SUBSEA STATION FOR CHEMICAL STORAGE AND INJECTION: 2 CASE STUDIES

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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
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 / 1,600ft
- 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 / 1,300ft
- 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)

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<th>Piston tank</th>
<th>Elastic bladder tank</th>
<th>Membrane tank</th>
<th>Rolling tank</th>
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REFILL OPERATIONS

- ROV 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** (continuous pump use)
   - Mechanical stroke adjustment (ROV actuated or remotely actuated)
   - Complex mechanism to marinized

2. **Recycling loop** (continuous 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
## SUBSEA INJECTION PUMP

### Oil development case
- **Pump requirements**
  - **Chemicals**
    - Corrosion inhibitor: Continuous, 0.1 kW
    - Scale inhibitor: Continuous, 0.1 kW
    - Demulsifier: Continuous, 0.1 kW
    - Biocide: Batch, \(\approx 5\)h per week, 1 kW
    - **Hydrate inhibitors**
      - LDHI: Restart, 10 kW
      - Methanol: Shut-down / Restart, 250 kW

\[\text{4 types of pump (very low to high power)}\]

### Gas development case
- **Pump requirements**
  - **Chemicals**
    - Corrosion inhibitor: Continuous, 0.1 kW
    - Scale inhibitor: Continuous, 0.1 kW
    - **Hydraulic control fluid**
      - LP / HP (345/690 bar / 5,000/10,000 psi): Intermittent, 3 kW
      - Recirculation: Intermittent, 2 kW
    - **Barrier fluid**
      - Barrier fluid: Continuous, 0.1 kW

\[\text{2 types of pump (very low to low power)}\]
**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
Gas development case

- 300km / 190mi to be installed

- Total length on carousel
  - Max. carousel capacity: 170 km
    - Two campaigns
      - 84 days
  - Max. carousel capacity: 310 km
    - Single campaign
      - 68 days (-20%)

- Benefits
  - Reduced installation time (16 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**

- 24km / 15mi: -11%
- 50km / 31mi: -30%
- Case study

**Gas development case**

- 41km / 25mi: -25%
- 150km / 93mi: -36%
- 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
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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