EXCELLENCE IN PROCESS ANALYTICS

Application Note

Industrial No. 03

Oxygen measurement in the water for injection technology in the oil industry

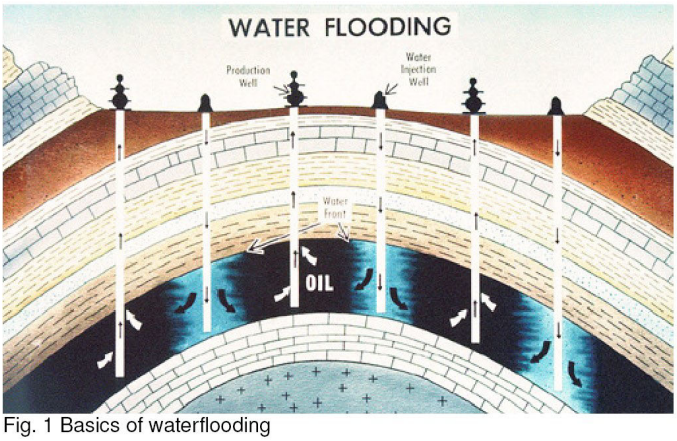


Fig. 1 Basics of waterflooding


Fig. 2 Offshore platform in the Ekofisk field

Application description

Waterflood also called water injection is a method of secondary oil recovery in which water is injected into the reservoir formation to displace residual oil. The water from injection wells physically sweeps the displaced oil to adjacent production wells. Water injection wells can be found both on- and offshore.

Waterflooding was born over 125 years ago and is the oldest enhanced recovery method. Water does not only displace oil but is used also for pressure support of the reservoir (also known as voidage replacement).

Why choose Hach Ultra?

- Full ATEX certified analyzer and oxygen sensor
- Sensor withstanding extreme conditions up to 100 bar
- Sensor with specific electrodes and electrolyte allowing the measure in samples containing H_2S
- Several high corrosion resistant material available for the sensor and the flow chamber (Monel ,Titanium and Hastelloy)
- Wide measurement range from ppm saturation levels down to 1 ppb.

Water quality required to maintain high efficiency

For a waterflood operation to be successful the water used for injection must be of a quality that will not damage the reservoir rock and injection rates must be maintained below the parting pressure of the reservoir. Poor water quality will result in lost oil production.

The proper balance between water quality and cost has to be determined. Rigorous water quality guidelines like 98% removal of particles above 2 microns, oil < 5 ppm, and oxygen < 50 ppb will nearly always provide water of sufficient quality. Because of increasing scarcity, fresh water will not generally be a viable source. Therefore, most injection projects use saline or brine waters.

Five components in water detrimental to a waterflood are:

- micro-organisms,
- dispersed oil,
- suspended solids,
- dissolved gases, and
- dissolved solids.

Dissolved gases frequently found in injection waters are oxygen, carbon dioxide and hydrogen sulfide. All three enhance corrosion problems but oxygen is the most common cause for corrosion and although it is not normally present at depths below around 330 ft (100 m), oxygen is often introduced in oil production through leaking pump seals, casing and process vents, open hatches, and open handling.

In addition, oxygen removal processes such as gas stripping and chemical scavenging often fail, allowing oxygen contamination in waterflood systems. Oxygen can be removed by an oxygen scavenger, such as cobalt-catalyzed sodium bisulfite. Proper gas blanketing of water tanks also minimizes oxygen entry. Material should also withstand H_2S corrosion as it is found in approximately 40% of all wells.

Closely related to the water quality is oxygen measurement and control. Oxygen measurement and control is such a challenge because of severe working conditions. In this aspect Hach Ultra provides the most resistant sensors of the market.

The Sensor

Fig. 3 Oxygen sensor for 100 bar pressure

The sensor is an electrochemical cell with the Orbisphere patented three electrode technology. Gold, silver and platinum are used in order to avoid H_2S interferences while measuring oxygen

Since the O_2 sensor is in direct contact with the chemical substances, chemical resistance is a must.

All wetted parts of Orbisphere's sensors are 316L stainless steel; as required, the sensor head can be made from other materials, such as Hastelloy C276, Titanium or Monel.

Kalrez washers are recommended instead of silicone to avoid swelling. Sensor head and sensor socket or flow chamber O-rings should be of Viton or Kalrez.

Installation and sampling recommendations

Orbisphere's **i**ntrinsically safe analyzers consist of an O_2 sensor and an indicating instrument (with display) which can be installed in either the hazardous or the safe area.

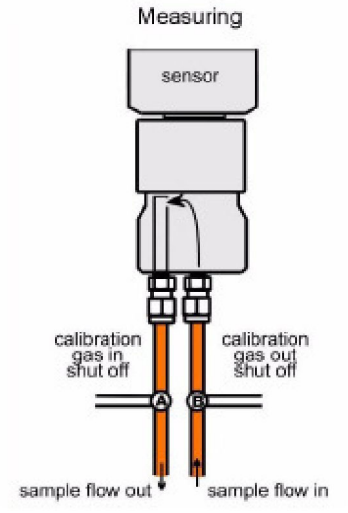


Fig. 4 Flow chamber and sensor

The instrument electronics are housed in one or two tough, watertight stainless steel enclosures, depending on your hazardous area needs. Compact and lightweight, the indicating instrument can be mounted on a wall or directly on a process control panel.

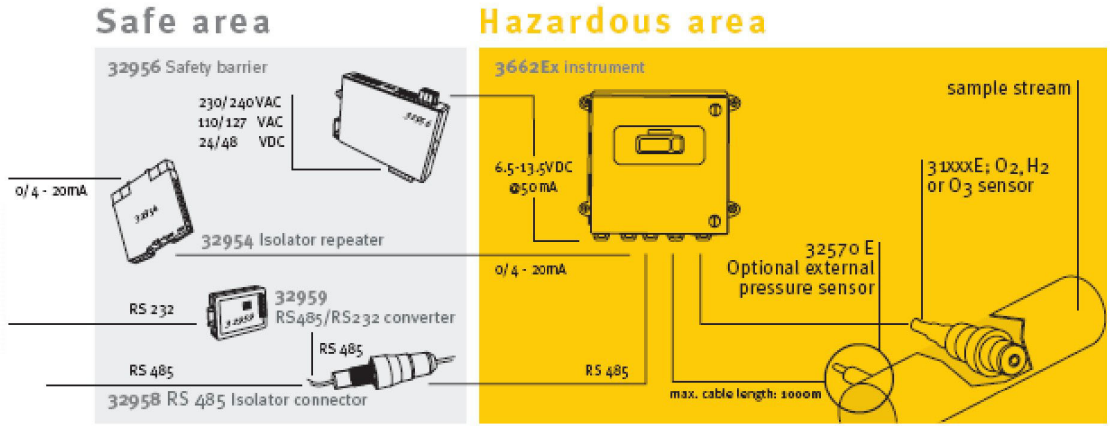
The sensor can be installed either in-line or on-line to the line to be controlled and up to 1000 meter distance from the transmitter.

For the waterflooding application, the liquid sample is transported through the tubing to a flow chamber of the series 32001, where the sensor is located. Calibration gas can be also connected to the flow chamber (see picture). Two valves at the inlet and the outlet allows isolating the sensor from the sample for easy calibration and/or service. Materials available are ss316l, Hastelloy, Monel and Titanium.

Instrument outputs

Analog 0/4–20 mA current output of O_2 concentration is available as an isolated signal in the safe area and a non-isolated signal for the hazardous area. Often an application requires the instrument's output to match a specific measurement range. These output levels can be adjusted with the supplied Windows® software.

Installation schematic



Recommended systems components

Model	Description
3662EX/100	Instrument ATEX, Substance measured: Oxygen, Configuration: Wall, Number of channels: 1, Temp. units: °C, Membrane 29552A, Measurement type: DO2, Thermal cut-off, Current output, Voltage output, RS485 serial output: requires 32958 for installation in hazardous area, Instrument voltage: 6.5 – 13.5 VDC by 32956.X. Intrinsically safe, Special sensor cable: 32515E, Special sensor: 311XXE, Measurement units: ppm/ppb.
31120E.11	EC Sensor, Substance measured: Oxygen, Sensing head material: Stainless Steel, Guard ring: Silver, Maximum pressure: 50 bar, O-Ring: Viton, Intrinsically safe.
32001.141	Flow chamber in Hastelloy with ¼" fittings. Supplied with Viton O-rings.
32515E.03	3 meter sensor cable for 366xEX, 5 wires. Supplied with 2 connectors, 2 sleeves with 32515E label.
32956.B	Intrinsically safe power supply incorporating DIN rail mounting safety barrier, for 3662Ex. For use in the safe area. 230 VAC
32954	Isolator repeater for 4/20mA current output. Must be installed in a safe zone if current output is utilized. For 3662EX
32696	Windows PC software ATEX3660 for 3660Ex and 3662Ex. Program in English, French, and German.
32706	Maintenance kit for oxygen electrochemical sensors. Includes membranes 29552A, electrolyte 2959, membrane holding ring 29229.01, and tools for sensor maintenance. (Replaces 32706L & 32706M.)

Options

Model	Description
31120E.14	EC Sensor, Substance measured: Oxygen, Sensing head material: Hastelloy, Guard ring: Silver, Maximum pressure: 50 bar, O-Ring: Viton, Intrinsically safe.
31131E.11	EC Sensor, Substance measured: Oxygen, Sensing head material: Stainless Steel, Guard ring: Platinum, Maximum pressure: 100 bar, O-Ring: Viton, Intrinsically safe, H2S insensitive.
31130E.17	EC Sensor, Substance measured: Oxygen, Sensing head material: Monel, Guard ring: Silver, Maximum pressure: 100 bar, O-Ring: Viton. Intrinsically safe
31130E.25	EC Sensor, Substance measured: Oxygen, Sensing head material: Titanium, Guard ring: Silver, Maximum pressure: 100 bar, O-Ring: Kalrez, Intrinsically safe.
32956.A	Intrinsically safe power supply incorporating DIN rail mounting safety barrier, for 3662EX. For use in the safe area. 110 VAC
32956.C	Intrinsically safe power supply incorporating DIN rail mounting safety barrier, for 3662EX. For use in the safe area. 24/48 VDC
32959	Converter RS232/RS485 for 3662Ex. Battery powered; batteries not included.
32538.02	2 meter RS232 cable, to connect the converter (32959) to a computer for the 3662Ex. Supplied with 2 female 9D connectors.
32958	Isolated Ex connector RS485/RS485 for 3662Ex.