Safe Hydrate Plug Management
From Prevention to Remediation

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Benefits in Simplified Architectures based on Continuous or Occasional Heating

Single Line Benefits:
- 50% less flowlines length
  - Less Procurement & Installation Costs
- 50% less risers
- Reduced size of chemical umbilical's & maniforlds
- Minimize number of spools & PLETs

CAPEX/ OPEX trade off:
- Lower insulation level by continuous heating
  On most projects, only short periods of production necessitate high passive insulation

More Insulation CAPEX vs. Less Heating OPEX
Less Insulation CAPEX vs. More Heating OPEX

25% CAPEX Savings
Benefits in Simplified Architectures based on Continuous or Occasional Heating

Active Heating Benefits in Operations

- Shorter shutdown duration (no touch time): Faster & Easier shut-down and restart
- Wax Management: No need for frequent pigging
- Reduced amount of injected chemicals
- Addresses most of flow assurance issues during life of field
- Potential IOR benefits (lower dP at the end of field-life enabled by continuous heating)

Resulting in OPEX savings
Hydrate Management in Simplified Architectures

Operations
- Production (Steady & Turn-Down)
- Shut-In & Restart (Transient)

Strategy
- Prevention (Avoid)
- Mitigation (Reduce Risk)
- Prevention (Avoid)
- Mitigation (Reduce Risk)
- Remediation (Plug Removal)

Actions
- Passive Insulation
- Virtual Monitoring
- Chemical Injection (Spools)
- Virtual Monitoring
- Pressure Management
- Continuous Chemical Injection
- Distributed Monitoring
- Deaerated Circulation
- Distributed Monitoring
- Coil Tubing
- Continuous Heating
- Temporarily Heating
- Depressurization
- Temporary Heating
- Depressurization
- In Service

Hydrate Management in Simplified Architectures
- Prevention (Avoid)
- Mitigation (Reduce Risk)
- Remediation (Plug Removal)
JIP: Safe Hydrate Plug Management in Active Heating Flowlines

- **ID = 6” (eq. to Islay ETH-PIP)**
- **U_{ID} = 1 W/m².K**
- **Length = 18 meters**
- **Hydrate Quantity > 200 kg**
- **Max Pressure = 110 Bar**
- **Max ΔP across plug = 30bar**

**Partners:**

- ExxonMobil
- Technip
- TOTAL
- Woodside
JIP Objectives

- **Plug Quality**: Produce low-permeability and low-porosity hydrate plug.

- **Full Scale Experiments**: Experiment ETH technologies for safe dissociation of hydrate plug and eliminate the risks for local pressure build-up and hydrate plug run-away by careful control of heating input.

- **Modeling**: Validate simulation tools based on CFD for subsea structures and develop an ‘in-house’ 2D for hydrate remediation subsea field applications.

- **Monitoring**: Qualify a monitoring system based on DTS for Hydrate Plug Condition Monitoring : Formation, Dissociation by Depressurization &/or Active Heating.
Target: Form the hardest plug that corresponds to the worst subsea conditions

- Plug permeability in the range of mDa.
- 35 bar Pressure Differential across the plug
- Large conversion rate from 60% to 95%.
- 200 kg of hydrates plug formed
- 16.5 m long
### JIP Achievements

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Dissociation Scenario</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 – 1</td>
<td>Base Case</td>
<td>✓</td>
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<tr>
<td>Phase 1 – 2</td>
<td>Sensitivity on Plug Length</td>
<td>✓</td>
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<tr>
<td>Phase 1 – 3</td>
<td>Sensitivity on ETH Power</td>
<td>✓</td>
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<tr>
<td>Phase 1 – 4</td>
<td>Sensitivity on Number ETH Cable “In Use”</td>
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<tr>
<td>Phase 2 – 1</td>
<td>Sensitivity on High $\Delta P$ across the plug</td>
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<tr>
<td>Phase 2 – 2</td>
<td>Sensitivity on Dissociation in a Closed Volume</td>
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<tr>
<td>Phase 2 – 3</td>
<td>Sensitivity on DEH Heating Conditions</td>
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<tr>
<td>Phase 2 – 4</td>
<td>Sensitivity on Presence of Oil in Hydrate Pores</td>
<td>✓</td>
</tr>
<tr>
<td>Phase 2 – 5</td>
<td>Sensitivity on Hydrate Structures</td>
<td>✓</td>
</tr>
</tbody>
</table>

Extensive 3 year experimental campaign covering the most severe cases subsea for defining safe operating conditions.
JIP Achievements

- JIP data are used for the development and the validation of 2D/3D In-House CFD Model.
- Identification of model’s limitations
JIP Achievements

- Development of i-DisHyd™ for simulation of Subsea Operations with regard to Hydrate Plug Detection, Dissociation and Formation.

Validation against Temperature Data

Validation against Gas Flow Rate Data

Validation against Pressure Data
JIP Achievements

- Demonstrated capacity to interpret live DTS Data
  - Hydrate Localisation
  - Plug In Dissociation – Yes / No.
  - Local Pressure Behavior – Increasing / Constant.
  - Has Plug Completely Melted – Yes / No.
Next Steps: ETH Blanket development

Develop a heated blanket for subsea flowlines, quick and asset light flow assurance intervention.

Short-Term application:
→ Detect & remove Hydrate/Wax/Gelling accidental plugs for Brownfield

Longer-Term application:
→ Risk Based Flow Assurance for Greenfield = CAPEX optimized design (single, wet-insulated lines) thanks to OPEX capabilities.

As an intervention kit, the ETH Blanket will allow to:
- Solve Hydrate Plugging issues in a complete, faster and cheaper manner compared to depressurization method or coiled tubing;
- Safely remediate Hydrate plugs with no risk of excessive pressure build-up or plug run-away
- Solving Wax Plugging in existing flowlines due to mis-operation or pigging;
- Decrease cold-restart pressure required to break gel plug → increase safety aspects

Combination of 2 New Technology Building Blocks to meet new field development challenges
New Active Heating Technologies for safer Hydrate Risk Management, lower CAPEX, better Operability and lower OPEX

- Efficient Building blocks for:
  - Greenfield: architecture simplification
  - Brownfield: long tie-backs / difficult reservoirs

- Can be efficiently combined with Subsea Processing and Topsides Optimization

- Can allow more flexible and cost effective operations including continuous integrity monitoring and new robust hydrate / wax management philosophies

- Retrofit capabilities (ETH Blanket) should assist in the development of a risk based flow assurance approach

- However, their potential benefits should be assessed at conceptual stage
Thank you for your attention!

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