Gearbox Misalignment on Combustion Gas Turbine Generator

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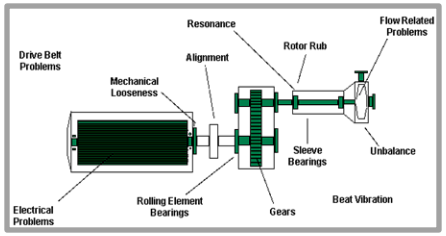
Objective

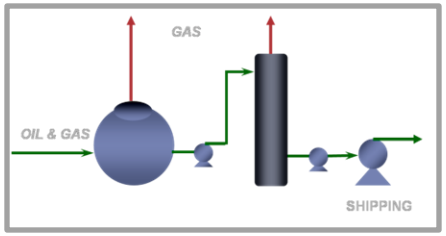
To share with you Abqaiq Plants' successful experience in resolving a high vibration problem on a Gas Turbine Load Gearbox

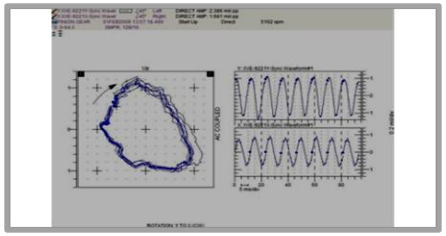
Outline

Machine Background



Machine Operation





Vibration Diagnostics

Field Observations

Machine Background

Turbine

- Frame 6 GE Gas turbine
- Horsepower: 42,400
- Running speed: 5,163 RPM
- Bearing type: Elliptical journal
- Compressor type: axial flow
- Number of compressor stages: 17
- Number of turbine stages: 3

* Image courtesy of Dr. Manfred Aigner, DLR website

Machine Background

Load Gearbox

- Manufacturer: Flender-Graffenstaden
- Horsepower: 72,386
- Running speed: 5,163/ 3600 RPM
- Bearing type: Elliptical journal

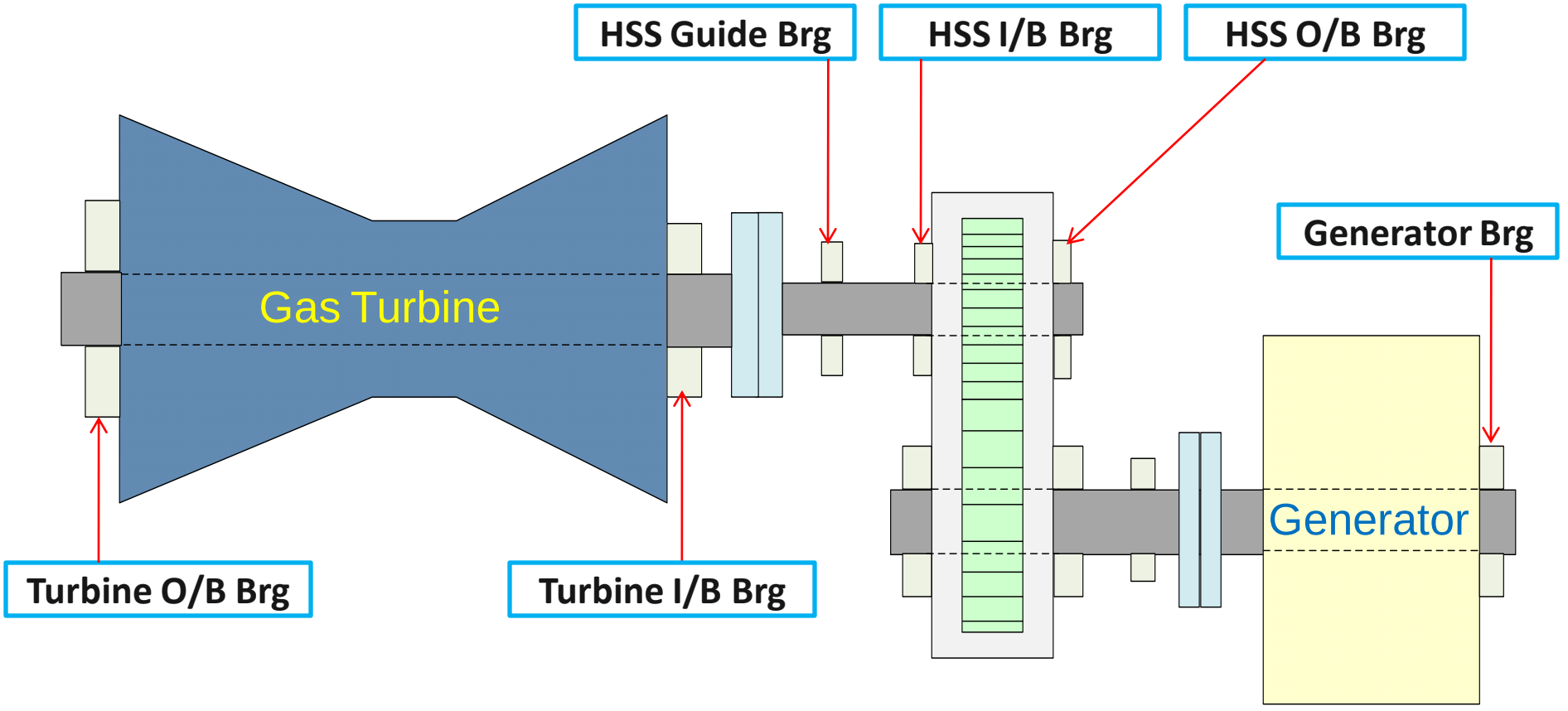
Machine Background

Generator

- Manufacturer: GEC Alstom
- Frequency: 60 Hz
- Running speed: 3600 RPM

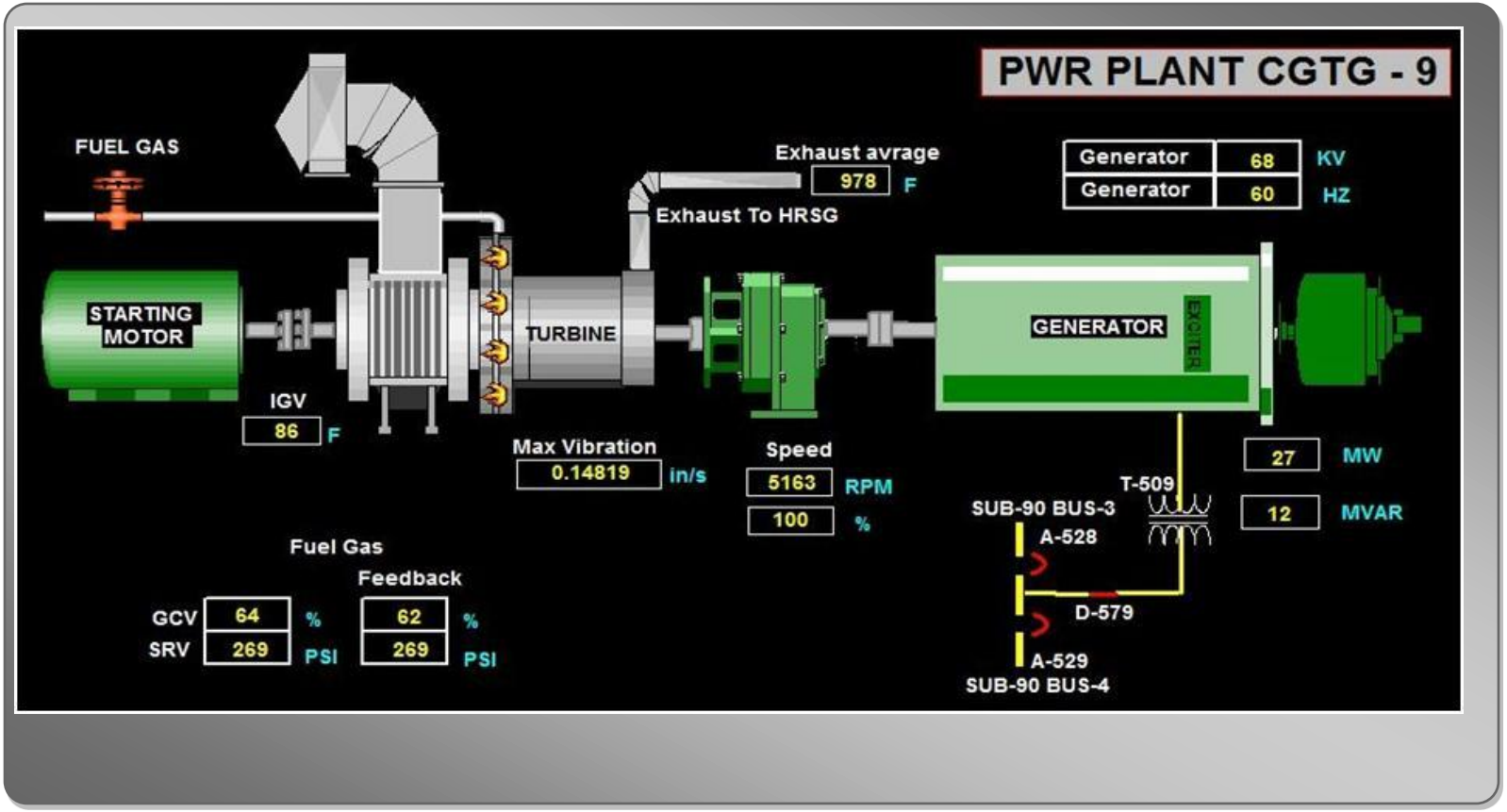
* Image courtesy of Alstom Power website

Machine Background



Machine Operation

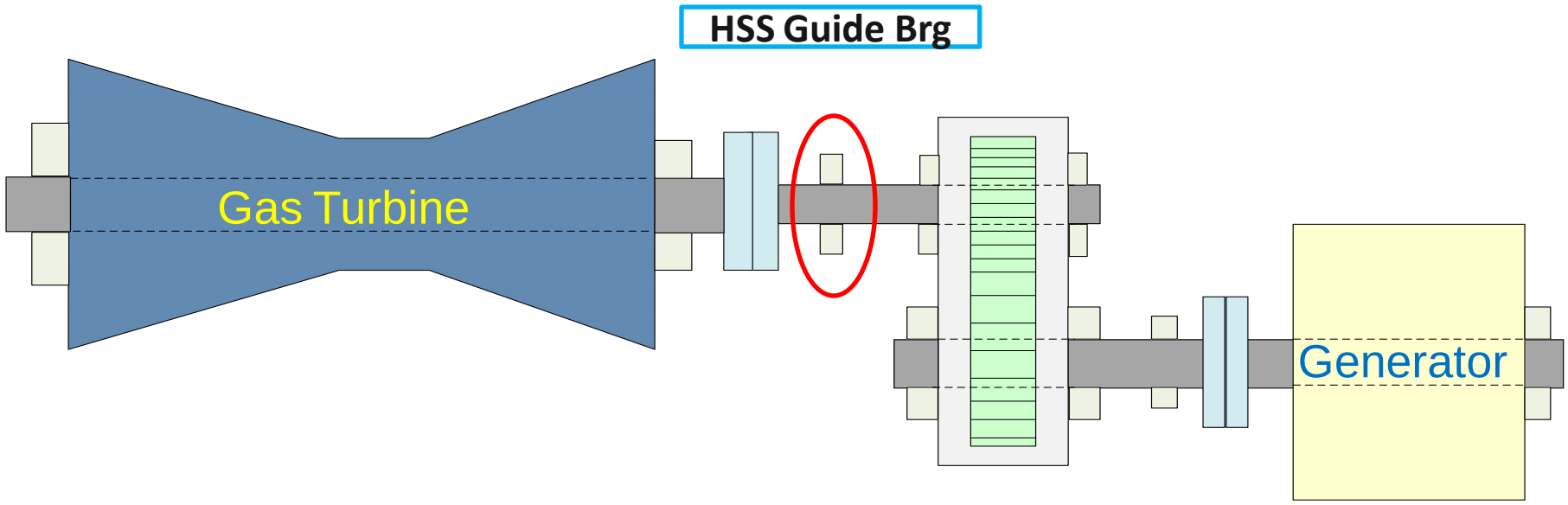
Power Plant CGTG-9



Vibration Diagnostics

Problem

- High vibration at the Gearbox HSS guide bearing reached 5.2 mils Pk-Pk (alarm is 4.9)



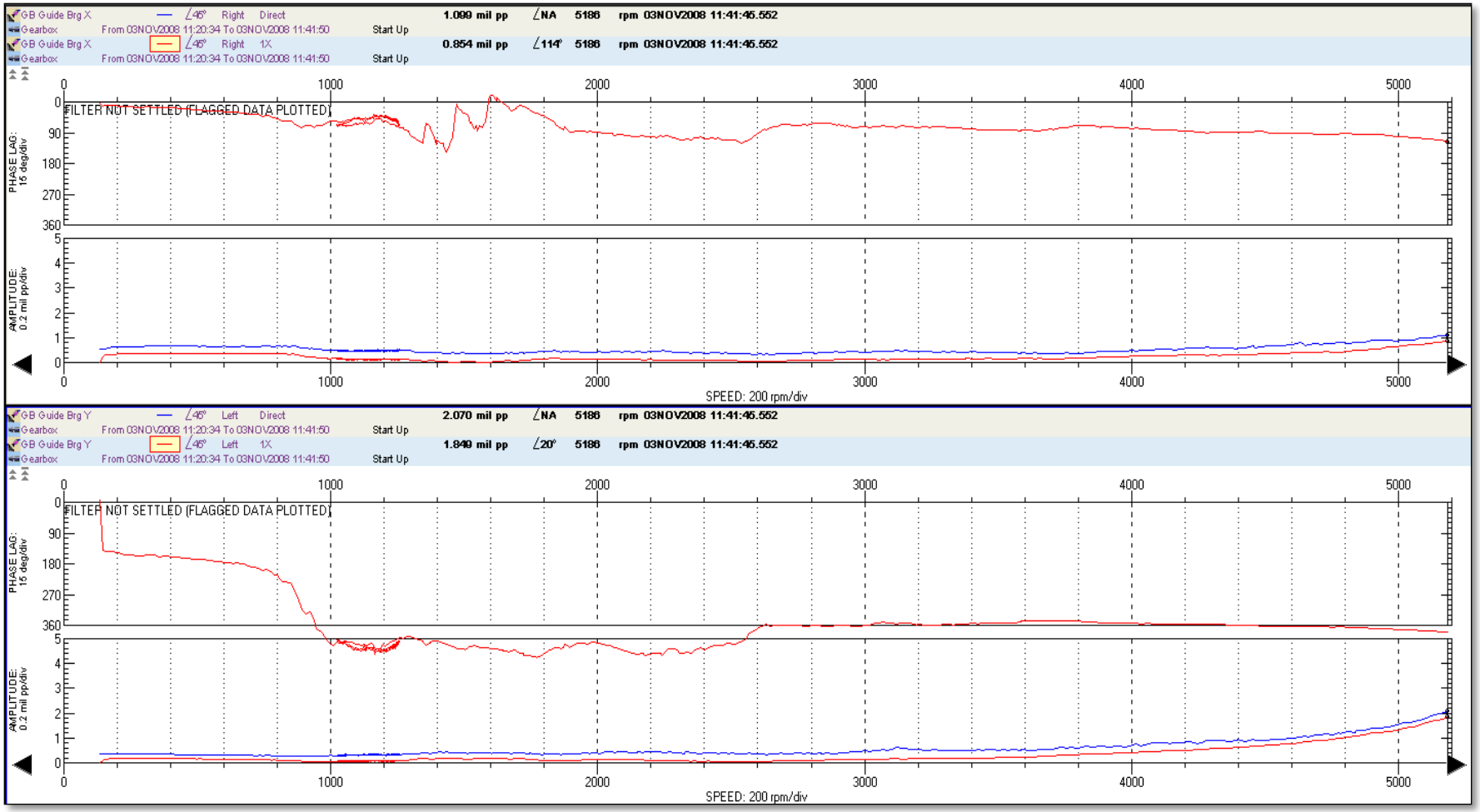
Vibration Diagnostics

Data Collection

- Data was collected using an ADRE 408 (Automated Diagnostic for Rotating Equipment) data collector
- The data was collected at transient (startup and shutdown), and at a steady-state operation at partial and full load conditions
- The Turbine inboard (I/B) bearing X&Y proximity probes are not functioning due to burned instruments (probes & extension cables)

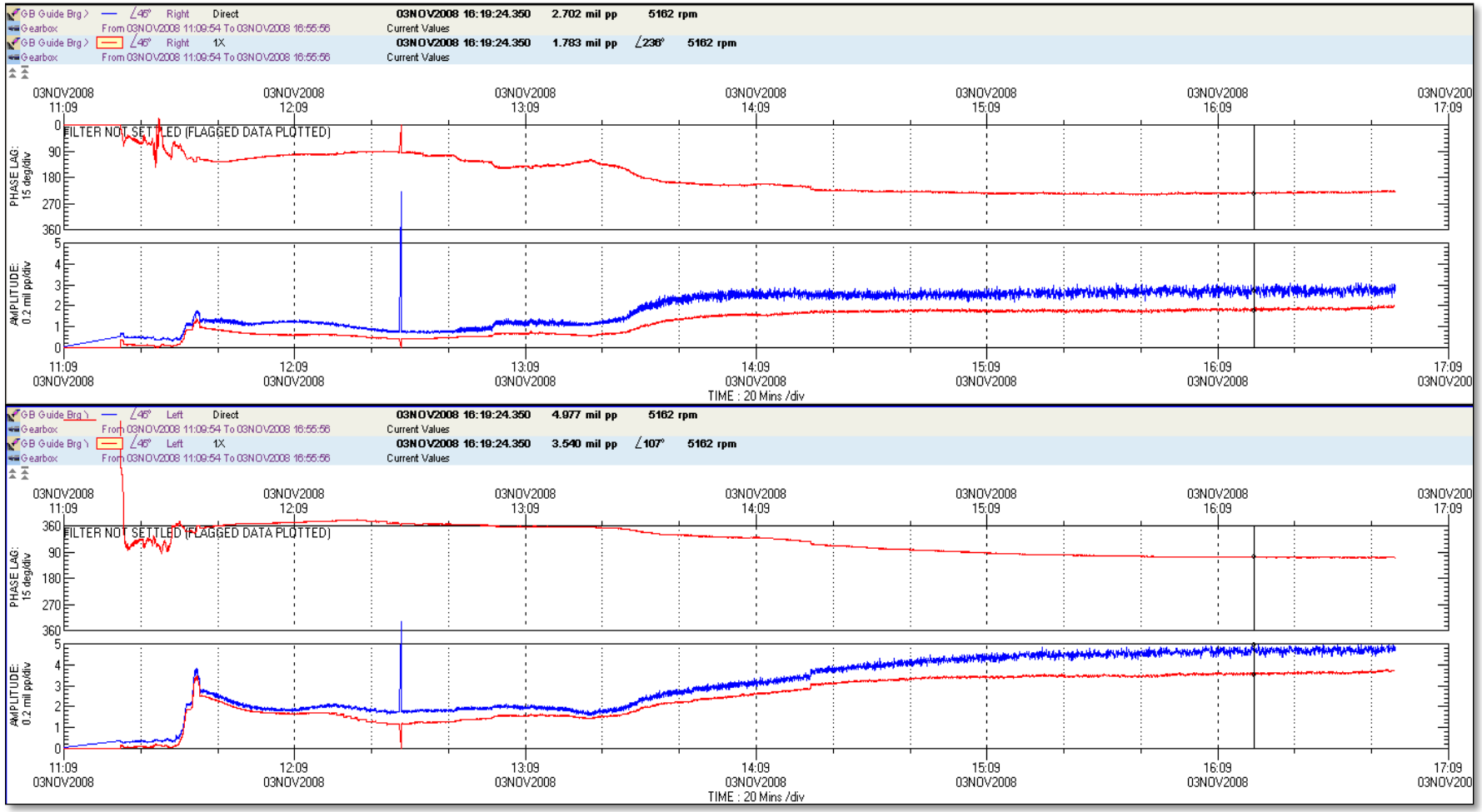
Vibration Diagnostics

1) Bode Plot



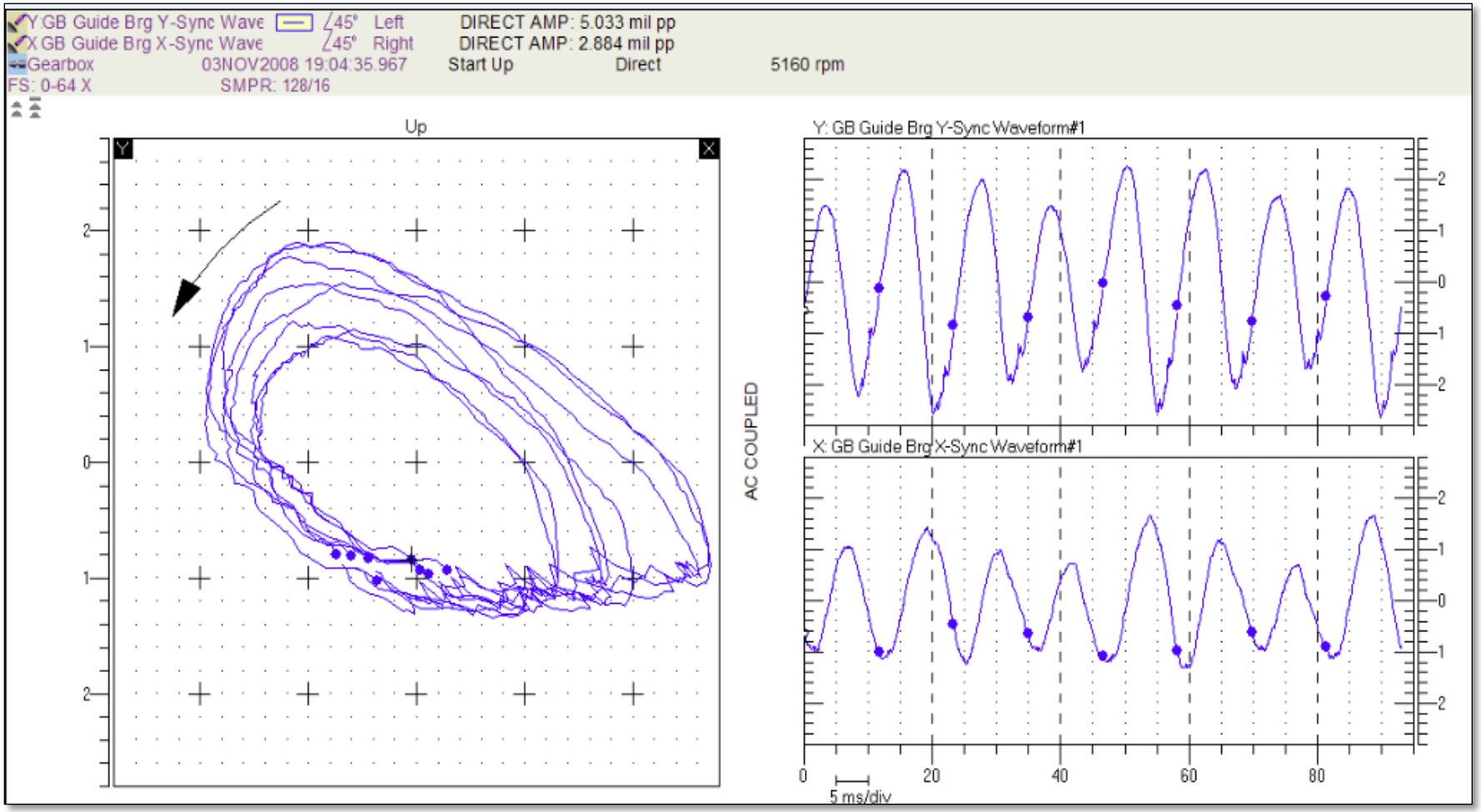
Vibration Diagnostics

2) Trend Plot



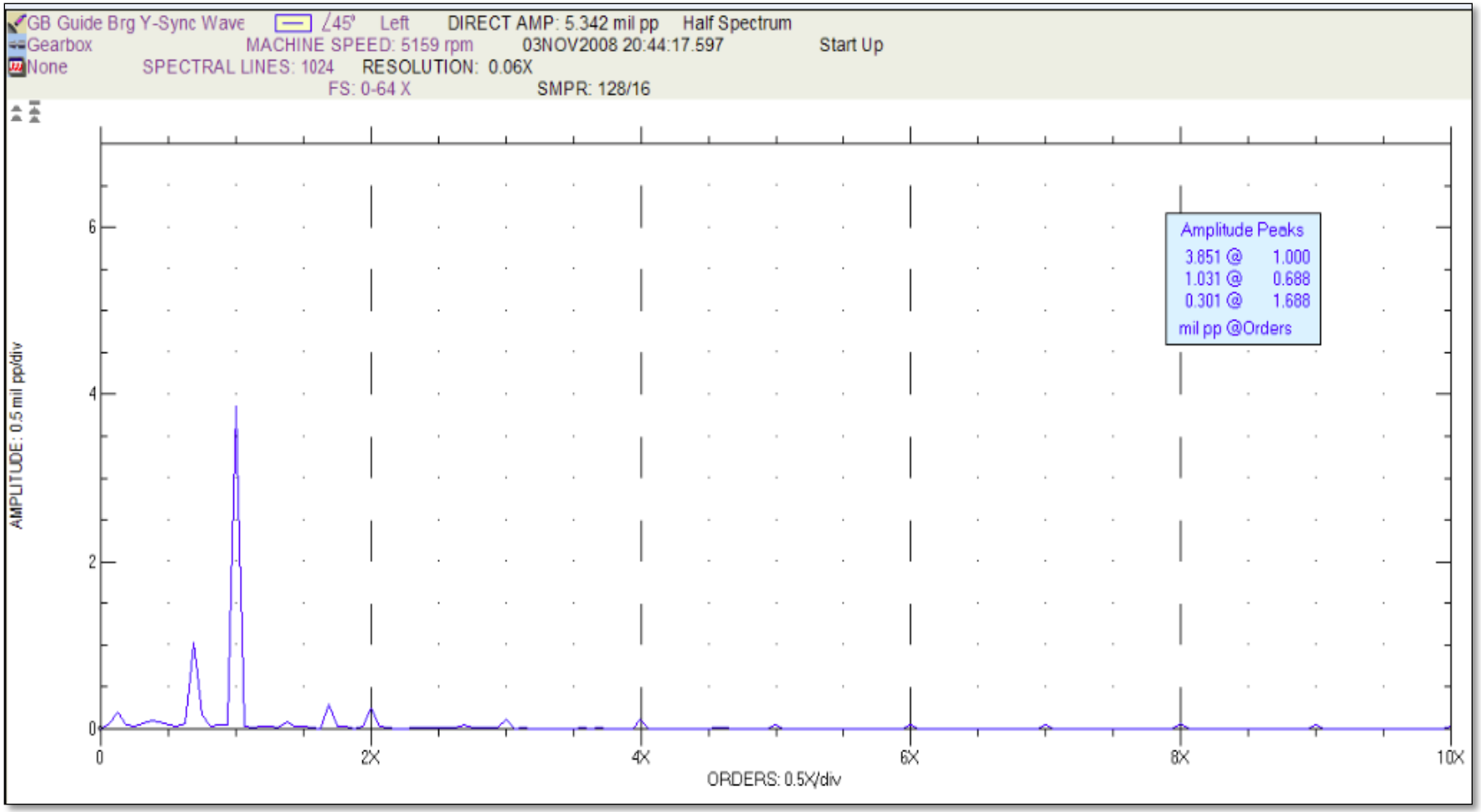
Vibration Diagnostics

3) Orbit Plot



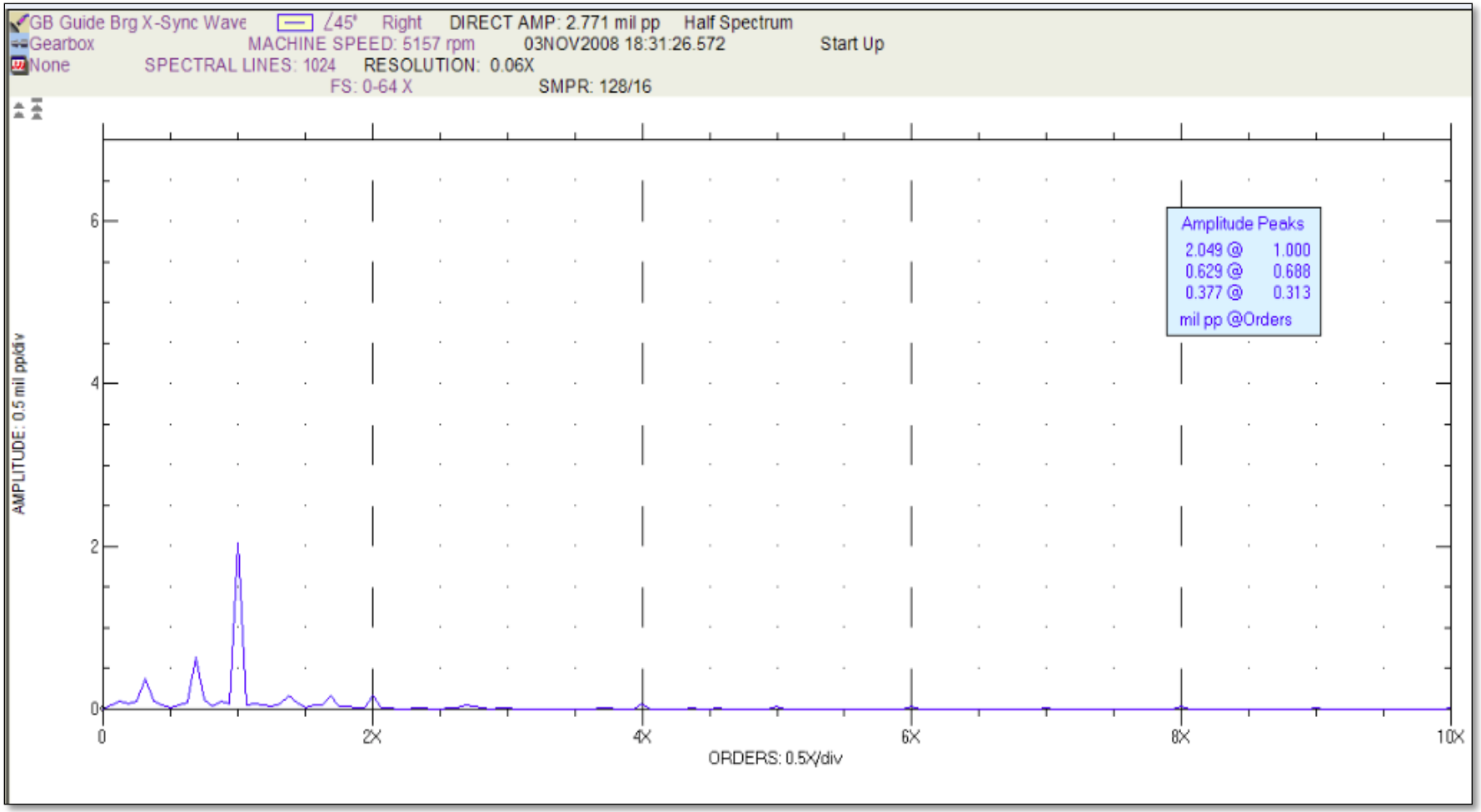
Vibration Diagnostics

4) Spectrum Plot (Y Probe)



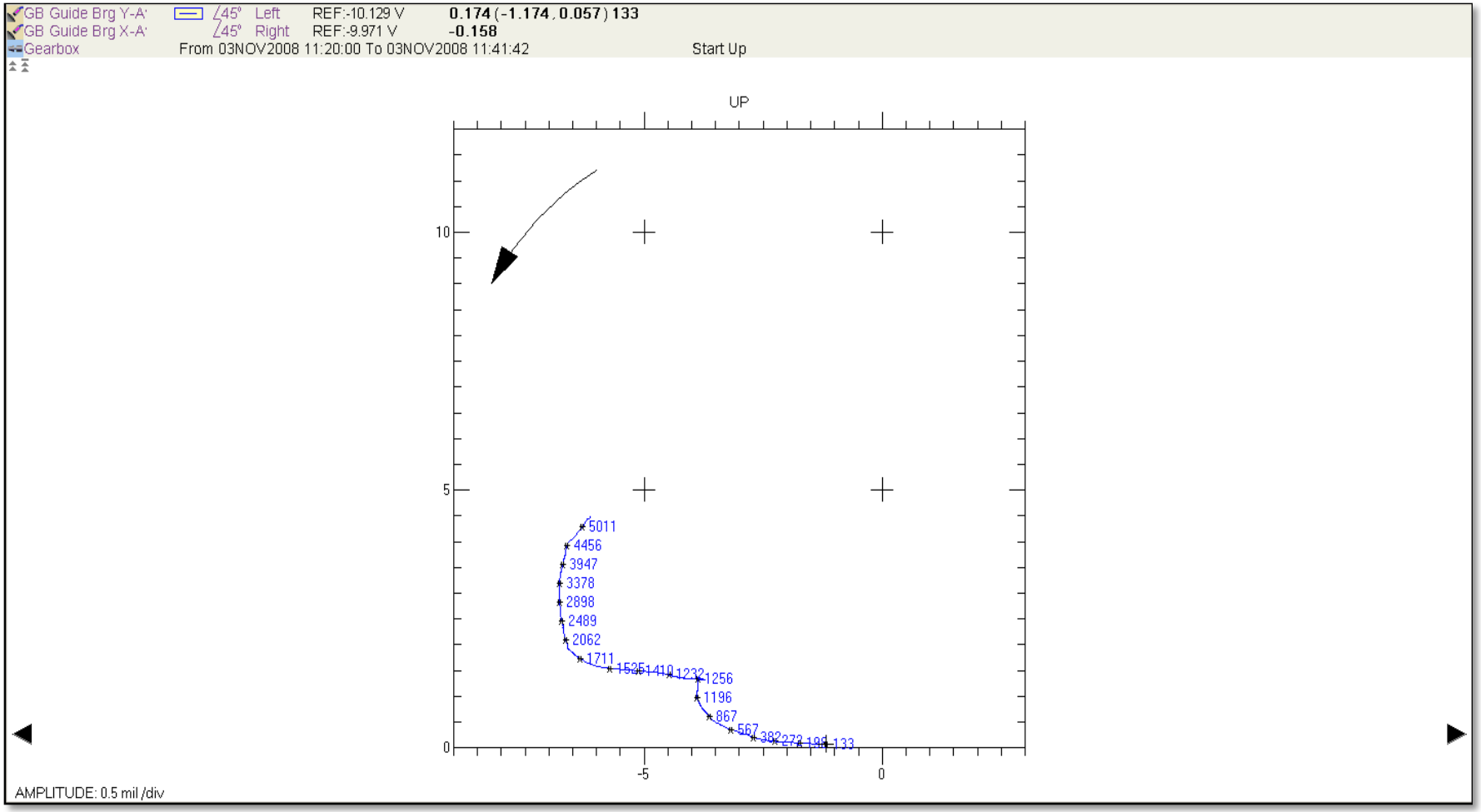
Vibration Diagnostics

5) Spectrum Plot (X Probe)



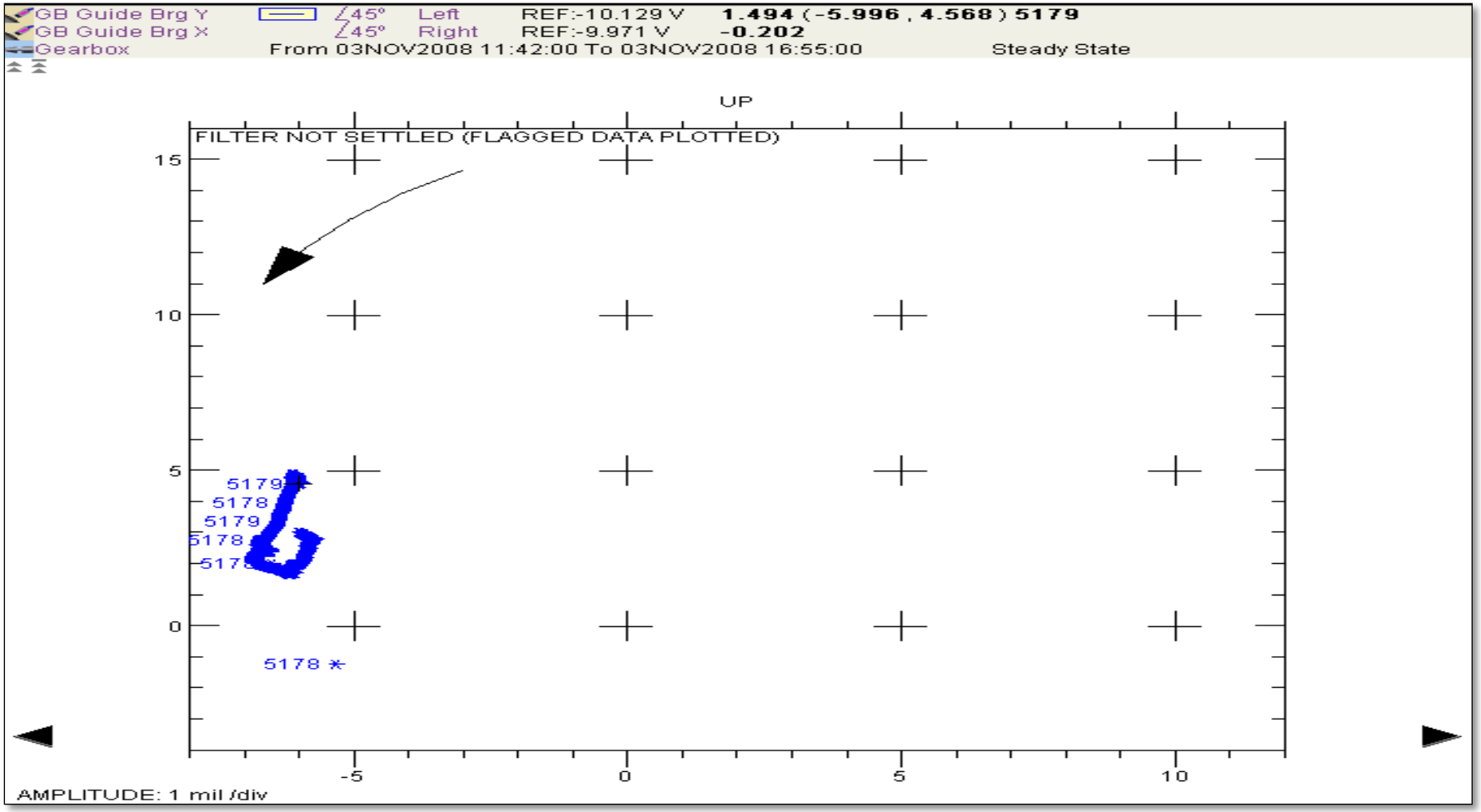
Vibration Diagnostics

6) Shaft Center Line (Startup)



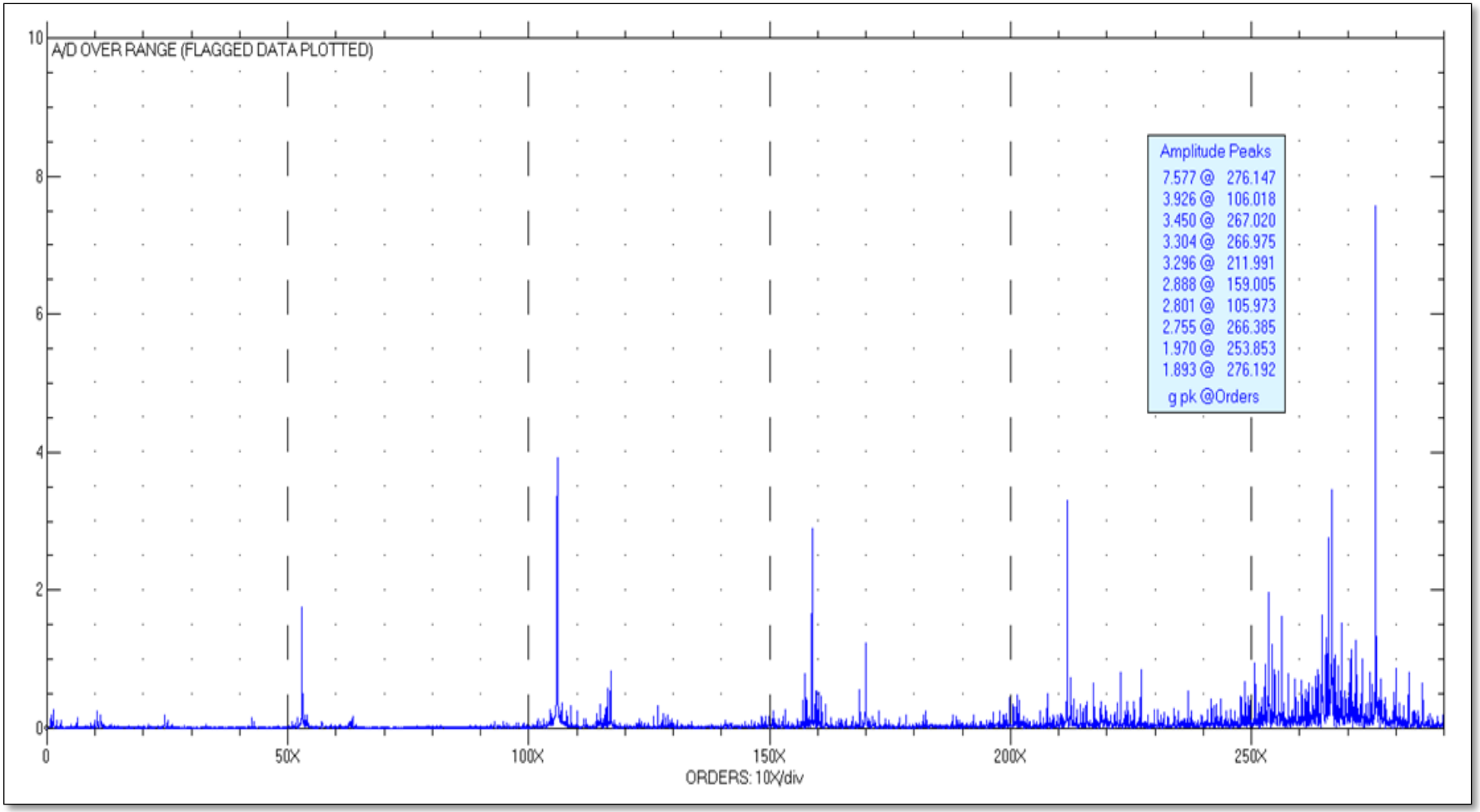
Vibration Diagnostics

7) Shaft Center Line (FSNL to 35MW)



Vibration Diagnostics

8) Acceleration Spectrum Plot



Vibration Diagnostics

Vibration Analysis Conclusion

- The thermal behavior observed on the Gearbox HSS guide bearing, the heavy multiple preloaded orbit and the presence of 2/3 X component could be due to hot misalignment to the turbine
- The gearbox acceleration vibration signature indicated high frequency components related to gear mesh frequency and its harmonics. This signature is most likely due to teeth wear or misalignment

Vibration Diagnostics

Recommendations

1. Inspect the condition & clearance of the guide bearing
2. Check the condition of the meshing teeth of the gear and pinion shafts
3. Check the alignment between the gas turbine and gearbox high speed shaft, and correct as necessary

Field Observations

- The unit has been removed from service to address the source of high vibration of the load gearbox guide bearing

- The load gearbox was uncovered and the respective bearing was removed for inspection

Field Observations

Bearing Condition

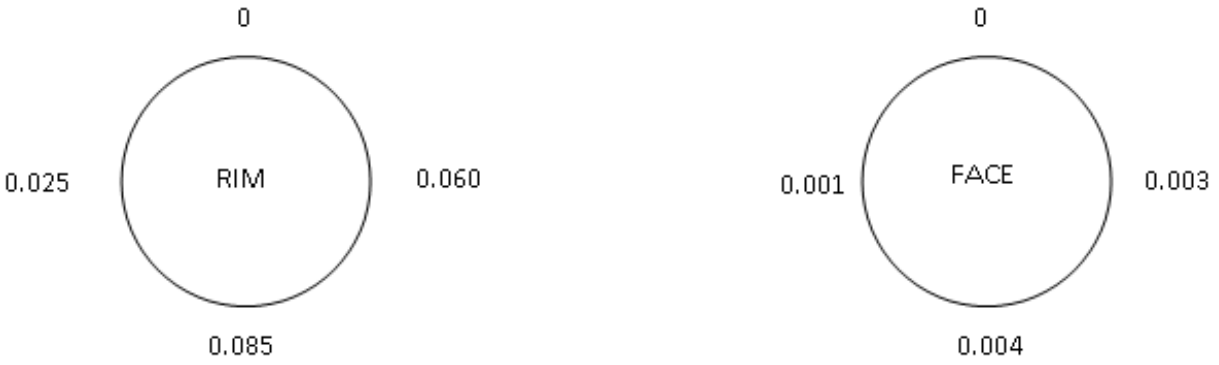
- The Bearing clearance was found above the limit with 17 mils.
  (Required: 11-to-12.9 mils)
- The bearing was found worn out with Babbitt metal loss

Field Observations

Alignment

- Alignment of the turbine and the generator was checked by means of dial indicators using rim and face technique

Load Gear Box to Turbine Findings Before Correction (All Dimensions are in inches)



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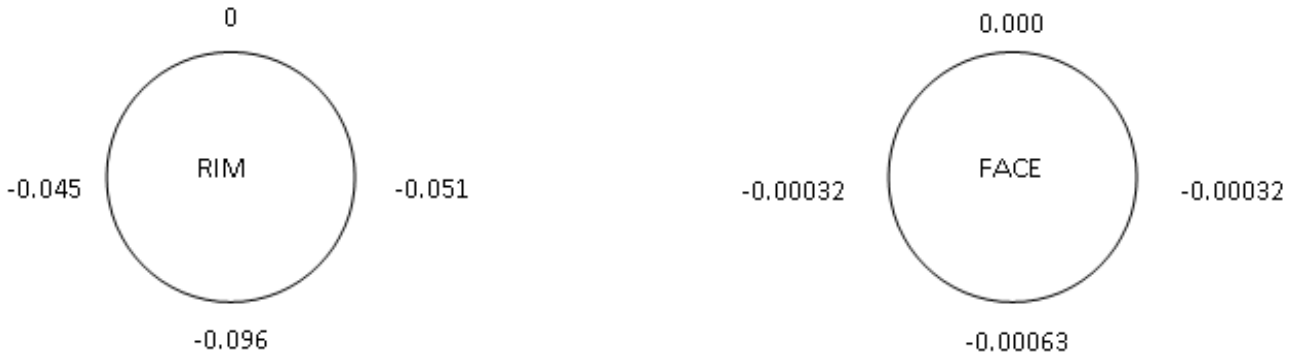

Field Observations

Failure Investigation

- The bearing failure was attributed to unit misalignment; however, this amount of misalignment is unusual for a machine, which has been running smoothly for years
- Therefore, the cause of this problem was investigated in order to prevent future failures

Field Observations

Failure Possible Causes

- In general, misalignment occurs on rotating machinery under the following conditions:

1. Installation and human errors
2. Unpredictable thermal growth on the machine or its supports
3. Worn bearings
4. Coupling distortion, run-out
5. Distortion due to external forces, strain
6. Settling of bases, foundations

Field Observations

Failure Root Cause:

- The main root cause of the misalignment was pointed out as a turbine exhaust frame support leg failure

Field Observations

Corrective Actions

- HSS guide bearing was replaced
- Alignment between the turbine and load gearbox was corrected
- The right side turbine support leg was Repaired

Field Observations

Current Situation

- The unit has been running successfully since February, 2009
- The vibration readings are below 2 mils Peak-Peak
- The turbine support legs temperature are stable and being monitored daily by the system control operator

Summary

- This case study demonstrated how the vibration of a gearbox misalignment could appear
- Vibration at gear mesh frequency and its multiple is an indication of gearbox misalignment
- Investigation of the misalignment root cause revealed that the main contributor of the alignment issue was a defective leg of the combustion gas turbine

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