Pseudo Dry Gas System

Steady state and transient analysis

September 2019
Stranded Gas – Simplified Overview

Recoverable Gas Field Size Bcf

Tie Back Distance km

Step change in cost FPSO / Compression

Not Stranded

Stranded

PDG
Objective

• Present an innovative Pseudo Dry Gas (PDG) separation technology to demonstrate that tie backs far in excess of the current threshold distance can be achieved.
Underlying Problem

- Gas pipelines diameter choice is a compromise between lowest well back pressure Vs operability driven by liquids.
- More distance = Greater Compromise = Greater Back Pressure = Less Revenue = Lower NPV = Stranded Gas Reserves.
Concept

- Compact - Installed as a pipeline in-line structure
- Passive - no moving parts or consumables
- Piggable

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Configuration

- Multiple PDG units are installed in-line and are piggable. Liquids are removed via small diameter pipe and small single phase centrifugal pumps < kW
- Power, telecommunications cables, hydrate inhibitor such as MEG and other service lines are deployed by means of an umbilical.
Case Study

- Trunkline; 170km long
- WD 0-1800m, no escarpment
- Two manifolds and 9 satellite wells

DESIGN REQUIREMENTS

Design Flow Rate = 880 MMscfd
Turndown Rate = 380 MMscfd
Arrival Pressure Early Life = 60 bara
Arrival Pressure Late Life = 30 bara
LGR = 12 bbl/MMscf
PDGS Enabled Tie-back Hydraulics

- **55 to 80 bar** reduction in wellhead back pressure across design cases

**Chart:**
- 60 bara, 880 MMScfd
- 60 bara, Turndown
- 30 bara, 880 MMScfd
- 30 bara, Turndown

**Legend:**
- Standard FA (30”)
- PDG System (36”)
- Dry Gas (36”)

**Notes:**
- 70-120+ bar in actual studies 1 Bcf/d
PDGS Enabled Tie-back Hydraulics

- Effective Dehydration
- Suppression of hydrocarbon phase
- No membranes
- No consumables
- No pressure loss

% on log scale

Trunkline Liquid Holdup (%)

Horizontal Distance (km)

Std FA - 880MMscfd - 30in TL
PDGS - 880MMScfd - 36in TL
PDGS Gas Condensate Behaviour

- Analogues of subsea gas systems have shown that the condensates continue to drop out of the gas after it reaches ambient temperatures due to pressure loss.

- The drop out slows down / stops once the ambient temperature increases due to pipeline moving into shallower waters.

Figure – Typical phase envelope

Figure – Typical Liquid drop out behaviour
Operational Performance

OLGA 2017 – HD module

- Dynamic Steady State
- Turndown
- Ramp-up
- Shutdown
- Restart
**Turndown**

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**Lower Minimum Stable Flow**

*Wet Gas Pipeline Minimum Stable Flow – 380 MMscfd*

<table>
<thead>
<tr>
<th>Flow Rate MMscfd</th>
<th>Wet Gas Total Liquid Content m³</th>
<th>PDG Total Liquid Content m³</th>
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</thead>
<tbody>
<tr>
<td>880</td>
<td>2053</td>
<td>264</td>
</tr>
<tr>
<td>250</td>
<td>10857</td>
<td>258</td>
</tr>
<tr>
<td>100</td>
<td>42579</td>
<td>5183*</td>
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</tbody>
</table>

* after 8 months operation
Shutdown

Liquid drains back to the separators
Liquid pumped back to shore

Extreme shutdown ~5000m³ can be drained
But time dependent:
• Pump size
• Liquid drainage to separator
• Gas sweeping to speed up drainage
Ramp-Up & Restart

Low liquid arrival rates onshore – no slug catcher needed
Development Plan

2017 - Initiation
Pseudo Dry Gas incepted as an idea
First funding gained for engineering definition and CFD studies

2018 - Engineering Definition
All related hardware & power systems at TRL 5-7
Liquid removal at TRL2
OGTC joint study on known stranded gas fields.
A number of Operators and tier 1 contractors joined the project

2019 to 2020 - Prototype (Flow Loop)
First Prototype tests completed
Liquid removal to TRL4
Work with OGTC to identify pilot test Operator / contractor collaboration opportunities

2021 - 2022
Install fully functioning pilot

2018 / 19

- Kicked off a techno-economic study for the Oil and Gas Technology Centre (OGTC) to assess the potential benefits of the PDG technology; within their portfolio of subsea initiatives (marginal, long distance, deep water)

- Testing of a prototype in lab conditions (Cranfield University (UK))

- Open to work with other Operators/ Organisations
  - Proof of concept studies
  - Invitations to participate in peer reviews
Questions

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