

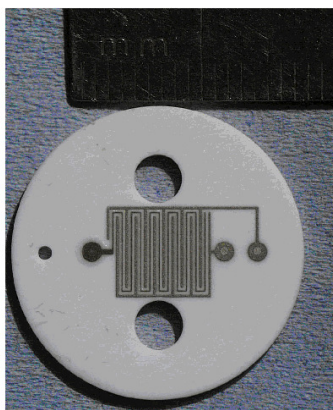
Down-hole sensor

Subsea wells are susceptible to chemical fouling. In particular, under certain conditions, barium and other salts can come out of solution to form scales which may hinder or even halt oil production. Once this happens rectification may be a hugely costly operation and there is even the possibility that the oil well will be lost. In order to avoid such problems, the water chemistry of brines must be monitored to detect the onset of scale formation and the appropriate remedial action taken usually by the injection of chemicals. Currently, this aspect of well management relies on off-line chemical analysis of well head or test separator samples. These often have to be flown out to remote chemical analysis facilities, and the results of the analysis relayed back to the well management team. This process can take several days, by which time it may be too late to take early remedial action and long term extensive intervention may be necessary.

The availability of reliable, real time chemical data for sub-sea operations is crucial to alleviate these critical problems and reduce oil production costs. Such data include pH and ion analysis. Intrinsically safe, environmentally rugged and remotely deployable chemical sensors are required to provide this data. While fibre optic systems for downhole video surveying and the distributed measurement of temperature and pressure using quartz sensors are already available, on-line chemical sensing systems for applications in subsea and other wells do not currently exist.

This patent US 6,478,950 (filed in 2002) describes an electrochemically cleaned sensor for monitoring pH and chloride ion concentration in the aqueous phase of a production fluid at temperatures $> 85^{\circ}\text{C}$ and a pressure of up to 340 bar.

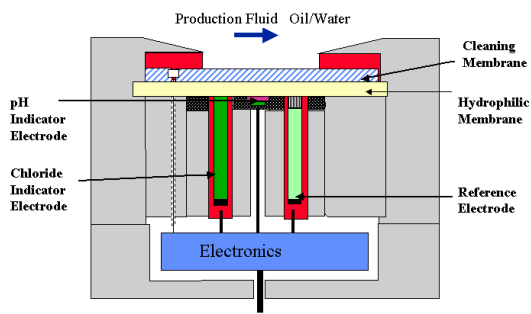
How it works



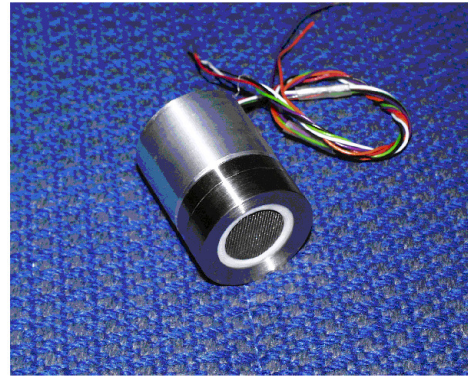
Glass pH sensor over Pt grid

The sensor comprises a pH and/or other Ion-selective electrodes together with reference electrodes and a temperature sensor, separated from the fouling environment by a hydrophilic microporous membrane (e.g. porous metal or a glass frit). This is resistant to oil fouling, while allowing sufficient aqueous phase access to enable sensing of its chemical composition as well as enabling electrolytic cleaning to occur. The pH electrode is a glass film covering a sensor on the surface of an electrical insulating substrate.

Periodic electrolytic cleaning by the scrubbing action of *in-situ* gas bubble generation from water electrolysis dislodges any fouling from the microporous separator so as to maintain access to the sensing elements and thus give a drift-free stable sensor. Typically, 10-200 cleaning pulses/day at $50\text{-}300\text{ mA/cm}^2$ with durations of ~ 1 minute is able to maintain sensor operation at pressures of 340 Bar.



Sensor schematic



Prototype probe

Benefits

Reliable sensors are essential for the control of enhanced oil extraction to minimise the use of chemical injection. The sensor needs to be able to withstand the aggressive environment of high pressure and temperature in a highly fouling liquid. In order to give a stable and reproducible signal, it is necessary to be able to clean the sensor without the need to bring it back to the surface (high cost and down-time), or to require significant power (cable too thick). This combination of fouling resistant membrane and *in-situ* cleaning meets these requirements.

Markets

Oil/gas recovery or CO₂ disposal are potential applications.