HeRU II | Ras Laffan He Recovery Unit II
Liquid Helium: 20 tons/day Loaded in Trucks

Rawia ALI SAID - ICEC 2014
Introduction

Qatar He production - 25% of the world production

- Successful operation of Helium Recovery Unit 1 designed, manufactured and installed by Air Liquide
- Installation and commissioning of new mega LNG trains in Ras Laffan Qatar site
- Growing Helium Demand
- ...

Air Liquide was awarded to built a new fully integrated helium plant
Designing, Manufacturing & Installation and commissioning

Air Liquide decided to push the Helium Technology Boundaries by building the largest helium recovery facilities in the world, including a single liquefier cold box

Qatar He production, 25% of the world production
Project HeRU II Key points

Scope description

NATURAL GAS FROM OFFSHORE
Helium ~ 0.1%

CRUDE HELIUM FROM NRU TRAINS
(50%He, 48%N2, 2%H2, Ne)

PURIFICATION System
- Compression
- Nitrogen Removal
- Catalytic Hydrogen Removal
- PSA Purification (~50ppm)
- Vapor Recovery Unit

LIQUEFACTION System
- Compression
- Final Purification
- Liquefaction

STORAGE/LOADING Bays
- Storage: 4 x 120m3 Liquid He
- 4 Loading Bays

He Recovery Unit: AIR LIQUIDE Scope

LHe ~ 20 TPD
~ 7000 l/h

ASU: LN2 for LIN Shield

A turnkey project executed by 3 entities of the Air Liquide Group:
- Air Liquide Engineering & Construction in Paris
- ALAT: Air Liquide Advanced Technologies in Grenoble
- Air Liquide Engineering Middle East in Doha

Air Liquide, world leader in gases for industry, health and the environment
Project HeRU II Key points

AL-AT scope of supply (pictures)

One single horizontal cold box - Liquefier: 4.2 m x 17m

x 4 Storages

x 4 Loading Bay
Project HeRU II Key points

**Liquefier Process design**

Liquefier 7000l/h, 20TPD loaded:
- (2x2) Compressors: 3 Pressure levels
- 6 static gas bearing expansion turbines
- No LN2 Precooling
- Push-pull 80K & 20K adsorbers
- 4x Fixed Storages of 120 m3

Liquefier adapted to process load variation from trucks:
- Truck depressurization
- Truck cooling down
- Truck loading

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Air Liquide, world leader in gases for industry, health and the environment
**Project HeRU II Key points**

**Technical challenges**

**Process Design Input:**
- Turndown 25% - 100%
- 20TPD loaded with one week truck scheduling constraint
- Helium Recovery 98%

**Equipment Sizing:**
- Large size of vacuum vessels; cryogenic valves; brazed aluminium heat exchangers, adsorbers, etc.
- From He I to He II liquefaction plants, same number of turbines (x6), but total power has been doubled [2kW to 97kW] up to [5kW to 180kW]
- Turbines design a key element for liquefier design allowing:
  - A robust, single and self sufficient liquefier
  - Flexibility for turndown and load variation

![Graph showing FIX STORAGES: Vapor Return TOTAL](image)

Load variation of 30%
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Construction, Commissioning and StartUp [1/4]

Project Planning

- 2010-2012: Engineering & Manufacturing: 20 Months
- 2012: shipment – 2 months

On site planning

<table>
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<th>2013</th>
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<td>02/2012</td>
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<td>2 months</td>
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- June 2013: 1st He Drop – Plant in Operation
- May 2014: Performance test – 31 Trucks loaded
Construction

- Started from setting out the site, breaking ground and creating formwork for foundation
- A peak of 850 workers on-site
- HSE management leading to an excellent safety record of 5 million man hours Lost Time Incident free
- A Close teamwork between RasGas, Air Liquide and Contractor: A hallmark of the project

Site Erection of Liquefier & Storages
Construction, Commissioning and StartUp [3/4]

A few construction Key Figures

- Concrete foundation: **3400 m³**
  ~ 1/6 of the ground floor of the Louvre (or 15 storey building)

- Steel structure: **1100 tons**
  ~ 1/7 of Eiffel Tower

- Piping Work: **27000 welded inch**

- Total instrumentation cables length: **81353 m**

- Total electrical cables: **54782 m**

*Dense and concentrated plot plant (60 x 100 m)*
Construction, Commissioning and StartUp [4/4]

First Helium Drop

- Commissioning Activities
  - Reliable Completion Management System developed for the project

- Purification and First Cool down started on June 2013
  - End June 2013: First Helium drop and Plant Hand-over with full automatic liquefier sequences
  - October 2013: Full production with Recovery Rate of 98%
Performances Test

Technical Challenges achieved

Plant Performance was demonstrated on May 2014:

<table>
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<th>Project Design Input</th>
<th>Performances Test Results</th>
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<td>Test 1</td>
<td>- 20TPD without loading</td>
<td>- &gt;20TPD</td>
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<td>- Recovery rate: 98%</td>
<td>- Recovery rate &gt;98%</td>
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<td>Test 2</td>
<td>- 20TPD</td>
<td>- &gt;20TPD</td>
</tr>
<tr>
<td></td>
<td>- Loading 31 Containers / week</td>
<td>- Loading of &gt;31 Containers/week</td>
</tr>
<tr>
<td></td>
<td>- Recovery rate: 98%</td>
<td>- Recovery rate &gt; 98%</td>
</tr>
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![Graph showing helium inventory and truck loading](image)

Typical One day schedule.

- Truck Cool down
- Truck Loading

Air Liquide, world leader in gases for industry, health and the environment.
Performances

Sum-up

**Fully automatic sequences developed to allow safe operation of the plant:**

- Cool down sequence of liquefier with a control of Exchanger $\Delta T$
  - Ex. Cool down of liquefier from Warm: ~24h

- Push-Pull 80K and 20K sequences: 1 Ads stand-by / 1 Ads. Autonomy >10days

- Robust control of Turbines: Allowing full automatic operation of turbines

- Good Vacuum Level ~1.10-7mbar

**Plant flexibility**

- High flexibility of liquefier demonstrated: Turndown from 100% to 20%
  - **Automatic Turndown based on feed availability or Manual turndown by Operator**

- Full plant capable of handling all load variations from trucks and recovering return vapor
  - **Robuste, efficient and powerful turbine operated at wide speed range**
  - No hydraulic limitation
  - LP and HP compressors, designed with margin to handle load variation
Conclusion

A technical challenge highly achieved

An Exceptional Safety Record

A Successful Performance test on May 2014
20 t/day – 7000 litres/h

A Package of Lessons Learnt in the domain of Helium liquefier / refrigerator:
+ Large helium turbine design and operation
+ Large liquefier design and manufacturing
+ Plant turn down management and corresponding process control tuning
+ Optimized plant process control strategy considering LHe truck loading constraints (considering container conditions: cleanliness, T, P)
HeRU II | THANK YOU FOR YOUR ATTENTION