RE-ENGINEERING & PREDICTIVE MAINTENANCE TO SOLVE INTERNAL RUBBING PROBLEM OF FCCU STEAM TURBINE

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AGENDA

- INTRODUCTION TO BAPCO
- STATEMENT OF PROBLEM
- TURBINE & COMPRESSOR DETAILS
- VIBRATION ANALYSIS & FINDINGS
- RECOMMENDATIONS AND CONCLUSION
- ROOT CAUSES AND LEARNING POINTS
- SUMMARY & DISCUSSION

INTRODUCTION TO BAPCO

- WHOLLY OWNED BY GOVT. OF BAHRAIN.
- AN OLDEST REFINERY IN GCC
- CAPACITY = 260,000 BPD.
- NEW UNITS LIKE LSDP, RGDP and LBOP

Integrated Machinery Inspection (IMI)

- PREDICTIVE MAINTENANCE TEAM
- RELIABILITY OF ALL ROTATING EQUIPMENT
- MACHINE MONITORING (ONLINE /OFFLINE)
- TRIBOLOGY
- RADIOGRAPHY (With Electrical section)

STATEMENT OF PORBLEM

- NEW TURBINES INSTALLED IN APRIL / MAY 2001
- COMMISSIONING HISTORY OF TRIP INCIDENTS DUE TO HIGH VIBRATION
- VIBRATION ANALYSIS : INTERNAL RUBBING
- INTERNAL RUB LOOKS LIKE UNBALANCE IN ORBIT ANALYSIS
- FREQUENT VIBRATION SPIKES WITH SUDDEN RISE AND DROP IN VIBRATIONS AT TURBINE OB BRG.
- DROP IN RELIABILITY OF TURBINE DUE TO UNCERTAIN AND UNPREDICTABLE BEHAVIOUR OF TRANSIENT RUBS

STEAM TURBINE DETAILS

- T601AX AND T601BX
- TYPE-SIZE : CONDENSING IMPULSE-S8
- CONSTRUCTION : Horizontal split - top exhaust
- NO. OF STAGES : 1 Curtis + 7 REACTION
- 2325bhp @ 4640rpm
- SPEED = 4950 (MAX) (1^{ST} CR.=2400)
- TRIP SPEED = 5700rpm mech/5400rpm electronic
- DRIVER FOR 15# AIR BLOWER COMPRESSOR
- INLET : 515 psig / 700°F
- EXHAUST : 3.93 psia (VACCUM)
- DATE OF INSTALLATION : 01/05/2001
- GOVERNOR : WOODWARD 5009 (3465 to 4950 rpm)

COMPRESSOR (# 15 AIR BLOWER) DETAILS

- MOUNTING : HORIZONTAL- 3 STAGE CENTRIFUGAL
- RATED RPM = 4950 (1ST CRITICAL = 2550)
- INLET = 14.00 PSIG
- DISCHARGE = 15.00 PSIG
- INSTALLATION DATE : 01/07/73
- POWER : 2030 HP (4950 RPM)
- COUPLING TYPE : GEAR

ANALYSIS-VIBRATION & INSPECTION

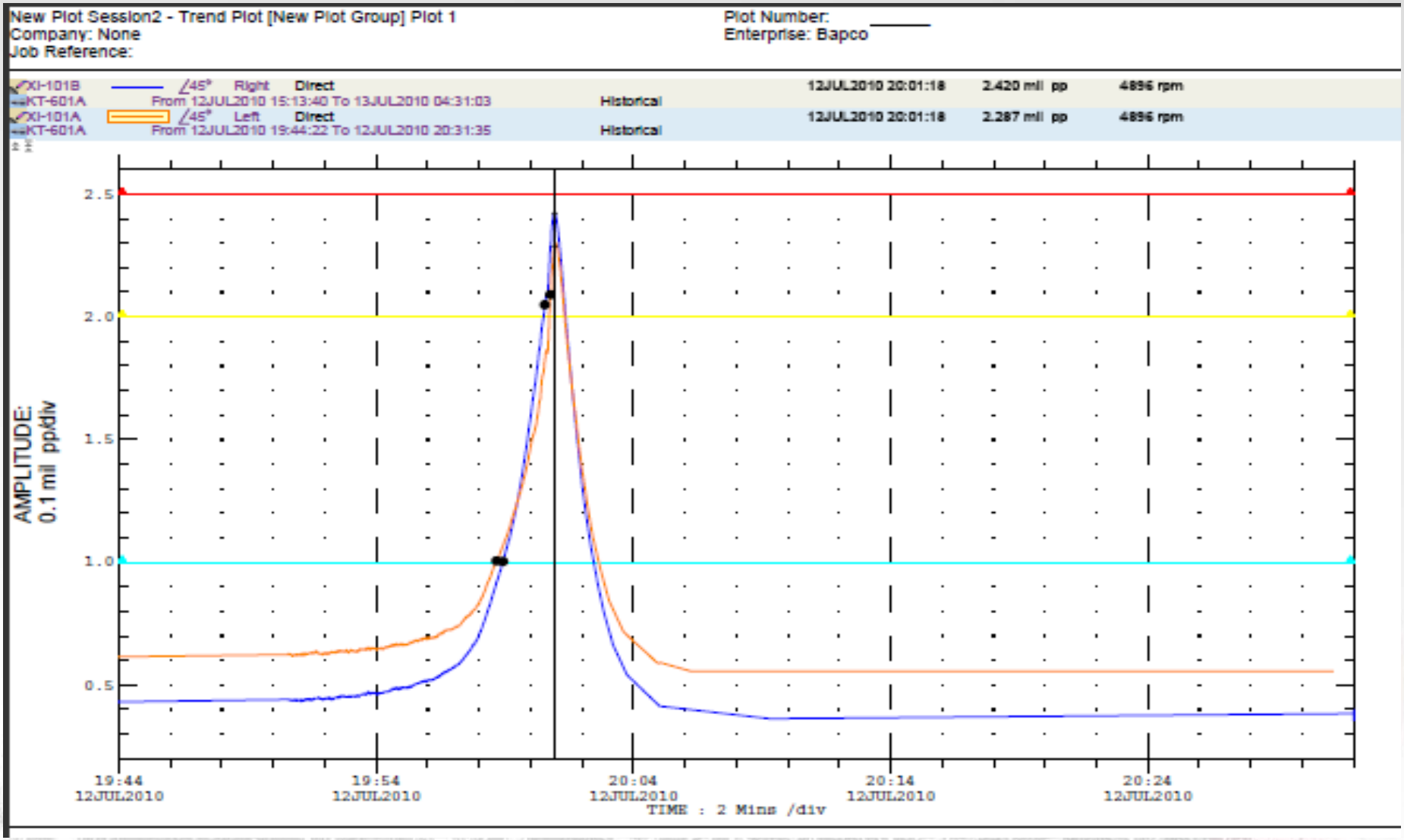
A) VIBRATION ANALYSIS

- ORBIT ANALYSIS : DIRECT AND 1X
- FULL SPECTRUM ANALYSIS
- AVG SHAFT CENTERLINE BEHAVIOUR
- TRANSIENT RUB ANALYSIS : BODE PLOTS

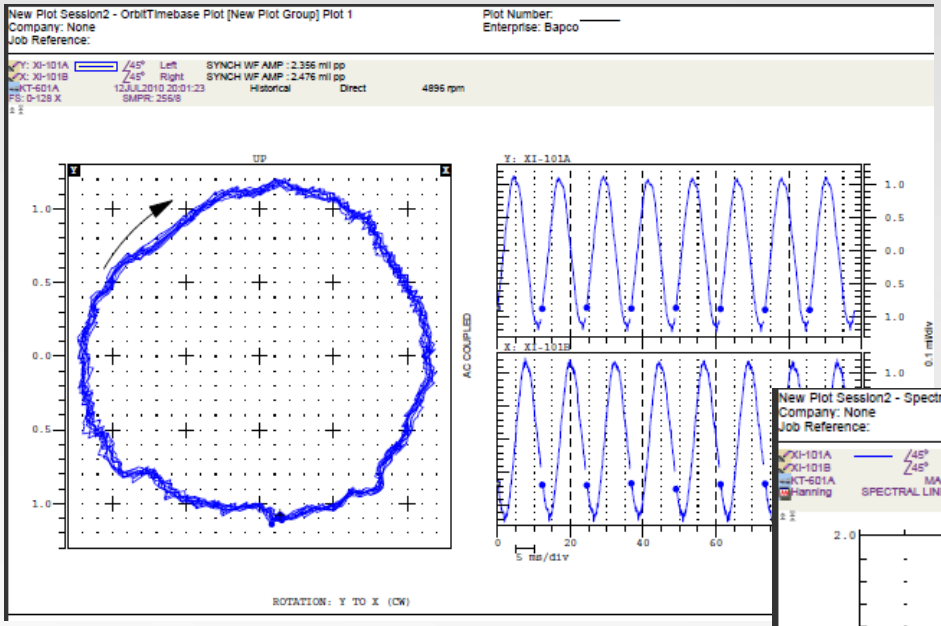
B) INSPECTION & ENGINEERING CHECKS

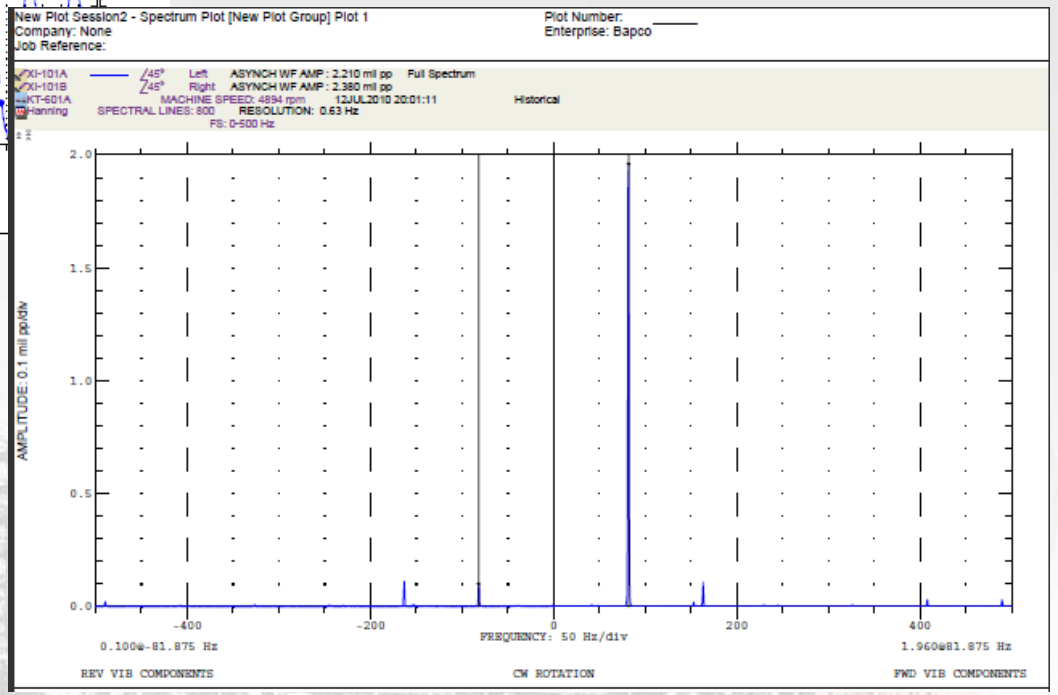
- OIL BAFFLE INSIDE CLEARANCE IS LESS THAN BEARING CLEARANCE.
- MANUFACTURING ERROR : STEAM END BEARING OIL BAFFLE PTFE RING GROOVE (CLEARANCES)
- OIL DEPOSITS FORMATION AT TURBINE OB STEAM END SIDE.

MACHINE BEHAVIOUR-TRANSIENT RUBBING

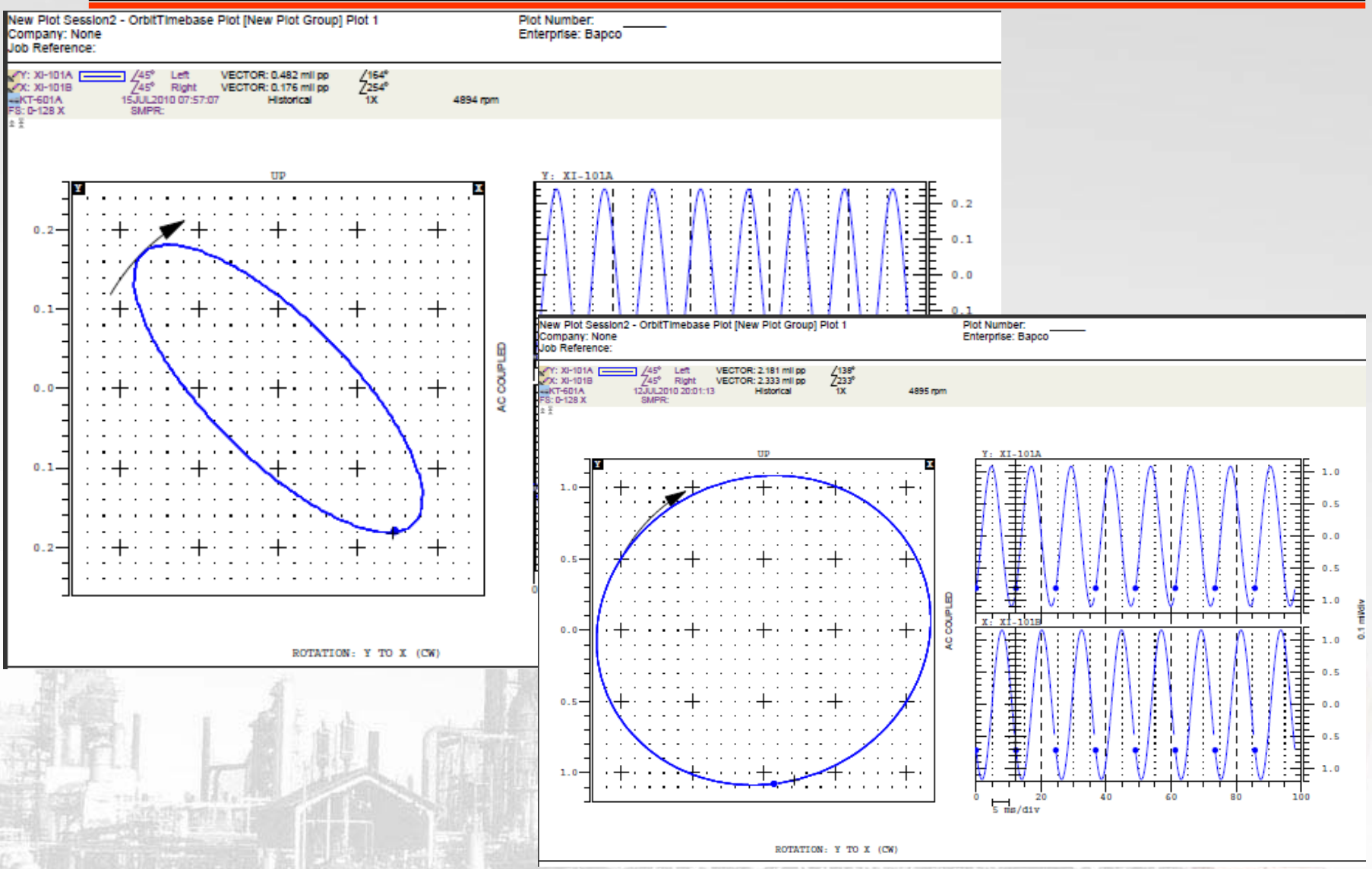


ORBIT & FULL SPECTRUM ANALYSIS

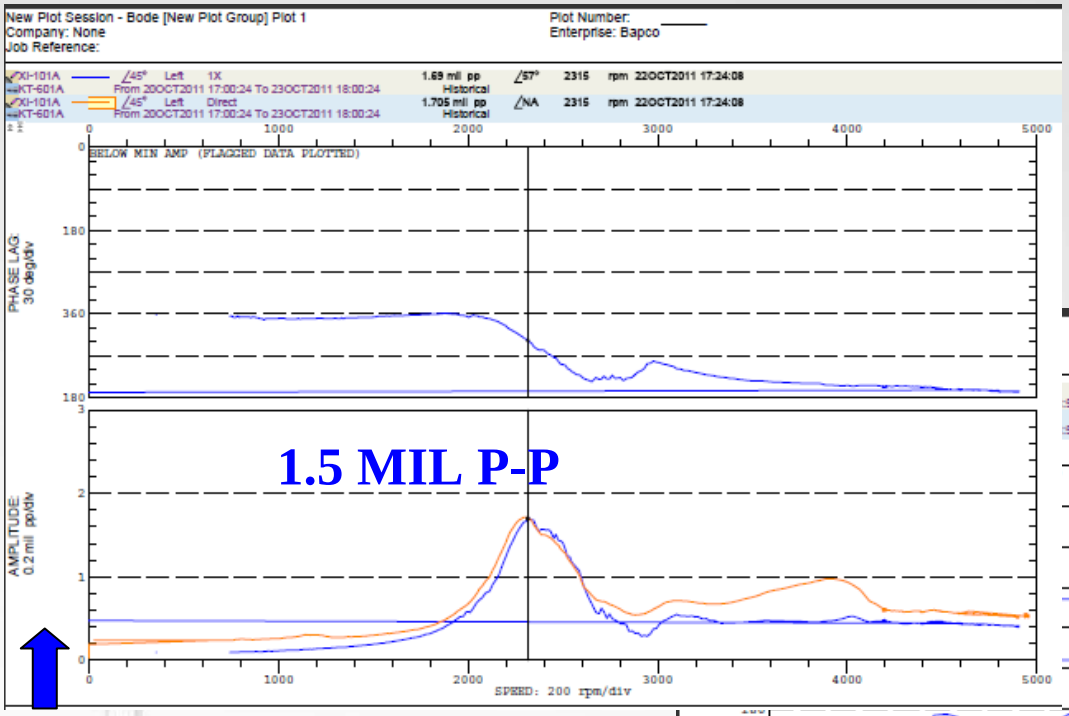




1X ORBIT PLOT ANALYSIS



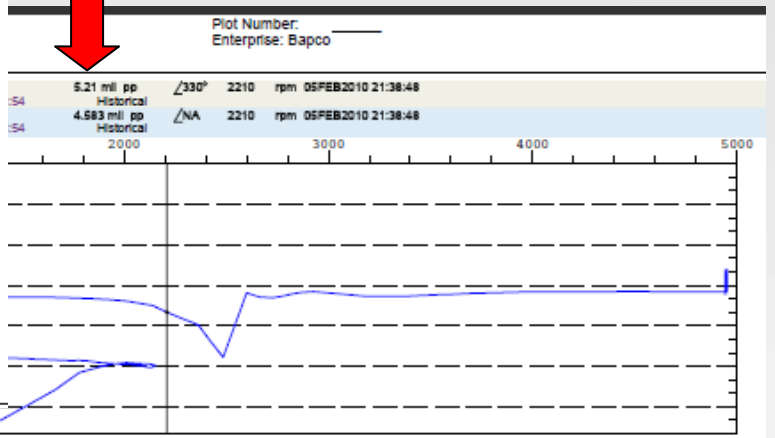
BODE PLOTO ANALYSIS

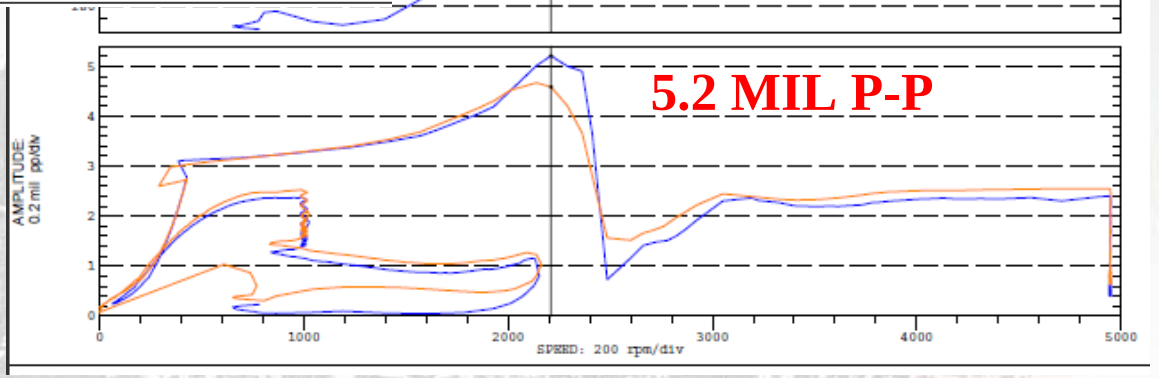


1.5 MIL P-P

NORMAL SHUTDOWN

RUB DURING SHUTDOWN





5.2 MIL P-P

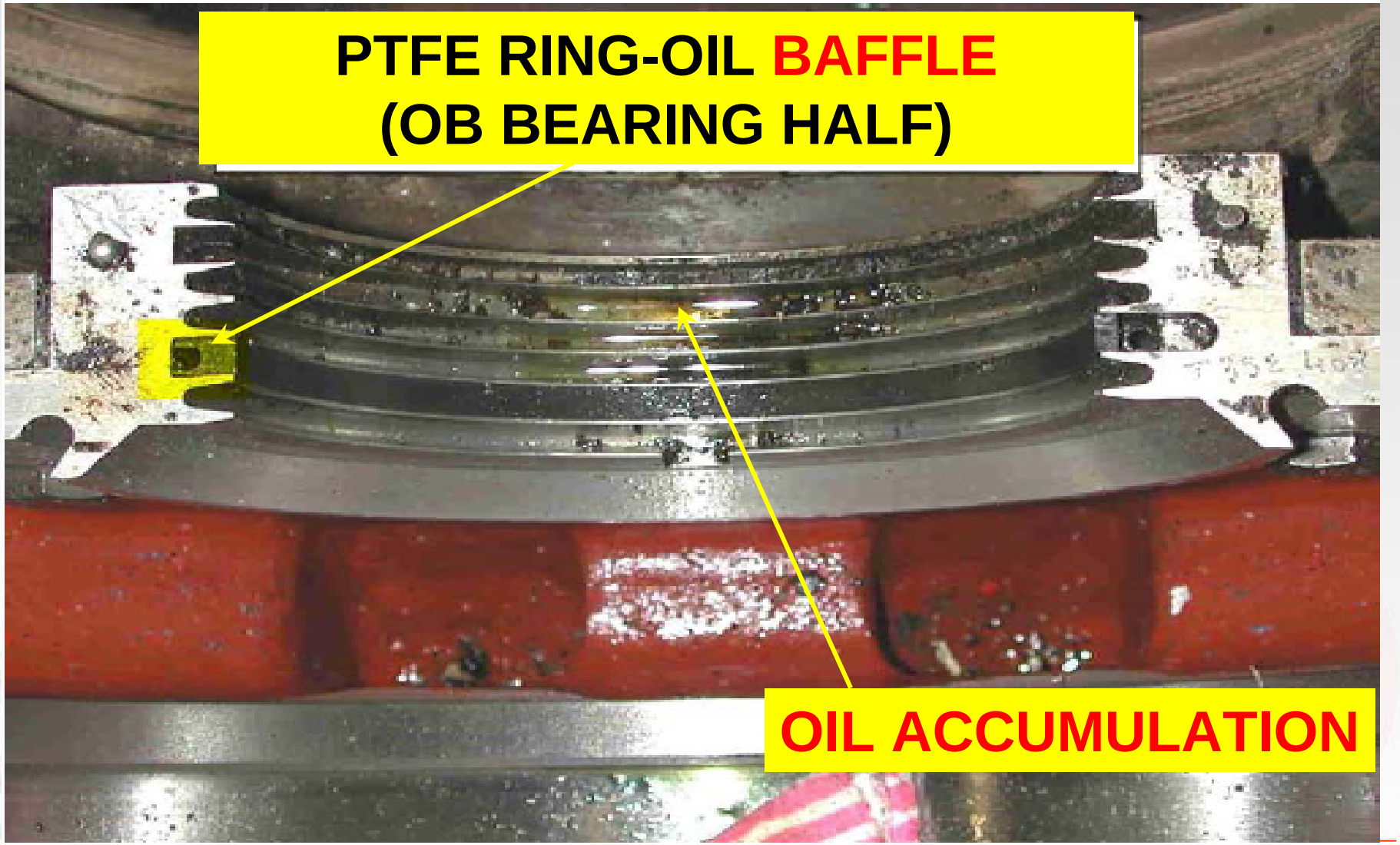
TURBINE ROTOR RED INSPECTION

CARBONACEOUS DEPOSITS-NDE TUBINE SEAL FACE

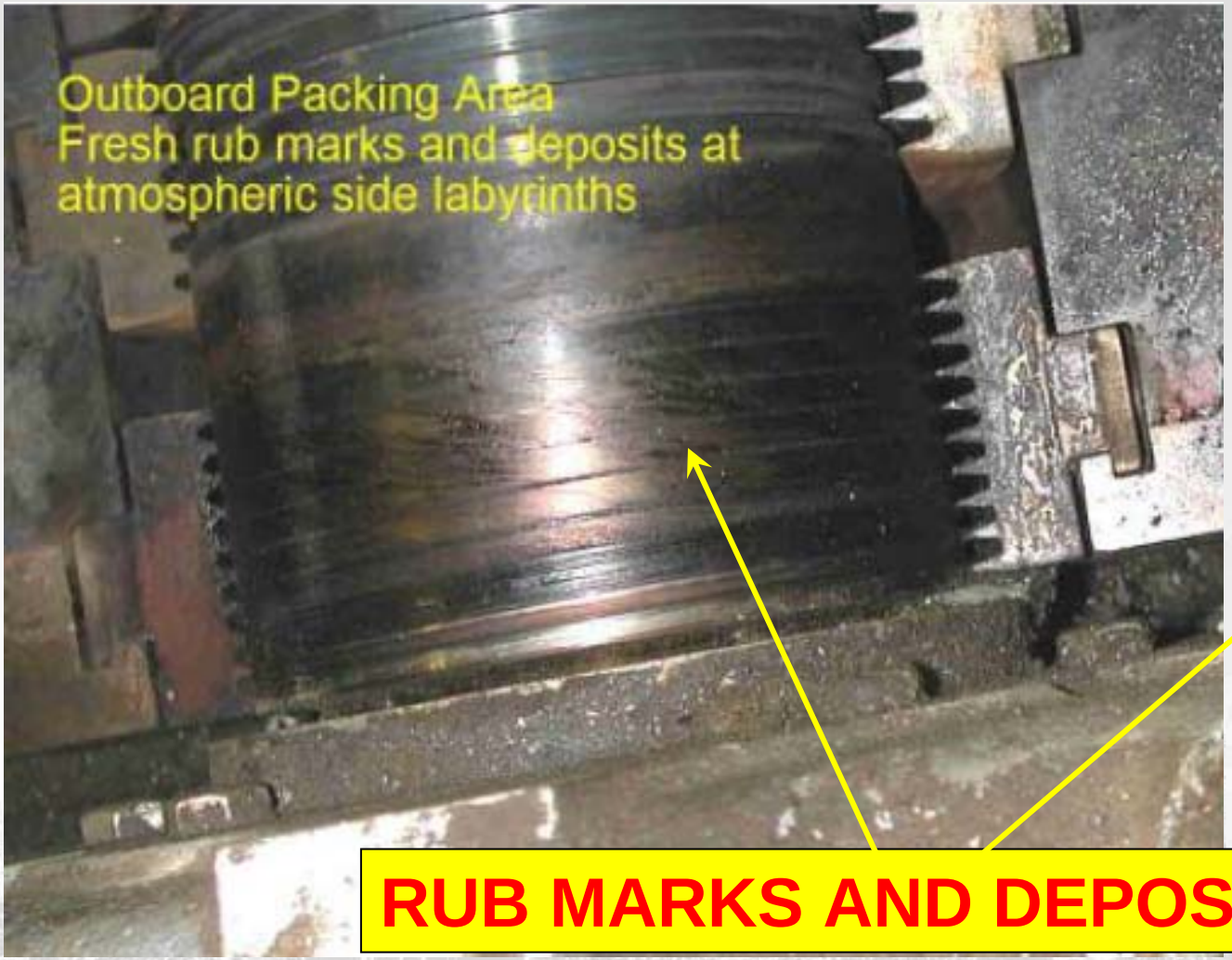
CARBON DEPOSITS- BETWEEN ROTOR & TURBINE CASING

LEAKAGE ACROSS TURBINE CASING SPLIT

OIL MIGRATION FROM NDE BEARING SEAL



CARBONACIOUS DEPOSITS ON TURBINE LABRINTH SEAL



RUB MARKS AND DEPOSITS

RECOMMENDATIONS AND CONCLUSION

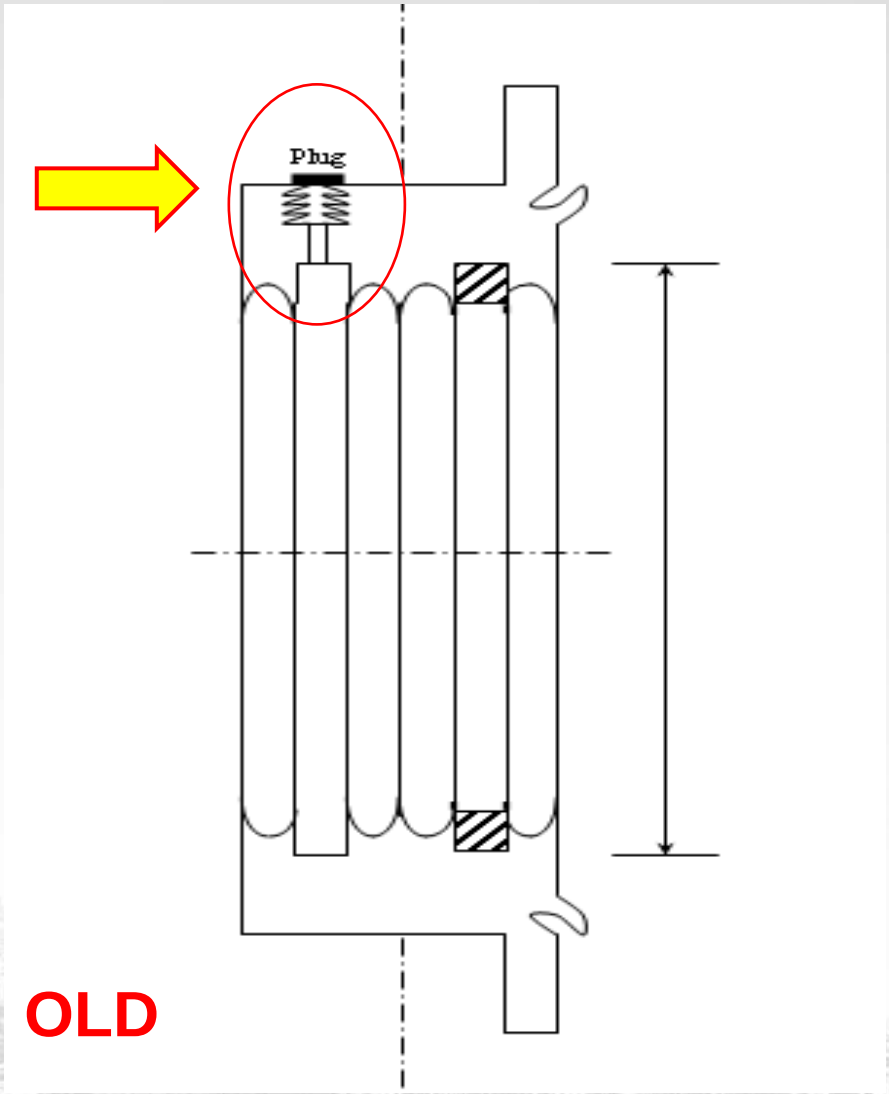
RECOMMENDATIONS

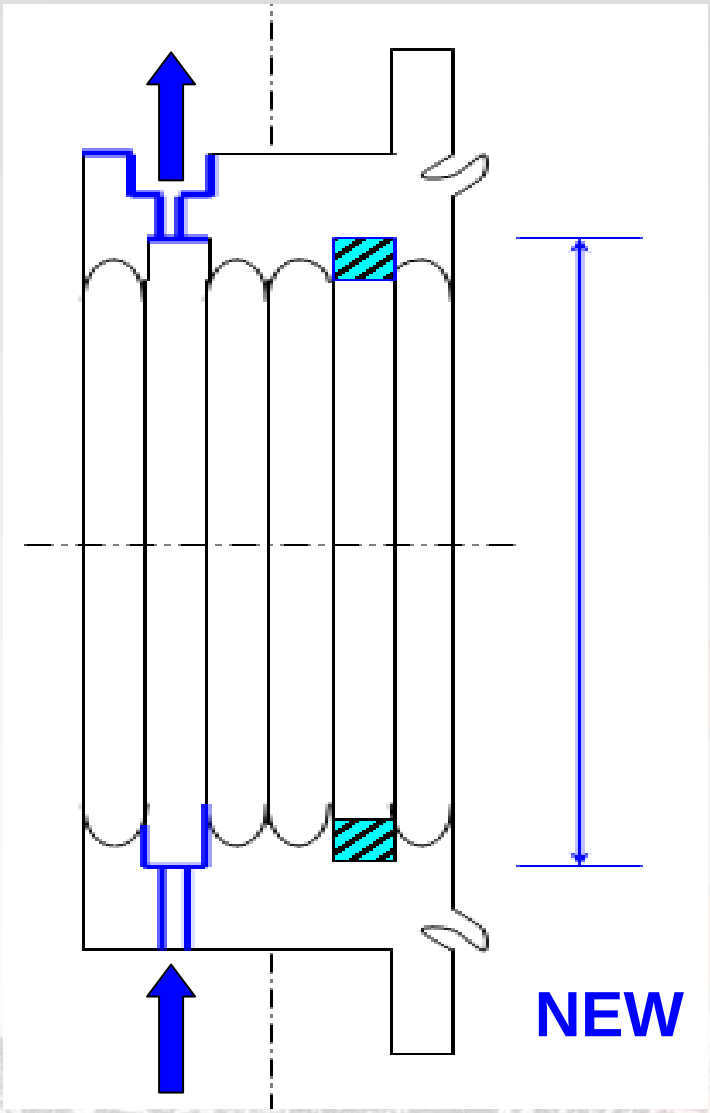
- OIL BAFFLE REDESIGN WITH IMRPOVED CLEARANCES.
- UPGRADE OB BRG FOR SELF ALIGNMENT DESIGN
- DESIGN SYSTEM TO AVOID CONTAMINATION AND MIXING OF LUBE OIL WITH STEAM.

IMPLEMENTATION OF SOLUTION

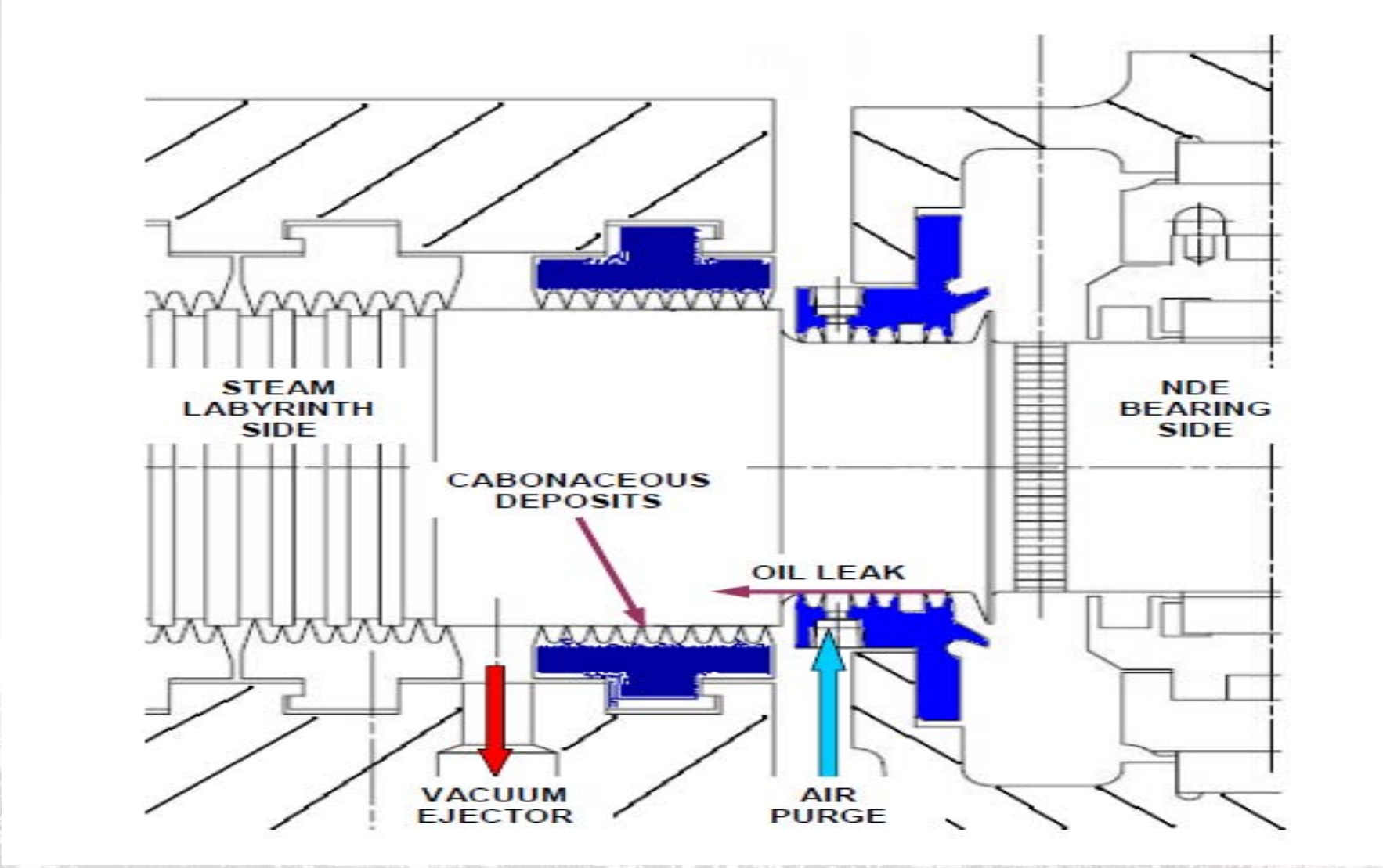
1. OIL BAFFLE REPLACED WITH IMPROVED DESIGN
2. PURGE AIR AT NDE BEARING HOUSING AT 5 PSIG
3. STEAM GLAND VACCUM IMPROVED TO -0.5” TO -1” HG
4. INDEPENDENT EJECTORS INSTALLED FOR EACH TURBINE TO CONTROL STEAM GLAND VACCUM PRESSURE.
5. INSPECTION AND CLEANING OF SUSPECTED DEPOSIT AREAS DURING EACH T&I.

RE-ENGINEERING : OIL BAFFLE DESIGN

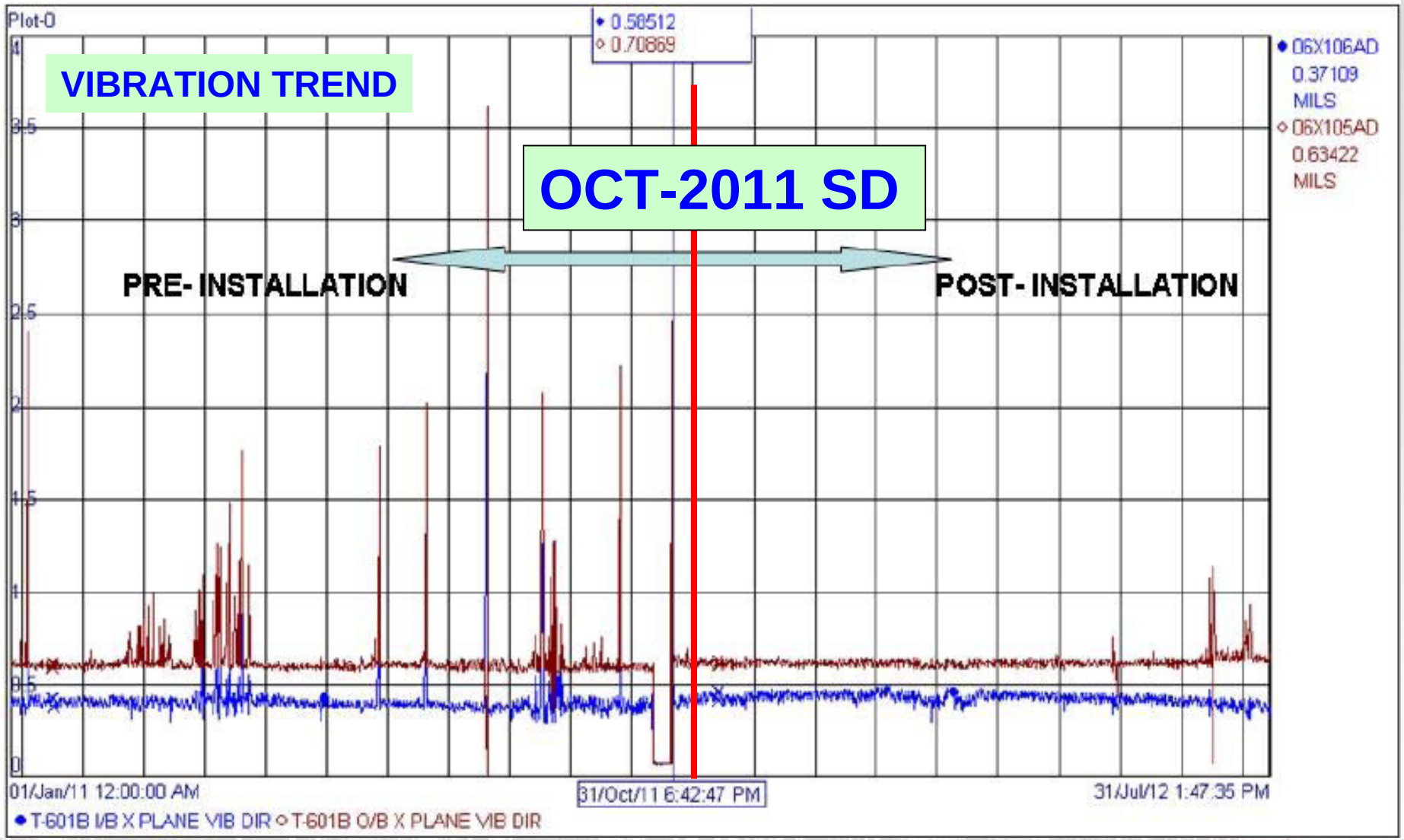




SECTIONAL DIAGRAM:LABYRINTH SEAL & NDE BEARING HOUSING



VIBRATION IMPROVEMENT



LEARNING POINTS & BETTER PERFORMANCE

- LOWER OIL BAFFLE CLEARANCES IN TURBINE OUTBOARD BEARING LEADING TO RUBBING.
- OIL BAFFLE DESIGN IMPROVED WITH BETTER DESIGN CLEARANCES.
- SELF ALIGNNING TYPE. BEARING INSTALLED ON TURBINE OB SIDE.
- SEALING STEAM VACUUM CONTROL IMPROVED WITH INDEPENDENT EJECTORS FOR EACH MACHINE.
- OPERATING ENVIRONMENT BETWEEN STEAM LABRYNTH & NDE BEARING HOUSING IMPROVED TO AVOID HARD DEPOSIT FORMATIONS.

Questions and Discussion

THANK YOU

The Bahrain Petroleum Company B.S.C. (Closed)

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