Pseudo Dry Gas System

An enabling technology for remote gas fields

28th September 2017

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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.
Challenge

- Increasing back-pressure generated by a combination of increasing frictional and gravitational pressure drop. The gravitational pressure drop is due to increasing liquid content in the pipeline condensed from the gas as it is transported, resulting in a regressive cycle with ever lower returns the further the subsea tie-back is extended.

Figure 1 - Fixed Flowrate

Figure 2 - Fixed Diameter
Solution

- Multiple compact (in-line) piggable separators are used to remove liquids generated by the well and condensing from the gas during transportation. This coupled with small single phase centrifugal pumps, allows significantly larger pipeline diameters to be used by eliminating the gravitational pressure loss mechanism from the system.
Coal Seam Gas - Overview

- Drain points are a proven solution for Coal Seam Gas gathering networks in Queensland Australia
Coal Seam Gas - Overview

<table>
<thead>
<tr>
<th>Pressure (KPa)</th>
<th>Wet Gas</th>
<th>Dry Gas</th>
<th>Wet Gas (LPDs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{drop}}$</td>
<td>133</td>
<td>18</td>
<td>22</td>
</tr>
</tbody>
</table>

Increased pressure drop is caused by water

Separators added to simulate Drains
Case Study - Context

- Typical subsea gas gathering and export system; with and without PDGS.
- Trunkline (170km long; WD 0-1800m), with two manifolds and 9 satellite wells (Furthest well at 187km away from shore)

**DESIGN REQUIREMENTS**
- Design Flow Rate = 880 MMscfd
- Turndown Rate = 400 MMscfd
- Arrival Pressure Early Life = 60 bara
- Arrival Pressure Late Life = 30 bara
- WGR = 1 – 8 bbl/MMscf
Pipeline Sizing

- Line size selection (30") driven by liquid holdup at turndown
## Water Production Impact

<table>
<thead>
<tr>
<th>Trunkline Size (&quot;)</th>
<th>Case</th>
<th>WGR (bbl/MMscf)</th>
<th>WH Back Pressure (bara)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>$P_{\text{SHORE}}$ 60bar &amp; 880MMscfd</td>
<td>1</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>$P_{\text{SHORE}}$ 30bar &amp; 880MMscfd</td>
<td>8</td>
<td>116</td>
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<tr>
<td></td>
<td>$P_{\text{SHORE}}$ 60bar &amp; 880MMscfd</td>
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<td>150</td>
</tr>
<tr>
<td></td>
<td>$P_{\text{SHORE}}$ 30bar &amp; 880MMscfd</td>
<td></td>
<td>132</td>
</tr>
</tbody>
</table>

$\Delta P = 16 - 18$ bar @ 880 MMscfd

More at turndown
Production Impact

Flow Rate

Lost gross Income for 4 years at US$6/MMbtu ≈ US$ 9 billion

At WGR=8 bbl/MMscf HP Production Ends at 4 years 6 months

Plateau Ends at 6 years (30 bar)

Drop P_a to 30 bar

WH BackP @ 30bar

WH BackP @ 60bar

WHP

WGR=8 bbl/MMscf

Reservoir A

Reservoir A
PDG System Design Methodology

• Standard subsea tieback approach:
  • Liquid holdup dictates sizing
  • Shortened plateau period
• Solution is to remove liquid phase:
  • Pipeline sizing not constrained by fluid management (pipeline diameter is only limited by installation / economic constraints)
• Flow assurance used to determine optimal placement PDG separators. The design considers:
  - Temperature profiles (design and turndown)
  - Terrain, liquid hold up and flow regime
  - Transient cases, i.e. shutdowns and start-ups
  - Installation constraints
PDGS Placement

- PDGS screening methodology determined 6 PDGS units required in the configuration below
- Separation efficiency predicted to be 90% for all separators

Last separator 80km from terminal after which gas no longer condenses water
PDGS Enabled Tie-back Hydraulics

- PDGS allows for line size selection to optimise backpressure → 36"
- PDGS backpressure as per dry gas system (30 – 60 bar reduction in backpressure)
PDGS Enabled Tie-back – Production Impact

Additional Income for 4 years at US$6/MMbtu ≈ US$ 9 billion

Flow Rate

PDG WH BackP @ 60 bar

HP Production ends at Y8

Drop P_a to 30 bar

Plateau ends at Y9.5

PDG WH BackP @ 30 bar

WH BackP at turndown limit

Reservoir A
Economic Advantage

- With PDG system implementation, CAPEX intensive structures can be removed without impacting recoverable reserves and significantly reducing upfront cost, which improves the overall NPV / IRR of the potential project.
- Power requirements are measured in Kilowatts – lower OPEX.
- Also - HSE benefit of removing manned structures.

Case Study – 190 km from shore – PDGS reduction in CAPEX upwards of 40-60% over alternative concept with surface facilities.
Conclusion
Application

Reduce cost, remove turndown constraints, increase recovery

**Greenfield**

- Current practice is to assume subsea gas compression or floating compression systems to produce from remote areas. A direct long distance tie-back can now be considered in concept evaluation.

**Brownfield**

- Enabler - a larger radius can be considered for tie-back of satellite or remote fields into hub platforms or to landfall. The value of an existing asset can therefore be improved.
Separator as an In-Line Tee

- A design requirement for the PDGS unit, complete with foundations and protective structure, is to allow handling by current offshore pipelay vessels.
- Generates the separation efficiency performance in relation to FA criteria to facilitate dry gas behaviour.
- No moving parts
- Details removed – please contact INTESCEA for information
Summary

• Value proposition:
  • Increase the geographical reach from existing LNG terminals to allow them to prolong their production life and process more gas without the need for expensive subsea processing technology or surface topside equipment

• PDG system benefits:
  • Doubling the distance of subsea gas tiebacks (200km to 300km) by the means of backpressure reduction on wellhead
  • Increase in recoverable reserves:
    - Turndown ratios are removed as a natural constraint on the system
    - Line size optimised to reduce frictional losses
  • Reduction in CAPEX upwards of 40-60% over alternative concepts
  • Highly accommodating to brownfield development scenarios
Thank you – any questions?

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