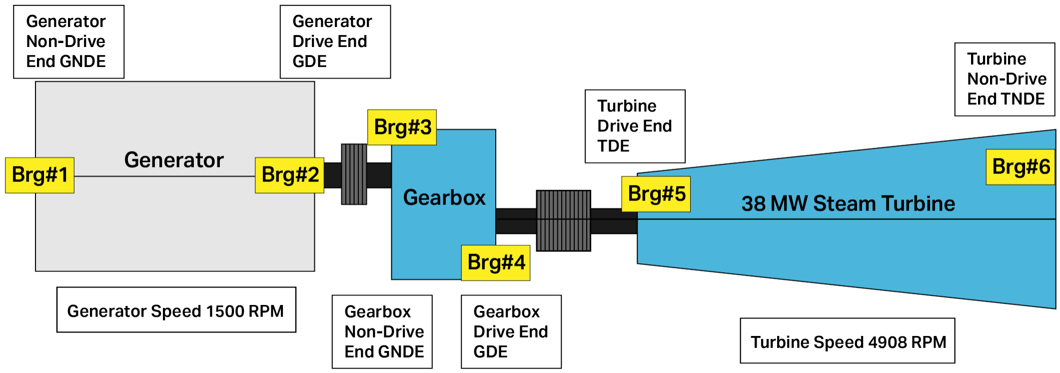
Case Study:
Vibration Management & Optimization of a 38 MW Steam Turbine

A turbine repair company recently undertook an overhaul and rotor balancing of a 38 MW steam turbine in Queensland, Australia. Post-overhaul, the client engaged Machinery Consultation and Service Pty Ltd (MCS Pty Ltd) to perform a comprehensive vibration assessment on the entire machine.

Machine Layout

The following diagram depicts the layout of the 38 MW steam turbine:



Initial Operation and Challenges

The turbine initially operated at a slow roll speed of 39 rpm. As per the Japanese turbine manufacturer's guidance, the speed was increased to 556 rpm, where it was to remain for four hours. However, after two hours and 30 minutes, the turbine experienced a trip due to high vibration levels, which were recorded as follows:

- HP - TDE - 1X: 86 µm pp
- HP - TDE - 1Y: 85 µm pp
- LP - TNDE - 2X: 36 µm pp
- LP - TNDE - 2Y: 35 µm pp

Revised Strategy and Execution

In a meeting with the maintenance team the following day, a new strategy was devised:

1. **Run the turbine at 556 rpm for 40 minutes before increasing to full speed**
   This approach allowed the turbine to reach full speed without tripping. At full speed (4906 rpm), initial vibration levels were within normal ranges, but increased from 19 µm pp to 56 µm pp. MCS Pty Ltd recommended maintaining the turbine at full speed no-load (FSNL) for one hour to allow for thermal stabilization. After one hour, vibration levels dropped back to 20 µm pp.

2. **Overspeed test and quick startup**
   For insurance purposes, an overspeed test was conducted, resulting in satisfactory outcomes. However, during a subsequent quick startup, the turbine rotor experienced high vibrations, reaching 156 µm pp while passing the first critical speed, causing another trip.

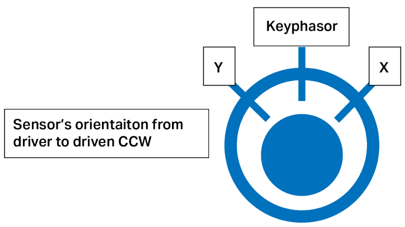
3. **Final optimized run-up sequence**
   MCS Pty Ltd recommended the following sequence:

   - Operate the turbine at a slow roll speed of 39 rpm for one hour
   - Increase speed to 566 rpm and maintain for 30 minutes
   - Reach full speed and maintain FSNL for one hour

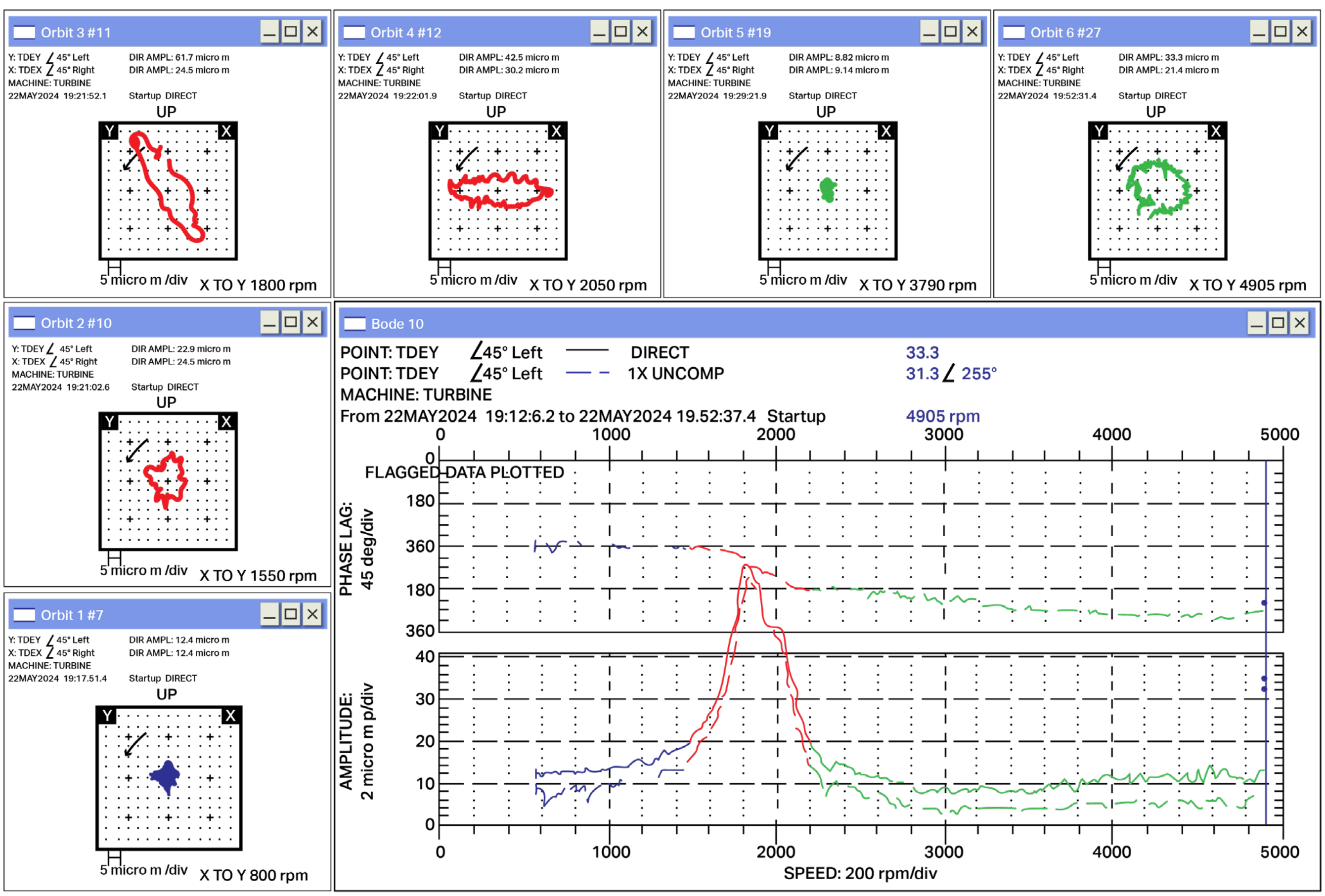
   This approach allowed for a gradual application of load while closely monitoring vibration levels.

Sensor Setup

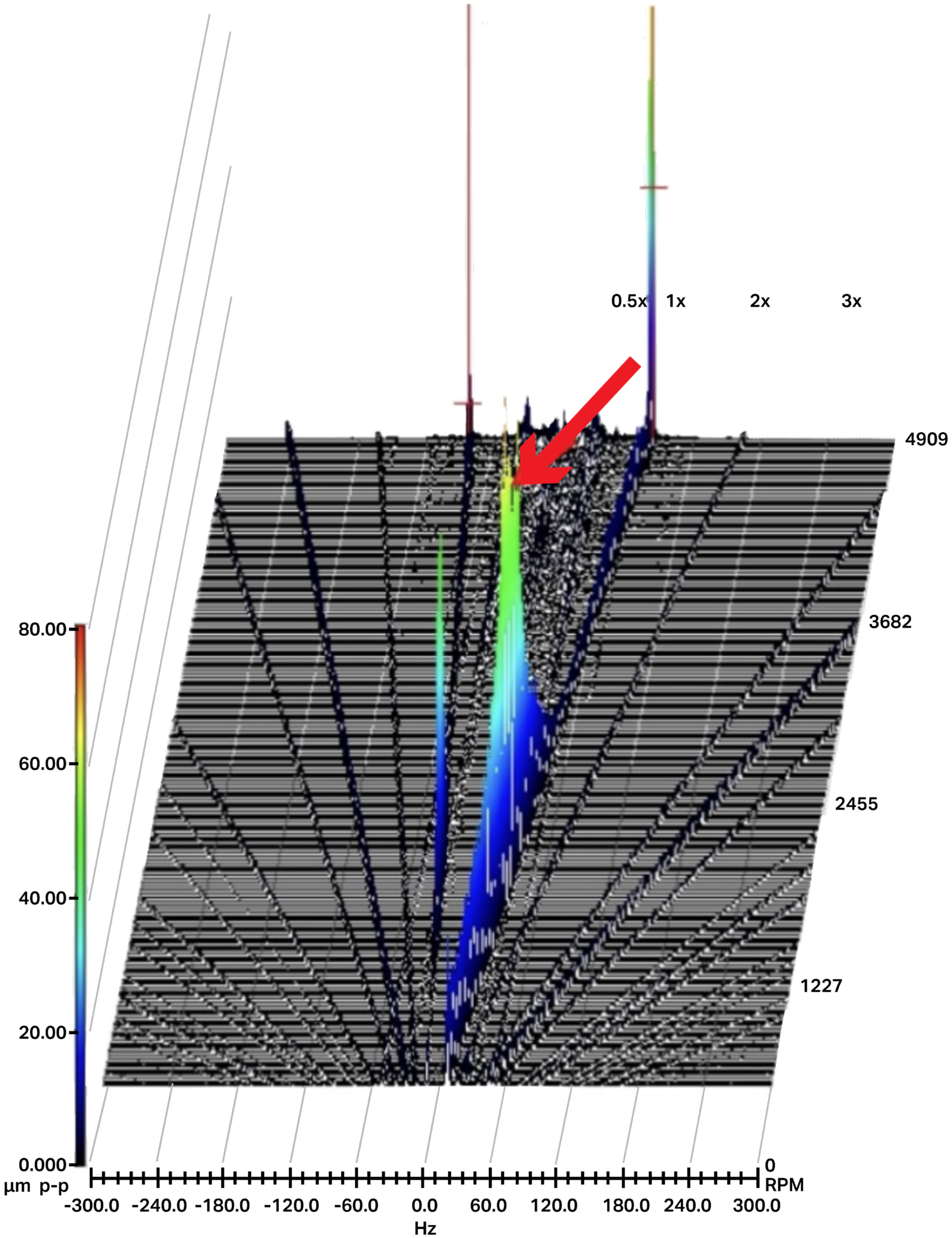
A PRO Line 8 mm Dynamic Voltage Probe System was the perfect selection for this application. Probes utilized in speed/phase applications should be mounted over the portion of the shaft that has one or more keyways in its rotation path. PRO Proximity Probes used in this manner will produce once-per-revolution pulse or multiple event-per-revolution pulses from a rotating shaft or gear. The PRO Proximity Probe System provides data that can be used to trigger a device that generates a digital pulse signal.



Orbit Plots



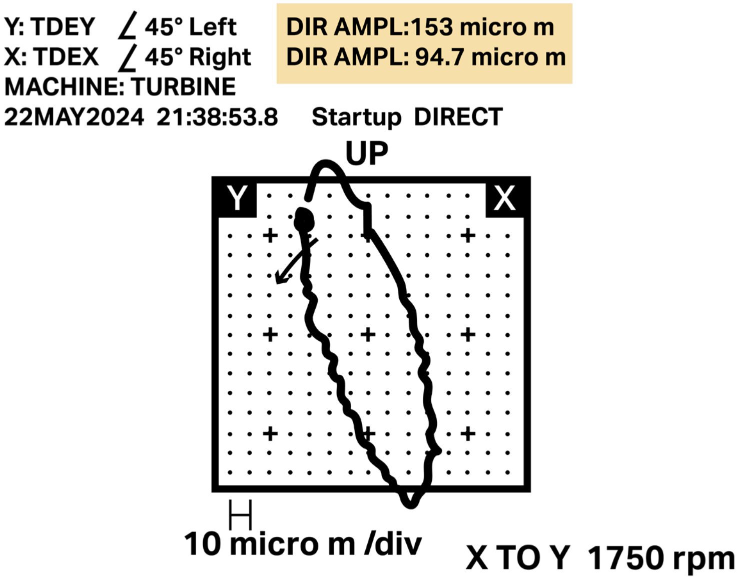
Full Spectrum Cascade Plot (TDE-2X-TDE-2Y)



Speed: 4904 RPM, Order: 1.0x, Forward: 82.5 Hz, 37.2 µm p-p, Reverse: -82.5 Hz, 5.31 µm p-p

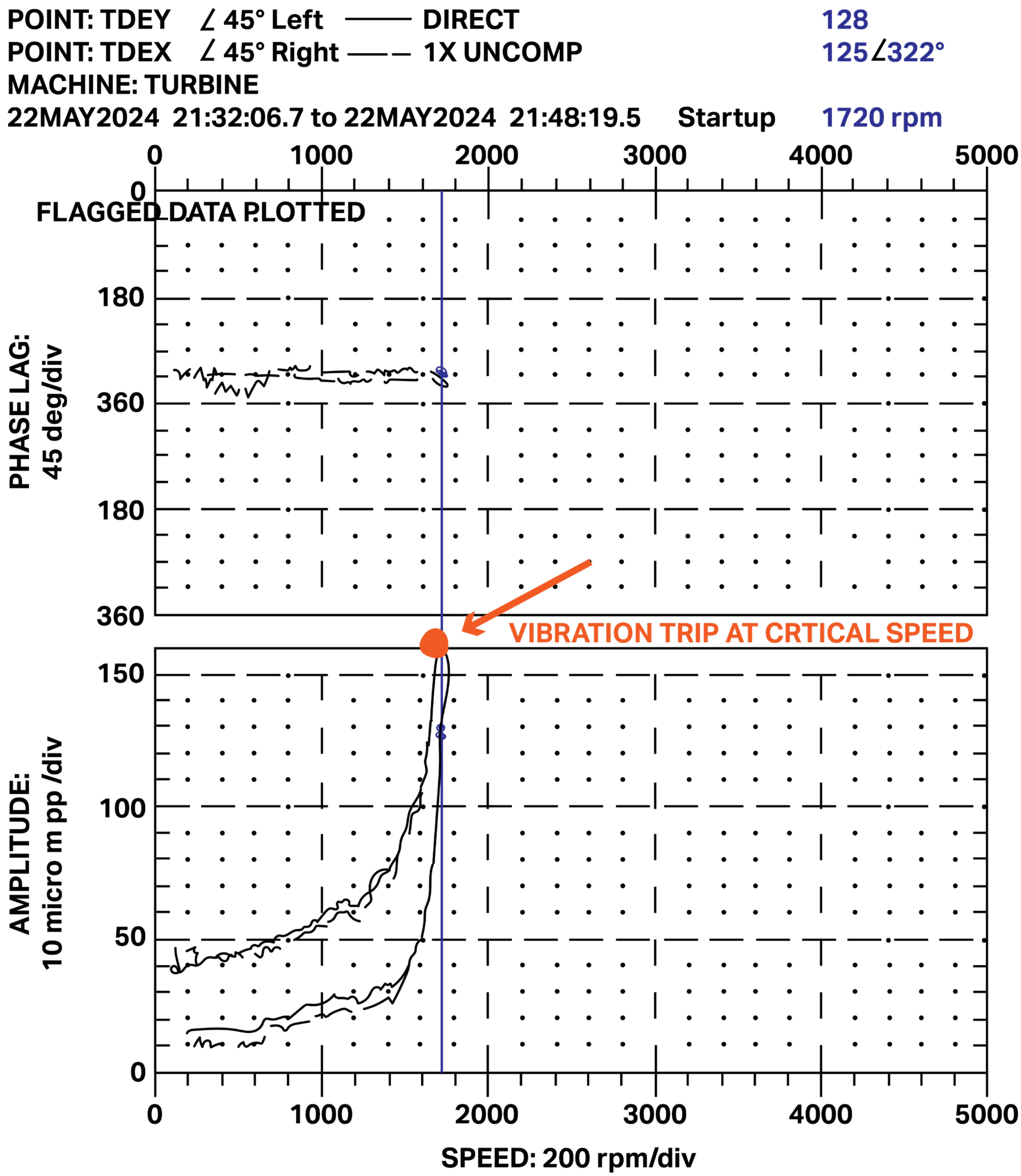
Orbit Plot at Critical Speed

Shows high vibration with high preload:



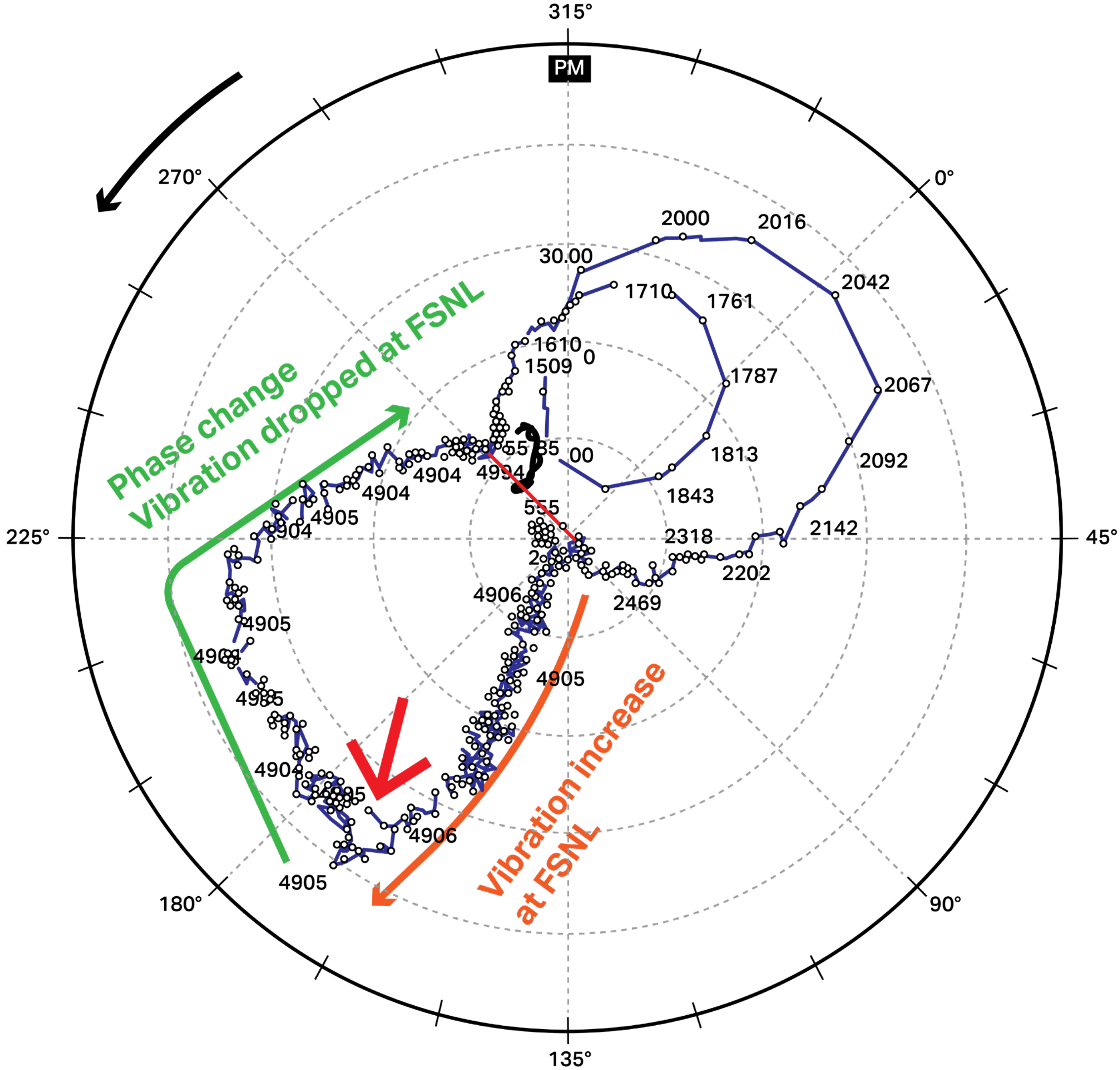
Bode Plot TDE

Tripped due to quick start - Levels up at 156 µm pp:



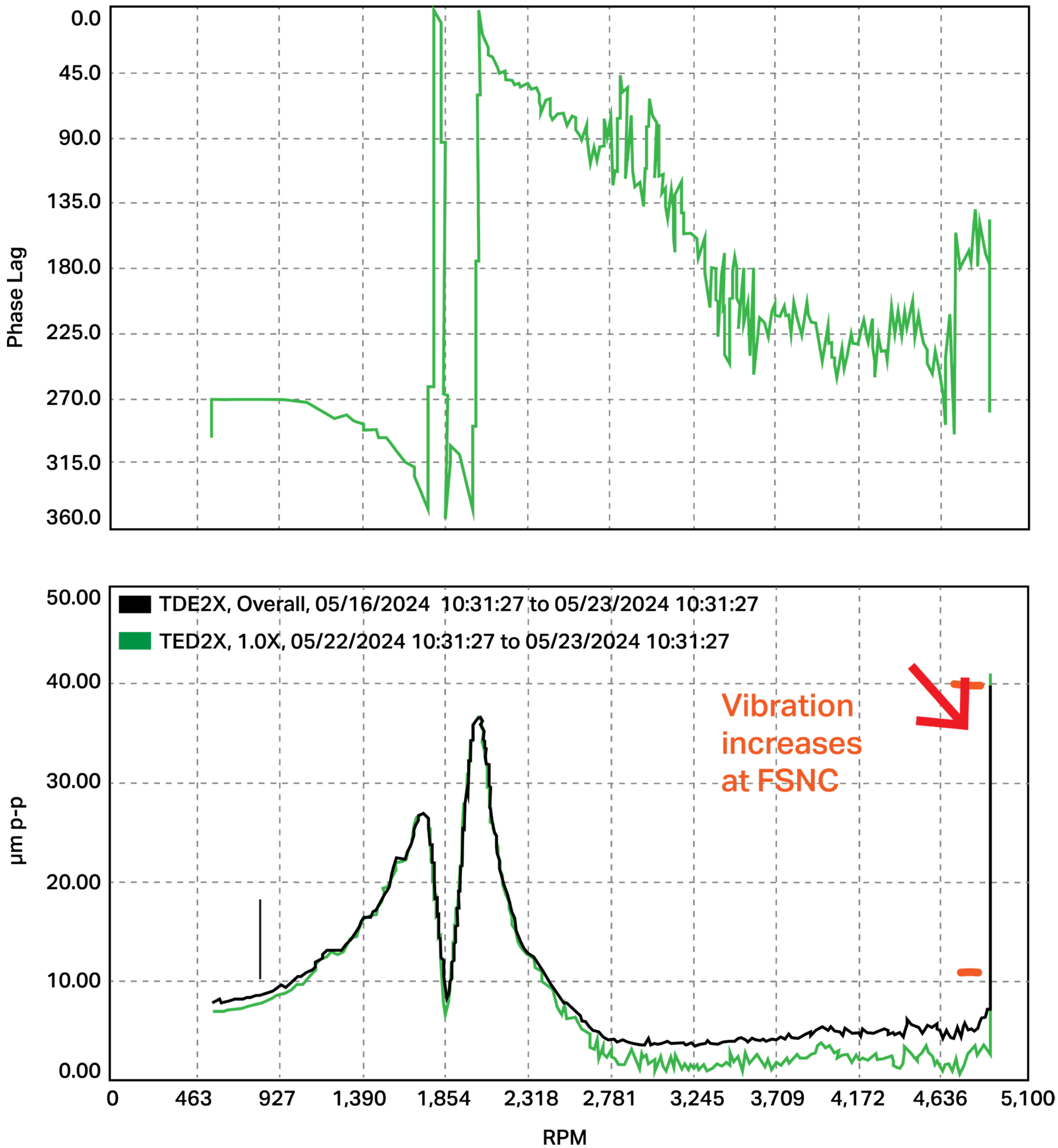
Polar Plot

For first run-up:



Bode Plots

For first run-up:



Outcome
This optimized run-up sequence proved effective, allowing the turbine to operate at full speed without tripping alarms or excessive vibration levels. The careful management of the turbine's thermal sensitivity was key to this success.

Conclusion
This case study highlights the critical importance of following the correct sequence during the run-up of a steam turbine. Proper planning and execution are essential to maintaining machine health and avoiding sudden damage or failure.