The 1st Middle East Turbomachinery Symposium (METS)
February 13 - 16, 2011
Sheraton Resort and Convention Center - Doha, Qatar

RCFA Case Study:
Infant Mortality: Lean Solvent Centrifugal Pump Motor

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QATAR SUPPLYING 77 MILLION TONNES OF LIQUEFIED NATURAL GAS PER ANNUM

DELIVERING ENERGY TO THE WORLD

قطر للغاز
QATARGAS

Agenda:

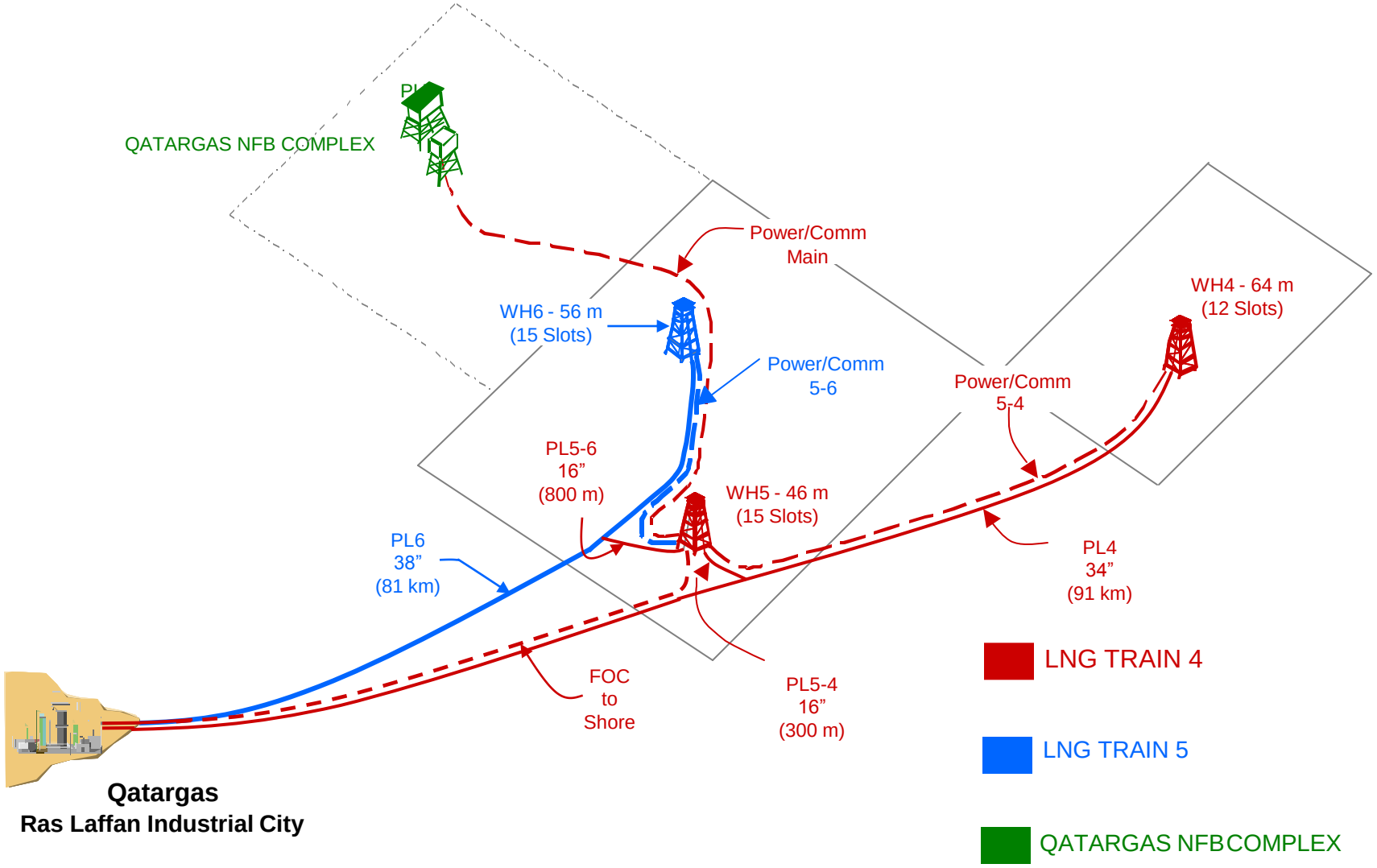
- **Introduction:**
  - Qatargas Operating Company Limited
  - Refresher: Bathtub Curve & Failure Regions (i.e. Infant Mortality)
- **Root Cause & Failure Analysis**
  - Brief Introduction – Incident and Action Plan
  - Simplified System Diagram
  - Basic Data – Pump & Motor
  - Event Diagram (Timeline)
  - Pictures of Failed Parts
  - PROACT Logic Tree & Vibration Data
  - Root Cause(s)
  - Recommendations & Lesson Learned
  - Q&A / Thanks

Introduction

Introduction:

- Qatargas is pioneer in Qatar's LNG production and will be the largest producer of LNG in the world by 2010 with total production of 77 MTPA.
- Qatargas existing LNG capacity is approx 25.6 MTPA of LNG
- Qatargas is going through phenomenal expansion and capacity will be 42 MTPA of LNG by end of 2010
- Qatargas Expansion Projects
  - 4 new Mega Trains (7.8 MTPA) : TR4&5 in production – Largest LNG Trains
  - Laffan Refinery (150K BPD): Naphta, Kerosene, Gasoil
  - Common Sulfur Project (12K TPD) – Granulated Sulfur
  - Q-Max & Q- Flex LNG Ships (Q-Flex:210,000 m^3 and Q-Max:266,000 m^3)
- High Availability & Reliability is a vital to meet global demand
  - Asset Management is key to achieve desired Reliability & Availability

A Glimpse - Qatargas Offshore:



DELIVERING LNG TO THE WORLD

A Glimpse - Qatargas Onshore:

DELIVERING LNG TO THE WORLD

Basics: Refresher!!

What is Bathtub Curve?

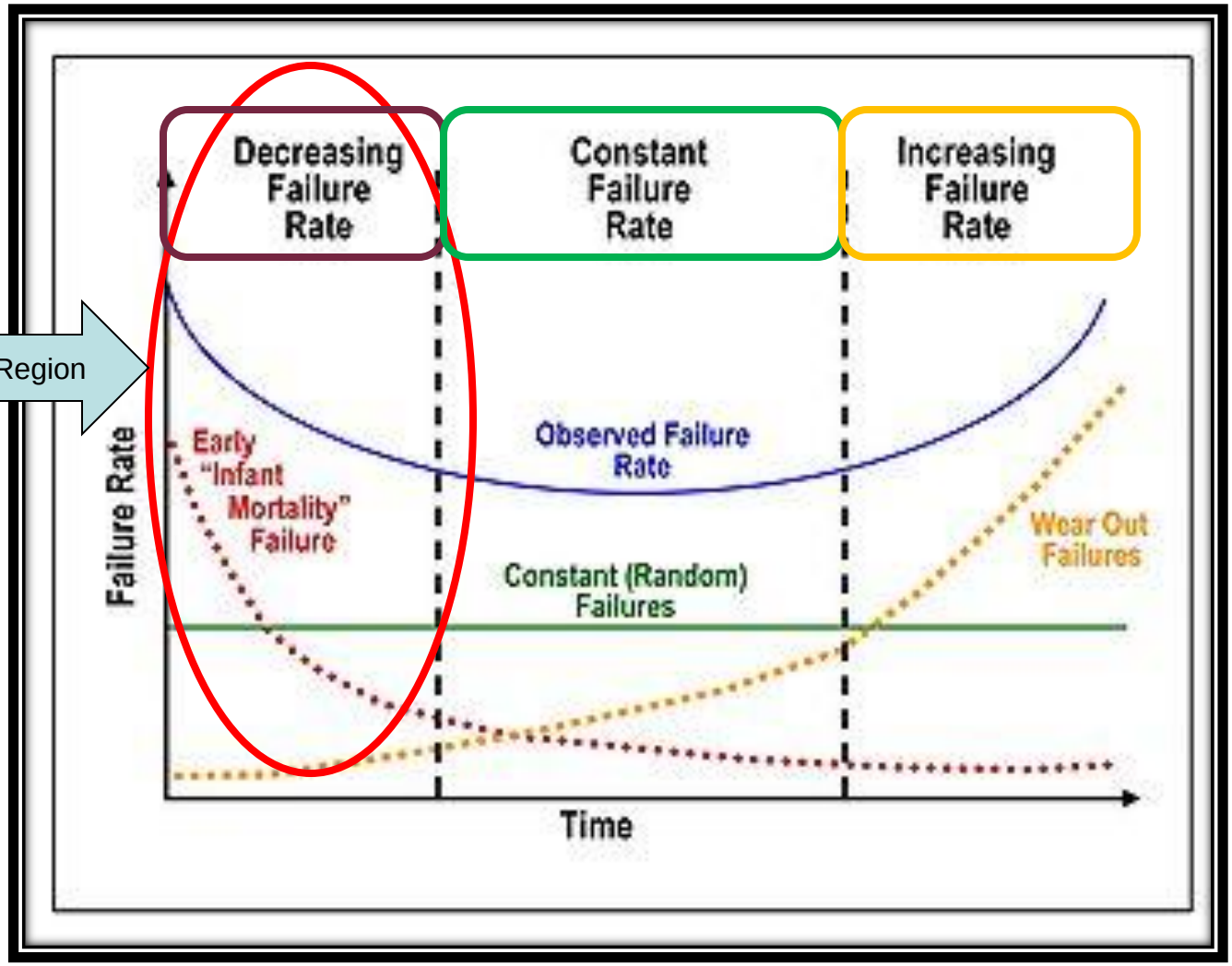
- **Bathtub Curve**
  - It is a Reliability Engineering tool which describe the particular form of Hazard Rate. Lifetime of a population of product in graphical representation. The bathtub curve mainly consist of three regions:

  - **Infant Mortality/Early Failure:**
    - It is a decreasing failure rate region in the curve mainly constitutes of early failures.

  - **Random Failures Region (Useful Life):**
    - It is a constant failure rate region in the curve mainly constitutes of random failures

  - **Wear Out / Aging :**
    - It is a increasing failure rate region in the curve mainly constitutes of wear out / aged failures

Bathtub Curve:



Source: http://en.wikipedia.org

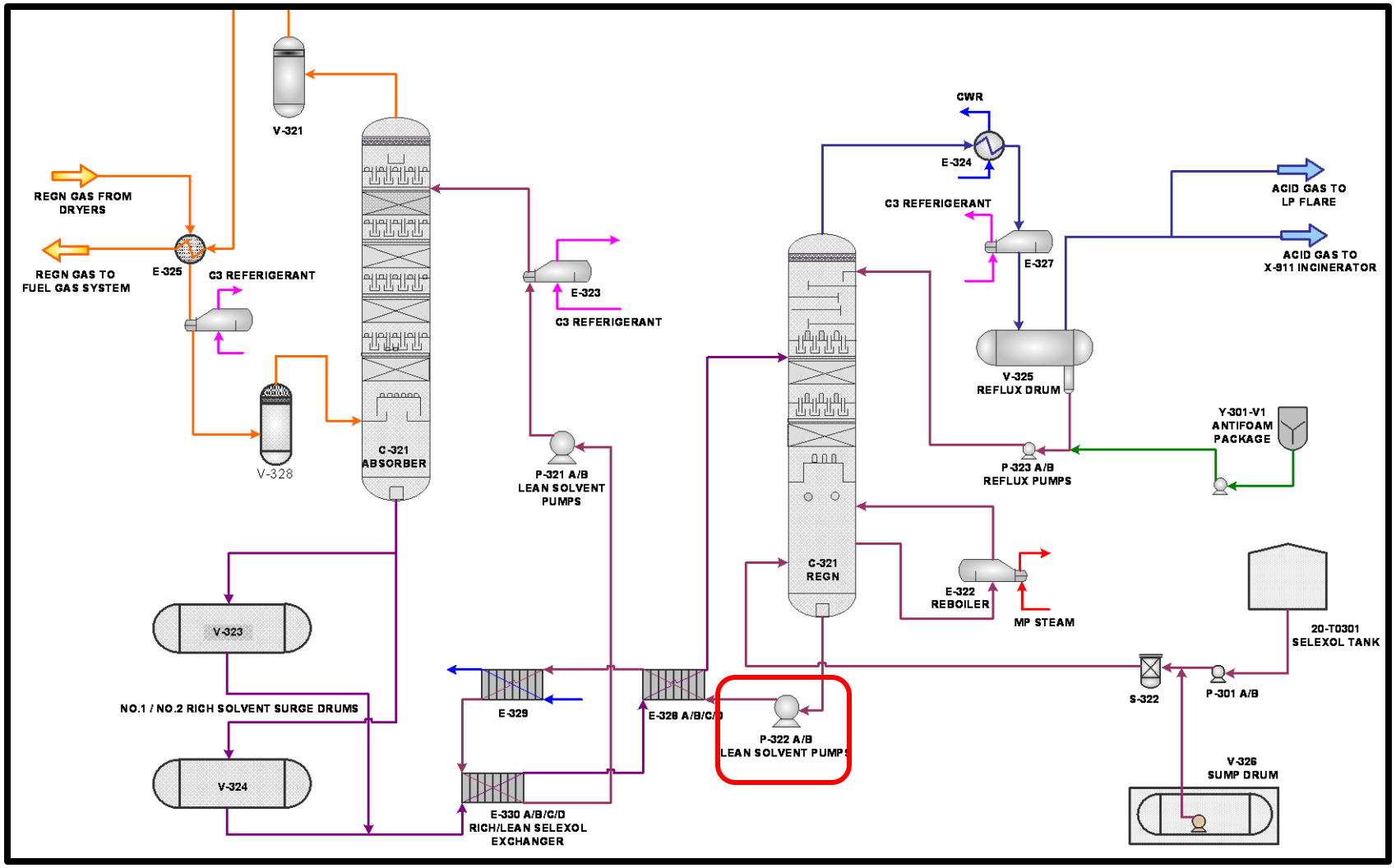
RCFA
(Root Cause Failure Analysis)

Incident Description:

- **Description:**
  - During the early stage of plant service, Two out of two motors failed within a short duration and caused disruption in normal operations and other consequential damages (pump, production etc..)

- **Action Plan:**
  - RCFA investigation was requested using Meridium PROACT
  - RCFA team was established (SMEs, Vendor, EPC invited)
  - RCFA Charter & Critical Success Factors were developed
  - All the events were collected in Meridium Event Manager
  - All the evidences and required data collected
  - All pictures, failure data, Trends and failed parts were analyzed
  - PROACT Logic Tree was developed with Failure Modes and Hypotheses
  - Root Cause Identified & Issued Recommendations

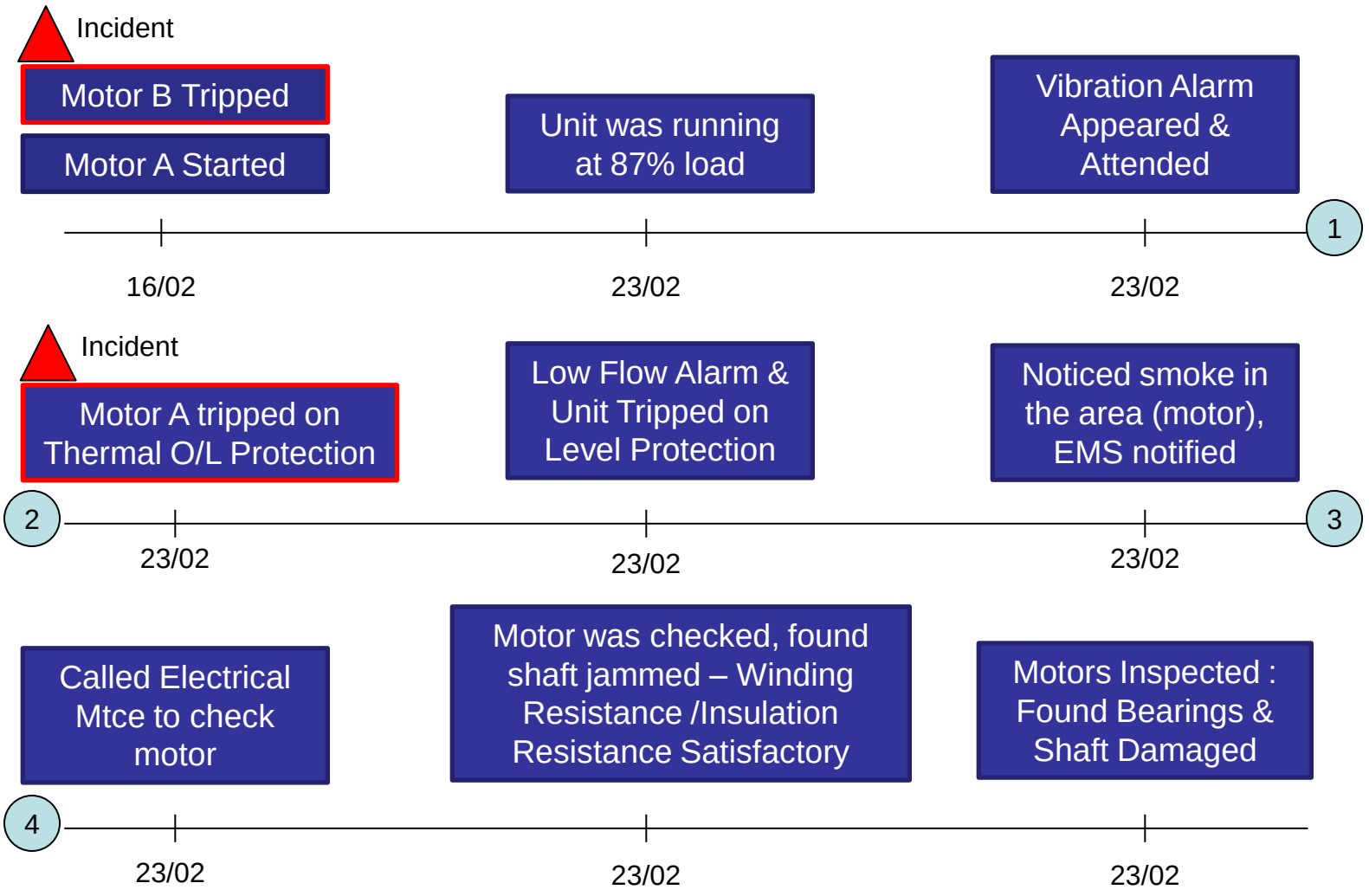
Simplified System Diagram:



Pump & Motor Basic Data:

Driver: Motor	Driven: Pump
• Type: Induction Motor • Voltage: 6.6 KV • Rated Output: 185 KW • Rated Torque: 593 NM • Speed: 3000 RPM • Bearings – Radial: Ball • Lubrication: Grease	• Type: Centrifugal • No. of Stages: 2 • Rated Capacity: 257 M^3/HR • Liquid: Lean Solvent • Bearings – Radial: Sleeve – Thrust: Ball • Lubrication: Oil Ring

Event Diagram (Timeline):



Pictures - Failed Bearings:

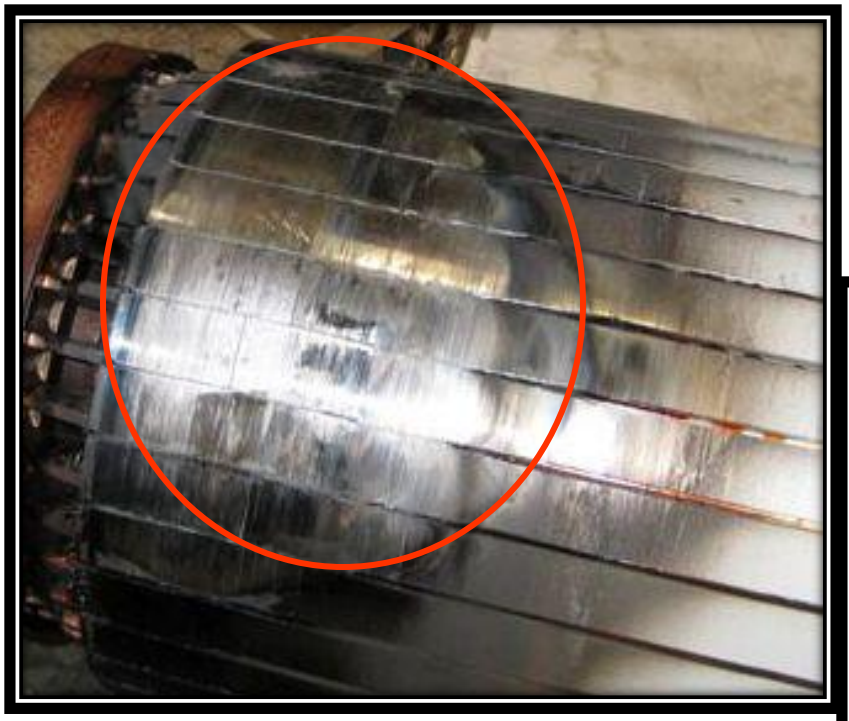
Motor Non Drive End

Motor Drive End

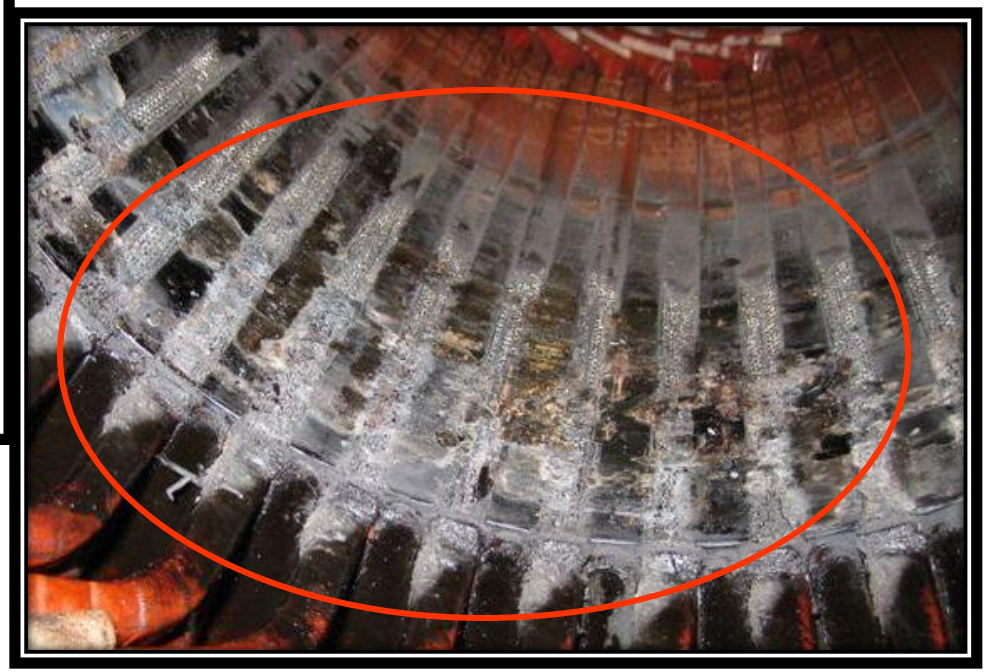
Pictures - Burnt Rotor Shaft:

Motor Burnt Shaft

Pictures - Burnt Stator / Rotor:



Cage - Drive End



Stator - Drive End

Consequential Damage:

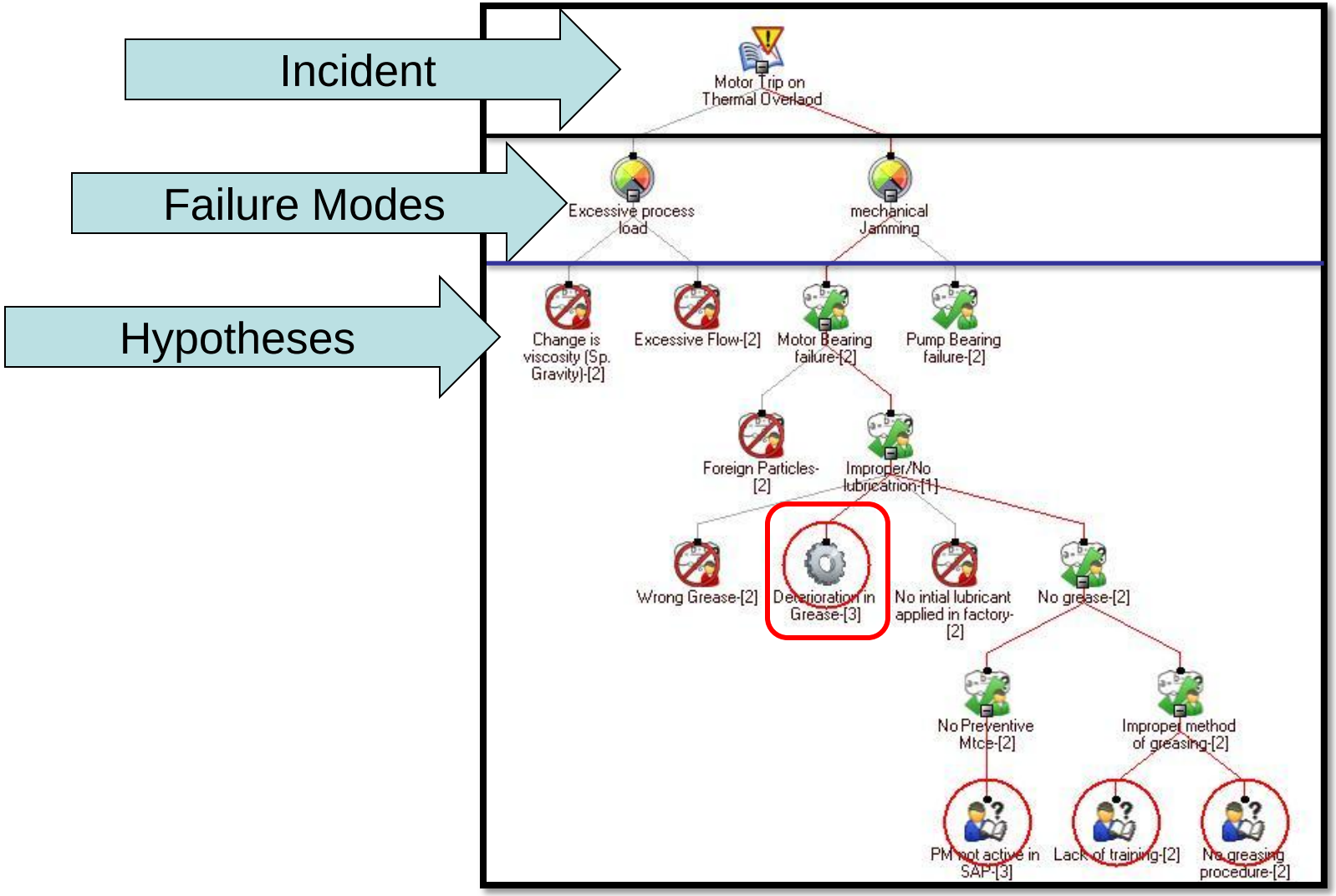
Peeled Off Coating

- Internal Coating Peeled Off
- Lube Oil Contamination

Pump Bearing

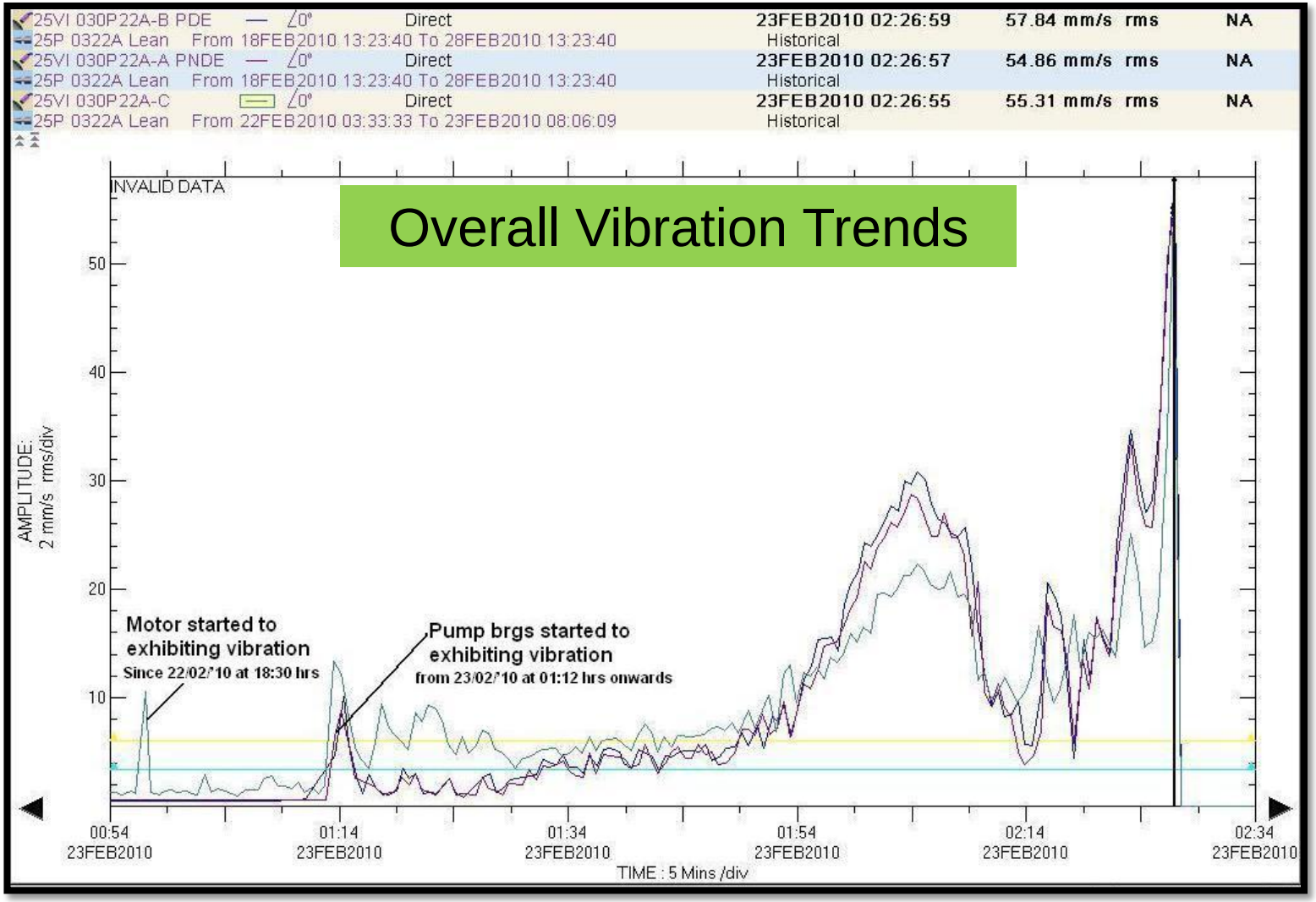
- Bearing Damage (Replaced)
- Excessive Clearance

PROACT Logic Tree:

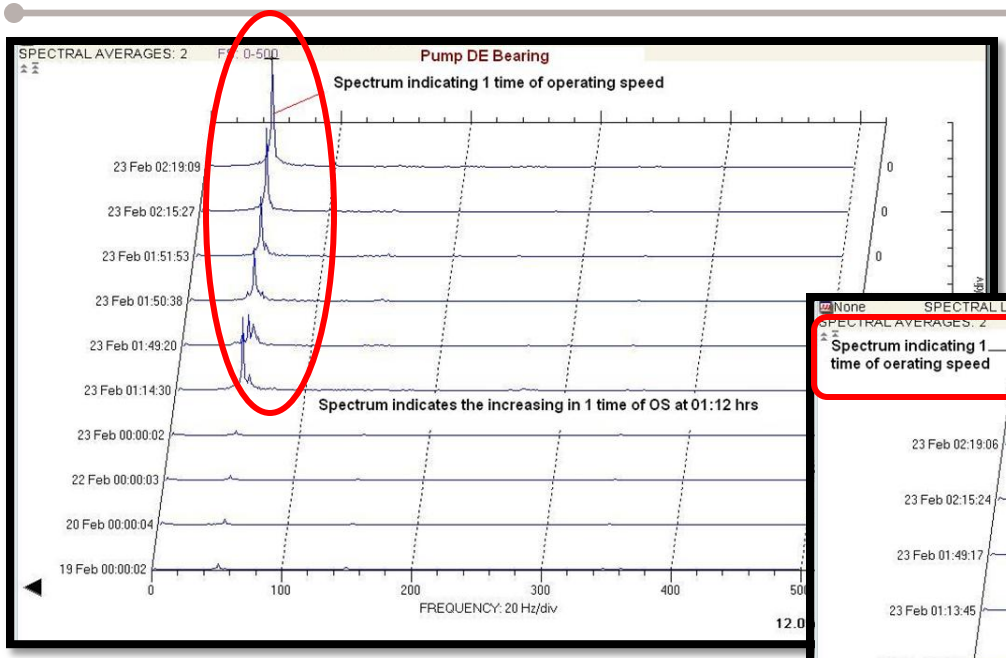


Verifications - Vibration Trends Motor & Pump

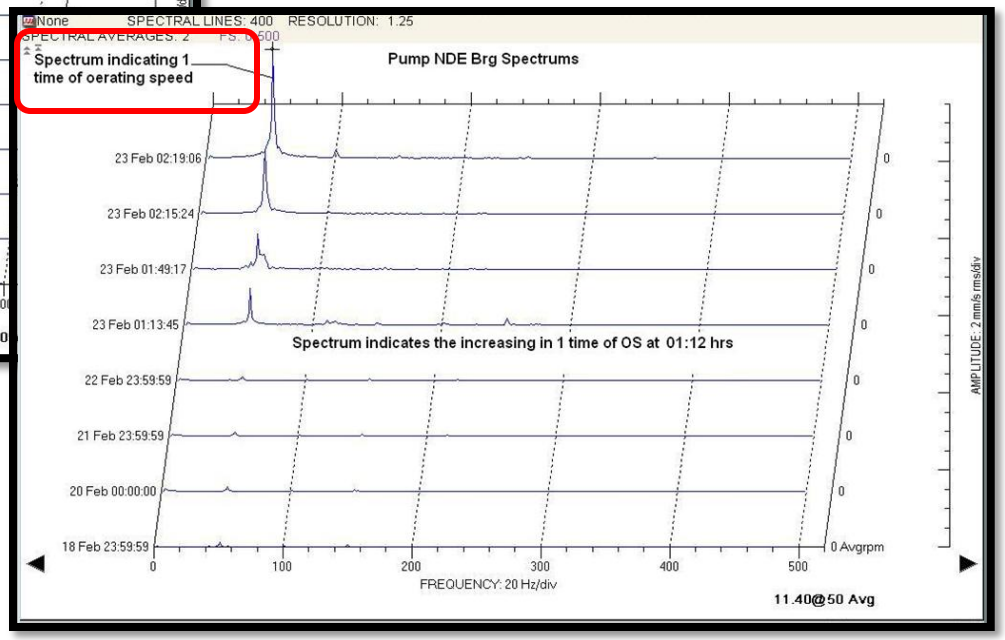
Vibration Trend – Overall:



Spectrum – Pump:

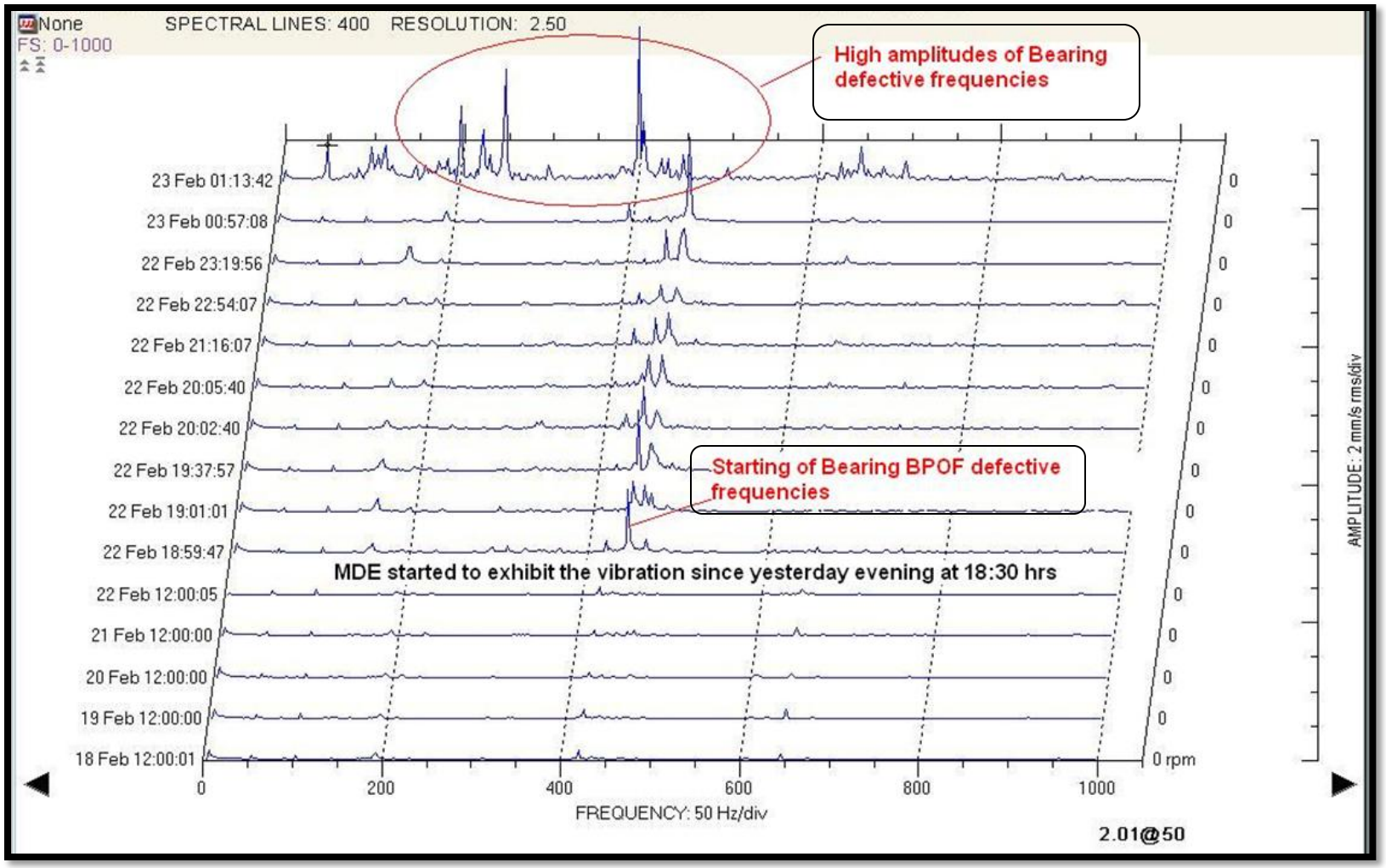


Pump Drive End



Pump Non Drive End

Spectrum – Motor Drive End:



Leading & Contributing Cause(s):

Leading Cause:

- Lack of lubrication is the leading root cause of this failure. No grease was found during inspection and bearing showed the clear signs of overheating. Vibration data supports and confirms the failure initiating point was bearing (BPFO -Ball Pass Frequency Outer Race).

Contributors:

- PMs to lubricate the bearings were not active in CMMS.
- Grease was not checked/replaced during commissioning (built in 2006).
- Greasing procedure was not available for such motors
- Vendor Recommendation were not followed about greasing.

Recommendations & Lessons Learned

Recommendations:

1. Activate the all PM plans in CMMS. Ensure to set the initial PM startup date manually. Revisit the equipment strategies to include vendor recommendations.
2. Create area based lubrication work orders and release for maintenance execution.
3. Develop greasing procedure for Motors (based on type of bearing).
4. Inspect the pump and accessories prior to installation of new motor.

Lessons Learned:

1. The Project Maintenance & Engineering was informed immediately to take appropriate measures to address similar potential issues.
2. The new project practices were issued. Check sheets were developed to ensure proper lubrication before the mechanical run test to avoid such failures. (No reported bearing failure)

Q & A ….
Thanks!!!