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# Case Study on resolving high vibration issue of a centrifugal compressor at an offshore platform

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- B.Tech Mechanical Engineering (2003) from Jamia Millia Islamia University, Delhi, India
- 10 years with GE-Bently Nevada Machinery Diagnostics Services since 2007
- Project Engineer- Rockwell Automation-Entek IRD

- **Sankar Ganesh – Technical Leader, MENAT**

- Technical Leader for GE Bently Nevada Machinery Diagnostics Services, MENAT region
- Bachelor Mechanical Engineering (1993) from Bharathidasan University, India.
- Over 20 years experience in vibration field and 10 years with GE Bently Nevada, including rotating equipment balancing, vibration analysis, diagnostics and root cause analysis
- Published case studies in METS and Turbomachinery symposium



# Abstract

Gas Injection Compressors are critical for offshore oil production facilities. A compressor downtime lowers oil production.

This case study is about a Gas Injection Compression train at an offshore platform in the Middle East.

This case study focuses on how the gradual increase in vibrations was successfully diagnosed, pinpointing the root cause for the high vibration, and finally how it was resolved.

The Compression train is equipped with an online vibration monitoring and protection system in addition to a condition monitoring software that was used to diagnose the issue.



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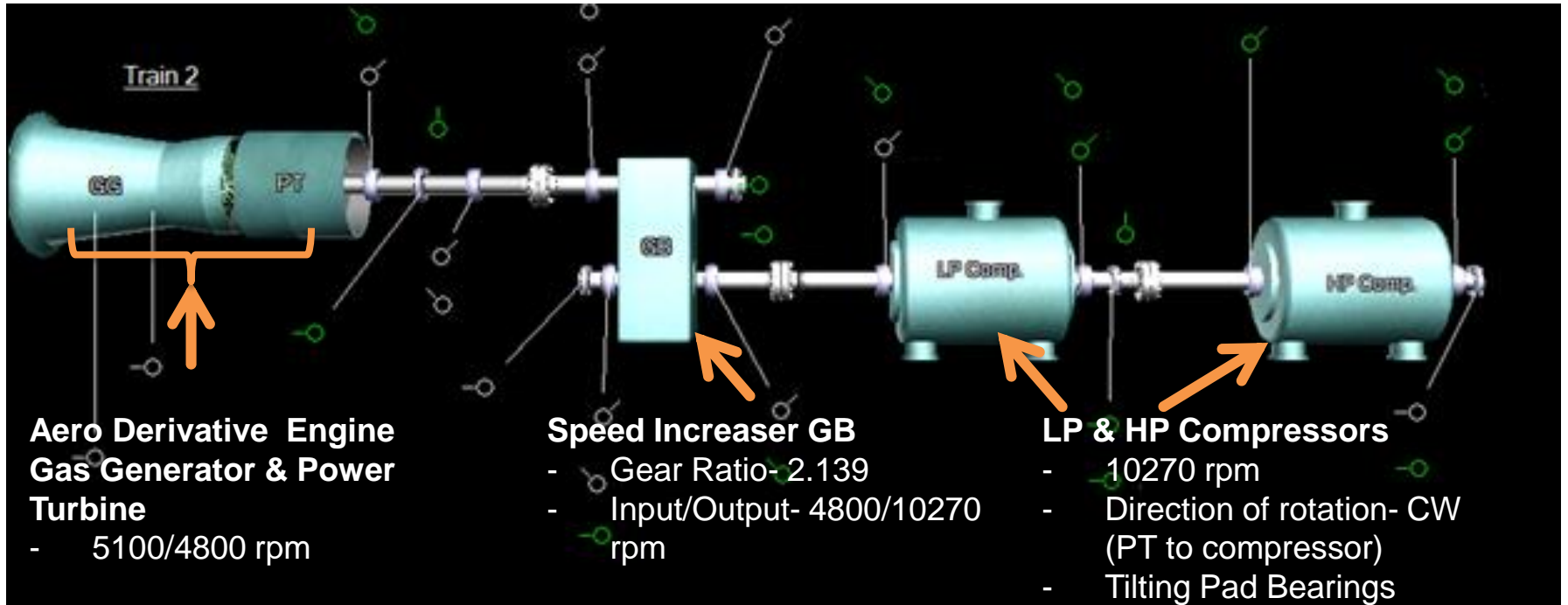


## Problem Statement

- 26<sup>th</sup> July 2015 The gradual rise in shaft vibration towards Non-Drive End (NDE) bearing began from startup onwards
- October 2015 Readings on Gas Injection Compressor Train were observed touching vibration alarm limits, 51  $\mu$ mpp (microns peak to peak) towards LP compressor NDE bearing at higher speed/load condition.
- October 2015 onwards From here onwards, the vibration amplitudes of LP Compressor NDE bearing intermittently reached alarm limits & Machine availability became a concern for the customer.



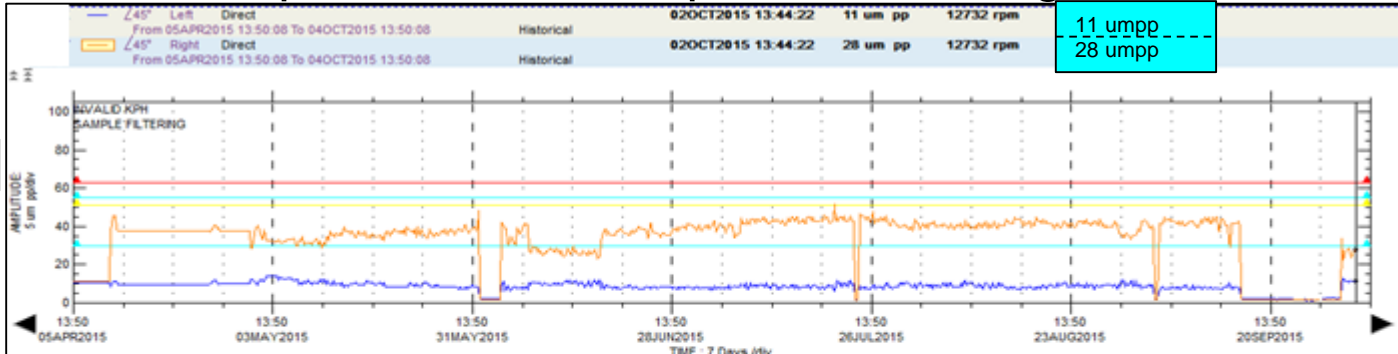
# Machine Details



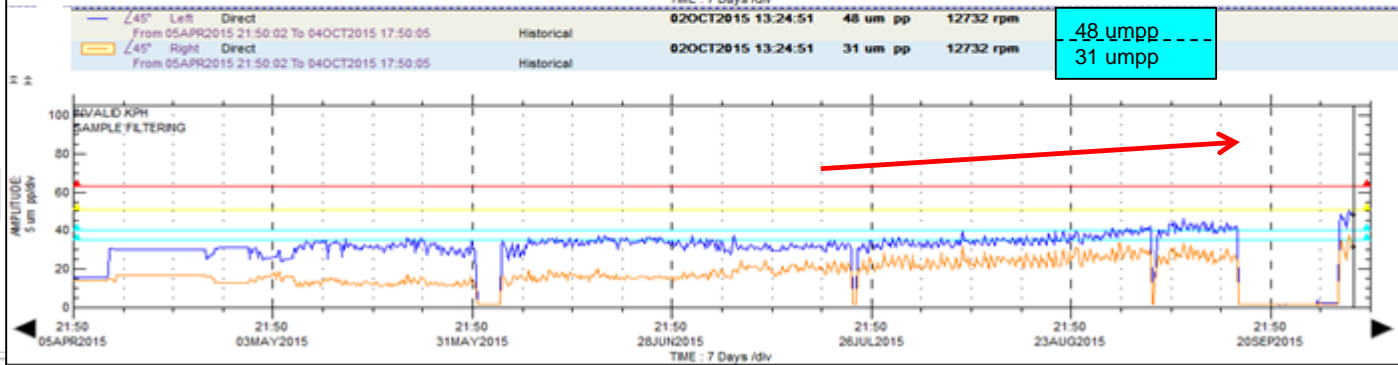
# Observations & Analysis

## Shaft Vibration Amplitudes- LP Compressor Bearings, Oct 2015

DE Bearing



NDE Bearing

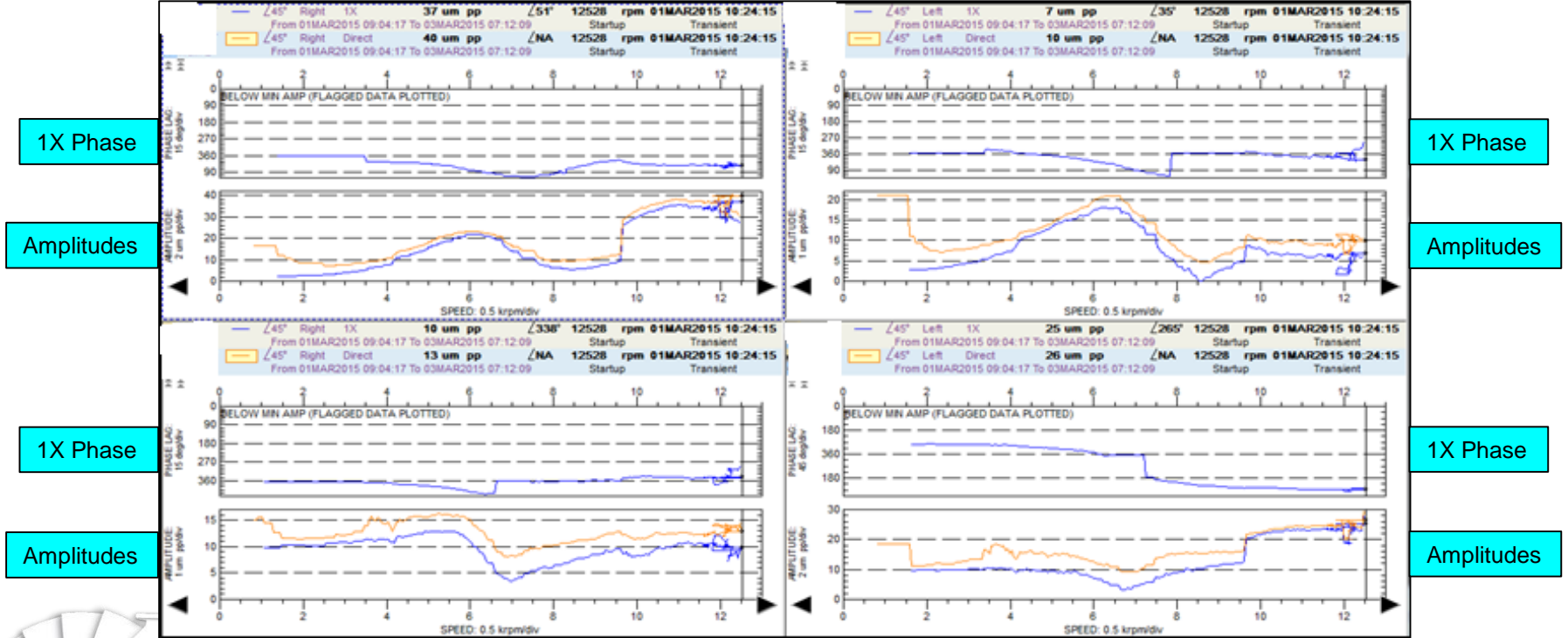


Startups after 26<sup>th</sup> July 2015, the NDE bearing amplitudes shows gradual rise approaching alarm levels (51  $\mu$ mpp)



# Observations & Analysis

## Bode Plots- 1<sup>st</sup> March 2015 Startup- LP Compressor Bearings



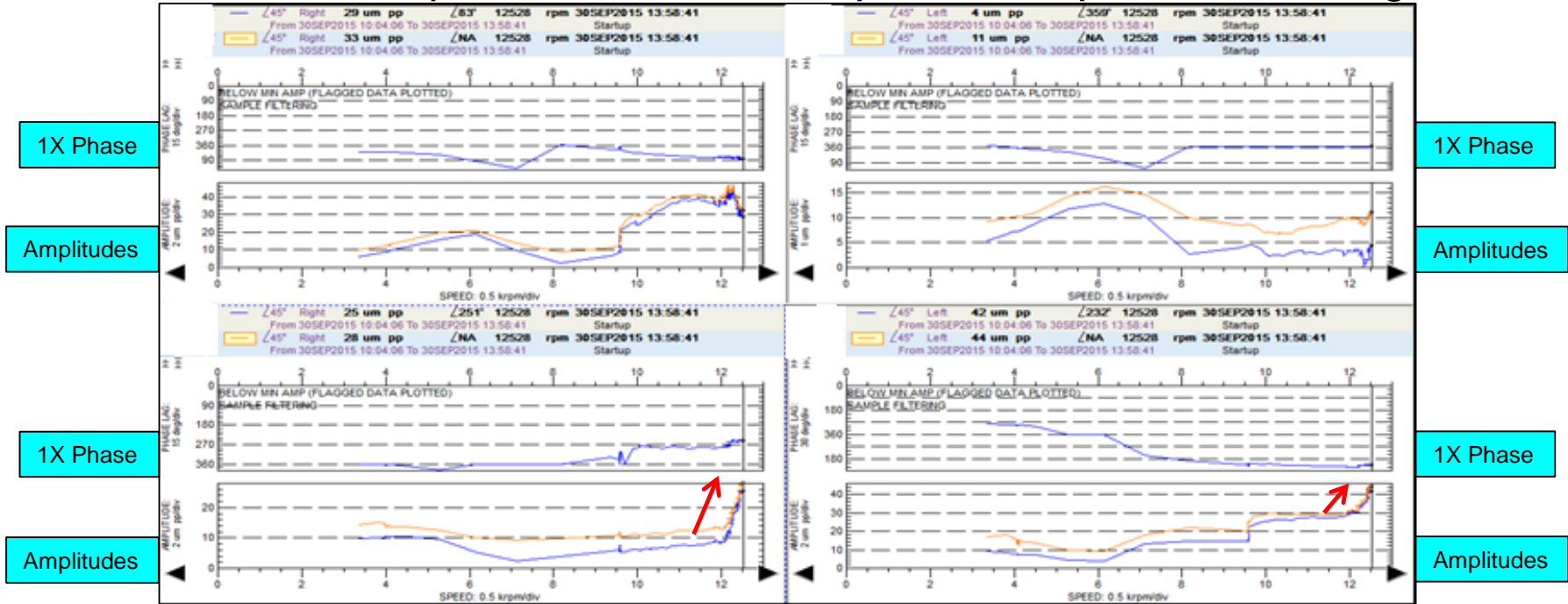
**Normal startup observed for both bearings, only Drive End (DE) bearing observed high (in line with machine history after Aug 2014 maintenance)**





# Observations & Analysis

## Bode Plots- 30<sup>th</sup> September 2015 Startup- LP Compressor Bearings

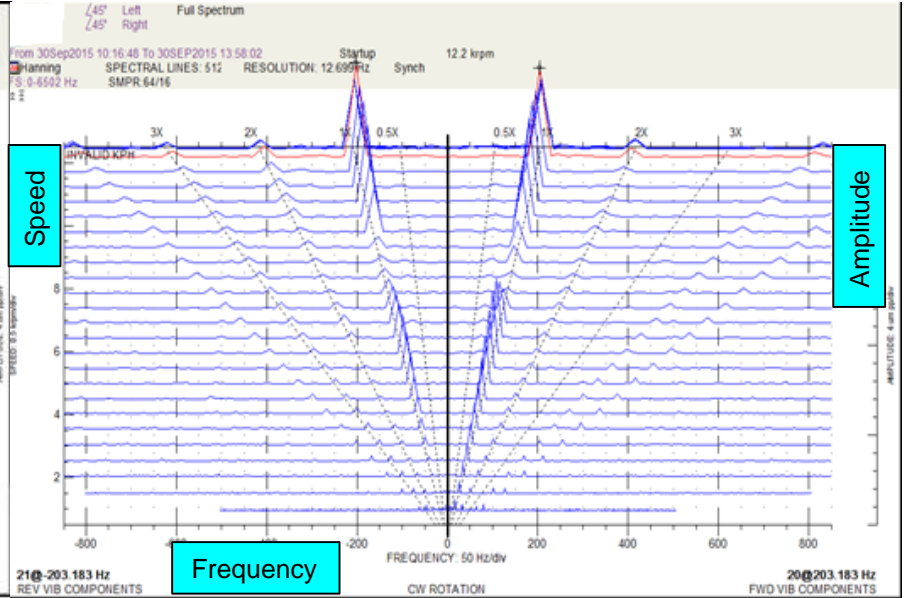
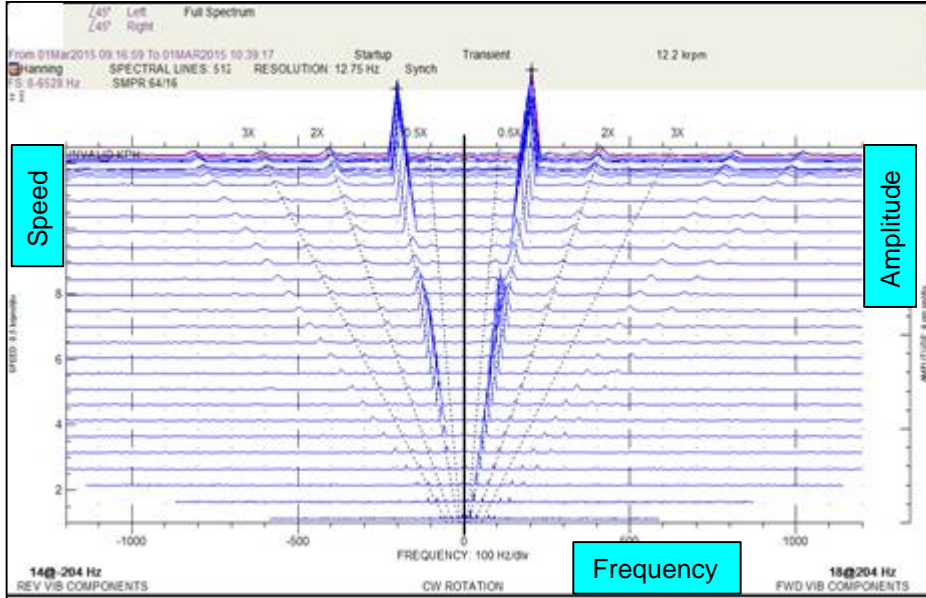


**Startup shows steep rise in amplitudes at NDE bearing, especially above 12000 rpm. DE bearing Vibrations reduces with rise in speed/load.**



# Observations & Analysis

## Full Spectrum Cascade Plots Comparison- LP Compressor DE Bearing



1<sup>st</sup> March 2015 start up

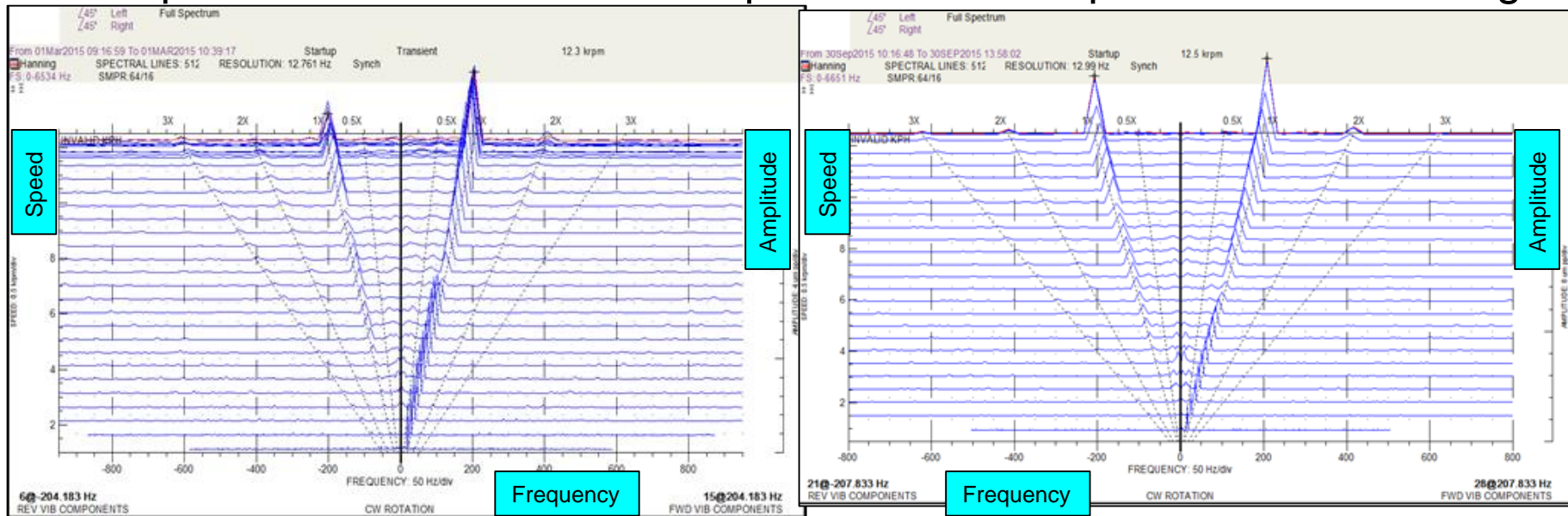
30<sup>th</sup> September 2015 start up

**Rise in reverse 1X component indicative of increased DE pre-load forces.**



# Observations & Analysis

## Full Spectrum Cascade Plots Comparison- LP Compressor NDE Bearing



*1<sup>st</sup> March 2015 start up*

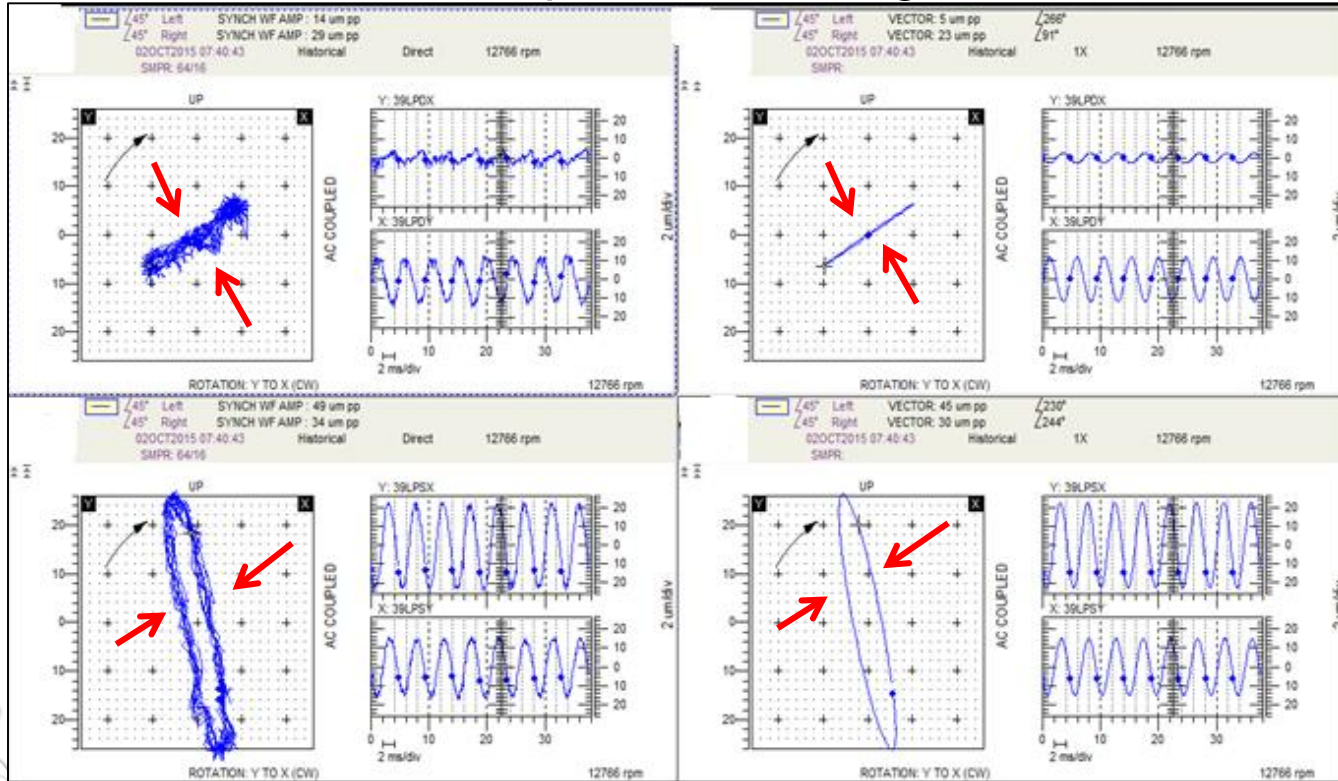
*30<sup>th</sup> September 2015 start up*

***Rise in reverse 1X component indicative of increased NDE pre-load forces.***



# Observations & Analysis

## Direct / 1X Orbit Plots: LP Compressor Bearings

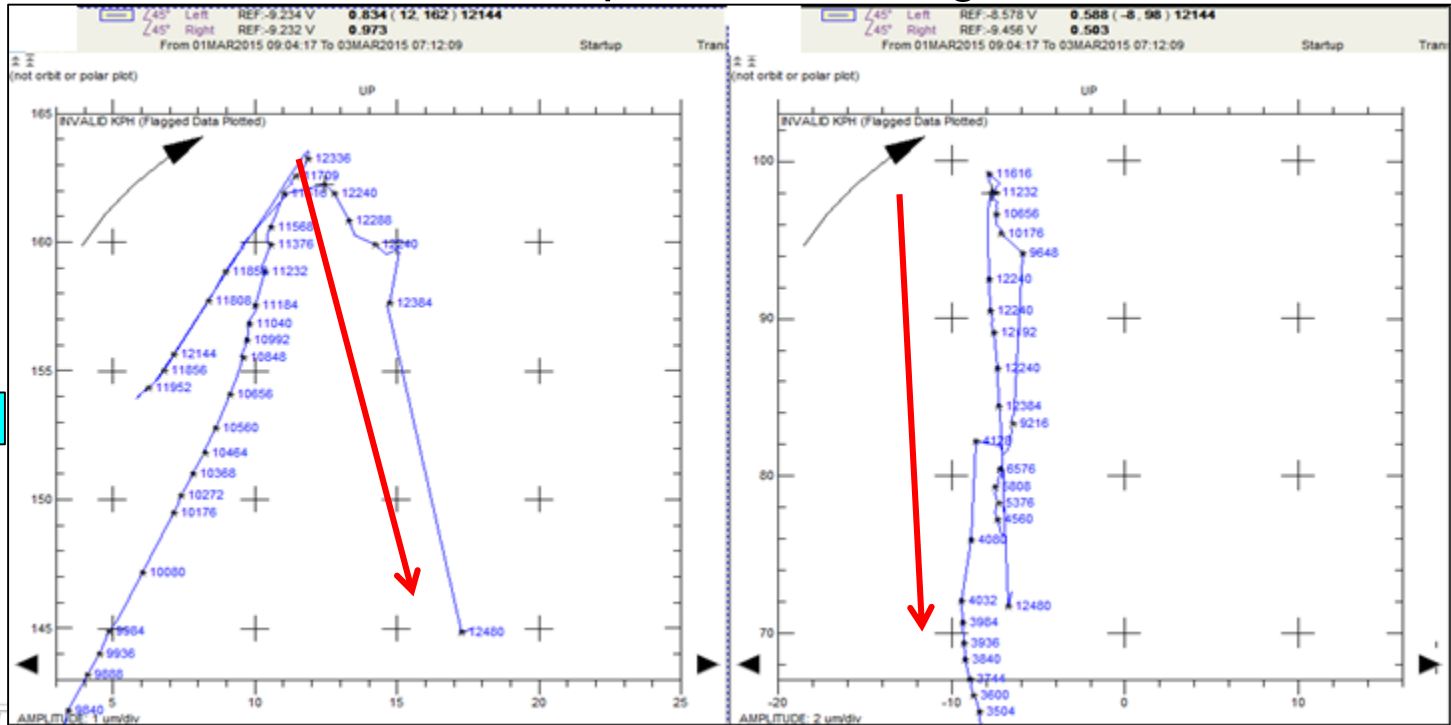


**Highly elliptical orbit observed, with higher amplitudes at NDE Bearing**



# Observations & Analysis

## Shaft Centerline Plots -LP Compressor Bearings



Amplitude

Amplitude

*As speed increased above 12000 rpm, the rotor shows downward movement.*



# Conclusions & Recommendations

## Conclusions:

- As speed increased above 12000 rpm, the vibrations at NDE bearing reached alarm limits ( $51 \mu\text{mpp}$ ) while the DE bearing showed reduction in vibration.
- Due to improper DBSE (*distance between shaft ends*), instead of thrust bearing taking the load, the load was absorbed by the coupling, resulting in rise in shaft vibration amplitudes at the NDE bearing.
- Abnormal movement of shaft centerline and increased ellipticity of orbit shape with speed/load rise indicates DBSE or alignment related issue.

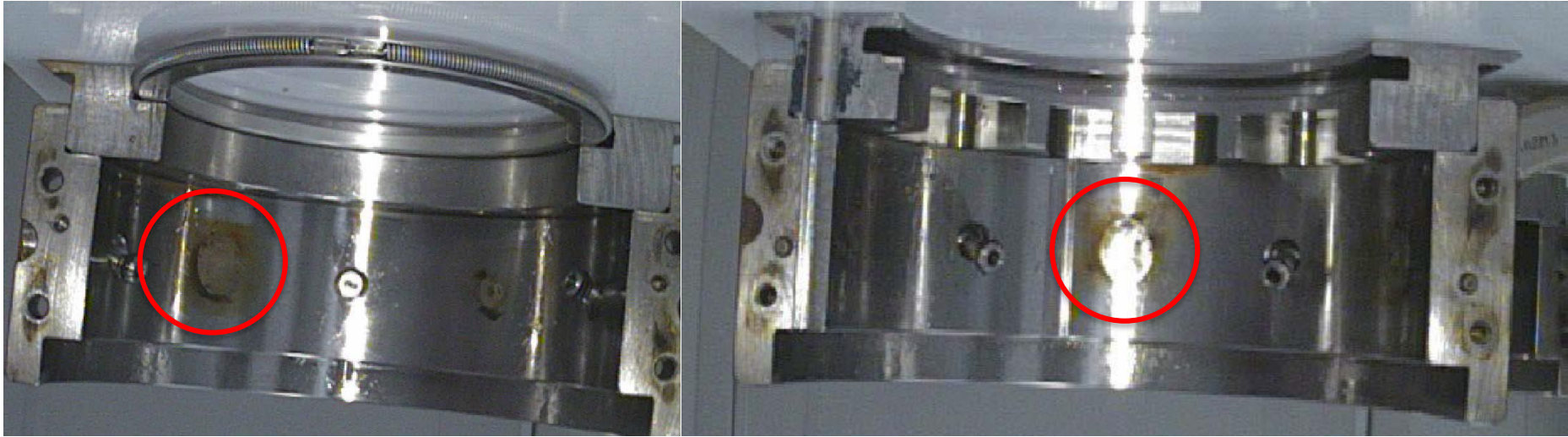
## Recommendations:

- DBSE & coupling pre-stretch shall be checked across both ends of LP compressor as per protocol values.
- Verify the alignment condition of the machine train.



# Machine Inspection Findings

Evidence of hot spots observed on the bearing pads which might be due to pre-load on the bearing.



- Coupling Pre-stretch between LP & HP compressor was found to be 1.72 mm compared to the recommended 1.32 mm.
- The bearings pads were observed with minor carbon deposits which might be due to burned oil in the pads.

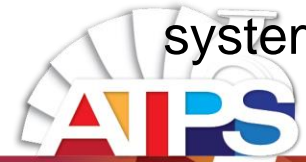
# Corrective Actions & Lesson Learned

## **Corrective actions:**

- Coupling pre-stretch between LP & HP compressor was found 1.72 mm against recommended 1.32 mm. Hence a shim of 0.4 mm was added.
- LP Compressor NDE bearing was replaced with new one with clearances maintained at 203  $\mu m$ . Alignment of the machine train was done as per design values.

## **Lessons learned:**

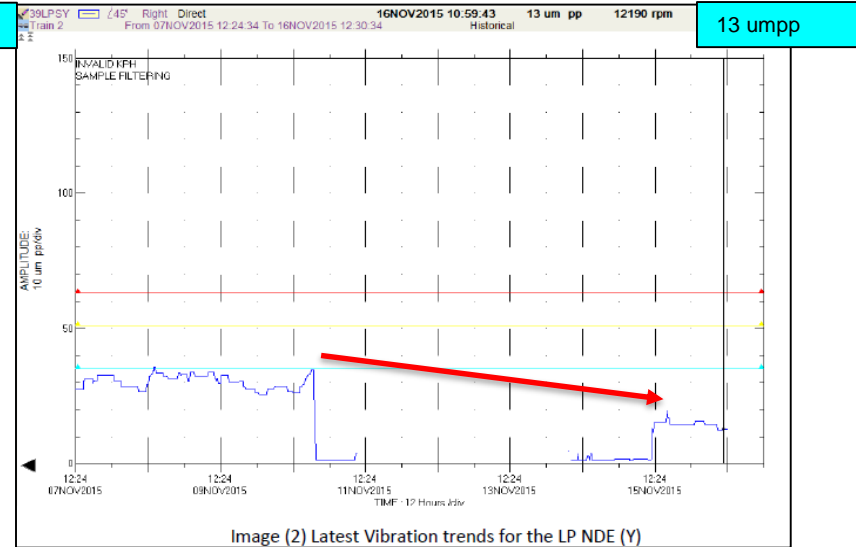
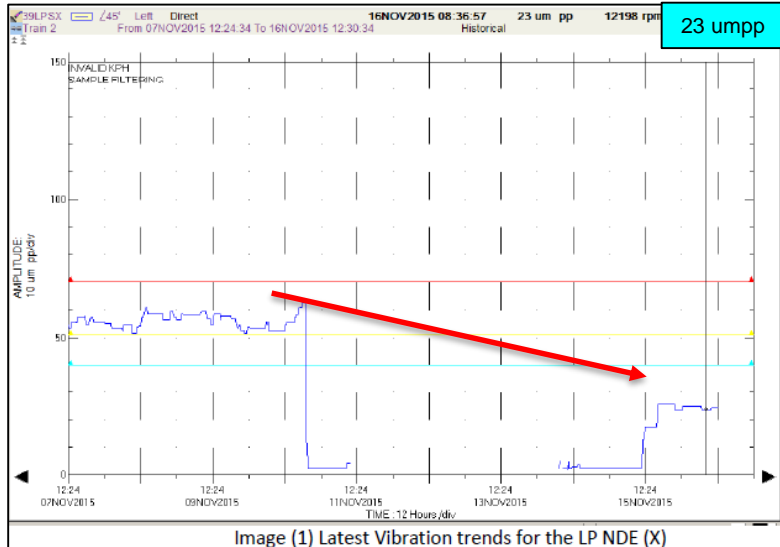
- Maintaining coupling pre-stretch is an important aspect of the maintenance, to avoid loading of the coupling instead of thrust bearings, especially during higher load conditions.
- Availability of historical information from online condition monitoring system enabled identification of the root cause.





# Post Maintenance Data Plots

## LP Compressor NDE Bearing Vibration:

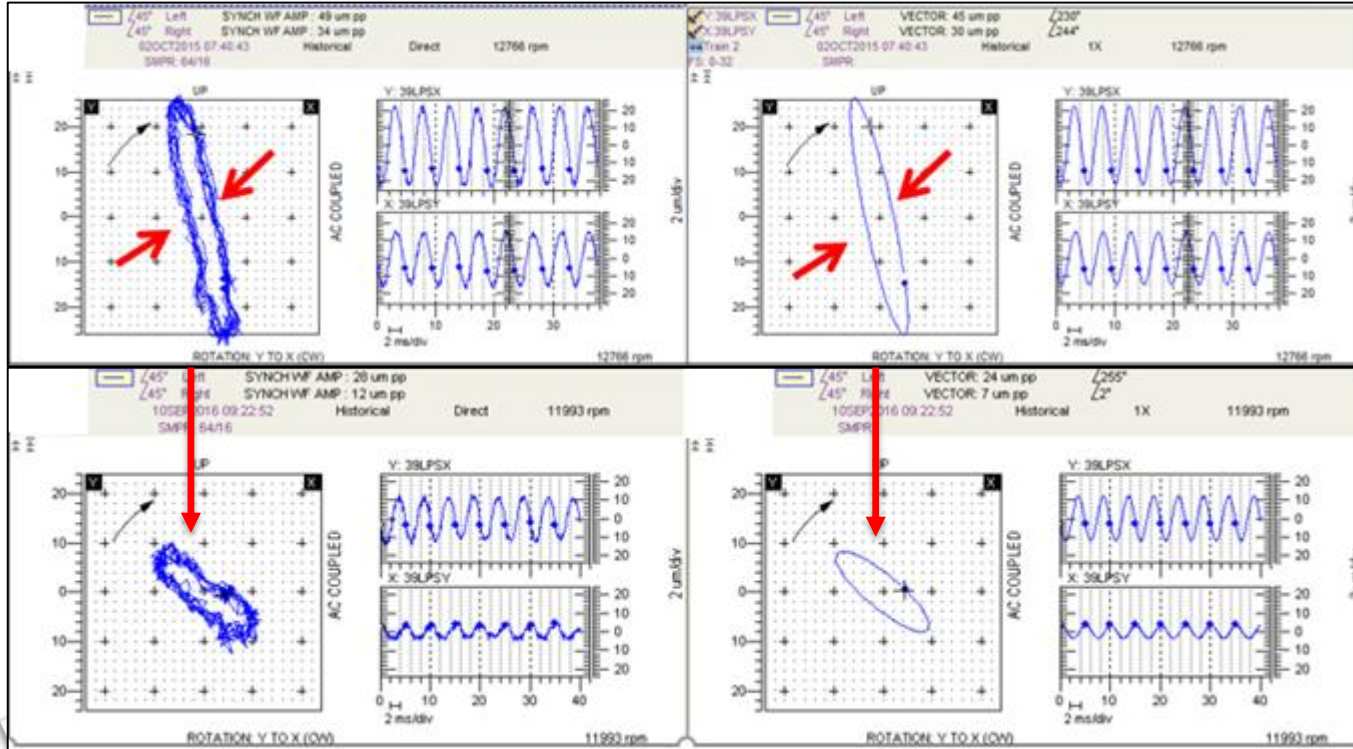


***Considerable improvement in LP compressor NDE bearing vibration amplitudes observed.***



# Post Maintenance Data Plots

LP Compressor NDE Bearing Direct/1X Orbit Plots:



Before Oct 2015

After Oct 2015

**Ellipticity of the NDE bearing improved significantly**



**QUESTIONS...**

