Fibre Optic Instrumented Pipeline Bundle for HPHT Developments

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Agenda

- Introduction
- HPHT Theoretical Development
- Bundles HPHT Trial
- Results and Analysis
- Conclusions
Introduction

• What is a Pipeline Bundle?
Introduction

• Why Pipeline Bundles?
  - Onshore SIT and pre-commissioning;
  - No need for specialist and expensive vessels;
  - Less congested field layout;
  - Improved flow assurance and thermal solution;
  - No need for trenching / rock-dump;
  - Fast hook-up and commissioning offshore;
  - Year round installation (with enhanced weather criteria).

• Pipelines bundle operating temperature range is currently at 160°C.
HPHT Theoretical Development

- Pipeline bundle pre-tensioning advantages:
  - Suitable for 220°C, 1379 bar;
  - Reduction of compressive axial forces due to high temperature;
  - Mitigate the need for expansion spools.
HPHT Trial – Instrumentation Setup

- **Fibre Optic Instrumentation FBG Chain**

- **Strain gauge Instrumentation**

- **FBG Chain**

- **Overall system schematic**
HPHT Trial – Testing Procedure

- Pressure Strength test (1 cycle):
  - Hold points: 35bar, 169.2bar, 253.8bar and 287bar.

- Mechanical Pre-tensioning test (3 cycles):
  - 4 pre-tensioning steps (104mm each; i.e. 416mm total);
  - Flowline extends by 253mm;
  - Sleeve compresses by 163mm.

- Unrestrained HPHT test (2 cycles):
  - Temperature applied 220°C;
  - Pressure applied 193bar

- Boulder case test (1 cycle):
  - Temperature applied 220°C;
  - 300mm prop bend.
  - Pressure applied 193bar
Results - Pressure Strength Test

Strain gauge results
(hoop and axial strains)
Results - Pressure Strength Test

Strain gauge results
(hoop and axial strains)

Hoop strain at pressure hold points
Results - Mechanical Pre-tensioning Test

- Jacks & extension legs installed
- During Jacking, installing packers
- All packers installed
- Insulation and half shells installed
Results – Mechanical Pre-tensioning Test

Strain gauge results (hoop and axial strains)
Results – Mechanical Pre-tensioning Test

Axial strain at Pre-tensioning steps

Strain gauge results (hoop and axial strains)
Results – Mechanical Pre-tensioning Test

Instrumentation technology comparison (axial strain)
Results – Unrestrained HPHT Test

Strain gauge results (hoop and axial strains)
Results – Unrestrained HPHT Test

Temperature: Axial strain drop  
Pressure: Hoop strain rise

Strain gauge results (hoop and axial strains)
Results – Unrestrained HPHT Test

• Distributed Temperature Sensing Video 3 heating cycles
Results – Boulder Case Test

Distributed Axial Strain Sensing Results (DSS)
Results – Boulder Case Test

Strain gauge results (axial strain)
Conclusions

• Trials performed safely in presence of third party.

• Pre-tensioning system generated strains within 7% of the FEA results.

• Friction coefficient was insignificant (0.17) due to the use of Subsea 7’s low friction HT centralisers (Patent Pending).

• Strain gauges verified the FEA model and the FO instrumentation results.

• Results are all within 90% accuracy of the maximum strain value during the given test.
Conclusions

- Subsea 7 demonstrated the technology required to pre-tension bundles for HPHT applications up to 220ºC.

- Subsea 7 demonstrated the technology required to use fibre optic and/or strain gauges for monitoring pipeline bundles during pre-tensioning and operational phases.

- Qualifications according to DNV-RP-A203 almost complete.