Extreme HP/HT well control
- Closing the technology gap

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Introduction

With the continuing challenge to develop hydrocarbon fields which are deeper and hotter, closing the many technology gaps to provide safe and reliable operation remains an industry priority

Focus for this presentation
1. Hydraulic control of HP/HT wells – present experience & future challenges
2. Review limiting factors of hydraulic fluids and interactions with key hardware
3. Environmental considerations
4. Power of collaboration
5. Technical recommendations and summary

Acknowledgements
Thanks to Susannah Linington (Environmental Toxicologist) and Ashley Woods (Environmental Modelling Advisor) for environmental impact assessment and modelling
Both water-glycol and synthetic based control fluids have their place in delivering high levels of reliability.

As an industry, the majority of experience is with water-glycol control fluids (>90% of subsea systems).

However synthetic fluids have enabled access to increasingly challenging reservoirs.

Total West Franklin pushes the boundaries into extreme HP/HT conditions, 197°C (387°F) 2015 start-up.
Thermal Effects on Control Equipment

**Downhole Safety Valve**

**CHALLENGES**
1. Long term extreme Temp/Press
2. Seal degradation and extrusion
3. Uncertain seal life (LET)
4. Friction – low fluid viscosity

**Subsea XTree**

**CHALLENGES**
1. Heat soak into actuators (Thermal FEA)
2. Rod and Piston seals life
3. Fluid/Material compatibility data gaps
4. Tree insulation

Images courtesy of Halliburton

EXTREME TEMP/PRESSURE - TRAPPED FLUID - NO FLOW

MODERATE TEMP/PRESSURE – FLUID FLOW - ENVIRONMENTAL
Vendor Collaboration Key to Success

- Shared technical expertise and experience
- Aligned specifications and safety factors
- Early identification of risks and mitigations
- Faster journey to TRL4

**EXAMPLE 1**
Fluid /Materials qualification with XTree Vendor for XHP/HT application
- Estimated actuator heat soak require testing close to 150°C (300°F)
- Polymers, Elastomers, Metals, Coatings - including 10% Seawater

**VALUE**
- Early alignment of key test conditions and pass/fail criteria
- Proved compatibility (Stage 1) before starting costly functional equipment tests (Stage 2)

**EXAMPLE 2**
Fluid approval work with Completion Vendors (Cyclic DHSV testing to API 14A)
1. Functional test at 215°C (420°F) - Castrol Brayco Micronic SV/3 Fluid
2. Functional test at 232°C (450°F) – Castrol Synthetic Prototype Fluid

**VALUE**
- Shared learnings on test setup and critical materials selection
- Increased the limit for reliable DHSV control to 450°F
Improved Environmental Assessment

Current Approach

HAZARD Based Fluid Assessment

- Generate biodegradation, bioaccumulation and toxicity data by testing
- National regulator assesses data and highlights components which are non compliant and require phase-out - ‘substitutable’
- Ranks components and products according to the country’s system (e.g. green, yellow, red, black for Norway, or A-E for UK OCNS).

Modelling Technique

RISK Based Approach

- Used to model produced water and drilling fluid discharges – now able to model discharges from subsea trees
- Includes historical current, wind, bathymetry, and sea temperature data
- Provides quantitative assessment of the potential environmental risk posed by a chemical discharge
- The risk at each location and time is calculated by summing the risk from each chemical component e.g. Water + MEG + each Additive (Inc. Qty)

**Hazard**
Something with the potential to cause harm – intrinsic property of the chemical

**Risk**
The Likelihood of Harm to the Environment Resulting from Exposure to a Potential Hazard

\[
\text{Risk} = \text{Hazard} \times \text{Exposure}
\]
Standard Modelling conditions used for fluid performance comparisons:
Discharge point = 4 m above seabed, Volume = 30m³, Discharge Duration = 1 day, Modelling Duration = 3 days
Subsea System Approach

### Conventional

- **Control Umbilical**
  - LP
  - HP
  - DHSV

**EXPERIENCE**
- Water based & Synthetic control fluids
- Open & Closed circuit systems
- Water based – Lower cost, up to 167°C
- Synthetic – closed systems, up to 200°C

### Deepwater ( Likely Ex & Ultra HP/HT )

- **LP**
- **HP**

**EXPERIENCE**
- Water based fluid
- Open circuit systems

**OPPORTUNITY**
- Synthetic fluid in open circuit (simpler syst.)
- Maximises reliability at extreme temps, up to 500°F

### Split Hydraulic System

- **LP**
- **HP**

**NEW APPROACH**
- Water based fluid to control LP XTree actuators (open circuit)
- Synthetic fluid to control HP high temperature DHSV
- Allows optimum fluid selection for each application rather than single compromise solution

**Separate fluid lines in single umbilical**
Summary

• A collaborative approach between equipment vendors and lubricant manufacturers is essential to reduce risk, cost and time to achieve TRL4

• Moving beyond current HP/HT conditions may require new system architecture to meet the different needs of subsea and downhole control

• Synthetic fluids have the potential to deliver optimum reliability in all elements of the control system right up to ultra HP/HT

• Environmental modelling shows that synthetic fluids can potentially be used in open circuit systems, which improves simplicity, especially important for deep water

• Continued investment in R&D is imperative to be prepared for new developments beyond the current environment