Floating LNG: The Challenges of production systems and well fluids management
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Introduction

For the successful operation of a FLNG vessel, interface between wells and LNG units has to be known, understood and managed.
Hydrocarbon Extraction Chain

- Upstream Separation and Compression
- Pipelines
- Pre-treatment, Liquefaction & Export
- Distribution
- Regasification Terminal
- Transportation
Hydrocarbon Extraction Chain – FLNG example

Upstream, Pre-treatment, Liquefaction & Export

Distribution
Regasification Terminal
Transportation
Typical Offshore Oil extraction Field
FLNG Dimension Overview

- Today a state-of-the-art large oil producing FPSO has the following characteristics:
  - Hull Dimensions = 310 m x 60 m
  - Topsides Weight > 40000 t
  - Production capacity is close to 200 000 bopd.
  - Flow from wells ~2000 t/h

- FLNG is quite different due to the complexity of processing.
  - Length > 1.5 x Oil FPSO
  - Weight > 1.5 x Oil FPSO
  - Production > 0.5 x FPSO
FLNG Units Description

Well fluids from subsea risers

Condensate Stabilisation

Inlet separator

Hydrate Management

Water & chemicals

Condensate

Dehydration

Acid Gas Removal

Acid Gas disposal

Mercury Removal

NGL Extraction

Fuel gas

Fractionation

Refrigerant Make up/ LPG reinjection

Refrigeration

Liquefaction

N2 Rejection

LNG offloading

LNG Storage

Condensate Storage

Condensate offloading

LPG Storage

& offloading
(if applicable)

Utility Production for the Plant
- Power Plant
- Cooling water
- Nitrogen Generation
- Fire Fighting Systems
- Flare
- Water Treatment

Technip
FLNG Weight Distribution

- If we focus by unit:

Unit Weight Repartition for FLNG

- Upstream facilities: 20-25%
- Liquefaction: 20-25%
- Utility: 25-30%
- Gas treatment: 25-30%
FLNG Operational constraints

Two sets of constraints have to be mitigated

- **Liquefaction**
  - Stability of operating parameters at liquefaction inlet
  - The option of extended shutdown
  - Minimization of restart time

- **Upstream facilities**
  - Reservoir dependency and the evolution of wellhead conditions with time.
  - Uncertainties of the wellstream composition.
  - Instabilities from multiphase flow, and during restart.
Well Fluid Management

- **Well fluids are characterized by the uncertainties:**
  - Reservoir depletion over time leads to modification of pressure, temperature and composition
  - Water break-through
  - Reservoir geology and drilling activities may cause pollution (sand, salts, completions fluids, radioactive material, tracers, etc.)

- **In addition process parameters can be modified by phenomena generated within the subsea architecture:**
  - Seasonal cycles (seawater temperature)
  - Start-up or shutdown of wells
  - Flow regime in flowlines and risers
Production profiles

Resultant of:
- Reservoir particularities
- Field architectures

Design shall:
- Take into account end of field life operation with several particularities
- Be based on clear definition of battery limit

Consequences:
- Upstream facilities design oriented to manage uncertainties
Temperature profile

Resultant of:
- Reservoir particularities
- Field architectures

Design shall:
- Maintain stable conditions at LNG
- Improve hydrate management

Consequences:
- Hydrate inhibitor injection
- Active heating Technology
Pressure profile

Resultant of:
- Reservoir particularities,
- Field architectures
- Specific operation (start-up of wells)

Design shall:
- Cope with WHSIP
- Cover Potential reservoir depletion over field life

Consequences:
- Additional compression unit due to depletion factors
- High rating material in upstream facilities
Sand and produced water

Resultant of:
- Reservoir particularities
- Well operation

Design shall:
- Be able to manage produced water and sands
- Be able to remove salts from oil

Consequences:
- Sand resistant material selection
- Desanding system
- Desalting system
Sand and produced water

Produced Wellfluids → 1 → 2

Produced Water → 4 → 3

Sand Jet Water → Sandclean System → 6 → Sand Disposal

Gas → 5 → Oil

Sand collection
Production systems

FLNG Receiving facilities control system challenges:

1. Protection of liquefaction unit
2. Safe Disposal of well fluids
3. Ensure Smooth liquefaction operation

Simple control and robust design
Production system

Control Approach:
- Liquid accumulation in separators to provide retention time for smooth control
- Route for safe disposal of gas
- Pressure control on the inlet separator which releases gas to flare.
- Route for safe disposal of off-specification condensate.
- Spacing and robustness of upstream equipment has to be carefully studied.
- Shutdown sequence shall take well fluids and LNG constraints

A good understanding of liquefaction and production systems is necessary as all points are interrelated.
Production system

**Purpose:**
- Treat condensate / liquids to commercial specification or environmental specification for disposal

<table>
<thead>
<tr>
<th>Condensate Export Specifications</th>
<th>Water Disposal Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVP &lt; 6 to 12 psi</td>
<td>OIW content &lt; 5 to 30 ppm</td>
</tr>
<tr>
<td>BSW &lt; 0.5 to 2%</td>
<td></td>
</tr>
<tr>
<td>Salt content &lt; 15 to 60 mg/l</td>
<td></td>
</tr>
<tr>
<td>H2S content &lt; 1 to 10 ppm</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Standard Condensate and Water outlet specifications
Production system

- **Condensate Treatment Technologies**
  - Separation of hydrocarbons and water to reach Base Sediment Water (BSW) specification
  - Heating and separation to reach Reid Vapor Pressure (RVP) specification on condensate product
  - Washing and purification to obtain H2S or Salt content
Production system Schemes

**Stabilization column scheme**
- Low target specification
- Less compression
- Higher COG => higher cost
- Wave effect on stabilization column
- Solid deposit

**Multi-stage scheme**
- Robust and Simple design and operation
- Lower COG => Lower cost
- Standard target specification
Conclusion

- For the successful operation of a FLNG vessel, it is most important to design the process from the wellhead to the liquefaction unit. This implies the following:

  - Good understanding of reservoir characteristics
  - Good understanding of fluid behaviour from wellhead to topsides,
  - Simple, robust, flexible designs and easy to operate upstream facilities
  - Smooth control of upstream facilities to stabilize process parameters upstream of liquefaction unit.
Thank you