Proposal for a presentation at the MCEDD 2014

Title:
Subsea Station for chemical storage and injection: 2 study cases

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Abstract:
For typical deepwater developments, subsea chemicals are conveyed from the floating facilities to the subsea injection points using umbilicals. Procurement and installation costs associated with these umbilicals can challenge the economic development of remote marginal fields. The main objective of this project is to develop a solution of local subsea chemical storage and injection that would allow removing chemical supply lines from the umbilical to reduce its cost, enabling a practicable development of remote subsea tie-backs.

Since 2011, this concept has been studied and developed by TOTAL and Doris Engineering. This presentation aims at presenting the recent developments of this study. In particular, the design of the subsea station has been applied to two specific study cases:
- One 30-km oil field subsea tie-back offshore in West Africa,
- One 300-km gas field subsea-to-shore in North Sea.

This study develops and presents the technical reasons that drive the subsea station design and operating philosophy based on the specificities of each study case. In particular, the following aspects are covered:
- Station integration into planned field development,
- Specific sizing of the storage and injection capacities based on the chemical injection requirements,
- Refill operation schedule and operation sequences based on available vessel and intervention means,
- Station design, dimensions and weight based on specific study case requirements (protection against trawlers …),
- Umbilical cross-section reduction and associated economic benefits.

These two case studies demonstrate that this innovative concept can successfully be developed and adapted to a wide range of subsea development.
SUBSEA STATION FOR CHEMICAL STORAGE AND INJECTION: 2 CASE STUDIES

TOTAL: Vincent PEYRONY
DORIS ENGINEERING: Gabriel BEAUDONNET
UMBILICAL LIMITATIONS FOR LONG SUBSEA TIE-BACKS

- Local subsea storage and injection of chemicals **to enable longer tie-backs**
  - Remove chemical / methanol injection lines from umbilicals
  - Reduce umbilical cross-section
  - Reduce CAPEX

- **Oil field / Gas field**
- **Tie-back length**
  - Oil 50-100km / 30-60mi
  - Gas 300-500km / 180-300mi
- **Up to 3,000m / 10,000ft** water depth

- **15km / 9.5mi**
  - OD = 160mm / 6in

- **30km / 19mi**
  - OD = 210mm / 8in

- **50km / 31mi**
  - OD = 245mm / 10in

- **OD = 110mm / 4in**

- **OD = 60mm / 2in**

MCE Deepwater Development – 09 April 2014
SUBSEA STATION MAIN EQUIPMENT AND SYSTEMS

- Subsea storage tanks
- Chemical injection pumps
- Piping for chemical distribution
- Subsea control module (SCM)
- Electrical distribution
- Structure
BASIS OF DESIGN – TWO CASE STUDIES

Oil development case
- Subsea tie-back to existing FPSO offshore West Africa
- Length: 30km / 19mi to existing FPSO
- Water depth: 500m
- 4 production wells over 2 drill centers
- Production: 35,000 blpd

Gas development case
- Subsea-to-beach development in North Sea
- Length: 300km / 190mi to shore
- Water depth: 400m
- 16 production wells over 5 drill centers
- Production: 10 MSm3/d / 350 MMScfd
CHEMICAL INJECTION REQUIREMENTS

Oil development case

- Chemicals
  - Corrosion inhibitor
  - Scale inhibitor
  - Demulsifier
  - Biocide
- Hydrate inhibitors
  - Low Dosage Hydrate Inhibitor (LDHI)
  - Methanol

Gas development case

- Chemicals
  - Corrosion inhibitor
  - Scale inhibitor
- Hydrate inhibitors
  - MEG (+Ph Stabilizer)
- Hydraulic control fluid: subsea (LP) and downhole (HP) valves actuation
- Barrier fluid (subsea compression station condensate pump)
## SUBSEA STORAGE TANK

- Pressure-balanced design
- No track-record for long-term storage
  - Pipeline pre-commissioning
  - Subsea dispersant (well containment)
- Screening of pressure-balanced tank concepts
  - Pipeline pre-commissioning
  - Subsea dispersant (well containment)

### Types of Subsea Storage Tanks

- Piston tank
- Elastic bladder tank
- Membrane tank
- Rolling tank
- Pillow tank

### Comparing Key Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Piston tank</th>
<th>Elastic bladder tank</th>
<th>Membrane tank</th>
<th>Rolling tank</th>
<th>Pillow tank</th>
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</thead>
<tbody>
<tr>
<td>Weight</td>
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<td>+</td>
<td>-</td>
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<tr>
<td>Chemical compatibility</td>
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<td>Manufacturability</td>
<td>+</td>
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</tbody>
</table>

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**Oil development case**
- Refill frequency: 6 months
  - Limited MPSV vessel capacities in West Africa
- Corresponding volumes:
  - Corrosion inhibitor: 65m³ / 17,000gal
  - Biocide: 30m³ / 8,000gal
  - Scale inhibitor: 25m³ / 6,600gal
  - Demulsifier: 20m³ / 5,300gal
  - Methanol: 210m³ / 55,000gal
  - LDHI: 40m³ / 10,600gal

**Gas development case**
- Refill frequency: 12 months
  - Limited weather window
- Corresponding volumes:
  - Corrosion inhibitor: 100m³ / 26,000gal
  - Scale inhibitor: 2m³ / 500gal
  - Hydraulic control fluid: 30m³ / 8,000gal
  - Barrier fluid: 10m³ / 2,600gal
## REFILL OPERATIONS

- TrROV skid
- Transfer tank
- Tank change-out
- Refill umbilical

- Storage tank volume has been standardized to 30m³ / 8,000gal

### Oil development case
- Refill frequency: 6 months
- Limited MPSV vessel crane capacities in West Africa (≈70/150 tons)
- Chemicals: 8 tank modules
- Hydrate inhibitors: 10 tank modules

### Gas development case
- Refill frequency: 12 months
- Limited weather window
- Chemicals: 5 tank modules
- Control fluid + barrier fluid: 3 tank modules
SUBSEA INJECTION PUMP

- **Volumetric pump** (positive displacement) – API 674 / API 675
- Use of **magnetic coupling** for mechanical transmission between pump and motor
- Flow regulation

1. **Gearbox** (continous pump use)
   - Mechanical stroke adjustment (ROV actuated or remotely actuated)
   - Complex mechanism to marinized

2. **Recycling loop** (continous pump use)
   - Flow is regulated through recycling
   - Recycling choke valve is ROV actuated or remotely actuated

3. **Accumulator + dosing valve** (intermittent pump use)
   - Pump is used to maintain accumulator pressure. Flow is regulated via a dosing valve
### Oil development case

- **Pump requirements**
  - **Chemicals**
    - **Injection mode** | **Pump motor power**
      - Corrosion inhibitor | Continuous | 0.1 kW
      - Scale inhibitor | Continuous | 0.1 kW
      - Demulsifier | Continuous | 0.1 kW
      - Biocide | Batch ≈5h per week | 1 kW

  - **Hydrate inhibitors**
    - **Injection mode** | **Pump motor power**
      - LDHI | Restart | 10 kW
      - Methanol | Shut-down / Restart | 250 kW

→ **4 types of pump (very low to high power)**

### Gas development case

- **Pump requirements**
  - **Chemicals**
    - **Injection mode** | **Pump motor power**
      - Corrosion inhibitor | Continuous | 0.1 kW
      - Scale inhibitor | Continuous | 0.1 kW

  - **Hydraulic control fluid**
    - **Injection mode** | **Pump motor power**
      - LP / HP (345/690 bar / 5,000/10,000 psi) | Intermittent | 3 kW
      - Recirculation | Intermittent | 2 kW

  - **Barrier fluid**
    - **Injection mode** | **Pump motor power**
      - Barrier fluid | Continuous | 0.1 kW

→ **2 types of pump (very low to low power)**
ELECTRIC POWER DISTRIBUTION

Oil development case
- 0.1 kW to 10 kW
  - Use of the 1kV standard electric network (same as for SPS equipment)
- 250 kW
  - Use of a dedicated 20kV HV electric network

Gas development case
- 0.1 kW to 3 kW
  - Use of the 3kV standard electric network (same as for SPS equipment)
ECONOMICAL BENEFITS – UMBILICAL PROCUREMENT COST REDUCTION

Oil development case

OD = 168 mm
Weight = 30 kg/m
Cost = Ref.

- 35%
- 30%
- 70%

OD = 107 mm
Weight = 21 kg/m

- 50%
- 50%
- 80%

OD = 85 mm
Weight = 16 kg/m

Gas development case

OD = 143 mm
Weight = 24.3 kg/m
Cost = Ref.

- 25%
- 4%
- 60%

OD = 107 mm
Weight = 23.3 kg/m

● 4% weight reduction
  - Superduplex tube replaced by steel wire armour
**ECONOMICAL BENEFITS – INSTALLATION SCHEDULE**

**Gas development case**

- 300km / 190mi to be installed

- Total length on carousel
  - Max. carousel capacity: 170 km
    - Two campaigns
      - 85 days
  - Max. carousel capacity: 310 km
    - Single campaign
      - 65 days (-24%)

- Benefits
  - Reduced transit time (20 days)
  - Only one transpooling
ECONOMICAL BENEFITS – CAPEX

- CAPEX
  - Station
  - Refill hardware
  - Umbilical
  - Chemical skids on FPSO (oil case only)

CAPEX if sufficient tie-back length

Oil development case

Gas development case

Case study

24km / 15mi 50km / 31mi

-11% -30%

Case study

50km / 30mi 140km / 87mi

-15% -25%

Case study
QUALIFICATION STUDY

- TOTAL qualification procedure for new systems / technologies
- Based on technology maturity, risks and uncertainties assessment
- TRL – Technology Readiness Level

- Equipment / systems with low associated TRL:
  - Injection pump systems
  - Chemical stability

- RMP – Resolution Management Plan
  - Reduce risk and uncertainties to an acceptable level
  - Identify required actions (further studies, qualification testing, scale pilots …)
  - Target: *increase TRL level to TRL5 for consideration at pre-project stage*

<table>
<thead>
<tr>
<th>TRL 1-3</th>
<th>TRL 4</th>
<th>TRL 5-6</th>
<th>TRL 7-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>System principles identified or demonstrated</td>
<td>Prototype or close analog demonstrated in lab environment</td>
<td>System demonstrated in representative environment</td>
<td>Field proven system</td>
</tr>
</tbody>
</table>
SUBSEA STATION – FOOTPRINT AND WEIGHT

Gas development case

- **Ormen Lange template**: 45m x 33m x 14m / 148ft x 108ft x 46ft, 1,150 tons
- **Asgard subsea compression station frame**: 74m x 44m x 26m / 243ft x 144ft x 85ft, 2,000 tons
- **Subsea Station for Chemical Storage and Injection (gas case)**: 50m x 30m x 14m / 164ft x 98ft x 46ft, 700 tons
CONCLUSION / WAY FORWARD

- Innovative system
- Cost effective for long subsea tie-backs
- Next step: qualification and testing plan to increase Technology Readiness Level
- Way forward: one step closer to a fully autonomous "Subsea Plant"
  - Subsea chemical storage and injection
  - Subsea seawater treatment and injection
  - Resident ROV / AUV
  - The only remaining connection to the FPSO / shore is the flowline
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