Learning and Development from the World’s First Operating Subsea Compression System

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14,000 EMPLOYEES
20 COUNTRIES
46 LOCATIONS
175 YEARS OF EXPERIENCE
Introduction
Subsea gas compression – the benefits

Relocating topside compression on the seabed, close to the reservoir, provides for a number of benefits:

- Enables **cost effective** development
- Provides for **increased total recovery**
- Enables for **accelerated production** and greater up-front return
- Enables **longer tie-back**
- Enables the use of **smaller pipeline**
- Replaces the need for topside manning
- Provides **flexibility** in flow assurance philosophies (avoid liquid accumulation)
- Reduces **carbon footprint**
Basic principles of gas volume & density

\[ \Delta p := k \cdot \rho \cdot Q^2 \]

- Pressure drop in the flowline / riser depend on the density and the square of the volume
- Placing the compressor upstream the flowline/riser will give the lowest wellhead pressure
Subsea gas compression – long term commitment

- 1985
  - Kværner Booster Station
- 1989-1993
  - Demo 2000 GasBooster™ Qualification
- 2001-2003
  - Ormen Lange Pilot Qualifications and EPC
- 2004-2011
  - Ormen Lange Compression System Testing at Nyhamna
- 2011-2013
  - Åsgard Subsea Compression system EPC
- 2010-2015
  - Well Stream Compression (WSC)
  - Conventional Compression System
- 2015 ->
Åsgard subsea compression project
Åsgard field layout and scope of supply

Compression station

Topside power & control module

Manifold station
Åsgard subsea compression – project details

Project details
- Water depth: 260 m
- Tie-back distance: 40 km
- Flow rate: 21 MSm3/d
- Power: 2 x 11.5 MW
- Shut in pressure: 220 bar
- IOR: **306 million** barrels of oil equivalent

Project schedule
- 2006 - 2010: studies, Pre-FEED, FEED
- 2010: EPC contract (1st December)
- 2013: equipment and modules testing
- 2014: SIT and FUT
- 2015: delivery and start-up (16th of September)
Åsgard subsea compression – process
Åsgard subsea compression – process details

- Multiphase Cooler
- Gas-Liquid Separator
- Gas Compressor
- Condensate Pump
- Discharge Cooler
Åsgard subsea compression – design challenges

Replacement of the a conventional platform

Subsea compression system shall be **ROBUST**, with high **system availability** or uptime
Solution selected – robustness within the design

1) Meticulous equipment selection and quality follow up
2) Redundancy on components (eg. sensors, jumper)
3) Modularization design – enable efficient repair & replacement
Excellent operational performance

- Accumulated running hours to June 2017: more than 25,000 in total (T1+T2)
- Increased production during the first year of operation = 16 million barrels of oil equivalent
- Producing more condensate than expected
- Very low vibrations
- No trips / shutdown caused by the subsea compression system
- >99% availability for the subsea system
Excellent operational performance – details

Subsea compression availability:
- 2015 – 99.27%
- 2016 – 99.99%
- 2017 – 99.97%

Operation time with peak machine load in the latest 12 months:
- T1 – 90%
- T2 – 85%

Courtesy of Statoil
Lessons learnt

Lessons learnt

- Total system responsibility
  - Managing technology qualifications
  - Integrating core technologies in the system
  - Designing, manufacturing and testing
- Early cooperation with installation contractor
- Core team retention and development

Going forward

- Optimization by challenging requirements
- Rationalization of the capital spare parts
- Simplification of the testing philosophy
Next generation subsea compression systems
Subsea Compression – Now and the Future

Åsgard System (SCS 1.0)
- Åsgard-like SSC
- 13 subsea modules
- Similar modularisation and layout philosophy
- Over-trawlable structure
- Proven technology & setup

Today (SCS 2.0)
- Optimisation with Åsgard technology, core components & functionality
- Up to 50% reduction in total size and weight
- 13 → 7 module subsea
- Lighter compressor module
- Able to be fitted in to a 4-slot subsea template

Future (Wellstream Compression)
- Further optimisation of the SCS 2.0 system
- Utilises liquid tolerance properties of MAN HOFIM compressor
- Eliminate the need of scrubber and pump
- Able to handle up to 30wt% liquid (95% GVF)
Subsea Well Stream Compression (WSC) system vision

- A robust, high capacity compression system that can handle wellstream conditions without scrubber and pump

- Design and operation philosophy
  - Liquid tolerant compressor handles normal liquid production
  - System design w/FCU handle upset conditions and transients
Summary

- The subsea compression system installed at Åsgard is approaching 2 years of successful operation.
- This is not only a technology leap, but it represents also a strong business case.
- The learnings from the first project will allow to improve the next generation of subsea compression.
- APAC could be one of the next offshore gas region to benefit from this technology.
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