Fr7AE Gas Turbines
Dry Low-NOx Combustion System

Operating Challenges in O&G Plants

Atul W. Deshpande – RasGas
Luis A. Rojas – RasGas
V. Venkatachallam – RasGas
Mustapha Chegchoom – RasGas
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 (NOx < 25 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

- Liner #5 Cracked Circumferentially
- Liner Caps Deformation
- Loss of Material
- Liners Lateral Cracks
- Material Melted Down Inside the Liners.
Combustion Inspection Findings:
Combustion Liner No 4: Major damage

- Liner #4 Cracked Circumferentially
- Missing Piece Near Hula Seal
- Cracks and Lateral Movement
- 3 Liner Caps Deformed Downward
Root Cause Failure Analysis (RCFA)

Event Diagram:

Jan 2007: Start up and commissioning


21 Sep: T5 MR machine tripped on fuel gas pressure upset. 56-KT004 stopped to replace passing purge valves.

22 Sep: Unable to transfer to DLN1 pre-mix combustion mode, due to high purge valve inter-valve pressure. Left on lean-lean mode.

23 Sep: Turbine tripped (high exhaust temperature) at 08:00 hours during transfer from lean-lean to pre-mix fuel mode.

23 Sep: Purge valves found to be incorrectly installed and passing. Machine restarted after purge valve replaced; running in lean-lean mode.

24 - 28 Sep: 16 attempts were made to transfer to premix

29 Sep: Unit shutdown for combustion inspection

Train 5VDT due to 56-KT004 21 Sep to 04 Oct

4 Oct: PR and MR machines restarted. LNG production restored.
Investigations.. 1
Control System Trends.

Fuel gas Pressure Fluctuations before the event
Investigations ..2

Control System Event Trends during transfer

Spike in Compressor Pressure & Exhaust temperature
Investigations..3
Purge Air Connection on Wrapper

Purge Air Connection on Wrapper Close to combustion can #4&5
Same SAP number Normally close actuator & Normally Open actuator

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
Main Cause: Backflow of Fuel gas through purge line

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