

SCCO₂ Flushing Technology: the Supercritical Revolution



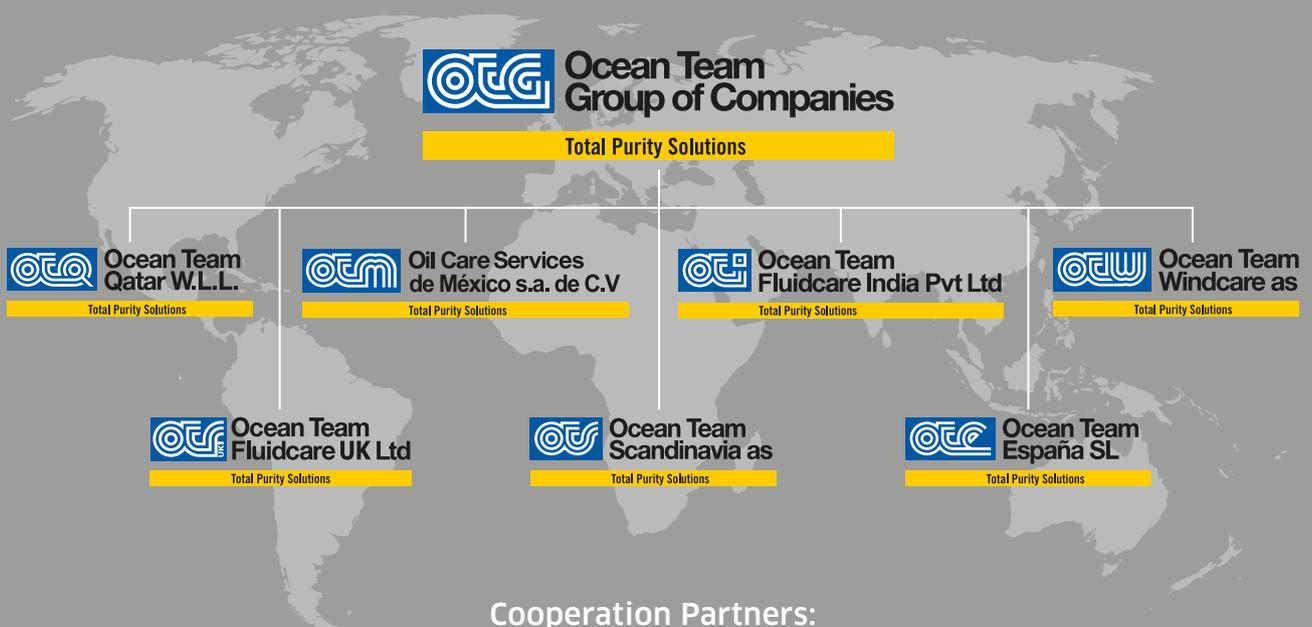
**Ocean Team
Scandinavia as**

Total Purity Solutions

Be Local by Going Global: the Ocean Team Group

Ocean Team Group (OTG) provides its services worldwide, especially to companies within the energy sector (e.g. oil and gas extraction, power stations, CHP plants, wind turbines, refineries). Our vision is clear: we aim to gain global recognition as the leader in purity solutions and treatment of technical and fluid transfer systems. In all that we do, we live by the philosophy “Be Local

by Going Global”. We are constantly looking for potential options of cooperation with local professionals and reliable service companies worldwide. Ocean Team Scandinavia A/S is based in Esbjerg (Denmark) and represents the Nordic region and supports the world. The revolutionary SCCO₂ technology was developed and made market-ready here.



Our Core Competencies



Oil Care



Mechanical Services



Chemical Cleaning



Special Equipment

The Quantum Leap in Cleaning Technology

The period of easy oil is definitely over. By now new deposits are only tapped into and used with considerable technical effort. This means: the conveyor machinery is more complex and vulnerable to disruptions. Failures can lead to immense damage.

The pipes for hydraulics and chemical additives, in particular, are subject to great strain due to contamination. So far, however, it has hardly been possible to guarantee the required cleanliness for safe operation.

This is why Ocean Team Scandinavia's revolutionary technology is a true quantum leap: by using supercritical carbon dioxide, for the first time especially thin and long pipes, too, can be thoroughly purified from production waste and contamination during operation. This is the prerequisite for the conveying systems to operate on an even keel.

Water

Supercritical CO₂

With supercritical CO₂, we can flush pipes ten times longer than with water - a true revolution in cleaning technology.

I have been accompanying the development for years and am glad that our patented SCCO₂ technology has not only proved itself in extensive tests, but also in first customer projects. Experts tell us: there is currently no other system on the market that comes even close to performing with the same efficiency as our solution does.

Come and see for yourself - I look forward to working with you.



A handwritten signature in black ink, appearing to read 'Espen Amundsen'.

Espen Kähler Amundsen
Managing Director, Ocean Team Scandinavia A/S

Contaminated Pipes

Cause Huge Costs

All parts of hydraulic systems (e.g. pipes, valves) as well as pipes for chemicals are suffering from dirt – up to the point when they stop operating properly: **80 percent of all breakdowns in fluid transfer systems are due to contamination of the fluids.** Therefore, the most important component inside a fluid transmitting system is the fluid itself. The consequences of contamination are fatal: failures of components (e.g. valves) and clogging

of return lines or umbilicals interrupt production, **causing huge costs for the subsea industry.** Until now, no efficient cleaning solution was available – especially for long pipes with small diameters, which are frequently found in the oil industry. The same is true when it comes to changing the hydraulic oil or cleaning the Xmas tree. Today, pipes and Xmas trees have to be raised topside – a complex and expensive procedure.

There are different sources of dirt:

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



Contamination Standards

Several standards define the purity of fluids like hydraulic oil. Widely used is NAS 1638 (National Aerospace Standard), defined in the 1960s. It is based on counting particles of different sizes under the microscope. The purity level of a hydraulic system should be better than NAS 1638 Grade 6. This means for example that less than 16 particles bigger than 100 micrometers should be found in 100 milliliters of fluid.

Our SCCO₂ technology achieves NAS 1638 Grade 3: there are only two particles bigger than 100 micrometers in 100 milliliters of fluid.

Recently, NAS 1638 was replaced by SEA AS4059. The last update is from 2013 and called AS4059F. There are some differences between both standards (e.g. calibration for APCs and particle counting). Users are encouraged to use AS4059, but NAS 1638 is still in use. Another alternative standard is ISO 4406-1999, which is also comparable to NAS 1638. Here, the quantities of particles per milliliter of three different sizes are counted: four micrometers, six micrometers, and fourteen micrometers (four micrometers is optional). Accordingly, the ISO code delivers two or three numbers.

Supercritical CO₂: the Perfect Solvent

Now a revolutionary new cleaning technology from OTS is available. It is based on supercritical carbon dioxide (SCCO₂) and allows flushing even very long and narrow pipes. What is supercritical CO₂? Alongside the well-known aggregate states solid, liquid and gas there exists another one: the supercritical state. In order to

transform a liquid into this state, the substance must be heated above its boiling point, and sufficient pressure must prevent its transition to the gaseous state. In the case of CO₂: the temperature and the pressure of the carbon dioxide have to be greater than 31.1 °C and 73.8 bar, respectively.

Supercritical CO₂ combines the best properties of a liquid and a gas:

- Low viscosity (gas-like and ten times lower than water) >>> turbulent flow even in long pipes with small diameter
- High diffusivity (gas-like) >>> penetrates wax, corners, blockings
- No surface tension >>> excellent solvent
- Tunable density >>> higher or lower, depending on the application
- Non-toxic and environmentally sound
- Kills bacteria
- Cost-saving

These extraordinary features make supercritical CO₂ the ideal solvent. It has the same carrying capacity as oil, but a much lower viscosity than water. Applying the same pressure, with supercritical CO₂ you can flush a pipe more than ten times longer compared to when

using water or oil. Due to the turbulent flow and its great solvent effect, supercritical CO₂ removes almost all wax and grease from the pipes, and kills the micro-biological growth – leading to an unprecedented level of cleanliness and reliability of your system.

Laminar and Turbulent Flow

There are two main kinds of flow: laminar flow and turbulent flow. Laminar flow consists of separate layers that do not mix and whose velocity decreases near the boundary. In contrast, turbulent flow is completely irregular – the velocity at one point changes continuously its magnitude and direction.

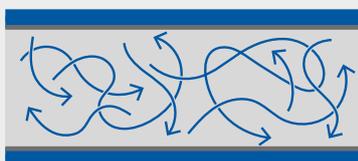
Laminar (filtrating a fluid)



The dimensionless Reynolds number (Re) predicts whether a flow is turbulent (ρ density, u velocity, d diameter, μ viscosity).

$$Re = \frac{\rho u d}{\mu}$$

Turbulent (cleaning a system)

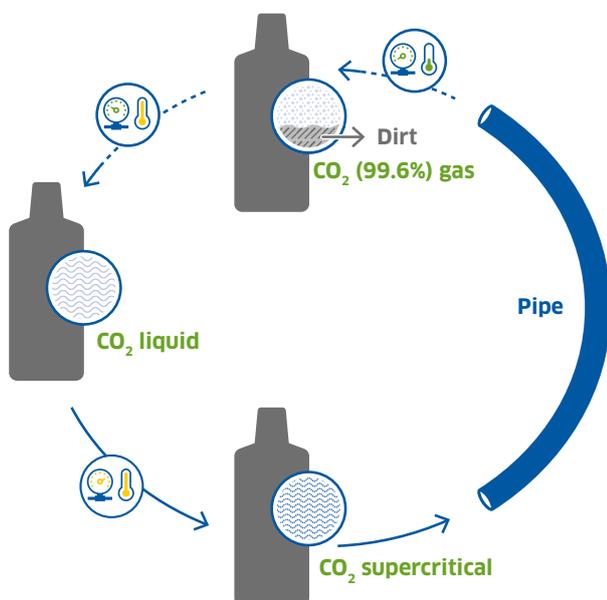


A Reynolds number of 3,000 or more guarantees a turbulent flow. With our SCCO₂ technology, we achieve Reynolds numbers greater than 50,000.

Flushing Becomes an Easy Task

Our revolutionary SCCO₂ technology is ready for you. Due to the use of supercritical CO₂, the flushing unit can clean pipes with lengths of 38 km and inner diameters of half an inch – without exceeding the pressure limits of pipes or valves. This makes flushing umbilicals, control lines and other pipes an easy task even under harsh conditions.

The flushing unit comes in a standard ten-foot container and can easily be transported to all platforms. It is equipped with an industrial PC and a big 24 inches color touch display. The user interface is optimized for intuitive control, and due to the unit's Internet connection, even remote technical support is possible. A log-file of the work flow guarantees complete traceability of all steps.



A closed loop: CO₂ is continually transformed from liquid to supercritical to gaseous state. Dirt is removed completely from the gaseous CO₂.

The flushing unit fits easily
in a standard 10 ft container

Specifications of the OTS Flushing Unit

The OTS supercritical flushing unit dissolves wax and grease. It can be used for long pipes with small diameters and cleans to AS4509 class 3 (ISO 4407 12/9).

Power supply	400 V, 50 Hz, 63 A
Max. working pressure	550 bar
Max. flow of CO ₂	> 200 kg/h
Design temperature	120 °C/-15.5 °C
In/Out connection	½ inch NPT

Packaging	10 ft container
Length	118 inches
Width	96.1 inches
Height	102.4 inches
Weight	3,800 kg

The OTS supercritical CO₂ flushing unit is CE-marked in accordance with the EC/2006/42 machinery directive and directive 97/23/EC.



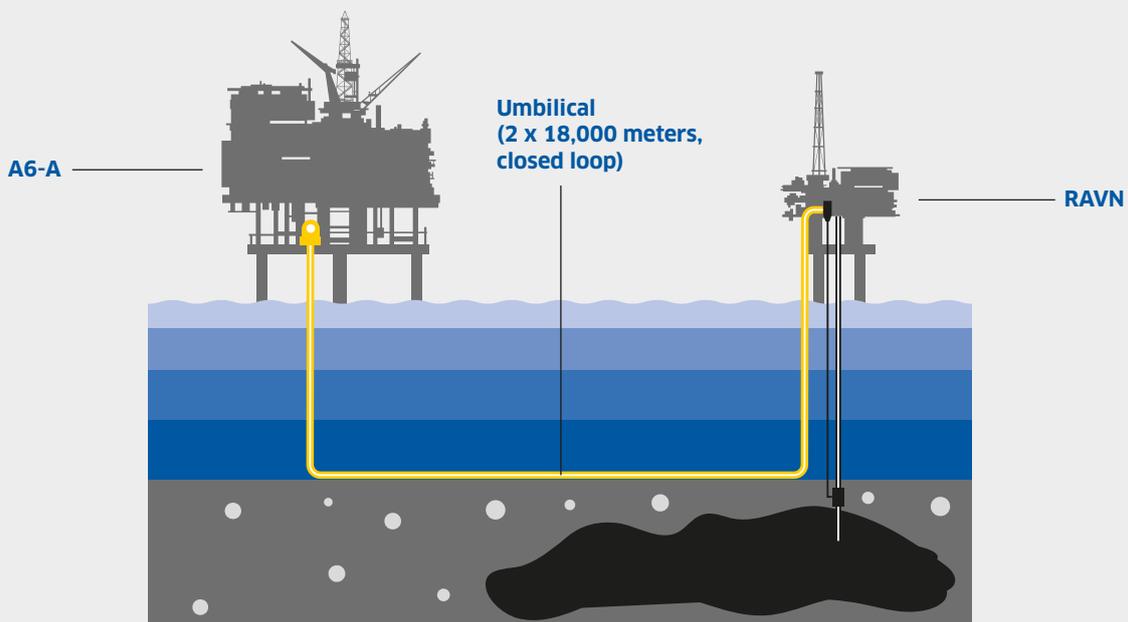
Ocean Team's SCCO₂: a Proven Technology

Before entering the market, we conducted exhaustive tests of our new technology. As proof of our concept an oil-filled control line (6,500 meters length, a quarter inch outer diameter, cleaned to a NAS 6, with laminar flow) was flushed with supercritical CO₂ and a Reynolds

number of approximately 35,000. The result: oil and wax could be almost completely removed. The final cleanliness level was NAS 1638 class 3. The maximum pressure drop along the 6,500 meters was only 200 bar.

Wintershall: CO₂-Flushing of an Umbilical

Wintershall's RAVN platform is located in the Danish part of the North Sea. An umbilical with 18,000 meters length (one-way) connects this satellite with the main platform A6-A. A single high-pressure hose inside the umbilical with a diameter of 12.7 millimeters is used to transport the asphaltene inhibitor to RAVN. This chemical will improve flow assurance by reducing negative effects of asphaltenes.



The challenge: the asphaltene inhibitor behaves like ketchup. Therefore, the hose inside the umbilical has to be extremely clean – cleaner than the hoses and pipes that are usually used in the oil and gas industry. Wintershall decided to target a cleanliness of NAS 1638 class 6 (before flushing, it was NAS 12). It soon became evident that existing technologies could not achieve this goal. Therefore, Wintershall turned to OTS to do the job and clean the loop with a length of 36,000 meters. The result was impressive: due to its unique properties, the SCCO₂ technology achieved NAS 3, significantly better than NAS 6. “That is exactly what we need: maximum high turbulences that transport all debris out of high pressure hoses and pipes,” says Wintershall engineer Ulrich Tiefes. “We achieved unprecedented levels of cleanliness with CO₂-flushing.”

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