

**TURBOMACHINERY  
& PUMP SYMPOSIA**



# **RESOLUTION of HIGH VIBRATION on a GENERATOR**

**BORHANE OUERTANI**

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# PRESENTER / AUTHOR BIOS

## **Borhane Ouertani—Lead On Site Services Specialist**

Borhane joined BHGE in 2016 in the Machinery Diagnostic services (MDS) group. Previously he worked for two different company (Diagnostique surveillance & instrumentation and SMT Food industry) where he was a Responsible for Condition Monitoring of process plant machinery, providing technical solutions for machinery problem and develop preventive maintenance strategy.

Over 14 Years experience in Vibration analysis, infrared thermography, Laser alignment including rotating equipment balancing. He has a Diploma of Electromechanical Engineer from ESPRIT University, TUNISA.

## **Sankar Ganesh — Technical Leader MENAT & Africa**

Sankar is the MDS technical leader for BHGE Bently Nevada Machinery Diagnostics in the MENAT & SSA region.

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

Over 20 years experience in vibration field and 12 years with GE Bently Nevada, including rotating equipment balancing, vibration diagnostic and root cause analysis. Published case studies in METS and Turbomachinery symposium.

# ABSTRACT

The machine train consists of a HP/LP Steam turbine driving a Generator of 118 MW.

The Generator shaft and casing vibration were extremely high above the alarm set points.

One of the observation was that the generator NDE casing was operating close to the second critical speed. Added a mass of around 800 Kg (2 blocks of 400 Kg each) on top of the Generator NDE bearing housing to shift the natural frequency. This exercise did not yield any positive response.

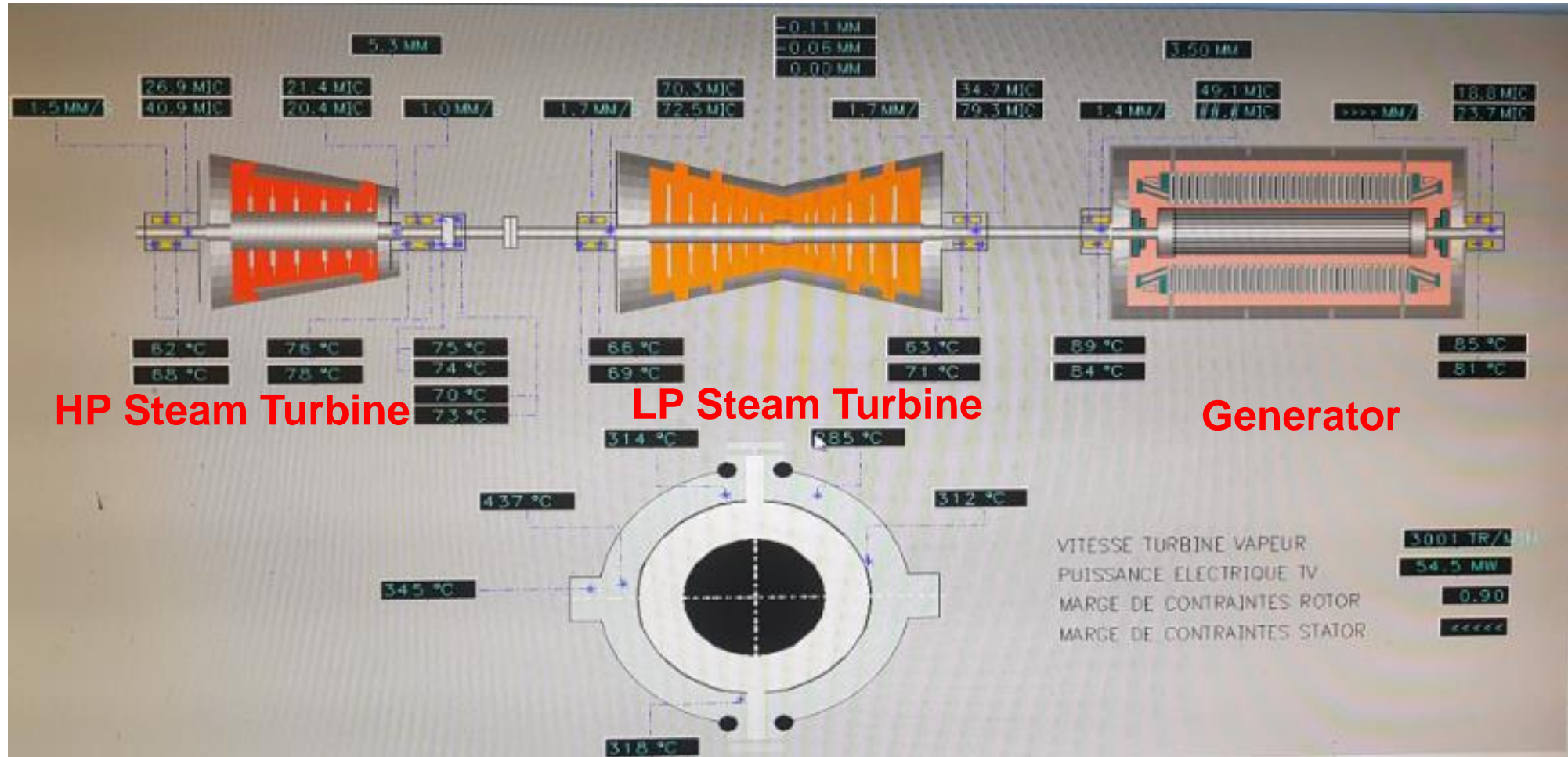
During the soft foot check of anchor bolts, an interesting phenomenon of gradual reduction of generator casing & shaft vibration to well below acceptable levels occurred over few hours upon opening of anchor bolt trap doors through which hot air was getting released.

The inspection revealed no looseness, but excessive gaps ranging from 0.1 to 0.61mm were found at four locations below the Generator NDE bearing pedestal.

Correction was completed by jacking up the generator frame up off of the baseplate. Shims at the interface point were removed and the interface points on the baseplate and pedestal were cleaned and new shims were then installed.

Upon restart the vibration levels were well below acceptable levels.

# MACHINE DETAILS



Machine Train consists of a HP/LP Steam turbine driving a Generator of 118 MW, Equipped with online protection system.



# PROBLEM STATEMENT

- The Generator shaft and casing vibration were above the alarms.
- The vibration was high on both the bearings of the Generator.
- Generator vibration in the axial direction exceeded ISO standard limits (28 mm/s rms or 1.1 in/s rms).
- The issue persisted for almost two years without the root cause being resolved.
- On site balancing by End user was not successful.
- Investigation by OEM - Generator bearing casing natural frequency close to the running speed.

# Action by OEM

Vibration absorber blocks installed by OEM on top of the bearing housing did not show any improvement in the Generator vibration level. (2 Blocks of 400 Kg each)



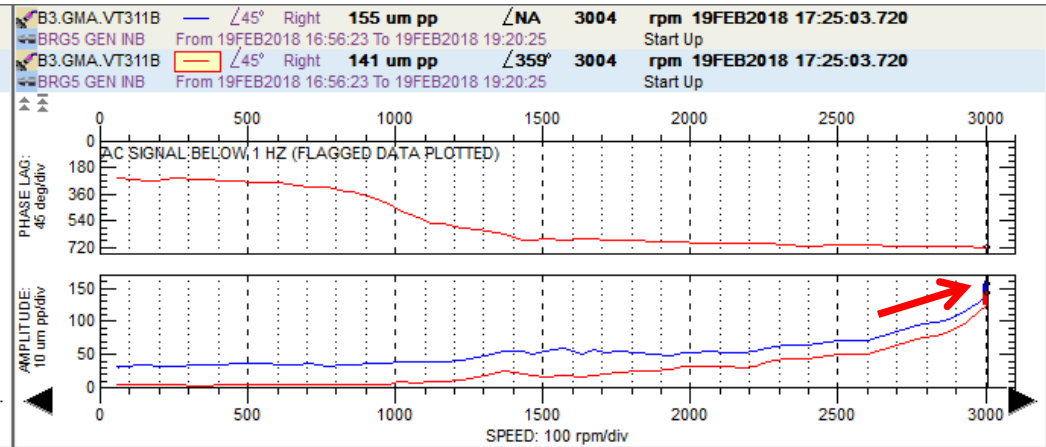
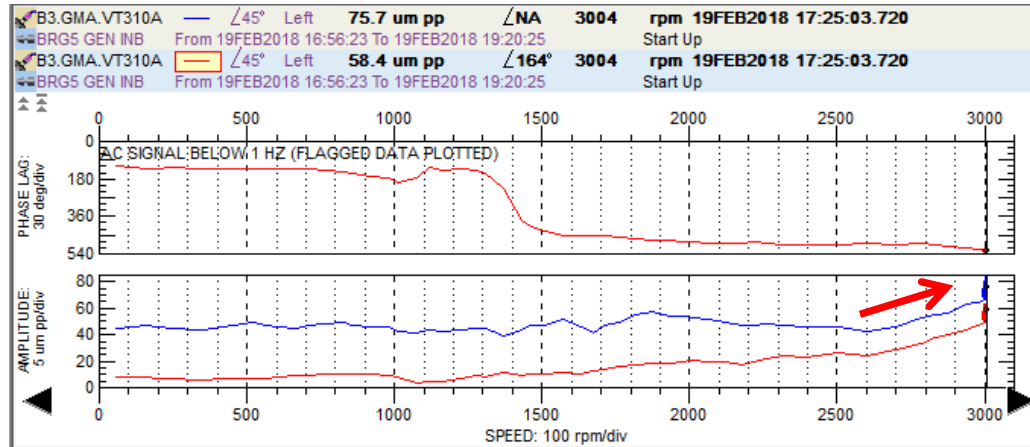
# OBSERVATIONS & ANALYSIS

## Bode Plots- Startup- Shaft Vibration- Generator In-board & out-board bearing

In-board Bearing

1X Phase

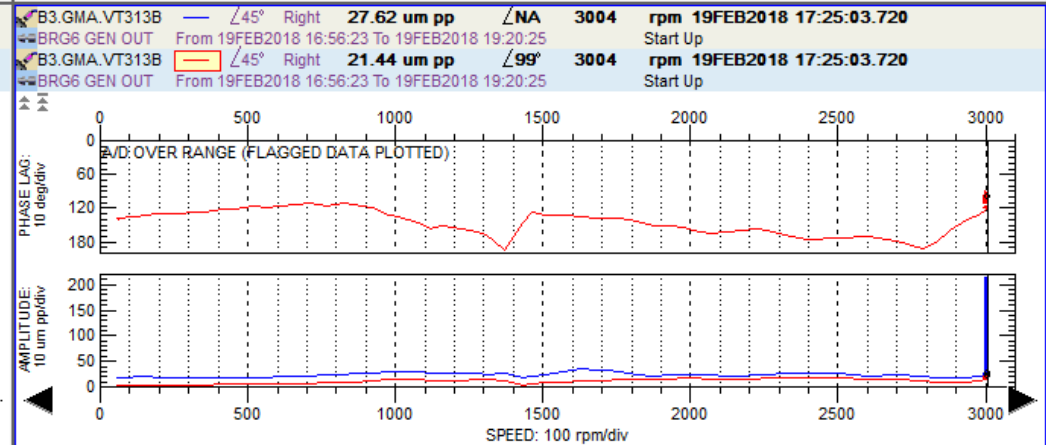
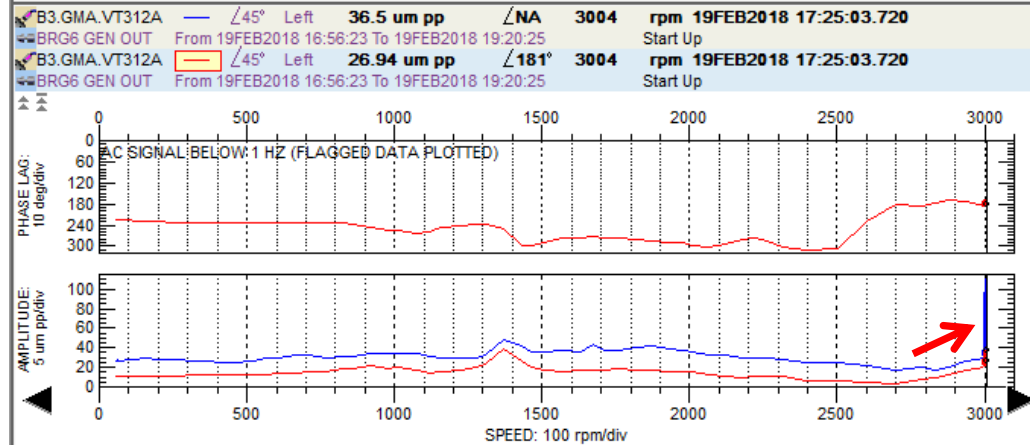
Amplitudes



Out-board Bearing

1X Phase

Amplitudes

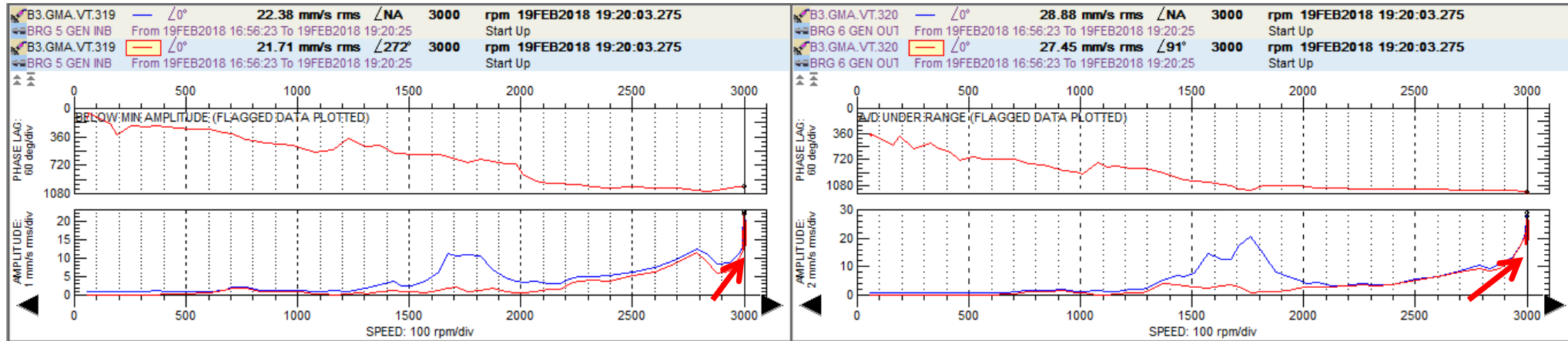


- The shaft vibration on Generator IB & OB bearings were high, close to 155  $\mu\text{m pk-pk}$  (6.1 mils PP).
- Bode plot of Gen IB & OB shows machine running close to second critical.



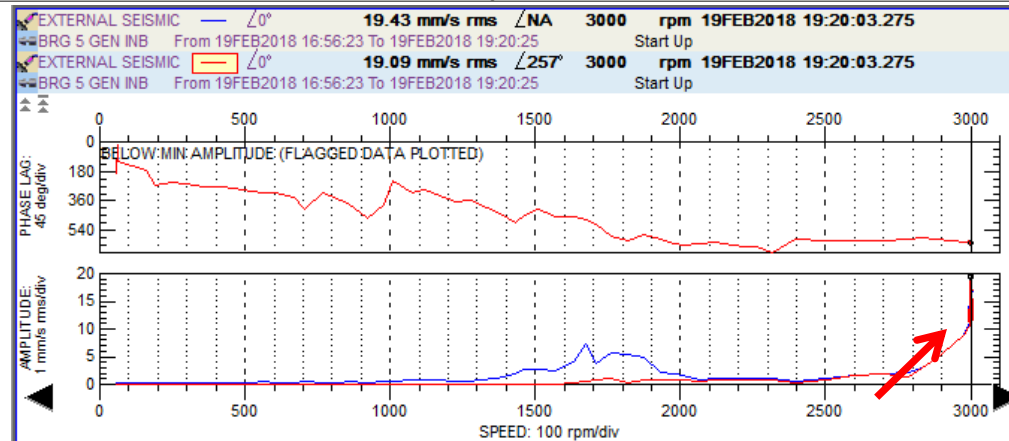
# OBSERVATIONS & ANALYSIS

## Bode Plots- Startup- Casing Vibration- Generator In-board & out-board bearing



Online transducer Generator In-board bearing in vertical direction

Online transducer Generator Out-board bearing in vertical direction



Temporary transducer Generator In-board bearing in axial direction

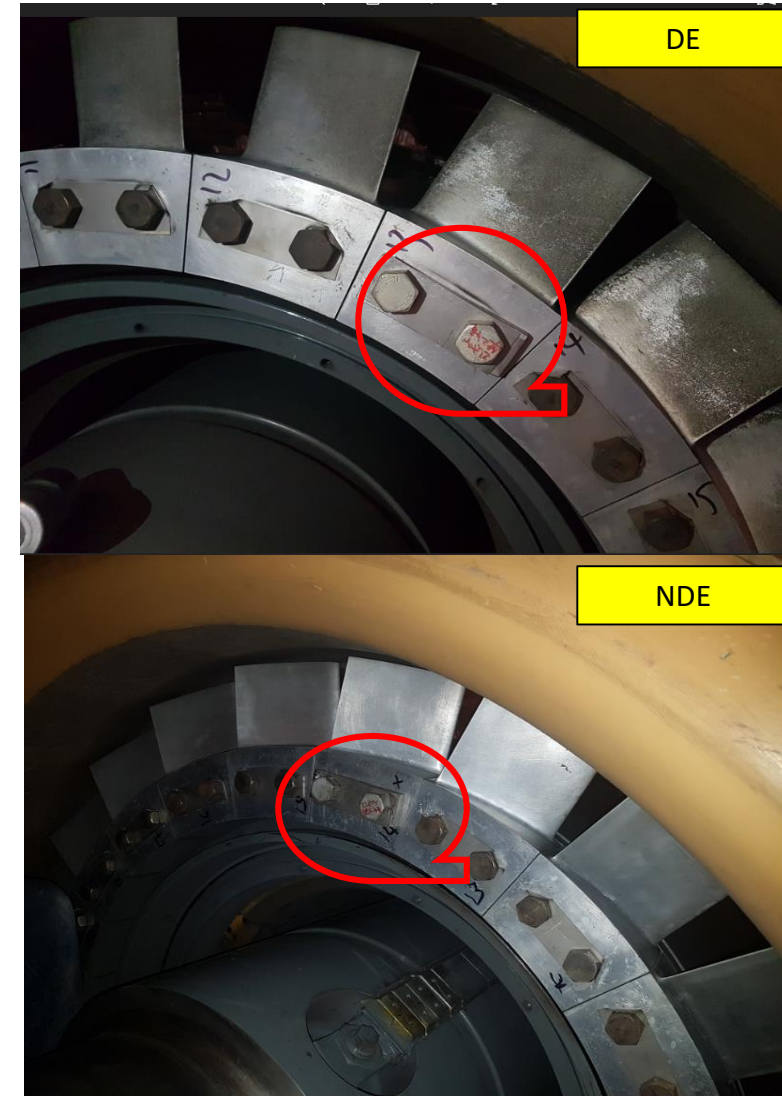
- Vibration readings on the IB and OB generator bearings were close to 29 mm/sec or 1.1 in/s (RMS). High vibration when the unit close to running speed.



# ACTION TAKEN # 1 & Results

## SINGLE & TWO PLANE BALANCING EXERCISE

- A single plane balancing lowered Generator outboard bearing shaft vibration.
- No reduction in casing vibration.
- A two plane balancing lowered shaft vibration on both the bearings of generator
- High casing vibration was still observed at both bearings.
- In-situ balancing didn't resolve the high vibration on the casing.

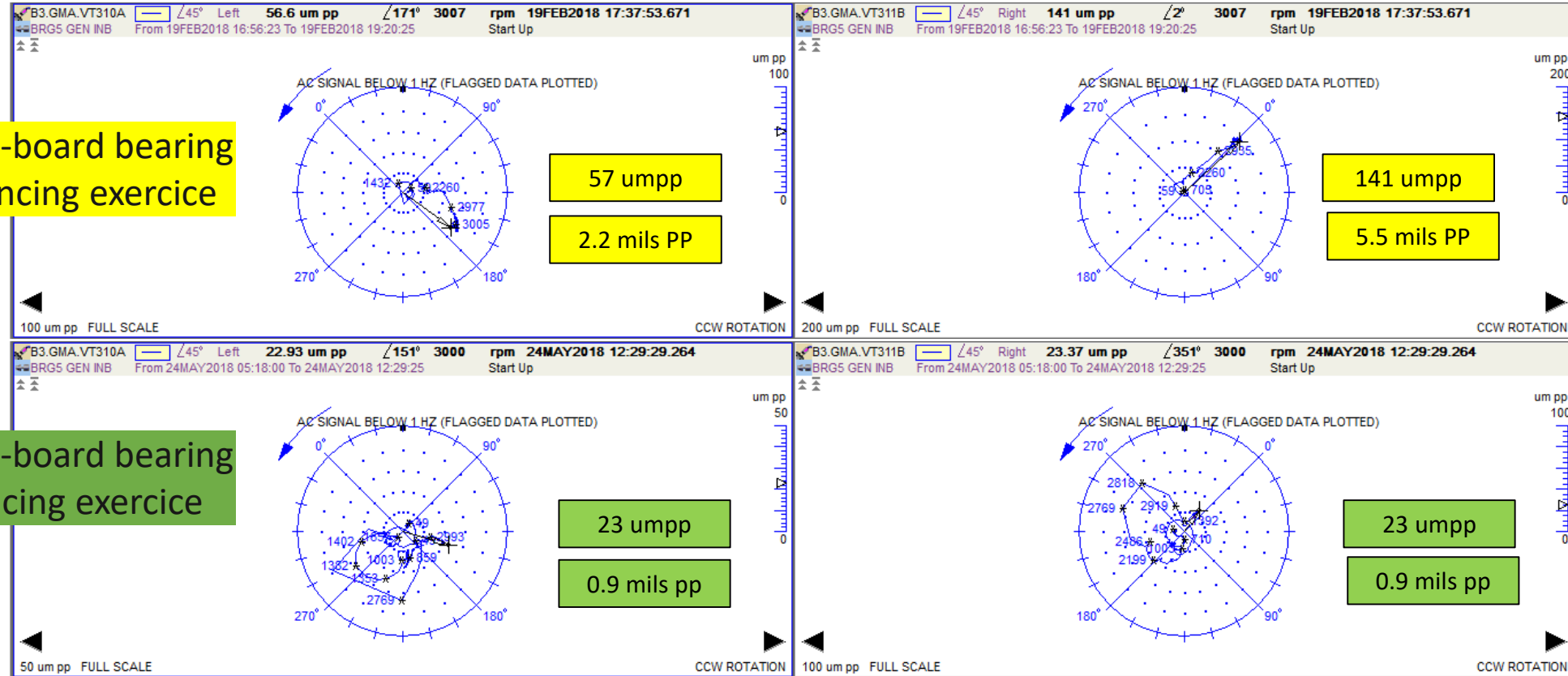


# ACTION TAKEN # 1

## SINGLE & TWO PLANE BALANCING EXERCISE

### Polar Plots- Startup- Shaft Vibration- Generator In-board bearing

Generator In-board bearing  
before balancing exercise



Generator In-board bearing  
after balancing exercise

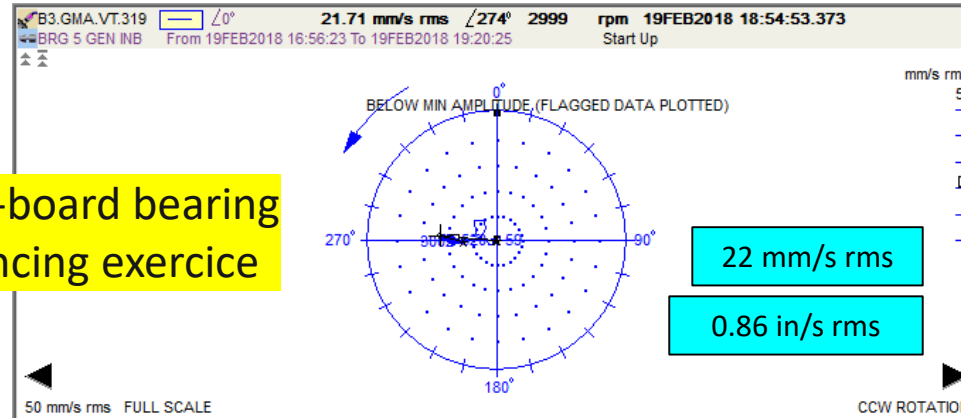
- Significant improvement noticed at Generator In-board bearing after balancing

# ACTION TAKEN # 1

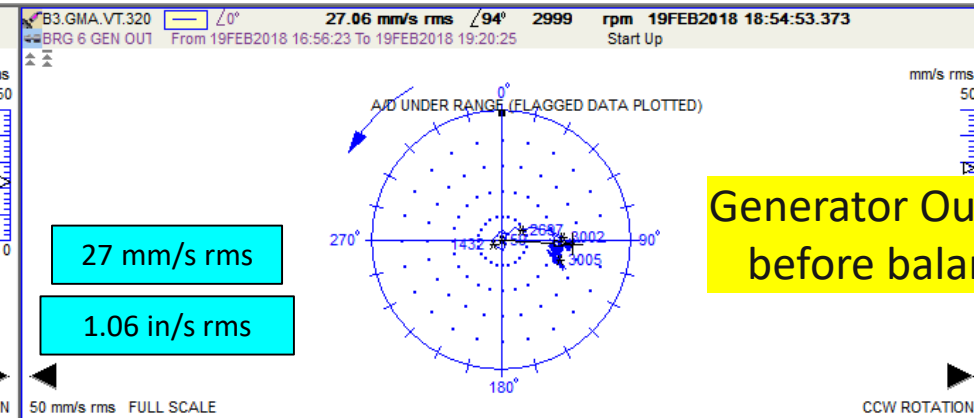
## SINGLE & TWO PLANE BALANCING EXERCISE

### Polar Plots- Startup- Casing Vibration- Generator In-board & Out-board bearing

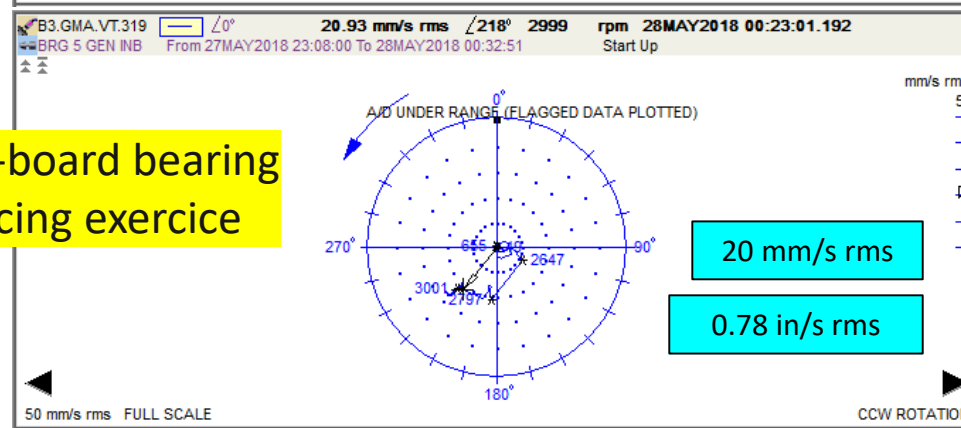
Generator In-board bearing  
before balancing exercise



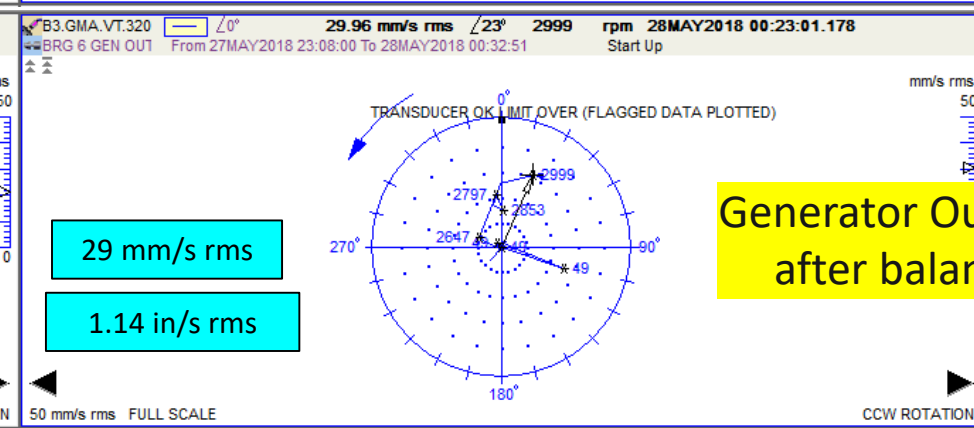
Generator Out-board bearing  
before balancing exercise



Generator In-board bearing  
after balancing exercise



Generator Out-board bearing  
after balancing exercise

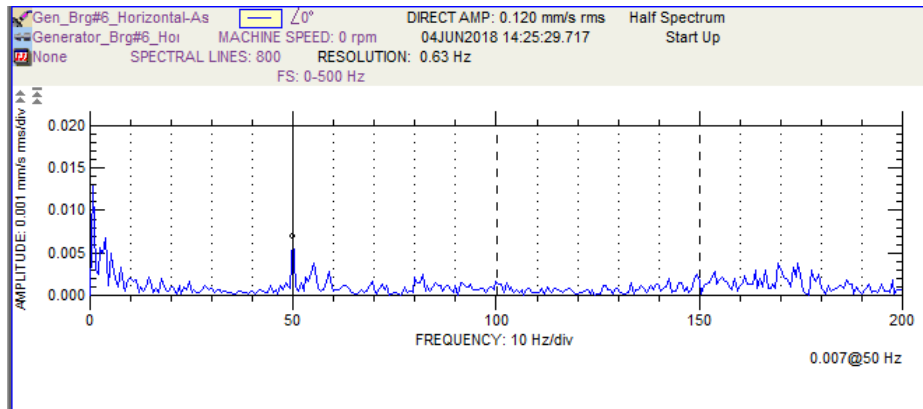


- *Not much changes noticed on the casing vibration even after balancing*

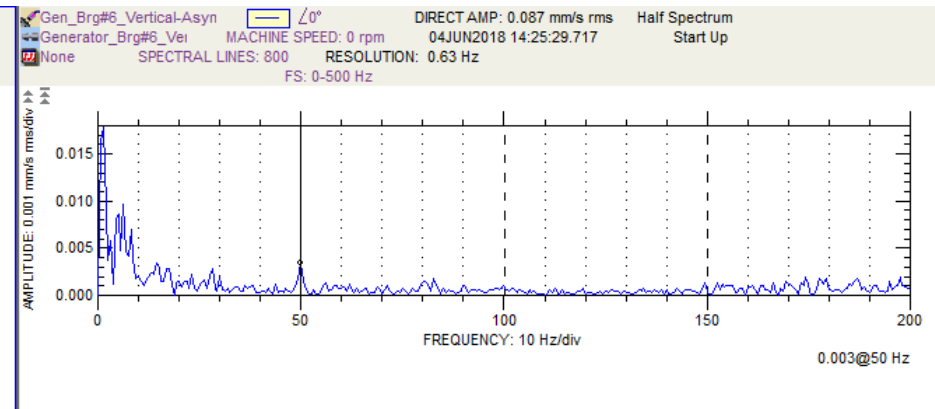
# ACTION TAKEN #2 & Results

## IMPACT TEST (THREE DIRECTIONS)

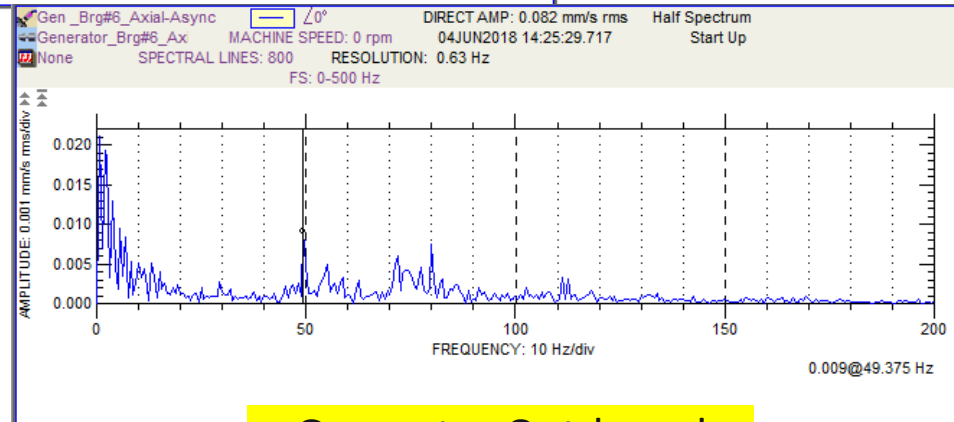
**Test result:** The impact test showed that the natural frequency of the outboard bearing aligns with the running speed.



Generator Out-board bearing Horizontal direction



Generator Out-board bearing vertical direction



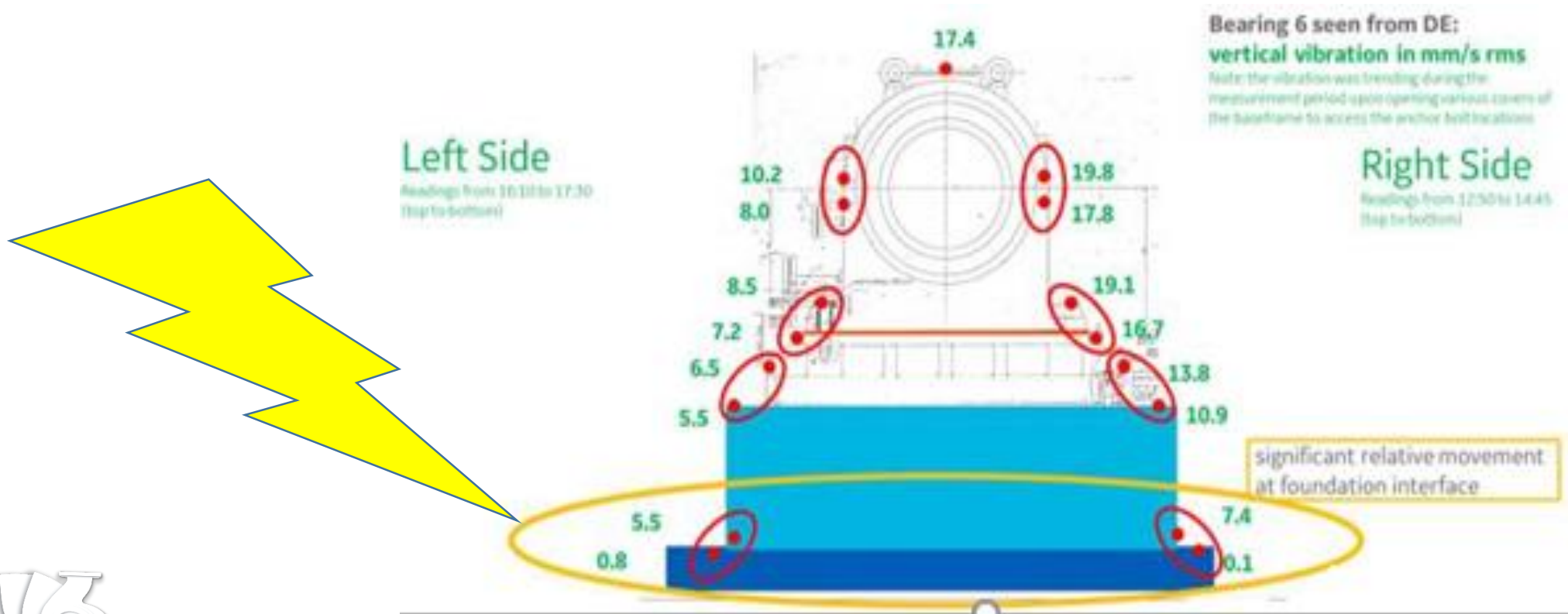
Generator Out-board bearing axial direction



# ACTION TAKEN #3 & Results

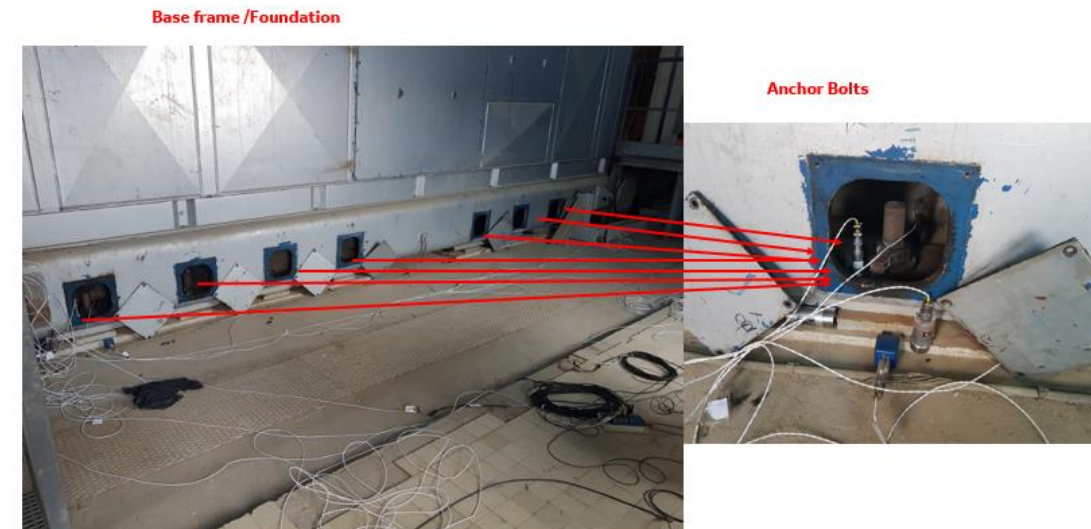
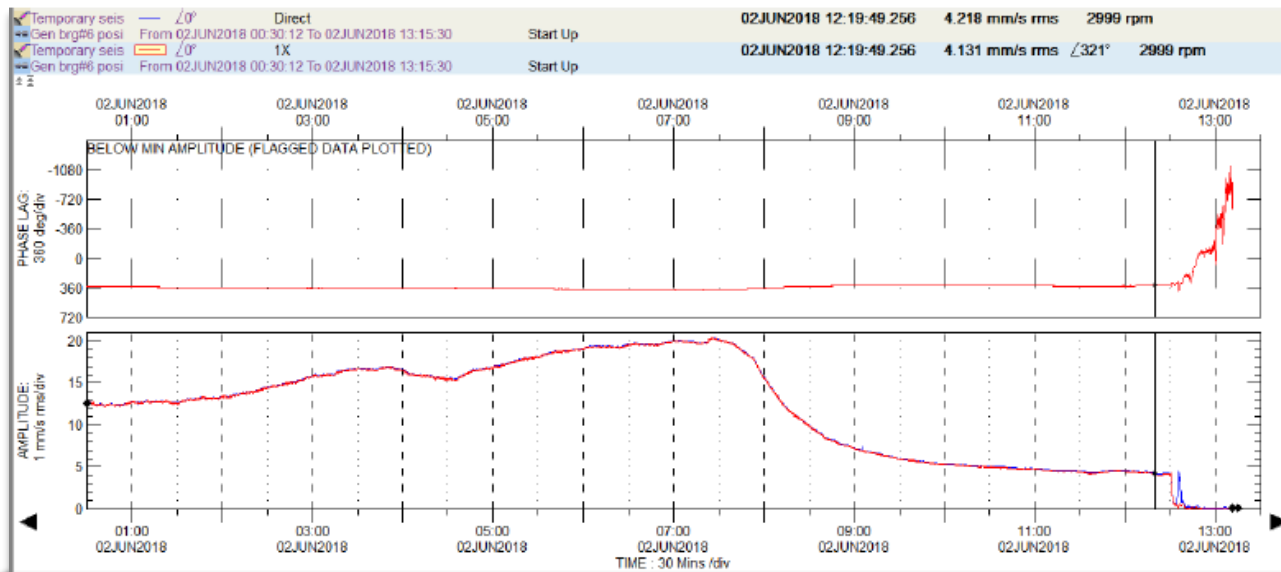
## PEDESTAL INTERFERENCES ASSEMBLY MEASUREMENT LOCATIONS

- Significant relative movement at interface foundation on outboard bearing (location 8) was located



# ACTION TAKEN #4 & Results

- An interesting event occurred during the soft foot check: The vibration readings started to decrease gradually on both Generator bearings and stabilized at low levels after opening the anchor bolts trapdoors.
- The above test was repeated with closing/opening of the anchor bolts trapdoors and the test confirmed that the trapdoors of anchor bolts location of base frame/foundation affected both shaft and casing vibration of generator.



# CONCLUSIONS & RECOMMENDATIONS FROM ACTION # 4

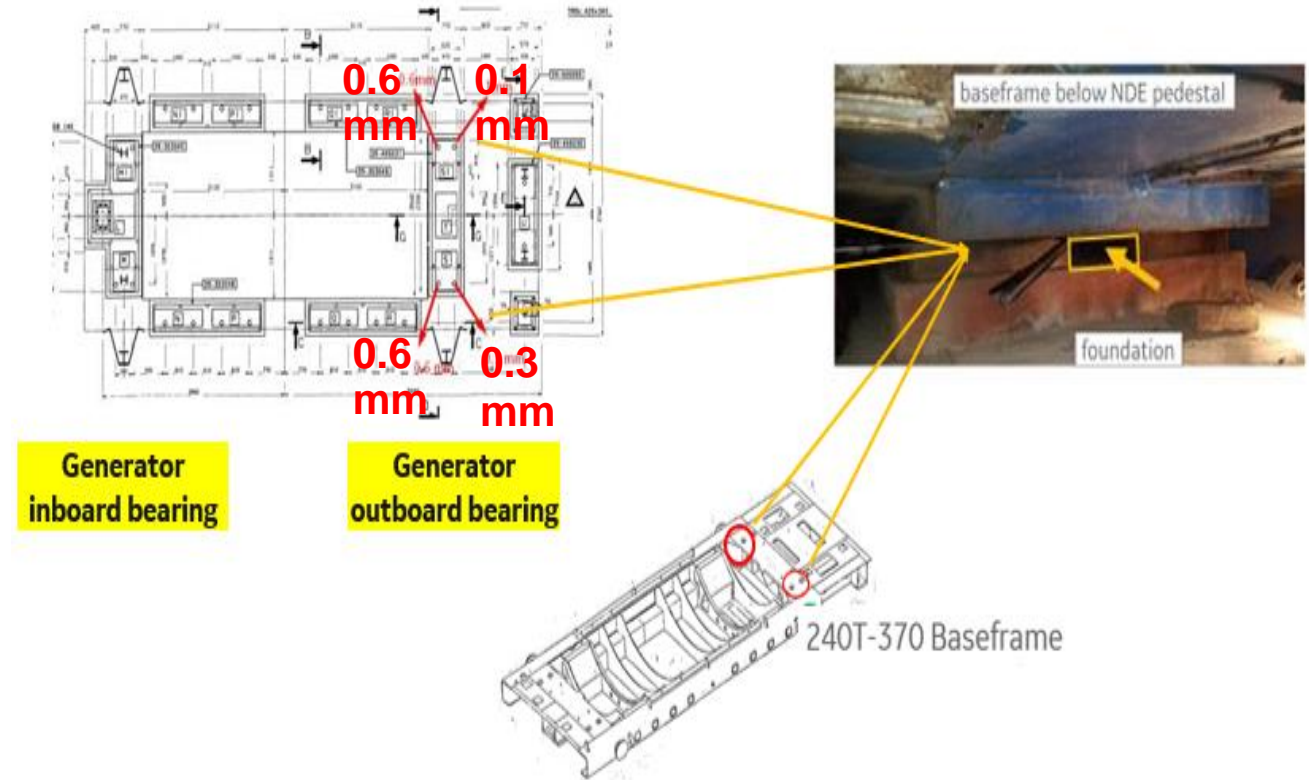
- The phenomenon of vibration reduction during opening of anchor bolt trap doors is suspected to be a resemblance of thermal transient where generator bearing housing and frame trying to attain thermal equilibrium whereas it is causing high vibration due to frame distortion when trap doors are closed.
- The above behavior suggested an issue on anchor bolts tightness or soft foot issue.
- Following was recommended:
  - ✓ **Check tightness at the 4 foundation anchors below the outboard bearing pedestal (area S and S1, area R and R1) and ensure proper tightness of shims.**





# MACHINE INSPECTION FINDINGS

- No loose shimming found at the 4 foundation anchors below the generator bearing pedestals.
- Anchor bolts were already properly tightened with a torque of 800 N.m but there was an abnormal gap of 0.1 mm and 0.61 mm were measured on the Generator NDE bearing pedestal.
- The above observation concluded that this is the root cause of high vibration on the Generator bearing casing.



- Encircled are the locations of NDE pedestal area where gaps found.

# MACHINE INSPECTION FINDINGS



- Gaps were measured below Generator NDE pedestal

# CORRECTIVE ACTIONS

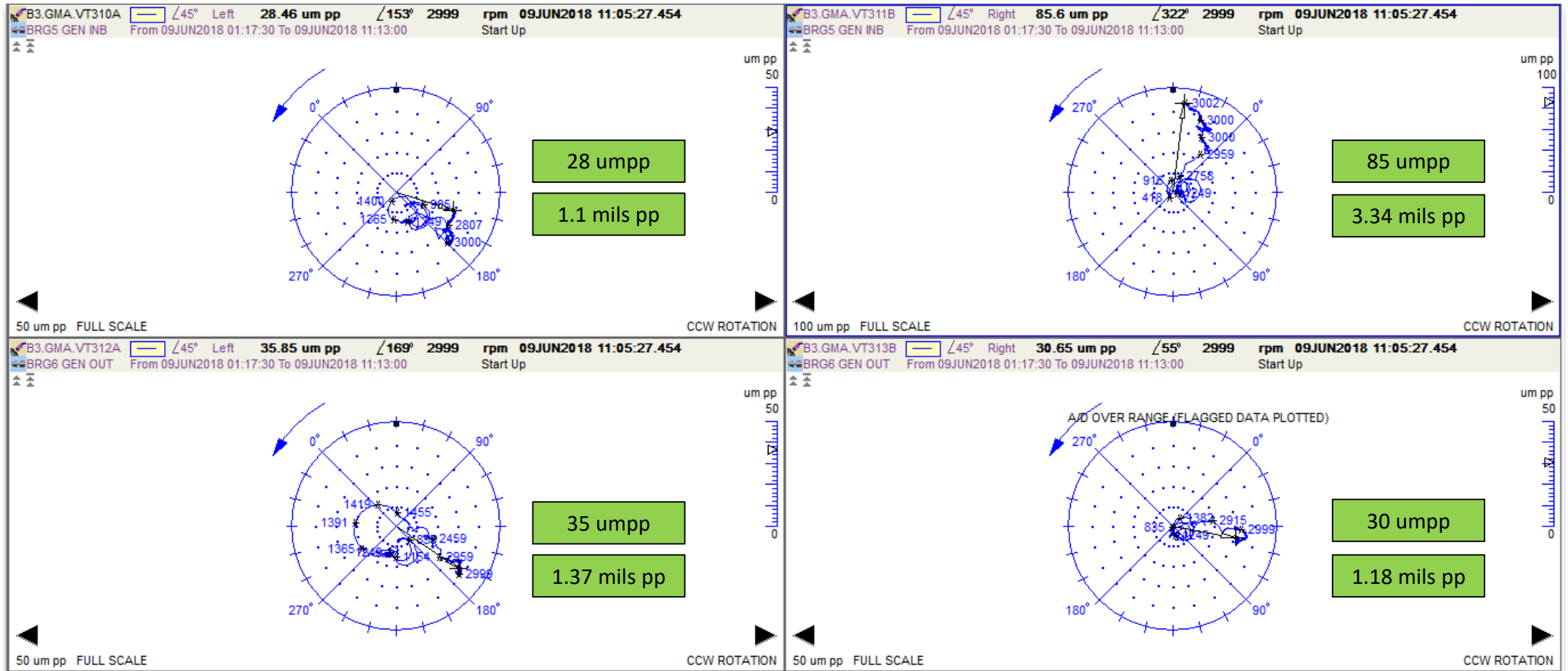
- Shimming was added below the 4 foundation anchors of the generator outboard bearing pedestal.
- Correction was completed by jacking the generator frame up off of the baseplate. Shims at the interface point were removed and the interface points on the baseplate and pedestal were cleaned and new shims were then installed. The generator frame was then lowered and proper level and contact was confirmed.

# RESULTS

- Upon restart of the unit, vibration amplitude was found to be significantly reduced at acceptable levels, we observed that the high vibration has been resolved on both generator bearings vertical & axial direction.

# RESULTS

## Generator Bearings after balancing exercise & shimming correction

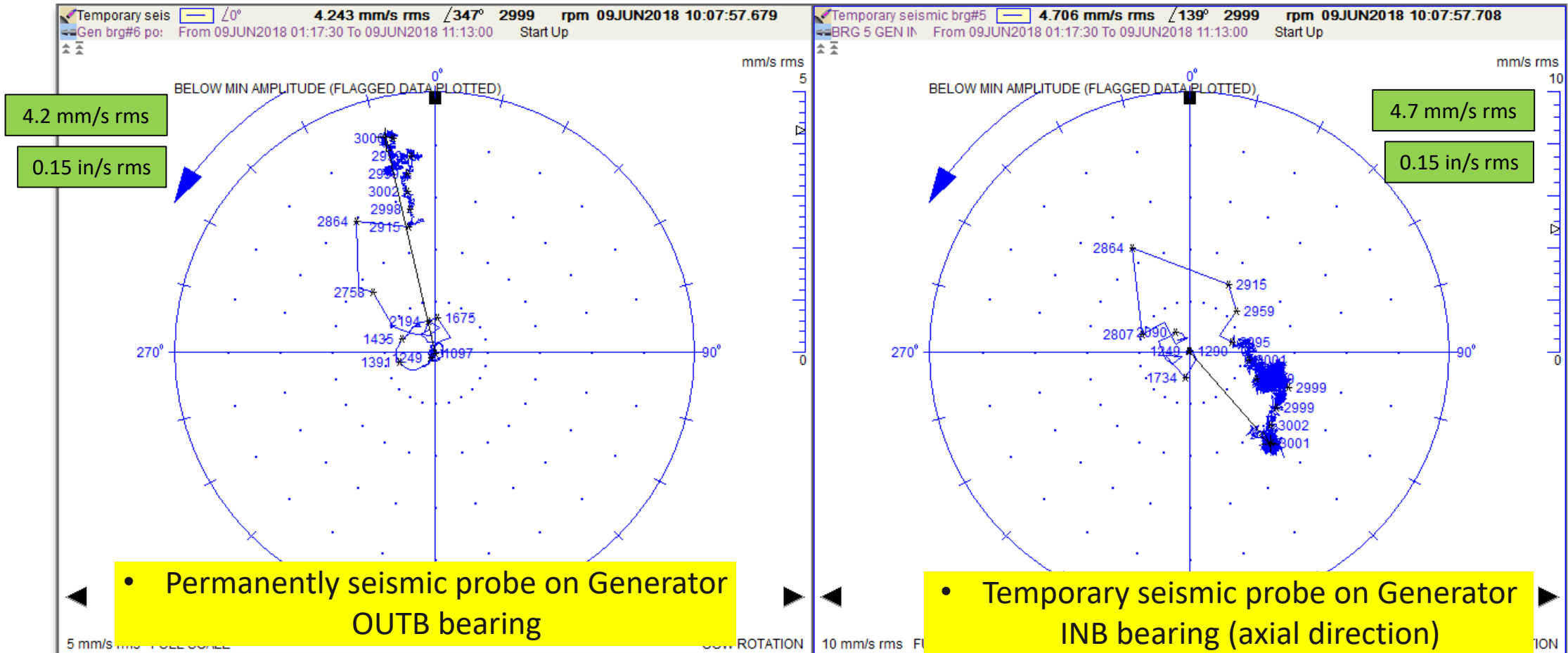


- Shaft Vibration / 1X polar plot after actions indicate acceptable vibration level



# RESULTS

## Generator Bearings after balancing exercise & shimming correction



- Casing Vibration / 1X polar plot after actions indicate acceptable vibration level

# THANK YOU FOR YOUR ATTENTION

*ANY  
QUESTIONS*

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