



PRO-ACTIVE MAINTENANCE TO RESOLVE RGC TURBINE BACK PRESSURE PROBLEM

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AGENDA

- **INTRODUCTION TO BAPCO**
- **LSDP COMPLEX-DETAILS**
- **RECYCLE GAS COMP & TURBINE DETAILS**
- **STATEMENT OF PROBLEM**
- **ALTERNATIVE SOLUTIONS**
- **IMPLEMENTATION OF BEST SOLUTION**
- **SUMMARY & DISCUSSION**

INTRODUCTION TO BAPCO

- **WHOLLY OWNED BY GOVT. OF BAHRAIN.**
- **OLDEST & LARGE 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 PROBLEM

SEP-2007 :

- **COMMISSIONING OF STEAM TURBINE DRIVEN RECYCLE GAS COMPRESSOR IN LSDP COMPLEX.**

MAY-2008 :

- **TURBINE SPEED REDUCTION WITH RISE IN AXIAL DISPLACEMENT AND RISING 1ST STAGE STEAM CHEST PRESSURE**
- **COMPRESSOR INTERNAL RE-CIRCULATION**

LSDP COMPLEX-DETAILS

LSDP-Low Sulphur Diesel Production Plant :

1. #1 HYDROCRACKING UNIT
 2. #2 HYDROGEN
 3. SULPHUR
- PROJECT COST (IN YEAR 2007)= \$700 Million (BD262m)
 - HYDROCRACKER CAPACITY= 100,000bpd
 - SULPHUR REDUCTION= 0.65% to 0.001% (6500 to 10 ppm)
 - HCU LICENSOR : CHEVRON Lummus Global

RECYCLE GAS COMP-DATA SHEET

EQUIPMENT TAG : K7701 (#1 HCU PLANT)

MANUFACTURER : ELLIOTT EBARA

TYPE : EETC 25MBH5 (MODEL: 25MBH5 / SNO. R04T014402)

NO. OF STAGES = 5

POWER RATING : 7291 hp @ 9769 rpm

MCS=10257 rpm (OST=11283)

CRITICAL SPEEDS : 1ST = 4700-5300 rpm, 2ND = 18400 rpm

RATED POLYTROPIC EFFICIENCY = 82.1%

FAILURE DATE : 28/05/2008

COMPRESSOR-OPERATING CONDITIONS

- CAPACITY : 252,348 (RATED) lbs/hour
- MOLECULAR WEIGHT= 4.26

- **INLET CONDITIONS** :
- VOLUME=213,985 CFH
- PRESSURE = 2043.8 psia
- TEMP=150 deg F

- **DISCHARGE CONDITIONS** :
- PLYTROPIC HEAD = 38,894 (RATED) ft-lbs/lb
- DISCHARGE PR.=2,394.1 psia
- DISCHARGE TEMP. = 185 deg F

STEAM TURBINE DATA SHEET

- **EQUIPMENT TAG : T7701**
- **MANUFACTURER : ELLIOTT EBARA TURBOMACHINERY CORP.**
- **MODEL : Elliott Ebara SRV-2 (STAGES=2, SIZE :18" base dia.)**
- **SR. NO. : R04T014403 (BLADING = IMPULSE TYPE)**
- **RATING : 7291 hp @ 9769 rpm**
- **MCS=10257, TRIP=11283 rpm**
- **CRITICAL SPEED : 1ST =4589 rpm, 2ND =18900 rpm**
- **OPERATING CONDITIONS :**
- **INLET PR.= 525 psig (TEMP.=700 deg F)**
- **EXHAUST PR.=115 psig**
- **GOVERNOR : WW5009 (GOVERNING SPEED =6838 to 10257 rpm)**
- **SOURCE OF STEAM : LSDP #2 HYDROGEN PLANT**

ROOT CAUSE ANALYSIS

- **ROOT CAUSE ANALYSIS OF SPEED REDUCTION**
 1. **GOVERNOR 100% OPEN CONDITION.**
 2. **RISE IN AXIAL DISPLACEMENT READINGS IN ONLINE MACHINE MONITORING SYSTEM.**
 3. **1ST STAGE CHEST PRESSURE RISING TREND.**
 4. **INCREASE IN STEAM FLOW NOT CONTRIBUTING TO SPEED IMPROVEMENT.**
 5. **ANALYSIS OF STEAM QUALITY - SUPPLY TEMPERATURE , PRESSURE AND STEAM SAMPLE INSPECTION**

ROOT CAUSES :

1. **TURBINE INLET NOZZLE / BLADES FOULING.**
2. **BUILD UP ON TURBINE BLADES**
3. **LIQUID CARRYOVER FROM STEAM DRUM**

DEVELOPMENT OF SOLUTION

➤ PROBLEM STATEMENT :

- STEAM TURBINE SPEED REDUCTION WITH 100% GOVERNOR OPENING AND RISE IN AXIAL DISPLACEMENT.

➤ SOLUTION STATEMENT :

- TECHNICAL ADVICE FROM OEM
- BRAIN STORMING SESSIONS

➤ DEVELOPMENT OF TWO SCENARIOS :

- 1. ONLINE WASHING OF TURBINE ROTOR.
- 2. OVERHAULING OF BOTH TURBINE AND COMPRESSOR

SCENARIO-1 : ONLINE TURBINE ROTOR WASHING

- **SOLUTION : TURBINE BLADE CLEANING WITH SATURATED STEAM**

ADVANTAGES :

- **SHORT DOWNTIME = 7 DAYS**
- **DEVELOPMENT OF IS-SITU CLEANING PROCEDURE**

DISADVANTAGES :

- **NO TECHNICAL SUPPORTED BY OEM.**
- **UNPREDICTABLE POST WASH PERFORMANCE.**
- **COMPRESSOR ISSUE NOT ADDRESSED.**
- **INSUFFICIENT CLEAN CAN LEAD TO ROTOR UNBALANCE AND VIBRATIONS.**
- **SAMPLE TESTING OF FOULING NOT POSSIBLE.**
- **SOURCE OF FOULING WILL REMAIN UNKNOWN.**
- **RISK OF FOULING TO RE-OCCUR**
- **GAS FLARING = 30 MMSCFD FOR 5-7 DAYS (#2H2 RUNNING)**

SCENARIO-2 : : UNIT SHUTDOWN

- **SOLUTION : UNIT SHUTDOWN FOR OVERHAULING OF STEAM TURBINE AND COMPRESSOR.**
- **ADVANTAGES :**
- **INTERNAL INSPECTION OF TURBINE ROTOR FOR RCA.**
- **COMPRESSOR OVERHAULING AND INSPECTION FOR RE-CIRCULATION.**
- **ROOT CAUSE ANALYSIS WITH INTERNAL INSPECTION AND SAMPLE TESTING-INSPECTION OF STEAM DRUMS**
- **RESTORE THE UNIT PERFORMANCE TO MAX FEED.**
- **DISADVANTAGES :**
- **LONG DURATION & HIGH LPO OF SHUTDOWN (17 DAYS)**
- **INVOLVEMENT OF OEM ADVISORS.**

ANALYSIS AND DECISION MAKING

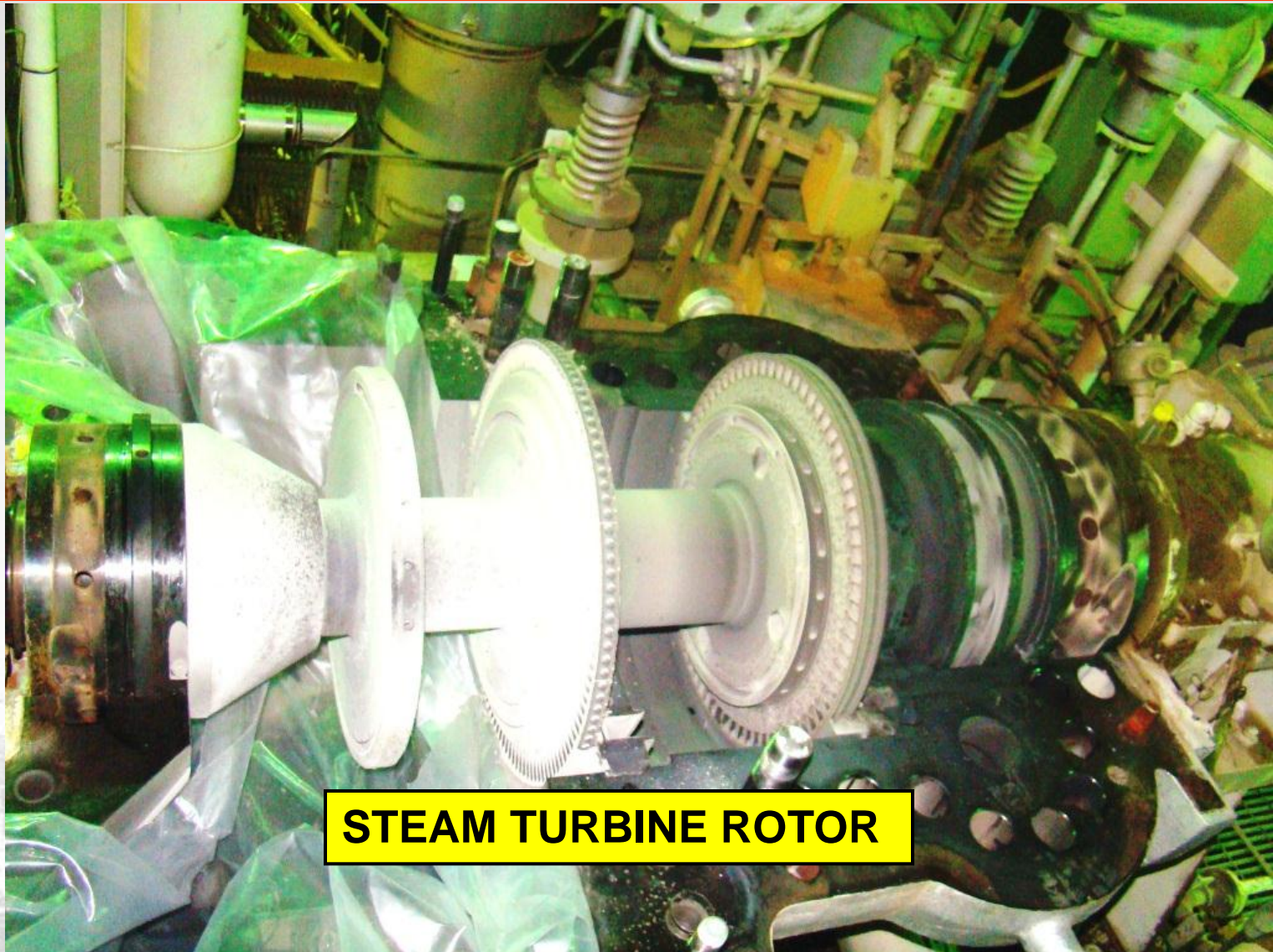
- LPO ALTERNATIVE-1 = \$ 9.1 MM
- LPO ALTERNATIVE-2 = \$ 22.1 MM
- ALTERNATIVE-1 :
 - RISK OF EXTRA WASH AFTER 6 MONTHS
 - COBINED LPO = \$ 18.2 MM (WITH EXTRA WASH)
- WORST CASE SCENARIO=\$31.2 MM (17 DAYS SD)

- DECISION MAKING : ALTERNAVITVE-2 FAVOURABLE
 - IMPROVED PERFORMANCE OF TURBINE AND COMPRESSOR
 - HELPS TO CONDUCT ROOT CAUSE ANALYSIS
 - WORK LIST TO METIGATE ROOT CAUSES
 - SCENARIO-1 MAY LEAD TO MULTIPLE SHUTDOWNS WITH UNKNOWN ROOT CAUSE.

IMPLEMENTATION OF BEST SOLUTION

- **LSDP UNIT WAS SHUTDOWN**
 - **STEAM TURBINE OVERHAULING**
 - **INSPECTION OF TURBINE ROTOR**
 - **OBSERVATION OF ROTOR / BADE FOULING**
 - **REPLACEMENT OF TURBINE ROTOR**
 - **COMPRESSOR OVERHAULING**
 - **REPLACEMENT OF COMPRESSOR BARREL 'O' RING WITH UPGRADE MATERAIL.**
 - **ROOT CAUSE ANALYSIS**
 - **TESTING OF FOULING MATERIAL**
 - **STEAM DRUM (76V7604) INSPECTION**
 - **REPAIR OF STEAM DRUM INTERNALS FOR DAMAGE TO CYCLONES.**

TURBINE ROTOR : IN-SITU CONDITION

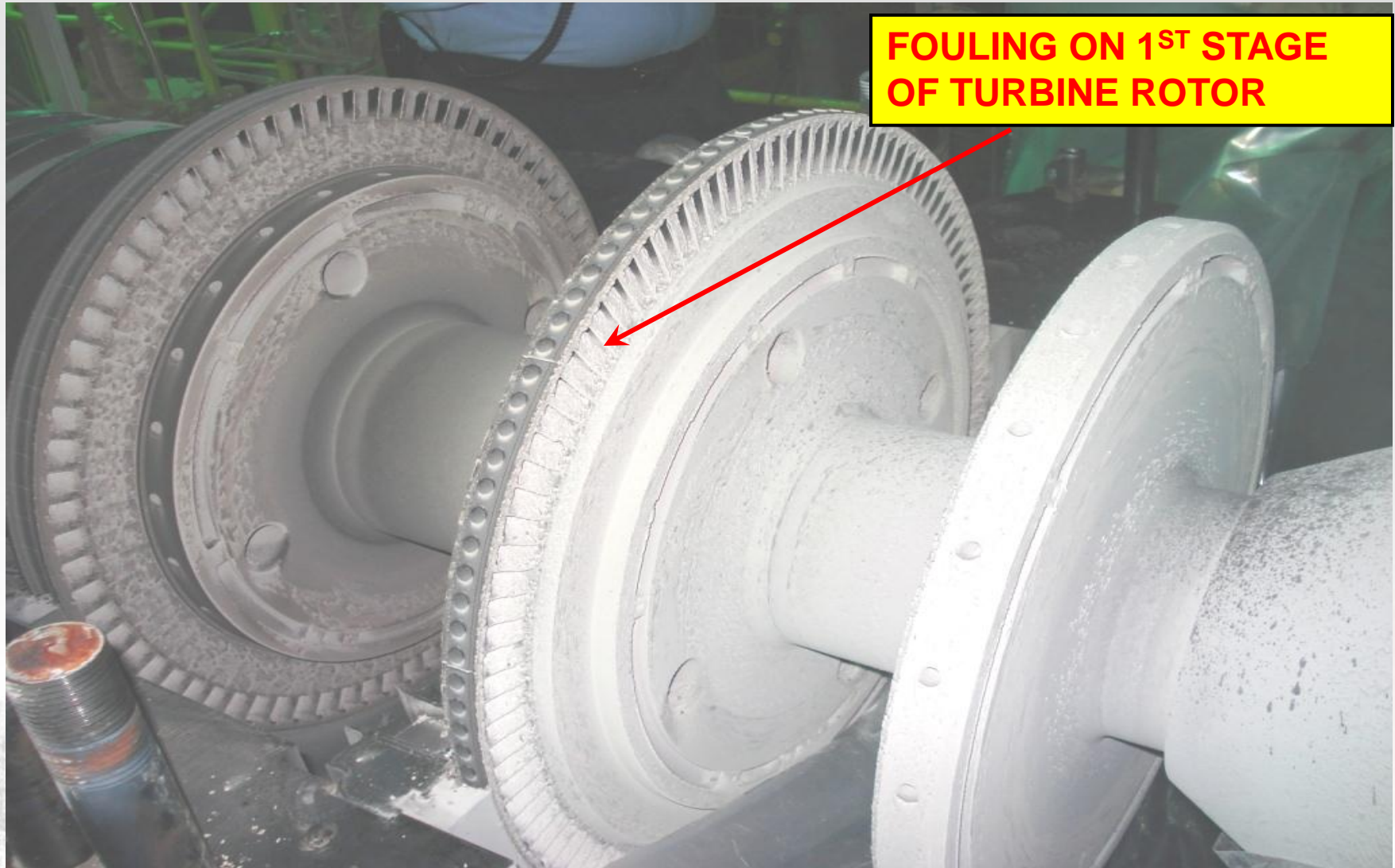


STEAM TURBINE ROTOR

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TURBINE BACK PRESSURE PROBLEM**

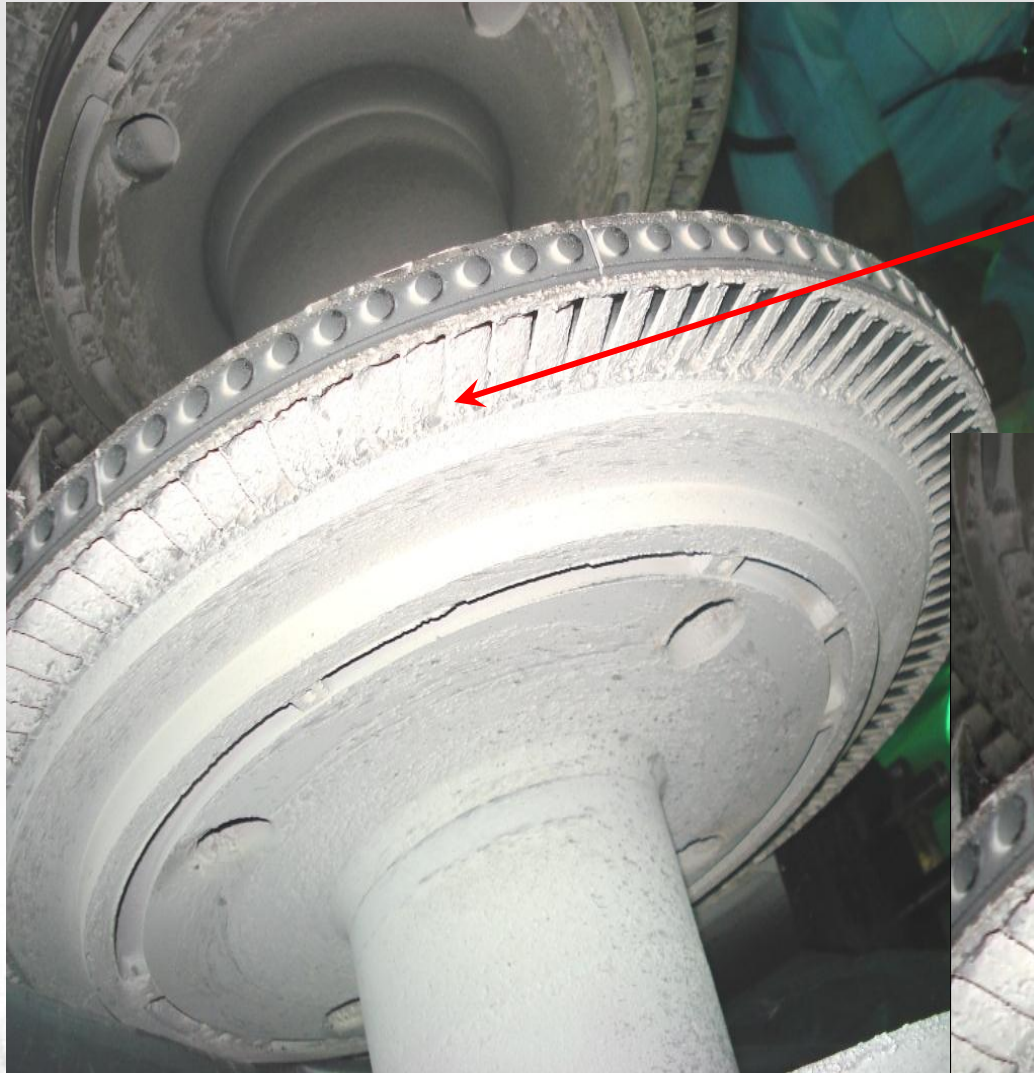
TURBINE ROTOR INSPECTION



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TURBINE ROTOR FOULING- 1ST STAGE IMPELLER



**FOULING ON 1ST STAGE
OF TURBINE ROTOR**

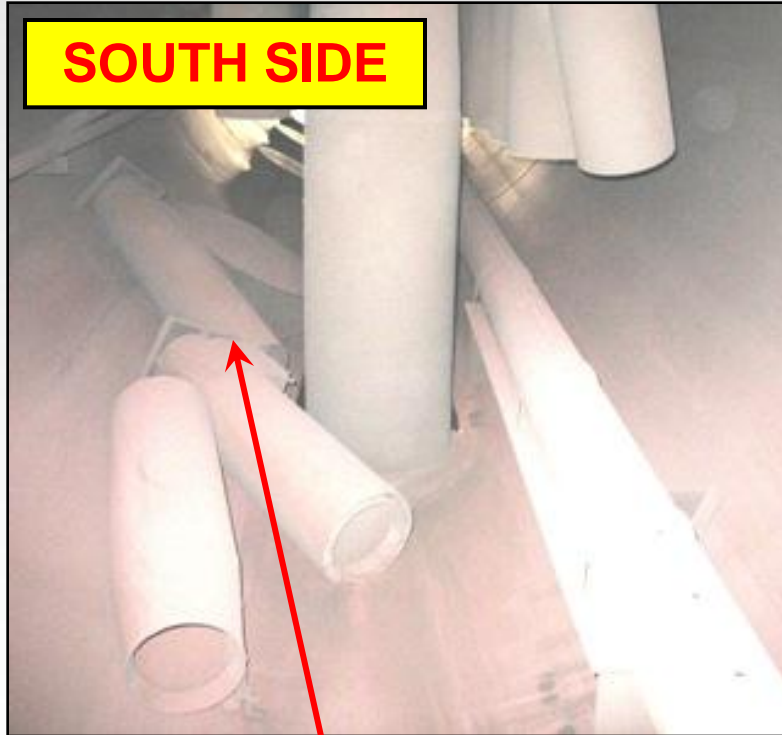


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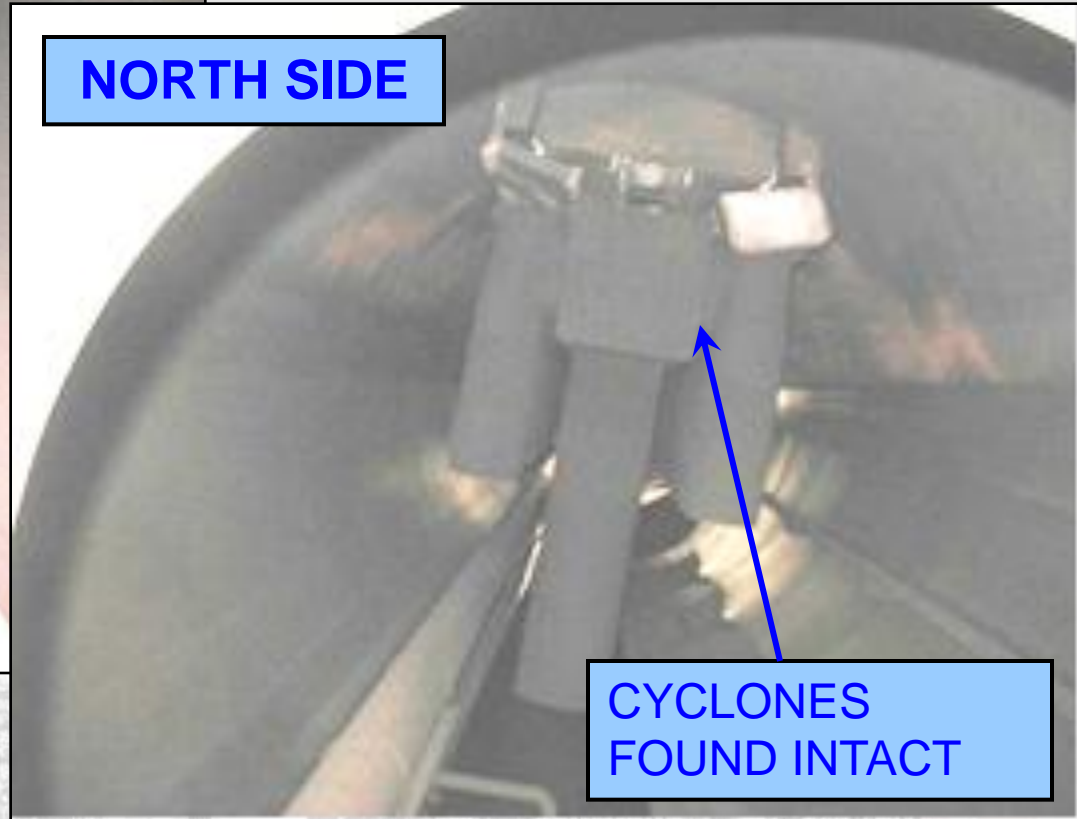
ROOT CAUSE ANALYSIS OF FOULING

#2H2 PLANT STEAM DRUM (76V7604) INSPECTION



SOUTH SIDE

**3 CYCLONES DISLODGED &
1 IN BENT CONDITION**



NORTH SIDE

**CYCLONES
FOUND INTACT**

LEARNING LESSONS

THE 5 MAJOR LEARNING POINTS FROM INCIDENT

- 1. MONITORING OF TURBIN TRHUST AND CO-RELATE WITH CHANGES IN 1ST STAGE STEAM CHEST PRESSURE.**
- 2. PRO-ACTIVE MONITORING AND SCHEDULE INSPECTION FOR STEAM TURBINES RUNNING WITH SAME STEAM SUPPLY FROM LSDP.**
- 3. MONITORING OF BALANCING LINE DP AND CO-RELATE WITH COMPRESSOR PERFORMANCE.**
- 4. APPLICATION OF PRO-ACTIVE MAINTENANCE USING RCA TOOLS TO ELEMIMATE THE ROOT CAUSE AND IMPROVE RELIABILITY.**
- 5. MEASURES TO IMPROVE AND MAINTAIN THE STAM QUALITY WITH STEAM SAMPLING SCHEDULE.**



Questions and Discussion
THANK YOU

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