Industry collaboration to develop next generation subsea (well stream) compression system

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Subsea compression – a brownfield solution

• Subsea gas fields need late life compression

• Subsea compression has the following benefits over a conventional platform solution
  • Increased recovery and production
  • Reduced capex and opex
  • Reduced carbon footprint

IOR ~306 million BOE

Source: Statoil Åsgard subsea compression
Subsea compression – a greenfield solution

- Early phase subsea compression is a tool to develop subsea gas fields differently
  - Smaller diameter pipelines
  - Significantly better turn-down
  - Different flowline configuration
  - Delayed completion of new wells

Max pipeline inlet pressure with subsea compression (artificial lift)

Max pipeline inlet pressure without subsea compression (natural flow)
The Subsea Compression Alliance

Long term, exclusive alliance to improve, develop and deliver competitive subsea compression solutions
Long-term commitment to Subsea Compression

- 1989-1993: Kværner Booster Station
- 1985:
- 2004-2011: Ormen Lange Compression Pilot
- 2011-2013: System Testing at Nyhamna
- 2010-2015: Åsgard Subsea Compression system EPC
- 2015 ->: Well Stream Compression (WSC) Conventional Compression System

108 compressor units

- First MOPICO® Standalone
- First HOFIM™ Standalone
- First HOFIM™ Sealed
- First HOFIM™ with MAN Motor for Commercial Operation
- First HOFIM™ Offshore
- First tandem HOFIM™ Sealed
- First tandem HOFIM™ Standalone
- K-LAB
- Marinisation programme

Subsea Compression Alliance
Åsgard subsea compression – our common basis

Contract AWARD Dec 2010
System integration test
Compressor module test

Template
Manifold station
Installation

Topside module

First Gas 17th Sept 2015
Approaching 7000 hr trouble free subsea operation this month
“operates like a Swiss watch”
Key drivers and focus areas for the Alliance

Primary drivers
• Reduced cost
• New applications

1. Åsgard Repeat
2. Simplified conventional
3. Wellstream compression system
4. High Pressure, Deep Water
5. Tandem HOFIM
6. Injection System
7. Low Cost & Capacity system
Conventional compression focus areas

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Proven through Åsgard SCS</td>
<td>Complexity</td>
</tr>
<tr>
<td>High capacity and efficiency</td>
<td>Cost, size and weight of 1st unit</td>
</tr>
<tr>
<td>Full suit of analytical tools</td>
<td>Need for compressor washing</td>
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<tr>
<td>Large range of compressors</td>
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<tr>
<td>Effective slug handling</td>
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- Reduce cost, size and complexity by implementing lessons learnt and challenging original requirements and design solutions together, without adding risk (“Åsgard 2.0”)
- Plan to invite major clients, suppliers and interface partners to participate in standardization work based on this Åsgard 2.0 concept and enhance it further towards other prospects and markets
Wellstream compression focus areas

- Utilize the inherent liquid tolerance of the compressor to establish a true Well Stream Compression (WSC) system and remove separator and pump system
- Subsea HOFIM™ has undergone comprehensive liquid tolerance testing with up to 95% GVF
- Most gas fields have a GVF within the tested liquid tolerance of the HOFIM (95 – 100%)

<table>
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<th>Pros</th>
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<tr>
<td>Lower cost, size and weight</td>
<td>Particle / drop erosion</td>
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<tr>
<td>Reduced system complexity</td>
<td>Limited long term test / field data</td>
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<tr>
<td>Internal cooling by liquid</td>
<td>Analytical tools not fully verified</td>
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<tr>
<td>No/limited scale build up</td>
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<tr>
<td>Higher head due to liquid</td>
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Improving from experience – “Åsgard 2.0”

Åsgard Subsea Compression EPC

Åsgard Lessons Learned

Alliance Program Agreement 1

Client, vendor and interface contractor engagement

Standard / simplified system specification and design solutions

Field specific applications

Cost & Schedule & Execution

- Overall system layout
- Process modules
- Compressor module
- Control and power system

Completed

Ongoing

Planned
Summary

• Subsea compression proven as field development solution through successful operation on Åsgard
• Cooperation Aker Solutions – MAN Diesel & Turbo already resulted in:
  • Significant cost, size and weight savings on simplified conventional
  • Well stream compression system development