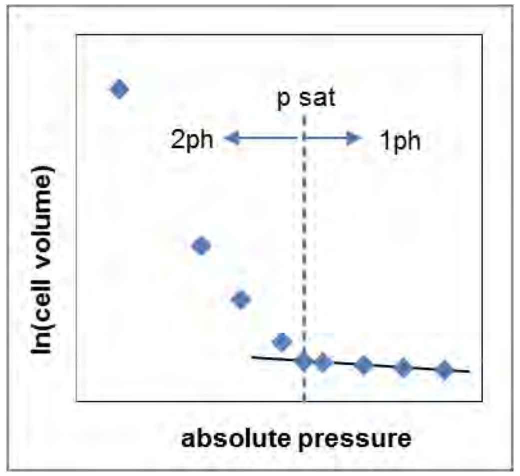
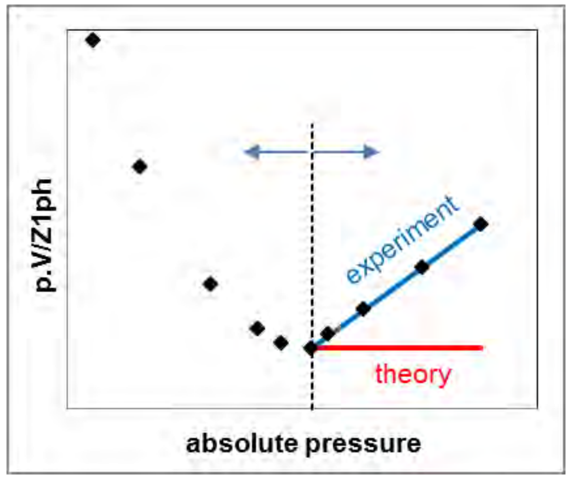
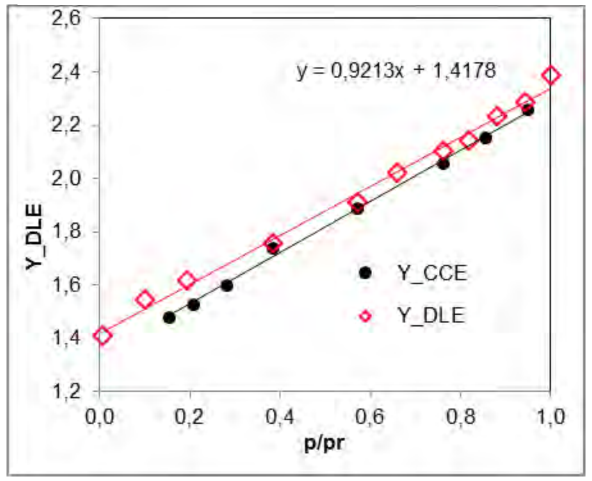


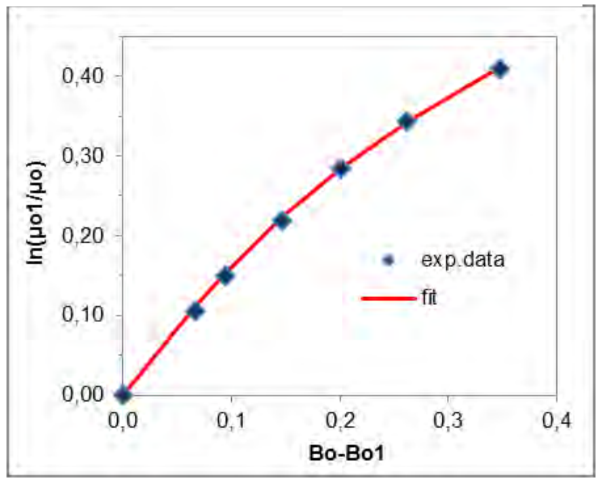
BO CCE, determination of the bubble point pressure



GC CCE determination of the dew-point pressure



Comparison of Y-function for CCE and DLE



Viscosity function versus volume increase

	pro	con
BHS	sample ready for cell, no recombination necessary	risky, small volume, composition through flash that may be inaccurate in GOR, Δp downhole inaccurate
Surface sample	easy and at any time accessible	GOR for recombination may be questionable
composition of a phase	detailed information	prior to analysis a flash may be necessary, what carrier gas was used, how many runs of the chromatograph were carried out? Grouping of higher ends needs check
GOR		changing from volume to molar units requires densities and molecular masses which are sometimes questionable for higher ends, M_{liq} very inaccurate
recombination		as above
CCE	easiest experiment accuracy depends on the type of sample, p_b determination within ±1bar	if performed too fast – inaccurate if p is always adjusted – thermodynamic equilibrium may not be reached, p too low or V too large step sizes too large
DLE		R_s: the gas readings may be inaccurate B_o: limiting factor = volume reading of the cell and V_{STO}
CVD		reaching V_{pd} after each step is difficult Well stream: heavy ends may be lost in not heated valves which results in an inaccurate mass balance

Discussion of the overall accuracies of experiments

Improved Operator Insight and Maximising Production in Offshore Fields

by Lars Anders Ruden, Emerson Process Management

Lars Anders Ruden
Strategic Marketing Manager, Roxar Flow Measurement, Emerson Process Management

Operators today are facing significant challenges in maximising production while reducing costs – at a time of geologically complex fields, challenging operating conditions and the pressure of low oil prices.

How are my wells performing? Are there any conditions that affect production flow? How do I keep my assets working for the full life of the field? All these questions and more must be answered, with operators' ability to maximise returns dependent on understanding reservoirs and generating accurate production information.

Measuring Flow Rates – Current Challenges

One of the key elements behind optimising production today is the accurate measurement of flow rates and fluids.

Real-time flow rates for oil, gas and water mixtures generate vital information. They detect critical information relating to water/gas breakthrough, hydrate information and increased sand production and ensure that wells are operating to the limit of their capabilities.

Yet, accurate flow measurement also comes with significant challenges. Many oil & gas wells, for example, are being produced over a wider range of process conditions, more liquid and water are present - especially in high GVF and wet gas fields – and there is also a need to detect changing fluid composition and salinity.

Furthermore, with the current low oil prices, the presence of undetected formation water and water coning, and the dangers of hydrates, scale, corrosion, and - in worst case scenarios - well shut-downs can have a highly negative impact on the field's economics.

New Technology Developments

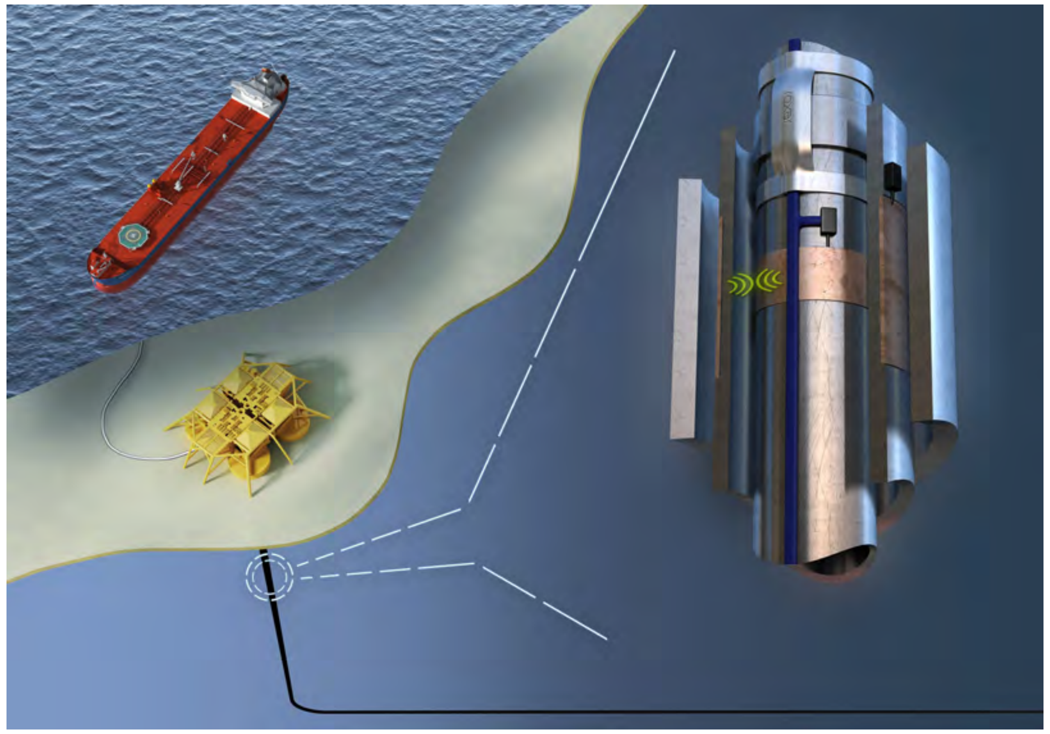
The latest technology developments in subsea and topside multiphase metering, however, are addressing these challenges.

Advanced signal processing, new field electronics (and in the case of subsea meters retrievable electronics) and electrode geometry are today providing more accurate characterizations of flow.

The field electronics system behind the Roxar Multiphase Meter, for example, allows for capacitance and conductance measurements to be combined in one unit and a Field Replaceable Insert Venturi improves accuracy and stability as well as removing uncertainties in sizing meters based on uncertain production forecasts.

The rise in wet gas fields with fast changing fluid compositions and increased salinity has also led to new technological developments that form the basis of the latest Roxar subsea Wetgas Meter.

The meter in question improves measurement uncertainty and salinity measurement as well as extends the operating range for wet gas meters. Let's take a look



The Roxar Downhole Wireless PT Sensor System monitors annulus B pressure and temperature wirelessly and continuously online for the life of the well

The rise in wet gas fields with fast changing fluid compositions and increased salinity has also led to new technological developments that form the basis of the latest Roxar subsea Wetgas Meter

at these different areas.

Improving Measurement Uncertainty

The microwave electronics behind wet gas meters have had a significant impact on measurement uncertainty.

The growth in digital frequency measurements has allowed for improved stability and time resolution as well as more accurate and sensitive wet gas measurements, where the microwave system is able to clearly differentiate between very small amounts of water content.

Emerson has also introduced a new multivariate analysis function, giving true PVT (Pressure, Volume, Temperature) independency on water fractions, especially in high GVF (Gas Void Fraction) flows. The multivariate analysis functionality is the result of the extensive analysis of raw data from several flow loop tests performed at Statoil's K-lab in Norway and CEESI (Colorado Experiment Engineering Station Inc.) in the United States.

It is this combination of the new microwave system with multivariate analysis that allows for an improved uncertainty specification of ±0.01% abs WVF (Water Volume Fraction) at GVF 99-100% and the detection of changes in the water content of the flowing well at as little as 0.2 ppm (parts per million). Such sensitivity has never been reached before and represents less than a droplet of water finely distributed in a volume equal to that of four car fuel tanks.

Salinity Measurement

Salinity measurement has also become increasingly important in managing wet gas fields and in determining risk mitigation strategies, such as chemical injection to prevent scaling and corrosion.

Recent technological developments in wet gas metering allows for the direct measurement of salinity via a new ceramic microwave based sensor.

The new sensor developed by Emerson is a dielectric cavity resonator mounted flush in the wall of the meter body, with one end facing the flow. The sensor is extremely sensitive to saline water on the sensor surface and is also highly predictable when faced with increasing salinities and water levels.

Combined with highly sensitive and accurate water measurement, the new salinity system provides a powerful and unique tool for the early detection of formation water breakthrough and the optimization of injection rates for MEG, scale and corrosion inhibitors.

Extending the Operating Range

Finally, another key development in wet gas metering is the extension of the operating range.

While the main focus of the new wet gas metering developments is in the 98–100% GVF range, where improved measurement uncertainty is being seen, progress is also taking place in the lower GVF as well.

As the liquid content and water content increases in the wet gas flow, the medium absorbs more and more of the microwave energy, limiting the operating range of the microwave resonance measurements. By introducing new microwave electronics that allows for transmission-based measurements in addition to resonance, this limitation can be overcome.

Going Downhole

Information on pressure and temperature downhole is also crucial for maximising production - not only warning the operator of threats to production and flow assurance but also providing crucial support to existing production systems, such as Electrical Submersible Pumps (ESPs) and well optimisation.

To this end, Emerson's Roxar downhole monitoring systems and high pressure and temperature gauges are today deployed in production, injection, observation and highly complex multi-zone intelligent wells across the world, where they generate reliable and real-time downhole information crucial to reservoir operations.

Statoil's Gullfaks C production platform in the North Sea, for example, has been using the same Roxar downhole gauge, uninterrupted and without maintenance or replacement for over 22 years.

Yet, there are still areas of the reservoir and the well where operators struggle to access crucial information.

One such information gap is between the well casings of subsea wells in a part of the well known as the annulus and, in particular, the annulus B located between the innermost casing strings.

While the annulus B is an area most likely to see the first indication of high pressures from further down the well, at present operators have little way of discovering this as the annulus B and the pressure & temperature information within is out of reach to operators after seating in the wellhead and the cementing of the casing.

In many cases, the completion engineer is faced with either increasing the pressure ratings of the casing to compensate for worst-case scenarios or relies on shallow well zones well to absorb pressure rises. In some instances, wells have even been unnecessarily shutdown in an effort to protect well integrity.

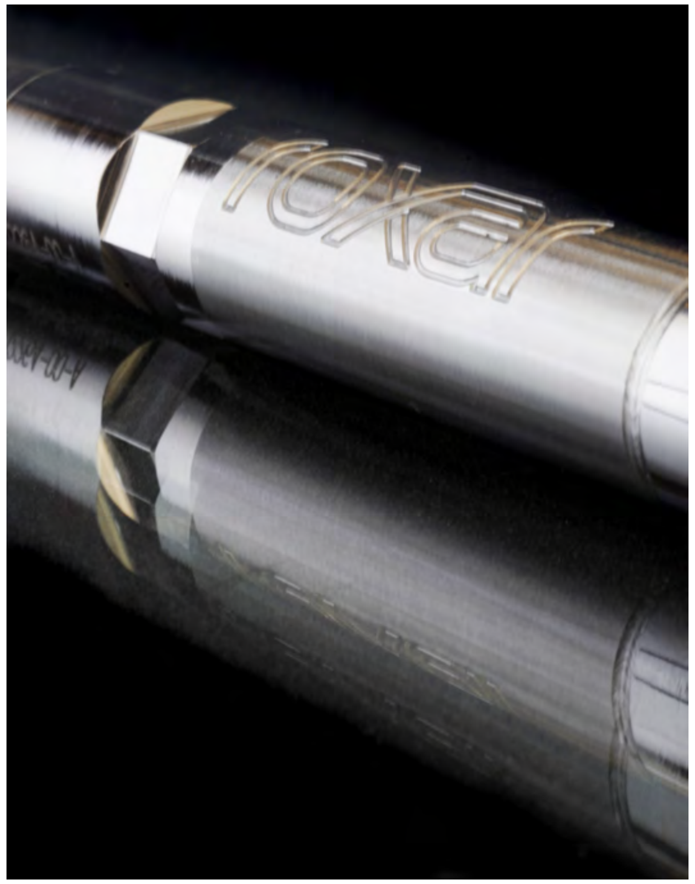
It is this need to improve the monitoring of subsea production or injection wells and, in particular, the B annulus that has driven the development of Emerson's Roxar Downhole Wireless PT Sensor System. The tool provides early warnings of abnormal pressures, protecting casing integrity and monitoring any pressure build-up and, in the worst-case scenarios, avoids production shutdown.

Emerson announced the successful first deployment of its Roxar downhole Wireless PT sensor system in 2014 on Statoil's Skuld field in the Norwegian North Sea where the result for Statoil will be a tool for well integrity monitoring and offshore safety, adherence to Norwegian safety requirements in monitoring pressure in the B annulus, and improved control over their production operations.

A Sustainable Production Strategy

Reservoir management today is all about creating a sustainable production strategy.

In generating real-time data on flow rates, pressure/temperature data and salinity, operators can enjoy improved insight into well production and a maximising of production in offshore fields.



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