Gas Processing Overview

Phil Hunt
Manu Van Leuvenhaege
UOP Limited, Guildford, UK

2017 Honeywell Oil & Gas Technologies Symposium

May 15, 2017
Cairo, Egypt
May 17, 2017
Alexandria, Egypt
Agenda

• Gas Processing Portfolio

• Separex Membrane Technology

• Mercury Removal Adsorbent Technologies

• Honeywell UOP Modular Gas Plants
Global Overview of Natural Gas Reserves

Unconventional: 328
Conventional: 462
World total = 790

Feed gas quality depends on location

No circle within a region indicates minimal known Acid Gas or NGL Content |
Sources: IEA, BP, PFC Energy, EIA
## Market Segments

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<tbody>
<tr>
<td>On-shore Gas Plant</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>LNG/NGL Complex</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Platforms &amp; FPSO</td>
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<td>X</td>
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<td>FLNG</td>
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Hydrocarbon Management

**C₂+ Gas Processing**

- Licensed Turbo-Expander Technology: 99+% 99+% 99+% 99+% 98+%%
- Open Art Turbo-Expander Designs: 99+% 99+% 99+% 95+% 90+%%
- Twister Supersonic Separator: 99+% 95+% 90+% 50+%%
- Joule Thompson Expansion: 99+% 85+% 70+% 35+%%
- Mechanical Refrigeration: 99+% 95+% 90+% 30+%%
- SeparSIV Adsorption: 99+% 98+% 20+%%

**Primary Hydrocarbon Recovery Goal**

- Heavies
- C₅⁺
- Butanes
- Propane
- Ethane

**Typical Recovery**

- Higher Pressure Drop: 99+% 99+% 99+% 99+% 98+%%
- Lower Pressure Drop: 95+% 90+% 50+%%

**Actual recovery dependent on feed gas composition, pressures, flow rates**

Complete portfolio of hydrocarbon management options
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Membranes are thin, semi-permeable barriers that selectively separate certain components.

Membranes are characterized by permeability or capacity (flux) and selectivity.

**Membrane Process**

- **High Pressure**
  - Hydrocarbons, N₂
  - Fast
  - Slow

- **Low Pressure**
  - CO₂, H₂S, H₂O

**UOP Continues to Expand Membrane Product Portfolio for Enhanced Capacity and Higher Selectivity**
Separax Membranes: A Proven Technology

- World-Scale Processing Plants Delivered as Modular Packaged Equipment
- Advanced Pre-Treatment Demonstrated to Improve Element Life
- Off-shore Experience
UOP Membrane Experience in Egypt

<table>
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<tr>
<th>Location</th>
<th>MMscfd</th>
<th>CO₂ Inlet</th>
<th>CO₂ Outlet</th>
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<tr>
<td>Nigeria</td>
<td>200</td>
<td>7%</td>
<td>2%</td>
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<tr>
<td>Pakistan</td>
<td>550+450</td>
<td>6.5%</td>
<td>2%</td>
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<tr>
<td>Pakistan</td>
<td>240</td>
<td>12%</td>
<td>3%</td>
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<tr>
<td>Mexico</td>
<td>120</td>
<td>70%</td>
<td>5%</td>
</tr>
<tr>
<td>Thailand</td>
<td>32</td>
<td>50%</td>
<td>20%</td>
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<tr>
<td>Egypt</td>
<td>107</td>
<td>6.7%</td>
<td>3%</td>
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<td>Egypt</td>
<td>218</td>
<td>6.8%</td>
<td>3%</td>
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<tr>
<td>Egypt</td>
<td>234</td>
<td>9%</td>
<td>3%</td>
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<tr>
<td>Indonesia</td>
<td>254</td>
<td>40%</td>
<td>20%</td>
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<tr>
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<td>680</td>
<td>44%</td>
<td>8%</td>
</tr>
<tr>
<td>Thailand</td>
<td>620</td>
<td>40%</td>
<td>21%</td>
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**Western Desert, Egypt**

- Khalda (EGPC & Apache)
  - Five two-stage membrane systems
    - 100 MMSCFD each
    - 6-9% CO₂ to < 3%
- 1-3: Commissioned 1999 (6% CO₂)
- 4-5: Commissioned 2008 (9% CO₂)
- Total feed capacity = 559MMscfd
Hybrid schemes – Combining the Best of Two Worlds

Grassroots
Bulk-cut with membranes
• Very attractive offshore to allow lower weight and footprint and reduce transport volume, or,
• Meeting pipeline spec at wellhead and further reducing to LNG spec downstream

Revamp
Debottleneck existing amine units
• Increasing feed gas flowrates, or,
• Increasing feed gas CO2 content membrane will treat the gas to a CO2 content that is acceptable to the existing amine unit

Each Application Has an Optimal Scheme:
Evaluate Simplicity & Robustness Versus Performance
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Why remove Hg?
1. Health, Safety & Environment
2. Equipment Protection
3. Catalyst Protection
4. Product Quality

UOP’s Experience in Mercury Removal

**UOP HgSiv Adsorbents**
- Regenerative System
- Removal to 0.01μg/Nm³ Hg
- Also combined with Molsiv adsorbents for removal of H₂O, H₂S, RSH and CO₂
- Small layer in Molsiv Unit
- Used in more than 50 units

**UOP Guard Bed Adsorbents**
- Non-Regenerative System
- Removal to 0.01μg/Nm³ Hg
- Also combined with removal of H₂S, RSH and COS
- No dry stream required
- Used in more than 70 units
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Why Modularize?

- More assembly work is done in the shop at a lower hourly rate and not subject to weather.
- Equipment and parts are more readily available at the shop location, closer to supplies.
- Much assembly work can be completed prior to field move in, while waiting on permits and weather.
- Equipment, piping, and instrumentation can be checked out prior to shipment to field.

Train sizes up to 300 MMSCFD can be easily Modularized.
UOP Natural Gas Modular Products

**Dehydration**
- Mol Sieve Adsorption
- Glycol (TEG) Absorption

**Acid Gas Treatment**
- Amine Units (100-1000 gpm$^1$)
- Membrane Units (1+ BCFD)

**Sulfur Recovery**
- Modular Claus (10-100+ LTPD)
- Sulfur Scavengers

**Hg Removal Units**

\[ 1 \text{gpm} = \text{gallons of amine per minute} \]

**Fractionation**
- Deethanizer / Depropanizer / Debutanizer

\[ 2 \text{GPM} = \text{gallons of NGL per thousand SCF of natural gas} \]

Complete Modular Equipment Solutions: Pre-engineered or Custom
How We Modularize

LPG Recovery Process Skids
Field Design Support Package
Pre-Engineered Cryo Plant

- Inlet Gas → MOLSIV™ → Cryo Plant → Residue Gas
  - Y-grade
  - 2 to 4 GPM C2+
  - Unsaturated Feed
  - “Low” CO₂ in Feed

Pre-Engineered Cryo Plants
40 – 200+ MMSCFD
Pre-Engineered Cryo + Supplemental Refrigeration (SR)

- Inlet Gas → **MOLSIV™** (saturated feed) → **Cryo Plant** → Residue Gas
  - **Y-grade**

  **6 GPM C2+**
  - Unsaturated Feed
  - "Low" \(\text{CO}_2\) in Feed

- Supplemental Refrigeration Units
  - 1000 – 6000 HP
Cryo + SR + Pre-Engineered Amine

Inlet Gas → Amine Treater → MOLSIV™ → Cryo Plant → Residue Gas

- Water Unsaturated Feed
- “High” CO₂ in Feed

Y-grade

Pre-Engineered Amine Units
100 – 1000+ gpm
Cryo + SR + Amine + Fractionation

Inlet Gas → Amine Treater → MOLSIV™ → Cryo Plant
(saturated feed) → Refrig Loop → Residue Gas

HMO System → Depropanizer → Propane

Debutanizer → Butane

Gasoline