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"Severe corrosion on rotor blades of back pressure type Steam Turbine due to unique reason". What Went Wrong ?

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Presenter/Author bios

Arun Kumar (Author)

Arun Kumar is working with HPCL- Mittal Energy Ltd., India, as Head of Maintenance & Reliability of high complexity Refinery complex, Guru Gobind Singh Refinery at Bathinda, India. Has over 30 years of experience in the areas of erection, commissioning, maintenance, equipment reliability, turnaround planning and execution, troubleshooting and performance improvement of Rotating Equipment, in Process Plant/ World Class Oil Refinery. Arun is mechanical engineering graduate with post-graduation in business management. He has presented number of technical papers at international venues and lectured at Turbomachinery and Pump Symposia, including tutorial and case studies. He is advisory committee member of Asian Turbomachinery Symposium , Turbomachinery Lab., Texas A&M University.

Anurag Chopra (Co-Author)

"The co-author is having more than 18 years of experience in field of Reliability & Maintenance of Rotating Equipment in the top refineries of India and presently working as Lead- Rotating Equipment Reliability at HMEL Refinery in India. Has been regular training faculty on rotating equipment for young engineers across refinery and has contributed in formulating overall rotating equipment strategies mainly predictive, preventive maintenance and bringing about transformation in rotating asset management by adapting latest technologies/tools available. The Co-author also has long exposure of rotary equipment vibration analysis – both casing and shaft and has designed, started and led condition monitoring programs in no. of refineries and has won accolades for the same."

Summary of the Case Study

The case study depicts an unique reason for corrosion on blades of a Back Pressure Turbine (BPT) for Generator drive leading to huge maintenance cost within 4 years of turbine installation and commissioning.

Based on the observations collected during overhauling and analysis thereafter, it was concluded that reason for the corrosion on turbine blading was wet ambience inside the turbine casing during machine idle condition.

Action plan was prepared and implemented to avoid reoccurrence and is discussed in detail in subsequent slides.

The equipment overhauling was mainly planned due to higher vibration from equipment along with other reasons like increased steam leakages from turbine end seals leading to lube oil contamination.

Brief Description

STG-3 (Steam Turbine Generator) installed in Captive Power Plant of Refinery is back pressure control machine and drives electric generator with reduction gear-box. The brief equipment specifications are:

Description	Value
Steam Inlet Conditions	105kg/cm2 g @ 505 degC
Steam Exhaust Conditions	5 Kg/cm2g @ 400degC
Turbine RPM	5000
Generator RPM	3000
Rating	32 MW
No of Impulse Stages	1
No of Reaction Stages	19

Brief Description

Steam Turbine major overhauling revealed deterioration to steam path components in the form of corrosion, erosion, pitting and other components in lube oil circuit like bearings.

The present case study is limited to investigation on corrosion on the steam path components, corrective actions taken and machine performance after corrective actions.

Brief History

Milestones

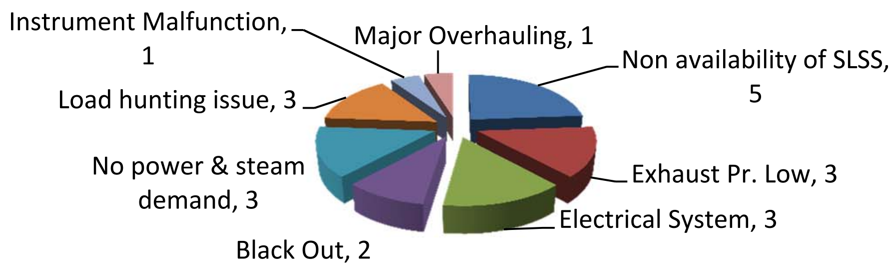
Mechanical Completion of Equipment	:	19-12-2011
Ready For Commissioning	:	06-04-2012
Commissioning (First Synchronization)	:	28-04-2012
Hours From Date Of Commissioning	:	30793 Hrs
Running Hours	:	27187 Hrs

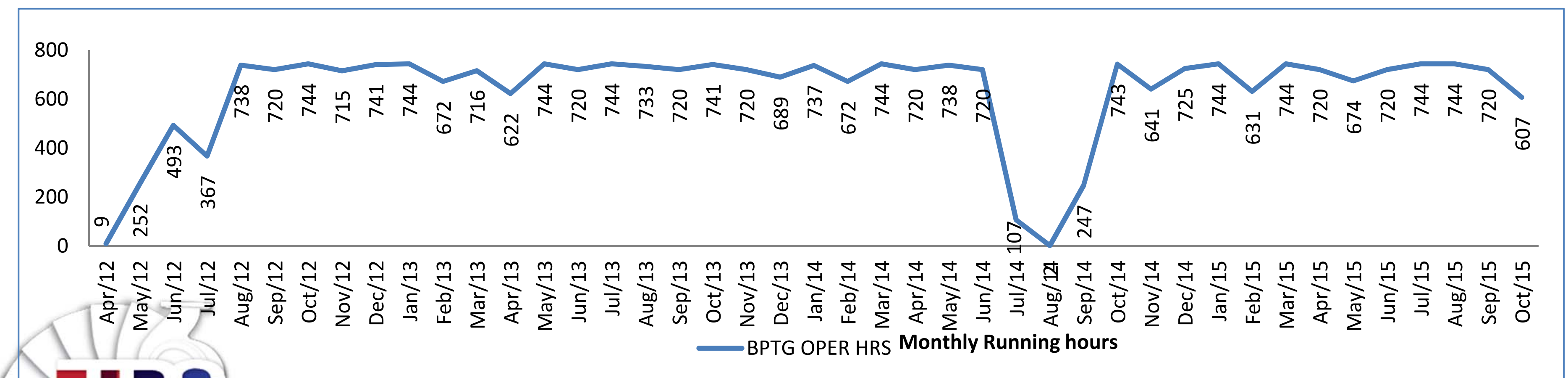
Note

- From April'12 to July'12, the no. of running hrs. 1121 against available 2280 hrs. due to intermittent running.
- From July'14 to Sep'14, the no of running hrs. 354 against available 2208 due to refinery shut down.

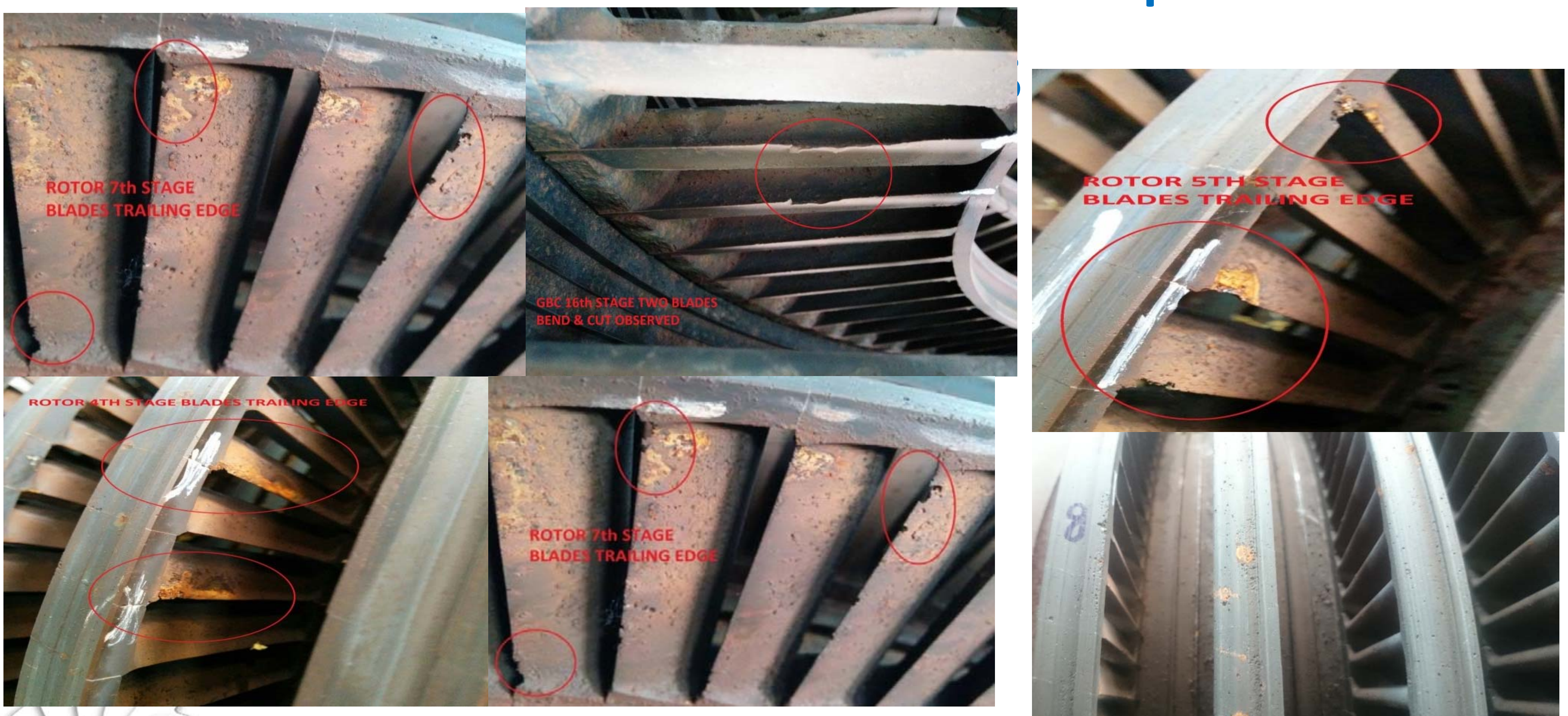
Start Stop History

Total No. of Stops Since Aug-12
21 Times

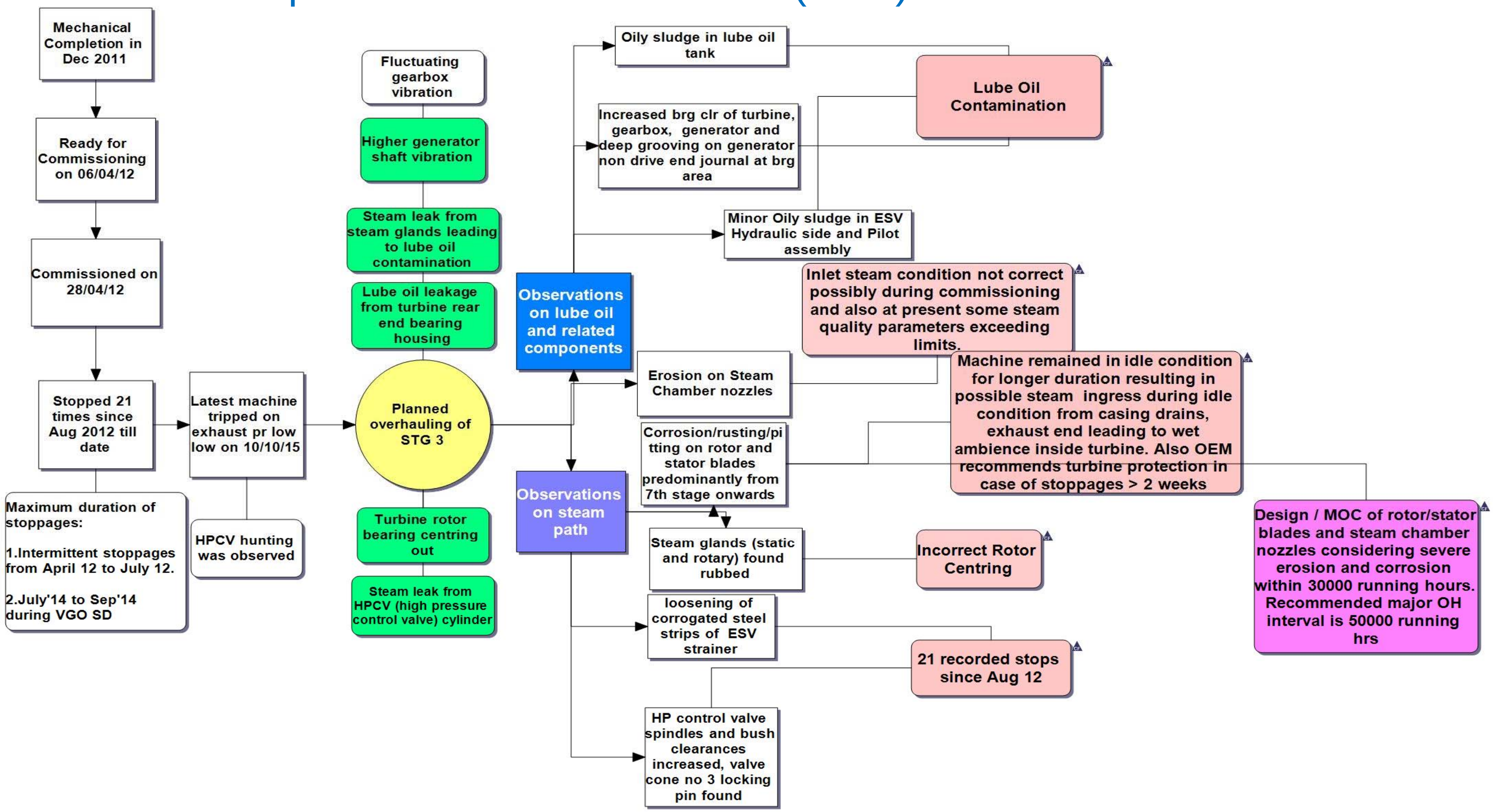




Observations on steam path



Snap Chart and Causal Factor (RCA)



Analysis of the Causal Factor

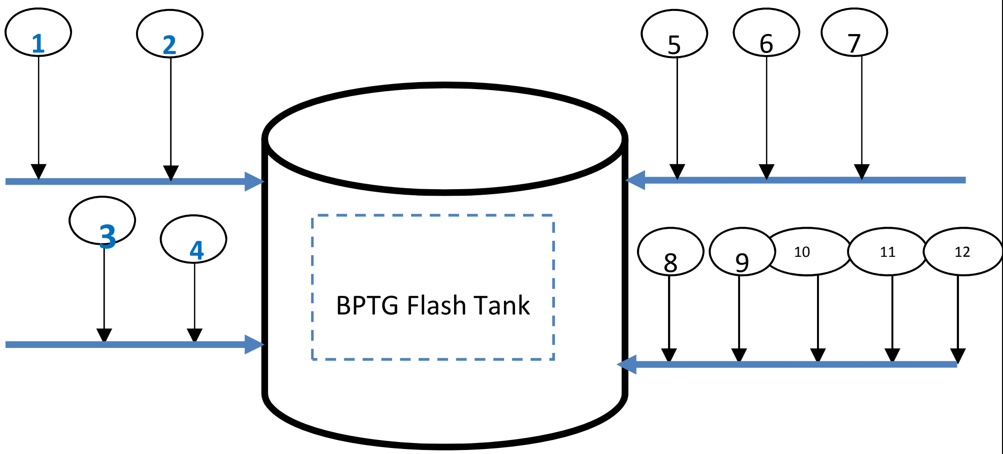
Wet Ambience In turbine during rotor standstill condition for longer duration

- Machine commissioned in April 2012.
- May'12 to July'12 - in intermittent start stop condition. Same time, the steam lines were charged and possibility of steam ingress inside turbine casing existed.
- July'14 to Sep'14 – machine stopped due to plant shutdown.
- More than 21 stoppages since Aug 12.
- BPSTG (Back Pressure Steam Turbine) flash tank -12 nos. drain lines : 9 no. intermittent (including 3 turbine casing drains) and 3 nos. continuous drains.
- Continuous drains are from VHP (Very High Pressure) header & remain in service during BPSTG trip condition too.

Analysis of the Causal Factor

- Back flow of flash steam from these continuous drains can create wet ambience in turbine during rotor standstill condition.
- BPSTG drains from upstream and downstream of exhaust steam (LP)
- Motor operated valve (MOV) are connected to same drain header, which has potential to create wet ambience in turbine during rotor standstill condition. (Refer schematic)

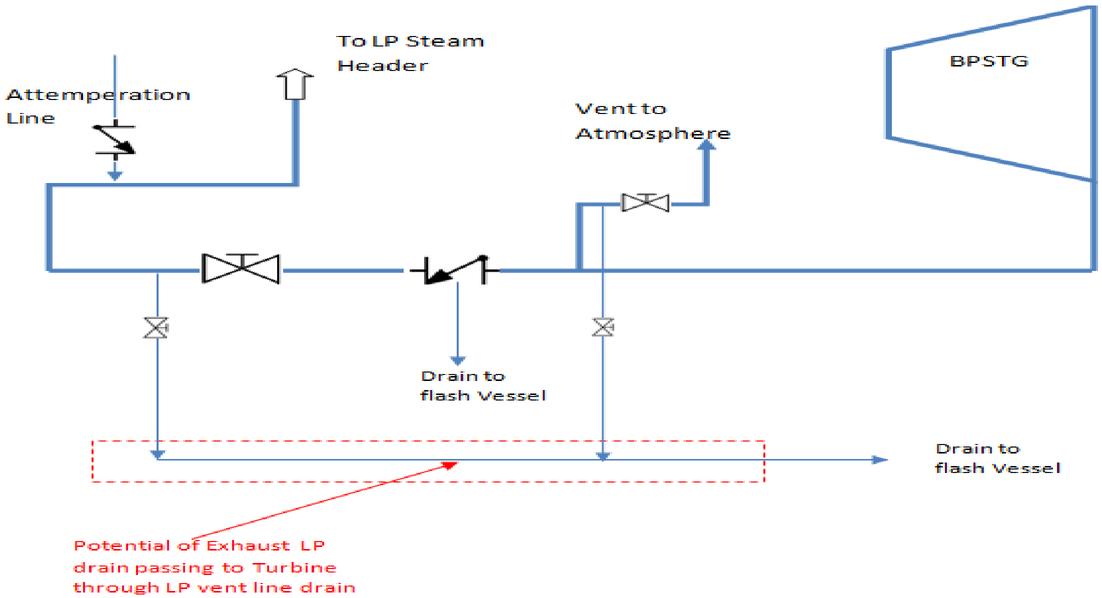
BPTG Flash Tank Drain Details



S No.	Type of Drain	Drain From	Valve near flash tank
1	Intermittent	Casing MP	Near Flash Tank
2	Intermittent	Casing LP	Near Flash Tank
3	Intermittent	Aux Steam Drain Header	No Isolation
4	Intermittent	Casing HP	Near Flash Tank
5	Intermittent	Common Header under QC NRV, after QC NRV,LP Vent	No Isolation
6	Continuous	ESV Drain	No Isolation
7	Intermittent	LP Steam to VAM drain	No Isolation
8	Continuous	VHP drain trap near Startup vent MOV	Near Flash Tank
9	Intermittent	VHP drain by Pass near Startup vent MOV	Near Flash Tank
10	Continuous	VHP drain trap near Flash Tank	Near Flash Tank
11	Intermittent	VHP drain by Pass near Flash Tank	Near Flash Tank
12	Intermittent	LP Exhaust	Before Q C NRV

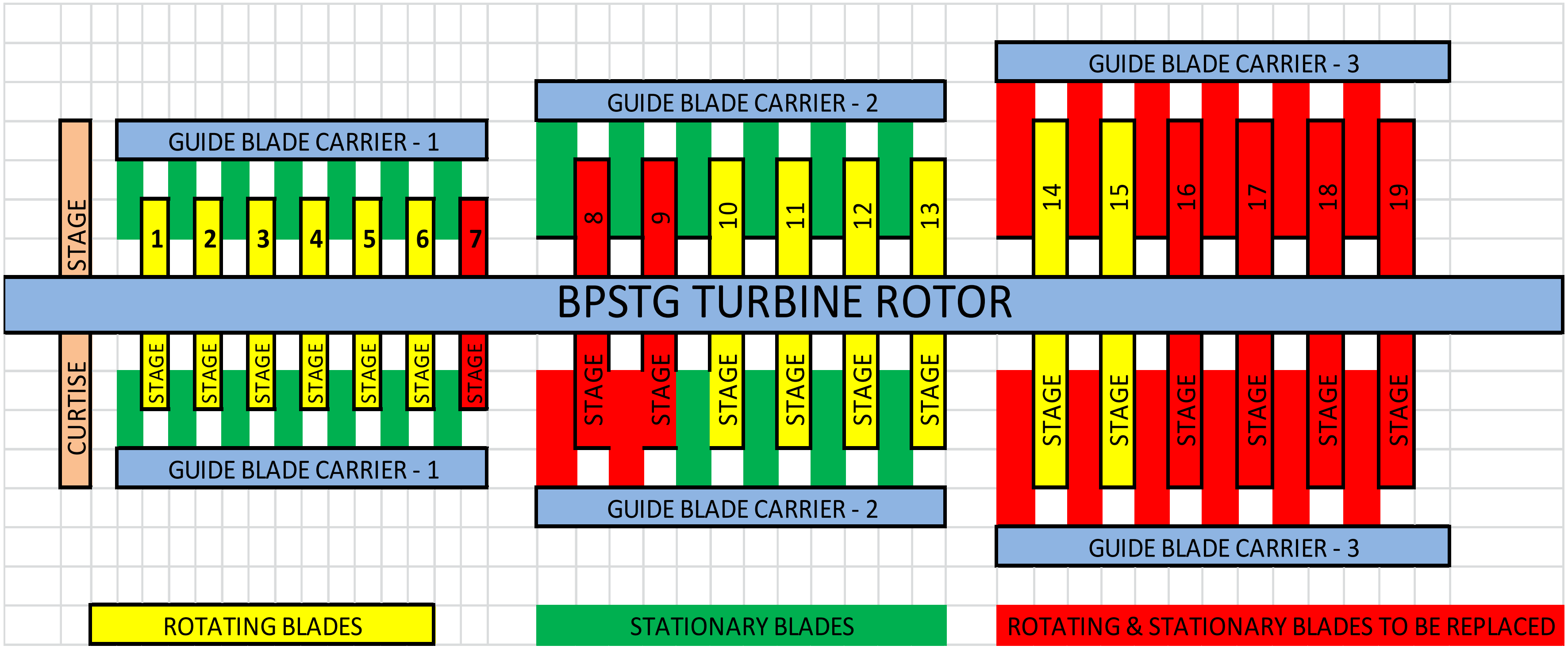
Note: During site test as part of RCA, back flow of steam from flash tank to turbine casing noted from HP casing drain and back flow from LP exhaust line.

Exhaust Steam Line Drains



BPSTG drains from upstream and downstream of exhaust steam (LP) MOV connected to same drain header and has potential to create wet ambience in turbine during rotor standstill

Graphics-Corrosion on Rotor and Carrier Blading



Drain

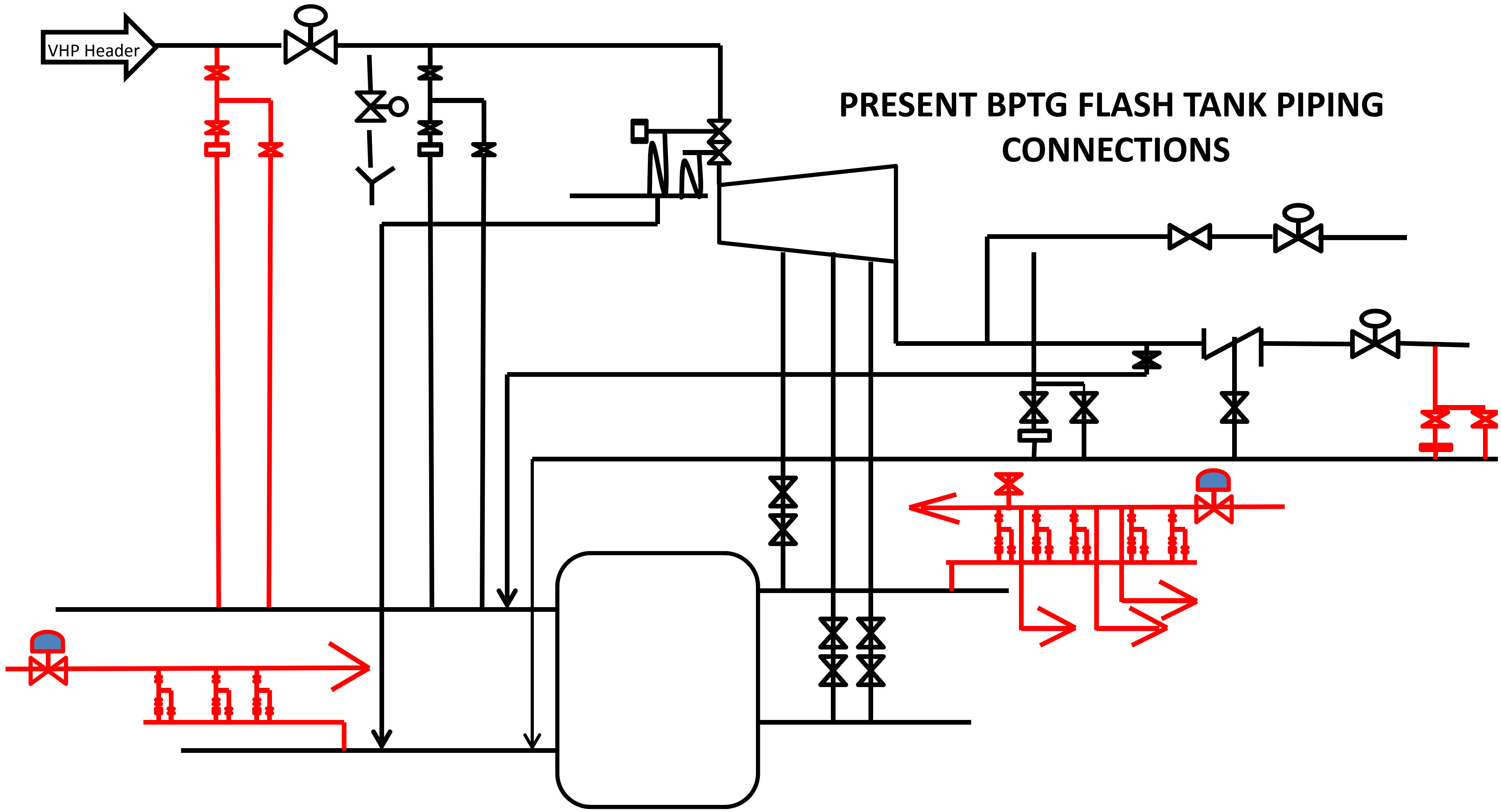
Action Plan Based on the Analysis

Causal Factor	Root Cause	Action Taken
Wet Ambience Inside Turbine leading to corrosion on turbine components.	**Back flow of steam to the turbine casing from:** 1.Casing Drains connected to common flash tank having total 12 no drains connected. 2.LP exhaust end drains. 3.Machine stoppages for longer duration.	1. Shifting of turbine header drain trap and bypass valve (Before MOV) from flash tank to atmospheric drain. 2. Shifting of Drain trap upstream Inlet valve, Trap root Inlet valve and Trap Bypass valve to approachable locations 3. Shifting of header after MOV drain trap and bypass valve from flash tank to atmospheric drain. 4. Shifting of VAM Boiler Drain Trap and bypass valve common drain header (2”) from flash tank to atmospheric

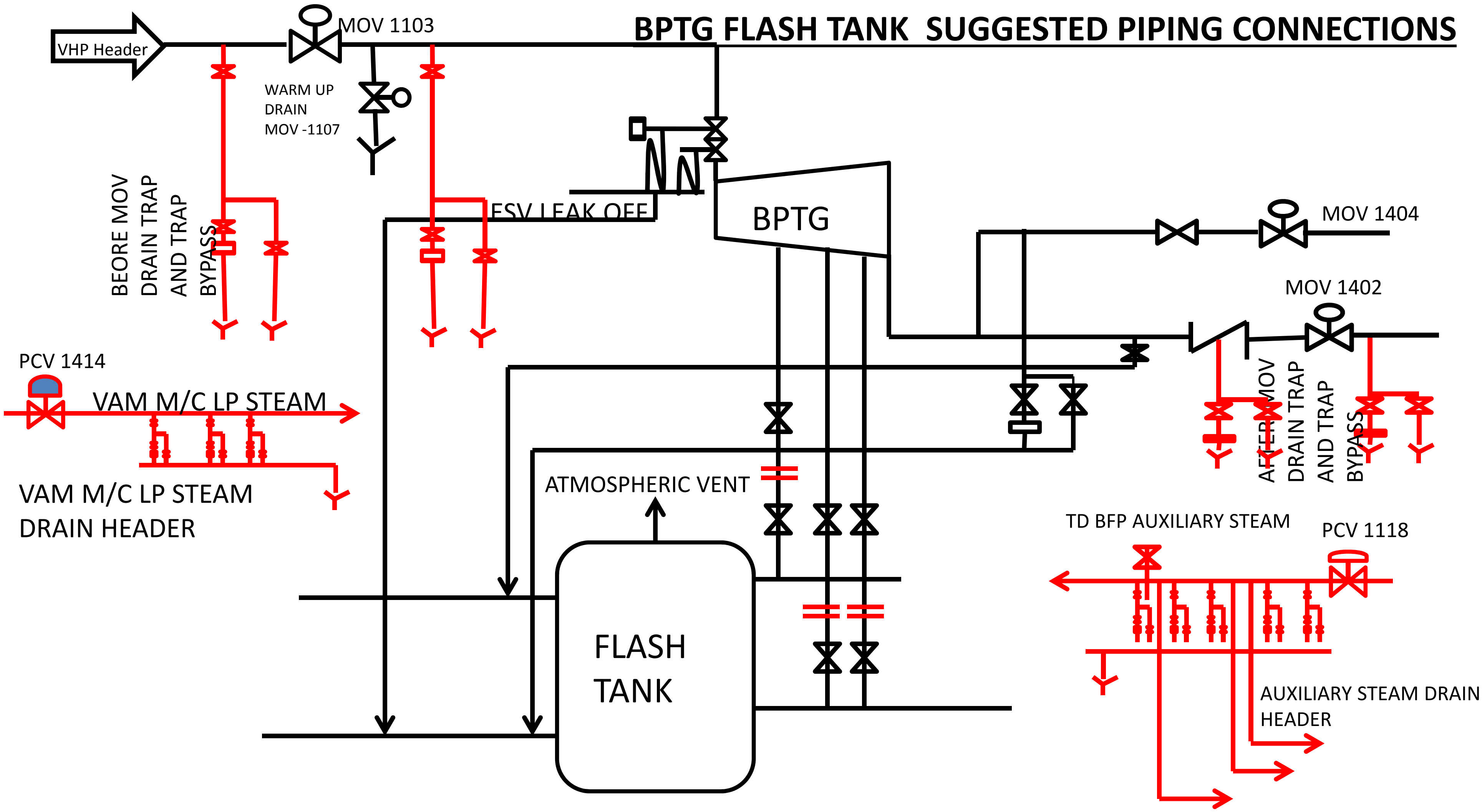
Action Plan Based on the Analysis

Causal Factor	Root Cause	Action Taken
Wet Ambience Inside Turbine leading to corrosion on turbine components.	**Back flow of steam to the turbine casing from:** 1.Casing Drains connected to common flash tank having total 12 no drains connected. 2.LP exhaust end drains. 3.Machine stoppages for longer duration.	5. Shifting of Aux. Steam Drain Trap and bypass valve common drain header (4”) from flash tank to atmospheric. 6. Shifting LP Exhaust After MOV Drain trap and drain bypass from flash tank to atmospheric 7. Shifting of LP Exhaust After NRV Drain from flash tank to atmospheric and provision of Trap. 8. Separation of Steam and oil Leak off drains. 9. Provision of Break out flanges in HP/MP/LP Casing drains.

PRESENT BPTG FLASH TANK PIPING CONNECTIONS



BPTG FLASH TANK SUGGESTED PIPING CONNECTIONS



Learnings

Based on the turbine satisfactory performance after taking corrective actions, following learnings can be implemented horizontally across all steam turbines:

1. Process Flow Diagrams must be verified at site during erection stage and during handover/take over. The same was overlooked in the subject case and resulted in huge maintenance cost.
2. During long shutdown of the turbine, OEM guidelines for preservation should be followed. The same were not followed in our case leading to creation of wet ambience inside turbine casing and hence corrosion on blades.
3. In subject case, OEM recommended “The turbine unit will be protected against internal corrosion during prolonged shutdown of more than 2 weeks after cooling down the turbine, by admitting Nitrogen into the turbine and maintain a low positive pressure of about 50 to 75 mm W.G. during whole time of shutdown at standstill condition, the protection shall include all steam spaces including the gland sealing”.