In-line Subsea Sampling: Non-disruptive Subsea Intervention Technology for Production Assurance

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Presentation Outline

- Production assurance challenges along the fluid journey
- Fluid PVT and importance of representative samples
- Subsea sampling system
- Subsea sampling demo
- Project example – subsea sampling application for scale squeeze optimization
Complexity and Multi-disciplines in Subsea Production

The Fluid Journey

The Project Development Timeline

PVT & Fluid Behavior | Thermo Hydraulics | Pressure & Liquid Mgmt | Hydrates | Wax & Asphaltenes | Scale | Corrosion & Erosion | Heavy Oil | Operability | Integrated Solutions | Production System Architecture | Production Optimization

Exploration | Feasibility | Concept Selection | Definition | Execution/Implement | Operation

Production Assurance Challenges along the Fluid Journey

Deposition management

Liquid management

Pressure management
Production Assurance Challenges along the Fluid Journey

Athabasca Bitumen $\rho > 1$

Asphaltene

Wax

Inorganic scale

Organic Scale

Gas Hydrate
Fluid PVT and Importance of Representative Samples

- **Temperature**
- **Pressure**
- **Hydrate Curve**
- **Wax Curve**
- **Asphaltene Curve**
- **Facility**
- **Bubble Point**
- **Reservoir P&T Start**
- **CaCO₃ Equilibrium**
- **SrCO₃ Equilibrium**

**OPERATING PROFILE**
- **Long-Term Look-a-head**
Subsea Industry Trends

Increasing production assurance challenges + high intervention costs
Almost all technical and economic reservoir studies require an accurate and reliable understanding of the reservoir fluids.
Drivers for Representative Sampling

Reservoir Monitoring
- At source verification of production fluids and characteristics

Production Enhancement
- Flow assurance
- Efficient well intervention
- Optimisation of subsea processing

Other
- Fiscal allocation
- Reservoir communication
Multiphase Representative Sampling

- Multi-phase sampling
- Sample Receptacle
- Onsite Analysis
- PVT laboratory
- Fluid Results
OneSubsea Sampling System - Demo
Key Functionality

Safety in design
- Well isolation and fail safe methodology

Accuracy
- Isobaric Sampling – High importance
- Isothermal Sampling – Medium importance

Phase Targeted Sampling
- Phase enrichment
- Optical phase detection

Sample Capacity
- No of sampling bottles and volumetric capacity

Flow assurance
- Module heating
- Subsea and Topside flushing procedures
Subsea Sampling System

Subsea Sampling Hardware

- **Sampling Interface**
  - Based on blind T, flexible access / retrievable
  - Dual pressure barrier philosophy

- **Sampling Module**
  - Isothermal and isobaric sampling
  - Phase detection and phase enrichment
  - Winch deployed / ROV assisted skid
  - Remotely controlled system
  - Transportable sample receptacles

Subsea Sampling Services
Anatomy of a Subsea Sampling Interface

Alignment and Connection
- Several flexible connection types.
- Fully qualified.

Blind T
- Flow conditioning via fluid dynamics.
- Dual takeoff for phase rich samples.

Dual Isolation Valves
- Hydraulic or manual control.
- Topside or ROV control.

Flexibility
- Horizontal or Vertical access.
- Manifold or Xmas Tree
- Permanent or Temporary installation
Anatomy of a Subsea Sampling Module

**Displacement Unit Pump**
- Automatic reciprocation via hydraulic power supply
- Facilitates near Isobaric sampling

**Separator**
- Phase enrichment
- Optical phase detection
- Facilitates targeted phase sampling

**Sample Bottles**
- Facilitates multiple discrete samples
- Sealed subsea for safe transfer to topside facility

**Heating Methods**
- Flow assurance
- Facilitated near Isothermal sampling

Heated Water Bath
Subsea Sampling Case Study - Overview

2 off ROV FLOT carried subsea sampling modules
- Design pressure: 5000 psi and 93°C
- Number of samples: 4
- Sample volume: 600cc
- Subsea Deployment System
- Capable of controlled fluid separation, during sampling.
- Heating system for hydrate mitigation

4 off ROV operated X-mas tree installed subsea sampling interfaces
- Design Pressure: 10,000 PSI and 121°C
- Subsea ROV interchangeable wearables for life of field operation and servicing
Subsea Sampling Case Study – Field Performance

First sample October 2016
12 samples taken from 3 individual wells
1st sample performed in approx. 6 hours from deployment to retrieval

Scale Squeeze Optimization
- Integrated modelling for accurate prediction of interval between Scale treatments
- Reduce intervention frequency
- OPEX saving and increased up-time

![Graph showing cumulative water production vs. inhibitor concentration with markers for field and modelled return concentrations.](image)
# Integrated Modeling to Diagnose and Optimize PA Problems

## Schlumberger Tools

<table>
<thead>
<tr>
<th>Wells / Pipelines Steady State</th>
<th>Wells / Pipelines Dynamic</th>
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<tbody>
<tr>
<td>PIP</td>
<td>OLGA</td>
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<tr>
<td>PIPESIM</td>
<td>OLGA</td>
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- Reservoir Simulation
- Integrated Modeling

## Third Party

<table>
<thead>
<tr>
<th>PVT Analysis</th>
<th>Scale Analysis</th>
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<tr>
<td>PVTsim</td>
<td>ScaleChem</td>
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<tr>
<td>INFOCHEM Multiflash</td>
<td>MultiScale</td>
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</tbody>
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- Corrosion Analysis
- Wells / Pipelines

- OLI Analyzer Studio
- Economic Analysis

- Prosper / GAP
- Process Simulation

- HYSYS

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**Schlumberger**

**Third Party**

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**OneSubsea**
Integrated Subsea Sampling In Summary

- Sample extraction
- Sampling interface
- QA, condition, segregate, restoration, and transfer

- Optimisation
- Production management workflows
- Modelling, EoS, Uncertainty, and decisions
- Analysis and reporting
Thank you!

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