Subsea Production Systems

Engineers Ireland – Dublin
Tony Pincombe – Regional Sales Leader
Ashish Jain – Principal Engineer
7th October 2015
Imagination at work
Subsea products and services

**SPS (Subsea Production Systems) = Trees + Controls + Manifolds + Power & Processing**

**Subsea Trees**
Complete portfolio to cover diverse field types, water depths, and operating environments

**Subsea Controls**
Industry leading technology to enable safe and reliable operation of subsea production systems

**Manifolds & Connection Systems**
Production Manifolds and connections to handle various field configurations

**Power & Processing**
Power, boosting, and compression solutions for both mature and new field developments

**Subsea Wellhead Systems**

**Specialty Connectors & Pipe**

**Floating Production Systems**

**Wellstream Flexible Pipe**
Dynamic risers, static flowlines, subsea and topside jumpers and fluid transfer lines to meet the demands of subsea and FPSO production.

**Service & Support**
- Field service
- Fleet and equipment
- Storage and asset management
- Triple S
- SmartCenter

INTEGRATED INTELLIGENCE FROM FLOOR TO SHORE
# Subsea Tree Structured Product Landscape

<table>
<thead>
<tr>
<th>Depth</th>
<th>Vertical</th>
<th>Horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 100m</td>
<td>SVXT</td>
<td>SHXT</td>
</tr>
<tr>
<td>“S Series”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 – 750m</td>
<td>MVXT</td>
<td>MHXT</td>
</tr>
<tr>
<td>“M Series”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>750 – 3000m</td>
<td>DVXT</td>
<td>DHXT</td>
</tr>
<tr>
<td>“D Series”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Deep Water Vertical Tree Installation

https://youtu.be/x8dXonwMjYw
SemStar5 – the Brain behind subsea

- Front End Assembly
- Power Supply Cardframe
- Data Acquisition & Control Cardframe
- Transformer Module
- Power Supply and Diplexer Cards
- Downhole Pressure & Temp (DHPT) Cards
- Electrical Connectors
GE’s Subsea Power & Processing Toolbox

**Boosting**
- Increase Oil Recovery and Production Rate from Maturing Subsea Wells
  - Prezioso -92

**Separation**
- Remove Water from Oil Stream at the Seabed – and Re-Inject Back into Reservoir
  - Troll Pilot -99

**Compression**
- Drive Gas from Matured Subsea Wells to Host
  - KBS -92

**Power**
- And all these systems need power, delivered at the seabed
  - Tyrihans -07

© 2015 General Electric Company - All rights reserved
Subsea Compression
Game Changer for the Atlantic Margin

Ashish Jain – Principal Engineer
7th October, 2015
Atlantic Margin - Introduction

Offshore west of Ireland is largely unexplored and least understood region of Europe

The Irish Atlantic Margin Basins share similarities to Atlantic Margin hydrocarbon basins in the UK and Norway

The Corrib Gas Field in the Slyne Basin was successfully appraised and opened up a new play in the region. The field has estimated gas reserve of 1.0 TCF.

Atlantic Margin - Prospect

Drilling by Providence in Dunquin North demonstrated presence of working petroleum system
Ref: offshoreenergytoday

Recoverable resources at Spanish Point between 100 mmbo and 202 mmbo
Ref: www.rigzone.com

Kosmos Energy identified two new prospects, Doyle A and Doyle B, prospective resources of 123 mmbo and 69 mmbo

Europa Oil & Gas also identified two prospects, named Beckett, Wilde & Shaw, prospective resources of 760 mmbo and 493 mmbo
Ref: offshore-technology

High interest by several operating companies in recently concluded licensing round further indicates the potential in the region
Ref: www.energy-pedia.com

Water depth range from 400m – 3000m, step out in excess of 100km
Challenges for deep water field development

Deepwater and a harsh environment, is a high-cost environment for designing and development of any discovery

Conventional platforms are not feasible in deeper water

With offshore activities, personnel risk exposure is multifold

Flow assurance is a critical challenge,
  - High pressure, high temperature developments
  - Low ambient temperature

Field development with subsea system can offer techno economic viable solution

Brage platform, North Sea, Norway

Ref: offshore-technology
The exploitation of subsea oil and gas fields is a mature industry that relies on qualified components and systems like subsea trees, flowlines, manifolds and electro-hydraulic control systems.
Why subsea processing?

Subsea Processing Adding Value

Green Fields
- Long offsets → Increased Recovery by Boosting
- Deep waters → Increased Recovery by Separation
- Near shore → Development Enabler
- Small field → Tie-in Alternative

Brown fields
- Increased recovery
- Deck space alternative
The evolution of more than 50 years of increased oil recovery

Challenging market dynamics for technology investment
GE ... Subsea, Processing and Power

**Processing System**
- Gas compression
- Full Wellstream boosting
- Seawater injection
- Separation & boosting

**Subsea Systems**
System design and integration:
Components:
- Controls
- MECON connectors
- Electrical actuators

**Power Conversion**
- Topside power supply
- VSD
- UPS
- Switchgear
- Electrical motors

**Power & Water**
- Water treatment

**Drilling & Surface**
- Electrical submersible pumps

**Measurement & Control**
- P/T sensors
- Leak detection
- Acoustic monitoring
- Flow metering
- RM&D
What is subsea compression?

- Compression system on sea bed
- Increased recovery by reducing back-pressure on the reservoir
- Typically less pressure ratio compared to compressor at host facility, lower power need
- Enable transport of wellstream over long distances (flow assurance concerns)
- Reduces need for offshore manning
Technology development based on conventional compression system

Marinization of topside system
Mainly suitable for larger fields

[Image: Ormen Lange Pilot, Nyhamna]

https://youtu.be/Ew1h9aU4odo

Photo: Svein Roger Ivarsen / Norske Shell
Exploring the subsea compression business case

Market Need

- Simple reservoir, production and pipeline model
- Rystad Energy ... water depth, reservoir depth, step-out, reservoir size, plateau production rates
- CAPEX and OPEX for entire system from topside to subsea
- Time period 2012-2030
- Run on >1100 gas fields around the world

Technology choice

Subsea compression concept evaluation tool

- Holistic view required while evaluating different system options
- Avoid simply moving cost around the system or shifting CAPEX to OPEX
Key findings from business case analyses

- 245 target candidates between 2012-2030
- 217 fields profitable with compression
- 82 profitable with subsea compression
- 11 subsea compression best option
- 3 early subsea compression best option
- Almost 100% of profitable subsea cases
  - <1500m, <2% LVF

- The largest savings are obtained with a system having only a wet gas compressor
- Lower savings on longer step-outs since the cable cost becomes dominant.

Simplified, robust, low cost centrifugal wet gas compression system best option
Next generation subsea compression

- Dry gas compressor
- Separate pump
- Scrubber
- AMB, AMBCS, UPS
- Subsea VSD ~50km

- Wet gas compressor
- No pump
- Simple slug catcher/distributor
- Topside VSD for longer stepouts
BlueC™ Subsea Motor-compressor

- Vertical configuration
- Configurable from 4-20 MW
- Closed loop cooling system
- Single shaft line (rigid coupling)
- Canned Active Magnetic Bearings

Compressor designed for subsea
Wet gas compression challenges

Technical Challenges

- Performance prediction
- Rotor dynamics
- Mechanics
- Droplets erosion
- Fouling

Considerable amount of experience from compression in wet conditions
Strong foundation to develop centrifugal wet gas compression
3rd generation system design

- Base design case ... two train station for long step-out with two inlets
- Subsea power distribution
- All electric
- Integrated manifold providing full flexibility
- Active cooling
- Standard module sizes ... Simple intervention and sparing
  - 6m x 6m x 12m (LxWxH): 60 tons
  - 12m x 6m x 12m (LxWxH): 250 tons

System and technology development by one integrated team
Main wet gas compression system modules

**Compressor Module**
- 12 x 6 x 12 m
- 168 tons

**Cooler Module**
- 6 x 6 x 12 m
- 60 tons

**HV Power Module**
- 12 x 6 x 12 m
- 250 tons

Three standard modules that can be used to build field specific systems
Hypothetical Case study
Corrib gas field

Using web based information
Corrib gas field facts

Pipeline 20” (510 mm)
Design pressure 345 bara, Operating pressure of pipeline 90-110 bara
Composition: 97% methane and ethane
Onshore processing capacity 9.0MSCMD, About 10 years field life
Estimated GIIP, 1.0 TCF
Estimated recoverable reserves, 0.6 TCF
Onshore arrival pressure 85 bara
Subsea compressor for Corrib gas field
Prediction using GE in-house tool

Additional 18% recovery achievable with subsea compressor
One subsea compressor of about 8MW
Possible solution for Corrib