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Resolution of high vibration on a Generator

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Presenter/Author bios

Sankar Ganesh – Technical Leader, MENAT

Sankar is the Technical Leader for BHGE Bently Nevada Machinery Diagnostics Services in the MENAT region.

He received a Bachelor of Mechanical Engineering from Bharathidasan University, India, in 1993.

He has over 20 years experience in vibration field and 9 years with GE Bently Nevada, including rotating equipment balancing, vibration analysis, diagnostics and root cause analysis.

He has published case studies in METS and Turbomachinery symposium.

Mustafa Shalabi – Lead MD Engineer

Mustafa works as Lead Machinery Diagnostics Engineer in BHGE Bently Nevada company, Saudi Arabia since December, 2012.

He is a certified vibration analyst CAT III by Mobius Institute. Mustafa graduated in 2006 with B.Sc. degree in Mechanical Power Engineering from faculty of engineering, Alexandria university, Egypt. He has been working in vibration diagnostics of rotating equipment for over 10 years. He started his career in 2007 as a condition monitoring engineer for rotating equipment.

In addition to his work as machinery diagnostics engineer, Mustafa is working as a Machinery Diagnostics training instructor in Bently Nevada.



Abstract

Subject machine is a synchronous generator driven by a Gas turbine through a speed reduction gearbox with a rated power of 25 MW, operating at 3600 rpm. Generator rotor is supported by two journal bearings and each bearing is equipped with a vertically mounted seismic transducer configured with an alarm and danger set point of 13 and 25 mm/sec Pk respectively.

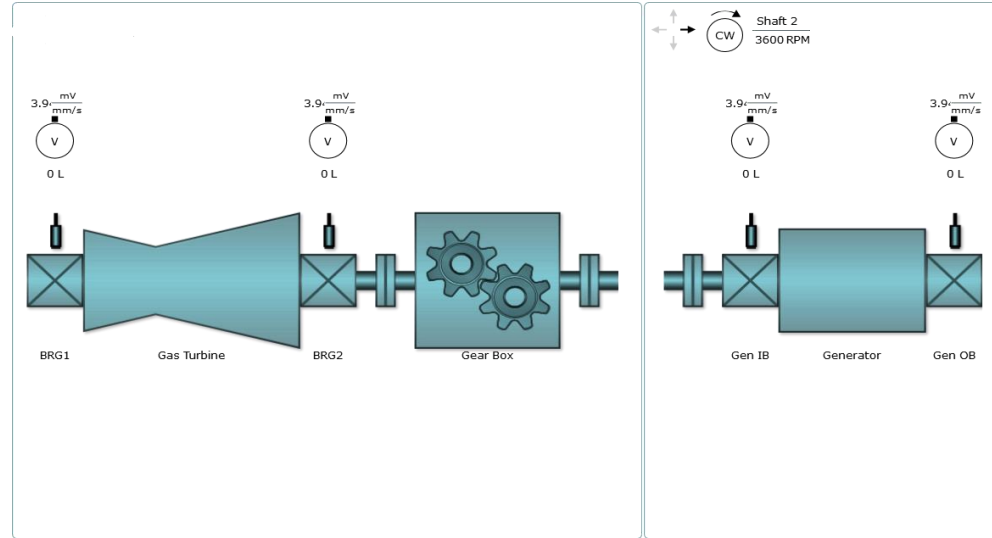
Generator bearing high vibration levels resulted in several machine trips during the startup attempt followed by a unit shutdown caused by high lube oil temperature. Generator bearings were replaced, exciter misalignment was rectified and in-situ balancing of generator rotor was attempted by plant maintenance personnel but did not yield desirable results preventing machine from attaining FSNL speed with acceptable vibration levels.

A systematic approach with additional temporary velocimeter pickups at various locations of generator bearings/pedestals along with optical phase pickup was installed for detailed data collection. Data indicated dominant 1X amplitudes up to 65 mm/sec Pk at generator inboard bearing confirming generator with high degree of anisotropic stiffness between horizontal and vertical planes. This case study intends to detail how the high vibration issue was successfully diagnosed using various plots from different machine state (startup/shutdown/steady state) and resolved by correct analysis using different test techniques to identify and eliminate structural issues.



Machine Details

- The unit is Synchronous Generator installed at electrical power production plant.
- Driven by gas turbine through a speed reduction gear box and rigid coupling.
- Rated power of 25MW, running at 3600rpm.



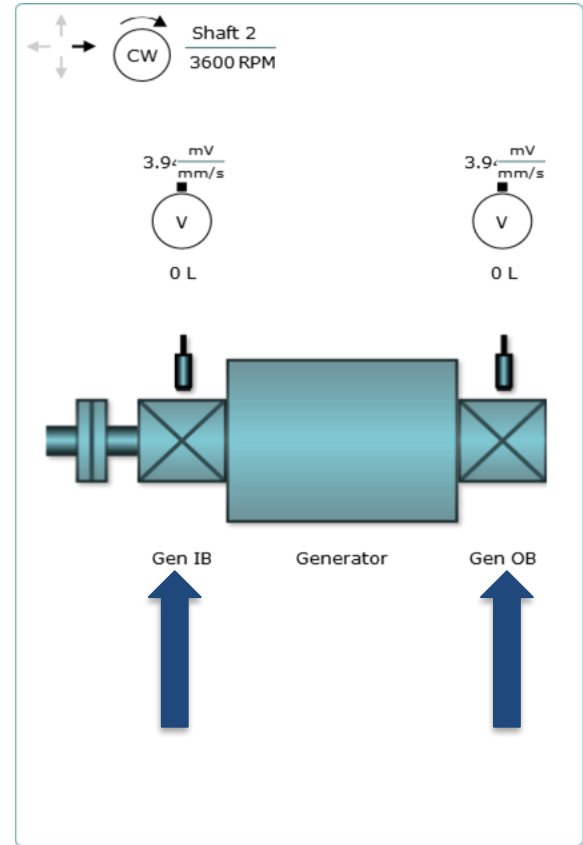
Machine Details

- The generator is supported between two journal bearings.
- Each bearing is equipped with one velocimeter transducer located vertically.
- Alarm and danger set points are 13/25 mm/sec Pk, respectively.



Problem Statement

- The generator was running with acceptable vibration level (in vertical direction only) which was below alarm set point till 20 Aug, 2013, after that the unit was tripped on 21 Aug, 2013 due to lube oil temperature as indicated in DCS.
- Several start up trials were done but failed to reach FSNL and tripped due to high vibration in vertical direction which was exceeding the danger set point.



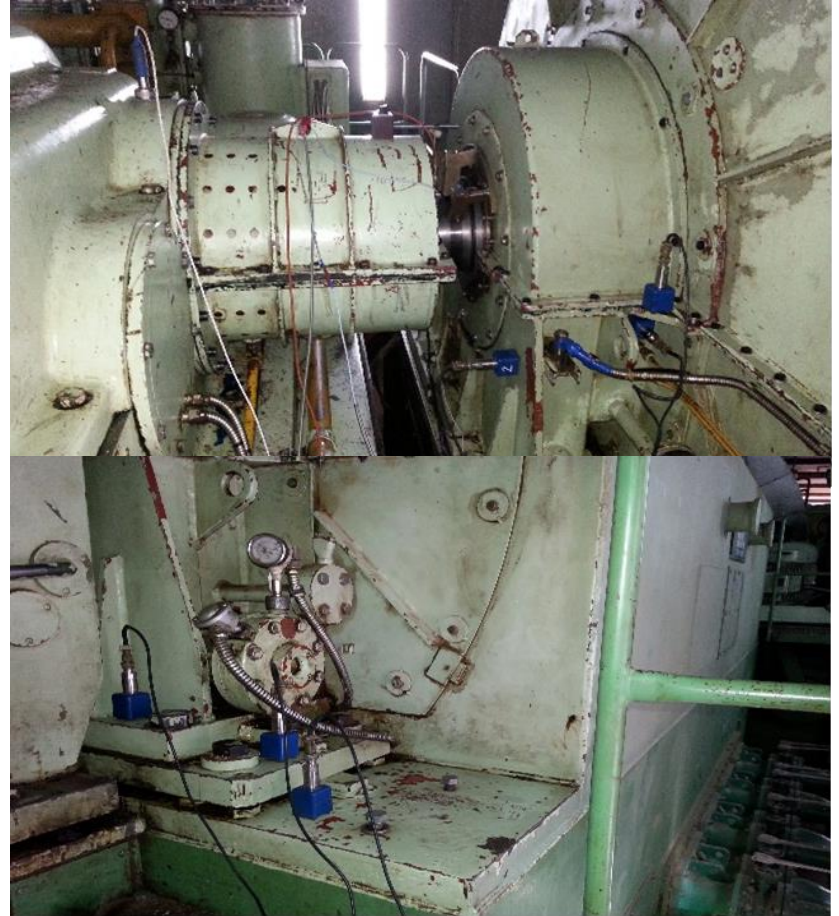
Problem Statement “cont’d”

- Balancing exercises were done by the maintenance team on the generator IB side, however the machine failed to reach FSNL and tripped due to high vibration.
- After that, all the trial balancing weights were removed.
- Initial corrective action was taken by replacing generator bearings with new bearings.
- Alignment between generator and gear box was checked.
- Exciter was found to be misaligned with the rotor due to looseness in the fixation bolts and the exciter housing was touching the generator rotor.



Data Analysis

- In order to study the problem in more details, temporary velocimeter transducers were installed at different locations on the generator bearings, pedestal and foundation with reference to the temporary optical keyphasor.



Data Analysis “cont’d”

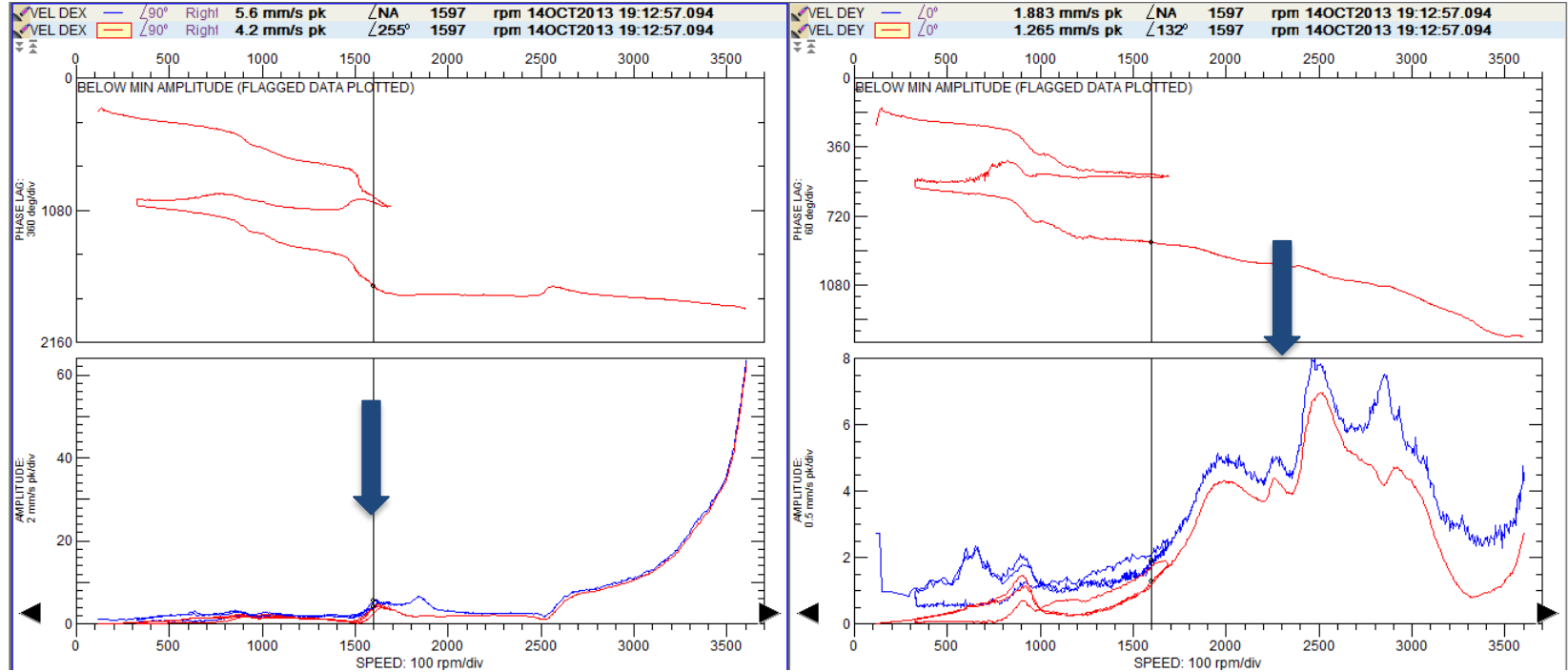
- Extremely high vibration levels on the generator bearings, pedestal and foundation in the Horizontal direction reached 64 mm/sec Pk (Vertical; 7 mm/sec Pk).

1Xgenerator dominant vibration component.

mm/sec pk		Direct	1X Amplitude	1X Phase
Gen. IB	Horizontal	64	63	88
	Vertical	4.2	3	265
Gen. OB	Horizontal	30	29	65
	Vertical	7	6	238



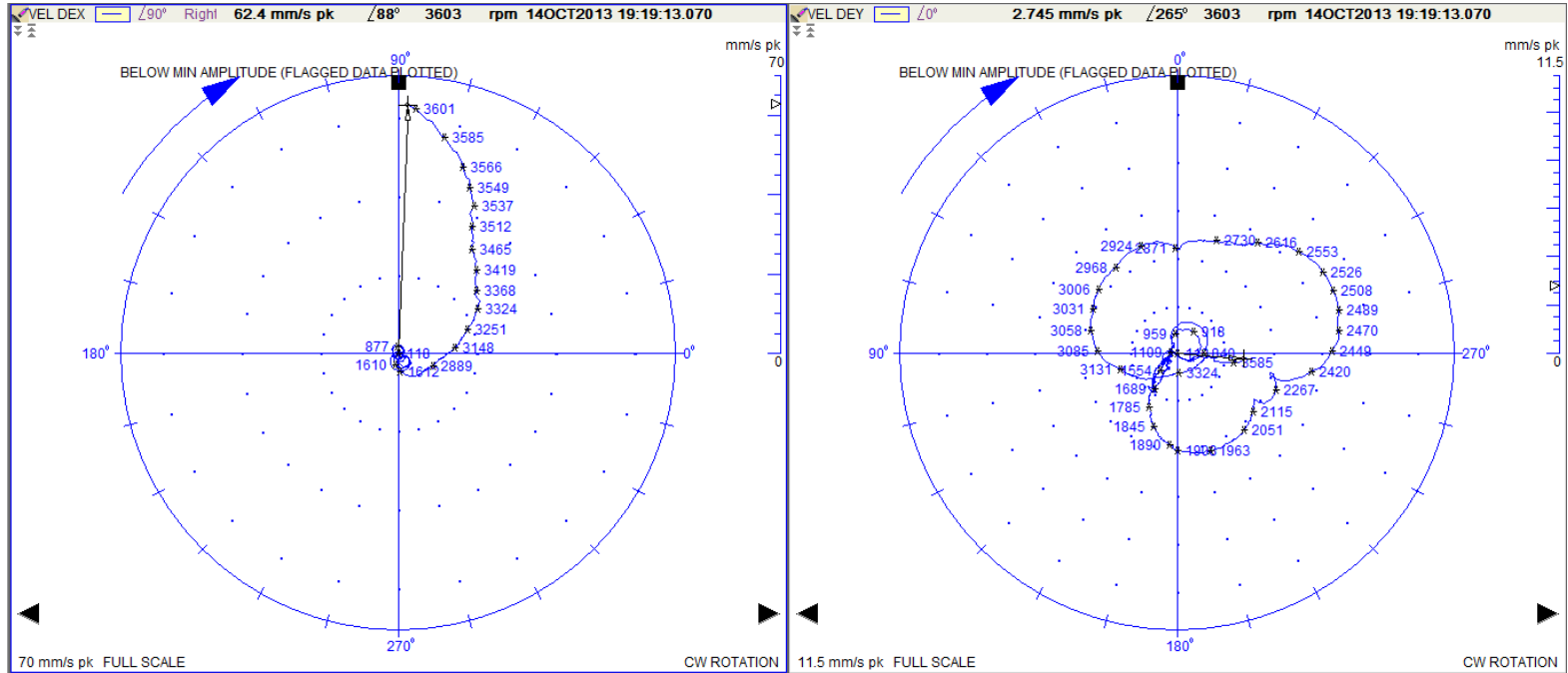
Data Analysis- Startup Bode "cont'd"



Anisotropic system was observed with big difference in the stiffness between horizontal & vertical axes $\Omega = \sqrt{K/M}$



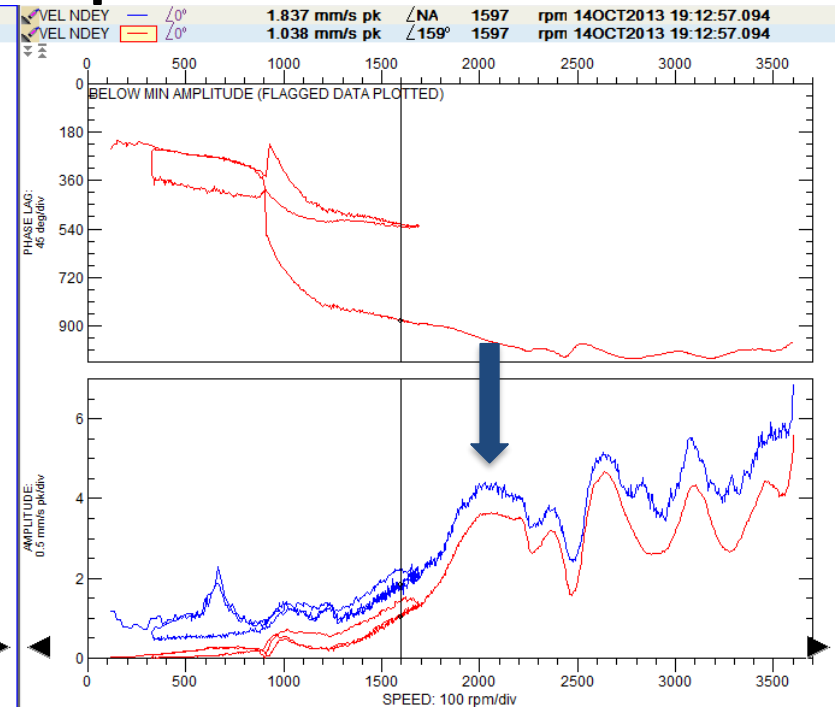
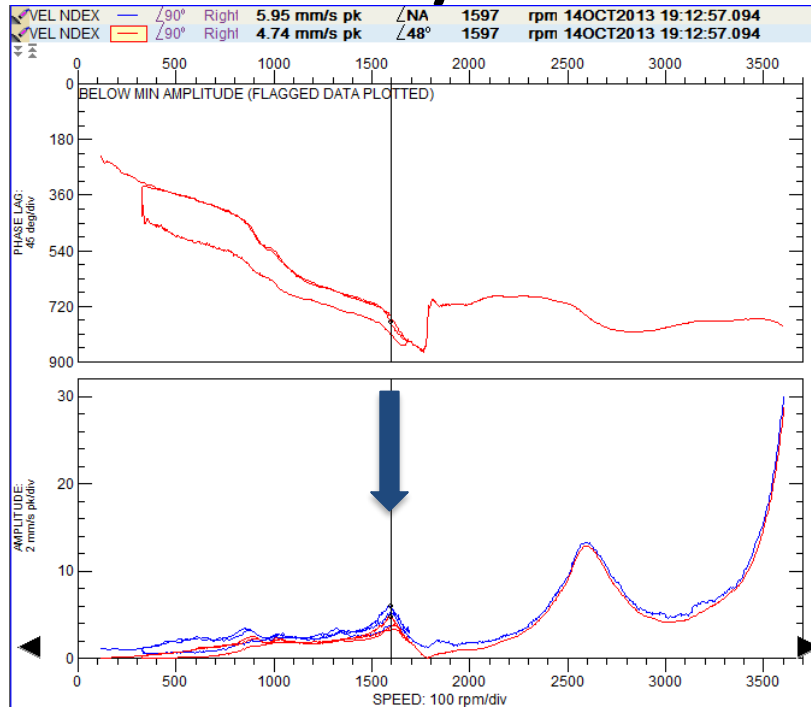
Data Analysis- Startup Polar “cont’d”



Anisotropic system was observed with big difference in the stiffness between horizontal & vertical axes $\Omega = \sqrt{K/M}$



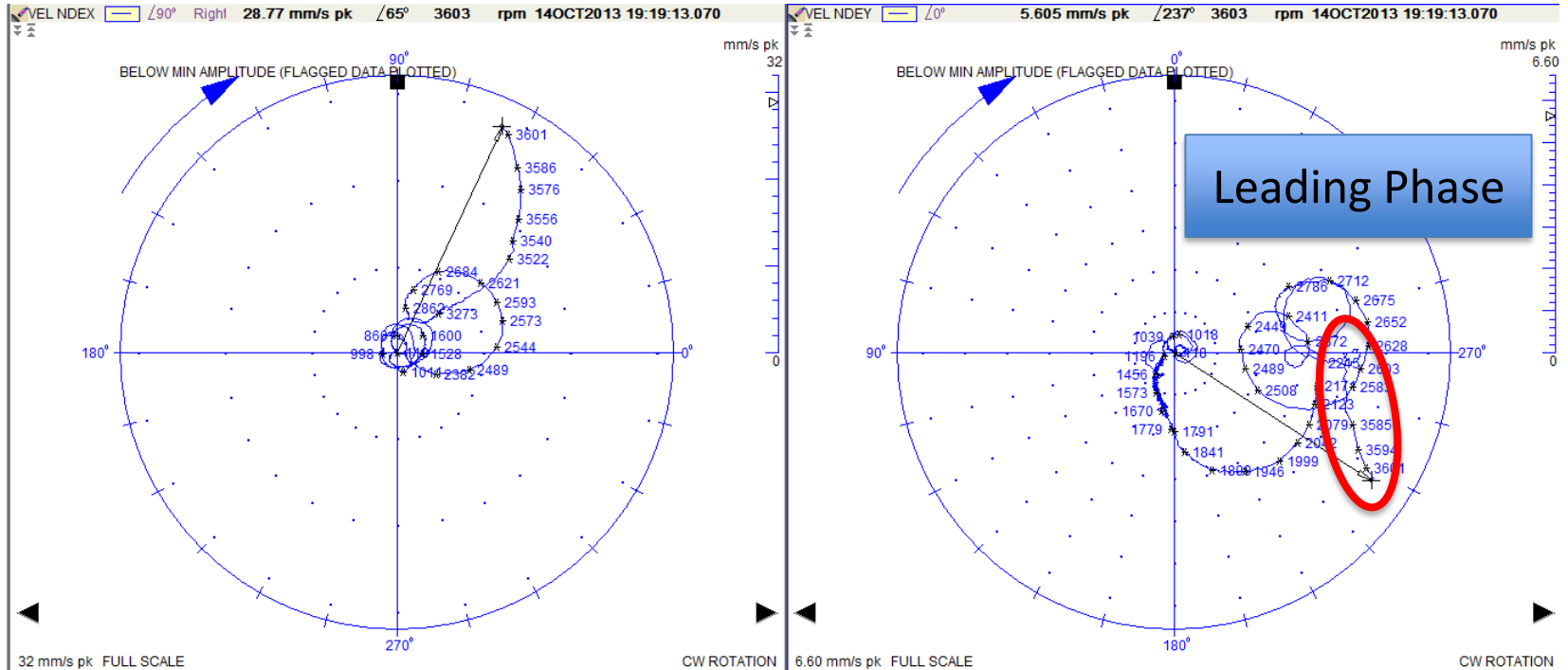
Data Analysis- Startup Bode "cont'd"



Anisotropic system was observed with big difference in the stiffness between horizontal & vertical axes $\Omega = \sqrt{K/M}$



Data Analysis- Startup Polar “cont’d”

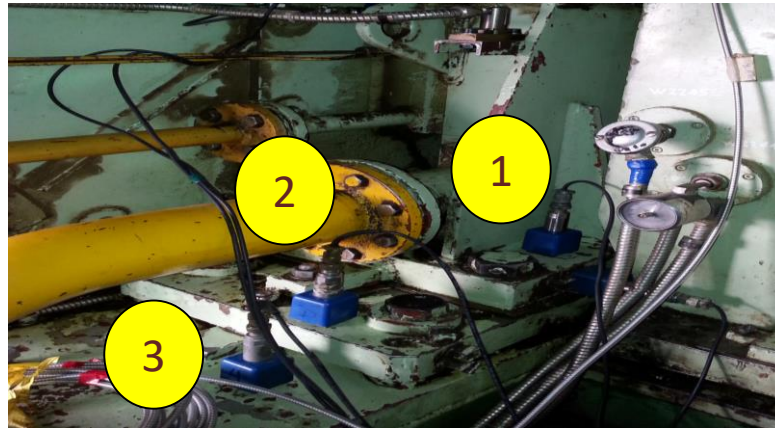
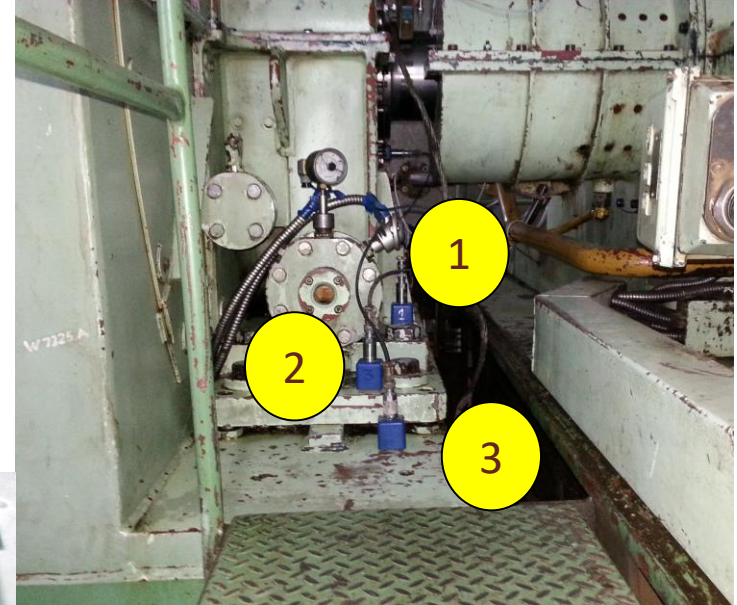


Anisotropic system was observed with big difference in the stiffness between horizontal & vertical axes $\Omega = \sqrt{K/M}$



Data Analysis-Structural measurement

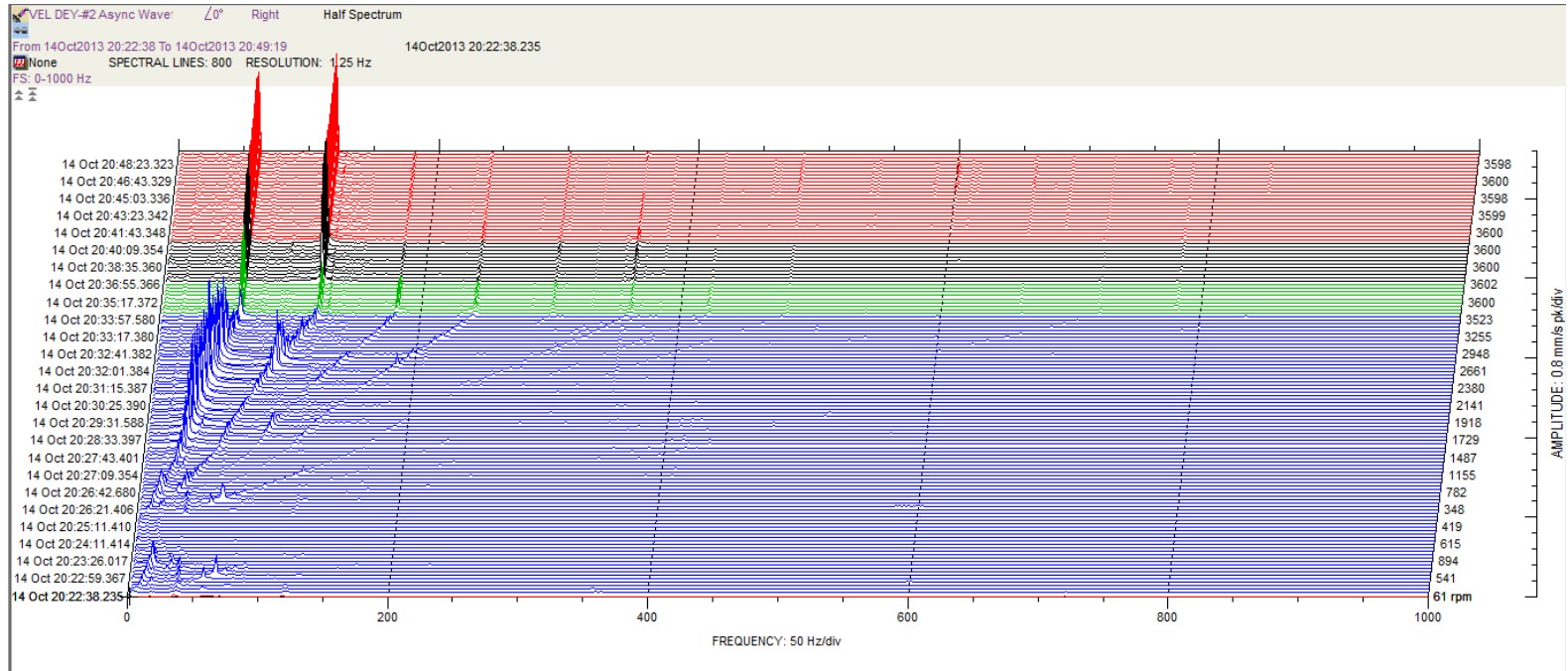
mm/sec Peak		Right Side		Left Side	
		1X	1X Phase	1X	1X Phase
IB	Point#1	6.7	222	0.2	65
	Point#2	8.7	230	4.9	54
	Point#3	7.3	221	7.3	60
OB	Point#1	9.9	236	5.5	245
	Point#2	8.3	238	1.6	281
	Point#3	10.1	237	1.3	299



Vibration levels at Foundation Point were Higher than BRG Housing in Vertical Direction



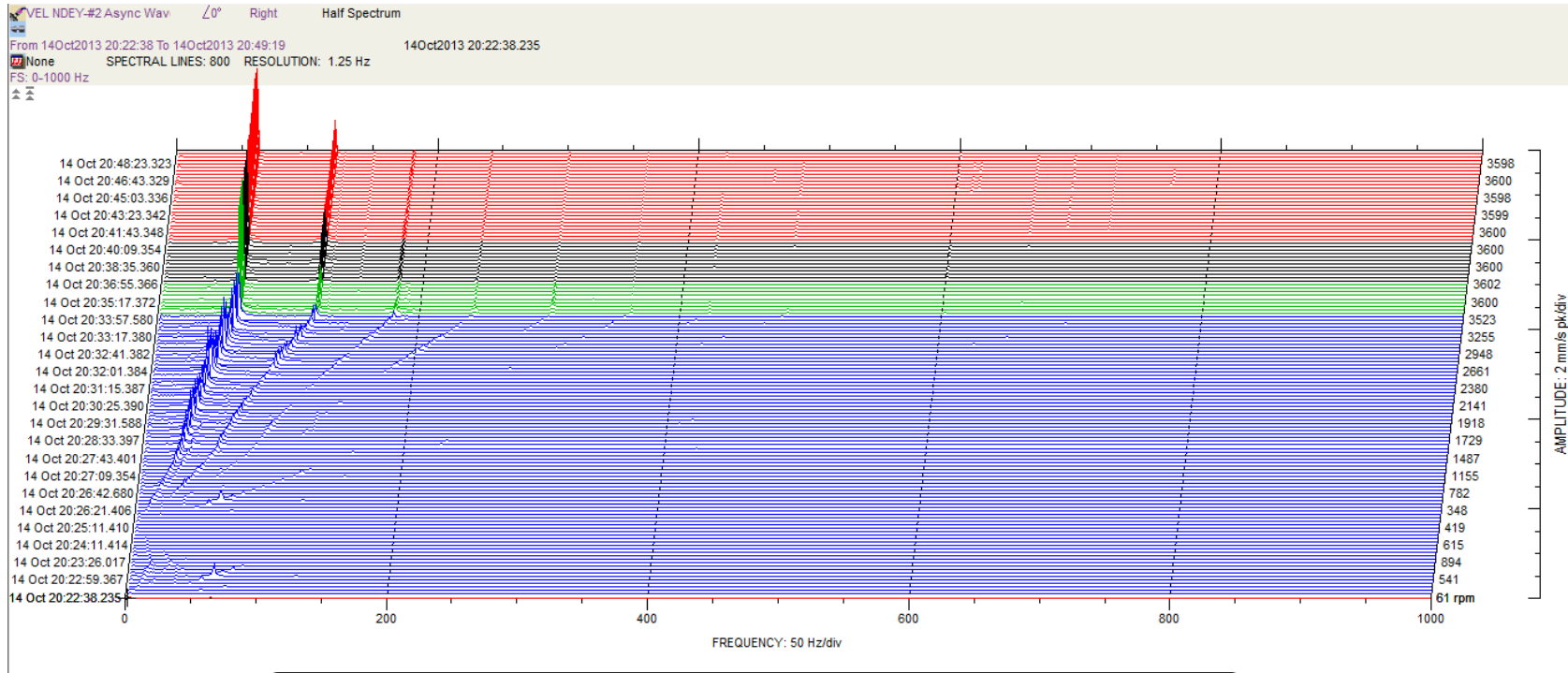
Data Analysis-Waterfall Plot "cont'd"



Generator IB/OB Waterfall Plot (Y- Direction)
showed excitation of 1X harmonics.



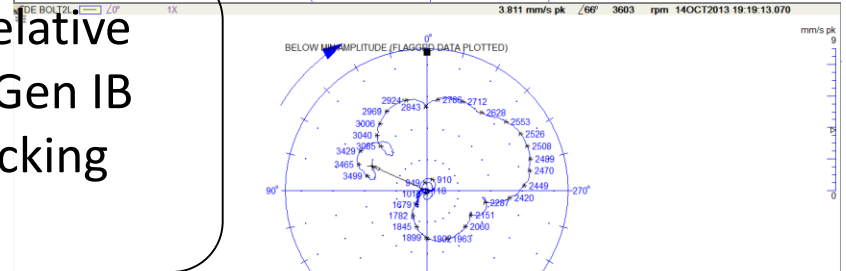
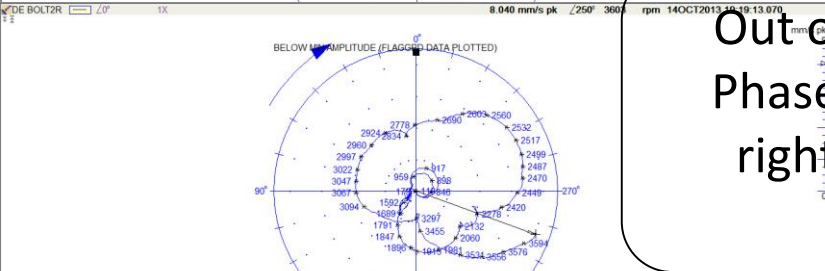
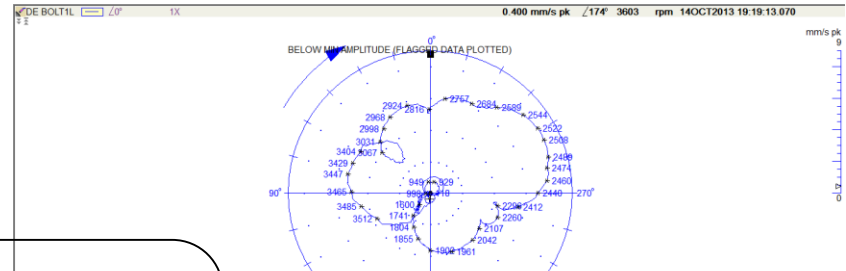
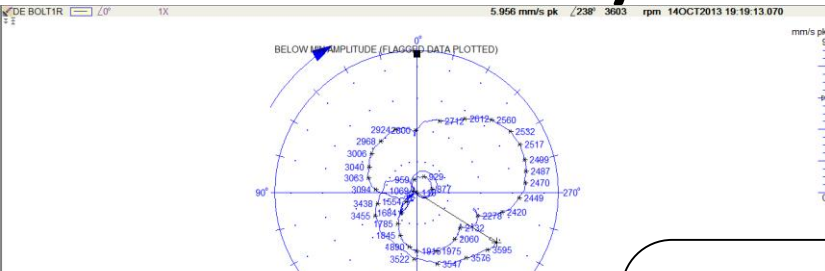
Data Analysis-Waterfall Plot "cont'd"



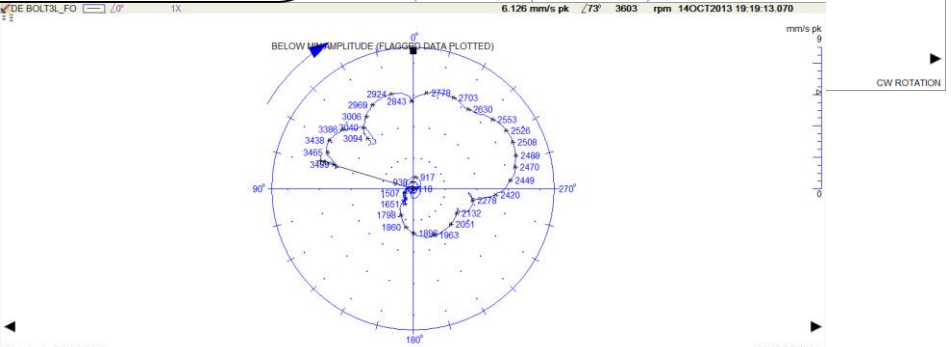
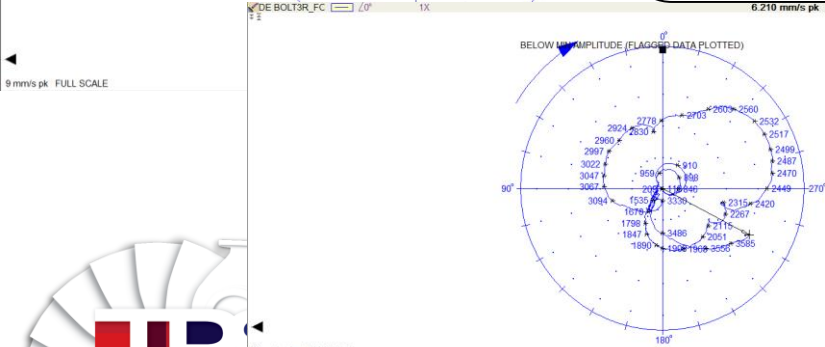
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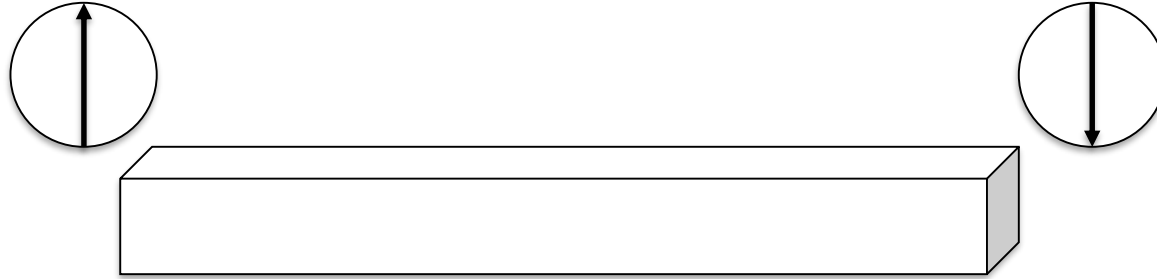
Data Analysis-Structural measurement



Out of Phase/ Relative Phase between Gen IB right & left "Rocking Motion"

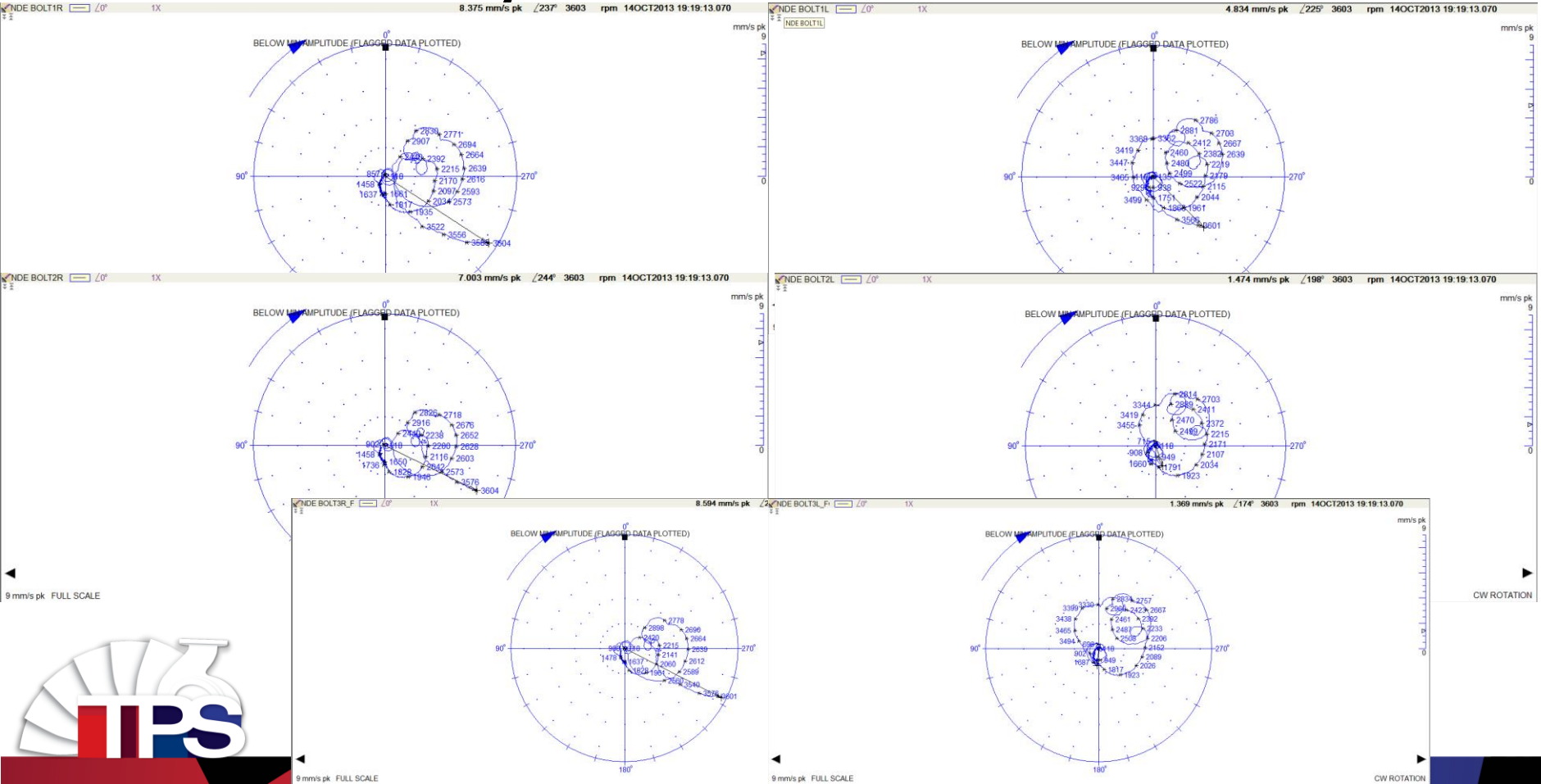


Data Analysis-Base Plate Mode Shape

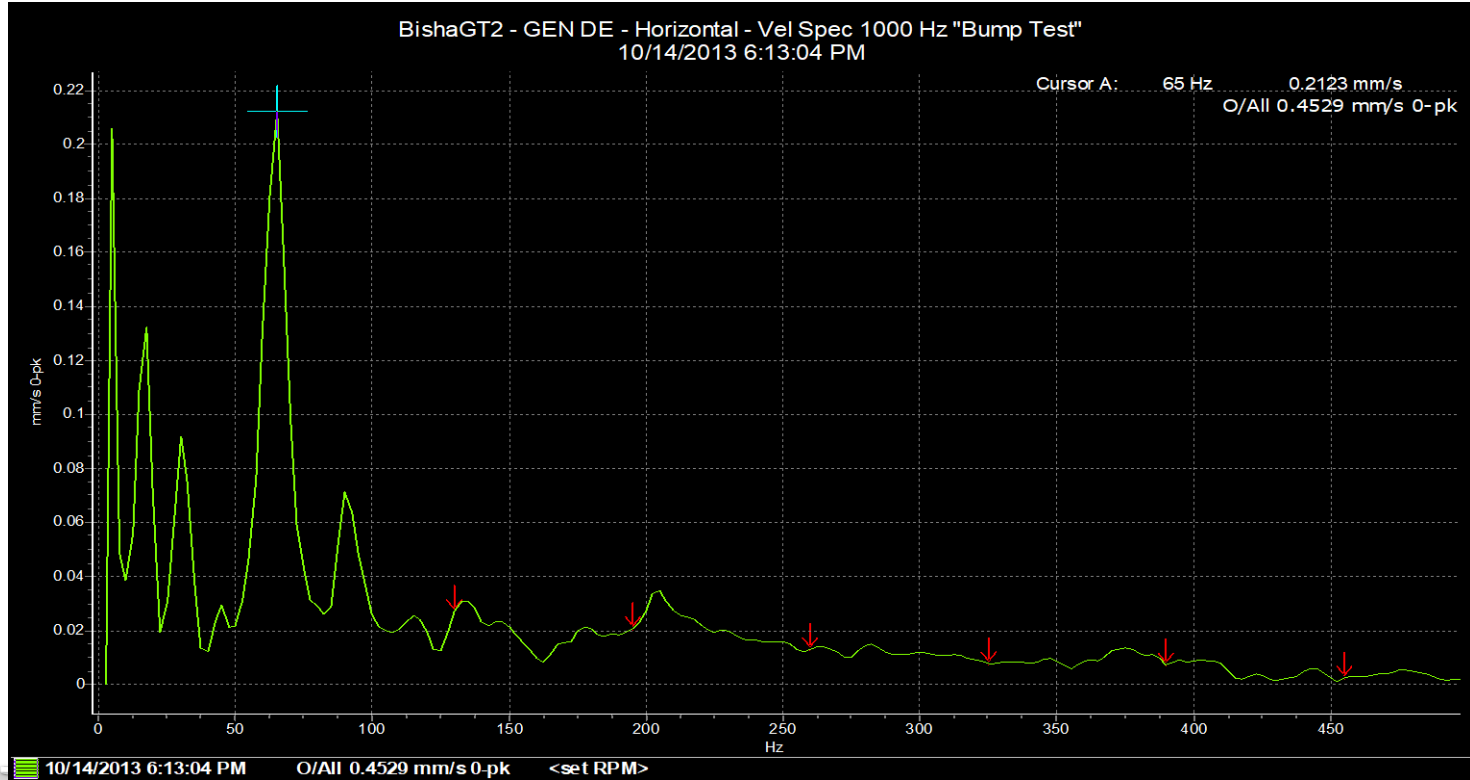


Out of Phase/ Relative Phase between Gen IB right & left
"Rocking Motion"

Data Analysis-Structural measurement



Data Analysis-Impact Test



Conclusion & Recommendations

- The extremely high vibration levels on the generator and structure was mainly due to foundation looseness.
- Rocking motion was observed at Gen IB between right and left side due to looseness.
- Anisotropic system was observed due to different stiffness between horizontal & vertical.
- Bump test showed natural frequencies near to the running speed (65 Hz) in the horizontal direction.



Conclusion & Recommendations

- Overall inspection for all generators supports structure including the foundation, baseplates, soleplates, bearing pedestals, grout condition, etc.
- Verify that all support leg bolts, base to pedestal bolts, anchor bolts and pedestal hold down bolts are torqued properly.



Action Taken



Removing Tag Weld, Tightening Anchor Bolts



Post Analysis

18 MW "Load"		Before Tightening Anchor Bolts	After Tightening Anchor Bolts
		Direct Vibration mm/sec Peak	
Generator IB	Horizontal	61	6.8
	Vertical	9.5	1.8
Generator OB	Horizontal	33.6	8.5
	Vertical	10.3	8.2



Lessons Learned

- **Extensive measurement and detailed analysis in the field helped to identify the root cause quickly** - substantially reduces the duration of unplanned downtime.
- Proper vibration analysis to avoid **unnecessary onsite balancing exercise.**
- Using the different vibration data analysis techniques and simple solutions to avoid unwanted maintenance activities.



Thank You

