LNG

Mini, Small and Medium scale

APC-U OIL & GAS, BOLOGNA, 26/9/2016
Small scale LNG
<table>
<thead>
<tr>
<th>Scale Type</th>
<th>Capacity Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini scale plant</td>
<td>&gt;0.004 MTPA (up to 4000 t/Y)</td>
</tr>
<tr>
<td>Small scale plant</td>
<td>&gt;0.01 MTPA (up to 10 000 t/Y)</td>
</tr>
<tr>
<td>Medium scale plant</td>
<td>0.3 - 1.5 MTPA (from 300 000 up to 1 500 000 t/Y)</td>
</tr>
<tr>
<td>Large base load plant</td>
<td>4 MTPA (8MTPA single train active in QATAR)</td>
</tr>
</tbody>
</table>
There is a global increasing need for diversification of energy suppliers due to politics, economics and reserves;

LNG supply chain is much more flexible than gas pipelines, being able to serve different markets at different times and able to avoid the political and geopolitical instability of transit countries that transcontinental gas pipelines have to deal with;

LNG carriers can be diverted to a number of LNG consuming countries easily providing higher confidence in security of supply for major gas-importing nations;

Emission restrictions favor gas over coal for power generation and gas supply companies make inroads into niche markets such as road vehicular fuel, as a marine vessel fuel, and as LNG replaces propane as a fuel for facilities not connected to the pipeline gas grid;

It typically takes about 600m³ of NG to yeild 1m³ of LNG, with 1 ton of LNG holding the energy equivalent of some 50.000 ft³ of NG;
Small-scale LNG plants applications

- Peak shaving plants
- Satellite LNG plants for gas transport where pipeline is nonexistent
- On-board ship liquefaction
- Coal bed methane recovery
- Bio-gas
- Landfill gas
- Shale gas liquefaction
Small to mid-scale liquefaction plants, up to 1 MTPA capacity, (around 10% of a base load liquefaction plant) focus upon standardizing compact, preassembled modular designs that can be deployed quickly with minimizing design and construction costs.

Design Objectives:

- Process simplicity
- Safety
- Easy operation
- Low Cost
- Plant reliability
Natural gas liquefaction processes

- **Cascade liquefaction processes**
  - Single component refrigerants
  - Refrigerant mixtures

- **Mixed refrigerant processes**
  - Without phase separators
  - With phase separators

- **Expansion based processes**
  - Single component refrigerant
  - Refrigerant mixture

- **Precooling**
  - Without precooling
  - With precooling

- **Precooling using single component refrigerants**
  - Precooling refrigerant evaporated at a single pressure

- **Precooling using refrigerant mixtures**
  - Precooling refrigerant evaporated at multiple pressures

**GEA solution for LNG**
## Cascade vs Mixed Refrigerant vs Expansion

### Cascade Liquefaction
- 3 separate loops to approach the cooling NG curve;
- Each refrigerant vaporizes at different but constant temperature (methane, propane, ethylene);
- Flexible in operation;
- More indicated for large size trains where the low heat exchanger area offsets the cost of having multiple machines;

### Mixed Refrigerant Process
- Cooling of NG with a blend of refrigerants (Light HC and nitrogen);
- Energy and heat exchangers can be optimized;
- Reduced numbers of compressors;
- Longer time for start up and line up.

### Expansion Based Process
- Use of turboexpander to generate refrigeration;
- Normally methane or nitrogen;
- The heat curve of the refrigerant has large T gap in the first phase of NG cooling (especially if NG contains significant amounts of C3+ components);
- Simplified process operation;
- No liquid hold up, inherently safe;
- Less efficient than cascade or MR;
- Suitable for small LNG scale and for ship based floating liquefaction plant.

### Best for large size trains
- Cascade Liquefaction

### Best for small and mid scale plant
- Mixed Refrigerant Process

### Best for FPSO, Off-shore, Space constraints
- Expansion Based Process
Mixed Refrigerant vs Cascade

- Thermodinamically Mixed Refrigerant is more efficient; the heating curve comes closest to a reversible process because it minimizes the T differences between the NG and the refrigerant;

- Cascade system requires smaller heat exchangers because the T differences are larger; large driving forces reduce the efficiency of the cycle
GEA Scope of supply

**LNG Process production diagram:** NG liquefaction with Single Mixed Refrigerant

- **Compressor Process:**
  - GEA oil injected
  - LNG Storage $\approx -170^\circ C$, P atm.

- **Compressor Gas Treatment:**
  - Dew point control
  - $CO_2, H_2S$ Sweetening AGRU ($H_2S$ 4 ppm & $CO_2$ 50 ppm)
  - Dehydration (0.1ppm)
  - Hg Removal (0.01μg/Hm³)

- **Refrigeration Unit:**
  - Mixed Refrigerant ($N_2$, Methane, Ethylene, Butane...)

*or different storage conditions
Detailed Single Mixed Refrigerant Process
### GEA Modules of LNG trains

<table>
<thead>
<tr>
<th>GAS Processing M Nm³/Y</th>
<th>Nominal Capacity</th>
<th>Liquefaction line number</th>
<th>Compressor Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>320 (2x160)</td>
<td>34 t/h</td>
<td>290.000 t/y</td>
<td>2</td>
</tr>
<tr>
<td>160</td>
<td>17 t/h</td>
<td>145.000 t/y</td>
<td>1</td>
</tr>
<tr>
<td>160 (2x80)</td>
<td>14 t/h</td>
<td>120.000 t/y</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>7 t/h</td>
<td>60.000 t/y</td>
<td>1</td>
</tr>
<tr>
<td>80 (2x40)</td>
<td>7 t/h</td>
<td>60.000 t/y</td>
<td>2</td>
</tr>
<tr>
<td>40</td>
<td>3,5 t/h</td>
<td>30.000 t/y</td>
<td>1</td>
</tr>
<tr>
<td>4,5</td>
<td>0,4 t/h</td>
<td>3.500 t/y</td>
<td>1</td>
</tr>
</tbody>
</table>
### Design data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of gas</strong></td>
<td>Associated</td>
</tr>
<tr>
<td><strong>Flow rate</strong></td>
<td>4,200 Nm3/h - 25,000 tpa</td>
</tr>
<tr>
<td><strong>Composition</strong></td>
<td>C1 92%; N2 2.5%; CO2 3.6%; C2 0.07%; C3+ 1.83%</td>
</tr>
<tr>
<td><strong>Inlet temperature</strong></td>
<td>20°C</td>
</tr>
<tr>
<td><strong>Inlet pressure</strong></td>
<td>1 bar</td>
</tr>
<tr>
<td><strong>P compressor suction (related to the well)</strong></td>
<td>1 bar</td>
</tr>
<tr>
<td><strong>P compressor discharge</strong></td>
<td>48 bar (excellent balance between thermodynamic &amp; CAPEX)</td>
</tr>
<tr>
<td></td>
<td>• Higher pressure is termodinamically useful (reduced heat and work);</td>
</tr>
<tr>
<td></td>
<td>• Below the critical pressure;</td>
</tr>
<tr>
<td></td>
<td>• Design pressure for the heat exchangers &amp; pressure vessels;</td>
</tr>
<tr>
<td></td>
<td>• Reduce to N.2 the number of stage of compressors</td>
</tr>
<tr>
<td><strong>Design T</strong></td>
<td>-195 °C / +120°C</td>
</tr>
<tr>
<td><strong>Design P</strong></td>
<td>52 bar</td>
</tr>
</tbody>
</table>
### Case study No.1

<table>
<thead>
<tr>
<th>Choice of operative parameters</th>
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</thead>
<tbody>
<tr>
<td>Type of liquefaction process</td>
</tr>
<tr>
<td>Composition of MR</td>
</tr>
<tr>
<td>P suction</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>P discharge</td>
</tr>
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<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Performances</th>
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</thead>
<tbody>
<tr>
<td>Mixed Refrigerant specific hold up</td>
</tr>
<tr>
<td>Water consumption</td>
</tr>
<tr>
<td>Electric Energy</td>
</tr>
<tr>
<td>Capital cost:</td>
</tr>
<tr>
<td>Plot requirement (storage excluded)</td>
</tr>
</tbody>
</table>
GEA bottom-up support and customized approach

Process design with **HYSYS** simulator

**GEA oil flooded screw compressors**
for NG compression & for MR compression

Only **0,2 ppm of oil carry over** due to process expertise and correct oil selection

**Best compressor technology** selection in case of higher capacity or different customers’ needs

Partnership with compact and light weight brazed **aluminum heat exchanger** manufacturer

Partnership with **pretreatment unit** supplier for the complete liquefaction plant

**High** reliability/ availability / maintainability
Our background
Refrigeration global reference map

Compressor type
- Screw: 18
- Reciprocating: 15
- Centrifugal: 368

Refrigerants
- Ammonia: 88
- Hydrocarbons: 95
- Freon: 159
- Mixed fluids: 59
Refrigeration global reference map
Process Propane / Butane Refrigeration

Customer: Agip Gas BV

Location: Mellitah – Lybia

Scope: EP by GEA

Aim: condense/cool down four propane/butane streams coming from storage tanks and LPG splitter trains. Boil off system (open cycle)

Duty: 6130 kW

Production rate: propane/butane storage tanks - 55tons/h of propane at -45°C and 58 tons/h of butane at -16°C. 
Gas Treatment and LPG Production Plant

**Customer:** STEG

**Location:** Gabès – Tunisia

**Scope:** EPCC by GEA

**Aim:** Turnkey basis

**Process units:** Gas & Condensate slug catchers, Drying sections (molecular sieves), Distillation Sections with relevant accessories.


**Plan Design Parameters:**
- Raw Gas Flow = 51000 Nm$^3$/h
- Raw HC Liquid Flow = 25 m$^3$/h
- Treated Gas = 40000 Nm$^3$/h
- Propane Production (Purity 98%) = 8.5 ton/h
- Butane Production (Purity 97%) = 5.9 ton/h
- Gasoline Production (Purity 99.5%) = 4.2 ton/h
LPG recovery from natural gas by turboexpander cryogenic process

Customer: Turkmengas (Turkmenistan)

Location: Gazajack - Najp Field

Aim: to recover maximum quantity of LPG and heaviers present in natural gas

Gas cooling in two steps:
first at -40°C/35 bar
second at -85°C/10.5 bar

Main characteristics of the plant:
- High percentage of LPG recovery from natural gas thanks to the low temperatures reached in the process;
- High plant efficiency due to the adiabatic process of gas expanding in the turbine side of the package.
**Ammonia Refrigeration and Boil-Off Unit**

*Customer*: Linde AG Division Engineering  
*End User*: SIMPLOT  
*Location*: Rock Springs (WY)  
*Plant*: Ammonia open refrigeration system;  
*Aim*: Cooling duty at n.2 temperature levels (+30°C and -37°C) for different process applications in an ammonia production plant;  
*Processed ammonia*: around 70 t/h  
*Inlet* to the refrigeration plant: ammonia vapor from ammonia storage & process lp/mp/hp separators.  
*Outlet* from the refrigeration plant: ammonia product/ammonia liquid to consumers.
Customer: Maraton Oil, UK

Location: North Sea

Aim: Dehydrate & Gas Dew Point to export and to gas lift;

Duty: 2.995 kW

Specials:
• Installation on an existing platform → weight & space constrains;
• Anti vibration system → 3 points support;
• Refrigerant R410a with GWP < 2.500

Refrigeration in Natural gas processing

Maraton Oil - UK - 2013

Brae Alpha Operational Information:
Is a regional hub, located in the North Sea, UK sector, for Oil & Gas production. Brae Alpha offers two 3-stage separation trains capable of processing 120,000 bpd of oil and NGLs with a third separation train capable of processing 55,000 bpd of liquids. The NGL recovery plant is capable of handling 17,000 bpd, and an average of 74 mmscfd gas processing.
Contact information
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