Technical Flushing and the Supercritical Flushing Revolution

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Failure in Subsea Hydraulic Systems

Typical subsea hydraulic issues associated with contamination include:

- Subsea valves slow to actuate or inoperable
- Blocked umbilical/control lines
- SSSV problems

Currently these issues are managed by:

- Flushing the hydraulic system prior to it being commissioned
- Online and offline filtration
- Expensive intervention works

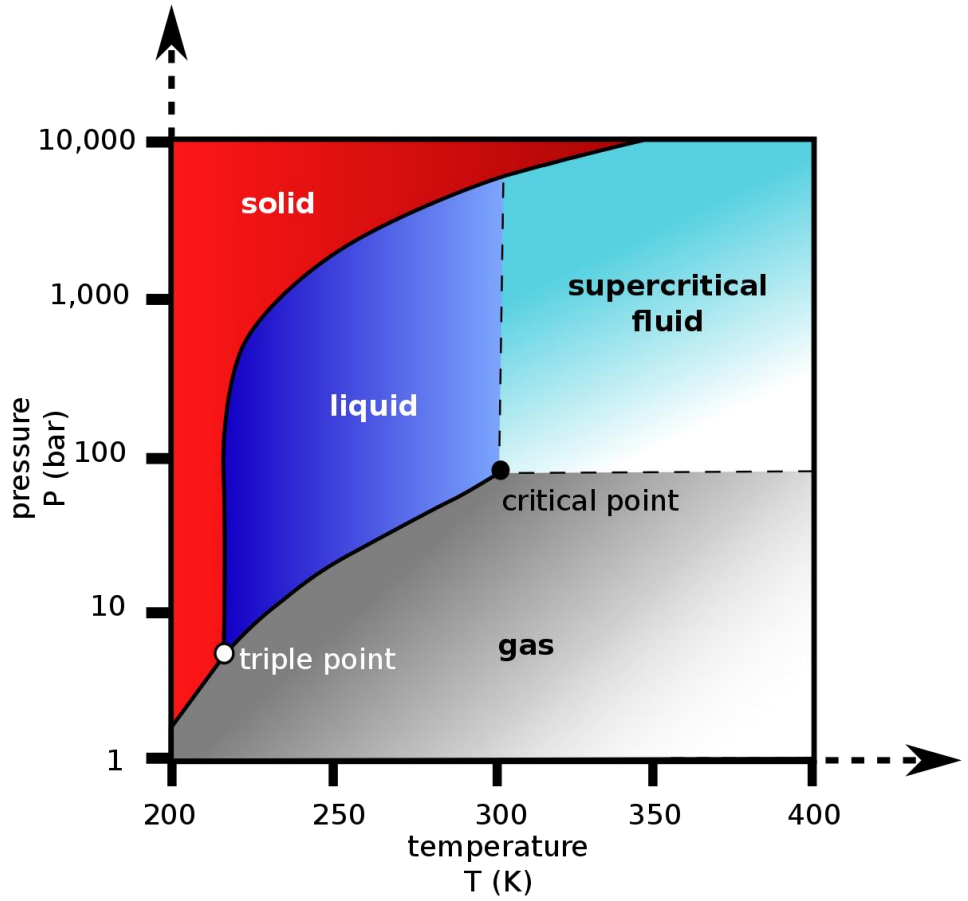
In one way control lines, there are no traditional methods capable of flushing or removing fluids and contamination.

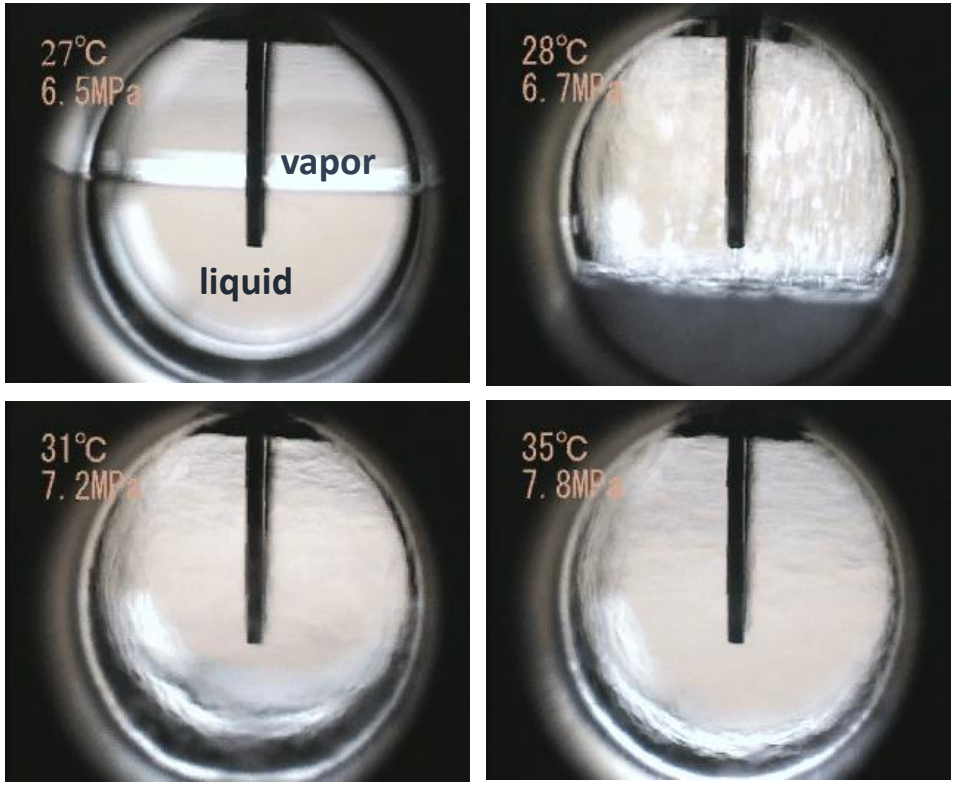
Failure in Subsea Hydraulic Systems

Sources of contamination include:

- Wax, containing many particles (a residue of pipe production)
- Particles from the production of umbilicals
- Microbiological growth (due to bacteria)
- Non-filtered fluid
- Particles from handling, component failure

What is Supercritical CO2?





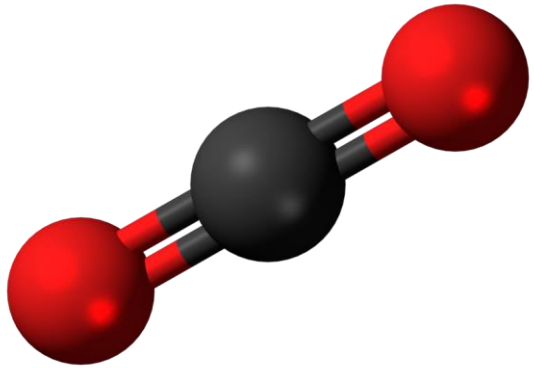
SC CO_2

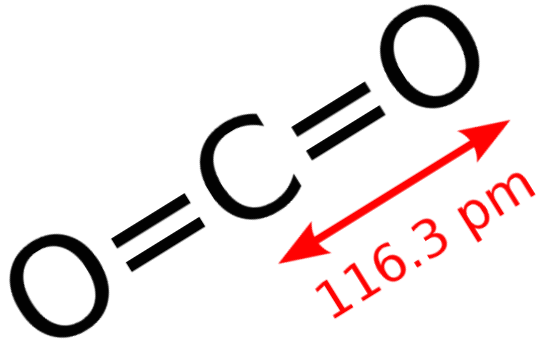
By increasing both temperature and pressure, CO2 can be controlled in a state that is neither liquid or gas. This phase is called Supercritical CO2 (SC CO2).

Why Supercritical CO2?

SC CO2 has specific properties making it ideal for use as a solvent:

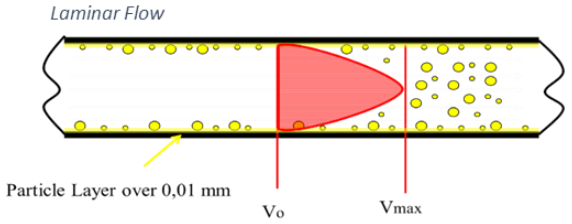
- Ability to effuse through solids like a gas (high diffusivity)
- Low viscosity (gas-like)
- Zero surface tension
- Density can be influenced (by controlling temperature and pressure)
- Nontoxic, environmentally safe and recyclable
- No residue/cross contamination
- The same dirt carrying capacity as oil

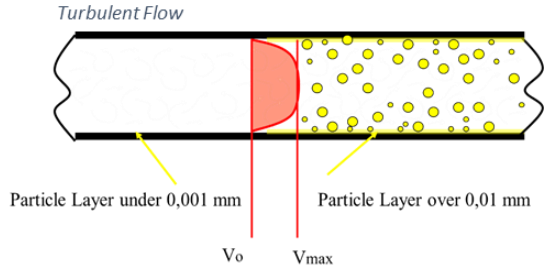




Application of SC CO2 – Flushing

The use of high velocity turbulent fluid to scrub the internal lining of a conductor (tube/pipe/hose).



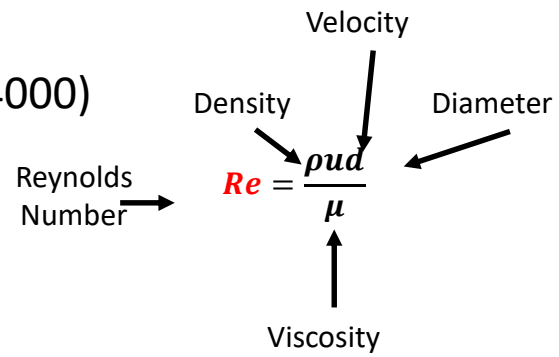


Traditional methods

- Use of oil or subsea control fluid
- Challenges in achieving acceptable turbulence for long lines (umbilicals) due to required pressure to circulate fluid

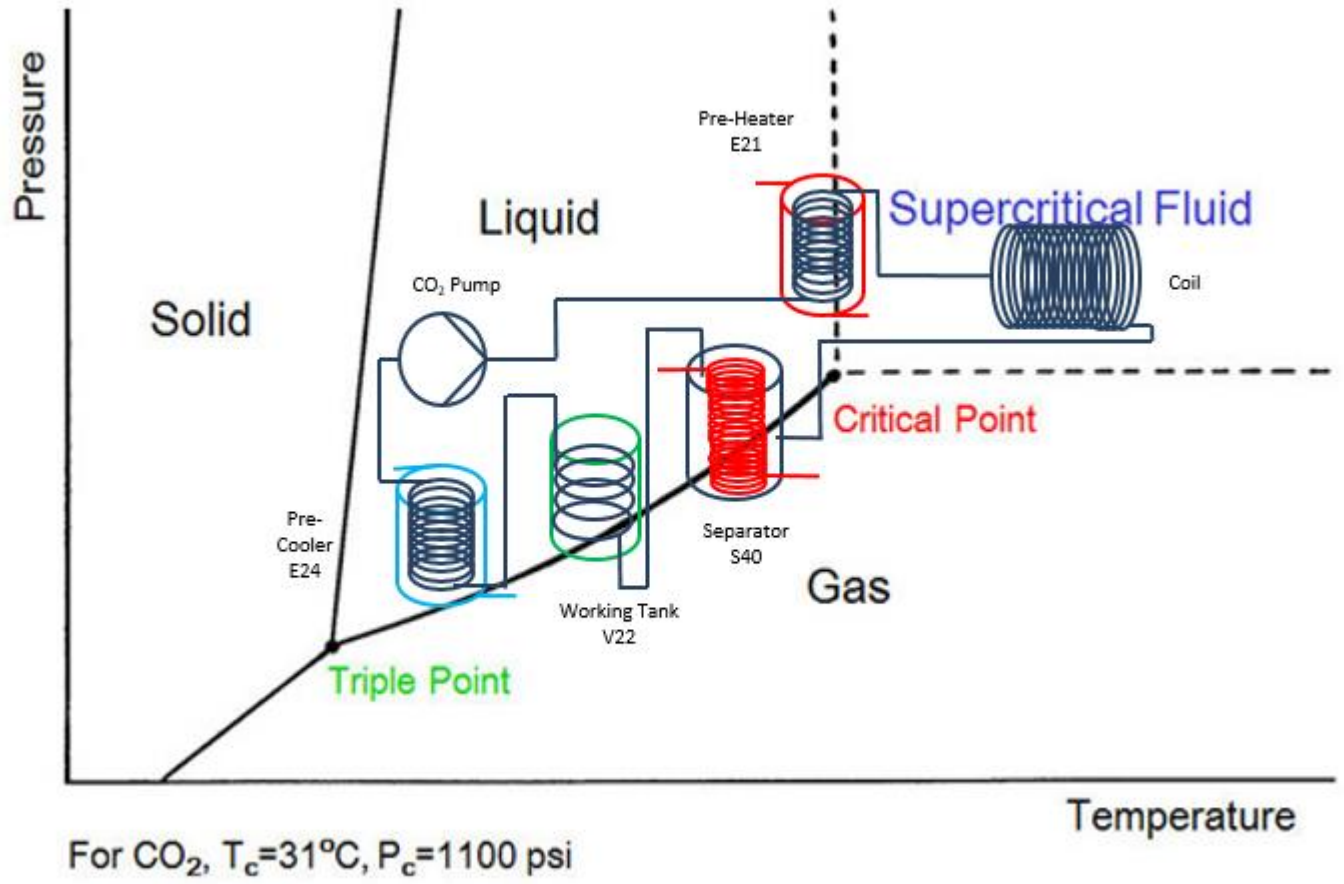
Concepts

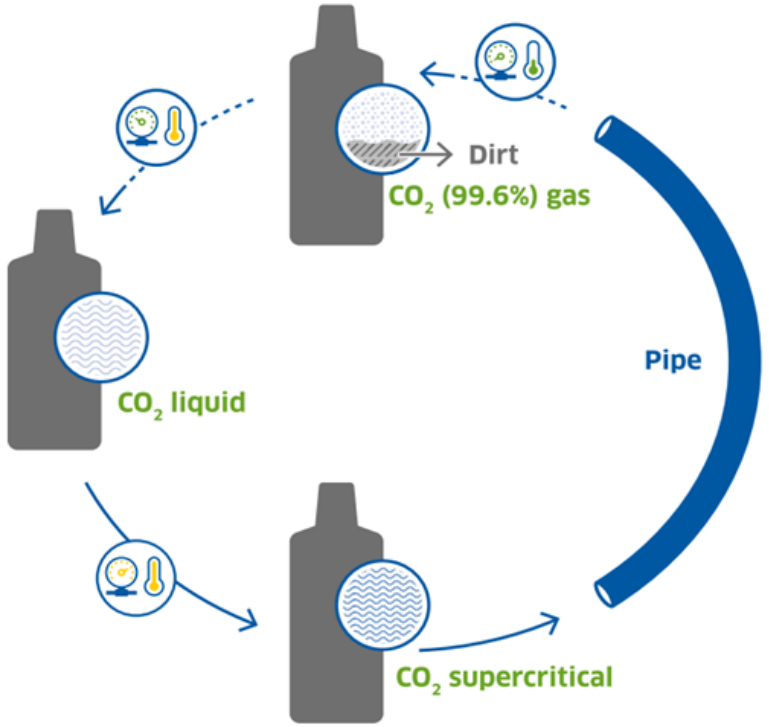
- Laminar flow
- Turbulent flow (Re > 4000)
- Boundary layer



Description	Density (g/ml)	Viscocity (cSt)	Typical Reynolds No	Dirt Carrying Capacity
Water/Glycol	0.998	4	1800	Average
Oil (Brayco)	0.820	18.9	80	Good
CO2 Liquid	1.050	0.1	20,000	Good
CO2 SC	0.950	0.088	30,000	Good

Application of SC CO2 – Flushing





Application of SC CO2 – Flushing

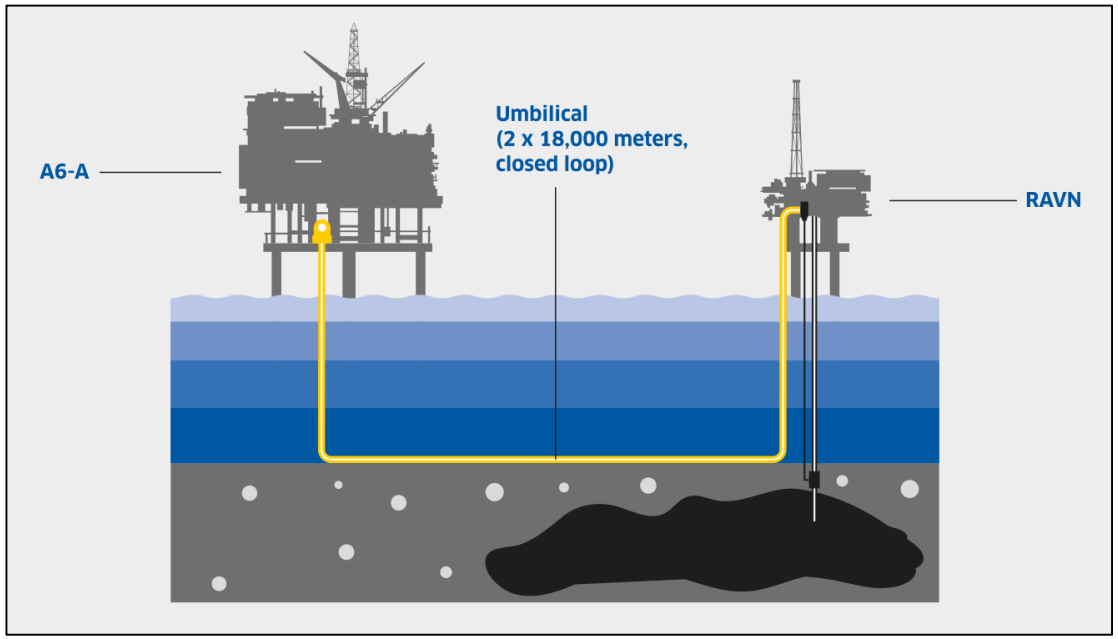
Circulation Pump

Ex-Heater

Tank + Separator

Application of SC CO2 – Flushing

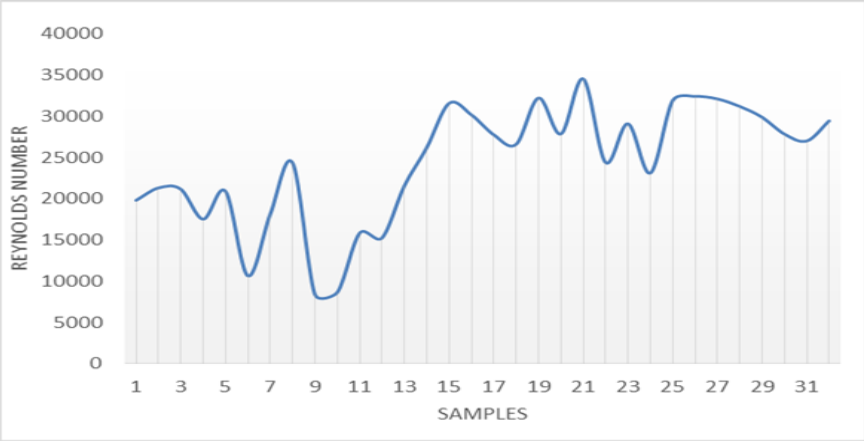
Case Study: Umbilical flushing on Wintershall Noordzee A6A-Ravn

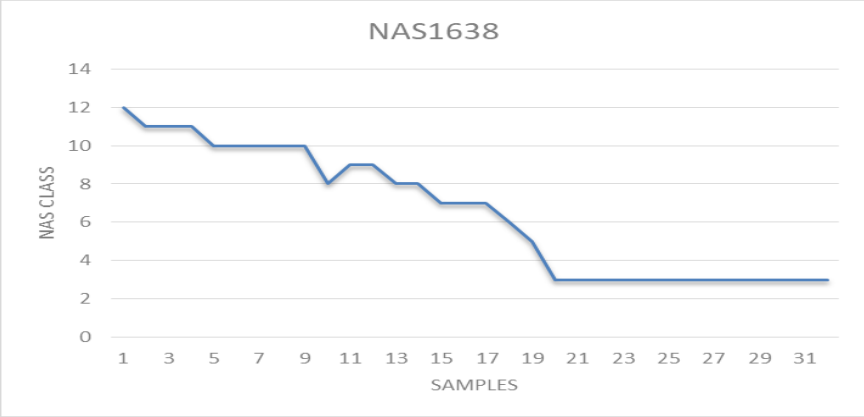


- 2x 19km control lines
- Previously flushed umbilical using traditional methods (subsea control fluid as the medium)
- Duration of 14 days

Application of SC CO2 – Flushing

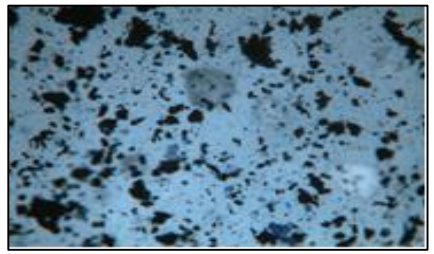
Flushing and samples





Patch test results

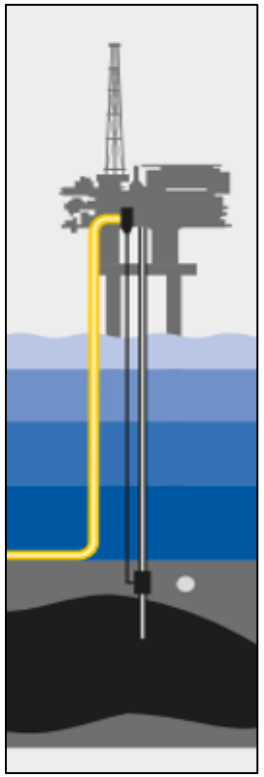
NAS1638 grade 12



NAS1638 grade 3

Application of SC CO2 – Back-flushing and Unblocking

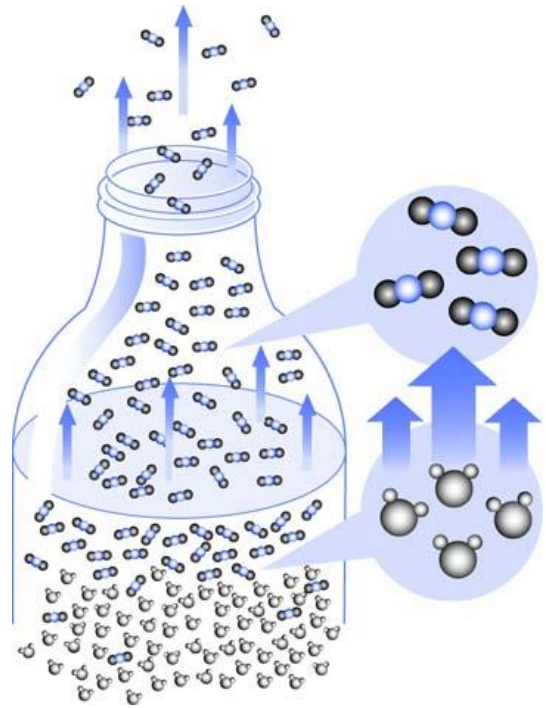
- Back-flushing
- Changing fluid in one way lines
- Unblocking of lines
- Lifting media out of one way lines



Application of SC CO2 – Back-flushing and Unblocking

The process of back-flushing/unblocking:

- CO2 manipulated as supercritical or fluid according to application
- Control line pressurised
- Pressure held in line for period of time (depending on line size and media)
- Depressurisation to remove fluid/contamination
- Process repeated as required



Notes:

- Measurement of fluid volume upon return into separator to determine depth during fluid removal
- Fluid removed from line prior to unblocking of control line
- Contaminant able to be inspected and sampled

Application of SC CO2 – Back-flushing and Unblocking

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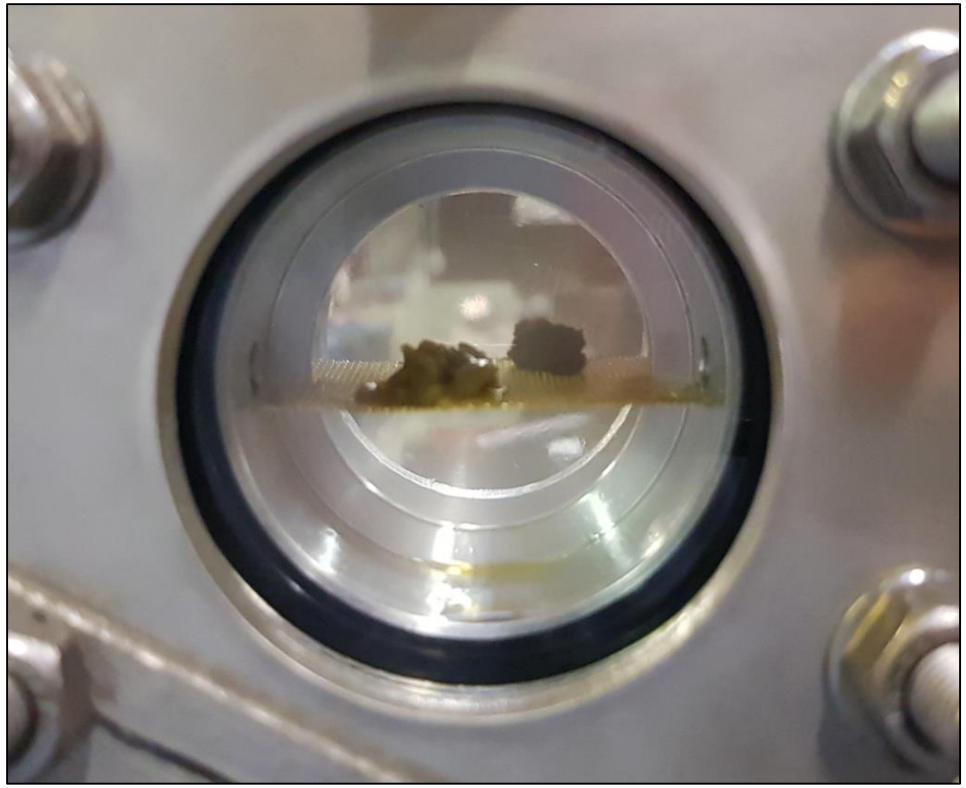

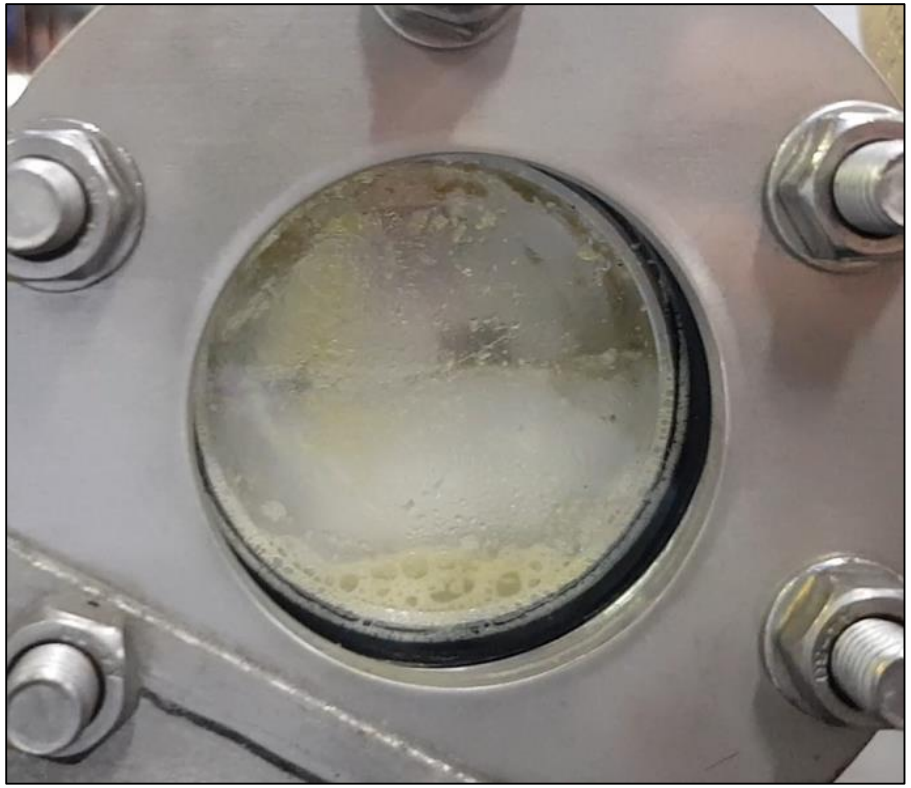

Application of SC CO2 – Back-flushing and Unblocking

Case study for a major North Sea oil & gas operator in Denmark.

- Blocked ¼”, 1.5km control line
- Three months spent attempting to unblock with alternative methods
- Within three days, a small hole achieved with SC CO2 technologies

Application of SC CO2 – Back-flushing

Case study for a major North Sea oil & gas operator in the UK.

Lifting up Barium Sulphate from a SSSV Control line at 600ft.

BaSO4 can be dissolved in concentrated hot sulfuric acid.

Thank you! - Questions?

Joel Woolerson
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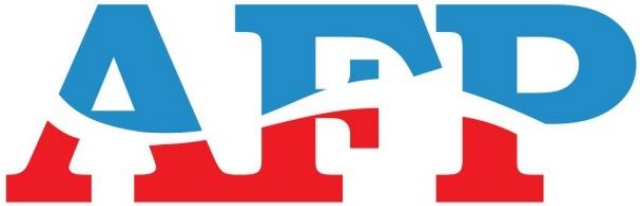

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