JM CANTY
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ON-LINE PRODUCED WATER ANALYSIS FOR OIL AND SOLIDS

I. ABTRACT: Separation of crude oil from its inherent water and solids mixture is a critical function in controlling quality and throughput of the refining process, especially at final stage separation. Produced water must be oil free and solids free in order to maximize efficiency and prevent solids from being re-injected to the well. The Canty InFLow instrument, via the use of vision technology, can monitor both oil and solids content immediately after separation to inform operations of the condition of the produced water. Systems can be installed in-line, land or sea, and provide results down to 1 ppm for both oil and solids. Results are in near real time. System is remote operated and can be contacted via Ethernet/Satellite connection and a virtual screen.

Figure 1. Canty InFlow, Rig Installation

II. Requirement:

Crude oil processes are on the extreme end of the application spectrum. Sensors must be able to survive the internal fouling inherent with oil. In addition, the sensor must also be cleanable in the normal course of operation. If these challenges aren't enough, measuring oil in water (OIW) and solids in water (SIW) are difficult to accomplish and usually cannot be done by a single instrument. Many instruments on the market today for this purpose simply do not work as judged by performance in multiple JIP test protocols carried out over the last two years.

Vision technology by Canty, who has lead its development into the process industries for the last 30 years, offers a solution that meets all these requirements. Systems are now developed for use in subsea environments as well as top side.

III. Application:

A. Meeting the Need

The Canty system has met the need in the field to perform OIW/SIW measurements due to the physical design of its produced water instruments as well as the optical component of the technology. Basic system configuration is as shown in Figure 2.

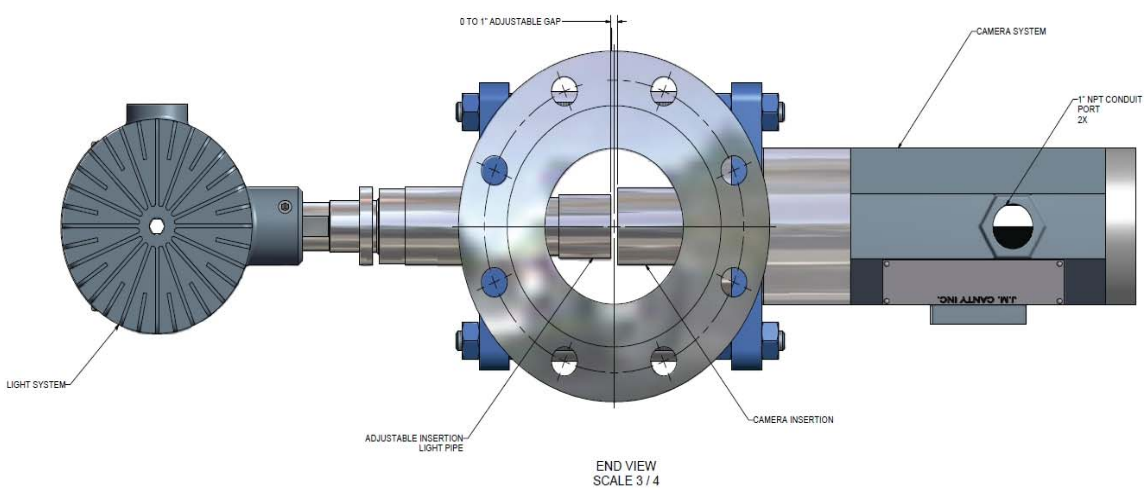

Figure 2. Canty InFlow View showing light (L), Camera (R) and the flow gap in the center.

Vision technology can see the oil and the solids, and maintain internal surfaces in a clean state to allow continual measurement.

B. Typical Results

The following shows a verification test of the OIW calibration by comparing what was injected into a flow loop, what was measured by Canty and what was measured by the EPA1664b method (See Appendix 1 for more complete results).

	BASELINE	5PPM	30PPM	50PPM	70PPM	100PPM	200PPM	400PPM	600PPM	800PPM	1000PPM
PPM AVERAGE (Canty)	6	12	49	58	64	81	217	314	404	611	719
PPM AVERAGE (EPA1664b)		17		59		108	228		361		684

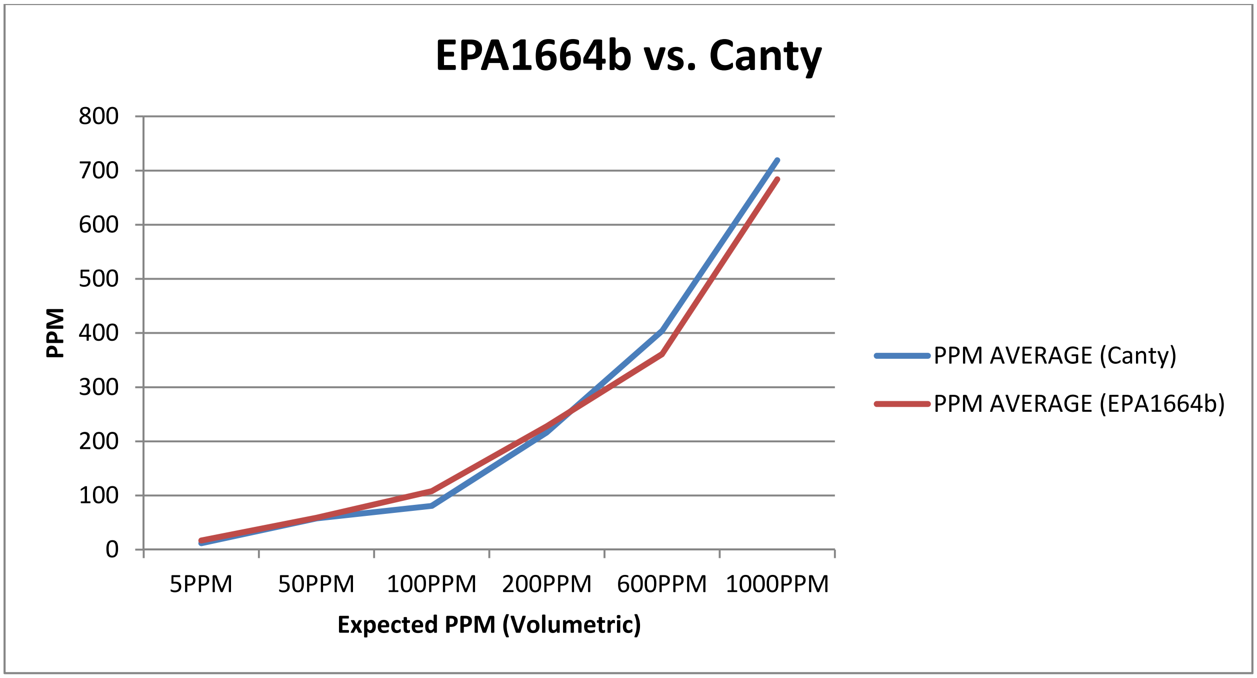

Figure 3. Graphical OIW Analysis

C. Physical Design

1. Fused Glass-to-Metal Lens Technology – This view into the process is rugged, able to withstand many thousand psi, thermally resistant, flush with the process and polished to a high finish. These attributes make it difficult for oil to cling to the viewing surface and there are no ledges or pockets where oil or solids can build up.

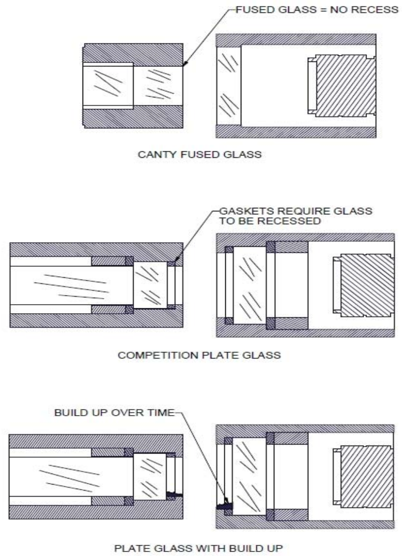

Figure 4. Fused Glass vs Gasketed

2. Patented Spray Ring Technology – Maintaining the view if oil eventually gathers onto the lens is critical for continuing system function. The Canty system is fitted with a spray ring which is able to blast clean the viewing and illuminating lenses and not interfere with the flow through the gap. This development is a critical building block in the larger design. Not only is the viewing lens resistant to fouling, but the spray ring, using water or solvent, can keep it in operating order indefinitely.

D. Optical Design

1. The ability to view the process transmits a great deal of information back to the operator including the state of the lens, accuracy of the particle detection and differentiation of particles and oil droplets by shape determination which is only possible visually.
2. Shape factors such as aspect ratio and circularity allow auto-classification of solids apart from oil droplets allowing the Canty instrument to perform both solid and oil detection from a single image. Air can also be eliminated from the data to avoid error.

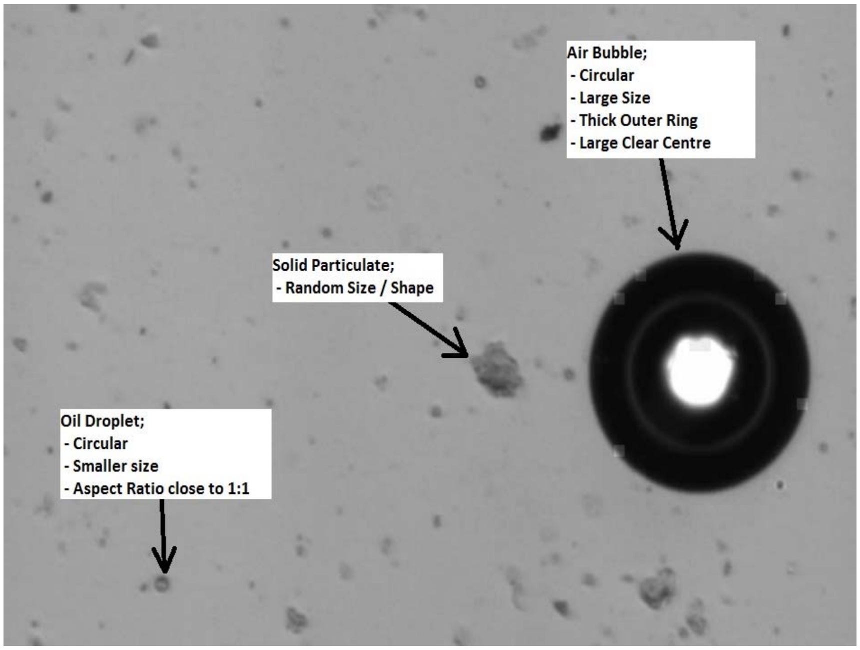

Figure 5. Oil, Solids in Water

IV. Benefits

There are several benefits to be derived from CantyVision technology that are unique in the market place:

A. Maintenance

1.System is remotely cleanable and resistant to fouling by design.
2. Fused Glass-to-Metal design provides a high pressure, rugged viewing port that is highly polished and extremely rugged with regard to vibration and impact.
3. The patented Spray Ring technology brings cleaning fluid to the fused lens ports without disrupting the process flow.

B. Low Cost / Long Life

1. Initial system costs are lowest in the industry.
2. System electronic components all have expected life spans of 5 years minimum.
3. Maintenance costs are very low over the lifetime. System runs unattended.

C. Vision into Process

1. View into the process is an enormous help in determining the process state and helpful in determining sources for upset conditions.

D. Field Experience

1. In multiple OIW/SIW Joint Industry Projects the Canty system has always been determined to be the best performing instrument.
2. Many systems are used top side in the industry. Exxon, Shell and numerous others all currently employ the technology.

E. Subsea Development.

1. The Canty system is undergoing tests in 2015/2016 to reach TRL 4.

Appendix 1.

JIP Conducted by TUV NEL, Glasgow, Scotland 2015. The following is an excerpt from a paper by Xiaolei Yin* et. al., Exxon Mobil URC given at the 2015 meeting of the Society of Petroleum Engineers, Sept 28 – 30, Houston Texas, describing the tests and results.

Oil-in-Water (OIW) Measurement

Figure 3 shows the sensor prototypes' OIW measurements for two different measurement ranges. For comparison, an error band of ±10% is provided in the left plot of Figure 1 for the low range sensor. Given the intention of using the high range sensor as a trend monitor, a relatively large error band, ±5000 ppm, is added in the right charter of Figure 1. Both sensor prototypes were tested at different concentration levels within their designed measurement ranges. It was observed that both the sensors can provide good OIW measurements as designed.

Figure 3 (bottom) provides examples of flow images taken by the high range sensor at different OIW concentrations. When the oil concentration in water increased, oil droplets started to overlap with each other. The high range sensor was able to capture and measure the overlapping droplets and include them into the concentration calculation. Therefore, the upper limit of the sensor measurement range was extended significantly to 50,000 ppm OIW.

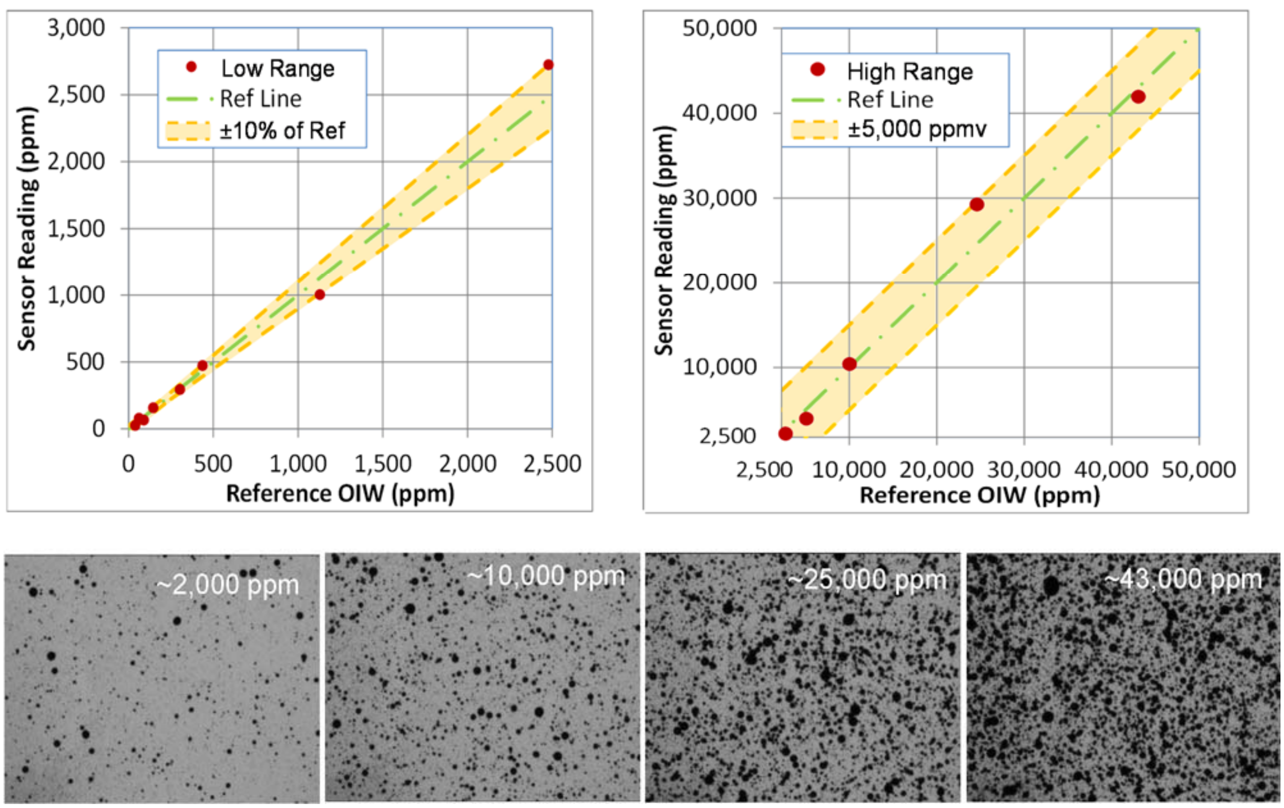

Figure 3. OIW Measurements: Low Range Sensor (Up-left) and High Range Sensor (Up-right); Images of Water Flow with Oil Droplets at Different Concentrations (Bottom)

Solids-in-Water (SIW) Measurement

Solids with Dv50 size of 68 µm was added into the loop at different feed rates to reach target SIW concentrations. Figure 4 shows the solids concentration measurements from the low range sensor. The sensor was able to measure SIW up to 300 mg/L and is expected to be able to measure higher SIW concentrations. However, large variations in sensor reading over time were observed in the solids tests. This is because a peristaltic pump that was used for pumping sand slurry introduced pulsed flow into the loop, which resulted in an non-uniform sand flow passing through the sensor. Relatively small amount (< 300 mg/L, or equivalently < 100 ppm) of solids in water also cause a small number of particles captured by the camera, which also added variations into the sensor reading. For such situations, averaging the sensor reading over a longer time is needed to provide meaningful SIW measurements.

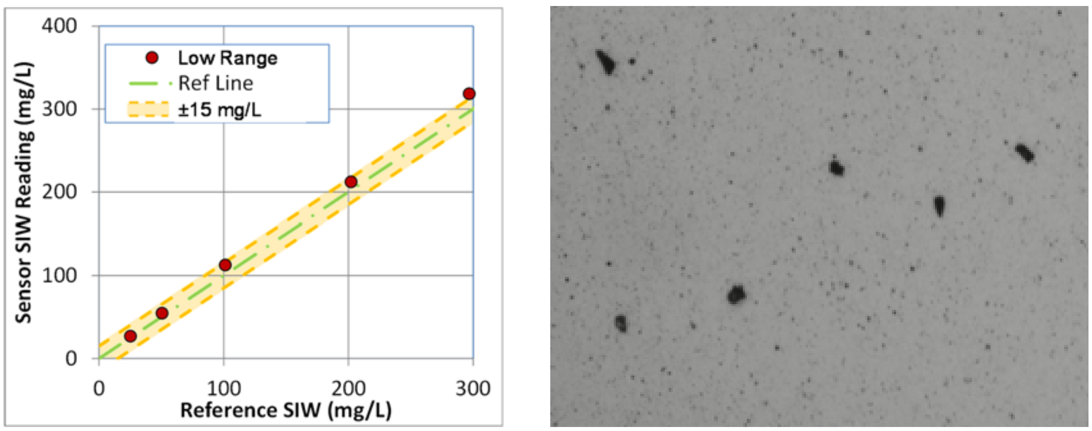

Figure 4. SIW Measurements (Left) and Image Example (Right)

References:

***SPE-174808-MS (Society of Petroleum Engineers, 2015, Houston Tx)**

Flow-loop Testing of Subsea Produced Water Quality Monitoring Sensor Prototypes, Xiaolei Yin, Jason Lachance, Patrick Moore, and Kamran Gul, ExxonMobil Upstream Research Company