DLN Retrofit in Two Frame 7 Gas Turbines
RasGas LNG Company-Qatar

Presenters:
Amr Gad
Atul Deshpande
RasGas, Qatar

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Summary of the project

- Regulations set by Ministry of Environment to achieve NOx emissions of 25 ppm for such turbines.
- Two retrofitted units are driving Mixed refrigerant and propane in the LNG refrigeration cycle.
- Project engineered in years 2009-2010 and implementation done in year 2011 successfully.
- 1st successful DLN retrofit for Frame 7EA Gas Turbines in an LNG train.
**DLN1 Fuel Staging & Operational Modes**

**Primary Mode**
- Diffusion Flame
- 100% Primary Fuel
- Ignition - 19% Load

**Lean-Lean Mode**
- Diffusion Flame
- ~60% Primary / 40% Secondary Fuel
- 19% - 50% Load

**Transfer Mode**
- Diffusion Flame
- 100% Secondary Fuel
- 50% Load

**Premixed Mode**
- Premixed Flame / Diffusion Pilot
- 81% Primary / 19% Secondary Fuel
- 50% - 100% Load For IBH machines
- or 80%-100% Load for machines without IBH

*Primary Zone Dual Purpose:* 1. Low Load Diffusion Flame  2. High Load Premixing Chamber
Process Compressors for RasGas Train 3

Propane Compressor
Mixed Refrigerant Compressors
Main Cryogenic Heat Exchanger
LNG to Storage
C₅⁺ NGL
Mixed Refrigerant Compressors
Propane Precooled MCR Process
Feed Gas

Frame 7 Gas Turbine

3,600 rpm

Frame 7
Propane Compressor
LP MR Compressor
MP MR Compressor
MOTOR

3,600 rpm

Frame 7
Motor
PROPA N COMPRESSOR
HP MR COMPRESSOR
MOTOR
Requirements for DLN retrofit

- Stable fuel gas supply pressure
- Rate of change of MWI
- Contaminant free fuel gas
- Turbine Control logic upgrades for mechanical drive application
Requirements for DLN retrofit

Fuel Gas Pressure

Adequate & stable fuel gas supply pressure

- Increase the fuel gas supply network pressure
- Fuel Gas Pressure Control Ramp Up Logic:
  - Considers scenarios of fuel compressor trip or upset
  - Ensures fast make-up from back-up sources of fuel gas i.e. Fuel From Feed (FFF) or Boil
    Off Gas (BOG) to sustain the minimum fuel gas supply pressure
Train-3 Fuel Gas Supply System

Train 3 FG Pressure Control Overview

How to achieve 27.8 barg at PC3003 and 26.3 barg at inlet to turbine fuel gas skid?

Current pressure at Turbine FG skid Inlet = 25.9 barg

PSV’s set at 34.5 barg

Fuel Gas Compressor

Fuel Gas From Feed KO Drum

Drier Regen. / Selexol

93-V061 Fuel Gas Mixing Vessel

Wet Gas Flare
Frame 7 Gas Turbines

36-KT001/004

Fuel Gas Compressor

38-K001

38-E005

Fuel From Feed KO Drum

93-V062

93-PV0002

93-PV0003A

93-PV0003B

93-PV0003C/D

Drier Regen. / Selexol

93-V061 Fuel Gas Mixing Vessel

How to achieve 27.8 barg at PC3003 and 26.3 barg at inlet to turbine fuel gas skid?
Requirements for DLN retrofit

Fuel Gas Quality

Limited changes in the fuel gas Modified Wobbe Index (MWI):

- Resized the Fuel gas mix drum to meet max. MWI rate of change of 0.3%/sec from existing of 0.5%/sec.
- The **new fuel gas mixing drum** is around 25% bigger in volume to meet the rate of change of MWI as above
Requirements for DLN retrofit

Fuel Gas Contaminants

- Meets OEM spec for fuel gas in terms of maximum allowable contaminants.
- LL from existing train indicates presence of Selexol can act as an ignition source & cause fire in fuel gas piping at valve skid in event of passing purge valves.
- Additional requirements resulted in upgrades in the fuel gas system as follows:
  - Upgraded fuel gas filter skid to meet specs for liquid carry over & particulate size.
  - Upgraded demisters for upstream fuel gas treatment column & KO drum.
  - Provision of demister in the fuel gas mixing drum.
  - Low point drains.
  - Modified fuel gas skid with piping layout to prevent Selexol accumulation.
Requirements for DLN retrofit

Contaminants Free Fuel Gas

Lessons learned from another train:

• Selexol carry over for fuel system
• Auto ignition of accumulated Selexol in presence of hot air from axial compressor discharge
• No combustion dynamics’ monitoring
Requirements for DLN retrofit

New Fuel Gas Valve Skid
Train-3 Fuel Gas treatment unit

Demister upgrades

Demisters upgrade for
Selexol Absorber 33-C010 &
Fuel gas KO drum 33-V010
Requirements for DLN retrofit

New Fuel Gas Filter Skid

- Filter elements are suitable for maximum operating temperatures 82°C.
- Cartridges elements, made of CS604LGBH1 which is an amine compatible element working as coalescer element.

New demister tray inside mix drum

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[Diagram of fuel gas filter skid with labeled parts: N I, N II, N III, N IV, Continuous flow phase, Dispersed phase, Condensate/ heavy Hydrocarbons, Perforated plates]
Milestones

- **Gate-1/ 2:**
  - Scope, strategy development, feasibility-technical & economic
  - Pre-Feed & management approval: Aug’09.

- **Gate-3:**
  - CDRA: Sep’10.
  - HAZOP: Oct’10

- **Gate-4:**
  - Constructability Readiness Review: Feb’11
  - Detailed Engineering completion & construction readiness: March’11

- **Gate-5:** Construction, commissioning & start-up: June’11

- **Gate-6:** Close out & LL: Oct’11
Project Details & Results

- Engineering man hours: 30,000 approx.
- Construction Man hours: 90,000 approx.
- Excellent safety records during construction.
- Construction and commissioning meet the plan schedules.
- Both turbines successfully re-commissioned post DLN retrofit
- Achieved NOx emission reduction:

![Graph showing emissions reduction](chart.png)
Challenges & Lessons Learnt

- Limited train shutdown duration of 22 days (Mechanical)
- Incorporate lessons learned from other frame 7EA DLN machines result in increase LNG train reliability:
  - Fuel gas contaminant control measures (Filters, demisters, etc)
  - Ramp-up logic for stable fuel gas supply pressure
  - Additional scope for reliability improvement : Combustion Dynamic monitoring system
- Job Clash: Simultaneous construction with other activities during shutdown (Compressor overhaul, turbine major inspection and heavy lifting activities)
- Interface management with multiple parties
- Technical & project management issues
- Brown field application : Requirements of Smooth startup without production impact.
Thank you