GTSE Service Engineering Vibration Trend Data Analysis

Timothy S. Irwin, P.E.

Vibration Trend Analysis Training

This document provides training and guidelines for performing initial trend analysis of changes in a machine’s vibration signature.

Vibration Monitoring System Introduction

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Review - **Vibration Transducer and Monitoring System Introduction**

Highlights

- Various Components
- Measurement Parameters
- Proximity Probes
- Seismic Probes
- Keyphasor™

GT Faults that can affect Vibration

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- Imbalance - mass change
  - Blade sequencing issue
  - Balance weight loss
  - Blade material loss
  - Mis-machined rotor (physical mechanical runout)
  - Rotor Bow
- Bearing condition
  - Excessive clearance (bearing to shaft)
  - Excessive clearance (bearing shell to housing)
  - Babbitt profile
  - Liner/pad wear

GT Faults that can affect Vibration

- Alignment
  - GT to Gen shaft alignment – misaligned
  - Coupling face runout issues (axial)
- Shaft Cracks
- Rub
  - Components
    - Inner-stage seals
    - Blade Tips
    - Bearing shaft seals
      - Oil Coking
    - Torque Tube seals

GT Faults that can affect Vibration

- Rub - continued
  - Casing Distortion
    - Pipe Support issues
    - Expansion Joint Issues
    - Trunnion Support Issues
    - Torsion Bar
    - Cat-back
  - Rotor Issue
    - Rotor Bow
      - Thermal sensitivity
      - Mechanical bow
        - Thermal distortion
        - Through bolt torque/tightness
      - Mis-machining

Generator/Exciter Faults that can affect Vibration

Generator/Exciter Faults that can affect Vibration

- Imbalance
  - Cooling air fan material
  - Loss of balance weight
  - Mis-machined rotor – physical runout
  - Rotor Bow
- Alignment
  - GT to Gen shaft alignment – misaligned
  - GT to Exciter shaft alignment - misaligned
  - Coupling face runout issues (axial)

Generator/Exciter Faults that can affect Vibration

- Bearing Condition
  - Excessive clearance (bearing to shaft)
  - Excessive clearance (bearing shell to housing)
  - Babbitt profile
  - Liner/pad wear
- Rubs
  - Components
    - Bearing Seals
    - Hydrogen Seals
- Thermal Sensitivity
  - Sticking Winding(s)
  - Shorted turn to turn windings

PI Trend Data Points

PI Trend Data Points

- Vibration Points
  - Proximity Probe (relative) channels (shaft movement relative to probe)
    - Typically orthogonal probes 45 degrees from top dead center (X & Y)
    - Could be a single probe at top dead center
  - Seismic Probe channels (bearing housing movement)
    - Typically will also be orthogonal probes at 45 degrees from top dead center matching the proximity probe positions (X & Y)
    - Can also be a single probe at each bearing (although many sites only have 1 vertical) (location - top dead center)
  - Refer to Transducer and monitoring system introduction presentation

PI Trend Data Points

- Bearing Metal Temperatures
  - Thermocouple that is mounted into the bearing shell that should have the tip of the thermocouple inserted into the babbitt. Babbitt thickness over the tip can vary from 0.020” to 0.040”
  - Thermocouple location should be in the load zone of the bearing.
- Bearing Drain Temperatures
  - Thermocouple installed in bearing lubrication drain line just outside of the bearing housing.
  - As bearing temps increase, drain temp will also increase
  - But this is a lagging indicator and responds much slower to changing bearing conditions
- Bearing lube oil supply
  - Temperature
  - Pressure

PI Trend Data Points

- Axial Thrust Position
  - Proximity probes mounted so that axial position of the rotor within the thrust bearing can be monitored
  - Most GTs do not have this data, but some do
- Operational Data that could be relevant to data analysis
  - Shaft Speed
  - Compressor Bleed Valves
  - Megawatts (and ramp rates)
  - MegaVars
  - IGV position
  - Casing temperatures

PI Trend Data Points

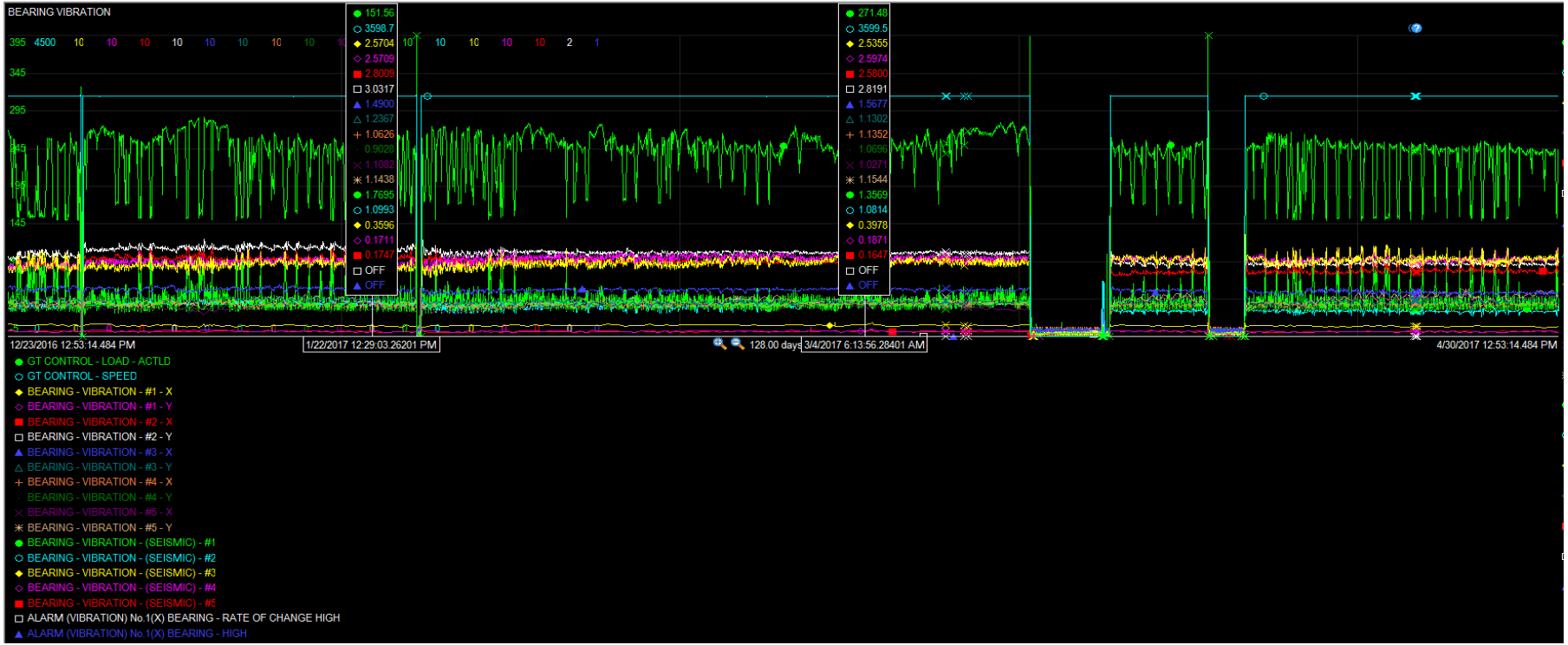
- Generator
  - MW
  - MVars
  - Stator Voltage/current
  - Excitation voltage/current
  - Hydrogen seal oil pressure/temperature
  - Hydrogen/Air cold gas/hot gas temperatures

PI Vibration Data Analysis Triggers

PI Vibration Data Analysis Triggers

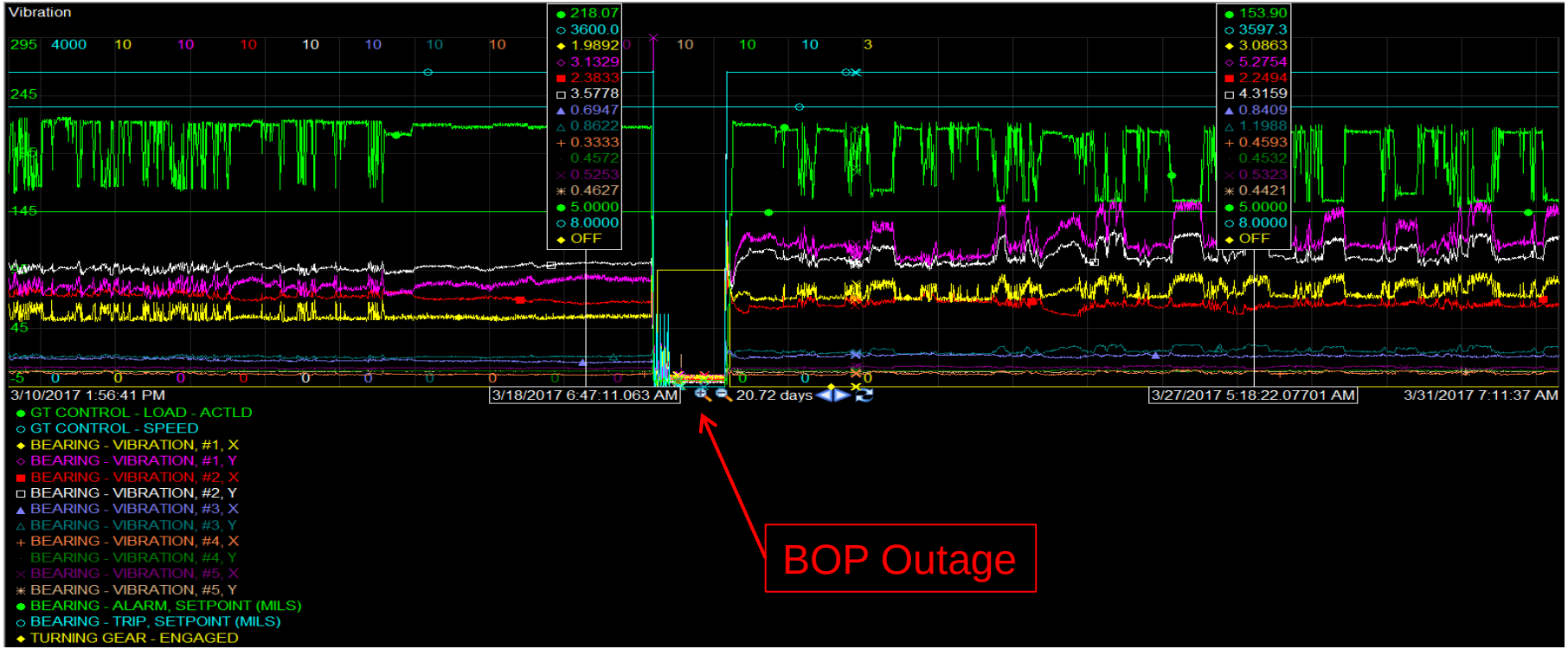
- Gradual change in indicated amplitude levels over a period of time
- Step change in amplitude level during routine operation
- Change in peak amplitude levels during transient conditions
  - Load ramps
  - Speed ramps (startup or coast down)

PI Vibration Data Analysis Triggers – gradual change



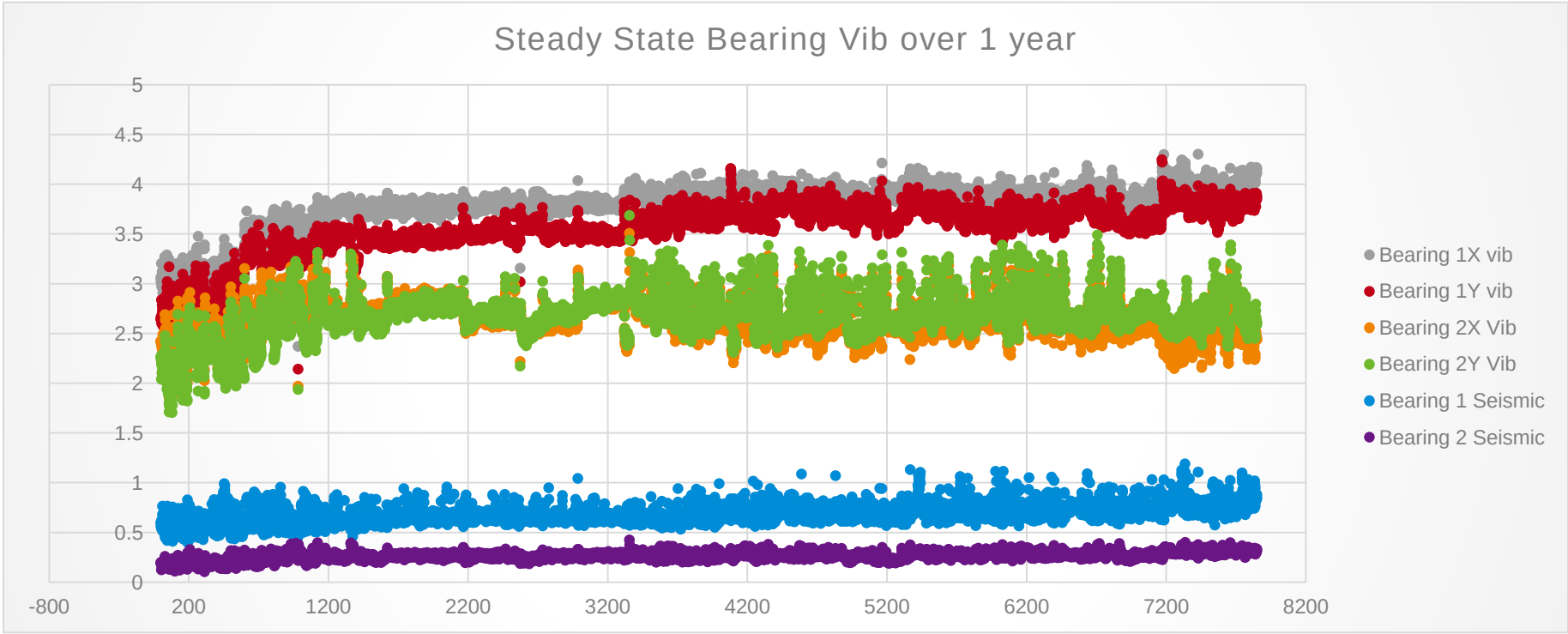
The trend above provides a general overview of the machine changes over the last four months. The trends on the following pages will provide details on the observations. Over the last four months changes of 0.1 to 0.4 mils are evident on several channels. Initial request was for 30 day trend review.

PI Vibration Data Analysis Triggers – changes with load



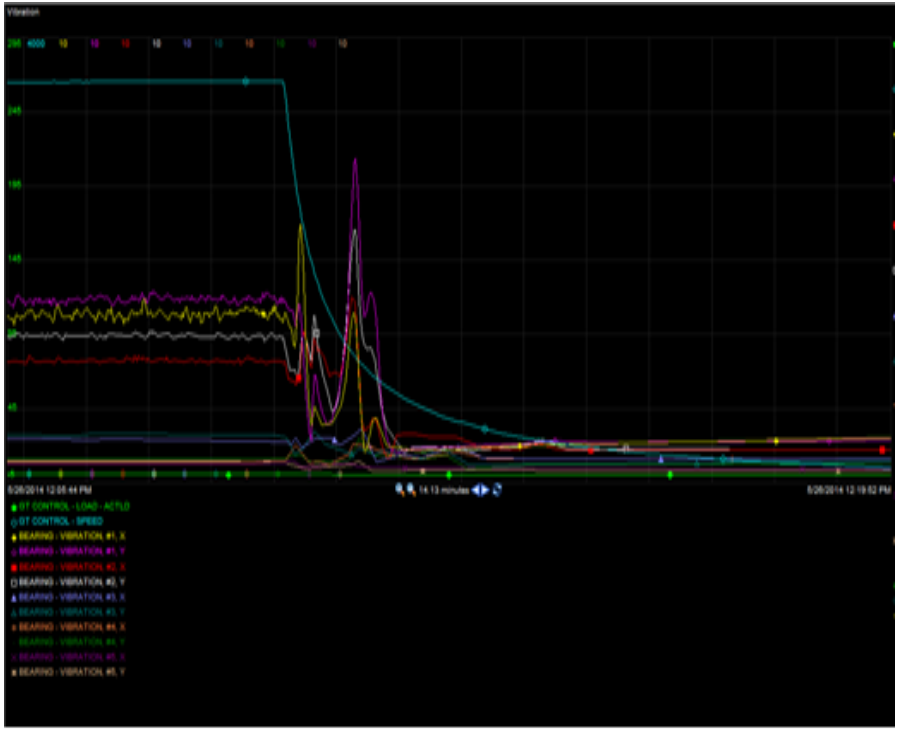
The above trend plot shows the time frame around the 03/20/17 startup that resulted in higher steady state vibration amplitudes then during the previous operational time frame. Note the changes from pre-shutdown to post shutdown in the #1 and #2 bearing amplitudes and behavior. Initial evaluation request was on 5 mils amplitude during operation

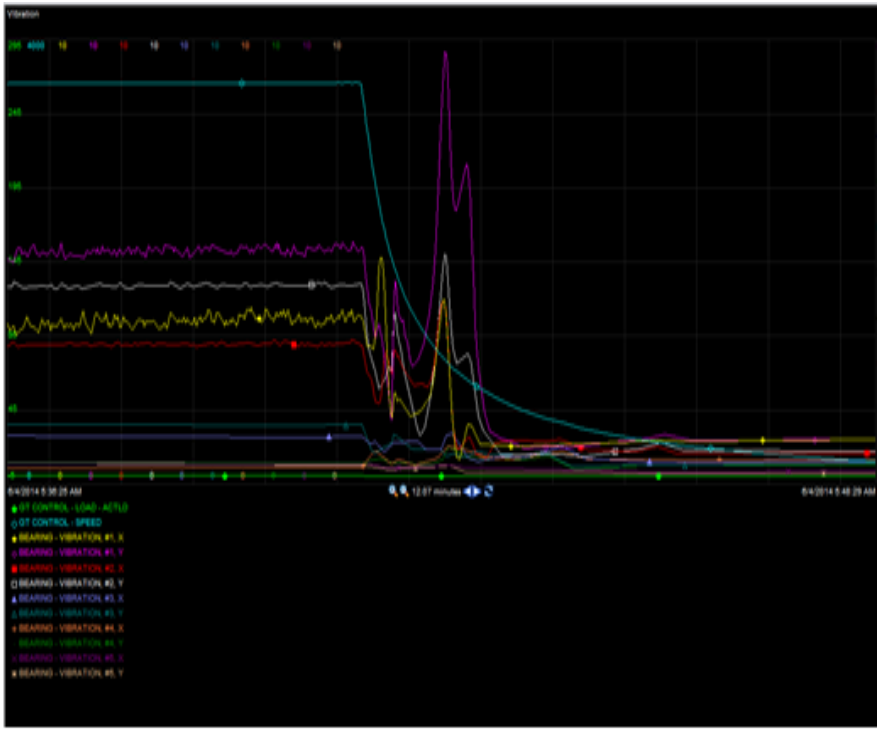
PI Vibration Data Analysis Triggers



The charts above (supplied by the RMC) show that the steady state vibration amplitude levels over the last year had increased. Most of that change occurred within the first 2 months, but there have been additional smaller step changes up as noted above. Initial request was to review the amplitude increase in operational amplitudes

PI Vibration Data Analysis Triggers – changes with load

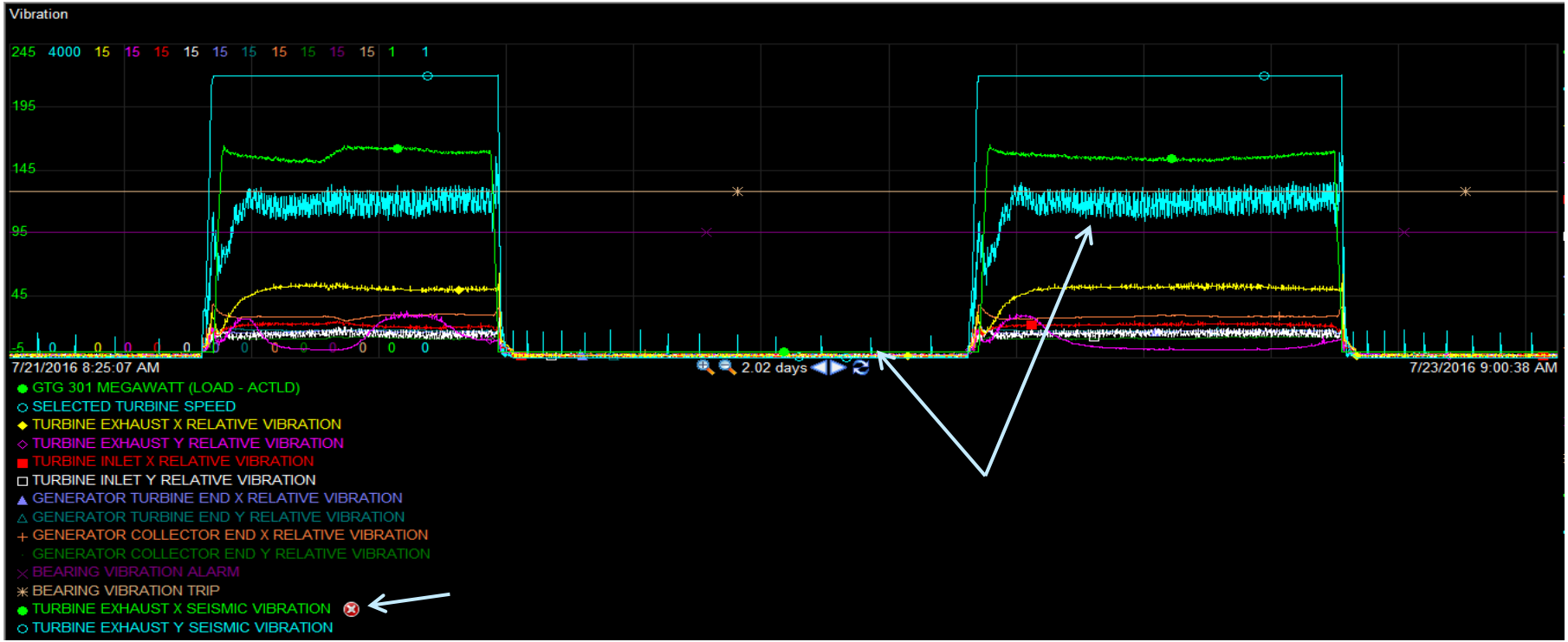




The above trend plots show the coast downs on 5/26 compared to 6/4 after a CI outage was performed. Initial request was to evaluate the high amplitude levels on the 6/4 coast down.

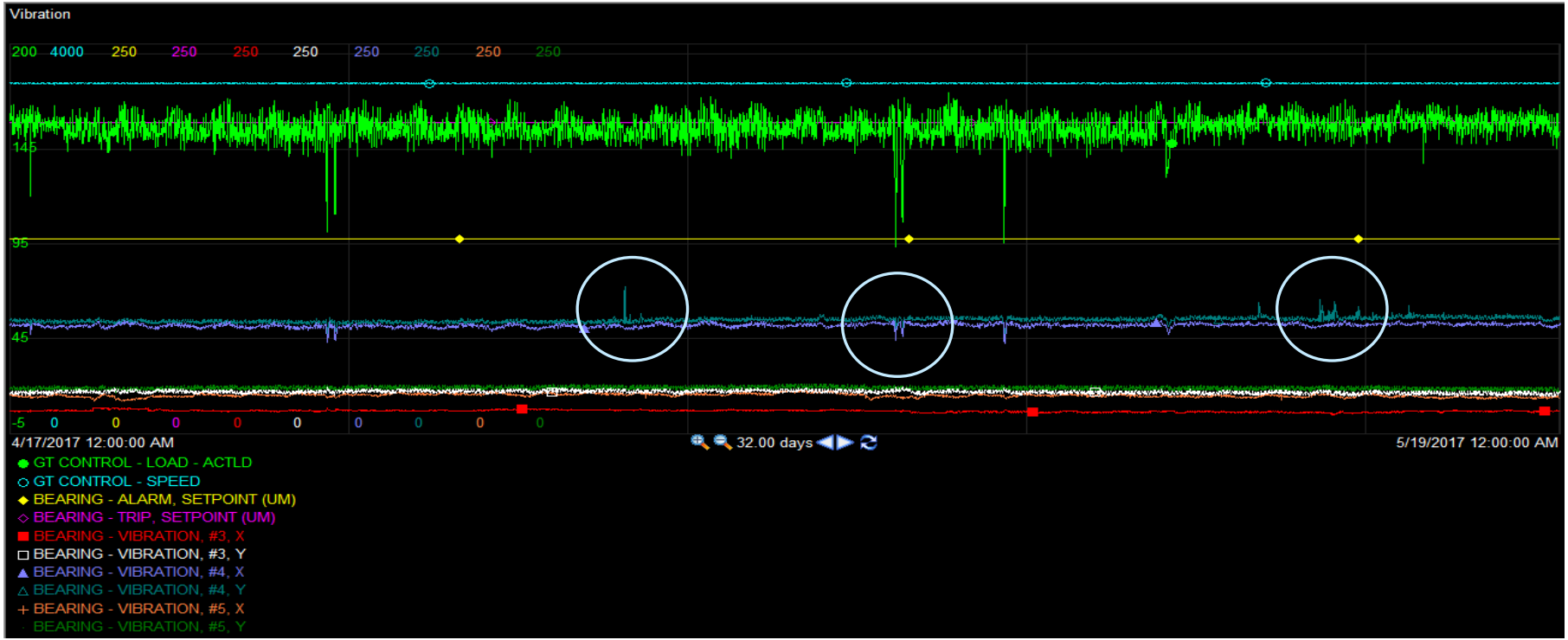
Transducer Errors (Glitch)

Transducer Errors



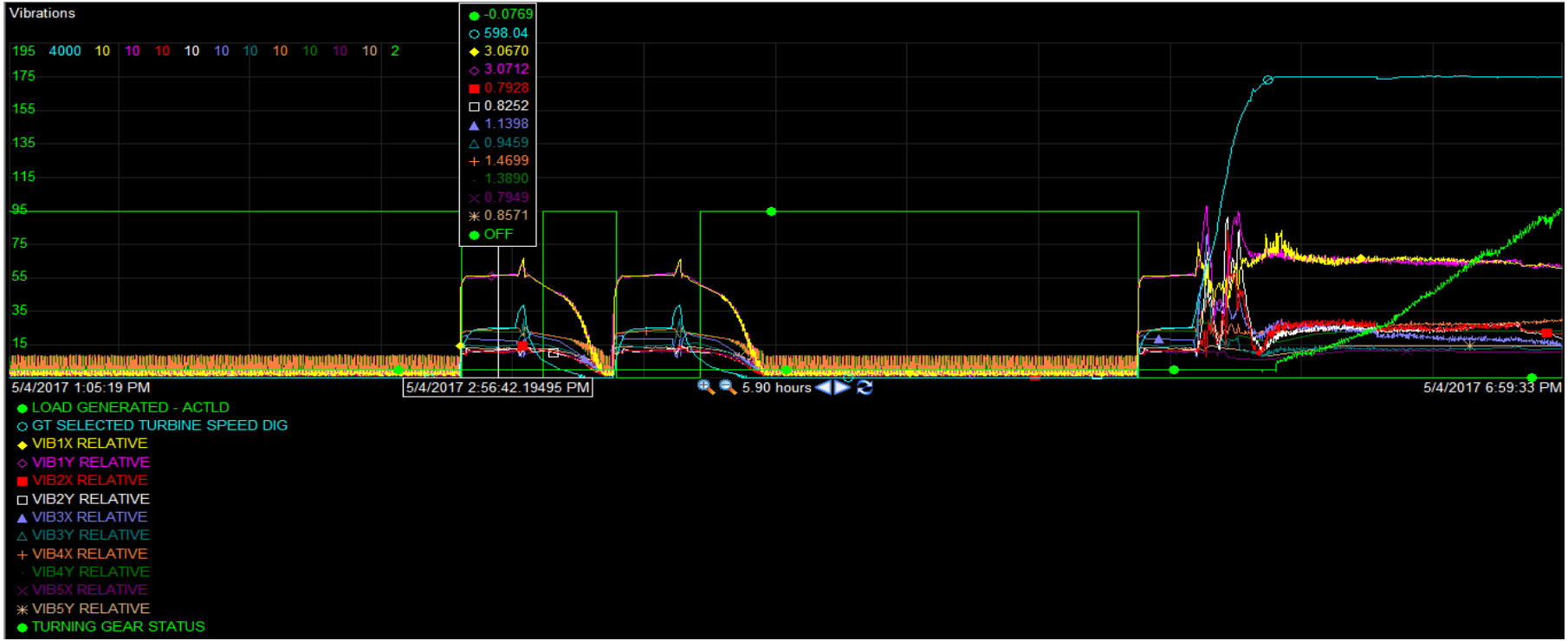
The plot above shows two conditions on seismic probes – ‘bad’ quality signal for one transducer. The other seismic channel shows high vibration levels and a series of spikes when the machine is on turning gear.

Transducer Errors



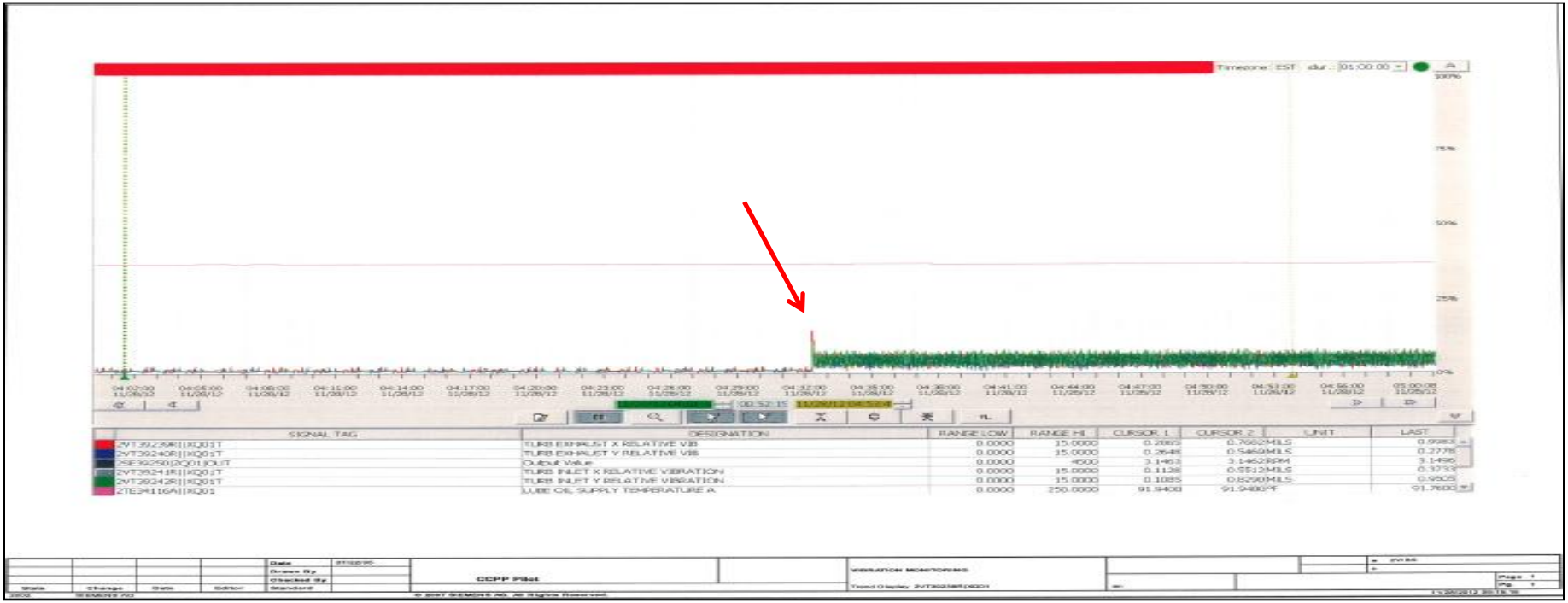
The plot above shows spikes and what appears to be noise in two relative vibration channels.

Transducer Errors



The plot above shows actual mechanical runout in a shaft that affects the indicated vibration signal. The cursor is at ~ 600 rpm spin purge for a gas turbine prior to startup. At only 600 rpm the #1 bearing channels are indicating over 3 mils of vibration. It is known that this is an actual mechanical runout in the journal.

Transducer Errors - ?



The charts above (a DCS System) show a machine that is on turning gear already, and then there is a change in the indication during turning gear operation. A spike and then a change in noise floor. Think about the physical assembly of the machine and what could change that would cause a change in rotor condition while on turning gear (this was on a large frame gas turbine).

Investigation Checklist

Investigation Checklist

- Understand the trigger for the investigation request as best as possible
- What's the history of the machine (recent, older, etc.)
- Considerations for timing of signature change:
  - After an outage?
  - Between outages?
  - Was there an operational change?
  - Has the site performed any investigation to date?
  - Does the site have any vibration data available besides PI trend data?
- Which bearing is the issue:
  - Turbine
  - Generator
  - Exciter

Investigation Checklist

- Vibration Trends
  - Relative channels
  - Seismic channels
  - Are axial thrust position channels available?
  - Determine timing for vibration data reviews
    - Startups
    - Coast downs
    - Steady state
    - Recent, historical (1 week, 1 month, 6 months, 1 year, previous years, etc.)

Investigation Checklist

- Additional operational data that may be relevant
  - Lube oil conditions
  - Bearing temperatures
  - Operational conditions
    - Load (MW)
    - Reactive load (MVARS)
    - IGV
    - Compressor bleed valves
    - Exhaust Temperatures
    - Casing Temperatures

Investigation Checklist

- Machine data that may be relevant
  - Last known alignment
  - Last assembly data
    - Spindle clearances
    - Blade ring alignment/Blade tips
  - Exhaust bearing sag
  - Turbine Trunnion maintenance
  - Exhaust Manifold Supports
  - Exhaust expansion joint
  - Piping support maintenance
  - Foundation Bolting tightness
  - Foundation Condition

Plot Setup

Plot and Report Setup

PI Plots

- Want to use at least a ‘10 font’ in all plots. Font should be same in all plots within a given report
- Take complete screen shots, unless there is a reason not to (i.e. presentation for industry)
  - Want to see data point IDs and point names for future reference

Report pages

- Always use latest template
- Use same size plot for pages as much as possible; and same location on the page; same goes for the text boxes
- Multiple plots per page can be used, but should be limited depending on detail desired
- Scale for best representation of condition being evaluated
  - Most of the time I leave the ‘database’ default for scale; but will change as needed
  - I use the default as it shows the overall condition of the machine relative to alarm/trip setpoints
- Use same scales throughout the report
- Keep observation Summaries and Recommendations as separate items

Summary

To perform accurate meaningful vibration analysis requires considerable information

- Understanding of the machine
  - Operational behavior
  - Physical configuration
- Operational conditions
- Historical information
  - Operation
  - Maintenance

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