51ST TURBOMACHINERY & 38TH PUMP SYMPOSIA

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Power Turbine Field and Shop Balance Experience

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Presenter/Author Bios

Dr. John Yu joined Bently Rotor Dynamics Research Corporation in 1998, followed by General Electric - Bently Nevada in 2002. He has performed not only rotor dynamic research but also machinery vibration diagnostics for customers worldwide and is now Global Technical Leader of Machinery Diagnostic Services at Bently Nevada. He has over 50 technical papers in peer-reviewed journals and conference proceedings. He holds a PhD in Mechanical Engineering from University of Alberta and is an ASME Fellow. He currently serves as an Advisory Committee member to the Asia Turbomachinery & Pump Symposium.

Mike Kirker joined General Electric Corporation in 1988 working with the U.S. Navy in the Naval Nuclear Propulsion Program, followed by GE Power Gas Turbine Packaging Engineering in 1993. He continued his career transitioning to Supply Chain Management in 1999 before returning to Engineering in 2007 as Engineering Master Black Belt for the Aeroderivative business where he certified in DFSS. He holds a BSME from Clarkson University, a MSME in Mechanical Engineering from Western New England University and an MBA from Texas A&M. He currently serves as Senior Customer Service Leader covering the LMS 100 Fleet in Texas.

Dr. Nicolas Peton joined GE in 2006 as Machinery Diagnostic Services engineer. Previously he worked for Alstom steam turbine and Cryostar expander/compressor where he was in charge of on-site startups. He also worked as an operation and maintenance engineer in chemical industry in US and as Free Lance for startup activities. He has been also a mechanical/acoustical research engineer at Technion Haifa and TU Berlin. He is currently Global Director of Machinery Diagnostic Services. He is also a member of Texas A&M International Pump Symposium Advisory Committee. He has a Diplome d’ingénieur and a PhD from Université de Technologie de Compiègne, France.

Abstract

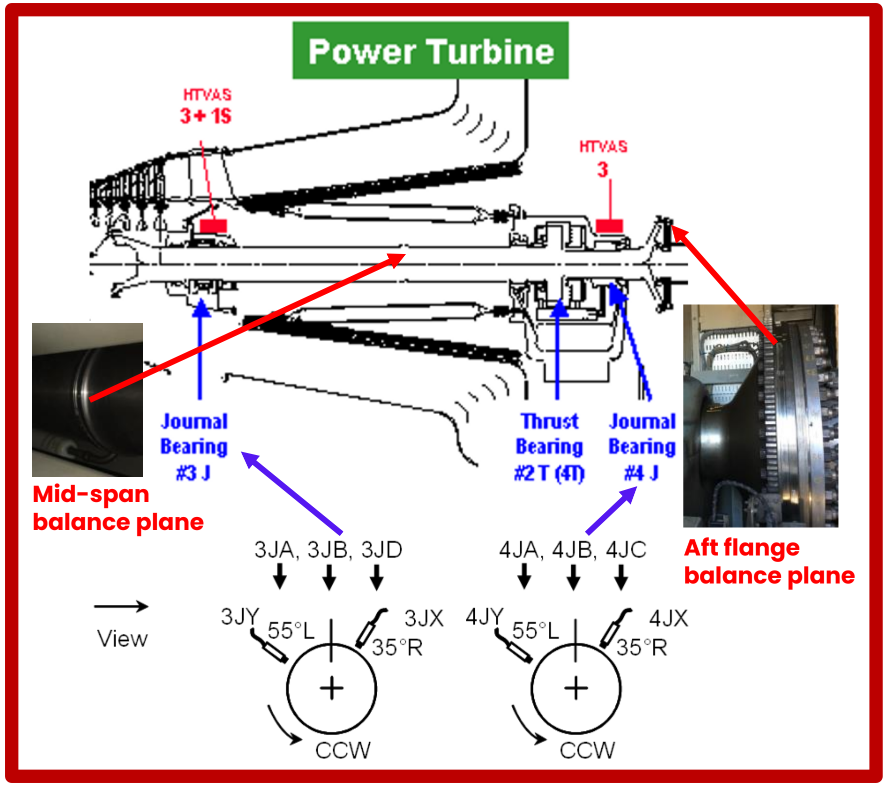
A power turbine (PT) experienced a high 1X vibration issue. Balancing was attempted at two accessible planes on the shaft section. However, the unit could only operate with vibration below the alarm level in steady-state condition while experiencing over 10 mil pp and 1 in/sec pk in transient condition, which is not acceptable. A decision was made to remove the PT section for workshop balance. Indeed, excessive unbalance was measured on it at workshop and then reduced by 97%. Vibration level became very low afterwards at both conditions. From the current case, weight sensitivity or influence data was obtained with respect to the PT section plane. This makes it possible in the future to add correct weights at the PT section on-site without having to ship it for workshop balance. The lesson learned here is that obtaining balance influence data from available balance planes at all different running conditions is very important to see if it is feasible to reduce vibration to an acceptable level at all these conditions by using the available balance planes. If not, an alternative must be found, instead of vain attempts.

Outline

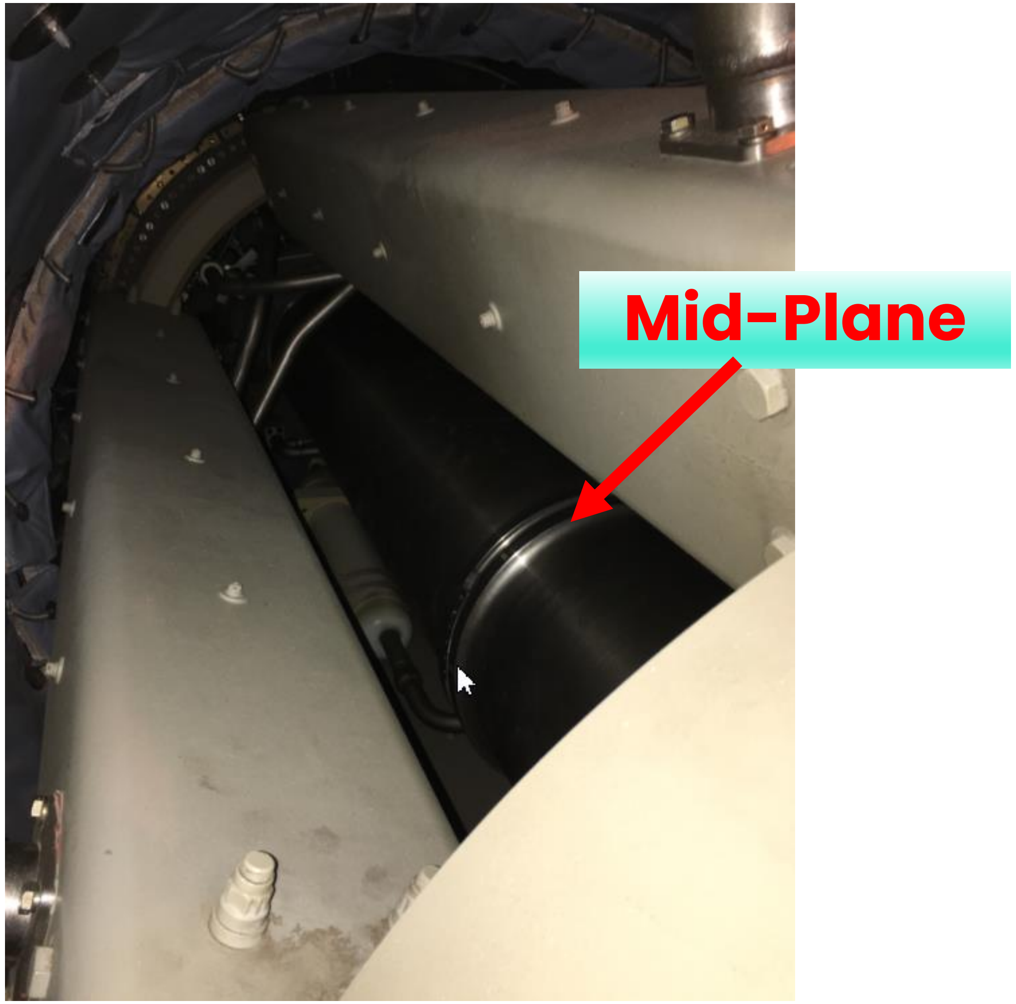
1. Introduction
2. Problem Statement
3. Data Review
4. Observations and Diagnostics
5. Conclusions and Recommendations
6. Power Turbine Shop Balance and Findings
7. Lessons Learned and Values Added

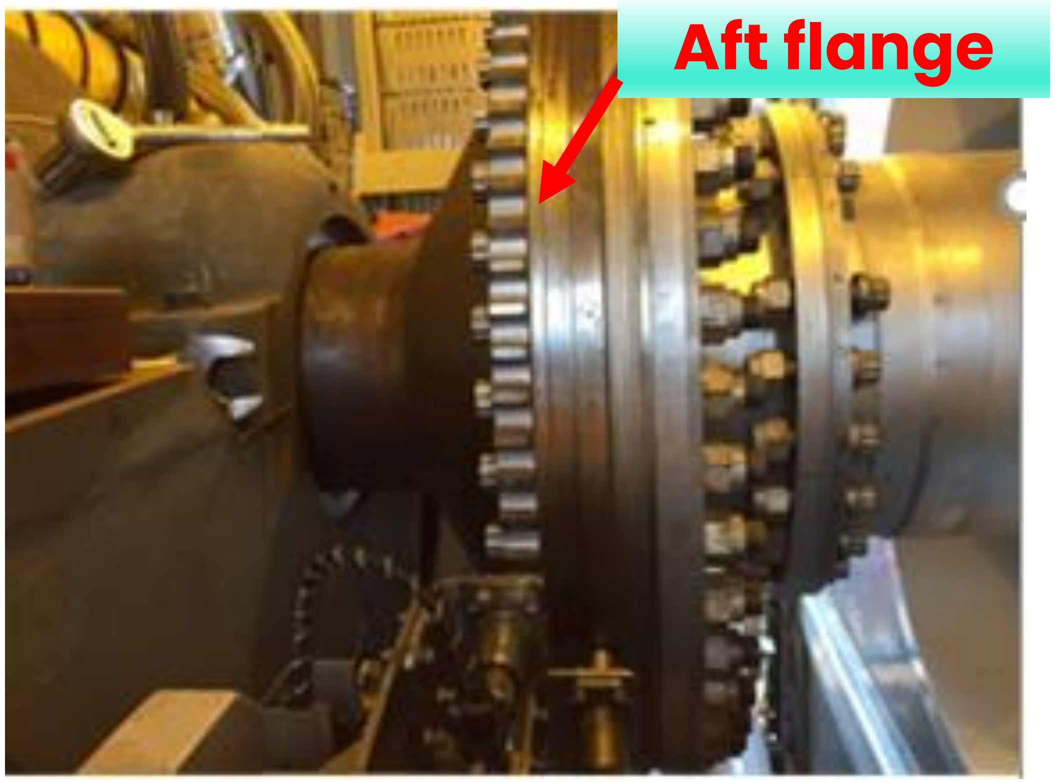
1. Introduction – power turbine

- A power turbine, driven by an aeroderivative gas turbine, and driving an air-cooled generator
- Supported by two fluid film bearing bearings
- Rated speed of 3600 rpm
- Vibration monitored by a pair of proximity probes along with 3 seismic transducers on top of the bearing casing at each bearing



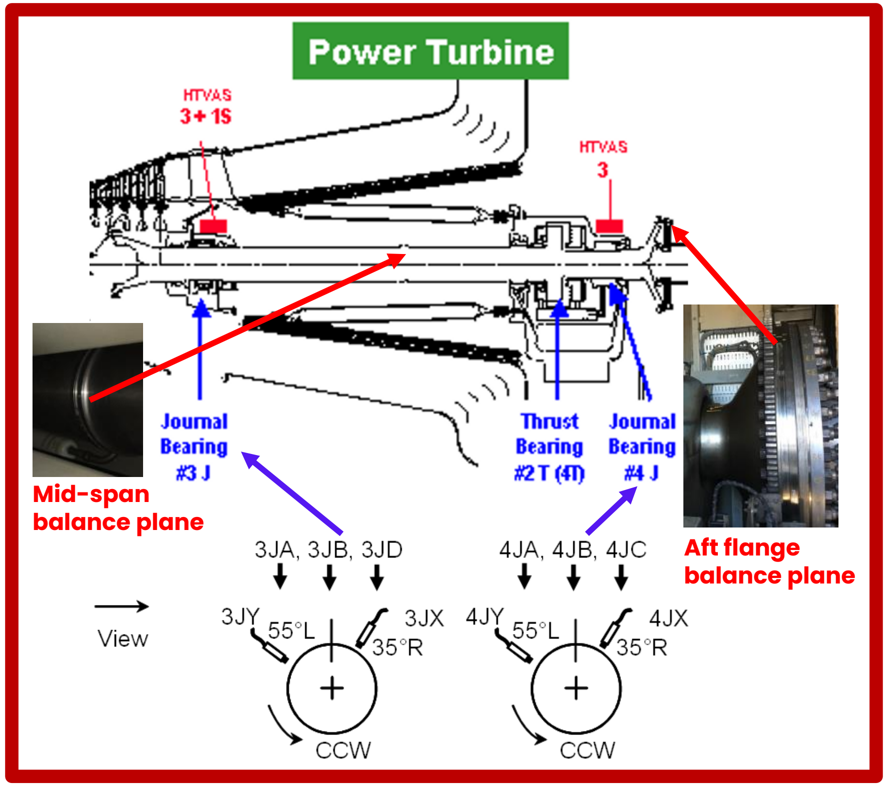
1. Introduction – power turbine field balance planes



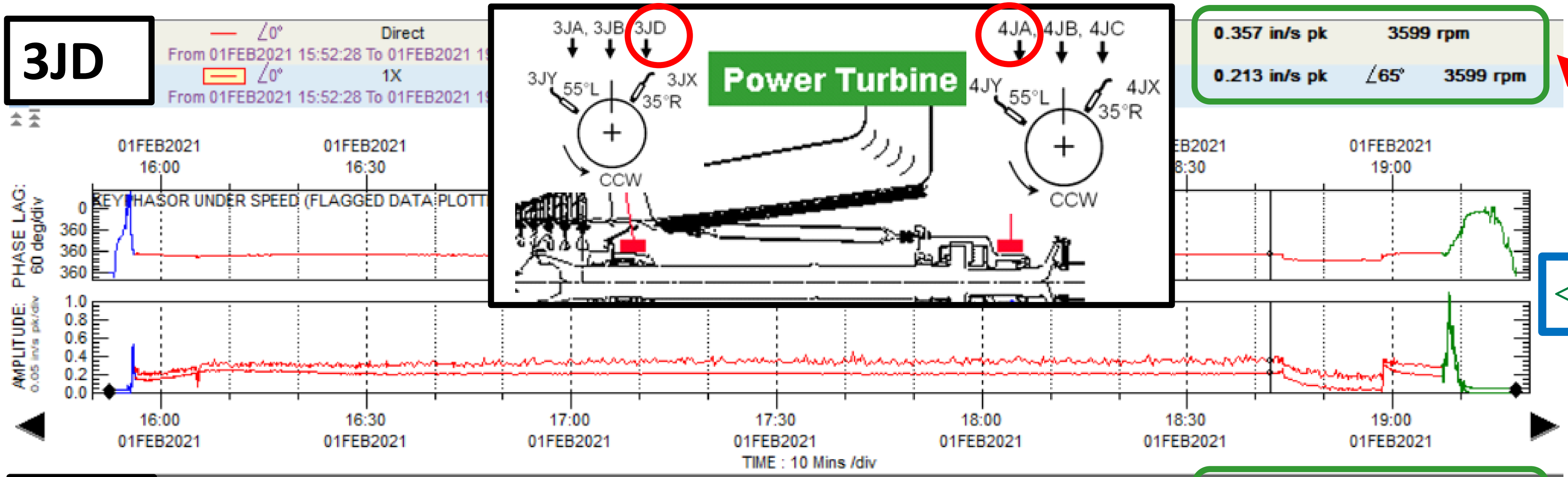


2. Problem Statement – high 1X vibration

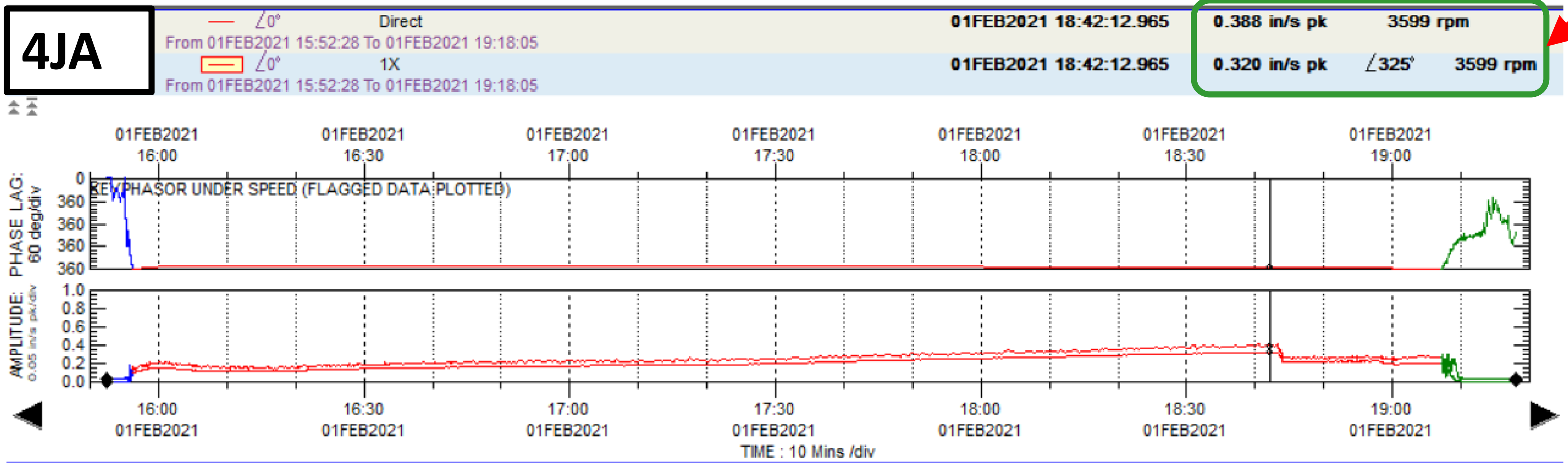
- Site experienced high 1X vibrations during operation of the power turbine.
- Field balancing was chosen to reduce the vibration without removing the rotor from the casing.
- Two field balance planes were available to add balance weights (as shown below).



3.1 Data Review – steady-state vibration from seismic sensors

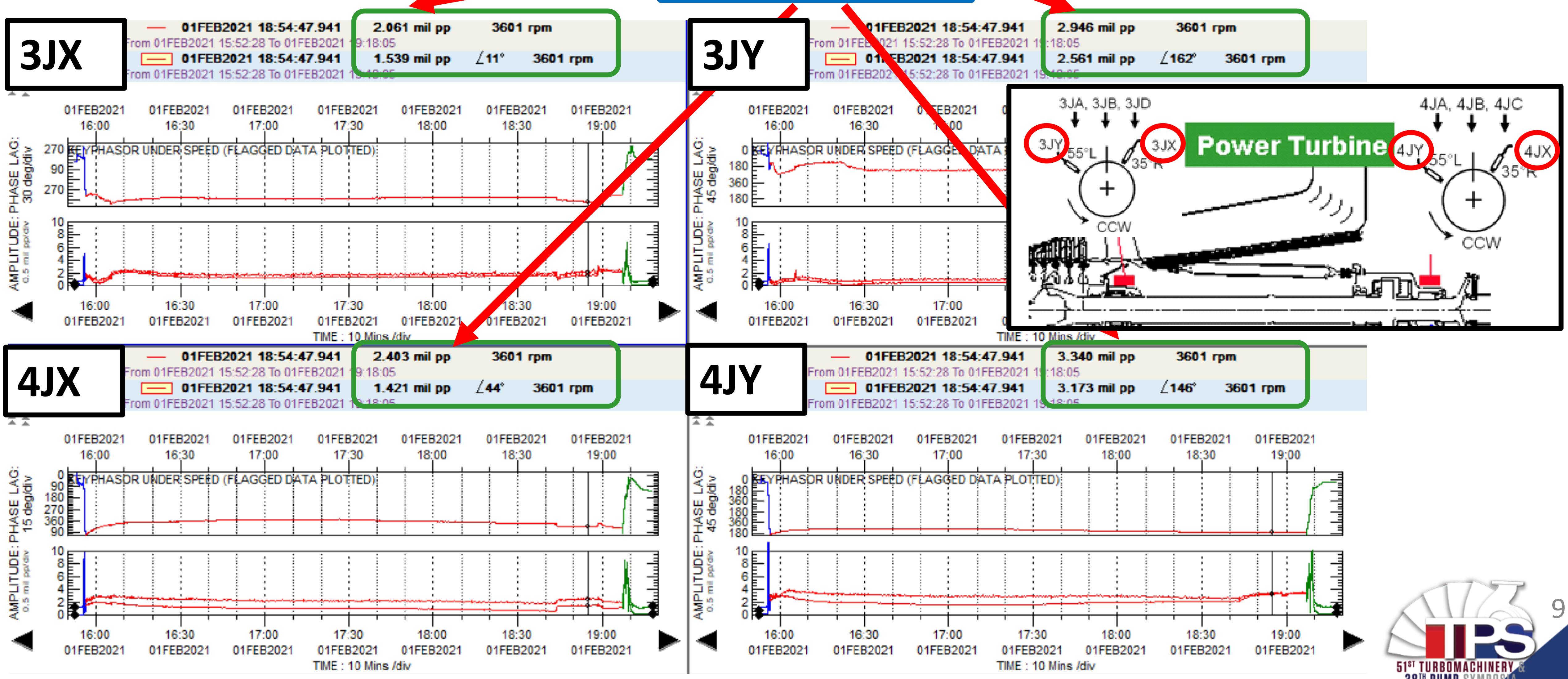


< 0.5 in/s pk (alarm)



3.2 Data Review – steady-state vibration from proximity probes

< 6.5 mil pp (alarm)



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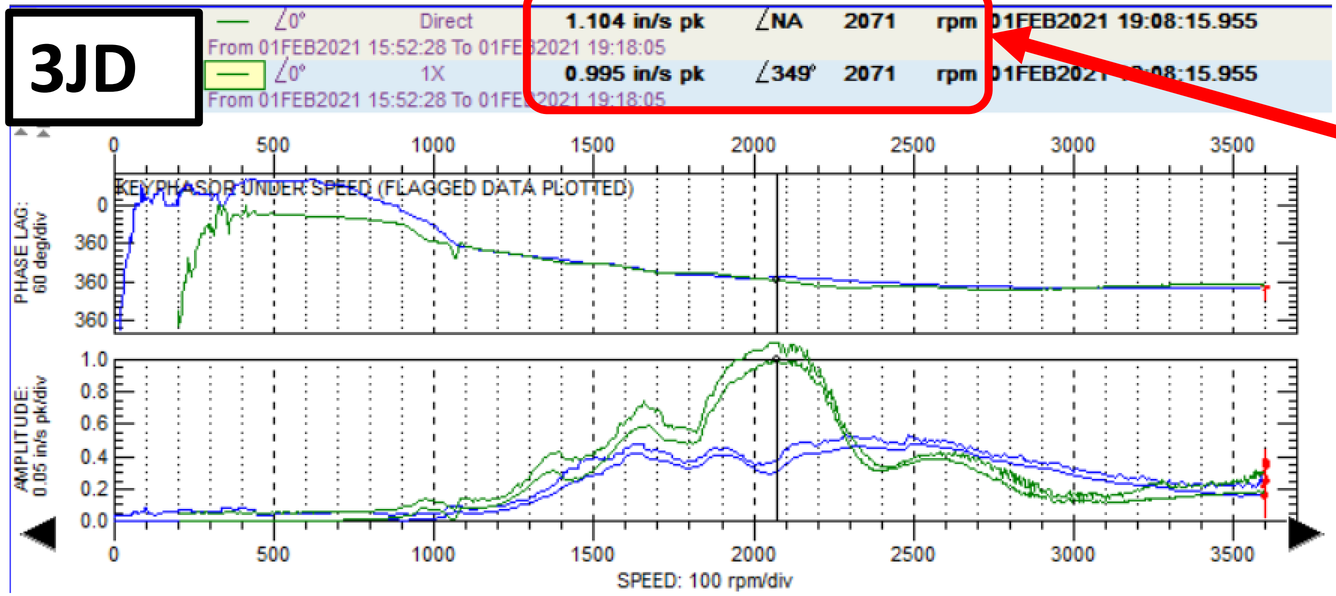
3.3 Data Review – Bode plots from seismic sensors

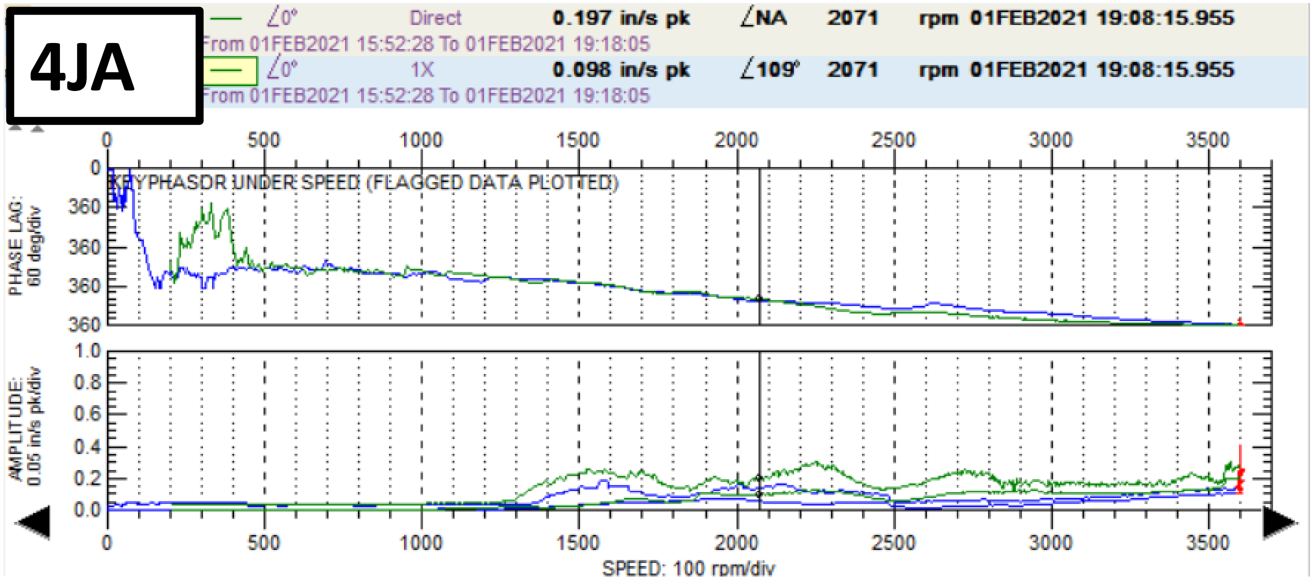
3JD

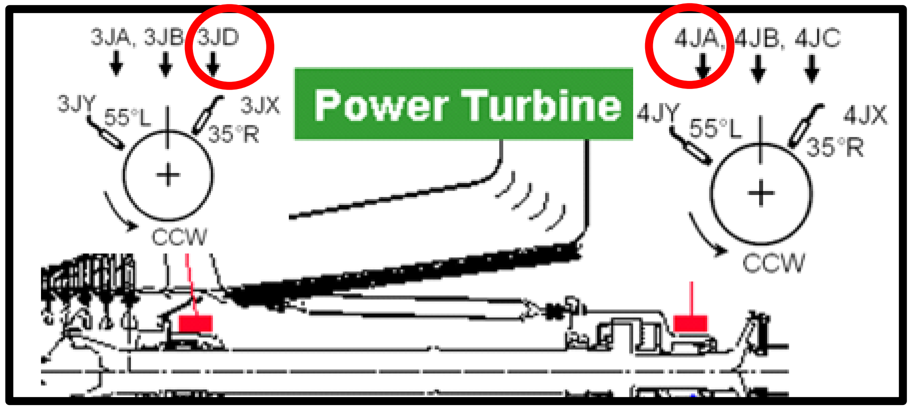


~ 2000 rpm during coastdown:

3J ≈ 1.0 in/s pk

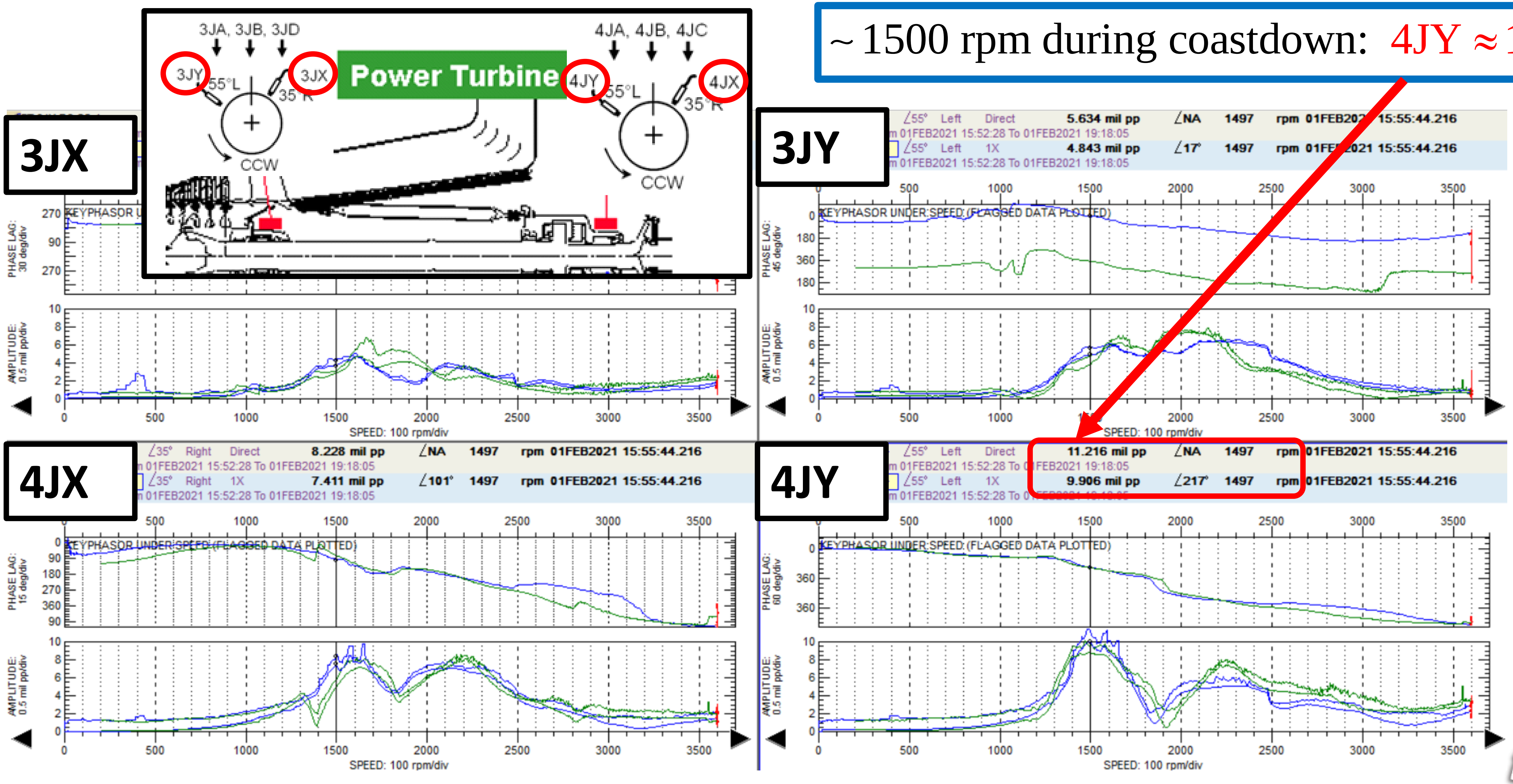
4JA



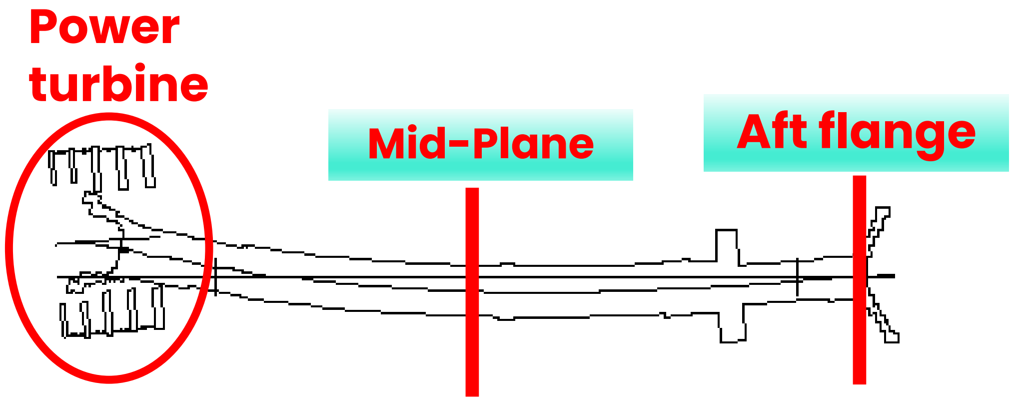


3.4 Data Review – Bode plots from proximity probes

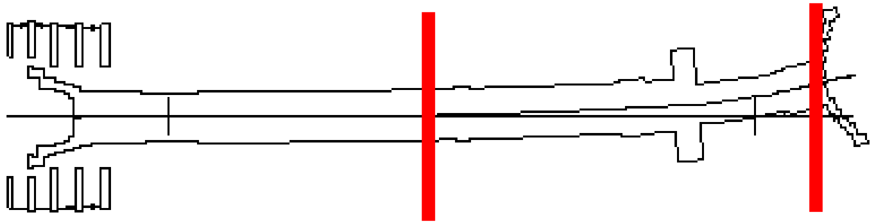
~1500 rpm during coastdown: 4JY ≈ 10 mil pp



4. Observations and Diagnostics



Mode 1 = 32.8 Hz (related to 1500 - 2000 rpm critical speed)



Mode 2 = 56.8 Hz (related to rated speed 3600 rpm vibration)

- **Attempts at placing correction weights at mid-span and aft flange did not produce acceptable results.**
- **A reduction in vibration at either the 1st critical or operating speed was possible but not both.**

No matter how balancing was performed, vibration would be

either

At steady-state condition (3600 rpm): 3J/4J < 0.5 in/s pk → Safe

At critical speed (1500-2000 rpm): 3J ≈ 1.0 in/s pk, 4JY ≈ 10 mil pp → Unsafe

or

At steady-state condition (3600 rpm): 3J/4J > 0.5 in/s pk → Unsafe

At critical speed (1500-2000 rpm): 3J < 1.0 in/s pk, 4JY < 10 mil pp → improvement

5. Conclusions and Recommendations

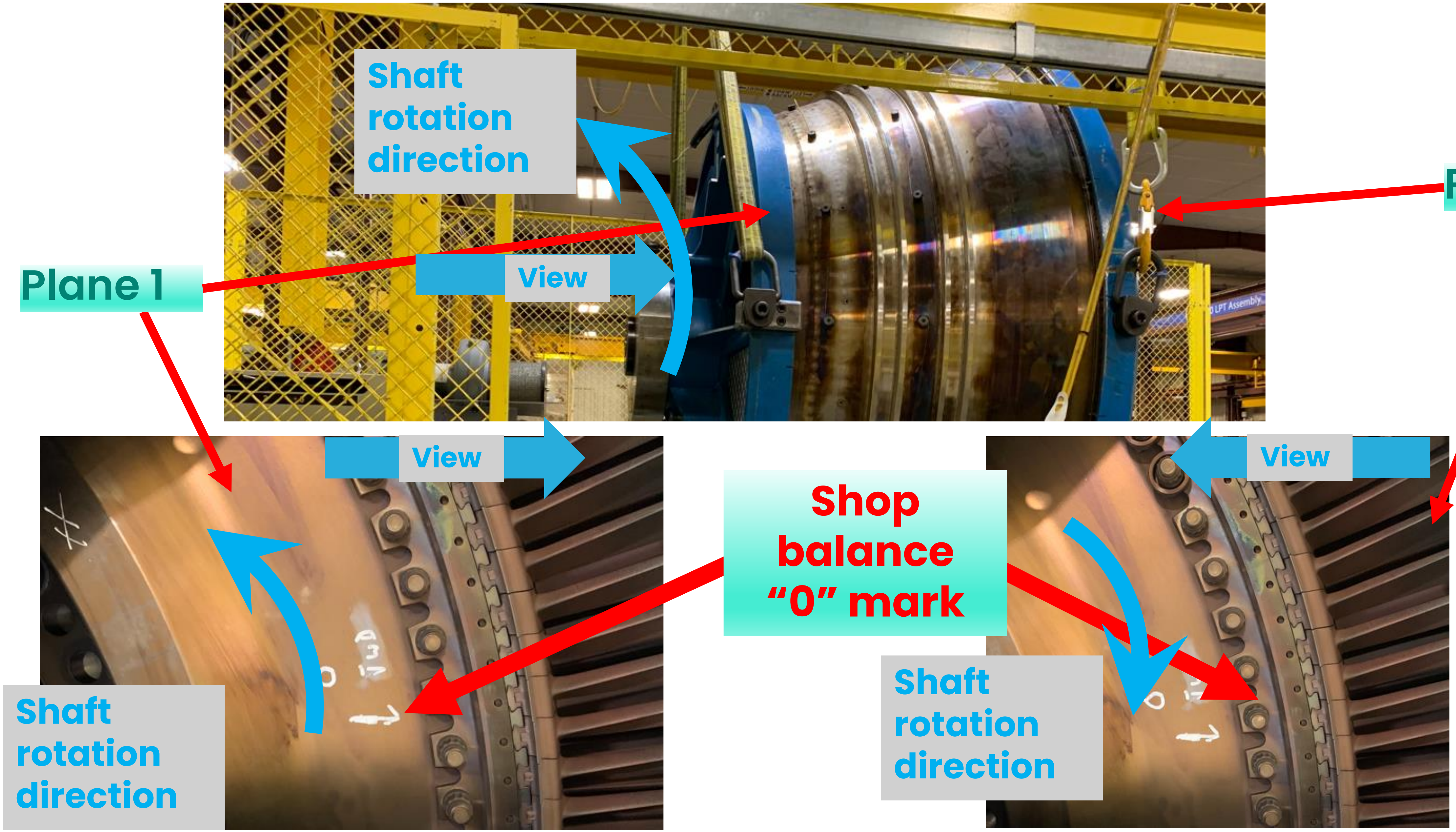
Conclusions:

- Weight placement at Aft flange and Mid-span balance planes alone cannot successfully reduce 1X vibration in both steady-state and transient conditions in this case.
- High peak transient vibration between 1500-2000 rpm needs to be addressed by power turbine balance planes. Very likely the high unbalance occurred at power turbine section.

Recommendations:

- Prior to access power turbine balance planes, weight placement at the available two planes should be such so that low vibration maintains in steady-state condition, and the unit should be run for a longer duration.
- Arrange for power turbine shop balance.

6.1 Power Turbine Shop Balance and Findings– overview



6.2 Power Turbine Shop Balance and Findings– before and after

Before
or
“As found”

Excessive unbalance

Unbalance:

3357 g.in @306°   4011 g.in @306°

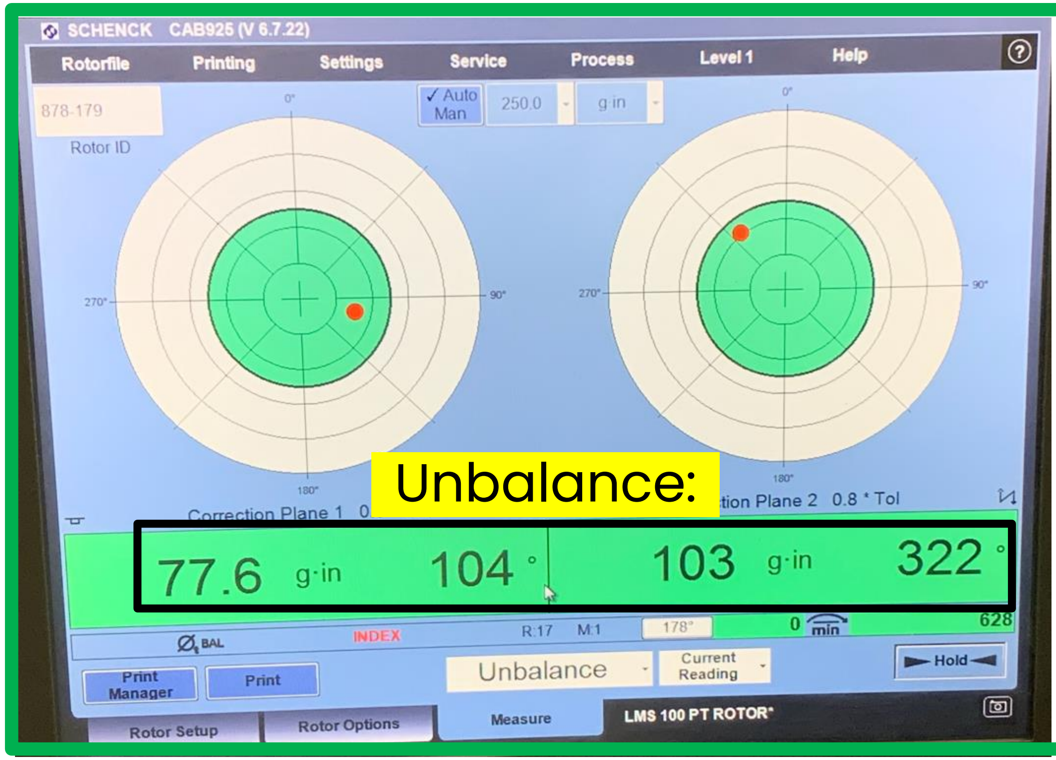
↔

Weights needed to offset:

152 g @126°   189 g @ 126°

	Plane 1 (radius 22.1 “)	Plane 2 (radius 21.2 “)
Unbalance (before)	3357 g.in @306°	4011 g.in @306°
Weights needed to offset (before)	152 g @126°	189 g @ 126°

After
or
“As left”
or
“Corrected”



Unbalance:

77.6 g·in 104 °   103 g·in 322 °

↔

Weights needed to offset:

3.51 284   4.87 142

Unbalance reduced by 97%

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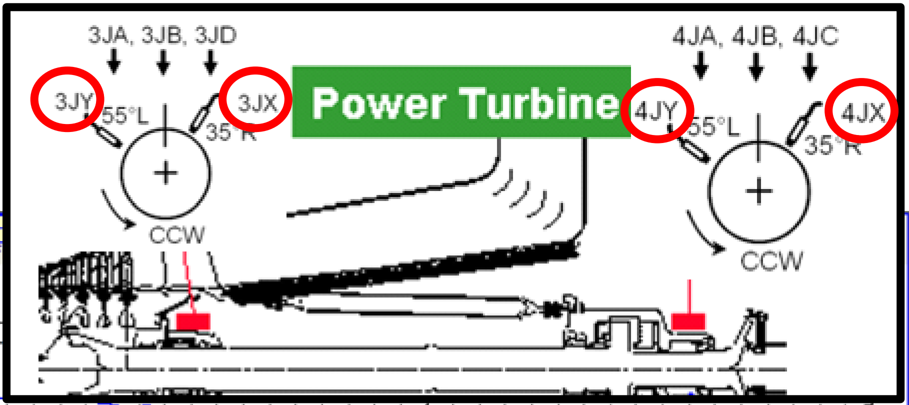
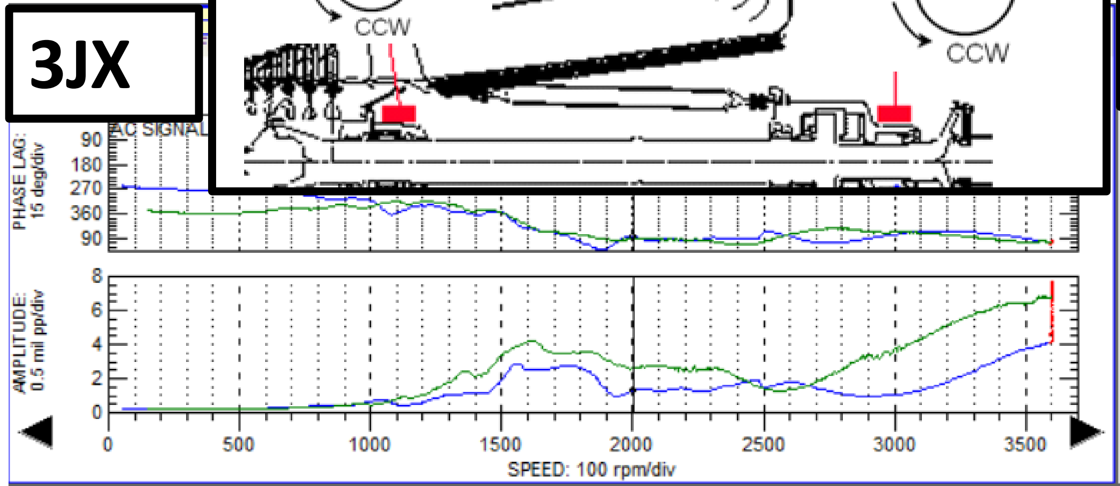
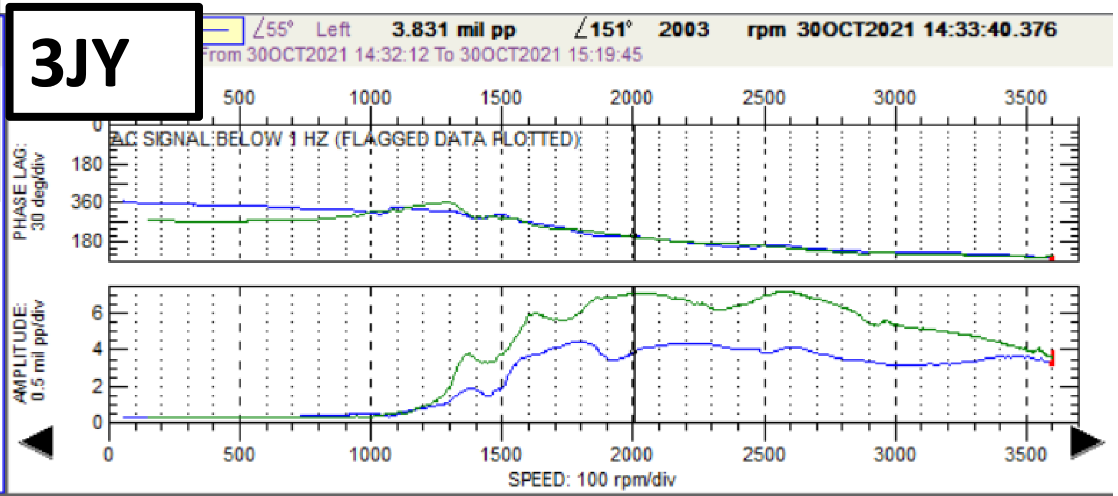
6.3 Power Turbine Shop Balance and Findings– Post balance data

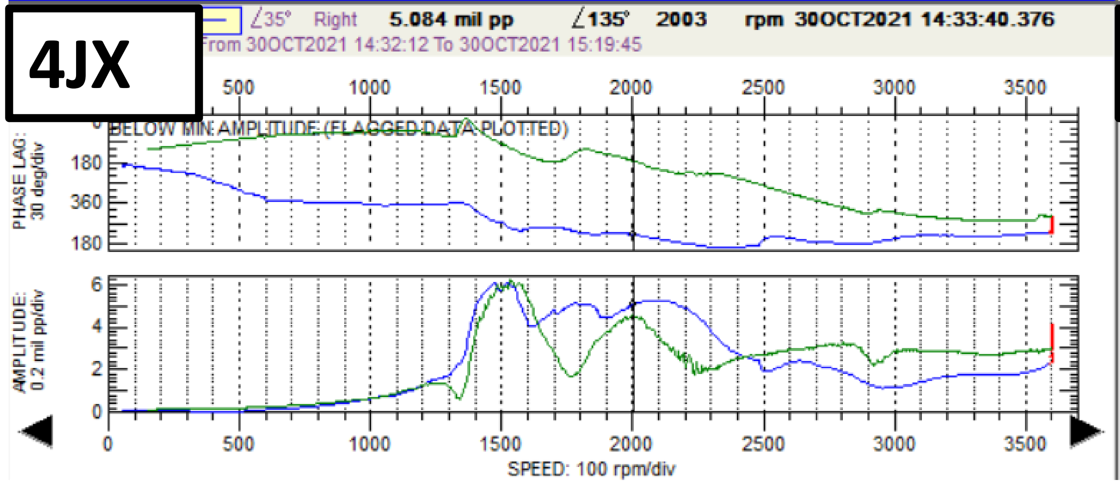
measured by proximity probes

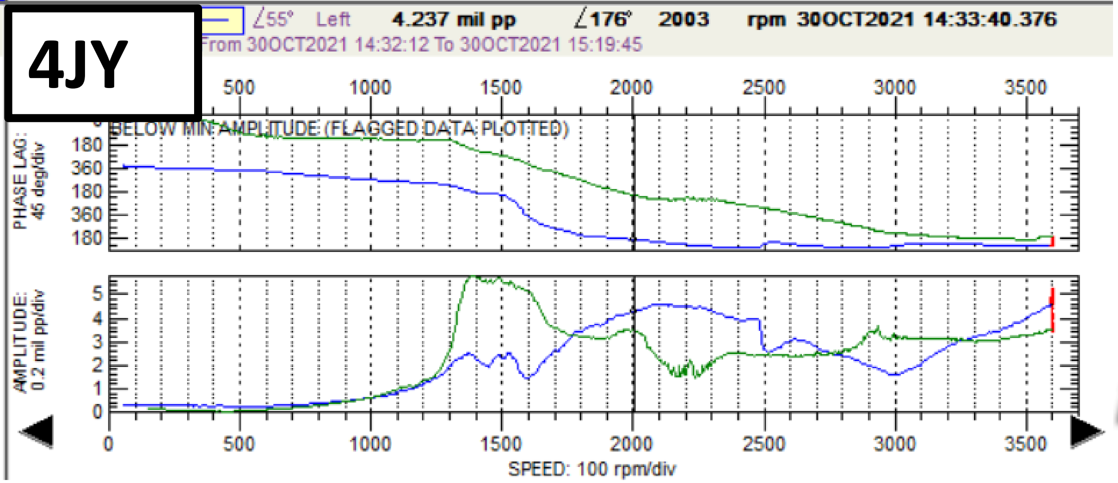
Vibration reduced but not to the satisfactory condition yet





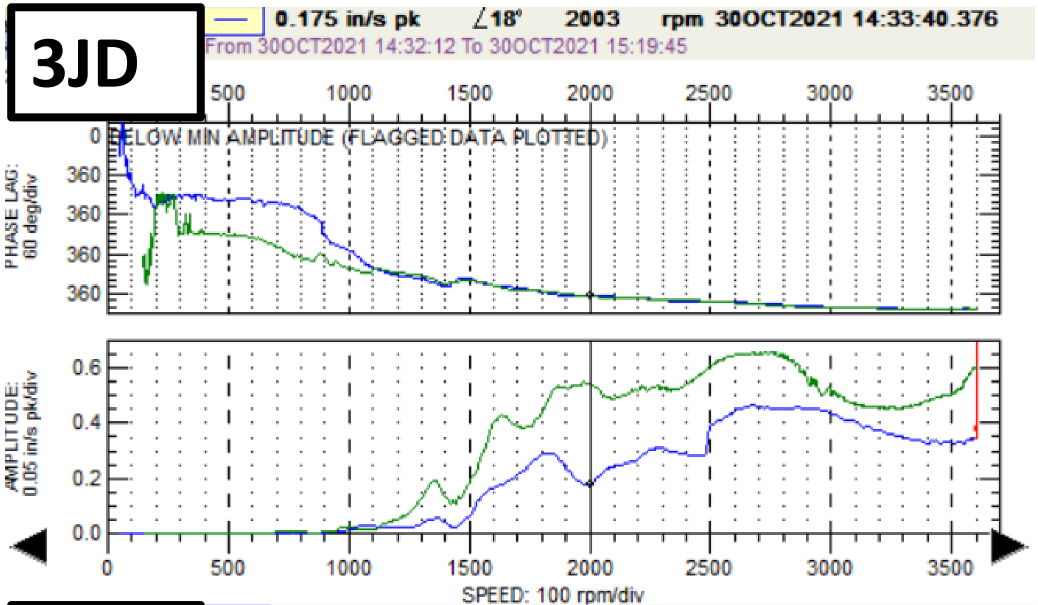


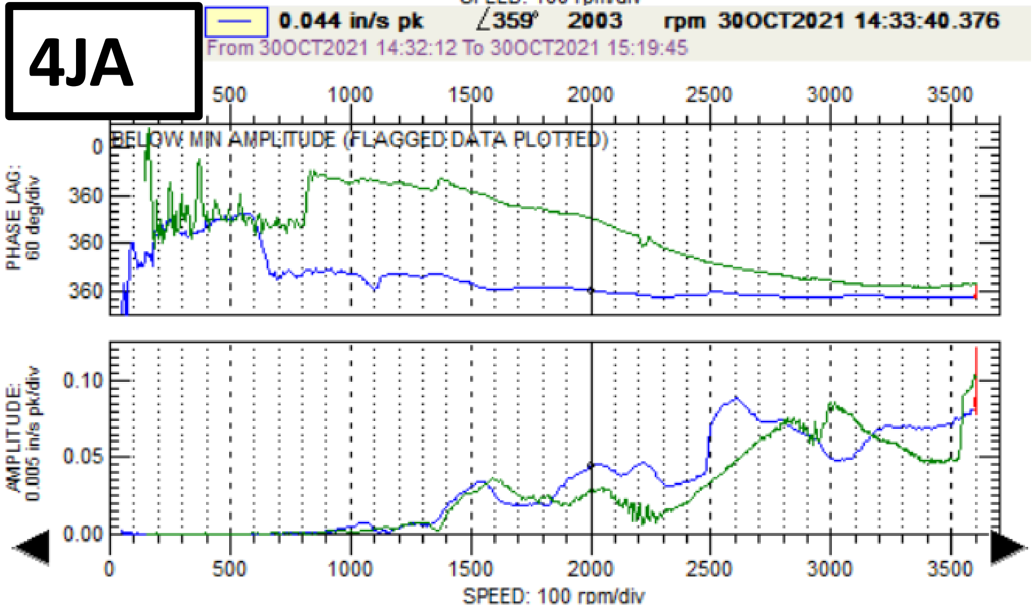




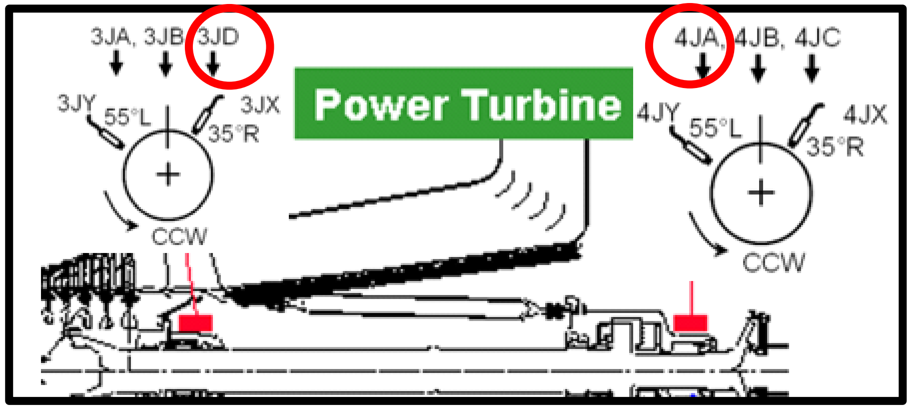
6.4 Power Turbine Shop Balance and Findings– Post balance data

measured by seismic sensors





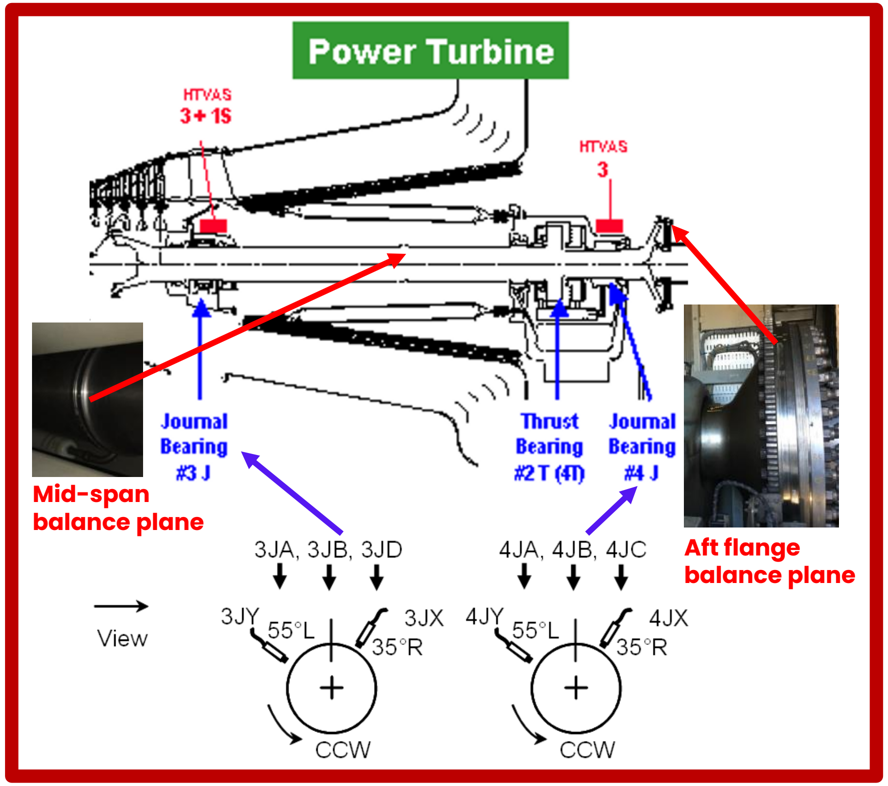
Vibration reduced but not to the satisfactory condition yet



6.5 Power Turbine Shop Balance and Findings– IC data

Influence vectors of power turbine balance weights when PT is normally coupled to the generator

Influence Vectors		mil/oz	deg	mil/oz	deg	mil/oz	deg	mil/oz	deg	in/s/oz	deg	in/s/oz	deg
Speed (rpm)	Condition	3JX (35R)		3JY (55L)		4JX (35R)		4JY (55L)		3JD		4JA	
1500	**startup**	0.23756	333	0.33129	296	0.203417	195	0.589572	169	0.019201	164	0.00009	217
2000	**startup**	0.20428	45	0.435292	9	0.242905	244	0.177928	226	0.026384	279	0.007428	129
3600	FSNL	0.483606	332	0.306365	31	0.078577	321	0.245915	16	0.034595	350	0.007112	304
2000	**shutdown**	0.079731	64	0.42699	1	0.237828	155	0.085845	48	0.055886	302	0.005743	110
1500	**shutdown**	0.188851	302	0.264799	270	0.150704	24	0.47677	142	0.018011	182	0.000759	190



Very important information for the future when PT is believed to be the major source of unbalance that cannot be offset by weights at Aft flange and Mid-span to make vibration low at both rated speed and transient conditions

6.6 Power Turbine Shop Balance and Findings– weight removal

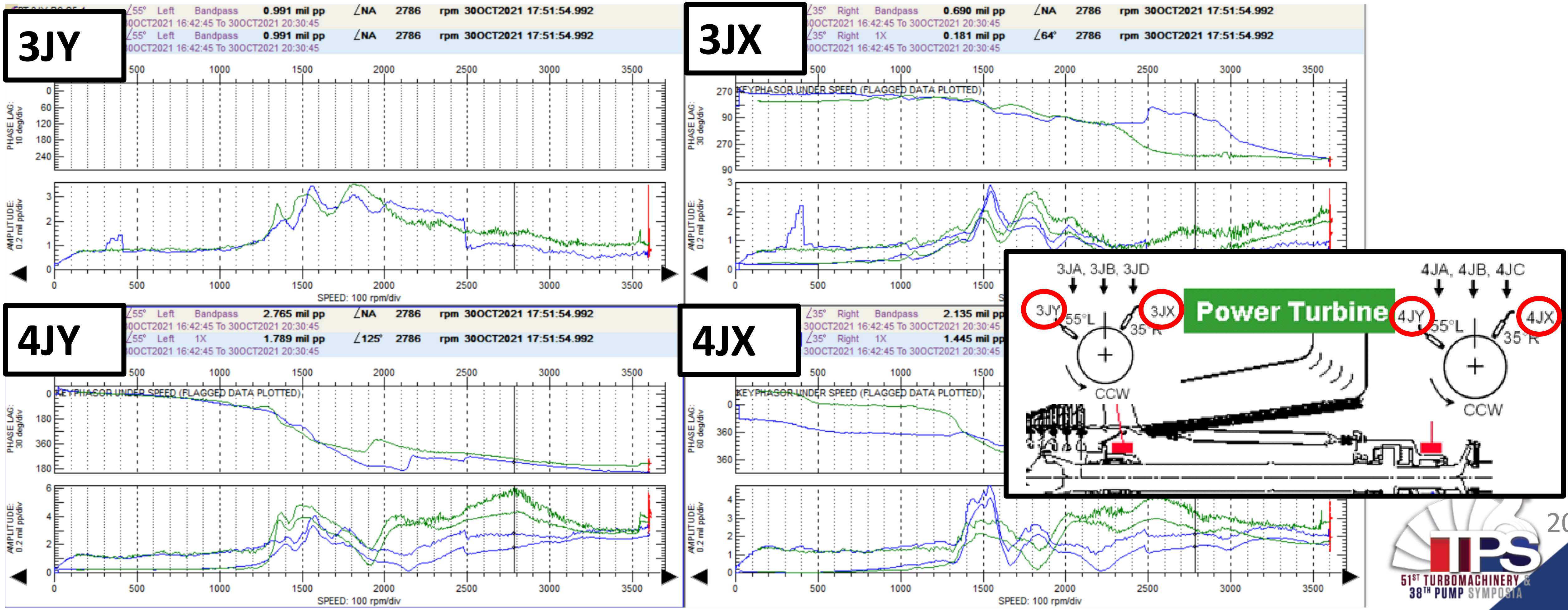
All the previous balance weights removed

- Run on Oct 30th was made with existing field balance weights at the mid-span and aft flange. Field balance weights were previously added to offset power turbine unbalance.
- With the shop balance of the power turbine, it was recognized that these were no longer needed.
- Power turbine was restarted with all weights removed from these locations.

6.7 Power Turbine Shop Balance and Findings– Final data

After weight removal

At any condition condition: proximity probe readings < 6.5 mil pp (alarm) → Safe

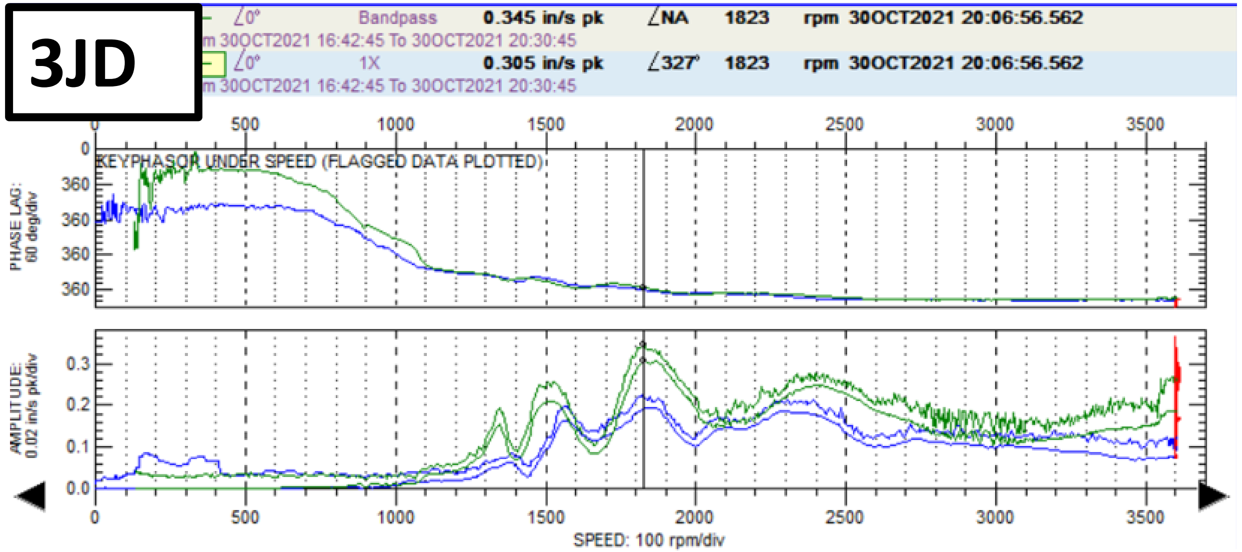


6.8 Power Turbine Shop Balance and Findings– Final data

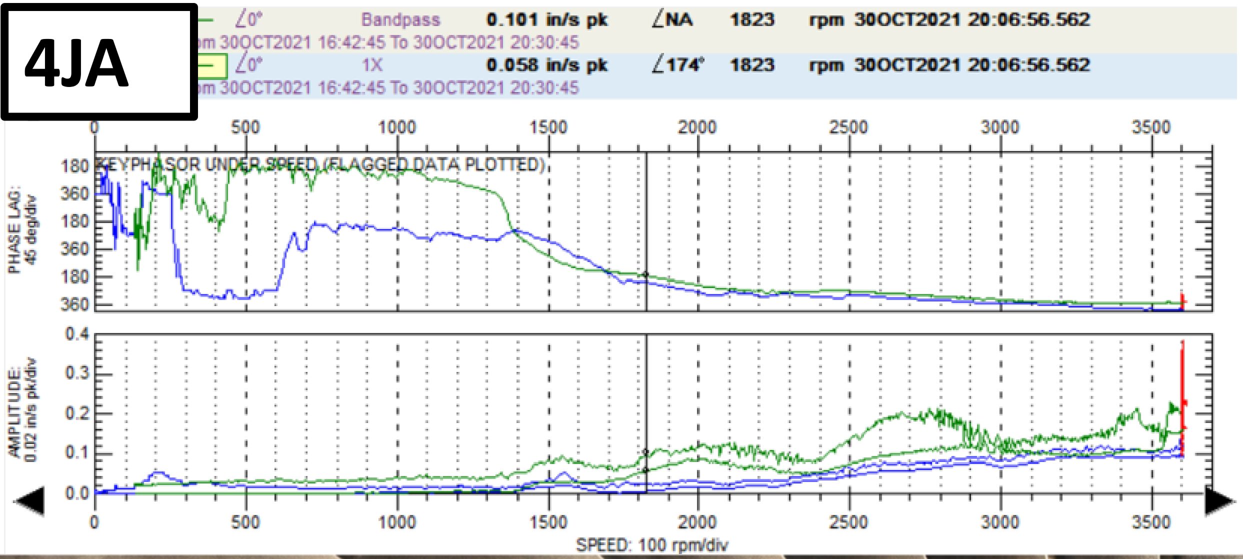
After weight removal

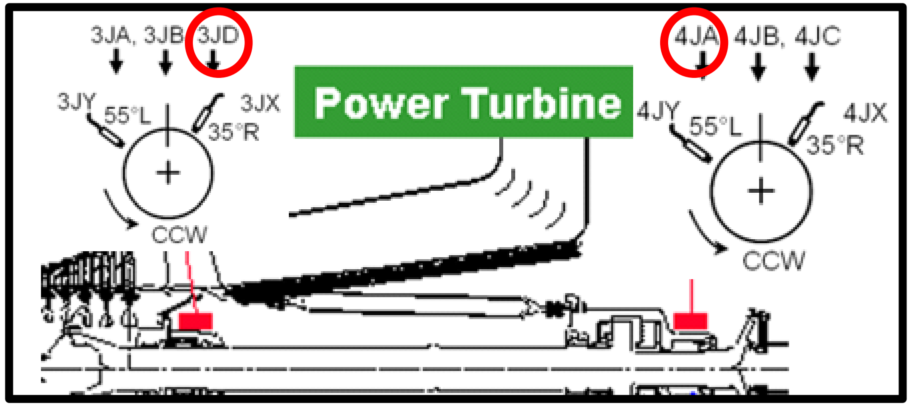
At any condition condition: seismic readings < 0.5 in/s pk (alarm) → Safe

3JD



4JA





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7. Lessons Learned and Values Added

- Obtaining balance influence data from available balance planes at all different running conditions is very important to see if it is feasible to reduce vibration to an acceptable level at all these conditions with the available balance planes. If not, an alternative must be found, instead of vain attempts.

- Aft flange and mid-span corrections were shown to be ineffective in correcting power turbine unbalance.

- Newly obtained influence data due to weights at power turbine balance plane can be used in the future without really having to ship the PT section off site. This can be implemented when weights at Aft flange and Mid-span balance planes cannot effectively reduce vibration to a satisfactory level.

Thanks….. and Questions (?)