Economic HPHT Developments Utilising Pipeline Bundles

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Agenda

- HPHT Design Issues
- Introduction to Pipeline Bundles
- Advantages of Bundles for HPHT
- Pre-tensioning & HPHT
- Wester Site trials
- Finite Element Analysis
- Conclusions
HPHT Design Issues

- Subsea pipeline pressures & temperatures gradually increasing with time, as technology permits.
- Trend to continue – As deeper oil & gas fields are developed subsea.
HPHT Design Issues

• Development of HPHT fields presents technical challenges for subsea pipeline design.

• High pressure technical challenges:
  – Higher wall thickness requirements.
  – Capability of existing vessels.

• High temperature technical challenges:
  – De-rated material yield strength and Young’s modulus.
  – Increased compressive axial forces requiring an increased wall thickness due to thermal expansion.
  – Insulation and coating requirements.

• These issues have traditionally made HPHT field development economically and technically challenging.
Introduction to Pipeline Bundles

- Pipeline Bundles consist of a carrier pipe containing individual pipelines and umbilical components which are carried by spacers on rollers.
- Pipeline Bundles terminate in Towheads.
Introduction to Pipeline Bundles

- Hot Water Heating
- Production
- Insulation
- Sleeve Pipe
- Gas Lift
- Scale Squeeze
- Methanol Injection
- Control Tubes
- Chemical Injection
- Power & Signal Cables
- Carrier Pipe
- Main Spacer
Introduction to Pipeline Bundles

• Fabricated onshore in a single length – 7.6km long fabrication site.
• Longest, moveable man-made structure in the world.
• Installed using Controlled Depth Tow Method (CDTM).
Advantages of Bundles for HPHT Design

• Suitable for 220°C, 1379 bar with pre-tensioning.

• Onshore welding and system integration test
  – Strength test, valve operations, etc.

• Pipeline Bundle installation
  – Greatly reduces offshore installation campaign
  – Mitigates need for expensive pipelay spread
  – Towheads replace large structures.
  – Low stress / fatigue process
  – Can be installed whilst drill rig, FPSO, Flotel are present.
  – Reduced installation corridor in congested fields
Advantages of Bundles for HPHT Design

- Efficient insulation systems
  - High thermal performance
  - Low cost materials available
  - Thermal / electrical heating systems

- No need to trench / Rock-dump
  - No risk due to soil type.
  - No risk of upheaval buckling

- Bundle tie backs can connect HPHT pools to either an FPSO or a production platform

- Can reduce need for multiple cooling spools & HIPPS.

- Fast hook up and commissioning for early first oil dates
Advantages of Bundles for HPHT Design

- Pipeline Bundles and High Temperature
  - Low resistance to flowline expansion
  - Axial forces much lower than equivalent Pipe-in-Pipe (PiP) system
  - Mitigates need for expansion spools.
Pre-tensioning & HPHT

- Compressive axial forces in pipelines are generated due to high temperatures.
- Compression can be reduced by creating an initial tension.
- Pre-tensioning can extend the operating temperature beyond its conventional limits
- Pre-tensioning can reduce the flowline wall thickness for a given design temperature.

- Two pre-tensioning methods have been explored:
  - Thermal expansion
  - Mechanical expansion

- Mechanical expansion has been selected for use in trials
Pre-tensioning & HPHT-Mechanical Jacking System

1. Fixed and sliding bulkhead is installed onto the end of the Pipe-in-Pipe
2. Mechanical jacking system is installed onto the PiP bulkhead arrangement
3. Mechanical jacks extended gradually & packers installed
4. Continue extension & adding packers until PiP is sufficiently pre-tensioned
5. Insulation and sleeve half shells installed to complete section
Wester Site Trials

Trials ongoing at Subsea 7’s Wester Fabrication Yard near Wick
Wester Site Trials

- Mechanical pre-tensioning trials performed on a 170m PiP section
- Testing the following components at 220°C & 188 bar:
  - Fixed and sliding bulkheads
  - Fibre Optic Monitoring System
    - Axial & Hoop Strain
    - Temperature
  - Low Friction/HT Centralisers (Patent Pending)
- Trials are a critical milestone in the development of the Pipeline Bundle pre-tensioning System
- Leading to qualification of the pre-tensioning concept and the fibre optic monitoring system.
Wester Site Trials

- Fibre optic monitoring to be verified against independent strain gauge readings, as well as calculations and FEA analysis.
- Pipe-in-Pipe strength tested to 282 bar before pre-tensioning
- 300mm boulder case where the PiP is raised to imitate a boulder
Wester Site Trials
Finite Element Analysis – Production Pipe

- The following graphs display the axial force and stress (von Mises) predicted for the production pipe.
- This considers a load case at a pressure of 188 bar and a temperature of 220°C.
Finite Element Analysis – 300mm Boulder Case

300mm boulder placed under the centre point of the PiP section. The following FEA shows the von Mises stress within the production pipe.
Conclusions

• Pipeline Bundles provide an economically attractive solution for HPHT field development, by incorporating advanced design and fabrication techniques.

• Pre-tensioning extends HPHT range & capability
  - Extended temperature range to 220°C, 1379bar
  - Full qualification & certification according to DNV-RP-A203

• Pre-tensioning reduces the required wall thickness for equivalent stress driven pipelines.

• Fibre optic monitoring system qualified to monitor strain and temperature for HPHT Bundles.

• Early engagement on HPHT developments allows Subsea 7 to maximise cost savings.