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Pelletizer Motor Bearing Damage Detection Based on Vibration Data

John J. Yu
Carl Feng Wang
Tony Wei Zhou
Nicolas Péton
Haibo Lin
Jun Quan

赛科 SECCO

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY

Authors

John J. Yu, PhD, ASME Fellow - Senior Technical Manager
General Electric, Bently Nevada, USA

Carl Feng Wang - Machinery Manager
Shanghai SECCO Petrochemical Co., China

Tony Wei Zhou - Rotating Equipment Engineer
Shanghai SECCO Petrochemical Co., China

Nicolas Péton - Global Director, Machinery Diagnostics Services
General Electric, Bently Nevada, France

Haibo Lin - Field Engineer
General Electric, Bently Nevada, China

Jun Quan - Senior Sales Operations Manager
General Electric, Bently Nevada, China

Abstract

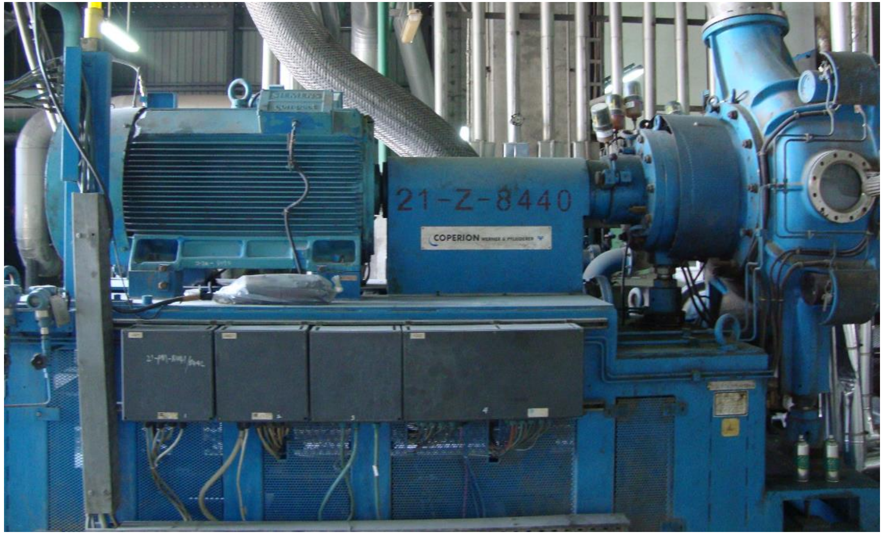
This presentation provides a case study that pelletizer motor bearing damage on an extruder was detected from on-line remote monitoring vibration data. Though vibration level was well below the acceptable limit, its abnormal signatures warranted a shutdown action. It was then observed that for each bearing, the whole outer raceway was spalled circumferentially into a “washboard” pattern. This was caused by electrical corrosion or fluting due to poor insulation resulted from damaged insulating washers. After replacing the bearings with insulated ones , vibration level and signatures have then become normal ever since its restart.

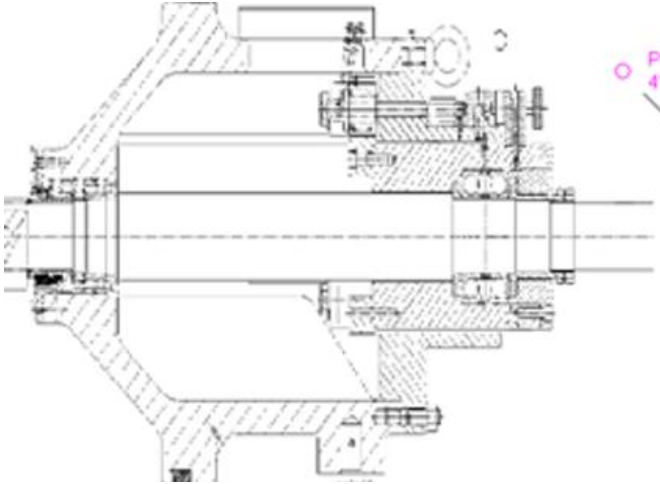
Outline

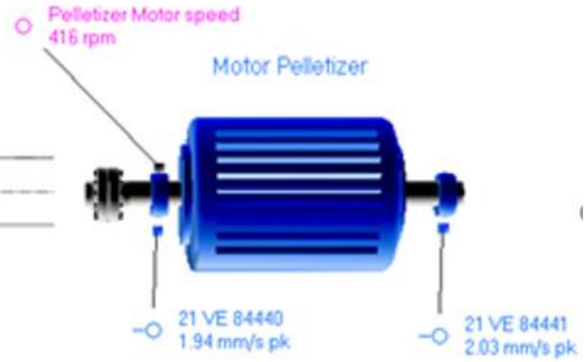
1. Introduction
2. Problem Statement
3. Data Review
4. Conclusions and Recommendations
5. Inspection and Findings
6. Resolution and Final Vibration Results
7. Lessons Learned

1. Introduction

- Pelletizer motor on an extruder
- Supported by two deep groove ball bearings
- Motor running at 350 ~ 390 rpm
- Vibration monitored by velocity transducers at each end of bearing housing

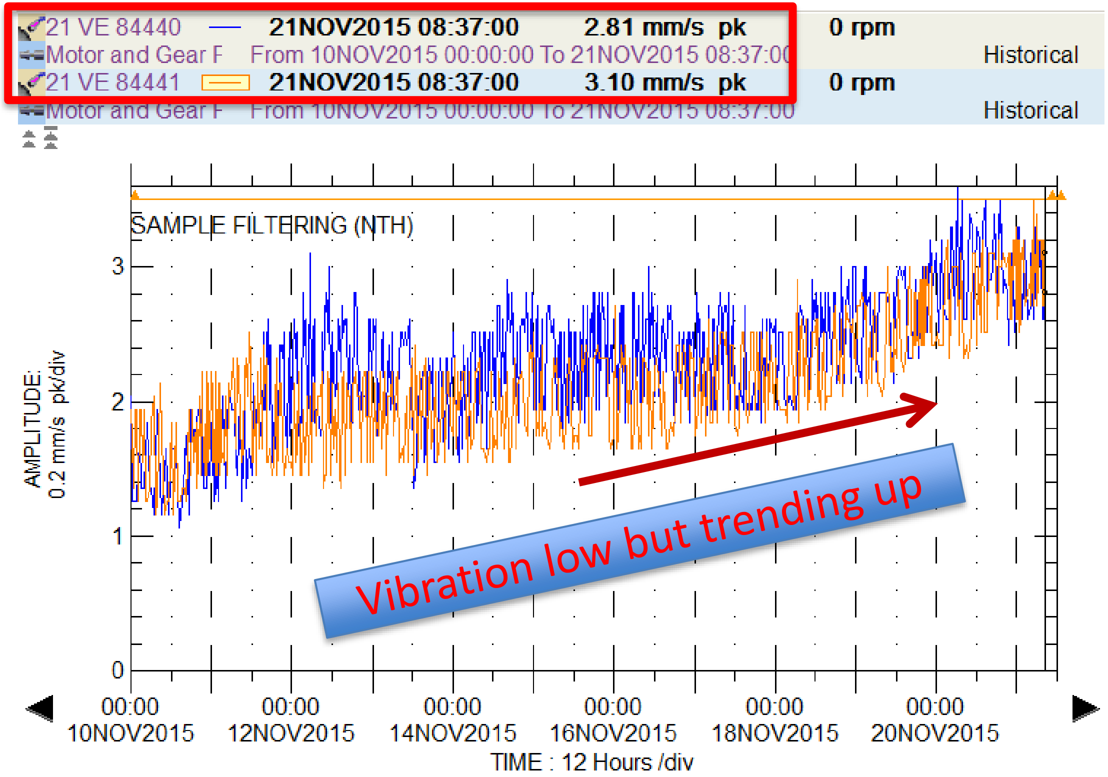






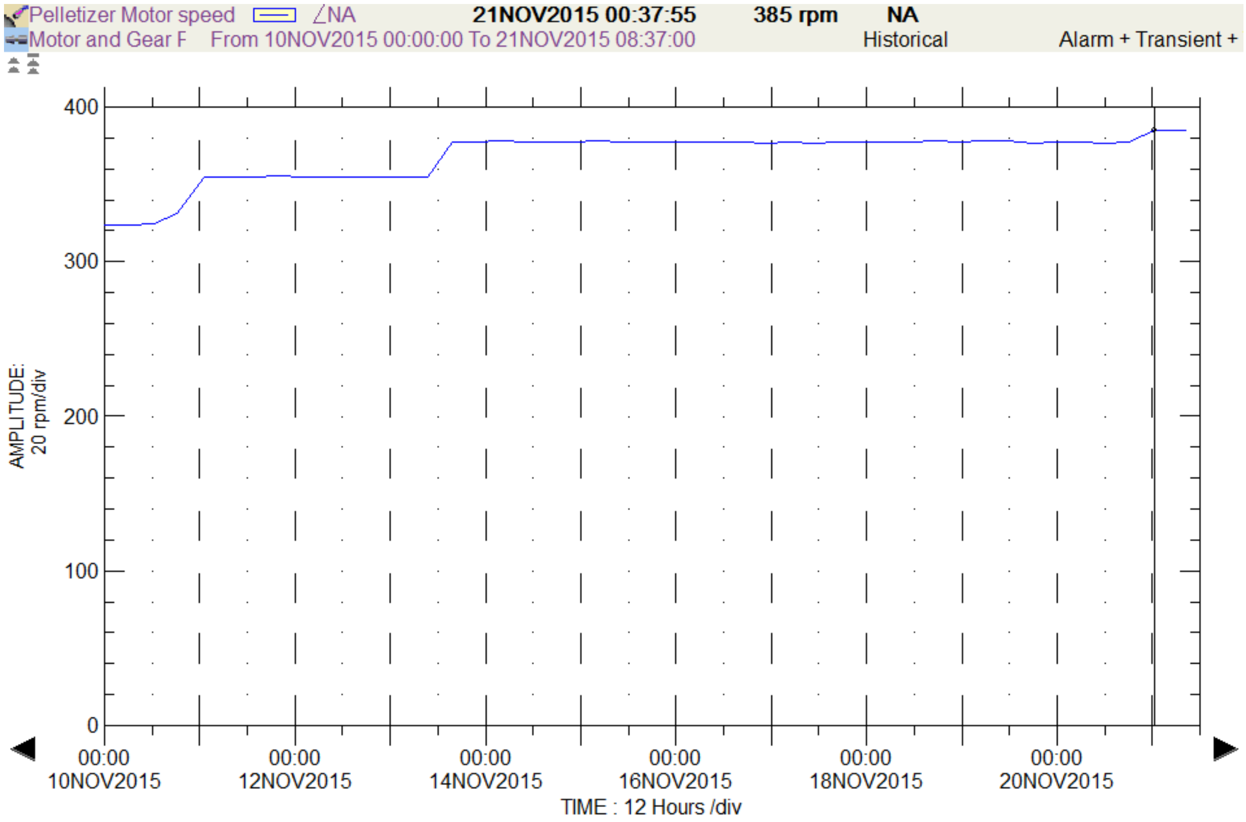
2. Problem Statement

- While reviewing high vibration data at other locations, vibration readings on motor bearings was found trending up.
- The motor vibration level was still within the acceptable limit, despite of trending up. Was there any problem?



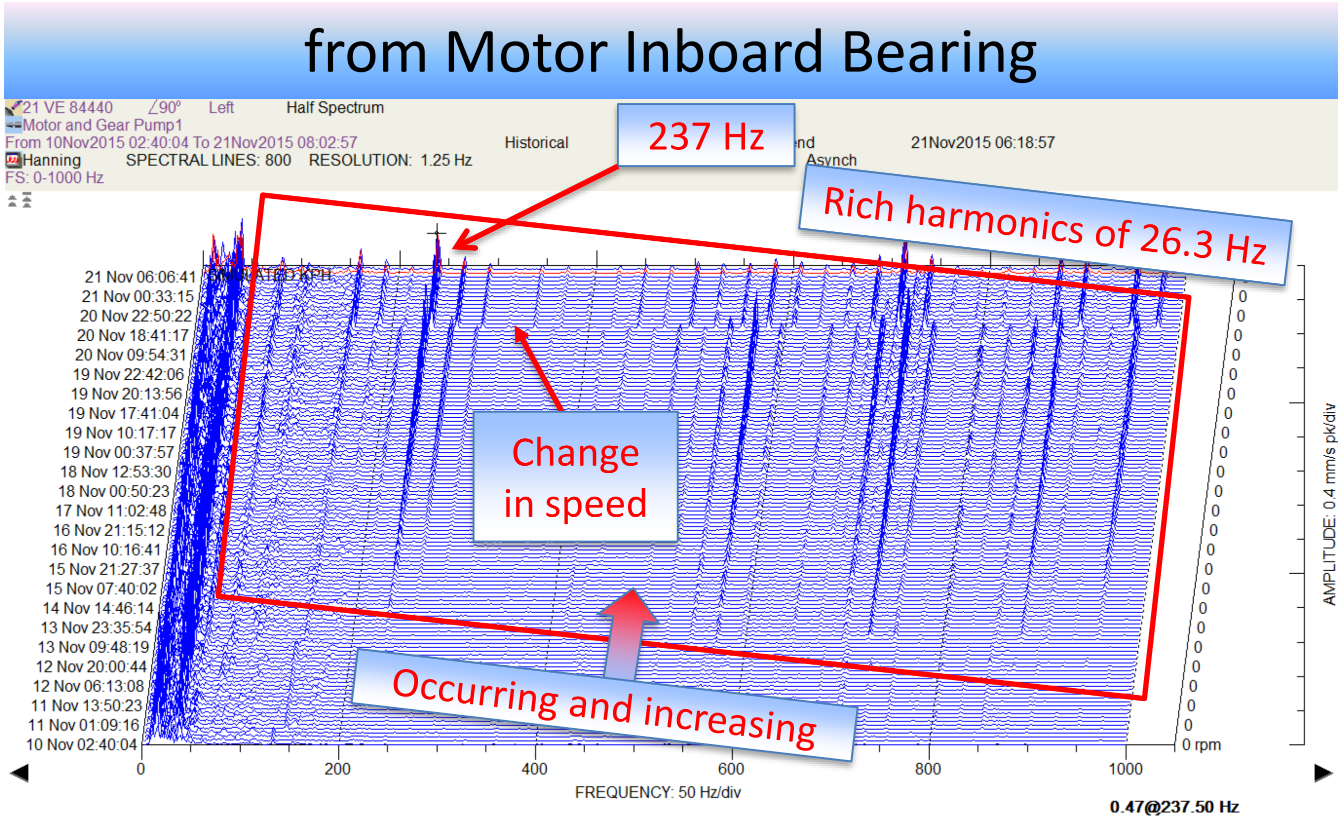
3.1 Data Review – Speed trend

- Stable in general, only varied with slight step changes
- 385 rpm used for bearing frequency calculation



3.2 Data Review – Waterfall plot at Motor IB

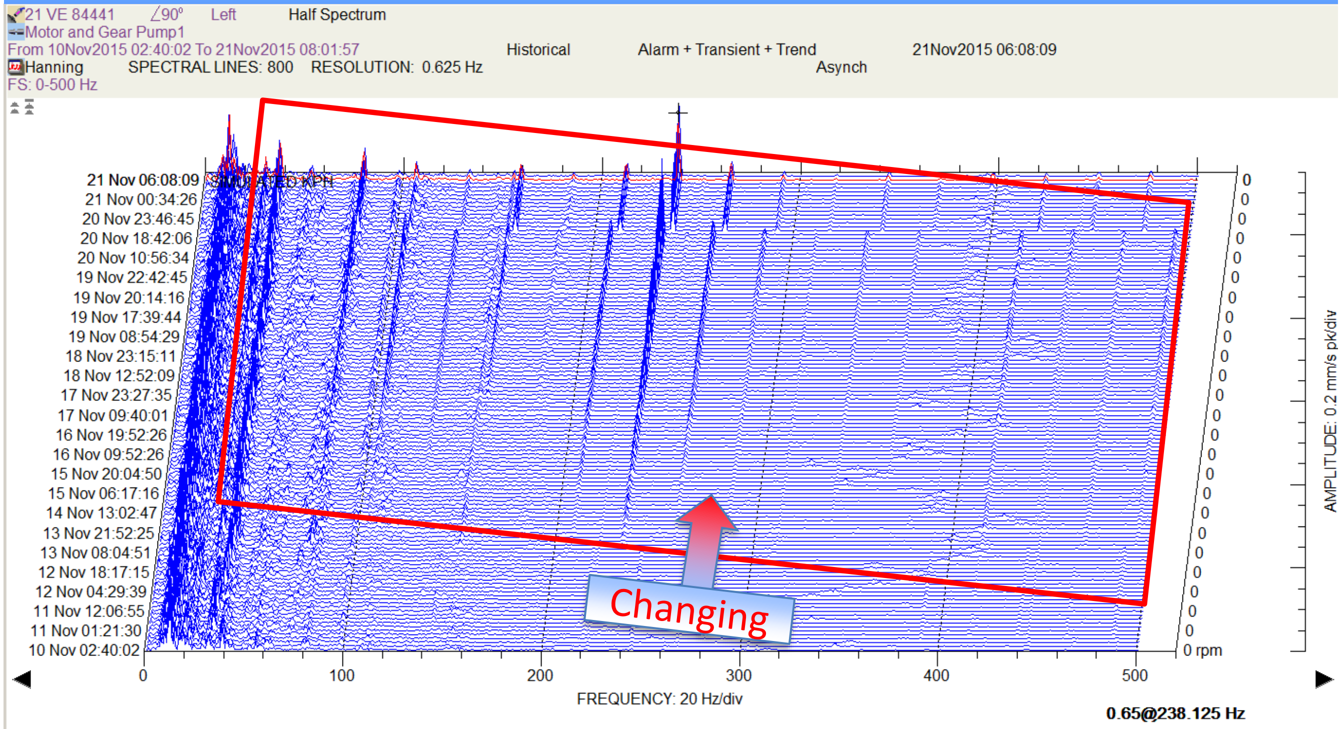
- Harmonics or side bands appeared and significantly increased – abnormal.
- Highest peak at 237 Hz (~ 9 X 26.3 Hz), and rich harmonics of 26.3 Hz.



3.3 Data Review – Waterfall plot

Same signatures as those from inboard bearing

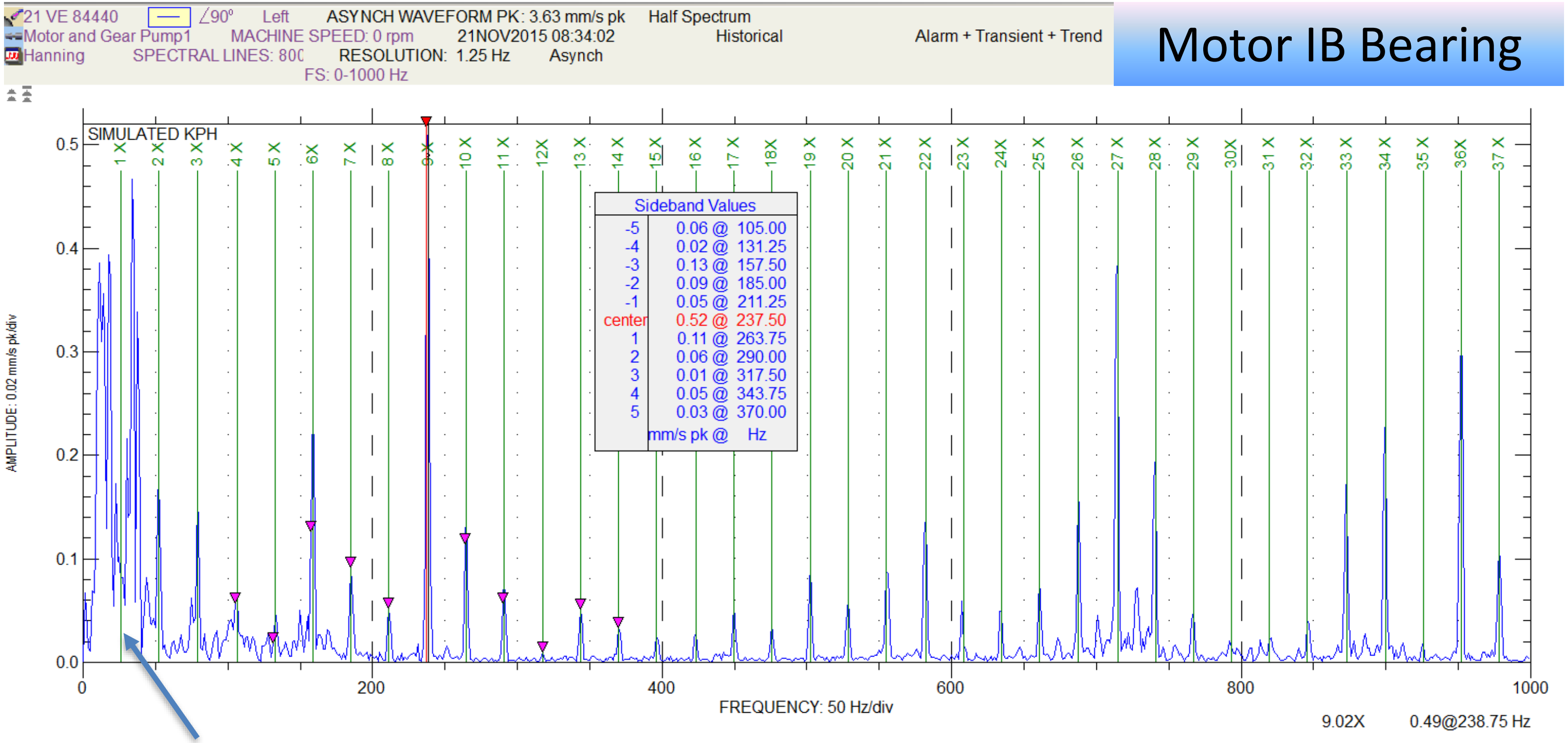
from Motor Outboard Bearing



3.4 Data Review – Spectrum plot at 385 rpm

Confirmation of rising vibration due to 26.3 Hz harmonics

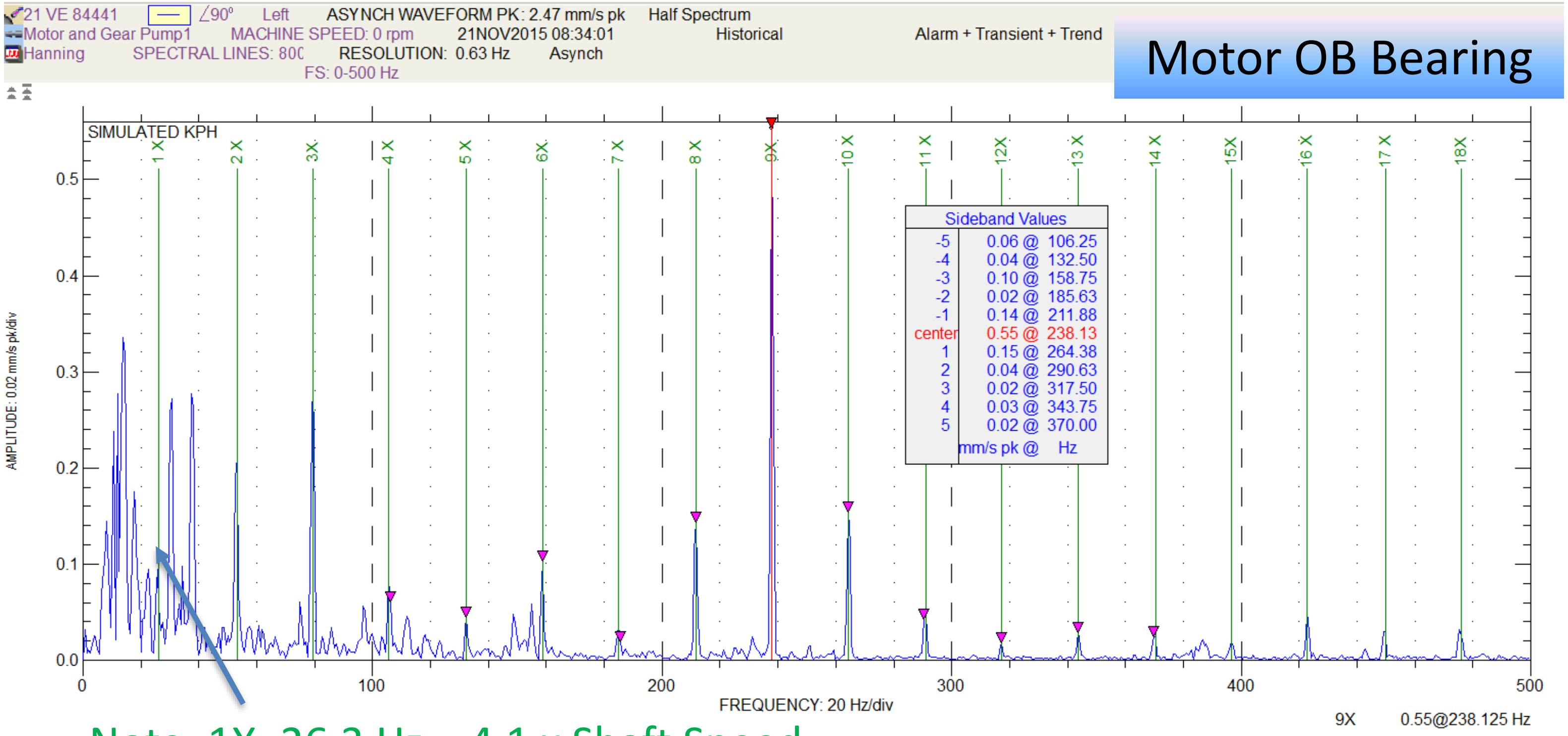
Motor IB Bearing



Note: 1X=26.3 Hz = 4.1 x Shaft Speed

3.5 Data Review – Spectrum plot at 385 rpm

Confirmation of rising vibration due to 26.3 Hz harmonics



Note: 1X=26.3 Hz = 4.1 x Shaft Speed

3.6 Data Review – Bearing fault frequencies at 385 rpm

The measured 26.3 Hz matches the calculated Ball Pass Frequency Outer Race (BPFO).

Bearing Data

Measurement system	(•) Metric ( ) Imperial	
Bearing type*	DGBB	
Pitch diameter*	140	mm
Rolling element diameter*	25.4	mm
Number of rolling elements (per row)*	10	
Contact angle*	0.0	degrees
Rotational speed*	385	rpm
Rotating ring*	(•) inner ( ) outer	

Output

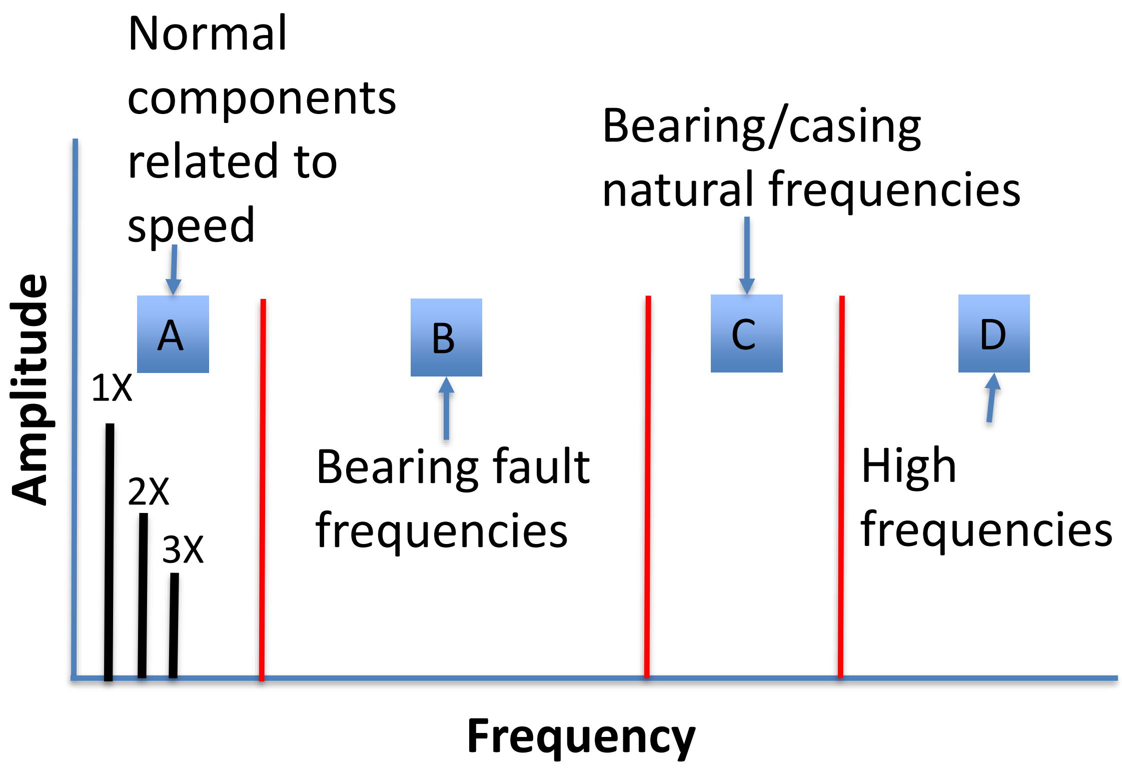
(•) Hertz ( ) CPM ( ) Orders

Shaft speed frequency	6.417 Hz
Inner race defect frequency (BPFI)	37.904 Hz
Outer race defect frequency (BPFO)	26.263 Hz
Cage defect frequency (FTF)	2.626 Hz
Ball spin frequency (BSF)	17.102 Hz
Rolling element defect frequency	34.203 Hz

Outer Race Damage Suspected!

BPFO = 4.1 x shaft speed
BPFI = 5.9 x shaft speed
FTF = 0.4 x shaft speed
BSF = 2.7 x shaft speed

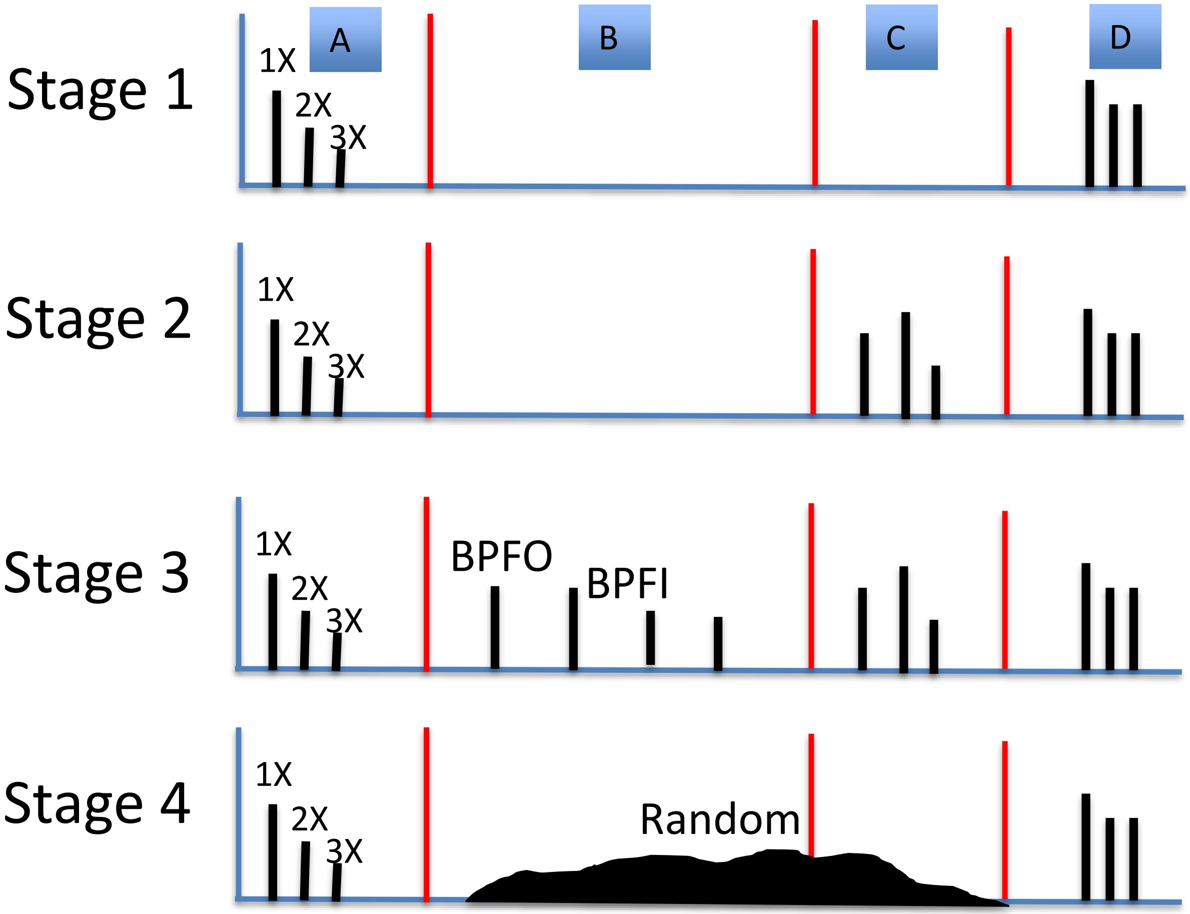
4.1 Conclusions and Recommendations



Four Stages of bearing life

- **Stage 1**: 10-20% life left, frequencies in Zone “A” & “D”
- **Stage 2**: 5-10% life left, frequencies in Zone “A” , “C” & “D”
- **Stage 3**: <5% life left, plus additional Zone “B” with bearing frequencies
- **Stage 4**: <1% life left, Zone “B” & “C” replaced with random noise.

4.2 Conclusion and Recommendation



Stage 1: Still a "good bearing"

Stage 2: Early stage, damage only detectable via enveloping

Stage 3: Bearing fault frequency detectable on direct spectrum

Stage 4: Close to total failure

4.3 Conclusions and Recommendations

After on-line remote data review and diagnosis, similar vibration signatures were measured via off-line portable devices. The following conclusions and recommendations were made:

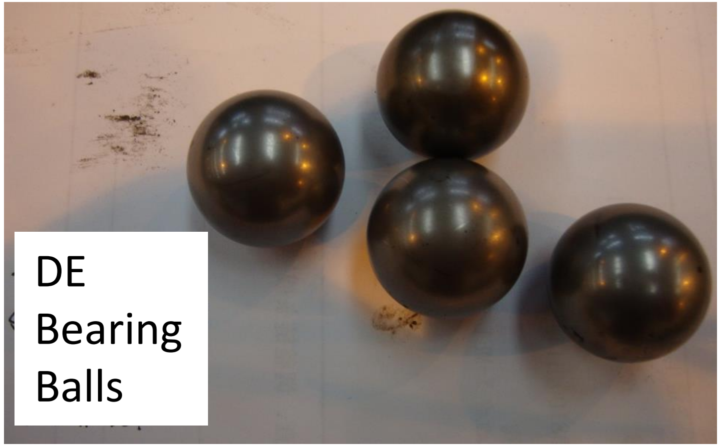
- Conclusions:
  - ➢ Outer race damage occurred on motor bearings.
  - ➢ Became severe in a fast progression.
  - ➢ Bearing life in later Stage 3, towards Stage 4.

- Recommendations
  - ➢ Stop the machine within a few days
  - ➢ Inspect the two bearings to confirm the damage
  - ➢ Find the root-cause of the damage
  - ➢ Install the new bearings

The motor was then shut down 3 days after the initial diagnostics & recommendation.

5.1 Inspection and Findings

"**Washboard**" pattern across the entire outer race circumferentially, plus wear on inner race and dark discoloration on balls



5.2 Inspection and Findings

Similar damages on NDE bearing

5.3 Inspection and Findings

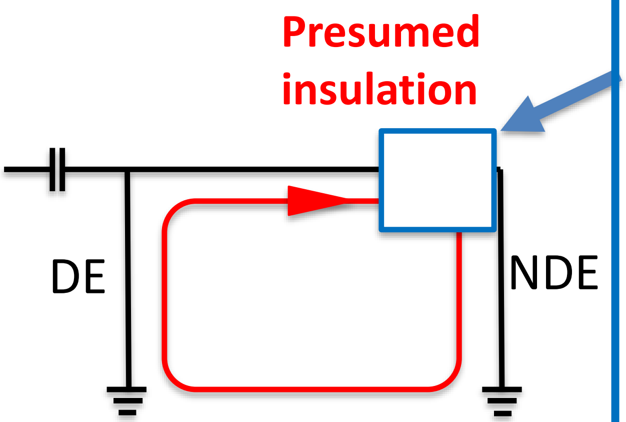
Insulated washers damaged on end cover of NDE bearing

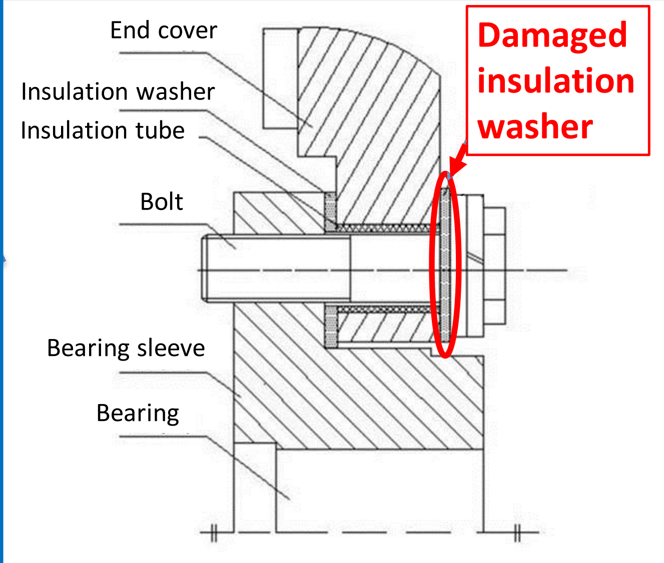
5.4 Inspection and Findings

Root cause of the bearing damage:

Presumed insulation broken due to damaged insulation washers → **Electrical Corrosion/Fluting**

The stator and rotor generate charge accumulation, which passes through the motor shaft to the bearings and discharges from the balls with enough energy to pit the race.





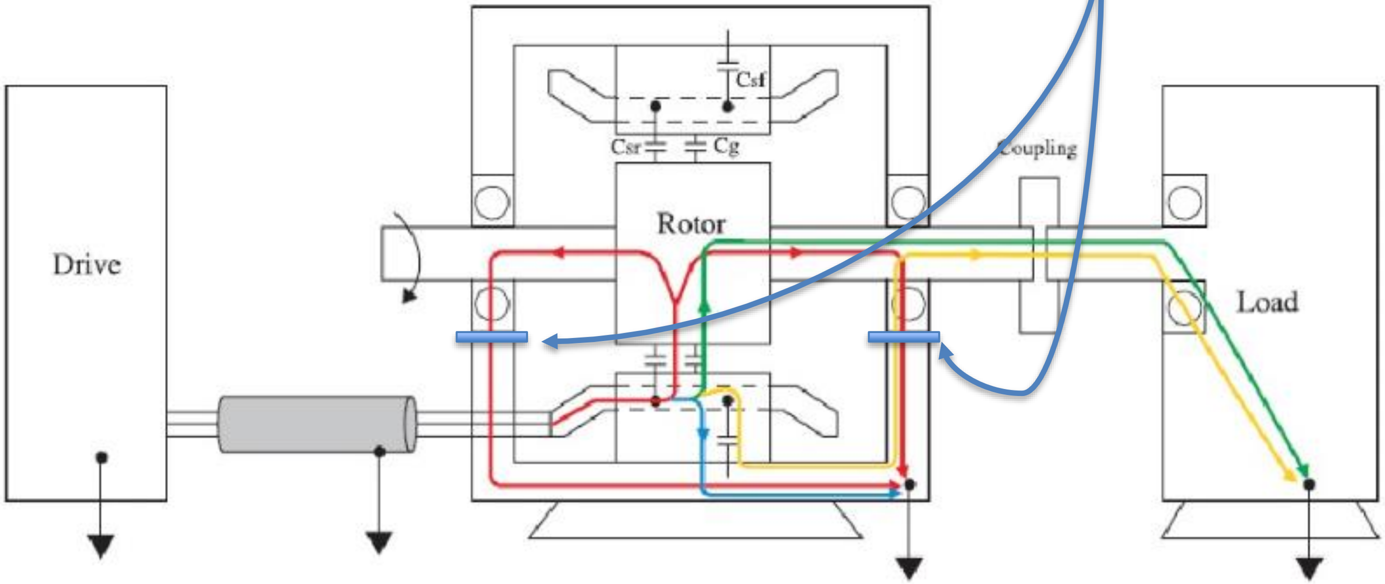
Insulated End Cover Assembly

6.1 Resolution and Final Vibration Results

Resolution:

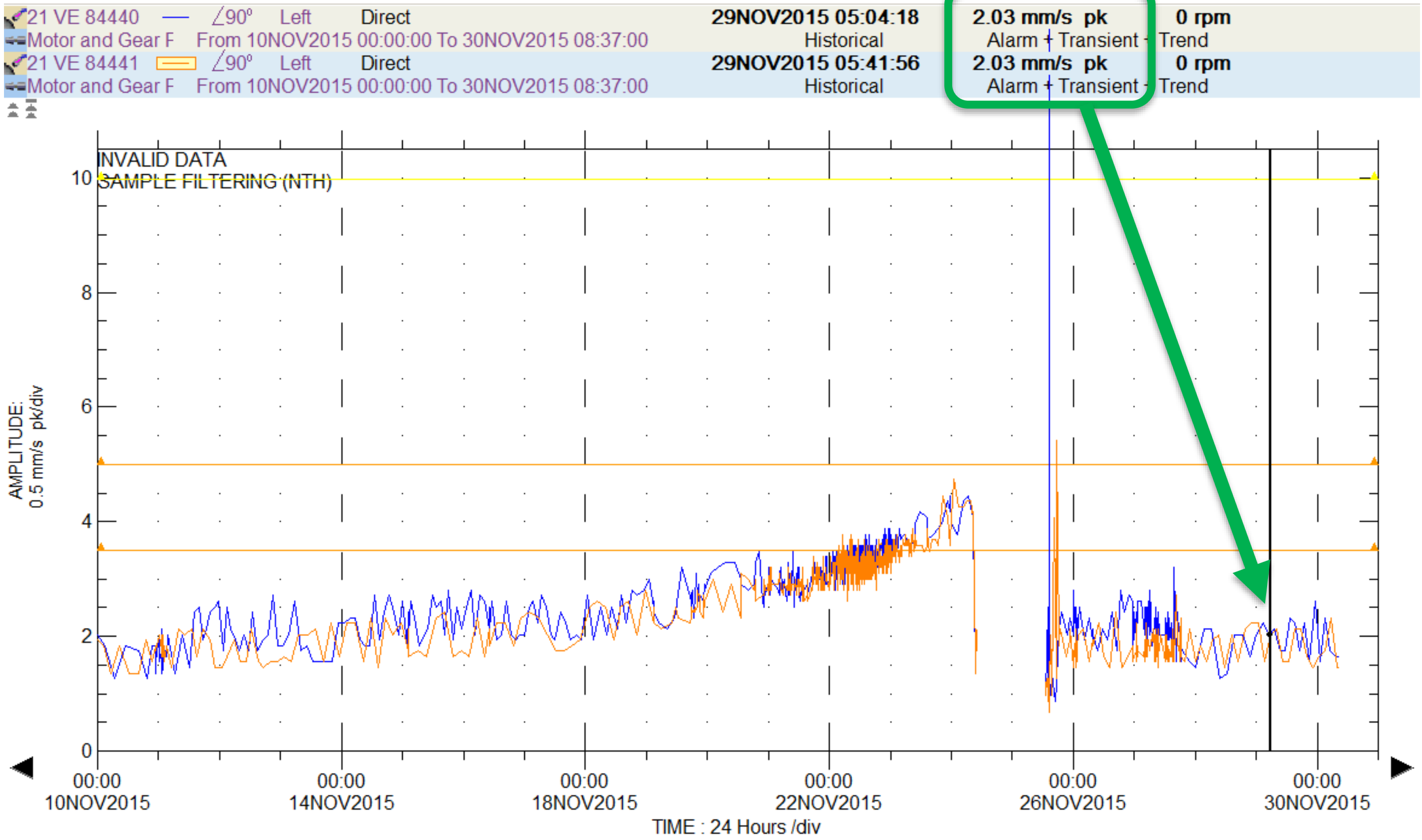
Damaged bearings → Replaced by → **Insulated** bearings

Aluminum oxide coated external surface of outer ring for electrical resistance



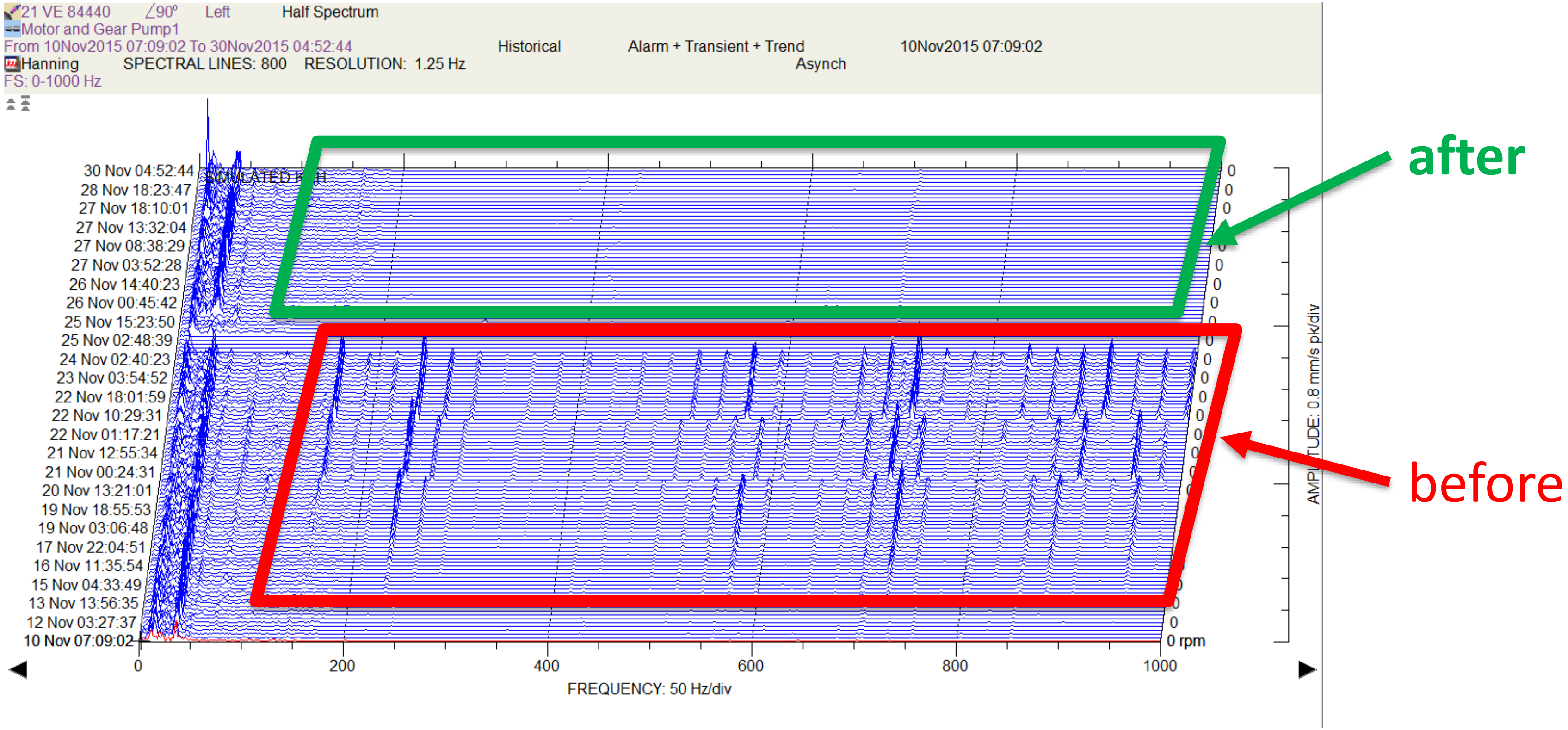
6.2 Resolution and Final Vibration Results

Vibration readings became low and stable.



6.3 Resolution and Final Vibration Results

Abnormal harmonics disappeared!



7. Lessons Learned

- Even if vibration is still within the acceptable level, it cannot warrant no malfunction. A change in vibration is more important than vibration level itself. Examining and understanding of the change are crucial to ensure a safe reliable operation of the machine.

- If the machine had continued its operation with the damaged bearings while maintaining electric arcing without knowledge, further deterioration would have led to complete bearing failure, and unscheduled equipment downtime and unanticipated maintenance costs would have likely followed. Electric corrosion can damage bearings very fast, and rolling elements can be welded to the raceways.