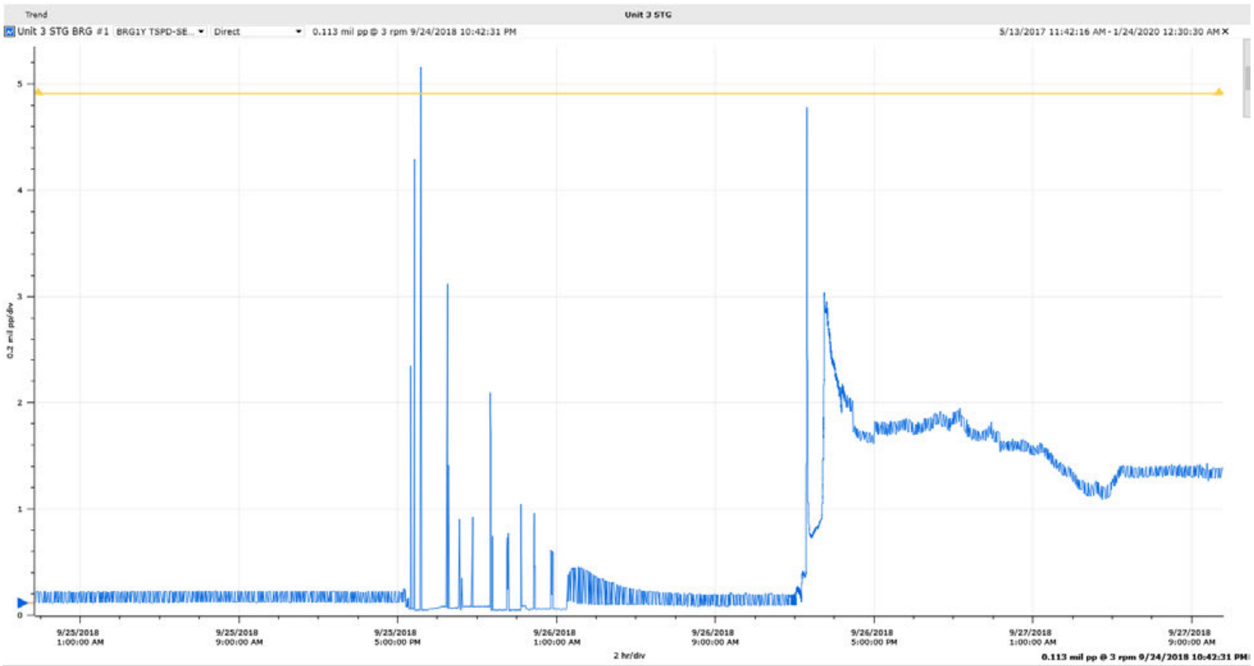

Figure 3: Bearing vibration amplitude in September 2018 as the unit rubbed on turning gear. Vibration peak during startup is at first critical speed of the HPIP rotor.

12/7/2018 High Vibration During Startup

After a seven-day outage the rotor sat at rest for 2.5 hours before turbine roll. The turbine was rolled with no indication of the high eccentricity and tripped at 9.8 mils vibration at 1600 RPM. After one trip and a second attempt to roll up to 2400 RPM, the machine sat at 500 RPM for 50 minutes. At low speeds it is difficult to detect potentially destructive rubs because vibration measured at the journals is very low.

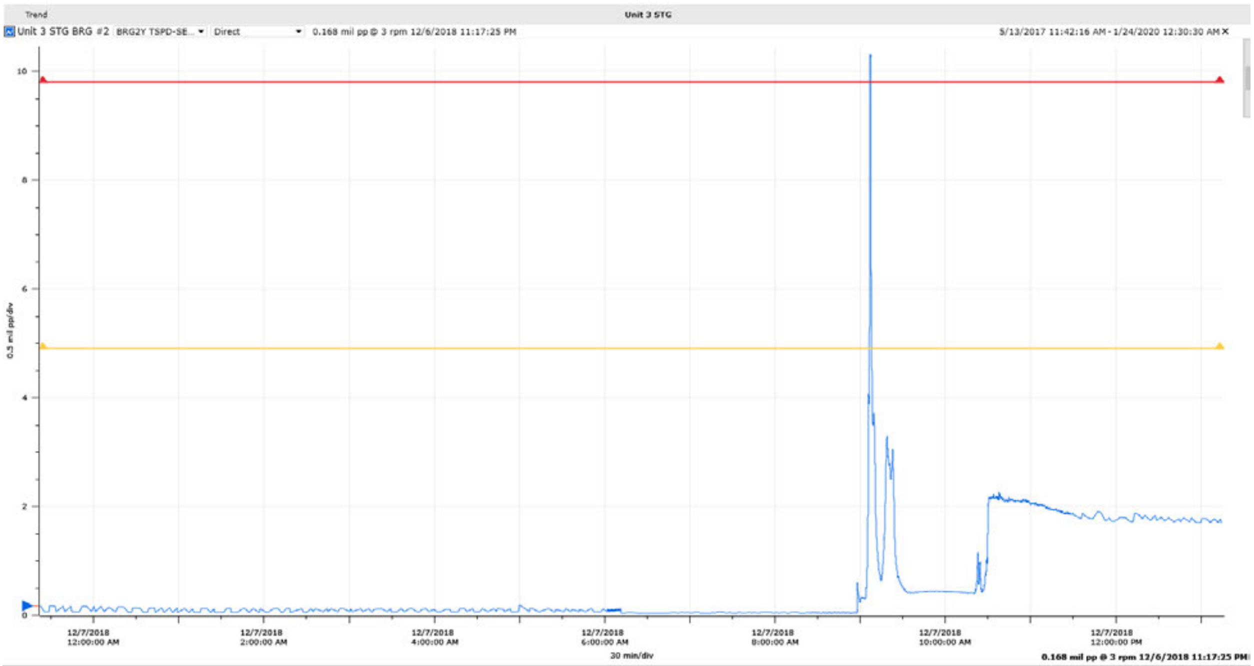

Figure 4: December 2018 startup including reaching trip level of 9.8 mils.

Analysis of other 2018 startups showed similar equipment issues:

a) During several startups, the turbine rolled off of turning gear to 10 – 50 RPM prior to the Control Specialist (CS) opening the governor valves. This was caused by governor valve leak through.
b) On several of those events, the CS tripped the turbine to stop the rollup and the turbine came to rest for significant time periods without being placed on turning gear. This allowed the HP Turbine rotor to develop a bow. The control room distributed control system (DCS) screens do not have low speed resolution to show shaft speeds less than 10 RPM. Turning gear operation is 3.4 RPM.
c) During several startups the bowed turbine was rolled up from rest to 2400 RPM, leading to high vibration through first HP/IP Turbine critical speed, around 1700 RPM. The eccentricity monitor appeared to have a faulty indication above 3 mils, due to an improper probe gap setting. This prevented the high eccentricity alarm from initiating when the turbine rotor was bowed.

Corrective Actions:

1) Address HP Turbine Governor Valve leakage
2) Verify turbine drains and their isolation valves are open during unit startups and shut downs.
    a. Continue to utilize the turbine drain checklist.
    b. If it is necessary to use the manual isolation or bypass drain valves a notification must be written for the associated automatic drain valve.
3) Develop an alarm for HP/IP Turbine casing differential above 108°F. If alarm comes in while on turning gear take the turbine off turning gear. Oil circulation must remain on.
4) Operational Modifications – change procedures and provide training on the following practices:

a. Remove the turbine from turning gear if the HP or IP Turbine casing differential temperature high alarm is received. The turbine must remain off turning gear, and not rolled, until the alarm has cleared.
b. Do not roll the turbine unless eccentricity while on turning gear is below 2.95 mils.
c. If the turbine rolls off turning gear and is reset, the turbine must be placed back on turning gear. Do not allow the turbine to sit at 0 RPM prior to unit startup.

5) Properly gap the eccentricity probe.
6) Fix non-return check valve, NRV 3107, in the HP Turbine exhaust extraction to the boiler feed pump turbines.

Recommendations:

1) Develop an alarm for 0 RPM turbine speed.
2) Install thermocouples after all valves on turbine drain valve checklist to allow validation of drain flow during turbine startup and shutdown.
3) Install a current transducer for turbine turning gear motor amperage and to allow turning gear motor amp monitoring.

Appendix

Historical Vibration Trends

Figure 5: October - Dec 2011 Vibration data for 1X and 1Y(top) and 2X and 2Y(bottom). Overall vibration peaked at 1.8 mils.

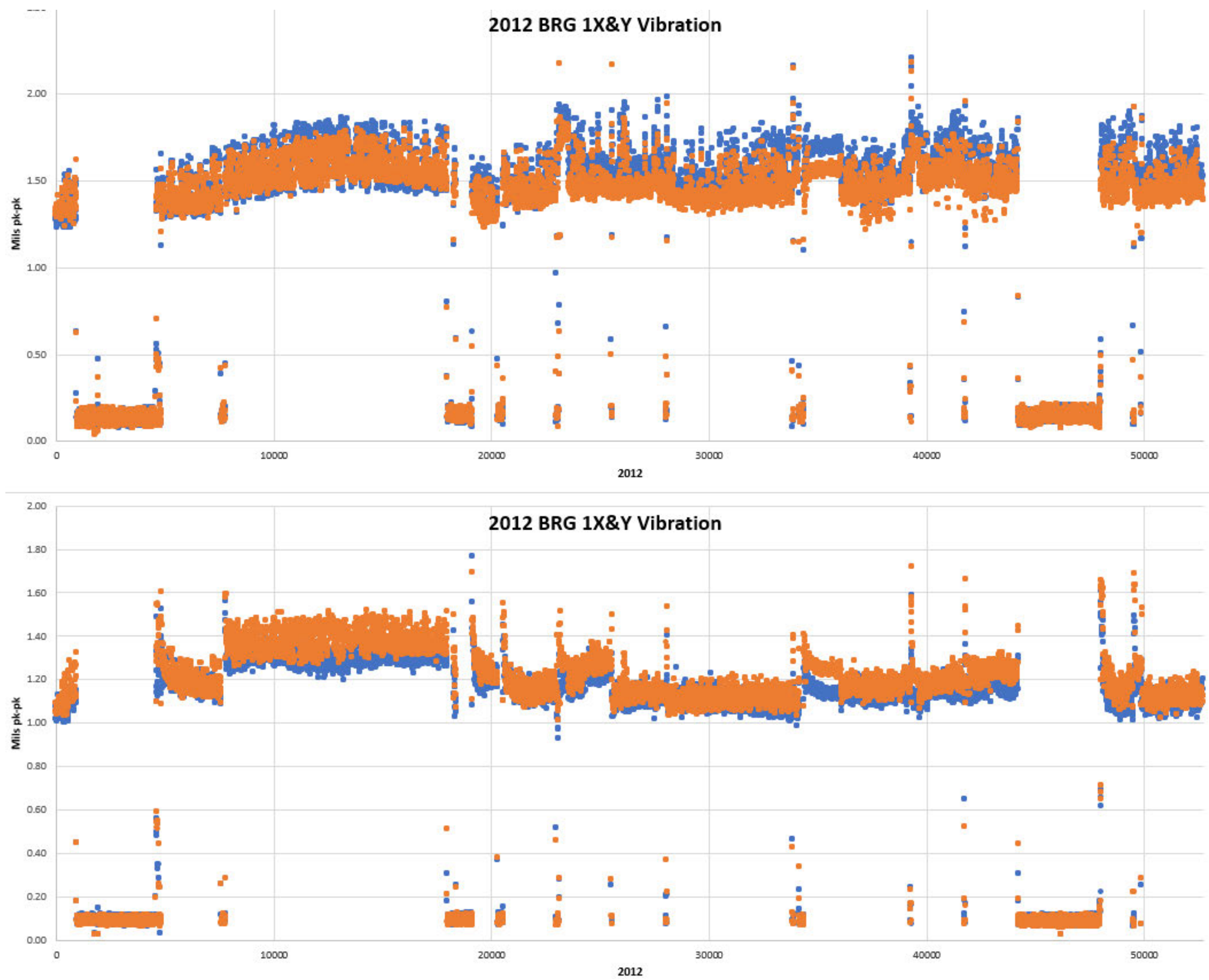

Figure 6: Vibration Trends BRG 1 & 2 2012. Running vibration below 2 mils, transient peaking at 2.25 mils

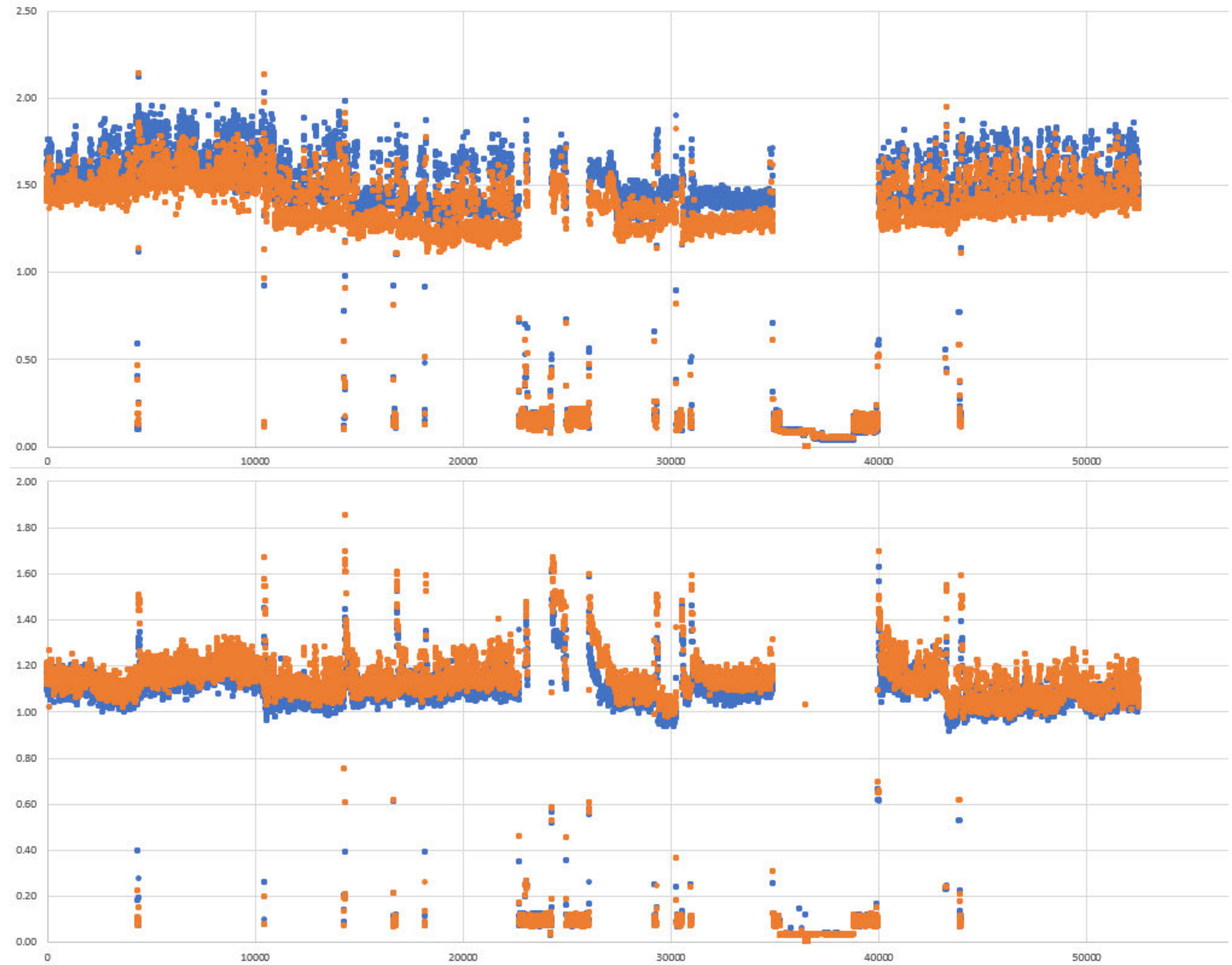

Figure 7: 2013 BRG 1(top) and BRG 2(bottom). Many starts but overall vibration levels remained steady.

Figure 8: 2014 vibration data

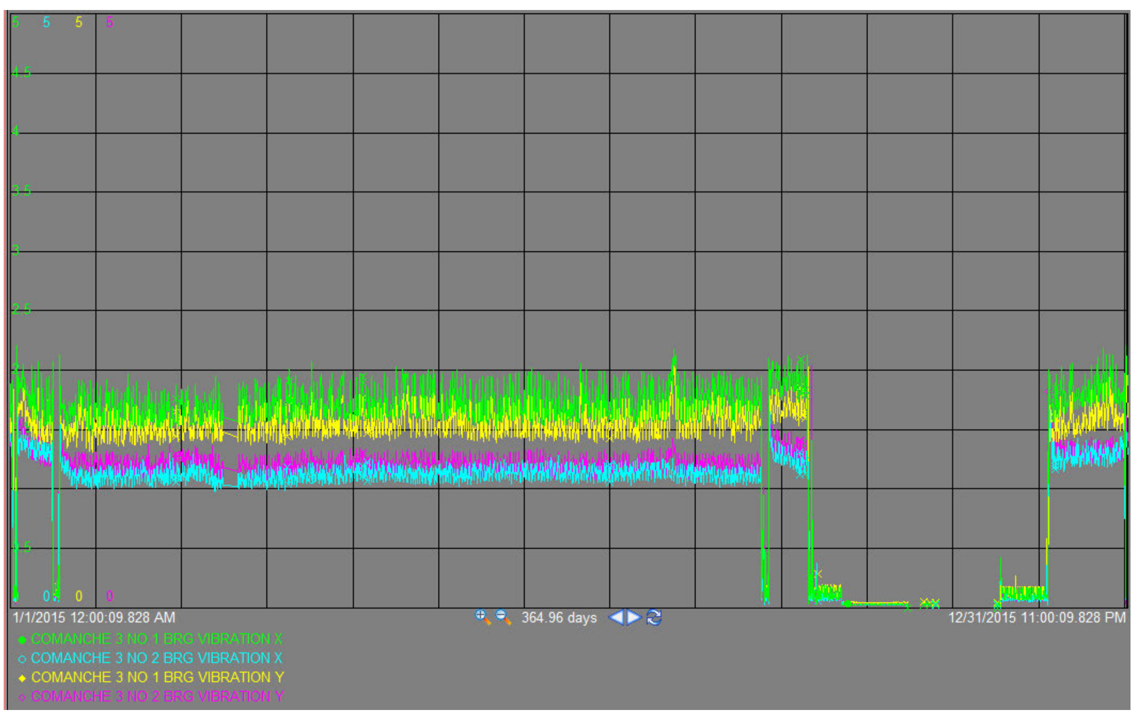

Figure 9: 2015 overall vibration for BRG 1 & 2

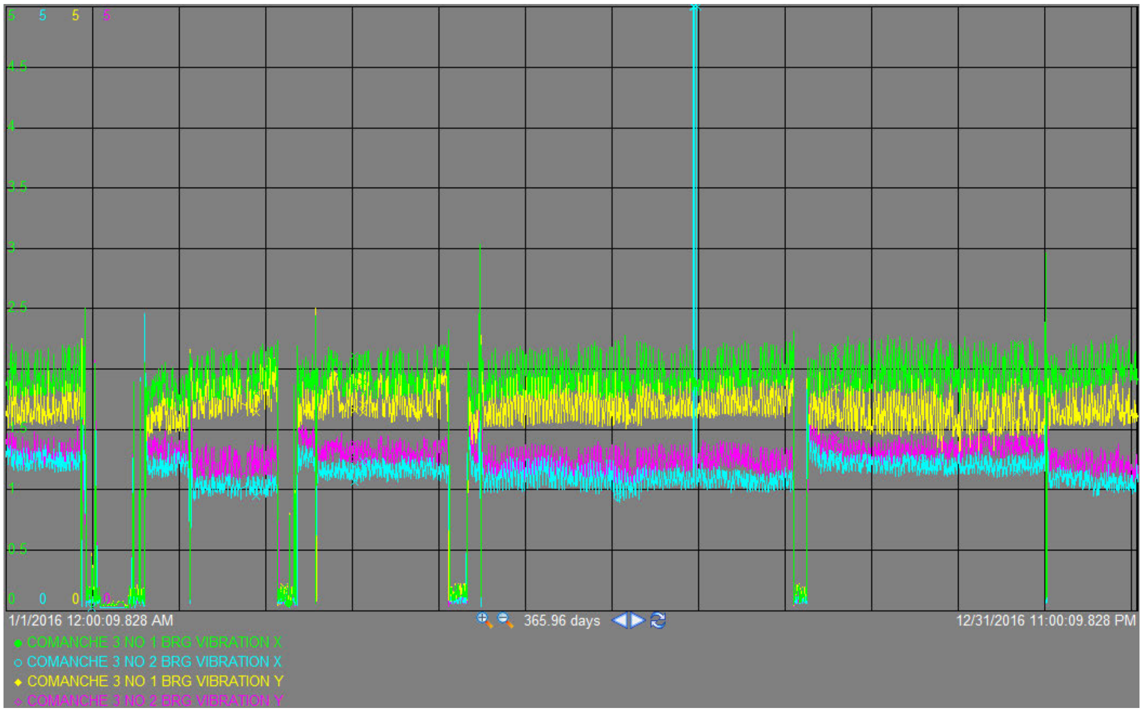

Figure 10:2016 overall vibration for BRG 1 & 2

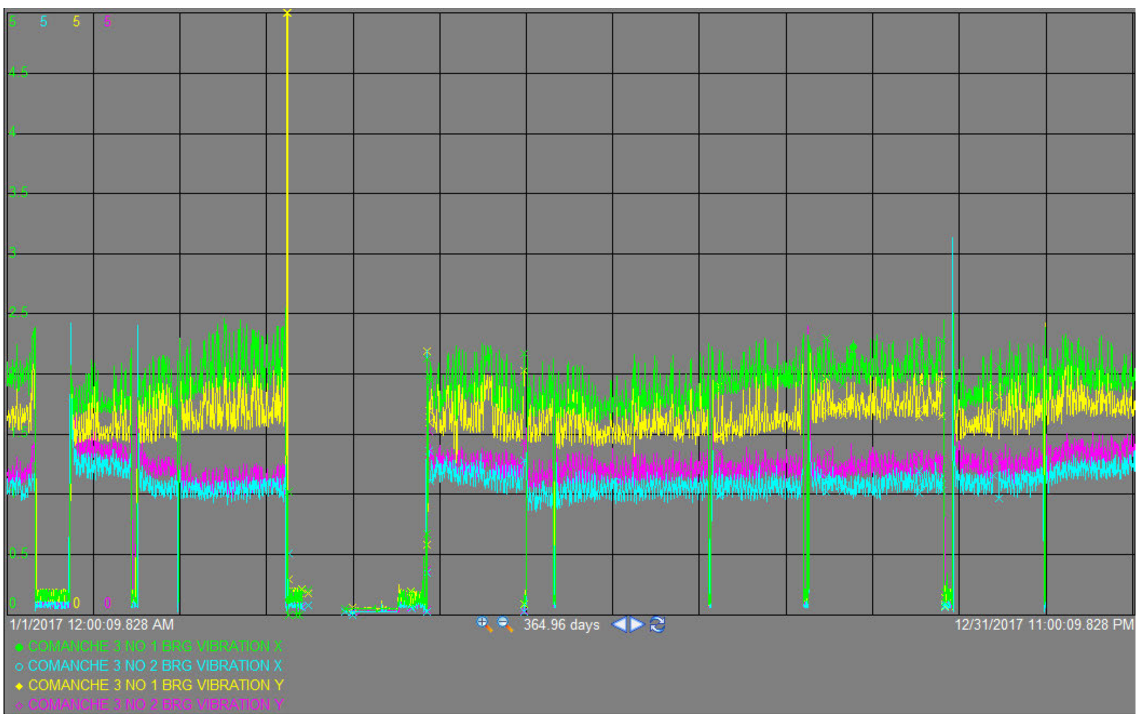

Figure 11: 2017 overall vibration for BRG 1 & 2. Peak after shutdown is instrumentation related.

Figure 12: 1X running speed vibration amplitude and phase through 2018

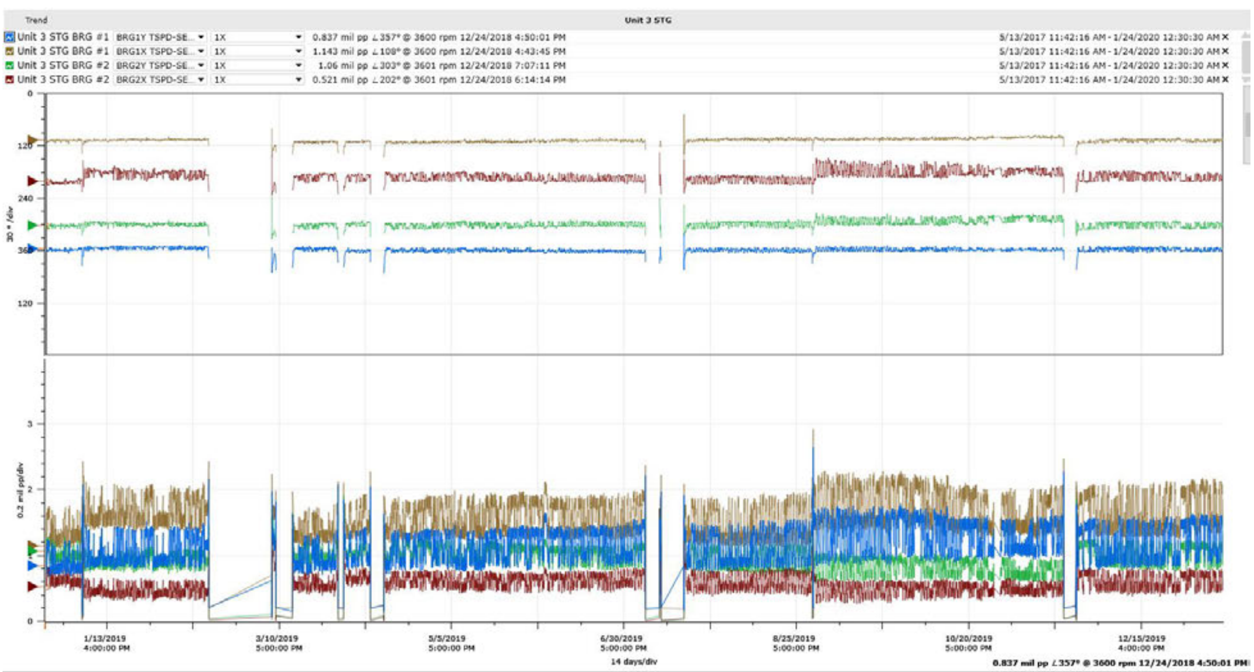

Figure 13: 1X running speed vibration amplitude and phase through 2019

Additional plots from turning gear vibration events

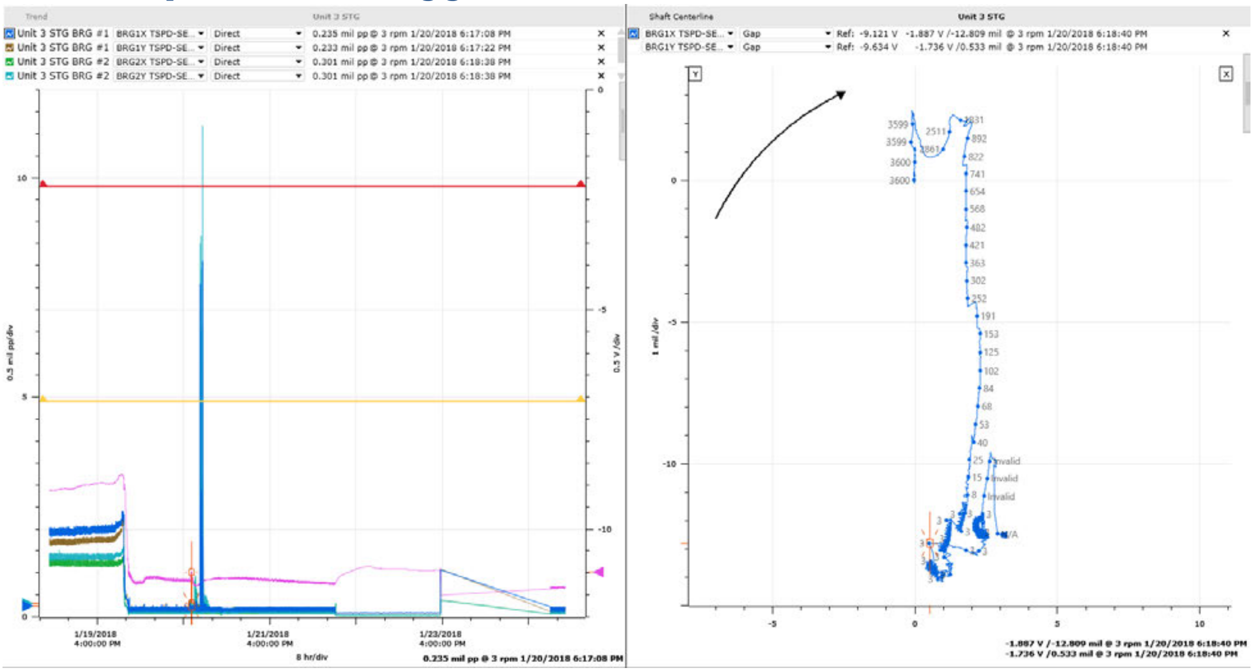

Figure 14: 1/20/18 Casing delta T event. High 37 Hz vibration amplitude every TG revolution began when Delta T increased. Vibration occured without raising shaft CL. There was a 2 mil move to the right when vibration increased, consistant with the direction a rub at the bottom of the case would push the rotor. The shaft CL measurement temporarily rose about 2 mils when the unit was taken off TG. Shaft CL plot shows normal drop of 14 mils during coast down.

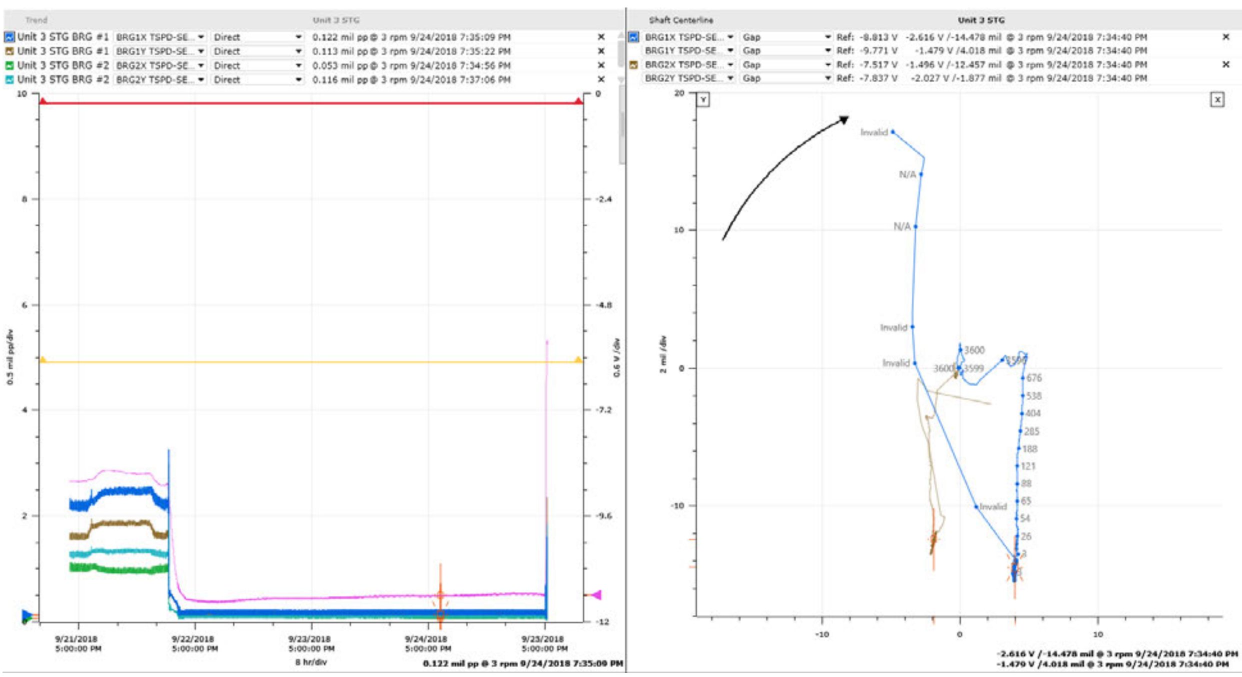

Figure 15: 9/25/18 Casing Delta T event. Shaft CL plot shows running position at (0,0) and coast down drop to (4,-14) for BRG 1 and to (-2, -12) for BRG 2. TG position was steady for 3 days until significant rise to +17 mils at BRG1 and -1 and BRG2

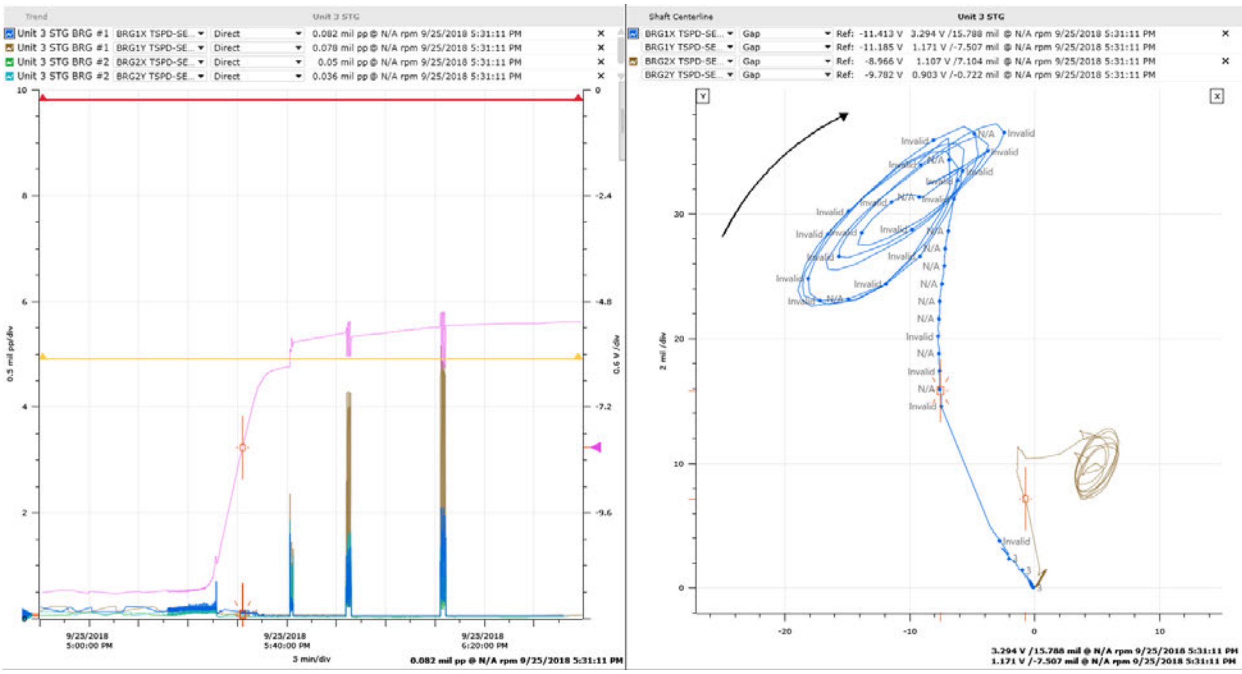

Figure 16: Shaft CL plot shows shaft position rising from new 0,0 point at bottom of bearing to +36 ils at BRG1 and +14 at BRG2. The "orbits" at the top of BRG1 are 1X TG speed, essentially measuring 12 mils of rotor bow. No 37 Hz vibration was measured during the 9/25/18 event.

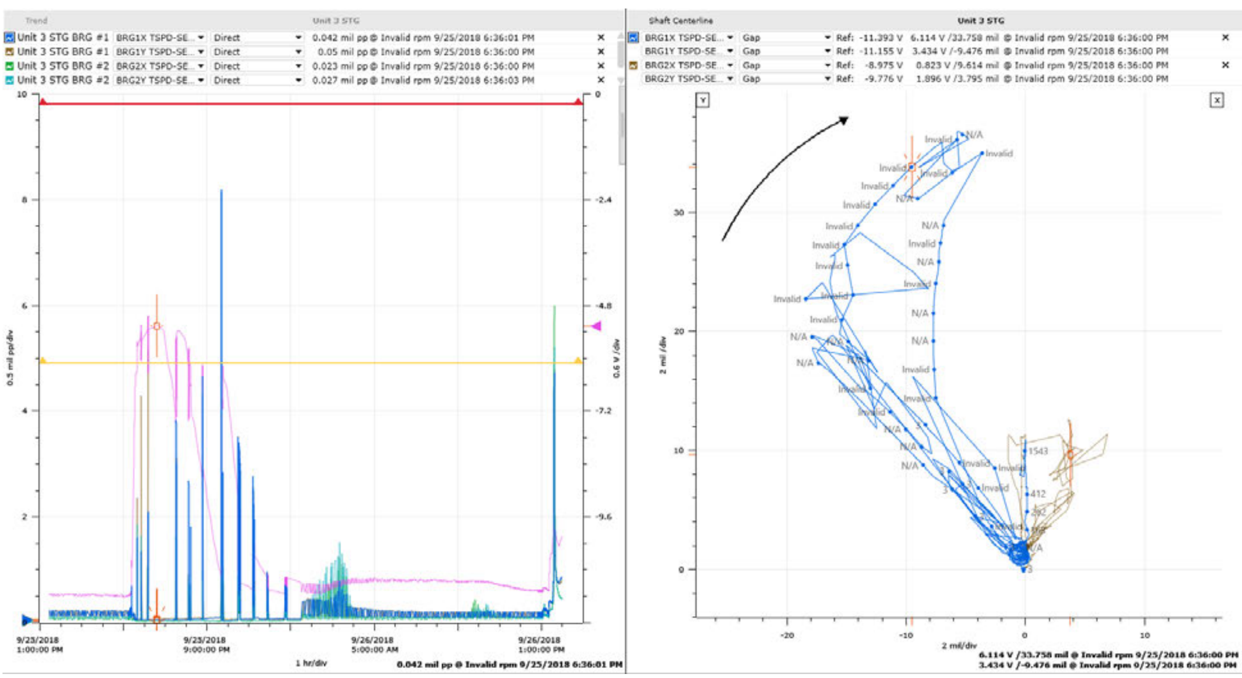

Figure 17: 9/25/18 event. Probe gap voltage shows a high shaft position for about 6 hours, from 5PM to 11PM. PI indicates there was still an HP casing Delta T of about 215F when shaft position returned to normal and the unit was able to stay on TG.

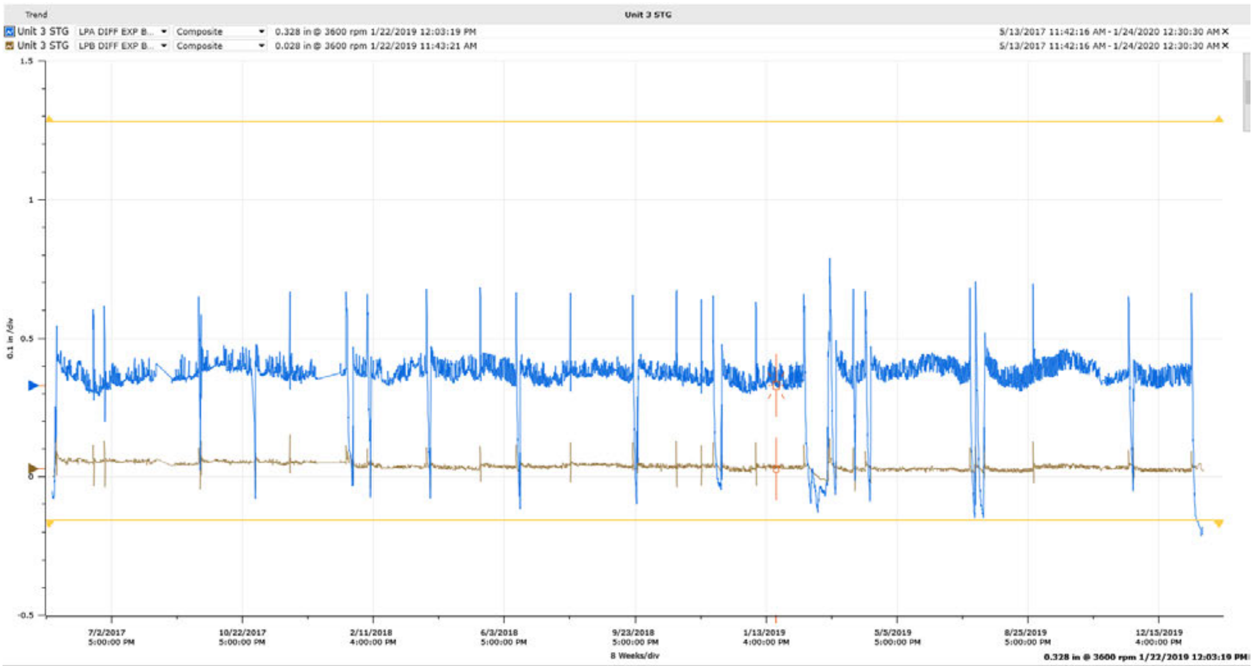

Figure 18: Differential expansion maximum of 0.75 inches and remains constant over historical trend.

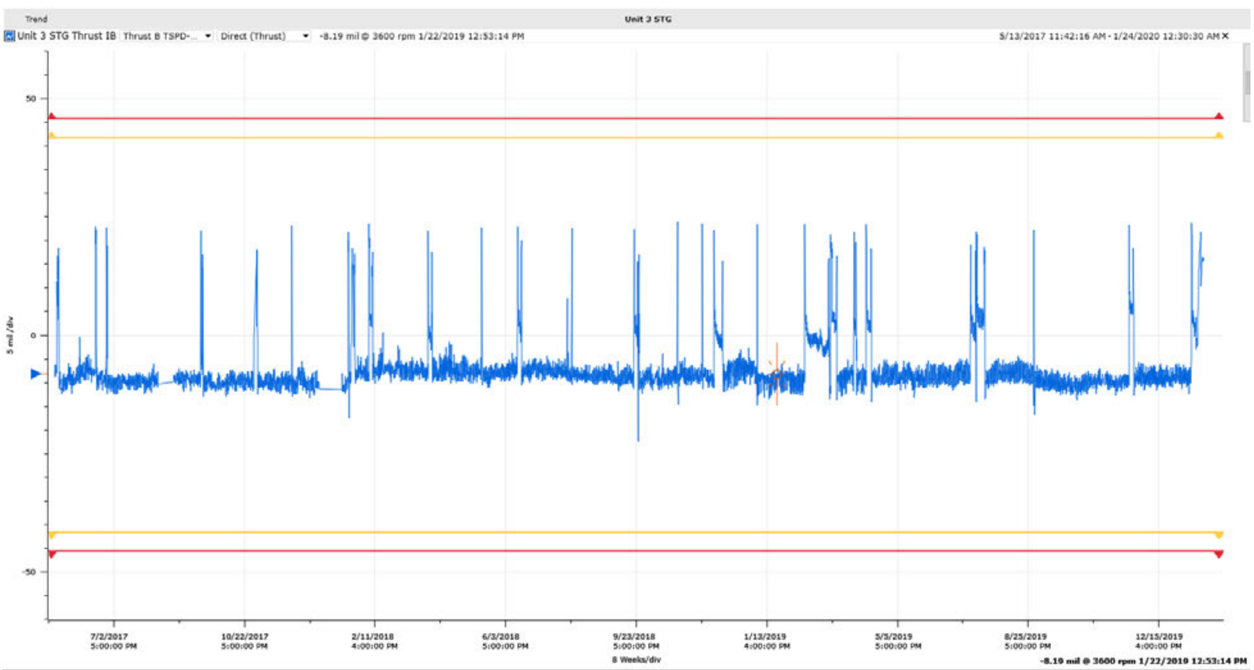

Figure 19: Thrust position indicates a total thrust of 35 mils.

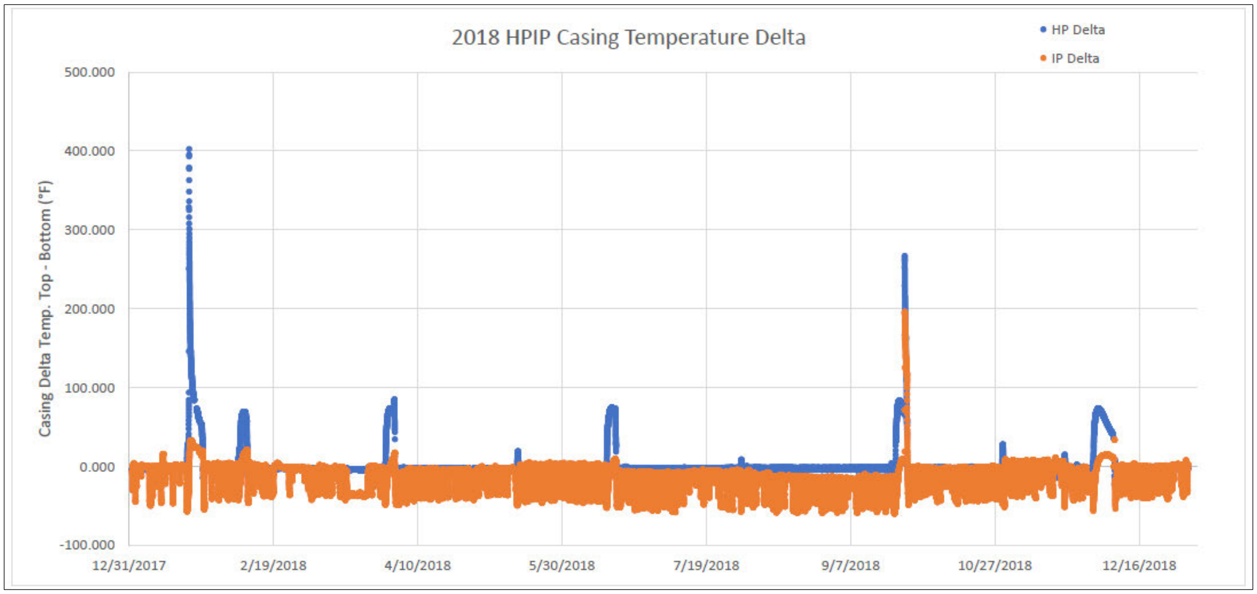

Figure 22: HP and IP turbine case top and bottom temperature differential.