CANTY

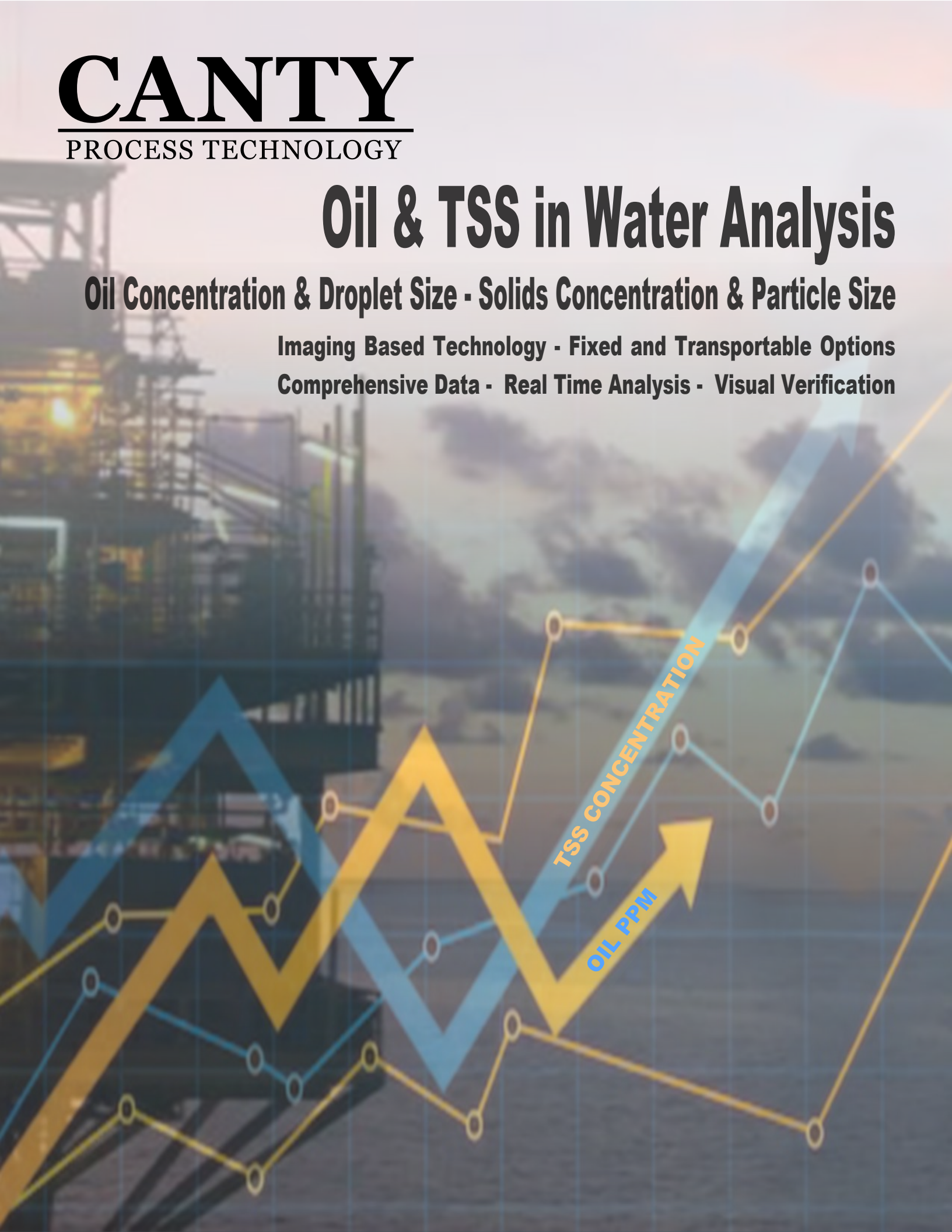
PROCESS TECHNOLOGY

Oil & TSS in Water Analysis

Oil Concentration & Droplet Size - Solids Concentration & Particle Size

Imaging Based Technology - Fixed and Transportable Options

Comprehensive Data - Real Time Analysis - Visual Verification



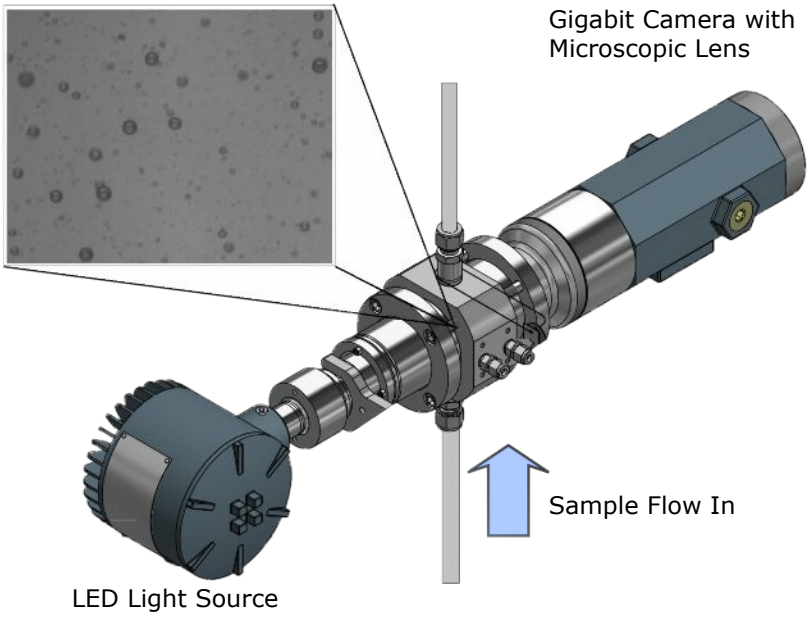
OIL CONCENTRATION - OIL DROPLET SIZE - TSS CONCENTRATION - TSS PARTICLE SIZE

CANTY's range of INFLOW™ analyzers combine the latest Gigabit Ethernet camera and microscopic optics technology, with our trademark fused glass, LED lighting systems, and CANTYVISION Intelligent Analysis™ software, to provide real time analysis (concentration & size) of Oil and Total Suspended Solids in Water.

Available in a number on configurations (**Direct Online, Side Stream, or Transportable),** the InFlow™ can be used anywhere within a produced water plant to optimise each stage of treatment, to ensure any separation equipment is running at maximum efficiency, and any environmental discharge limits are met. The performance of any separation equipment (hydrocyclone, CFU, IGF, membrane filters…..) is based on operating at the correct configuration for the inlet fluid condition. Similarly, the dosing volume & rate of production chemicals such as of emulsion breakers or droplet coalescers, is based on understanding what is present within the fluid to be treated. The InFlow™ gives this information by providing real time data for oil concentration & droplet size, and total suspended solids concentration and particle size.

SEPARATOR OPTIMISATION - CHEMICAL DOSING CONTROL - ENVIRONMENTAL REPORTING

How it works…



The INFLOW™ works on the principle of Dynamic Imaging. This technique works on the fundamental principle of flowing the water stream through the analyzer flow cell, where it passes between a high intensity LED light source and microscopic optics, allowing for high resolution image capture and analysis.

Image analysis is performed in real time by CANTYVISION Intelligent Analysis™ (CVIA) software, which measures the suspended particulate (oil, solids, gas bubbles) under a number of parameters to provide concentration and size data. The software's AI applies a multi level classification to differentiate particle types, meaning oil, solids, and gas bubbles are separately classified & analyzed.

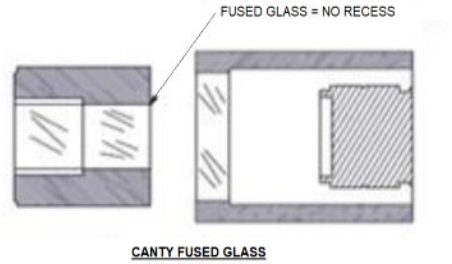
Key Technology

CANTY's **Fused Glass** technology is incorporated into the INFLOW™, where it is used for the windows on the system's camera and light. This provides a high pressure, impenetrable process barrier, with no crevices or spaces for particulate to build up and foul the glass.

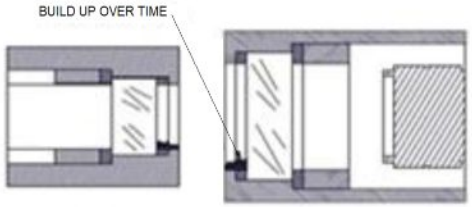
Lighting is the key to any imaging based measurement. The wavelength and intensity of the light, along with how to efficiently transmit that light from it's source into the imaging area, determine the quality of the images captured, and therefore the quality of the analysis performed.

The INFLOW™ high intensity LED light source, draws from CANTY's long history and vast experience in process lighting, allowing the camera optics to perform to their maximum specification to provide high resolution images, of high velocity droplets and particles, as small as 1 micron.

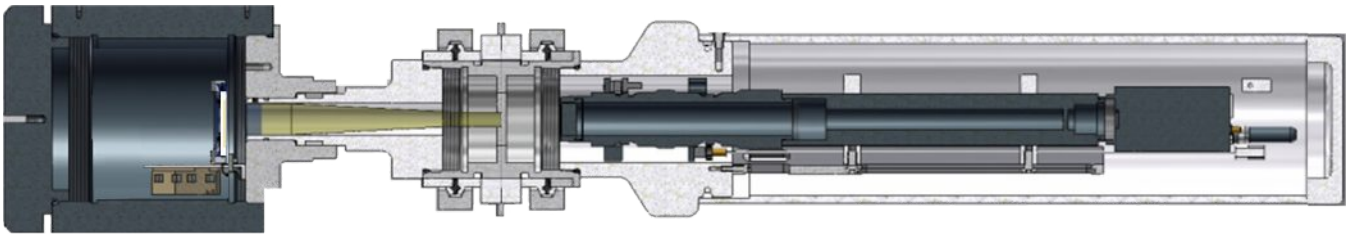
The light source was developed as part of the subsea marinisation of CANTY's technology, where reliability and long life are priorities, so the light source is rated for 50,000 hours of continuous use.

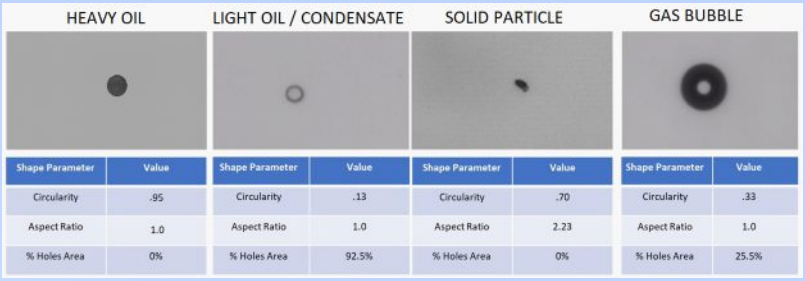


CANTY FUSED GLASS

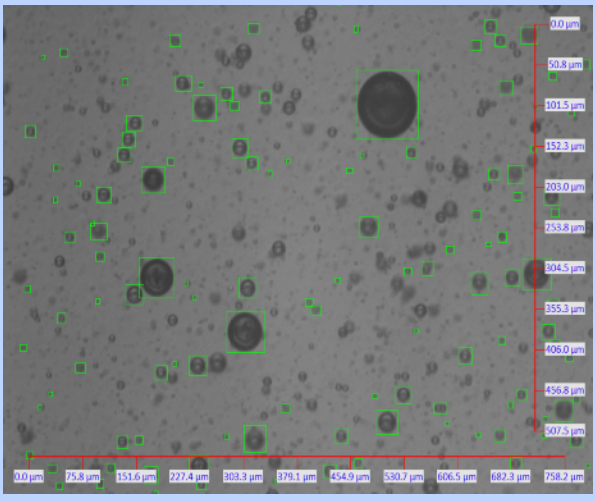


NON CANTY - PLATE GLASS WITH BUILD UP





CantyVision Intelligent Analysis (CVIA) software analyses each droplet and particle under 30+ visual parameters, allowing the system to differentiate between oil, solids and gas. The high speed processor ensures all of this is done in real time.



The intuitive CVIA interface allows the user to visually verify what the system is analysing, and view real time graphical trends for any parameters they may be interested in, while the user friendly functionality means adjusting any analysis parameters is a simple task.

Different types of oils are no issue, with light oils such as condensates also easily visualised and analysed.

Why Use Imaging Based Technology?

To put it simply, Dynamic Imaging based analysis is the most comprehensive and representative type of measurement that can be done for Oil and Total Suspended Solids in Water. With a single device, oil concentration, oil droplet size, TSS concentration and TSS particle size can be measured.

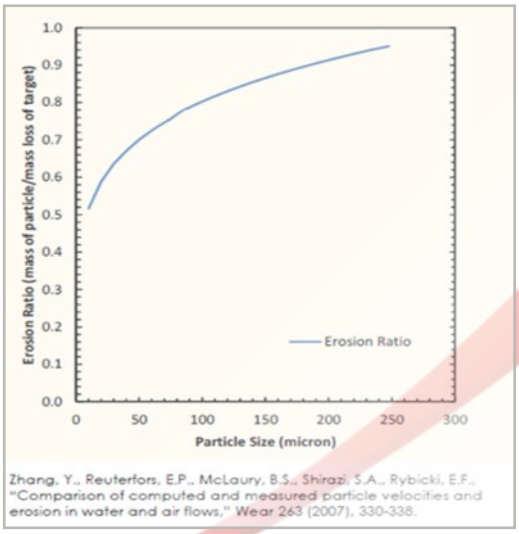
Unlike other technologies in use in the industry, Dynamic Imaging is a direct measurement technique. It is not measuring an often unreliable related property of the process fluid, and trying to back calculate concentration or size measurements. It is completely unaffected by changes in the chemical composition or salinity of the water, or the type of oil within the water. It essentially provides eyes in the process, and allows for real direct measurement of the size, shape and concentration of the oil droplets and solid particles within the fluid. All of this is done with the added benefit of seeing what they system is measuring, and visually verifying that the measurement parameters are correctly configured.

RELIABLE, REPEATABLE & DIRECT MULTI PARAMETER MEASUREMENT, WITH VISUAL VERIFICATION

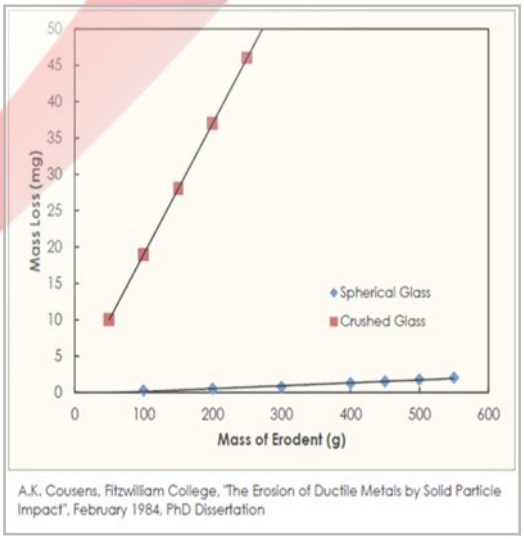
Importance of Droplet & Particle Sizing

Measuring oil concentration is very important, but in reality it only gives part of the picture.

A large percentage of oil - water separation technology is based on an accelerated gravity principle (Hydrocyclone, CFU, IGF…). Larger oil droplets will have a higher raising velocity, and smaller oil droplets will have a lower raising velocity. 100 ppm oil in water with a median droplet size of 40µm, would require very different treatment to 100 ppm oil in water with a median droplet size of 10µm. Therefore it is impossible to optimize any separation equipment without knowing the oil droplet size, in addition to the oil concentration. Similarly, how can the performance of an emulsion breaking or droplet coalescing chemical be assessed, without measuring the oil droplet size within the water.



Zhang, Y., Reuterfors, E.P., McLaury, B.S., Shirazi, S.A., Rybicki, E.F., "Comparison of computed and measured particle velocities and erosion in water and air flows," Wear 263 (2007), 330-338.



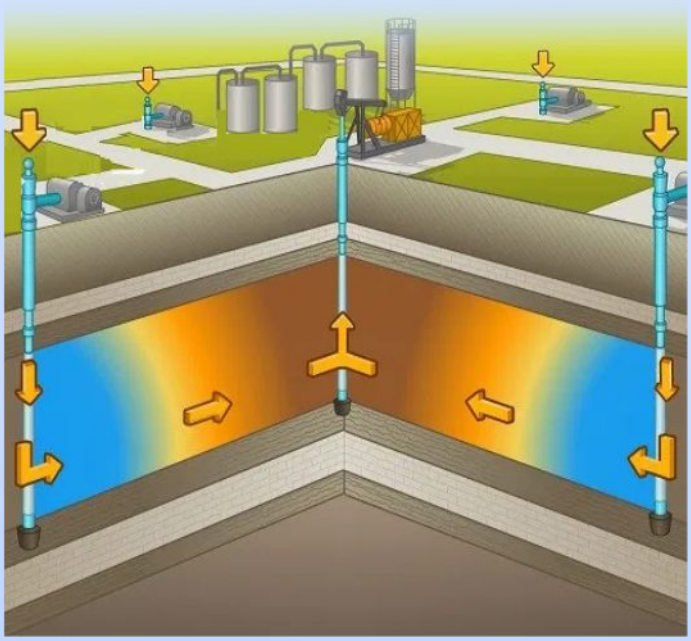
A.K. Cousens, Fitzwilliam College, 'The Erosion of Ductile Metals by Solid Particle Impact', February 1984, PhD Dissertation

The size, shape and concentration of the suspended solids within the water stream is equally, if not more, important. Larger solids, more angular solids, and a higher concentration of solids, leads to increased damage due to erosion, as well as significant plugging of pipelines, equipment, and reservoir pores if the water is to be re-injected.

Process Performance

Process Understanding

Optimizing EOR Strategy



"Treating Back Produced Polymer To Enable The Use Of Conventional Water Treatment Technologies", H. Al Kalbani (PDO) et al., SPE EOR Conference at Oil and Gas West Asia, 31 March-2 April 2014, Muscat, Oman

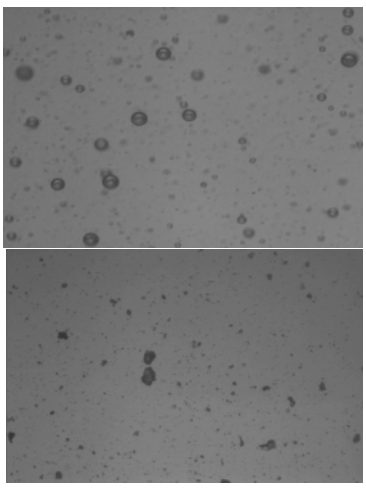
A study on the raising velocity of oil droplets in produced water within an IGF vessel, which found that the performance of the flotation cell decreases dramatically if the viscosity of the water increases by just 1.5-2 cP. It highlighted the importance of inlet droplet size, and investigated a variety of chemical and mechanical means to reduce viscosity while trying to avoid creating smaller droplets.

Enhanced Oil Recovery often includes water injection or water flooding. The specification of this water is critical to it's performance, with the suspended solids size and concentration of particular importance. If too large solids or too many solids are injected into the formation, they can plug up the pores in the well and reduce the production efficiency. TSS concentration and size within WFI can easily be measured using CANTY's INFLOW™ analyzers.

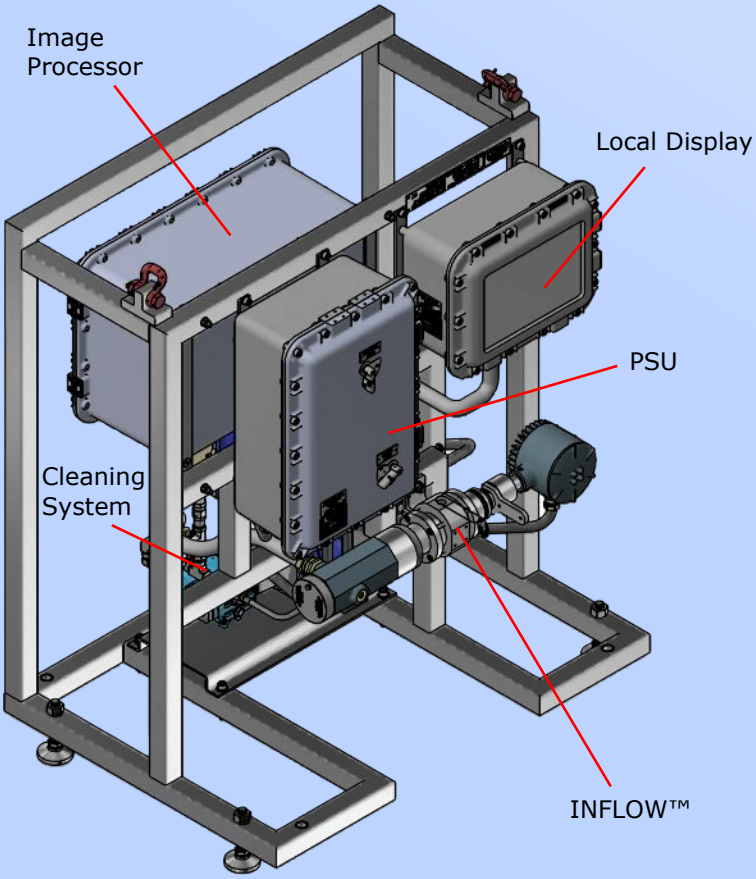
Chemical EOR via polymer flooding is now commonplace. Polymer-augmented water injected into the formation can significantly improve the sweep efficiency in the reservoir, when compared to standard WFI. This is due to the increased viscosity of the water providing better mobility control between the injected water and the hydrocarbons within the reservoir. However this polymer eventually returns to the surface as back produced polymer within the production fluid. This results in a produced water with a higher than typical viscosity, meaning it requires non typical water treatment.

Raising velocities and therefore separation of oil droplets is reduced in waters of higher viscosity. This is often combated by chemical or other pre-treatments to reduce the viscosity prior to feeding the water to the separation equipment. How much the viscosity needs to be reduced in order for the separation equipment to work effectively, is directly related to the droplet size. For larger droplets, the viscosity of the water does not need to be reduced as much, so less chemical can be used. For smaller droplets, the viscosity of the water needs to be reduced more, so more chemical is required. Knowing the droplet size is critical!

	Dynamic Imaging	UV Fluorescence
Oil in Water Concentration	✓	✓
TSS in Water Concentration	✓	✗
Oil Droplet Size	✓	✗
TSS Particle Size	✓	✗
Direct Measurement	✓	✗
No Fluid Conditioning	✓	✗
Unaffected by Chemicals	✓	✗
Suitable for Light Oil Condensates	✓	✗



Fixed Installations



For fixed installations, the INFLOW™ can be installed in a variety of ways.

It can be supplied mounted to free standing frame, which in addition to the INFLOW™ itself, also supports the system PSU, image processor with local display, and the automatic cleaning system.

This self contained solution simply requires a plumbing of process sample and cleaning system lines, input power, and a connection to the plant DCS. Communication with the operator's control system can be via 4-20mA, OPC, or Modbus TCP/IP.

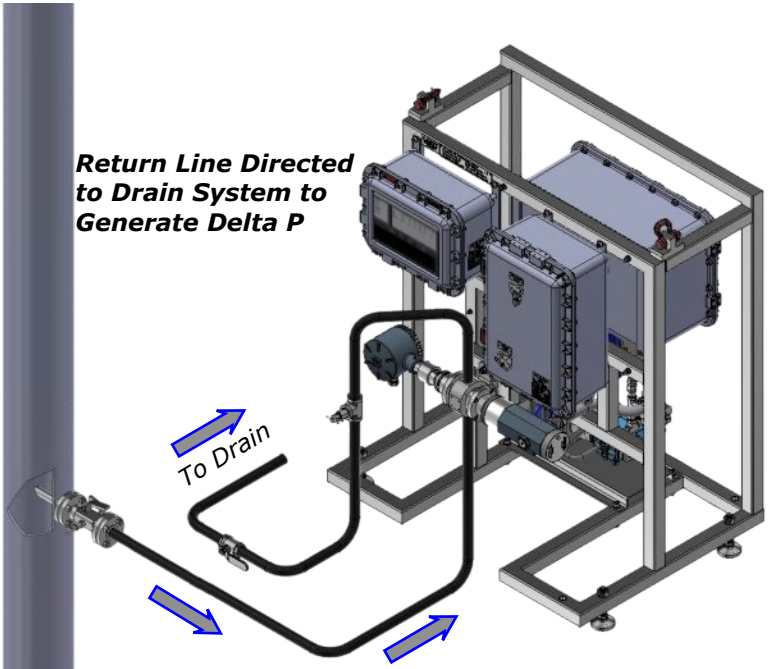
The local display shows real time images, and numerical as well as graphical data for the various concentration and size parameters being measured.

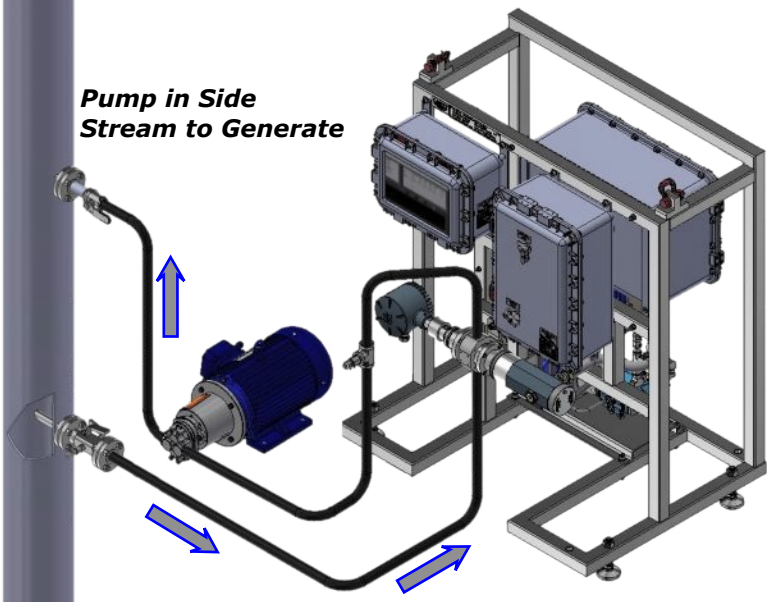
The INFLOW™ can also be supplied to be mounted as a spool piece within the main pipeline, or within a side stream line. Various connection types, sizes and ratings are available for maximum flexibility.

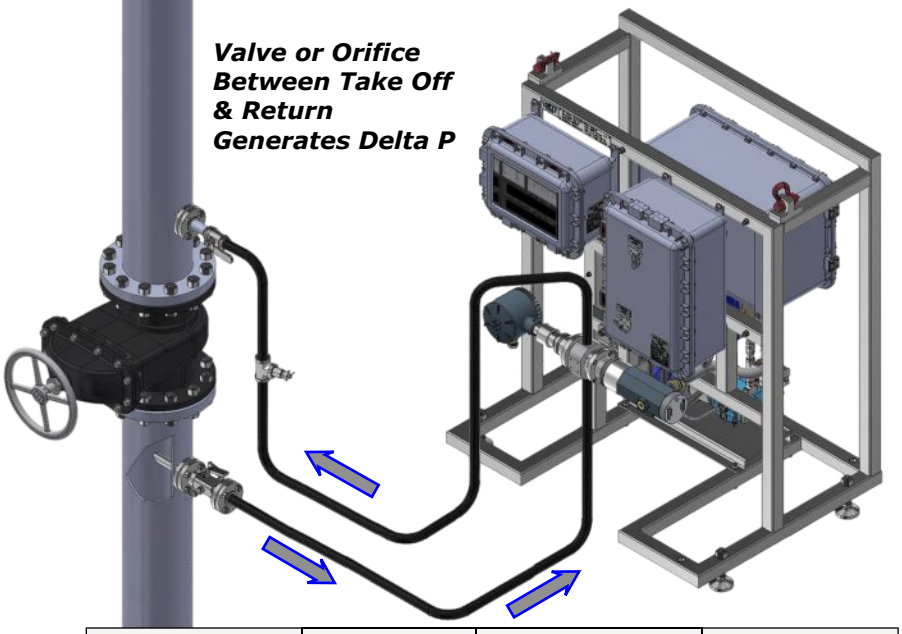
In this setup, a smaller auxiliary equipment skid can be provided to support the system PSU, image processor with local display and the automatic cleaning system.

Alternatively the operator can choose to have only the INFLOW™ and cleaning system in the field, with the actual image display and processing taking place in the control room.

A network connection runs between the field equipment and a CANTY Vector Control Module (VCM) in the control room. The images captured by the INFLOW™, are transmitted and analyzed in real time by the VCM, which also controls the activation of the automatic cleaning system, and sends any required measurement or control signals to the operators DCS. This arrangement allows for direct viewing of the INFLOW™ images in the control room.



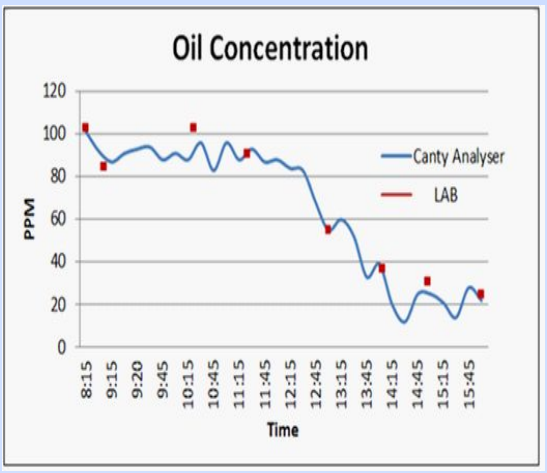




For fixed side stream installation, the user supplies piping or tubing from the mainline take off point to the analyzer inlet, and from the analyzer outlet to the return point.

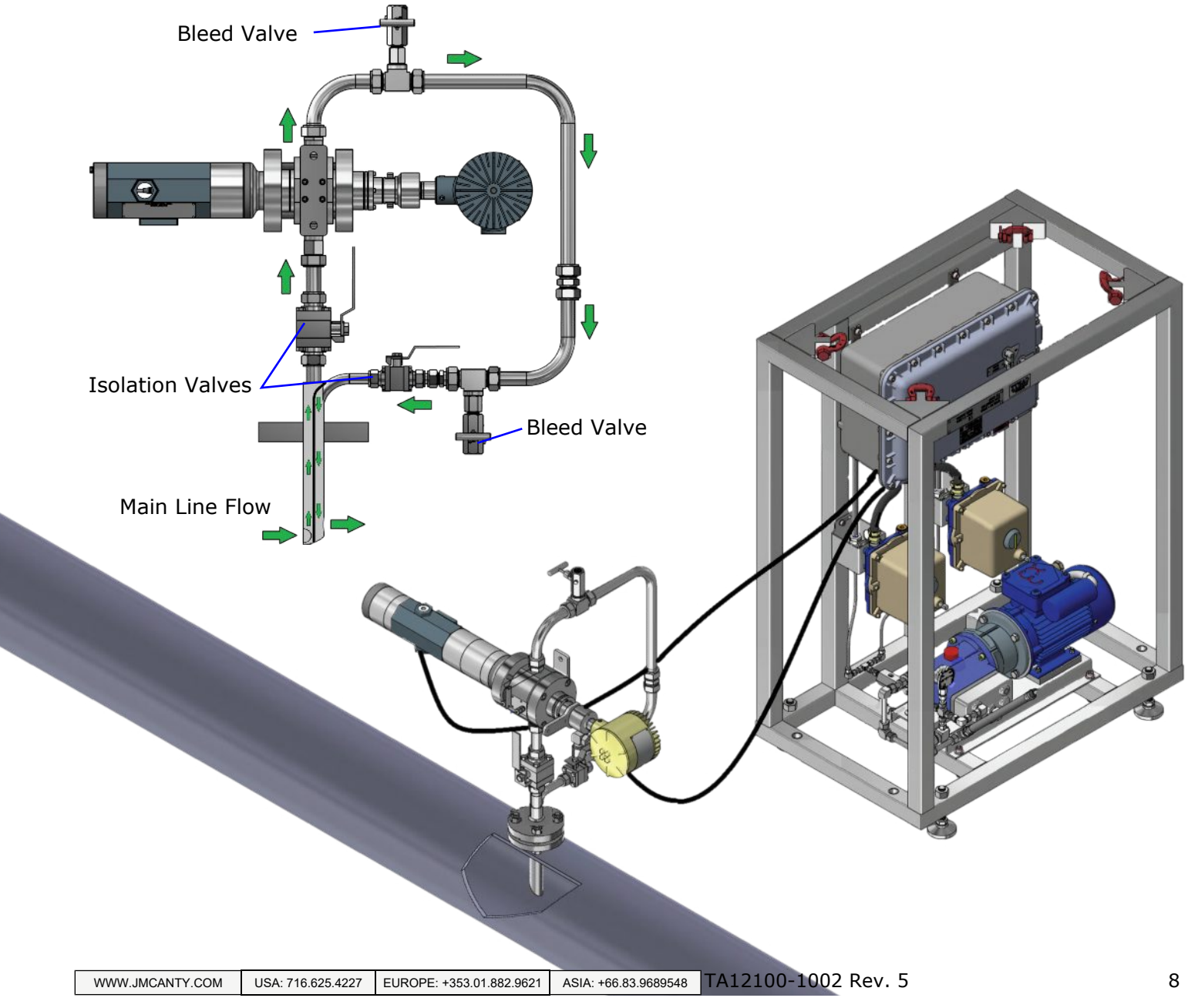
To generate flow through the side stream loop, one of the configurations shown on the left is typically used.

The side stream is typically fitted with a regulator valve to control the flow within the side stream, and a sample valve for laboratory comparison.



If an inline probe type installation is required, and the mainline process flow velocity is above 2.5ft/s (0.76m/s), then the INFLOW™ in Short Loop Sampler (SLS) can be used. The SLS unit mounts directly to the pipeline itself, while a slimmed down version of the skid for the auxiliary equipment sits adjacent to the pipeline.

This unit features a single probe with 2 separate internal channels (inlet and outlet). Based on the relative size & position of the inlet and outlet, and the flow velocity in the mainline, there is a sufficient Delta P generated to drive representative fluid flow through the loop, and through the analyzer flow cell. The SLS unit also features isolation valves and bleed valves for ease of maintenance.



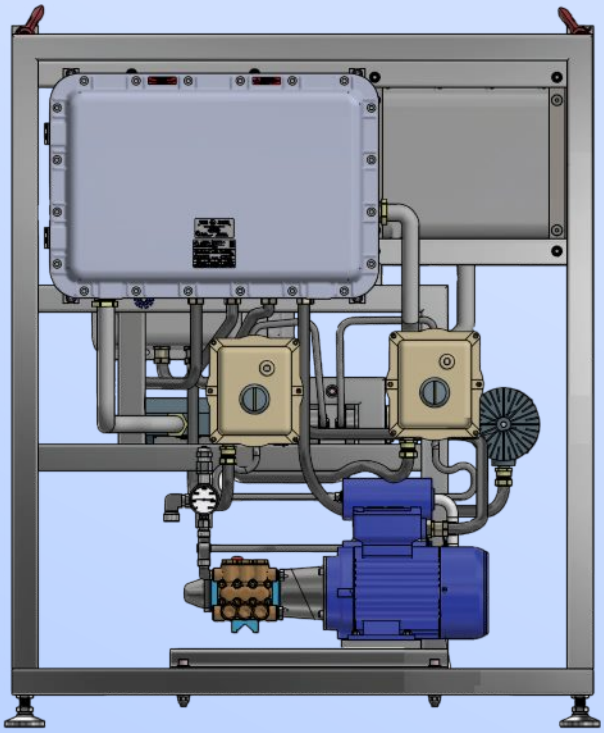
Auto Cleaning System

The automated cleaning system ensures that the fused glass windows within the analyzer flow cell remain clean at all times, allowing for high quality image capture, and therefore highly accurate measurement.

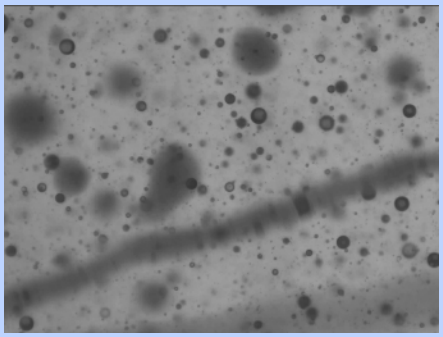
The cleaning system features a high pressure pump and a series of actuated valves, to automatically clean the glass of the camera and light sides of the INFLOW™.

Internal to the flow cell is CANTY's unique jet spray ring, which directs the wash fluid onto the glass circumferentially, to ensure uniform cleaning of the fused glass window surfaces.

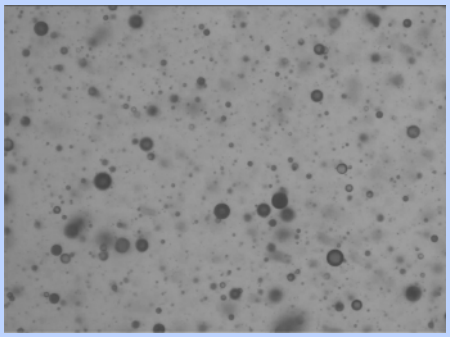
The cleaning medium can be the process water itself, or a separate water supply if available.



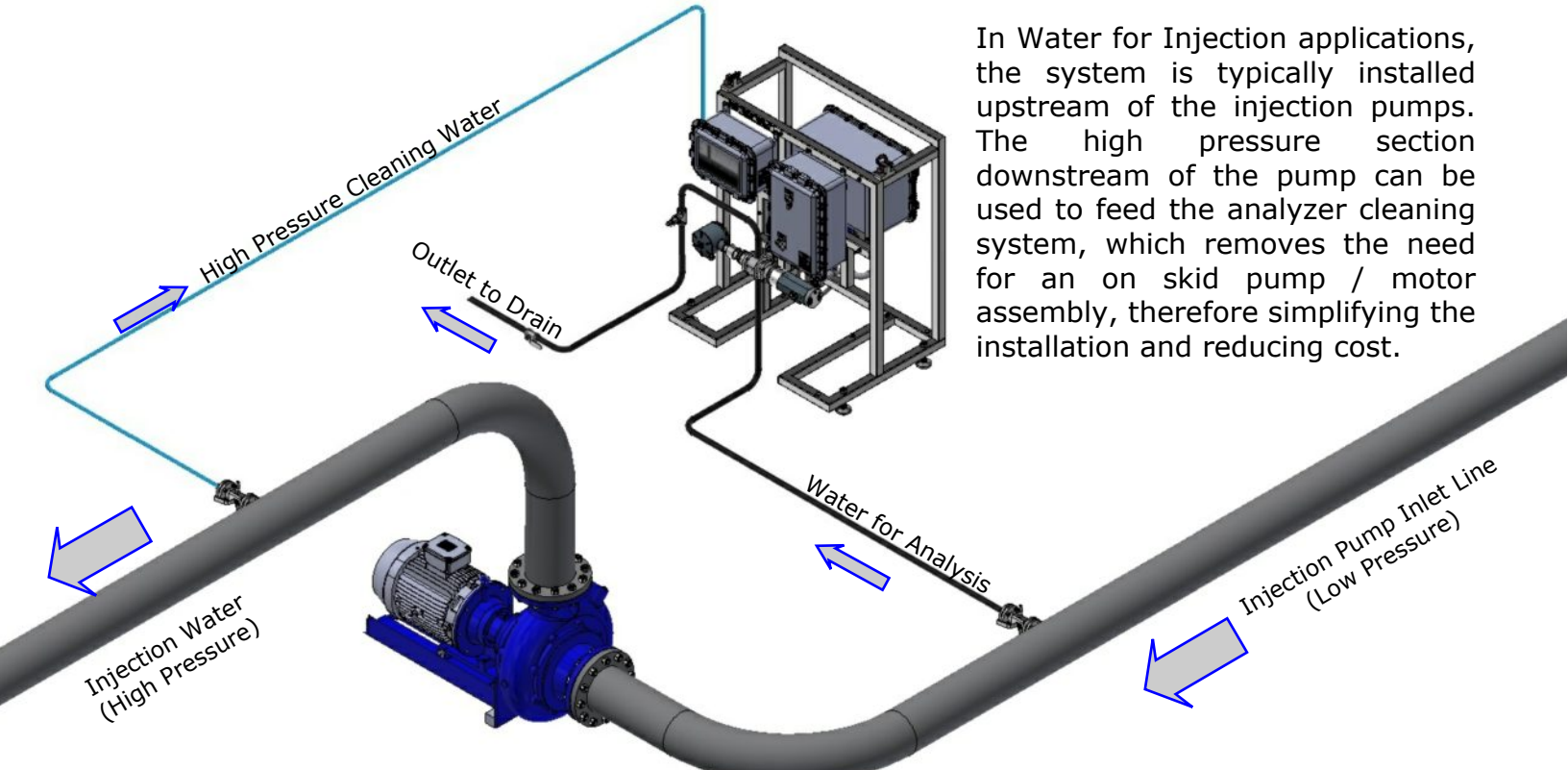
Jet Spray Ring



Visible Fouling on Glass



Fouling Removed



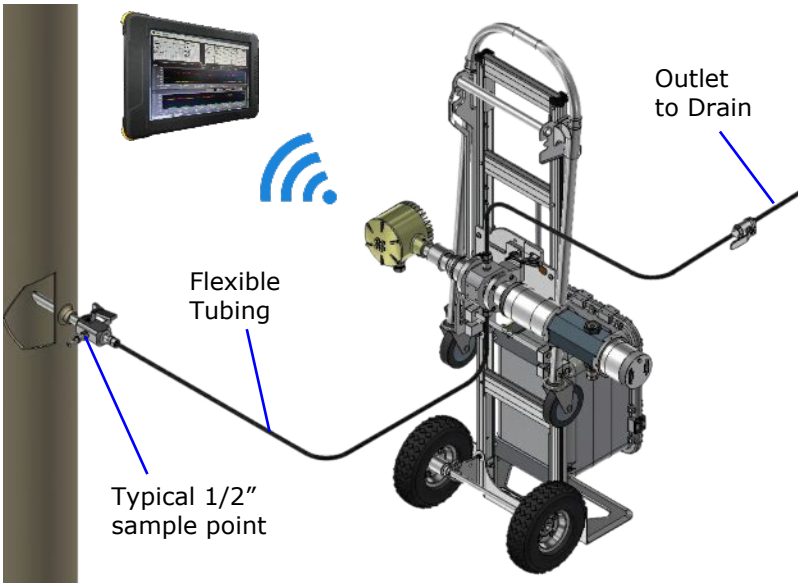
In Water for Injection applications, the system is typically installed upstream of the injection pumps. The high pressure section downstream of the pump can be used to feed the analyzer cleaning system, which removes the need for an on skid pump / motor assembly, therefore simplifying the installation and reducing cost.

Transportable InFlow™

The Transportable INFLOW™ is designed for short term installation, such as multi point site surveys, and testing or trouble shooting of any oilfield separation systems.

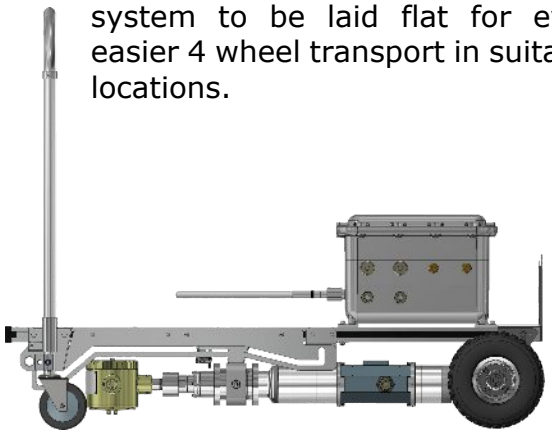
It features 1/2" Swagelok inlet and outlet connections, for quick and easy hookup to typical 1/2" sample points. This is most commonly done via flexible hosing with a regulator valve in the outlet line, which is directed to the drain system or a lower pressure point for the duration of the test.

The system can be hooked up and analysing within a matter of minutes, while the wheeled trolley with large pneumatic tyres allows the unit to be easily moved from sample point to sample point within the oilfield facility.



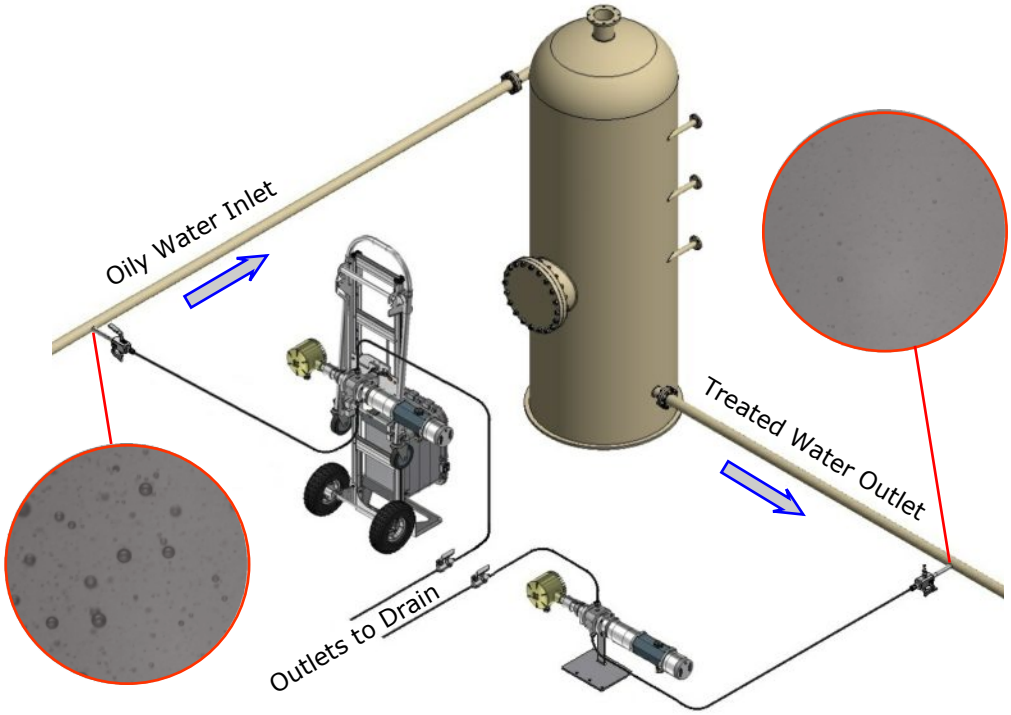
The system also features a USB connection which can be easily accessed once out of the hazardous area. This allows for easy extraction of data / images / video from the onboard processor. It also facilitates hooking up to a Universal Docking Station (user supplied), which allows the user to perform in depth review and interpretation of the data, directly on the system's high speed industrial processor but on a larger screen in a more comfortable environment.

The Transportable INFLOW™ central pivot point, allows the analyzer to be rotated to a vertical position for transportation & storage. The trolley design allows the entire system to be laid flat for even easier 4 wheel transport in suitable locations.



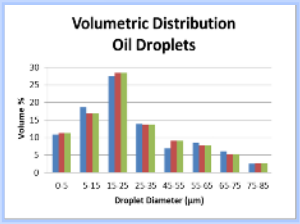
There is also the option to add a second INFLOW™ unit, so that the inlet and outlet of any separation equipment can be analysed simultaneously.

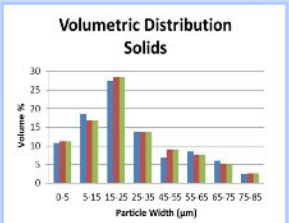
The second INFLOW™ is supplied as a separate unit with it's own stand, and is hooked up to the main system electrical enclosure as and when required. Both INFLOW™ units are then configured and operated via the single wireless tablet.



Portable InFlow™

Combining the latest in high speed gigabit ethernet camera technology with Canty's high intensity lighting, portable design, and imaging software, the system provides real time particle analysis of solids, water and air bubbles in oils and fuels. The method involves flowing the lubricating or hydraulic oil between a microscopic camera and high intensity light source. Images are then analyzed under a number of different parameters to provide size, shape and concentration data. As per ASTM D7596, particles in oil are classified under sliding/cutting/fatigue wear, nonmetallic particles, fiber particles, water droplets & air bubbles to provide a comprehensive understanding of the condition of the fluid, and indicate where and how possible failures are likely to occur. The portable design allows for in testing in the field leading to the quickest and most reliable results possible.





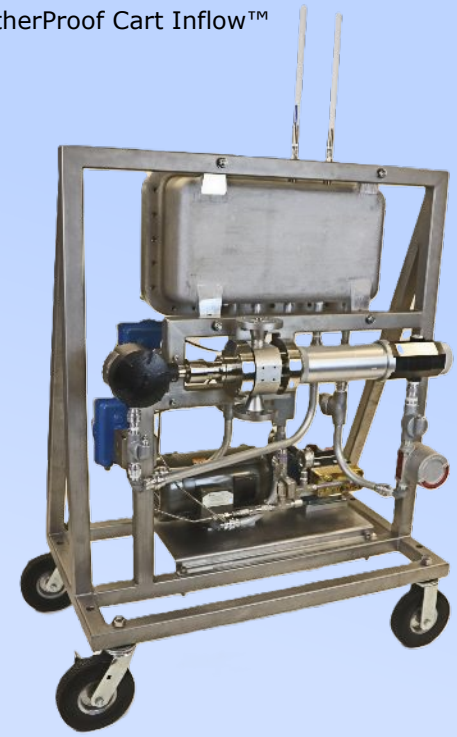
WeatherProof & Explosion Proof Mobile Solutions

If a mobile solution is required for a longer installation period—where an operator will not be continuously available to run the system and periodic manual cleaning of the flow cell is not possible—cart-mounted options are available for both hazardous and non-hazardous areas. These units include the INFLOW™ analyzer, an onboard image processor with local display options, and an automatic cleaning system.

WeatherProof Cart InFlow™

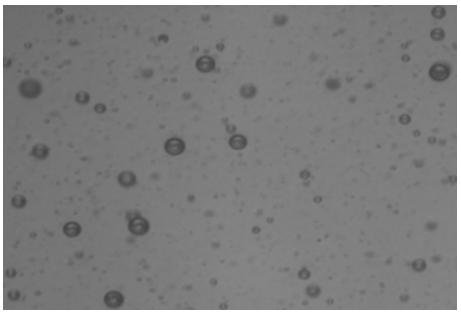
The compact cart design features a powerful image processor with integral touch screen display, below which sits the automated cleaning system. The INFLOW™ can be mounted to the back of the cart itself, or sit adjacent to the cart depending on the installation location. Once started up, this system runs as an operator free system, with the added feature of mobility around the oilfield facility.

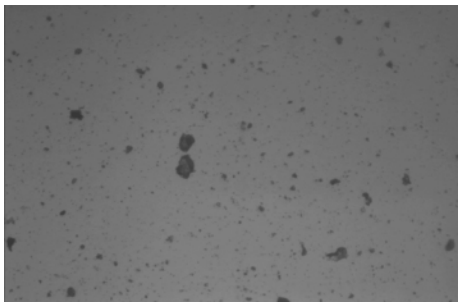
WeatherProof Cart Inflow™

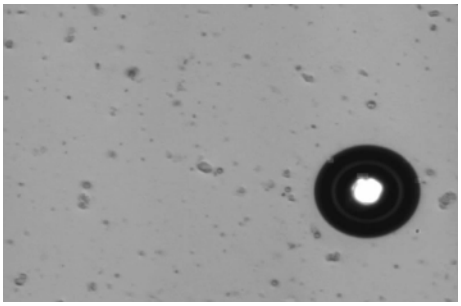


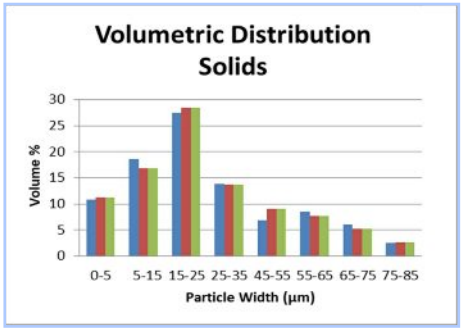
EXP Cart InFlow™

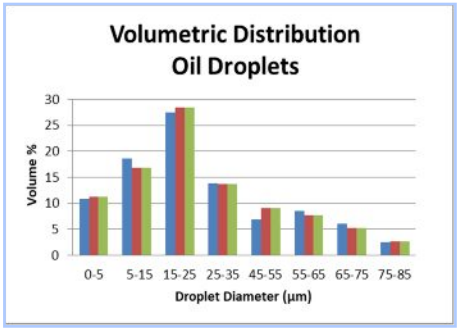
The EXP version operates in a similar way, with the added benefit of being Explosion Proof rated. The EXP enclosures do add some size and weight to the system, so it is mounted on a larger wheeled cart for increased stability. Configuration and viewing of the systems high speed image processor within the main enclosure, is performed via the units wireless capability using an EXP rated tablet.











Lab MiniCell

For offline lab sample analysis, the MiniCell can be used. It features the same optical setup as the field systems, and has the addition of an automatic sample feed system.

The grab sample is agitated and placed at the inlet point. Once the operator presses "analyse" on the systems touch screen, everything is automated, with a comprehensive sample report generated within 1-2 minutes.

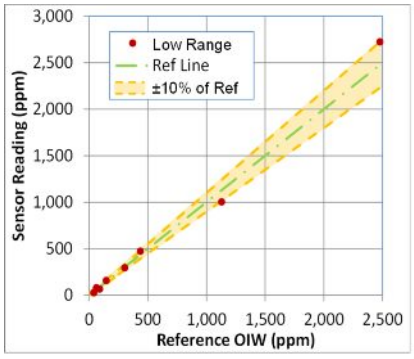
Offline lab analysis is typically only recommended for oil concentration, solids concentration, and solids particle size measurement. Oil droplet size analysis should only be performed online as droplets within any grab sample are subject to settling and coalescence.

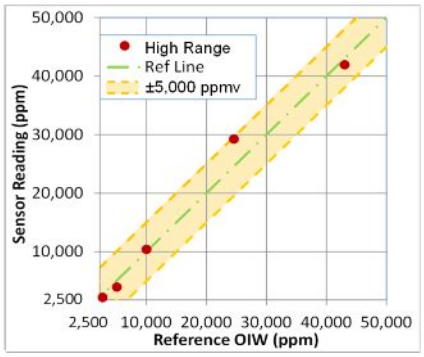
Development of a SubSea Analyzer

As exploration & production moves into deeper water, and the industry focus shifts towards subsea separation, CANTY have undertaken a project to develop our INFLOW™ for subsea use. This development work to date has been directly funded by one of the world's largest oil & gas operators, as well as forming part of multiple operator sponsored Joint Industry Projects run by TUV NEL Ltd.(UK) and RPSEA (USA).

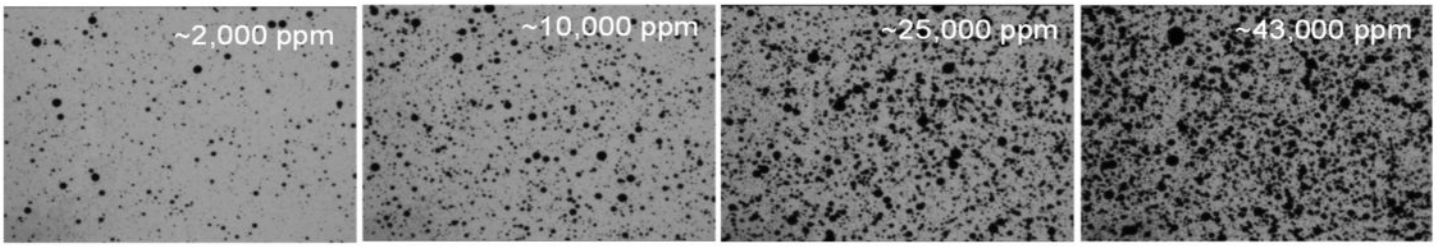
Numerous challenges have been overcome to adapt the technology to the subsea environment. These included the design of housing rated for 10,000 PSI internal and 5000 PSI external pressure, with the capability to operate in both deep water temperatures of -2°C and mid depth waters at 20°C, without affecting the performance or life of the internal electronic components. Given the installation location on the sea floor, system reliability was also considered key, with all components of the system rated for a minimum lifetime of 5 years.

The system, as both a low and high range sensor, is currently at Technology Readiness Level (TRL) 3, with a design in place to be tested to TRL 4 as defined by the API 17 N.



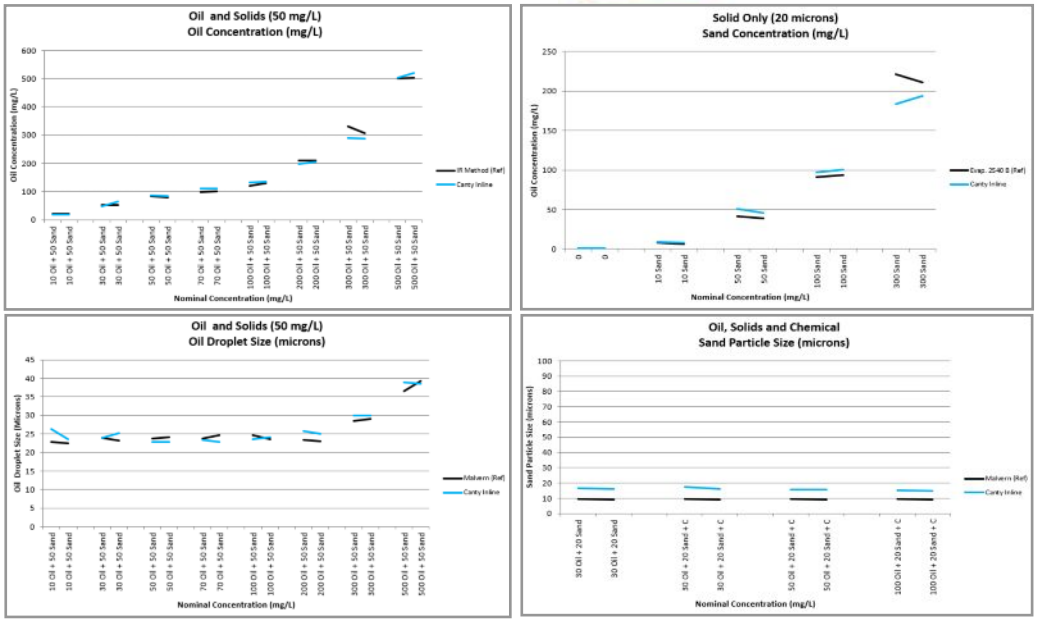


Graphs and images from "Flow-loop Testing of Subsea Produced Water Quality Monitoring Sensor Prototypes" presented by Xiaolei Yin et. al., Exxon Mobil URC at the 2015 meeting of the Society of Petroleum Engineers, Sept 28 – 30, Houston Texas



Case Study 1 Operator Joint Industry Projects

CANTY have taken part in numerous independently executed JIP's, both to assess the performance of the INFLOW™ analyzer vs competitor technologies as both a topside unit, and also for it's potential for development for subsea use. These JIP's examined the capability of the analyzers in measuring Oil Concentration & Droplet Size, Solids Concentration & Particle Size, with different concentrations, flow rates, gas injection, and chemical additions.

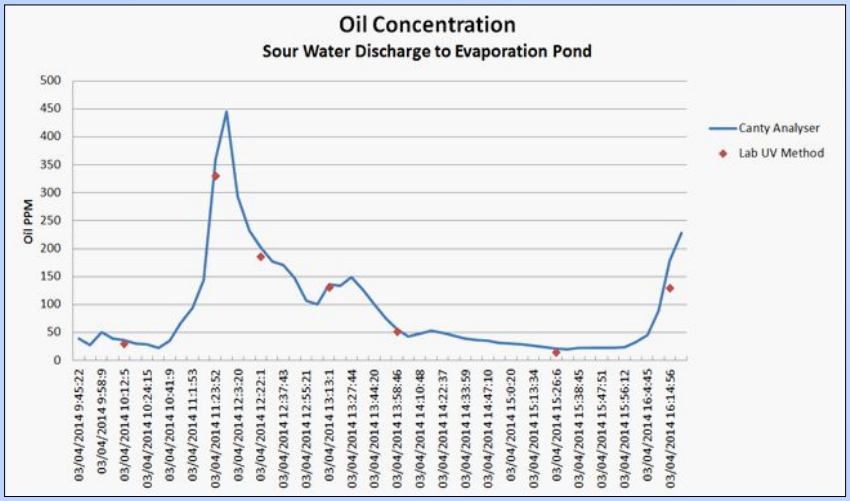


Case Study 2 Oil Concentration in Discharge Water

The INFLOW™ was deployed at a Mid-East gas plant to monitor the oil concentration in the sour water discharge to the evaporation ponds, to ensure the oil concentration was within the environmental limits.

The real time continuous reading showed significant fluctuations in concentration, prompting an investigation which resulted in the identification of 2 defective water level control valves, on an upstream slug-catcher. The defective valves resulted in the water level in the slug catcher varying over time in a waveform pattern. As the water level decreased, more oil was released into the slug-catcher's water outlet, with the opposite happening when the water level was high.

Lab samples which were analysed, but with a 24 hour delay on results, supported the analyzer's readings. Intermittent sample analysis may have eventually discovered the issue, but the use of the INFLOW™ allowed it to be identified and rectified in a much more efficient manner.



Case Study 3

Part 1: CFU Performance Assessment

- A major operator had issues with a high concentration of oil in water at a CFU outlet, despite the inlet concentration being within equipment's range.
- The initial theory from the CFU manufacturer, was that the high concentration at the outlet, was due to the presence of a large number of sub 11 micron oil droplets, which was the low limit for that particular CFU's optimum separation efficiency.
- The INFLOW™ connected at CFU inlet and outlet showed that droplet distributions were almost identical, and that 70% of the droplets at the outlet were larger than 11 micron!
- The CFU manufacturer was able to understand the real situation in detail and improve performance.

	CFU Droplet Diameter (µm)		CFU (without Chemical) Droplet Diameter (µm)	
Dv	Upstream	Downstream	Upstream	Downstream
10	8	7	9	7
20	10	9	11	10
30	11	11	13	12
40	13	12	14	14
50	14	14	15	15
60	15	16	17	18
70	17	18	19	20
80	19	21	21	24
90	22	27	23	27
100	30	32	33	30

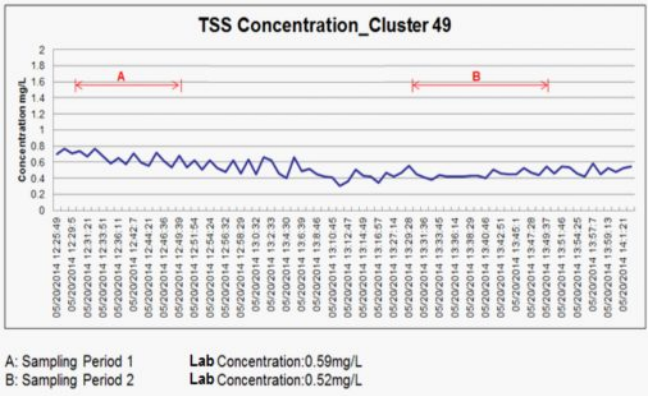
Part 2: Coalescing Chemical Effectiveness

- Operator had doubts about the effectiveness of the current coalescing chemical dosing regime.
- The CFU test above was carried out both with and without coalescing chemical being dosed.
- The droplet size distribution was almost identical with and without dosing, concluding that the current dosing is completely ineffective.
- Chemical vendor returned to site to re-assess type and volume of coalescing chemical used.

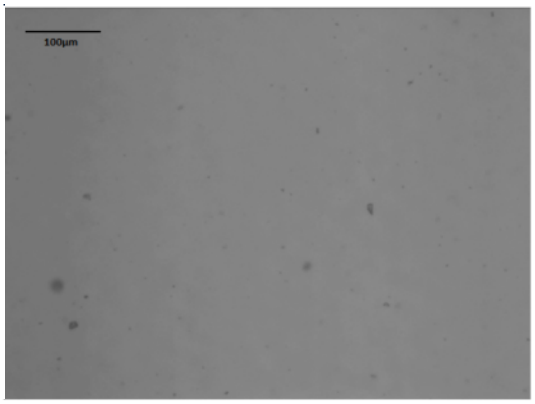
Case Study 4 TSS Concentration & Size in Water for Injection

The Bu Hasa Field in the UAE contains approximately 300 injection wells, used as part of the operator's EOR program. The Portable INFLOW™ was used to measure the concentration and size of the solids particles with the water for injection, at a number of wells which were deemed to be critical.

The online TSS concentration measurement matched up well with the operator's offline lab technique (Millipore Filter) as shown on the graph below left, with the INFLOW™ also providing directly measured data for the solids particle size, supported by captured high quality process images.



TSS Size Data	
Dv	Size (µm)
10	2.7
20	3.5
30	3.9
40	4.7
50	5.1
60	5.6
70	6.0
80	6.9
90	8.1
100	11.8



CANTY'S GOAL IS TO PROVIDE EQUIPMENT TO ENHANCE PROCESS UNDERSTANDING AND CONTROL. WE ACCOMPLISH THIS BY DESIGNING, MANUFACTURING AND SERVICING THE FINEST EQUIPMENT IN THE WORLD

CANTY

PROCESS TECHNOLOGY

SOME OF THE COMPANIES WE HAVE WORKED WITH

Exxon Mobil	ADNOC	Qatar Petroleum
Total	Chevron	Shell
NOV	Daleel Petroleum	Petronas
Marathon Oil	TUV NEL	BG Technical
Cameron	BP	ProLabNL
FMC	Imperial Oil	Saipem
SINTEF	MYCELX	SMS Oilfield
Wintershall	Premier Oil	Siemens Water
SNF	Oil Plus	SGS

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