SMI Subsea R&D Workshop

Subsea Production System – Current and Future Trends
Key Industrial Observations

- Demand for oil & gas will continue to grow.
- NOC control most of the world current oil and gas reserves.
- Oil Companies are moving towards more difficult reserves (heavy oil, sub-salt, ultra-deep, Arctic).
- As E&P moves towards deeper water and difficult to access reserves, well equipment are moving towards HPHT as well as long step out solution.
- Oil companies are focusing on both project and operation cost.
- They are also looking for increase reservoir utilization - ultimate hydrocarbon recovery – IOR.
- Environment Friendly Oil and gas development.
- Subsea Completion is favored over other completion.
The Future of Subsea

Broadly, the influence could be look into as 3 areas:

- Subsea Field Development
- Increase Oil Recovery and
- Subsea Processing

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<th>Subsea Field Development</th>
<th>Increased Oil Recovery</th>
<th>Subsea Processing</th>
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<td><img src="image1" alt="Subsea Field Development" /></td>
<td><img src="image2" alt="Increased Oil Recovery" /></td>
<td><img src="image3" alt="Subsea Processing" /></td>
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Subsea Field Development

- Flexible Field Architecture
- Standardization to lower cost
- Enhance Control and Data management System
- HPHT
- Deep Water
- Long Distance
- Arctic Development
Increased Oil Recovery

- Light Well Intervention
- Coil Tubing Intervention
- Through Tubing Rotary Drilling
- Condition Monitoring
Subsea Processing

- Separation
- Pumping / Boosting
- Gas Compression
- Reinjection water/gas
- Combination of all to form a system.

Gravity Separation

Compact Separation System

Raw Seawater/ gas Injection

Boosting Station

Heavy oil applications

Subsea Compression station

Subsea to Market
FMC’s Subsea Processing Major Projects

Activity in every major deepwater basin

- **Tordis – Statoil Hydro**
  - Brownfield
  - Gas/Oil/Water/Sand Separation
  - Boosting/Water Injection
  - Installed 2007

- **Cascade - Petrobras**
  - Greenfield
  - Boosting
  - Install 2010

- **Pazflor - Total**
  - Greenfield
  - Gas/Liquid Separation
  - Boosting
  - First oil 2011

- **Perdido - Shell**
  - Greenfield
  - Gas/Liquid Separation
  - Boosting
  - Installed 1Q 2010

- **Marlim - Petrobras**
  - Brownfield
  - Gas/Oil/Water/Sand Separation
  - Water Injection
  - First oil 2011

- **BC-10 - Shell**
  - Greenfield
  - Gas/Liquid Separation
  - Boosting
  - Installed 3Q 2009

- **Greenfield**
- **Brownfield**
Petrobras - Cascade and Chinook Project

• Subsea ESP boosting
• Challenges:
  • Ultra Deep water
  • Viscous oil
  • Artificial lift required to enable production
  • First delivered seabed Horizontal ESP packaging
  • First Seabed ESPs in series
Total - Pazflor Project

- Gas/Liquid separation + L Boosting
- Challenges with the Miocene Reservoir
- Main Challenge:
  - Low energy reservoir
  - Deep water ~ 800m
  - High viscosity and stable emulsion
    - Large pressure drop in flowlines and risers
- Free flow is not possible
Shell - Perdido Project

- Vertical ESP + G/L Separator
- World deepest subsea processing in 2,500m
- G/L separation effected by cylindrical cyclonic process in caisson.
- Overcome back pressure from riser.
- Liquid boosted by ESP.
Shell - BC-10 Project

- Vertical ESP + G/L Separator (Booster station)
- First full-field Gas-Liquid Caisson Separation system in Brazil
- Separator are part of Manifold
StatoilHydro – Tordis Project

- Enhance Brownfield oil recovery
- First full-scale subsea separation system
- Gas/Oil/Water/Sand Separation
- Injection of Produced water
- To overcome limited topside water handling capacity
Petrobras – Marlim Project

- Enhance Brownfield oil recovery
- Gas/Oil/Water/Sand Separator
- Subsea separation of Heavy oil in deep water, matured field
- Advance compact separation System – Pipe separator
- Water treatment - Hydro Cyclones
- Reinjection of water into production reservoir
Thank You!