Subsea UK Lunch & Learn
Aberdeen, 19th May 2015
Neil Gordon, CEO Subsea UK
Welcome

Matt Corbin, MD & SVP Subsea UK Region, Aker Solutions
Subsea Boosting and Processing

Marco Gabelloni | BD Emerging Subsea Technologies
Agenda

- Introduction
- Subsea Boosting technology
- Subsea Power Supply for long step-out
Complete Subsea Processing Solutions

- **Single phase pumping**
  - LiquidBooster™ Pump
  - SeaBooster™ System

- **Multiphase pumping**
  - HybridBooster™ Pump
  - MultiBooster™ Pump

- **Gas-liq sep & liquid pumping**
  - DeepBooster™ System

- **Water sep & re-injection**
  - FlexSep™ System

- **Gas compression**
  - GasBooster™ System
Main Benefits of installing Subsea Pumps

- Increased production through life
- Increased production late life
- Enables development and production of low pressure reservoirs
- Makes deep water development possible
A long heritage as Pump Manufacturing Company

Since 1815: Thune, Eureka, Kværner
Pumps for ships & topside applications

Subsea process first: Kværner Booster Station

1990

2000

2010

TODAY

TODAY: A FULLY QUALIFIED SUBSEA PUMP PROVIDER
Subsea Pumping Experience

Åsgard Condensate Pump
2+1 LiquidBooster
Installation 1H2015

Ormen Lange Pilot
Condensate Pump
1 LiquidBooster
Deployed 2011

Tyrihans
2+1 LiquidBooster pumps
Raw Sea Water Injection
Deployed 2009

Lyell, UK Sector
1 Twin-screw MPP
First with vibration mon.
Deployed 2005

King, GoM
2+1 Twin-screw MPP
1700 meters depth
Deployed 2007

Jack & St. Malo
Qualification program
3MW - 15ksi
Pressure Generation vs GVF Capabilities

- **LiquidBooster™**
- **HybridBooster™**
- **MultiBooster™**

![Graph showing pressure generation vs GVF capabilities with different booster technologies.](image)
Today’s product portfolio

- LiquidBooster
- MultiBooster
- HybridBooster
Key Features of Aker Solutions Pump Systems

- Liquid filled motor
- Rigid coupling
- Opposed impeller design
- No barrier fluid control system
- Full machine condition monitoring
- High pressure boosting capability, configurable
Aker Solutions Multiphase Test loop

- 62 bar pump suction
- 0-100% GVF
- Full flow rate for 6MW pumps
- Water/air/model oil
Subsea Power Supply Technology

- Enable Increased Oil & Gas Recovery
- Reach new prospects
- Eliminate topside equipment / weight
Subsea Power System Type 2 – Åsgard Compression

Supply: 11kV / 50Hz

18MVA 6.6kV

VSD

VSD

VSD

VSD

1.2MVA 3.3kV

33kV

13kV

26/45(52)kV

2x

3x1x95mm²

43.5km

19MVA

300m w.d.

Compressor

6.6kV

11.5MW

VSD Building

40MVA total power

Pump & CPDU Transformers

Control Power Distribution Unit

Subsea Compression Station

Compressor Transformer

Subsea Compression Station
Subsea Power System Type 3 – Ormen Lange Pilot

Supply: 132kV / 50Hz

Topside

40MVA 90/20kV

STATCOM

125km
76/132(145)kV
3x1x240mm²

90kV

40MVA 90/20kV

900m w.d.

20kV

CBs

16MVA 6.6kV

VSD VSD VSD VSD

M M M M

P P P P

Compressor
6.6kV
12.5MW
200Hz

Pump
2.5kV
400kW
50Hz

1MVA
3.3kV

Shell’s Nyhamna Test Pit with power/process modules

40MVA / 22kV Circuit Breaker Module

16MVA Compressor VSD Module

500kVA Pump VSD Module

Confidential © 2015 Aker Solutions
Topside VSD with RotoConverter™ for Long Step-out

- Electrical “frequency converter”
  - 10-20Hz motor input
  - 50-200Hz generator output
- More MW through power cable
- 3-5x longer step-out
Variable RotoConverter™ - Alternative to Subsea VSDs

Motor + Variable Coupling + Generator = Variable RotoConverter™

- Hydrodynamic or magnetic coupling between Motor and Generator
- Adjustable high frequency on pump/compressor motor
- Proven and reliable technology topside/onshore
- 10-20Hz frequency for long step-outs

16 MVA module
Study Case 1: 300 km step-out with Variable RC

- Transmission system
  - 145kV 300mm² cable
  - 16.7 Hz
- Subsea Loads
  - 4x 6 MW compressors @ 120 Hz (shaft power)
- Subsea Variable RotoConverter™ Modules
  - 1x VRC per compressor
  - No existing subsea VSDs for this step-out / power
- System design
  - Verify compressor start-up with VRC
  - Check transient stability
Simulations Within Design Standards for 300km / 40 MVA

- VRC acceleration of 4 compressors, starting one at a time
- Only 2% speed drop of other compressors during start of the 4th compressor (green)
- Stable speed profile of 4th compressor during start-up (red)
- Voltage drop on onshore terminal = 1% (within IEC 61000-2-4)
- Voltage drop on subsea terminal = 16% (within IEC 61000-2-4)
- Trip of all 4 subsea VRCs / Compressors
- Subsea main bus transient of +19%
Study Case 2: RC for 200 km control system supply

Load flow results – 16.7 Hz instead of 50 Hz:

- Transmission power losses reduced by 86 % (less heat/ageing in umbilical)
- Cable current reduced by 63 % (smaller cable)
- Topside power need reduced by 63 % (reduced power supply)
RotoConverter™ summary and technology benefits

- **RotoConverter™ technology**
  - Enabler for stranded prospects
  - Expand topside VSD based solutions
  - Qualified for subsea control systems power

- **Variable RotoConverter™ technology**
  - Cost effective replacement for subsea VSDs for long step-out
  - Free up topside space for short step-out brown-field applications
  - Under qualification - JIP program to be established during 2015
Subsea Compression

Marco Gabelloni | BD Emerging Subsea Technologies
Agenda

- Introduction
- Åsgard subsea compression project update
- New technology developments
Why subsea gas compression

- Gas fields require boosting of the reservoir flow as pressure depletes

- Advantageous to place the compressor close to the well
  - Increased production
  - Reduced CO2 emissions

- Subsea gas compression replaces the need for an offshore platform or onshore compression facility

- Safer due to unmanned operation
Long step-out gas fields - Multiphase pipeline sizing

OTC Paper 25802 • Deep Offshore Gas Fields: A new challenge for the industry

Production rate vs. Pressure Drop

- Minimum flow
- Plateau
- Maximum pipeline inlet pressure limited by reservoir energy

Production rate vs. Years

- Plateau
- Min Flow

Pipe diameter 1

Pipeline design capacity
Multiphase Pipeline Sizing with Subsea Boosting

Maximum production rate (target plateau)

Maximum pipeline inlet pressure limited by Subsea Boosting

Minimum flow

Pipe diameter 2 < Pipe diameter 1

OTC Paper 25802 • Deep Offshore Gas Fields: A new challenge for the industry

Plateau

Min Flow

Production rate

Years

Confidential © 2015 Aker Solutions
Åsgard Subsea Compression Project

Statoil says….

“Åsgard subsea gas compression will be realised in 2015 as the world’s first project of its kind.”

“The installation of the compressors will allow us to add a formidable 278 million barrels of oil equivalent to our production”

Åsgard subsea compression recovery example

- Subsea compression providing average 18 MMBoe additional recovery per year
Subsea Compression Station Data

Key facts

- Water depth: 260 m
- Flow rate: 21 MSm3/d
- Differential pressure: 60 bar
- Shut in pressure: 220 bar
- Tie-back distance: 40km
Compression System – Scope of Supply

Asgard A

Asgard B

Compression station

Manifold station
Pump and Control UTA Overboarding

Photo courtesy of Statoil
Compressor Transformer Installation
Pilot Compressor Installed in KLAB
Compressor Module System Integration Test
Åsgard project status

- Manifold station
- System integration test
- Compressor Module test
- Compression template
- Top side module
- Umbilical w/UTA

- Delivery of Train 1 - Q1 2015
- Delivery of Train 2 & 3 - H1 2015
- Installation Train 1 - H1 2015
- First Gas 2015
Well stream compression system
Re-use Åsgard technology with a simplified architecture

- Leverage liquid tolerance of the compressor unit
- Implement lessons learned
- Challenge requirements
Subsea boosting systems in the GVF range – most prospects are above 95% GVF

- LiquidBooster™
- HybridBooster™
- MultiBooster™

Gas field | GVF [%] | DP [bar]
--- | --- | ---
Åsgard | 89 | 57
Gullfaks | 95 | 32
Ormen Lange | 97.5 | 60

Selected other prospects
Copyright and disclaimer

Copyright
Copyright of all published material including photographs, drawings and images in this document remains vested in Aker Solutions and third party contributors as appropriate. Accordingly, neither the whole nor any part of this document shall be reproduced in any form nor used in any manner without express prior permission and applicable acknowledgements. No trademark, copyright or other notice shall be altered or removed from any reproduction.

Disclaimer
This Presentation includes and is based, inter alia, on forward-looking information and statements that are subject to risks and uncertainties that could cause actual results to differ. These statements and this Presentation are based on current expectations, estimates and projections about global economic conditions, the economic conditions of the regions and industries that are major markets for Aker Solutions ASA and Aker Solutions ASA’s (including subsidiaries and affiliates) lines of business. These expectations, estimates and projections are generally identifiable by statements containing words such as “expects”, “believes”, “estimates” or similar expressions. Important factors that could cause actual results to differ materially from those expectations include, among others, economic and market conditions in the geographic areas and industries that are or will be major markets for Aker Solutions’ businesses, oil prices, market acceptance of new products and services, changes in governmental regulations, interest rates, fluctuations in currency exchange rates and such other factors as may be discussed from time to time in the Presentation. Although Aker Solutions ASA believes that its expectations and the Presentation are based upon reasonable assumptions, it can give no assurance that those expectations will be achieved or that the actual results will be as set out in the Presentation. Aker Solutions ASA is making no representation or warranty, expressed or implied, as to the accuracy, reliability or completeness of the Presentation, and neither Aker Solutions ASA nor any of its directors, officers or employees will have any liability to you or any other persons resulting from your use.

Aker Solutions consists of many legally independent entities, constituting their own separate identities. Aker Solutions is used as the common brand or trade mark for most of these entities. In this presentation we may sometimes use “Aker Solutions”, “we” or “us” when we refer to Aker Solutions companies in general or where no useful purpose is served by identifying any particular Aker Solutions company.