The SpoolSep
An innovative solution for Subsea Produced Water Separation for deep-water / high pressure applications

SpoolSep Testing Loop

Artistic view of SpoolSep Subsea Separation Station
Agenda

- Subsea L/L separation
- SpoolSep principles and design
- Qualification tests
- Conclusion
Principles and Incentives

- **Subsea L/L separation and water Re injection**
  - **Principle**
    - SpoolSep for subsea bulk water separation
      - Made of several horizontal pipes working in parallel
      - Dedicated to deep/ultra deep waters as well as high internal pressure applications
      - High flowrates
  - **Incentives**
    - **Mature fields**
      - Decrease back pressure on wellhead
      - Increase recovery
    - Debottleneck topsides
      - Allow new tie back to existing facility
    - **New fields**
      - Increase recovery
      - Optimize topsides

- **Flowrate**
  - **Water Depth (m)**
  - **Marlim**
    - 900m WD
    - 20 kbdp
  - **Troll Pilot**
    - 340m WD
    - 60 kbdp
  - **Tordis**
    - 210m WD
    - 100 kbdp
SpoolSep Liquid/Liquid Separator

- **SpoolSep**
  - Does not require Large Pressure Vessels
  - Suitable for Deep and Ultra Deepwater
  - Reliable Process Design (Gravity Separation)
  - Good Slug Handling Capabilities
  - Modular system: based on deepwater spools design
  - “Off the Shelf” Components

- **Subsea Station Architecture**
  - 2 foundations
    - 1 for the station with all the process
    - 1 smaller for pipes support
  - 1 subsea station with main process equipment
  - All active parts gathered on the same structure
    - standard integration and test principle
Separation Principle

Outlet: several options
- Independent outlet for each phase
- Oil and gas recombination (stand pipe)

Base case with stand pipe
- a single outlet for water and for light phase (collectors)
  - Water level controlled by liquid pumps
  - Oil and Gas exported to surface (MPP)
**Test facility design & Test philosophy**

**FROM**

- SpoolSep design (full scale)

**Performances vs Design criteria?**
- OiW content
- WC in oil outlet

- Scale 1 design:
  - 8 pipes of 21.75” ID, 50m L

**Design criteria**
- Flow regime
- Residence time
- Cut off diameter

**TO**

- Reduced scale tests & Prototype design

**Same performances**

**Superficial velocities conservation**

**Flow regime conservation**

**Scale (1/2.8)**

**Flow loop capacity**

- Reduced scale design:
  - 4 pipes of 8” ID, 18m L

**Prototype design and definition of tests conditions**

**Several variable parameters**
- Flowrates – flexibility
- Inlet water content
- Inlet gas volume fraction
- Inlet shear/mixing condition
- Water hold up
- Inclination
- Flow regime

**Base case for design: WoA**
- Liquid 92-50 kbdp
- 75-10% GVF
- 30-85% WC
- DP 235 bar, 1340mWD
- Separation @60 bar, 50°C
- Oil @ sep cond. 4 cP, 790 kg/m³
Flow Loop Principle

Test facility at Nantes
Flow Loop Assembly

Transparent Model
Reduced scale 1/2.76
4 spools L 18m
MainPipe 200mm ID
Feedline 56mm ID
Part 1 Experimental Program: Separation performances

- 144 tests
- 4 spools working in parallel
- Data acquisition
- Photos /films
- Operating points
- Flow patterns

Horizontal flows
GVF impact

OP1_ QI_40m3/h_WC35%_GVF57%
OiW content

Design criteria references for OiW performances with

- water velocity
- residence time
Conclusions

- **Evaluation of design criteria...**
  - velocity, residence time, flow patterns

  ...**versus targeted performances**
  - Oil in Water content / Water in Oil content
  - Level control

- Better assessment of **gas impact on SpoolSep design**

- Confidence in **design flexibility** (diameter and length) to accommodate wide range of requirements
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