



Fr7AE Gas Turbines
Dry Low-NOx Combustion System
Operating Challenges in O&G Plants



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Executive Summary:

After a planned Shutdown and transfer valve replacement, Propane unit -GT Fr7AE DLN1- started;

Unit failed to transfer to pre-mix steady state Mode (PMSS) and Trip.

05 Days of online troubleshooting using Fishbone Diagram, to determine why the unit couldn't sustain on PMSS mode after several transfers.

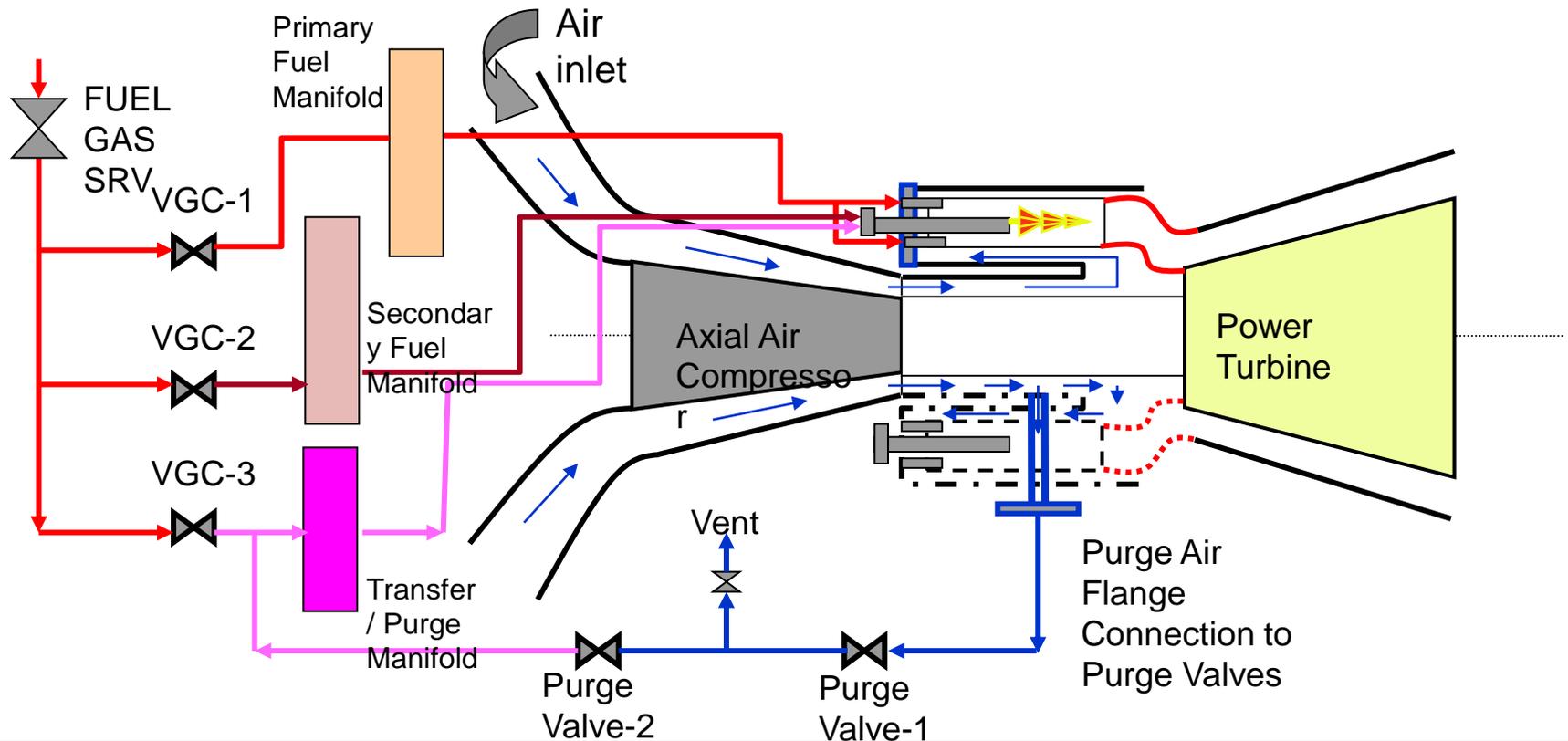
Visual inspection of the internal Combustion system reveal hardware damages.

RCFA-PROACT Methodology used to investigate and find the causes of the damages.

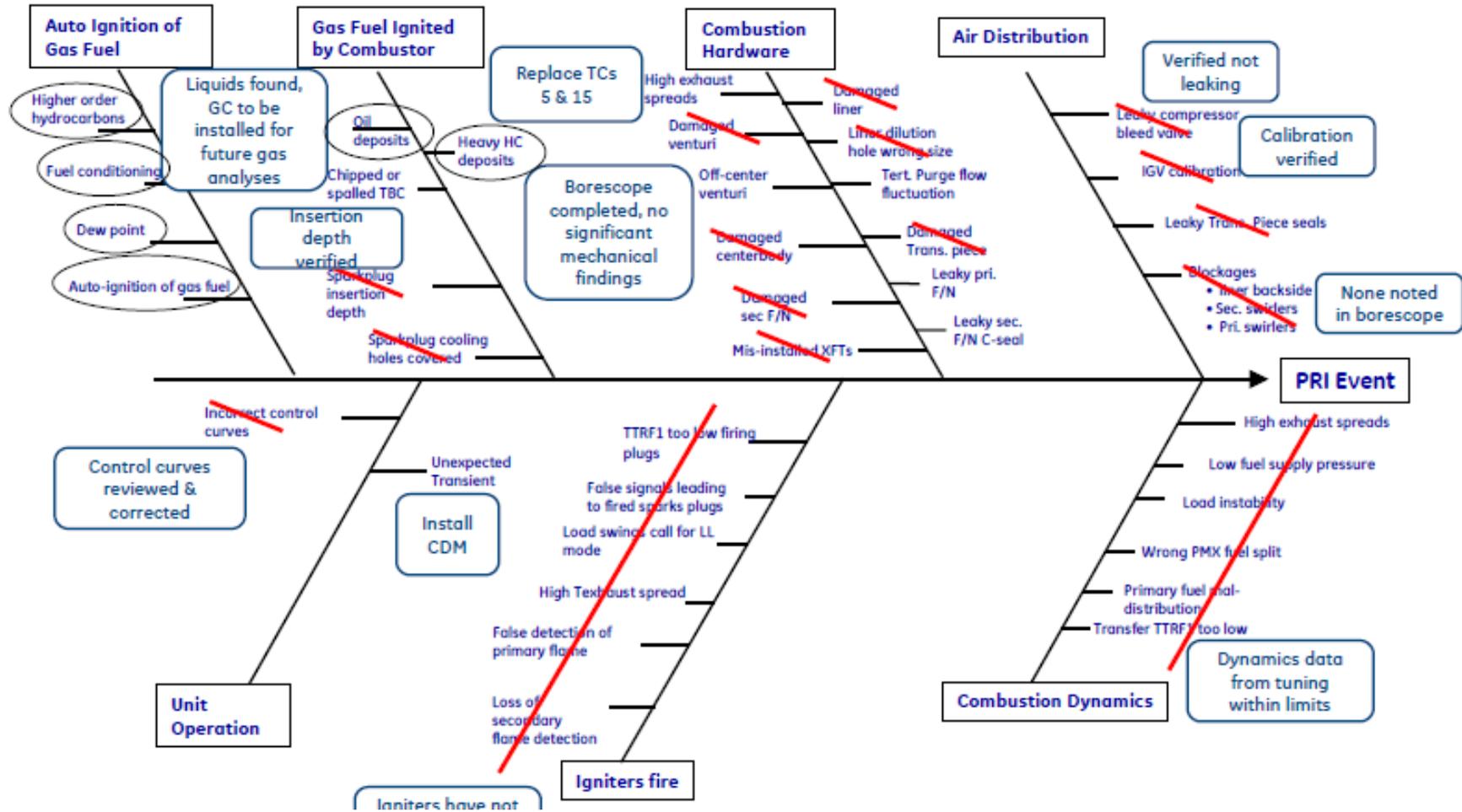


Why DLN1 system on Gas Turbine and How it works during Startup?

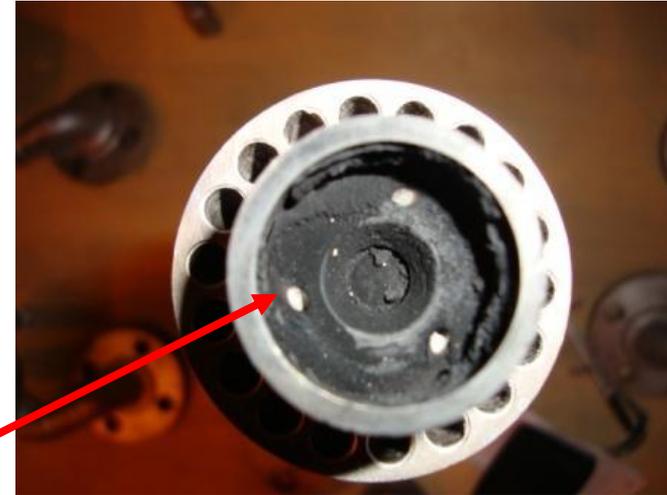
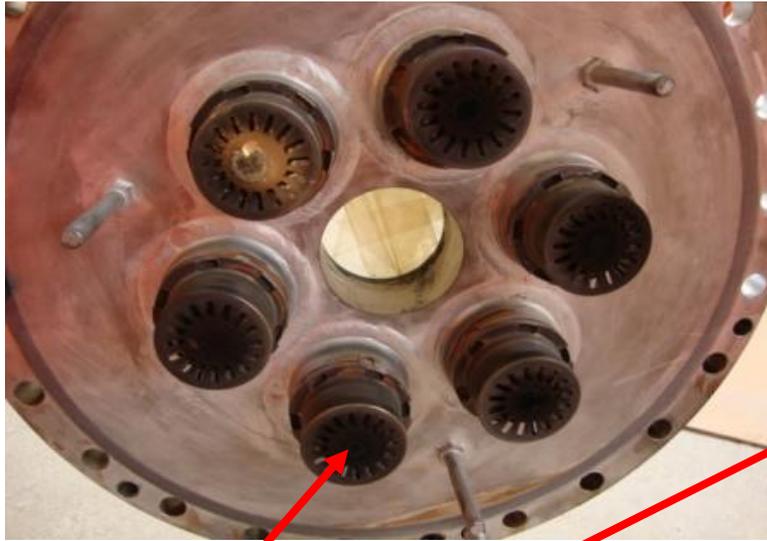
- The DLN-1 for FR7AE GT meet Qatar Ministry of environment (MOE) in terms of emission norms ($\text{NO}_x < 25 \text{ ppm}$).



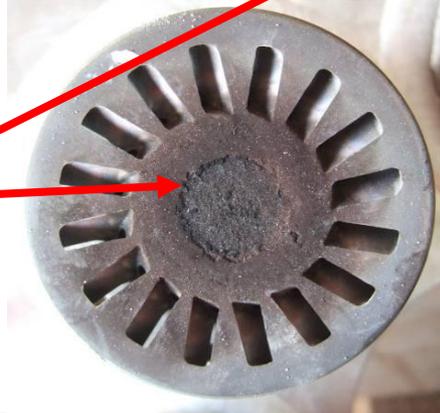
Fishbone Diagram for Online Troubleshooting



Combustion Inspection Findings



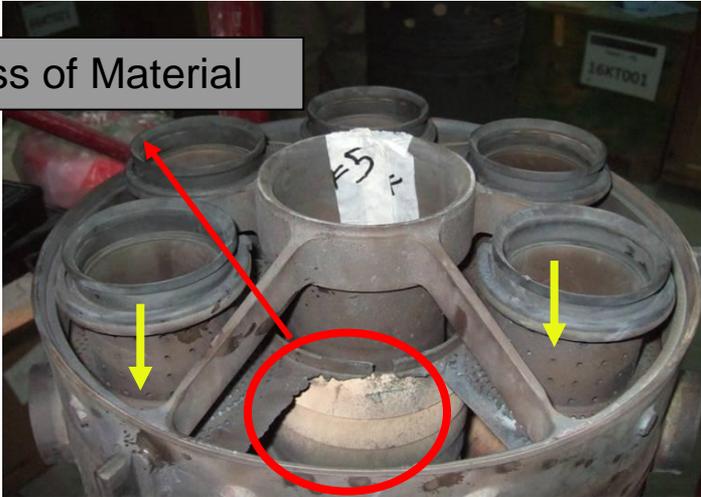
**Carbone Deposits
On Primary and
Secondary Nozzles**



**Thermal
Damage**

Combustion Inspection Findings: Combustion Liner No 5: Major damage

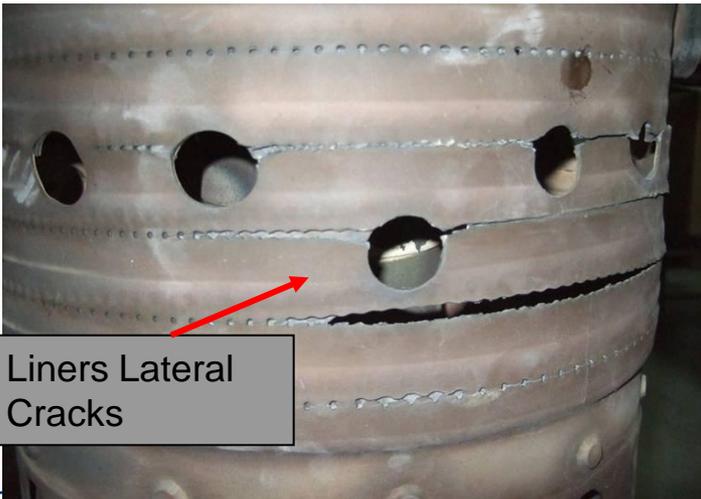
Loss of Material



Liner #5 Cracked Circumferentially



Liner Caps Deformation

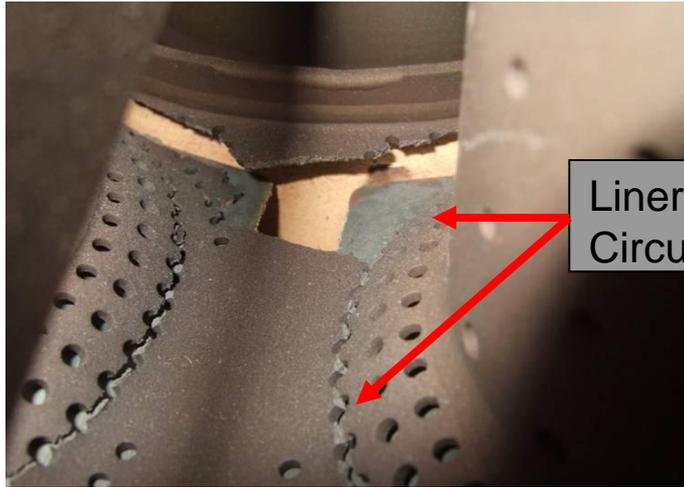


Liners Lateral Cracks

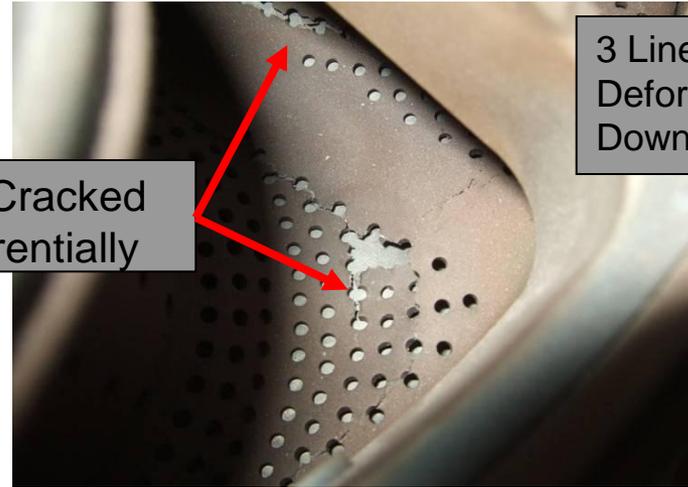


Material Melted Down Inside the Liners.

Combustion Inspection Findings: Combustion Liner No 4: Major damage



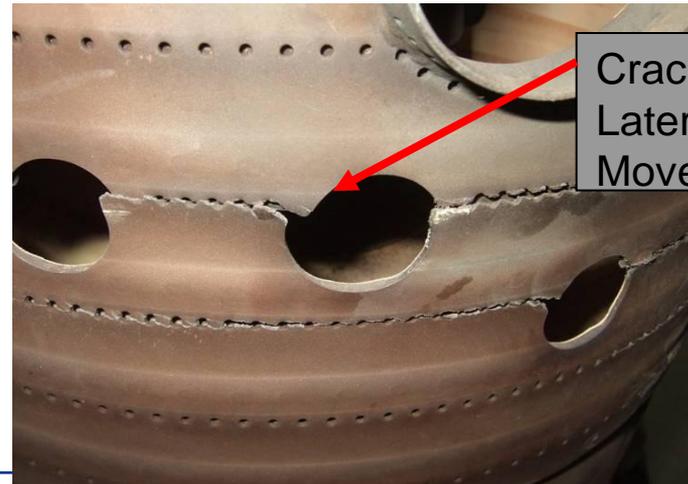
Liner #4 Cracked
Circumferentially



3 Liner Caps
Deformed
Downward



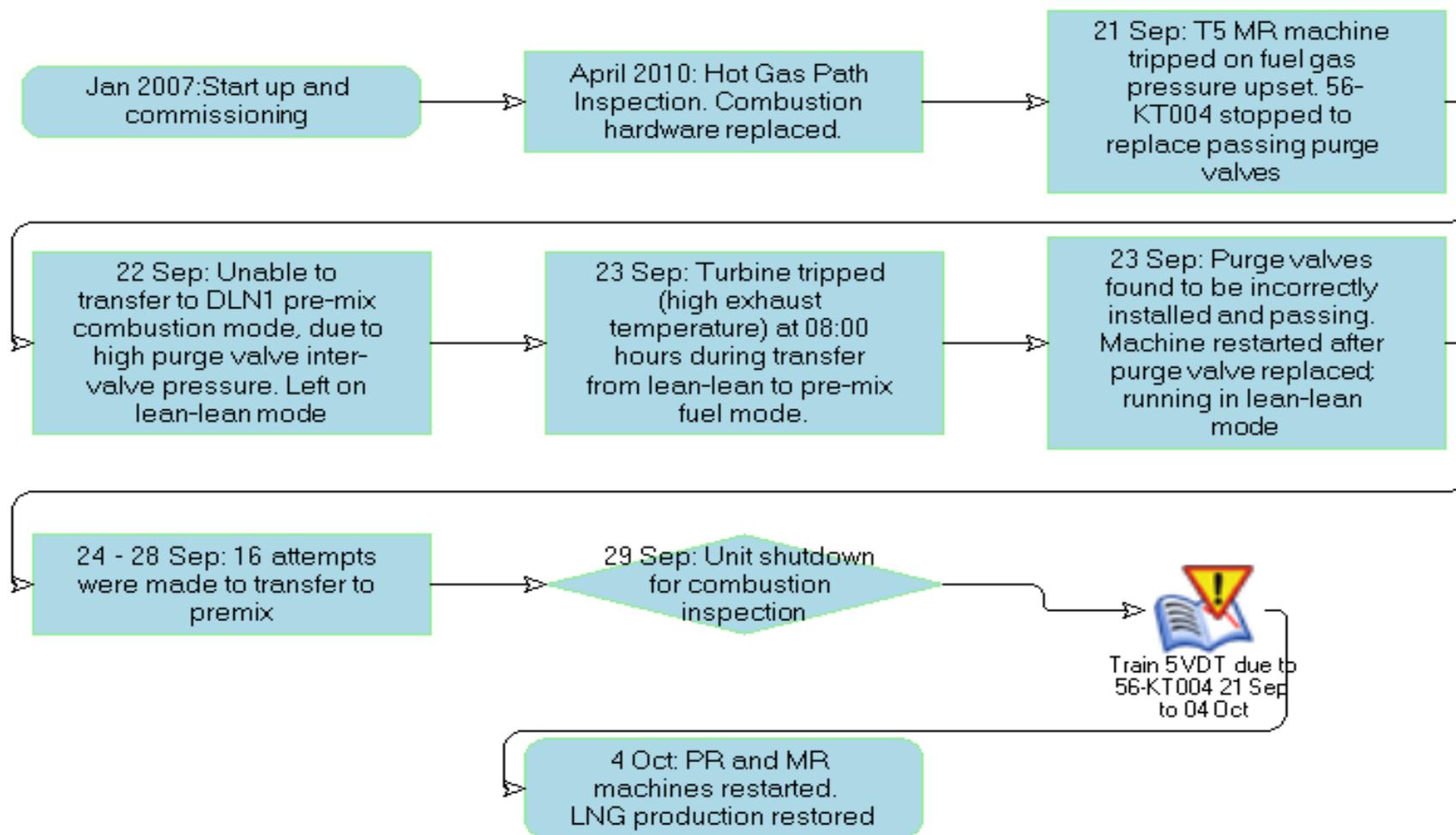
Missing Piece
Near Hula Seal



Cracks and
Lateral
Movement

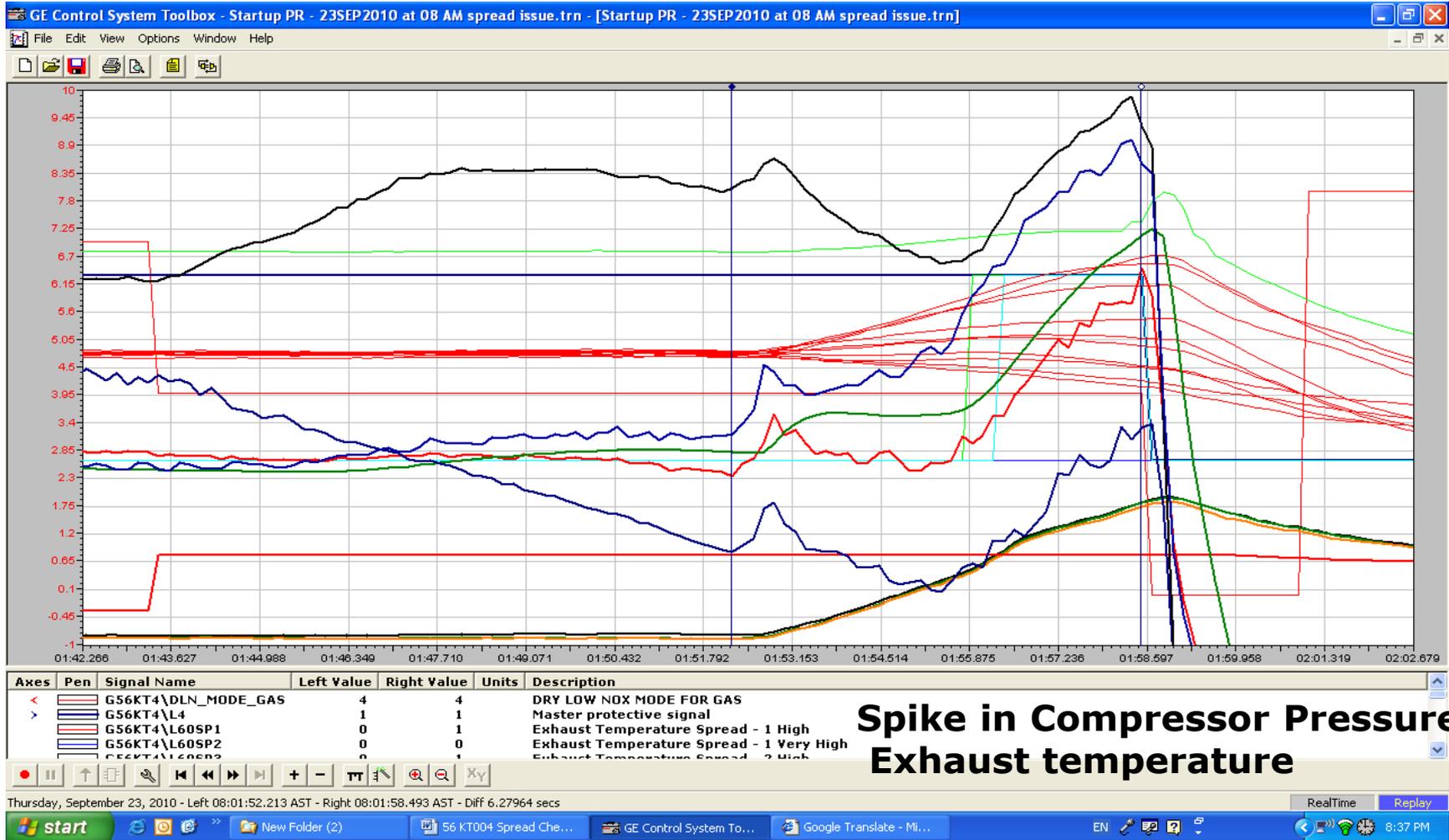
Root Cause Failure Analysis RCFA

Event Diagram:



Investigations ..2

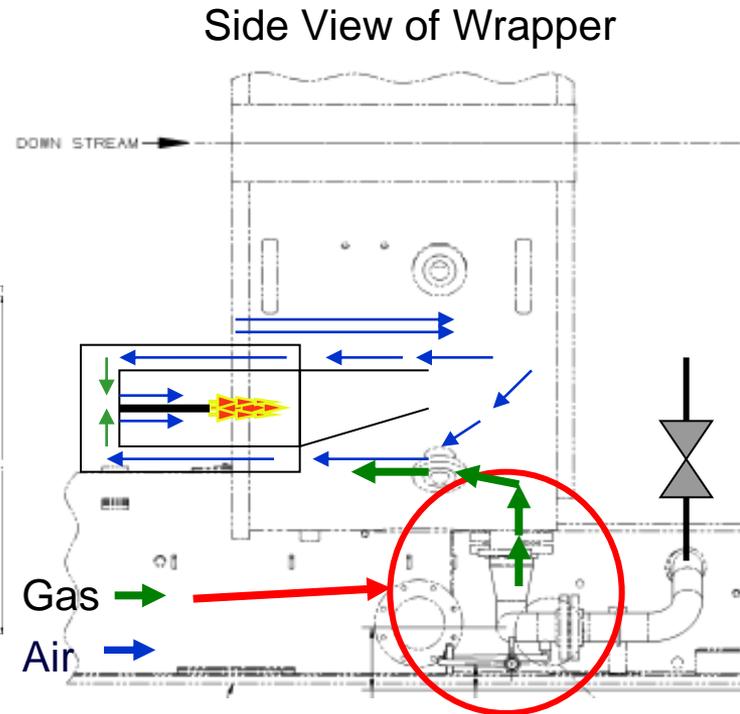
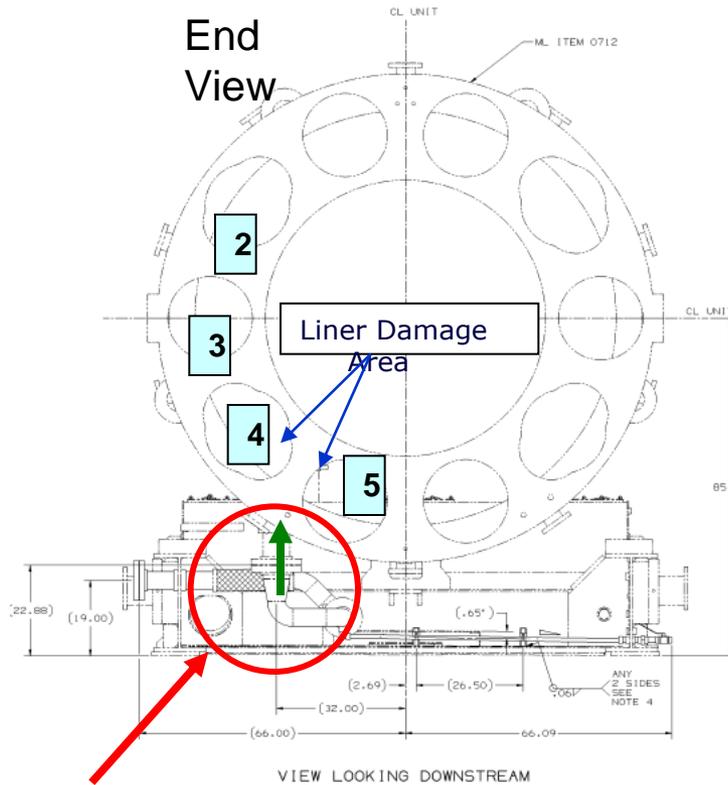
Control System Event Trends during transfer



Spike in Compressor Pressure & Exhaust temperature

Investigations..3

Purge Air Connection on Wrapper



Purge Air
Connection
To Wrapper

Purge Air Connection on Wrapper Close to combustion can #4&5

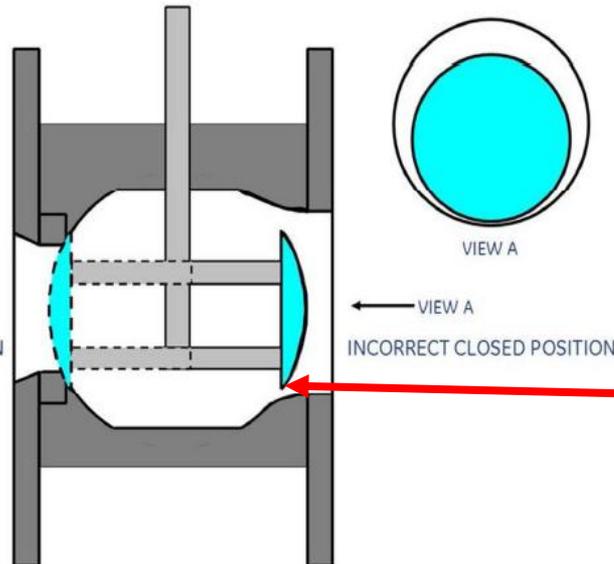
Investigations..4

Purge Valve installation

Same SAP number Normally close actuator & Normally Open actuator



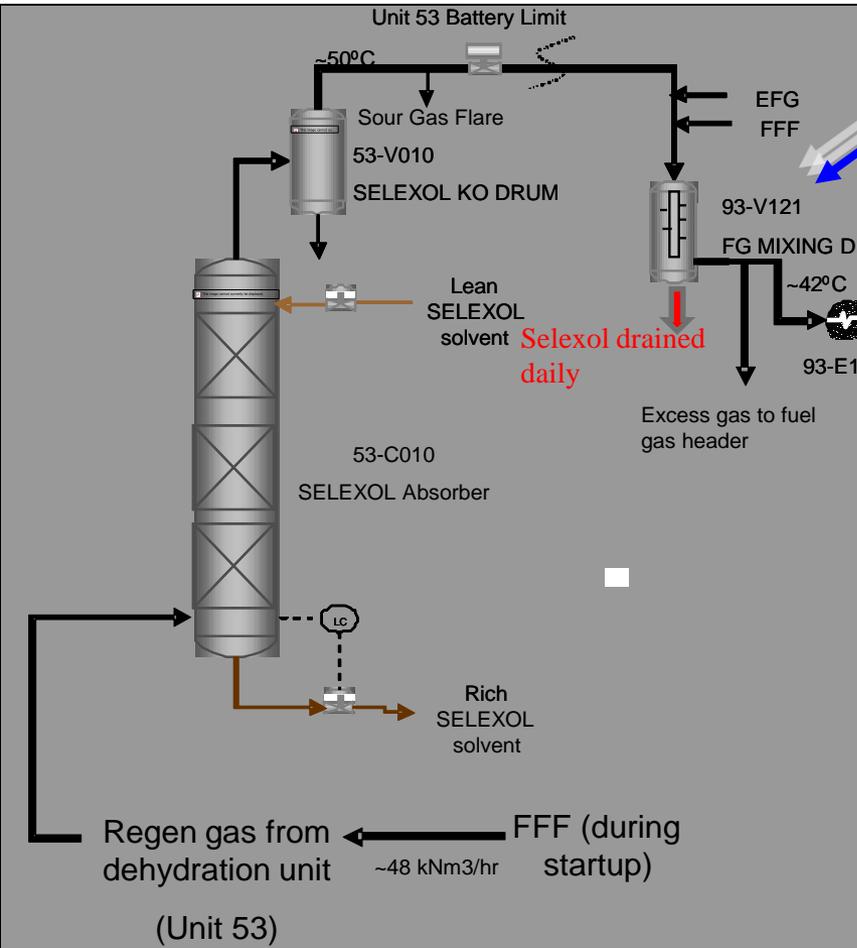
CORRECT CLOSED POSITION



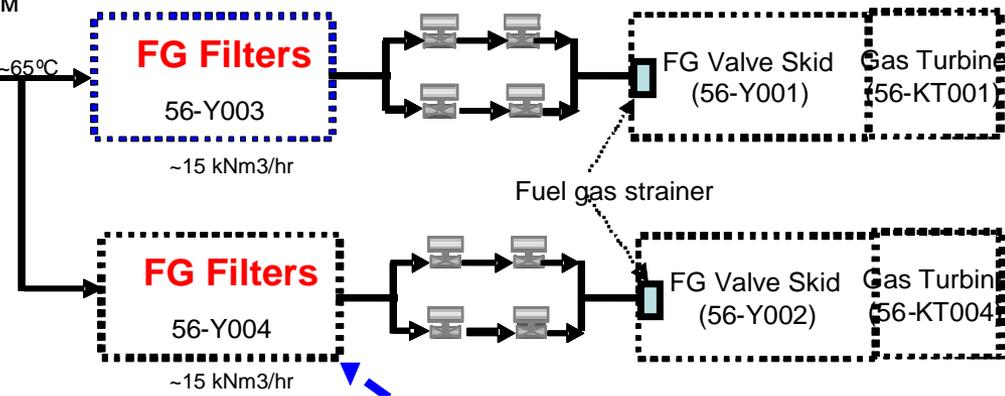
Ball closes opposite to seat leaving wide gap in closed condition

Closing opposite to seat/Incorrect SAP material number

Investigations..5 Fuel Gas System.

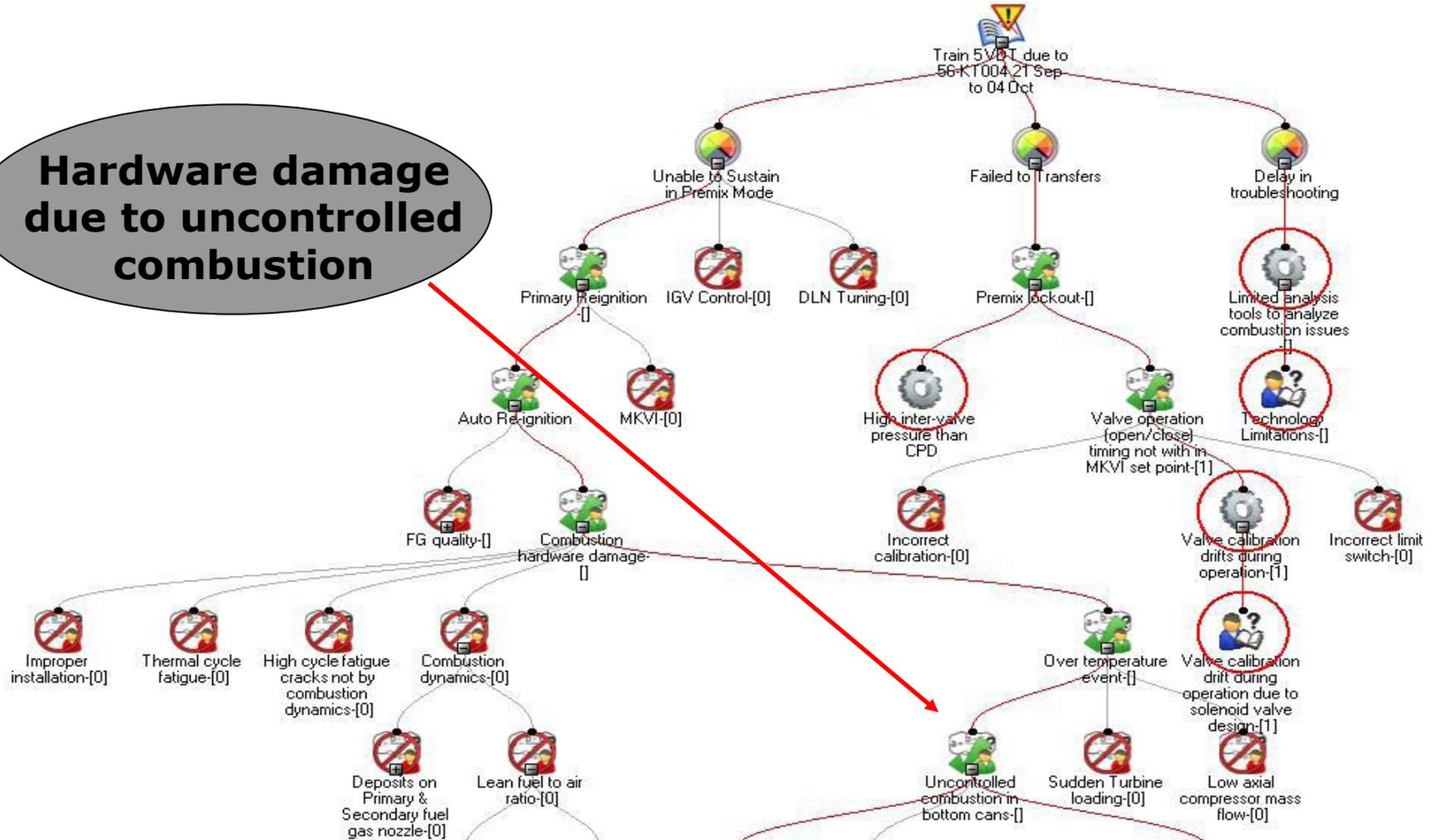


- Mixing drum not a knock out drum (no demister)
- Upstream demisters not effective

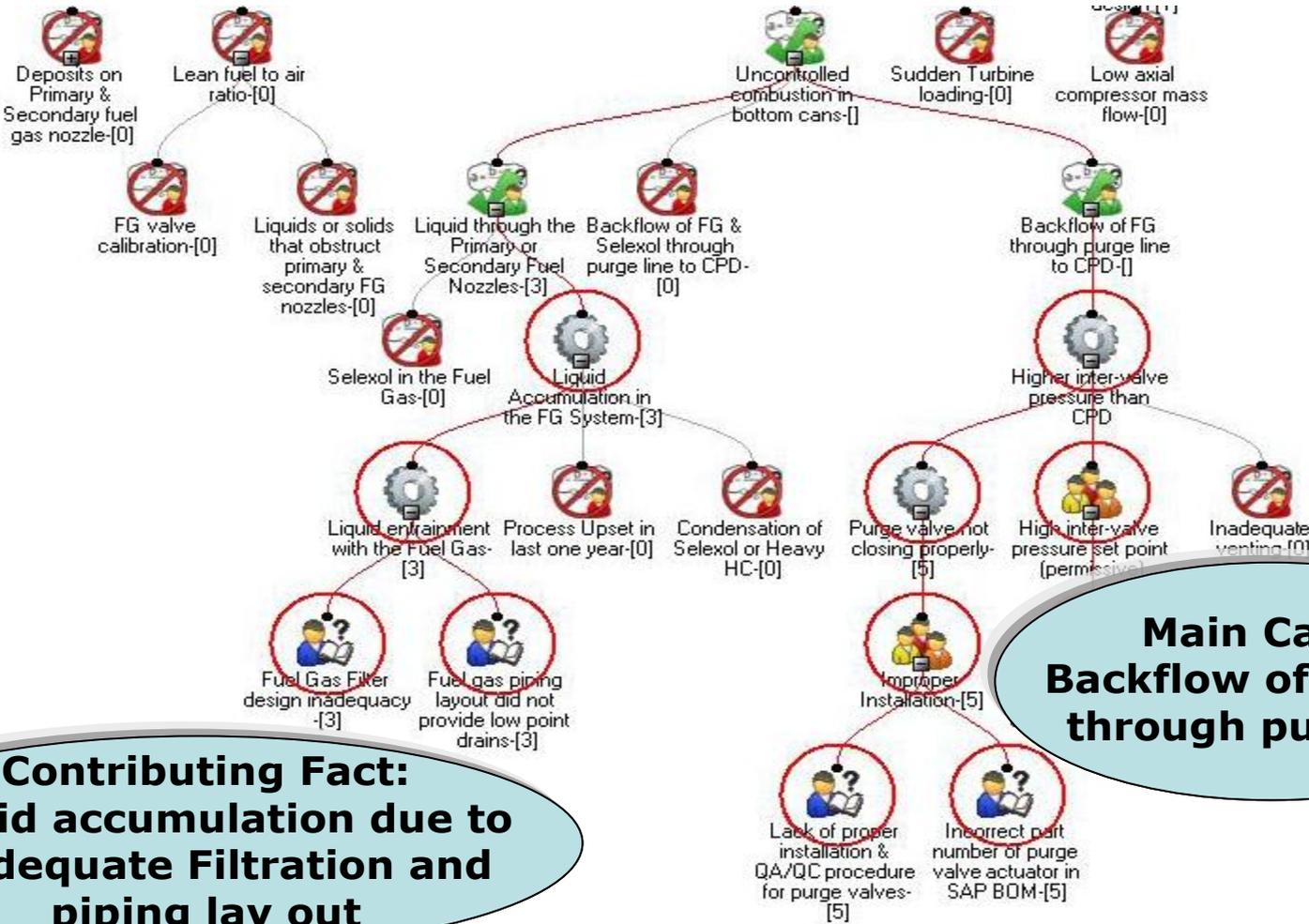


Filters Specification 0.3µm for solid & liquid removal, existing 3µm for solid only.

Hardware damage due to uncontrolled combustion



RCFA Logic Tree (suite)



**Contributing Fact:
Liquid accumulation due to
inadequate Filtration and
piping lay out**

**Main Cause:
Backflow of Fuel gas
through purge line**

Work Management:

- Change SAP material code for the purge valve actuator.
- Develop Purge Valve Installation Procedure.
- Time based purge valve replacement.

Engineering Design:

- Upgrade purge valves, actuators, solenoid.
- DLN mode transfer software modification.
- Upgrade fuel gas filtration system & DLN valve skid layout.
- Upgrade demisters of Selexol Absorber & mixing drum.
- Install Combustion Dynamics Monitoring system for all Frame 7 DLN Gas turbines.

All recommendations have been implemented.

Questions?