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GEORGE R. BROWN CONVENTION CENTER

# APPLYING ROTORDYNAMICS ANALYSIS TO IDENTIFY THE CAUSE OF HIGH SYNCHRONOUS VIBRATION ON OVERHUNG-ROTOR COMPRESSOR


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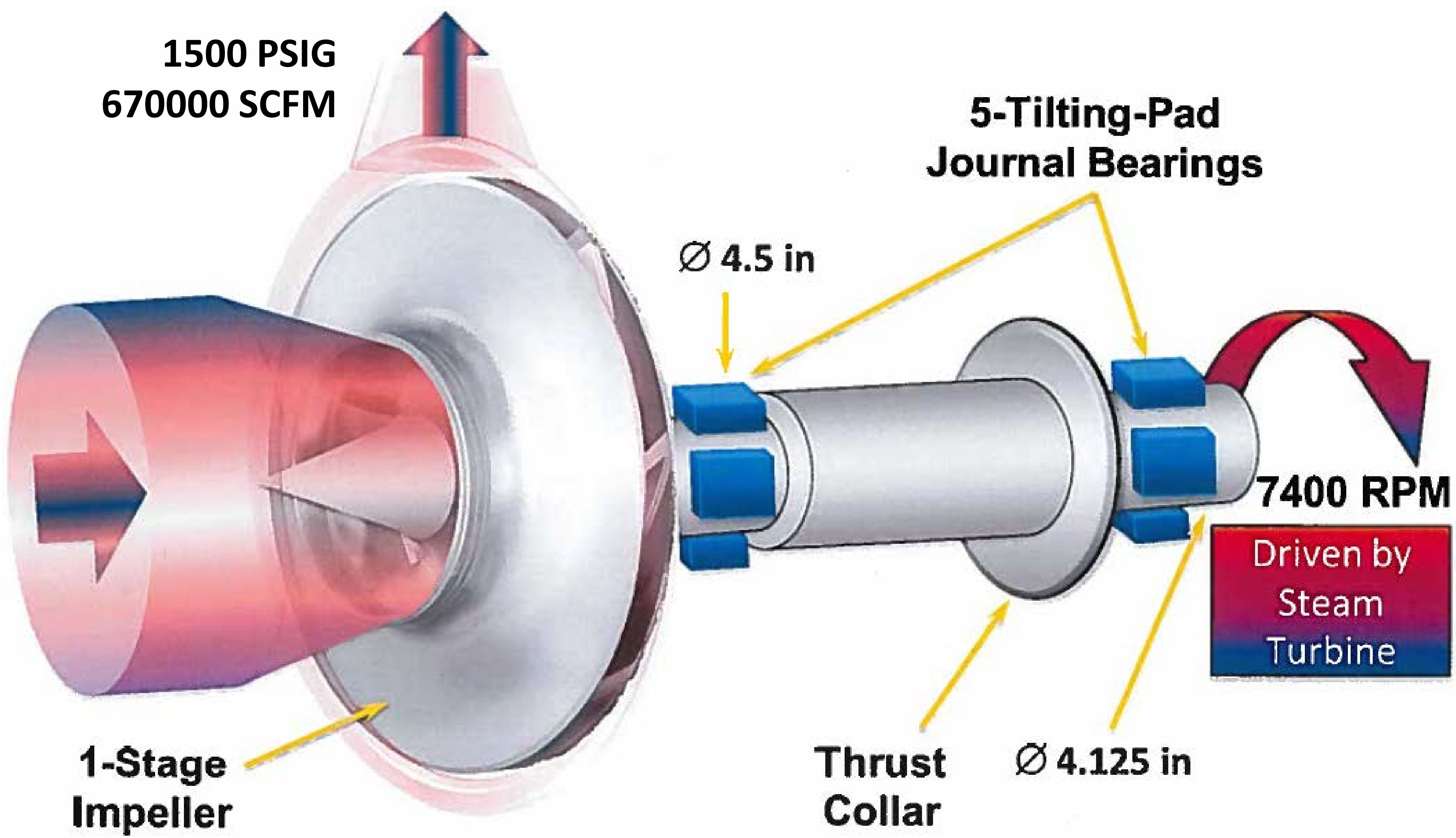
# Author Bio

- Manuel Marin joined LyondellBasell Industries in Channelview, Texas in 2013 as a Sr. Reliability Engineer and previously, he worked for Dresser-Rand as a Sr. Rotordynamics Engineer, and for PDVSA as Rotating Equipment Engineer. He has over 25 years' experience, leading several root cause failure analyses and troubleshooting turbomachinery. Mr. Marin is a graduate from Polytechnical University in Venezuela obtaining a B.Sc. degree in Mechanical Engineering. He received a MSc degree in Mechanical Engineering from Texas A&M University. He is a Certified Vibration Analyst Category III, and he is member of the ASME and the Vibration Institute.

# Problem Statement

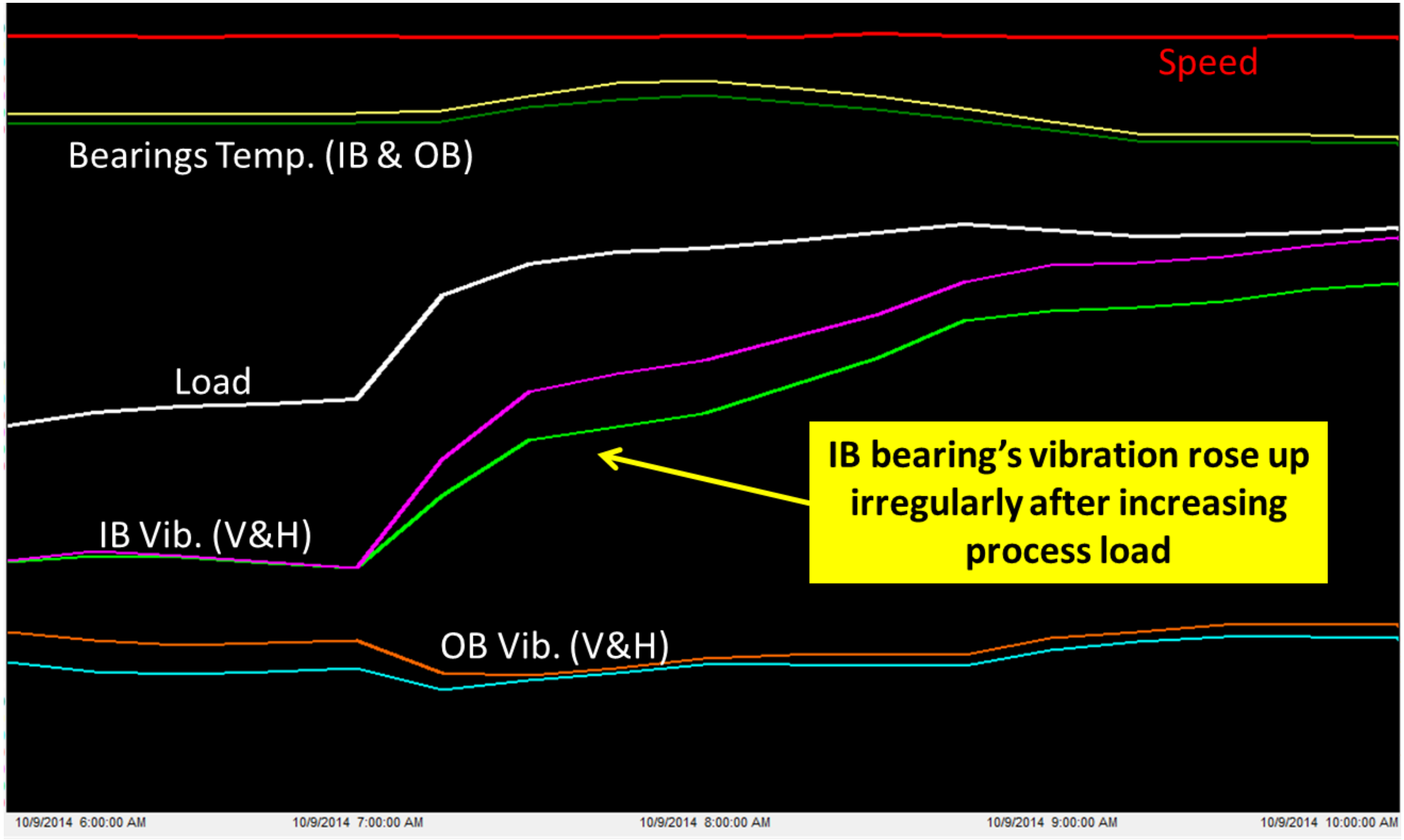
- After being overhauled, a one-stage overhung rotor, running at a constant speed rate, showed high vibration on the coupling end during loading.

# Overhung Centrifugal Compressor Overview



# Sequence of Events – Relevant Parameters

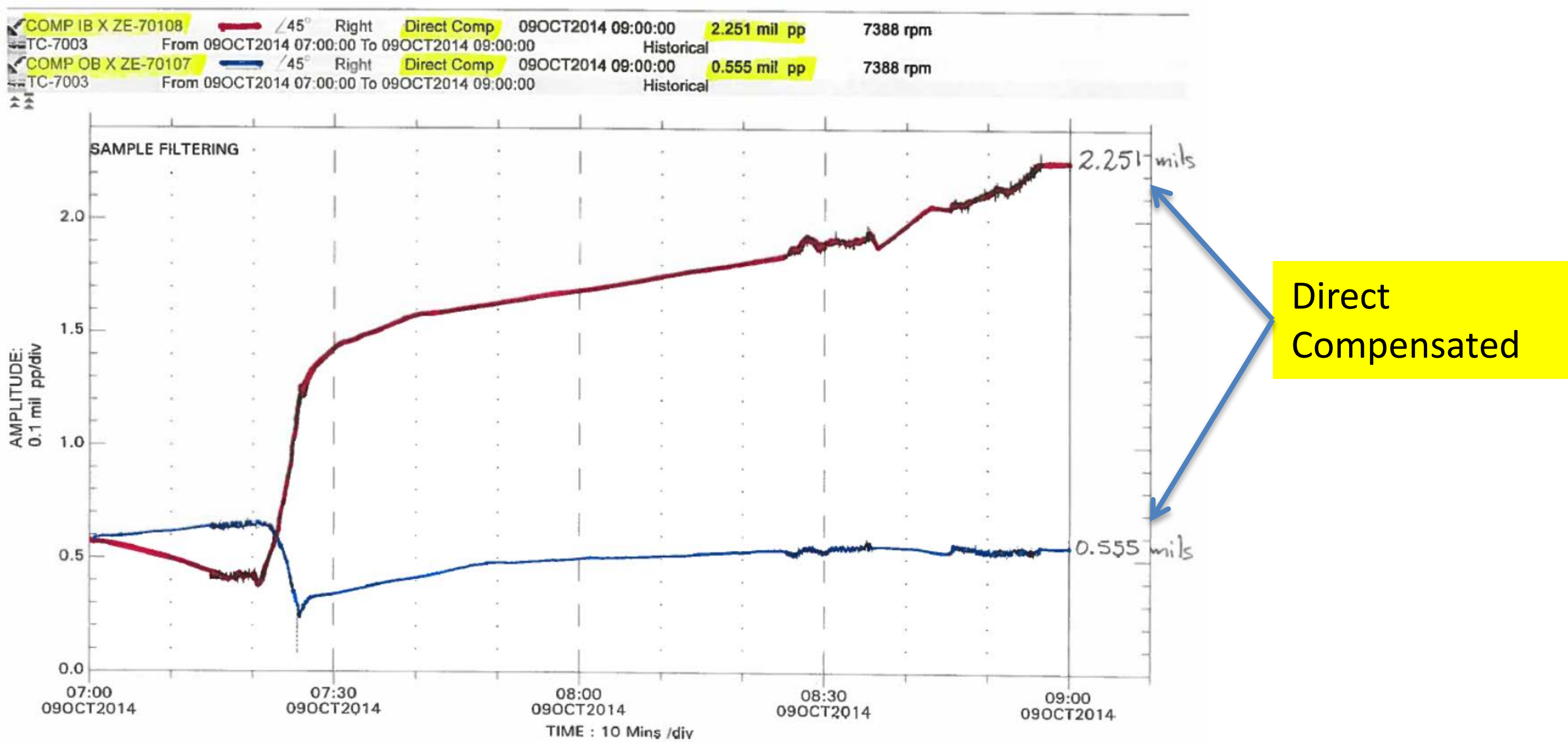
- During re-start, bearing-vibration trend plot showed an irregular increase on the inboard end (coupling end) when the unit initiated the loading process.




IB Vib. (V&H): Inboard Bearing Vibration (Vertical & Horizontal)
OB Vib. (V&H): Outboard Bearing Vibration (Vertical & Horizontal)

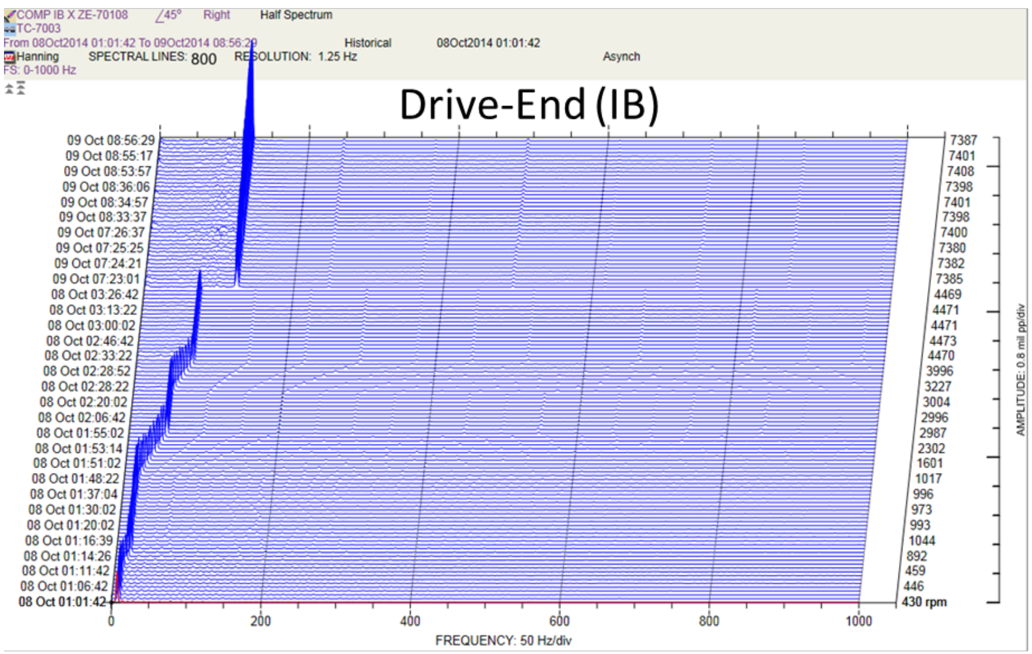
# Sequence of Events - Vibration Data

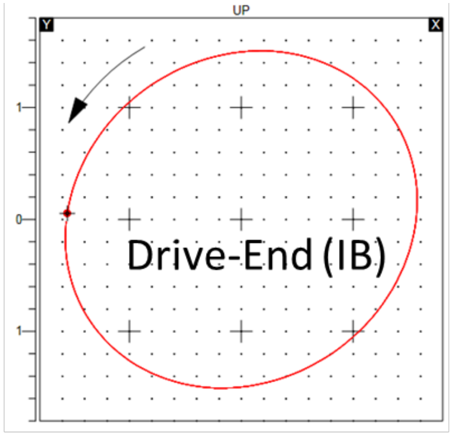
- The direct compensated vibration trend plot recorded in the field showed how the vibration at the coupling end was rising up from 0.4 mil Peak-Peak to 2.2 mils Peak-Peak while the unit was loading up at constant speed of 7400 RPM. On the non-drive end, the vibration kept below 0.6 mil Peak-Peak, even after loading the unit.

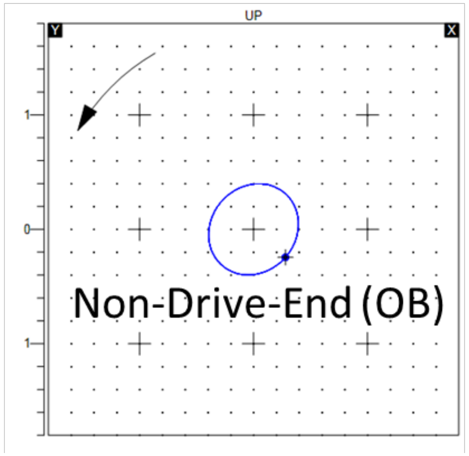


# Sequence of Events - Vibration Data

- The waterfall plot showed just a 1X component.
- The orbit plot on the drive-end probe was pretty round with not evidence of preload.



# Analysis Approach

- Based on the severity of the vibration, it was decided to perform a rotordynamics analysis to try to identify the possible causes of the observed behavior.

INPUTS

- M.E.D (Geo Model)
- Bearing Dynamics Coefficients
- Unbalance

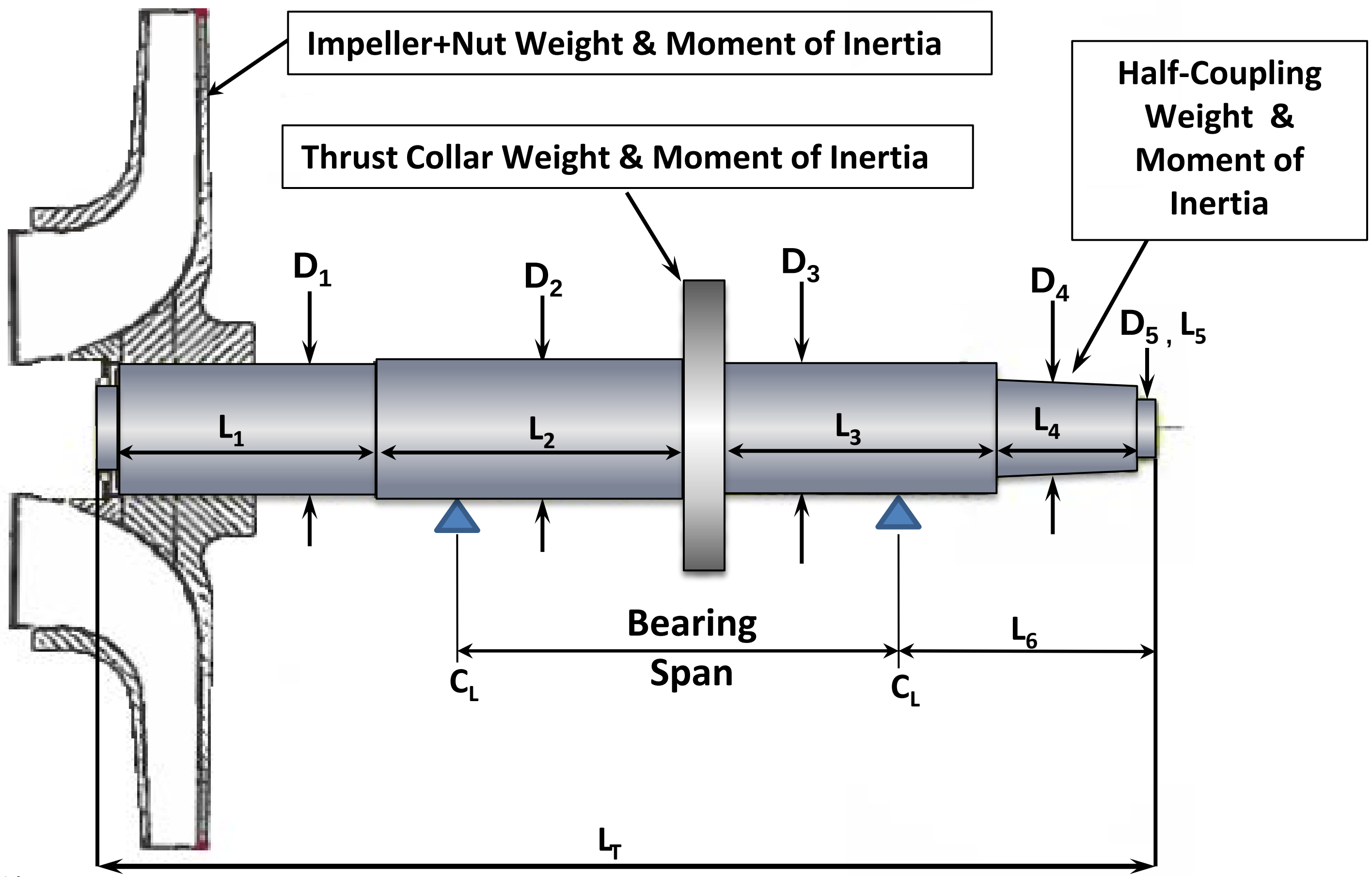
**Finite Element Based Rotordynamics Software**

OUTPUTS

- Critical Speeds
- Mode Shapes
- Unbalance Response

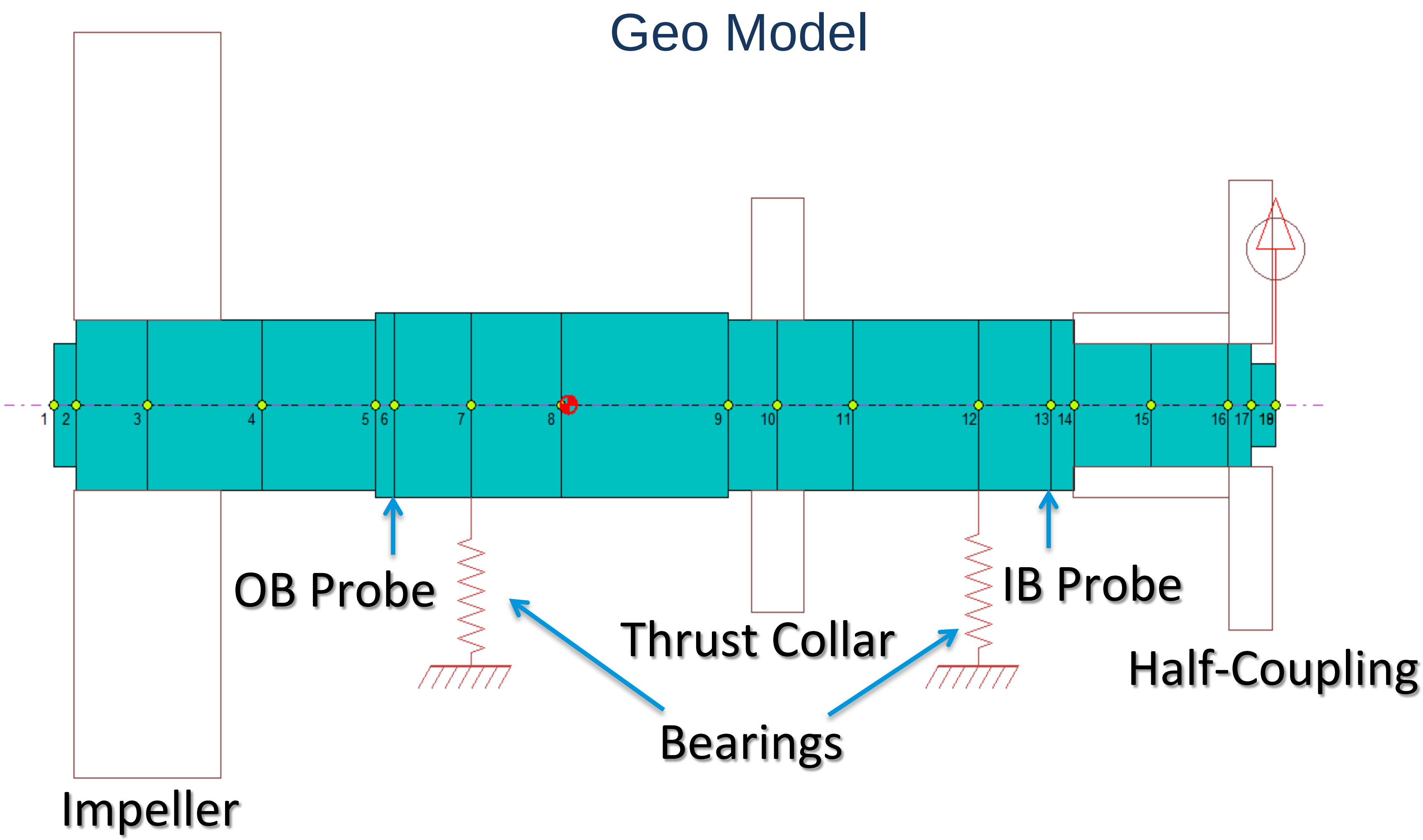
# Rotordynamics Analysis - Inputs

- Rotor Mass Elastic Data (M.E.D.)



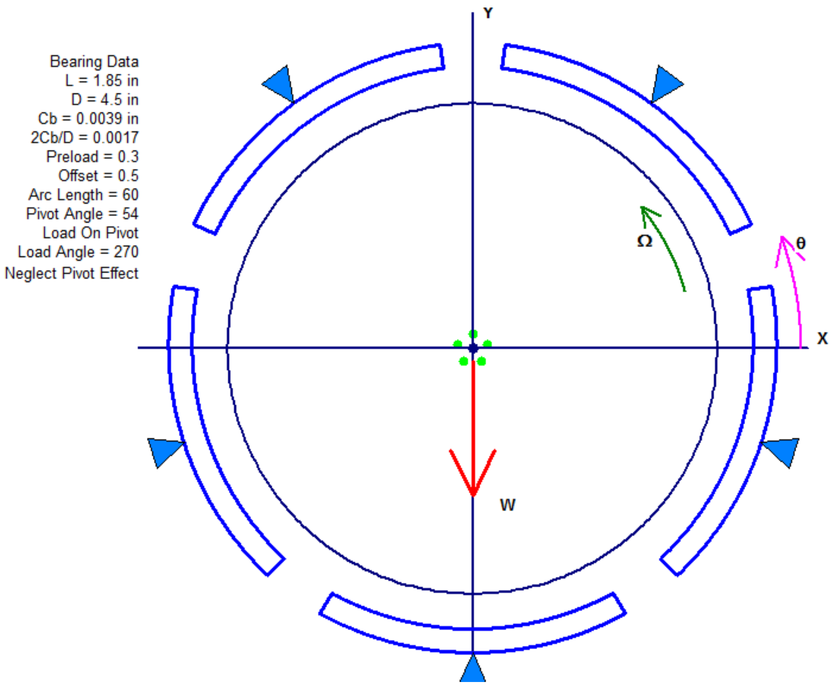

**D**: Diameter
**L**: Length
**C$_L$**: Bearing Center Line

# Rotordynamics Analysis - Inputs

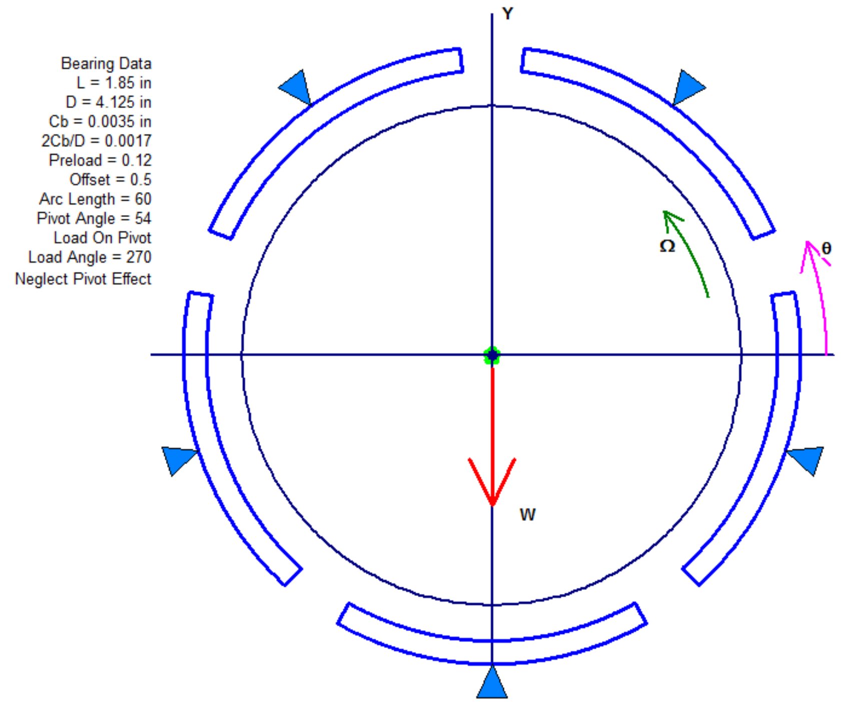


# Rotordynamics Analysis - Inputs

- Bearing Characteristics & Dynamic Coefficients Calculation




Non-Drive-End Bearing (OB)




Drive-End Bearing (IB)

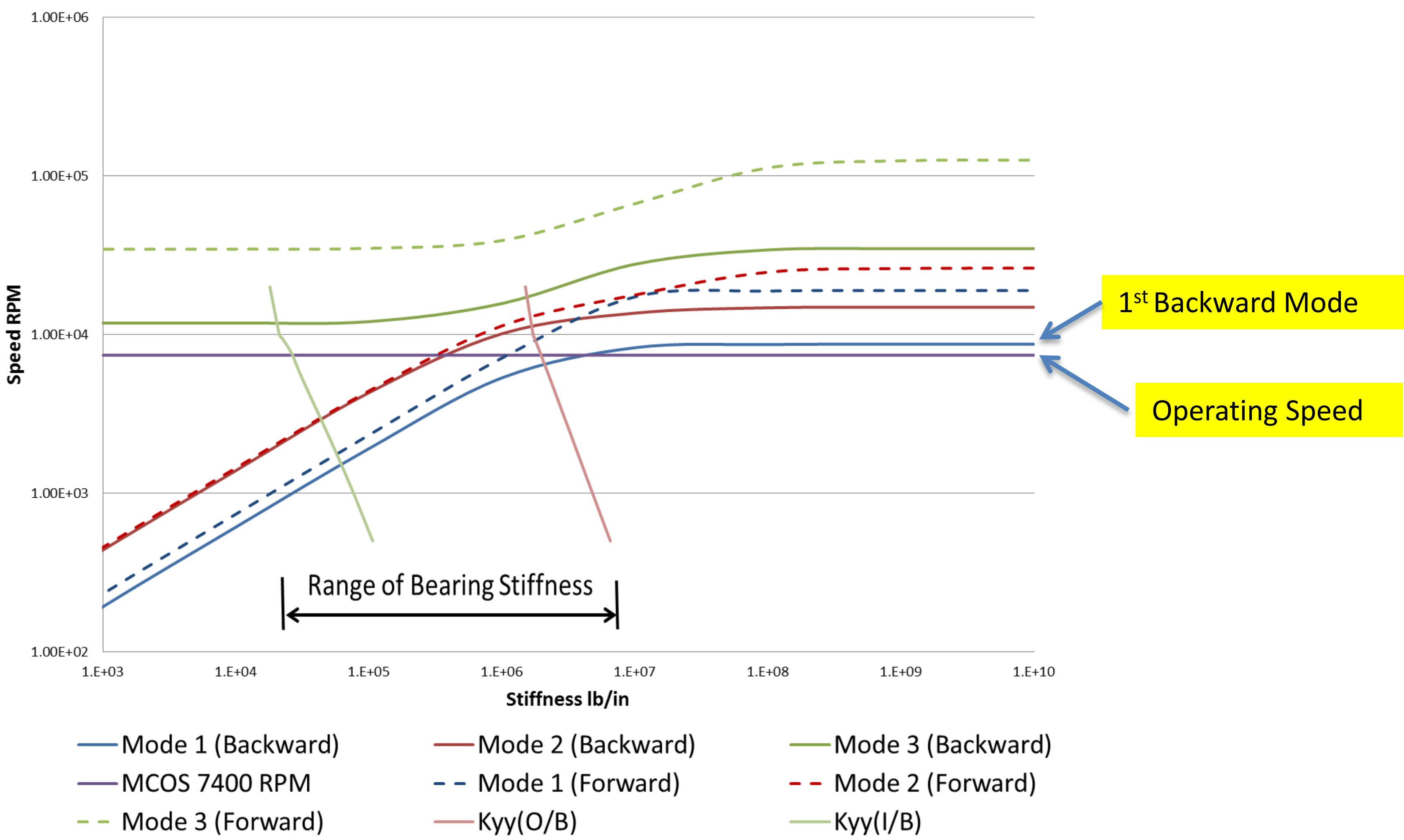
Design Radial Clearance

Non-Drive-End Bearing (OB): Min: 0.0025” Max: 0.0035”

Drive-End Bearing (IB): Min: 0.0023” Max: 0.0033”

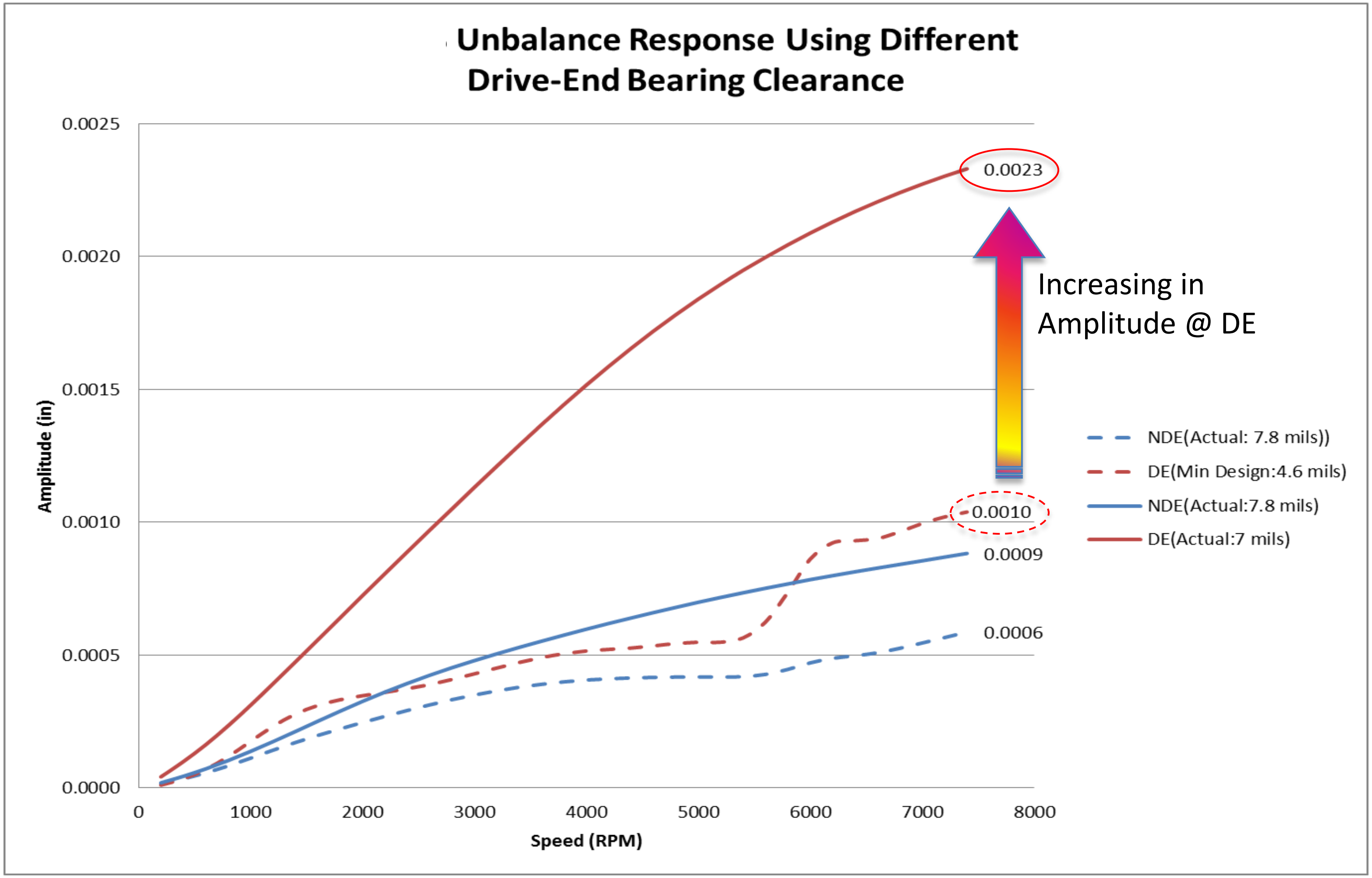
# Rotordynamics Analysis - Outputs

- Undamped Critical Speed Map – Forward & Backward Modes



# Rotordynamics Analysis - Outputs

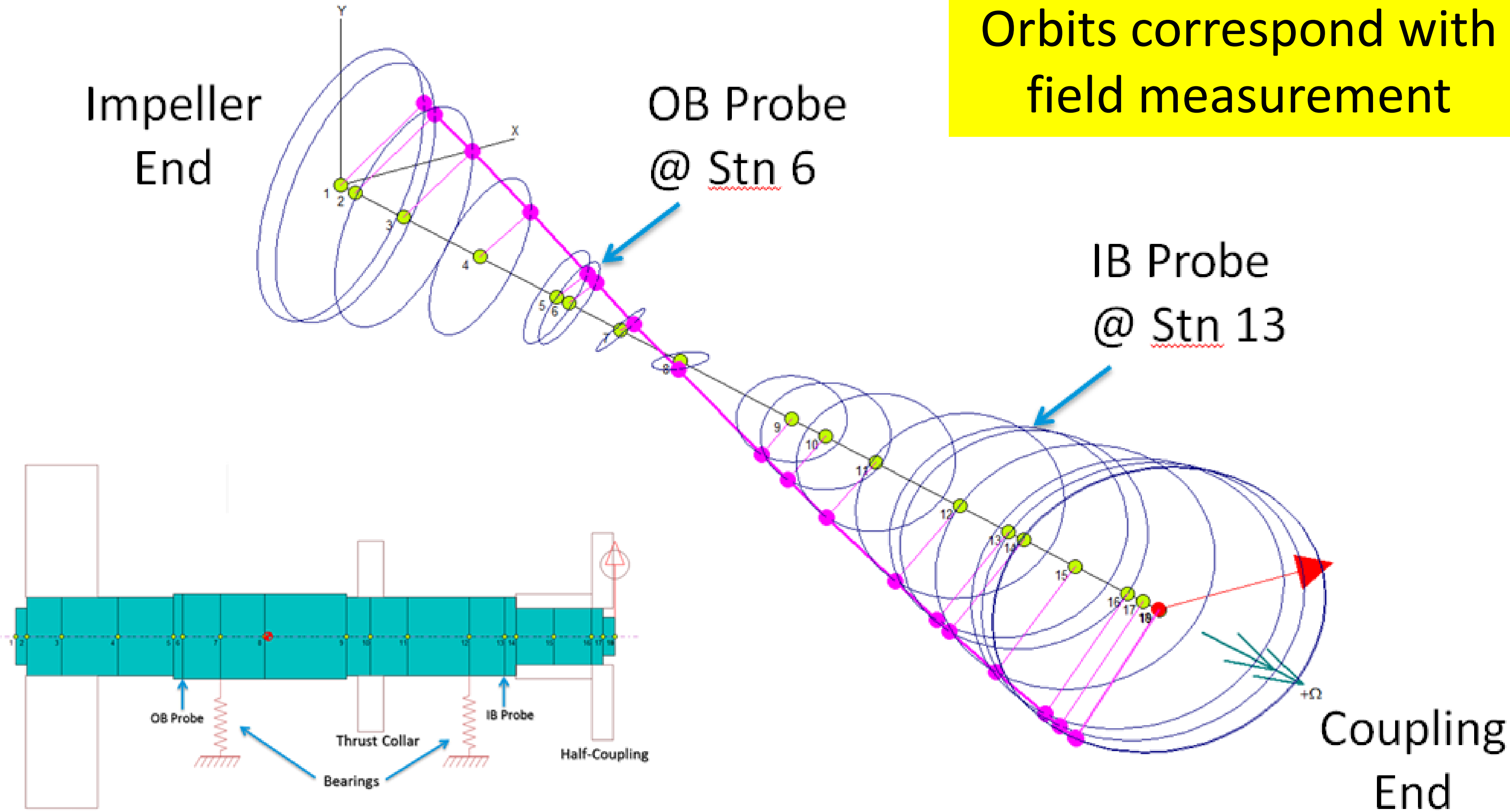
- Unbalance Response Comparing Drive-End Bearing Clearance



# Rotordynamics Analysis - Outputs

- Mode shape @ 7400 RPM

Orbits correspond with field measurement



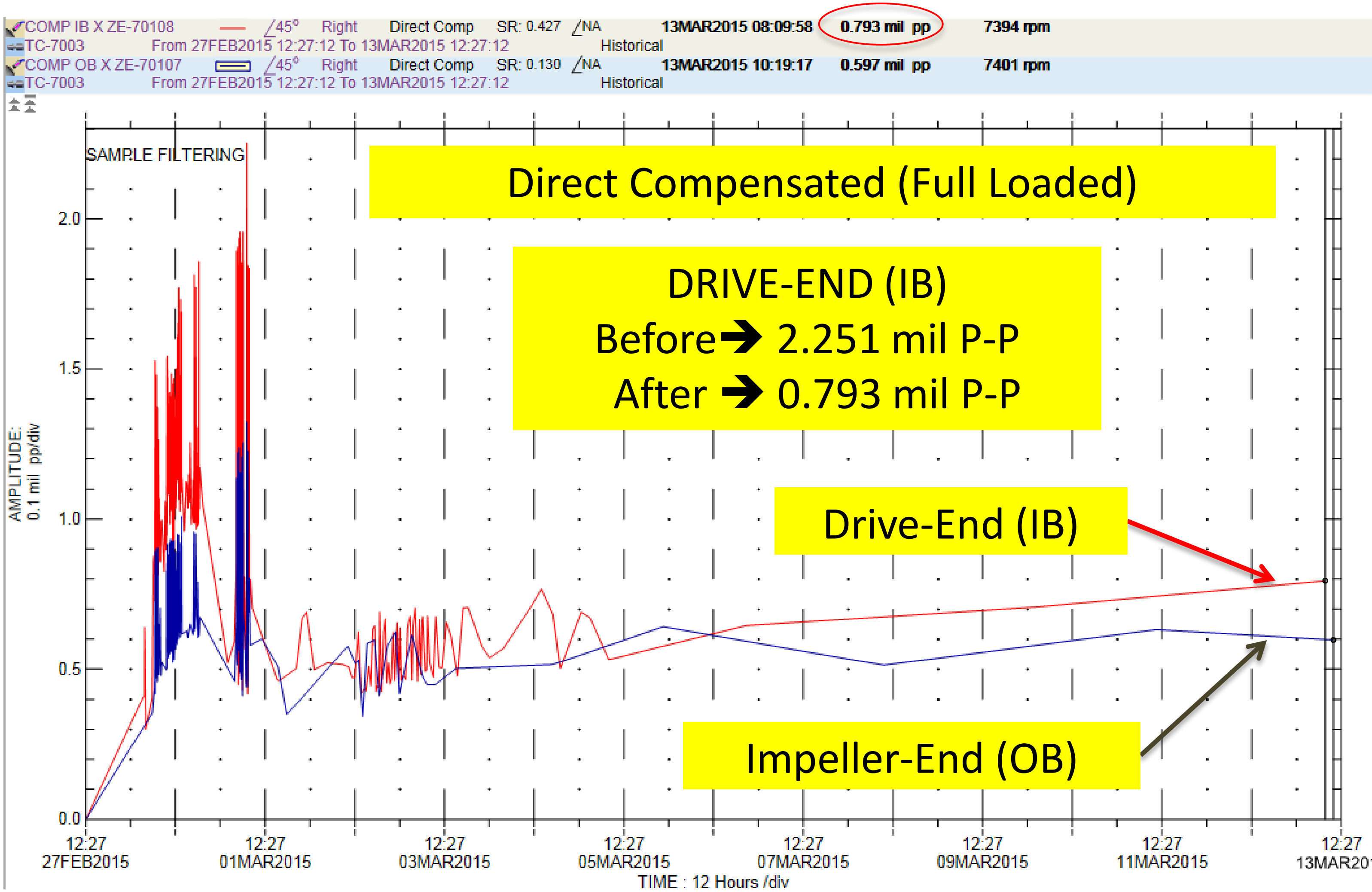
# Analysis of Results

- The rotordynamics analysis confirmed that the overhung compressor response was sensitive to the coupling-end bearing clearance.
- Having drive-end-bearing clearance bigger than the maximum recommended, created shaft orbits bigger at the coupling end than the ones at the impeller end.
- It was found that a high drive-end bearing clearance could make the first backward mode to become closer to the operating speed range, consequently increasing the vibration at the drive end.

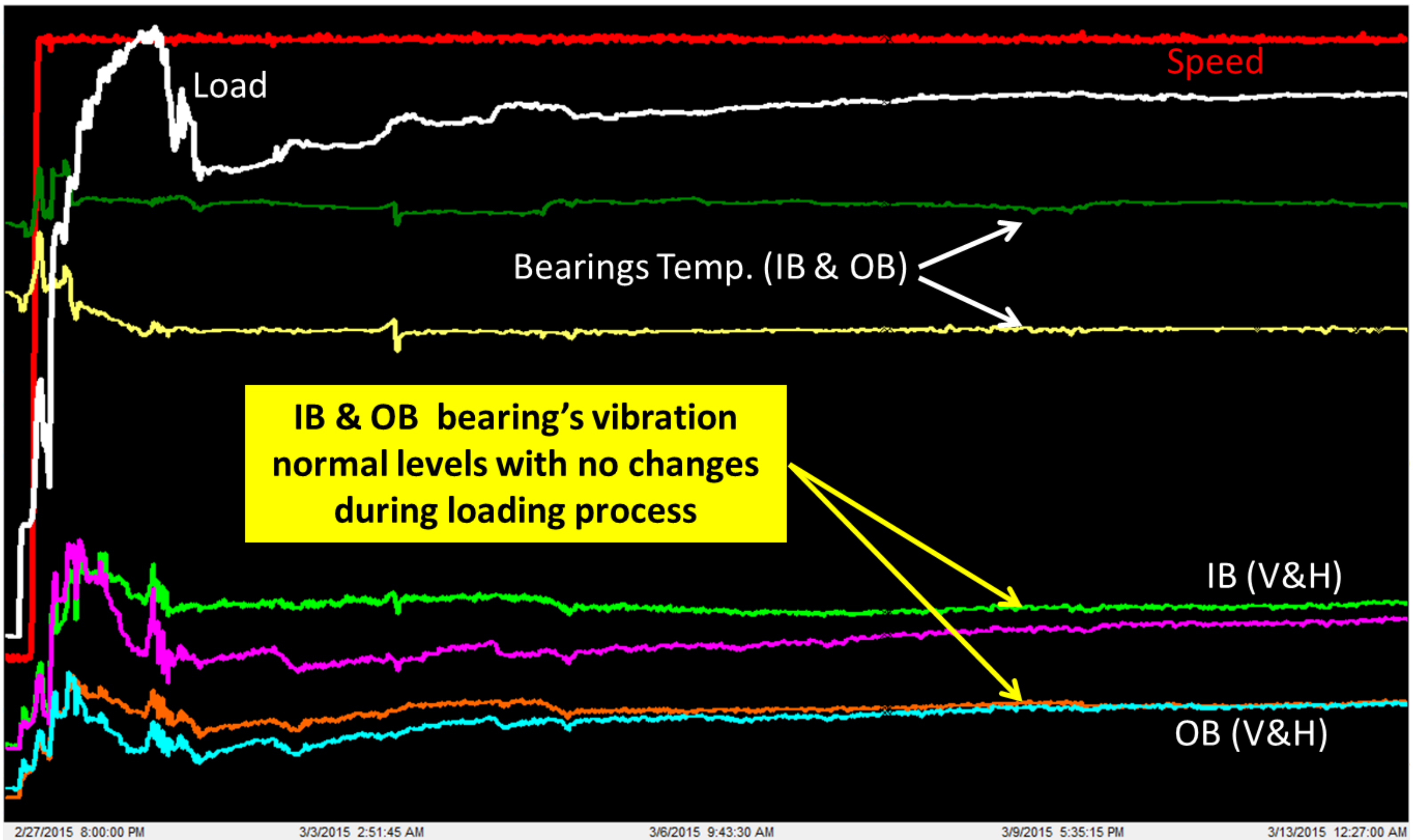
# Solution

- After running at full load conditions, it was confirmed that by using the minimum design bearing clearance at the drive-end bearing, the vibration levels of the overhung rotor were under acceptable values, which was in accordance with the rotordynamics analysis' results.

# Actual Field Data with Revised IB-Bearing Clearance, Running at Full Load



# Relevant parameters trend after Revised IB-Bearing Clearance

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# Lesson Learned

- This case shows how minor deviations on bearing clearances can makes big differences on the rotor response.
- Rotordynamic analysis is a useful tool, and it can be applied to real-world situations, helping to understand complex rotating machinery problems.