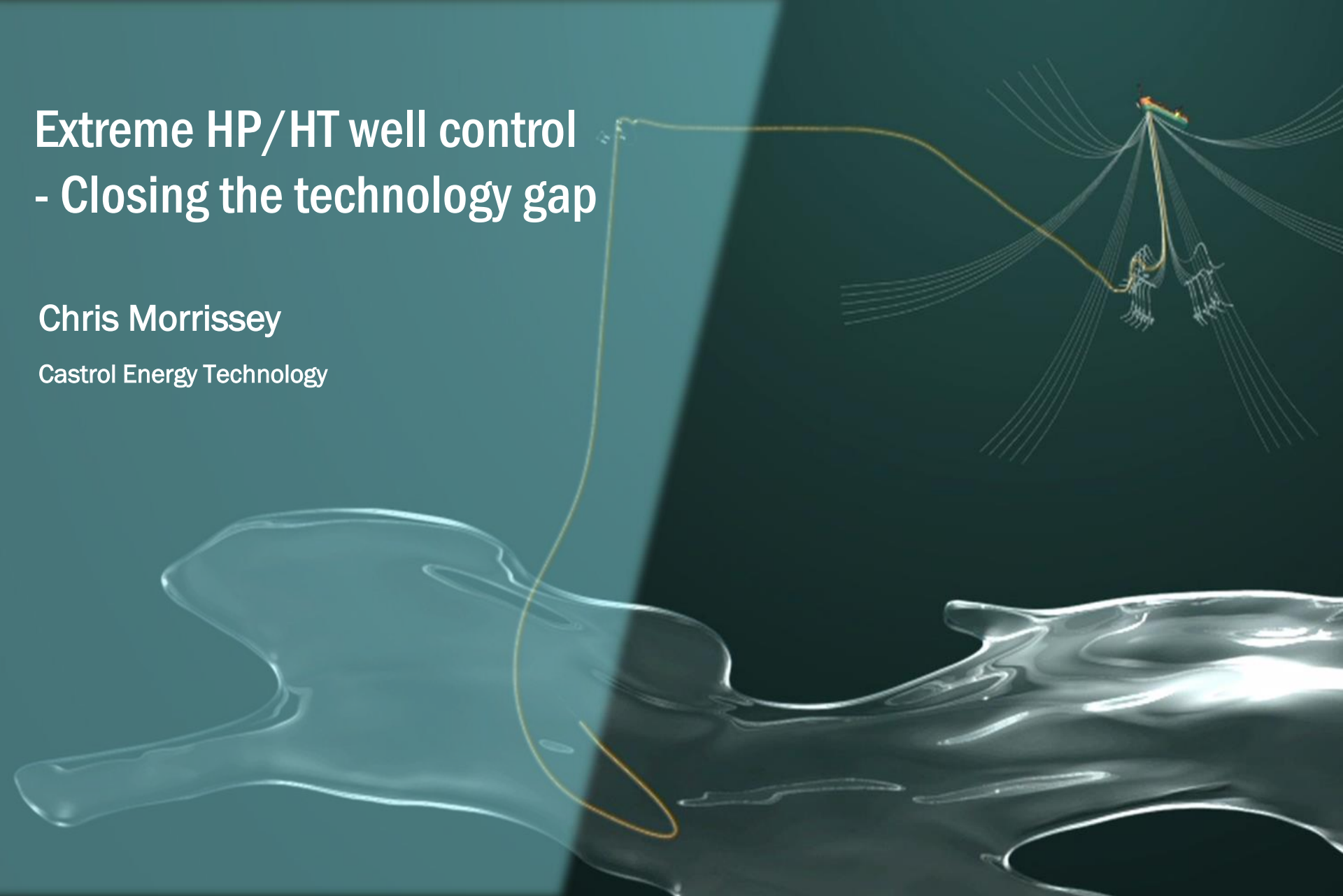


Extreme HP/HT well control - Closing the technology gap

Chris Morrissey

Castrol Energy Technology

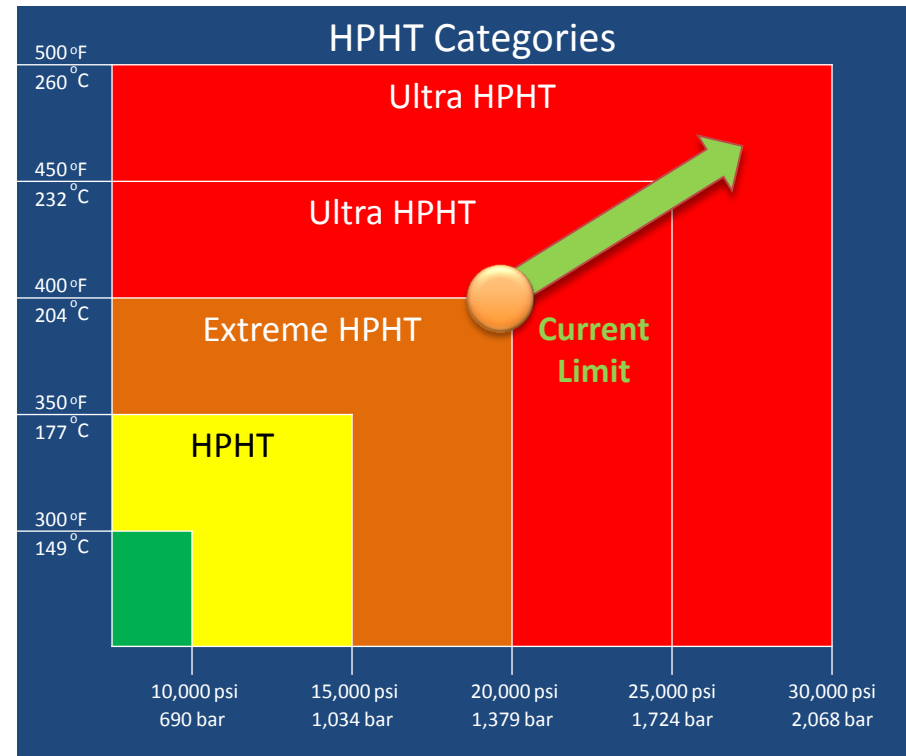


Introduction

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. Present HP/HT experience to date
2. Review limiting factors of hydraulic fluids in control hardware
3. Explore a new system approach
4. Technical summary



Existing Operational Experience

Water-glycol

(CASTROL TRANSAQUA HT2)

(CASTROL BRAYCO MICRONIC SV/3)

Synthetic

Canyon Express
Akpo

Thunder Horse

Erskine

Kristin

Åsgard

Elgin/Franklin

West Franklin

120°C

135°C

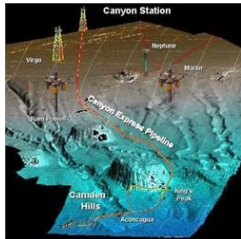
150°C

140-150°C

135-167°C

180°C

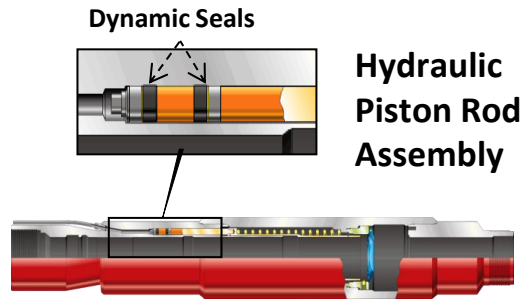
199°C



- Both fluids types have their place in delivering high levels of reliability
- As an industry, >90% of subsea systems run on water-glycol fluids
- Synthetic fluids have enabled control of increasingly challenging reservoirs

Thermal Effects on Hydraulic Fluid & Control Hardware

Downhole Safety Valve



Images courtesy of Halliburton

Subsea XTree



Hydraulic Fluid



Aqueous

Synthetic

CHALLENGES

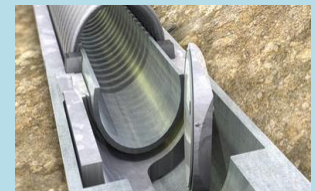
- Long term extreme Temp/Press
- Seal degradation and extrusion
- Uncertain seal life
- Heat soak into actuators
- Rod and Piston seals life
- Material data gaps
- Tree insulation
- Fluid breakdown
- Deposit formation
- Increase in acidity
- Materials attack

RISK MITIGATIONS

- Thermal FE analysis
- Polymer LET (Norsok M710, API6J1)
- Long term fluid aging
- Functional equipment test

IMPLICATIONS

- Time & Cost \$\$\$\$
- Equipment availability
- Relevant standards

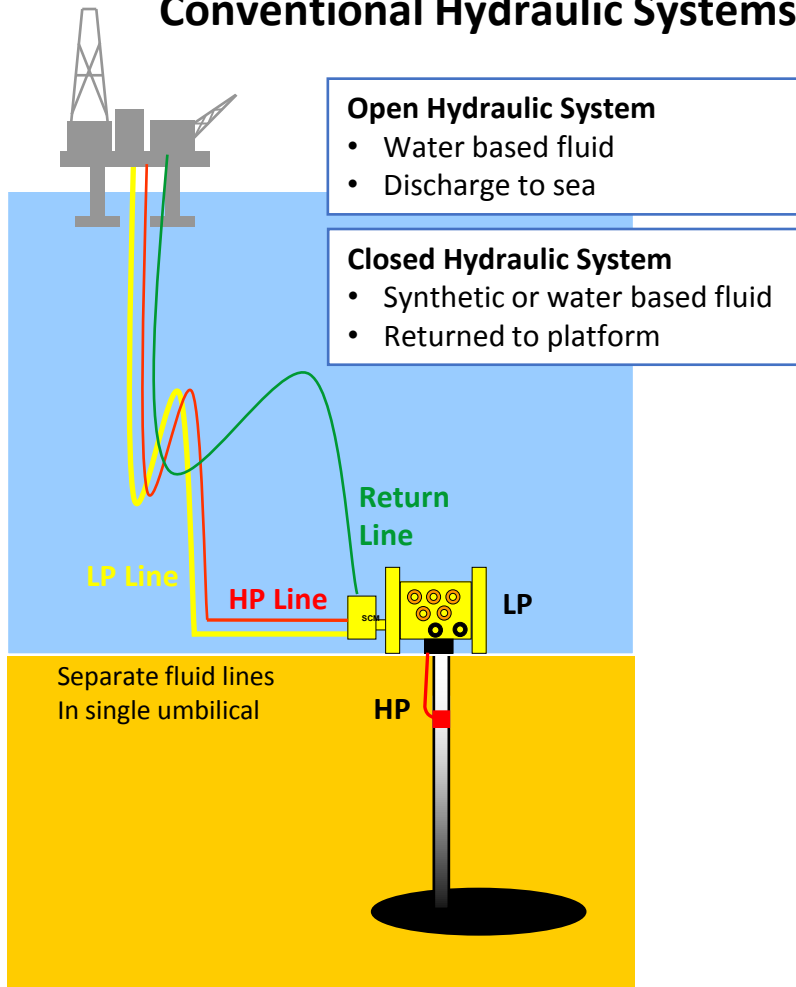


Fluid Comparison – Aqueous v Synthetic

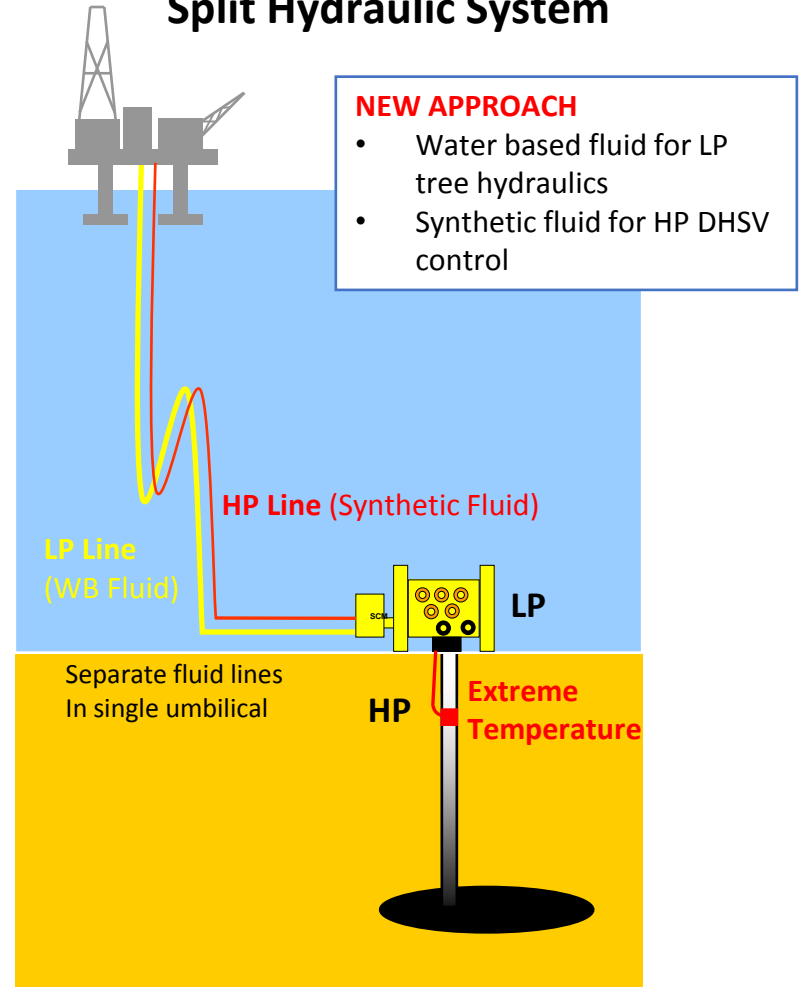
| Parameter | Aqueous Control Fluid | Synthetic Control Fluid | Significance |
|-----------------------------|---------------------------|--|--|
| Chemistry | Water / MEG / Additives | Synthetic Hydrocarbon / Additives | Different properties |
| Viscosity @ 0°C | 8 cSt | 20 cSt | Long offsets |
| Specific Gravity | 1.04 | 0.83 | Deepwater |
| Upper Thermal Limit | 177°C (350°F) | 204°C (400°F) 230°C (450°F) Qual DHSV | uHP/HT |
| Materials Compatibility | Good | Excellent | Critical Materials Protection, Storage |
| Environmental Compliance | OSPAR No Substitutable | OSPAR No Substitutable | Identical Testing Suite Similar performance |
| System Configuration | Open or Closed | Closed | Operator Choice |

Subsea System Approach

Conventional Hydraulic Systems



Split Hydraulic System



IT'S MORE THAN JUST OIL. IT'S LIQUID ENGINEERING.



Summary

- The push to uHP/HT may require a fresh look at system architecture – optimising systems to meet different needs of subsea and downhole control
- Aqueous and synthetic fluids both have good environmental profiles and go through the same rigorous testing
- Synthetic fluids already qualified with DHSV at 230°C (450°F), with good stability up to 260°C (500°F)
- Continued investment in R&D is imperative to support facilities to qualify new materials and components, including operational fluids

QUESTIONS ?