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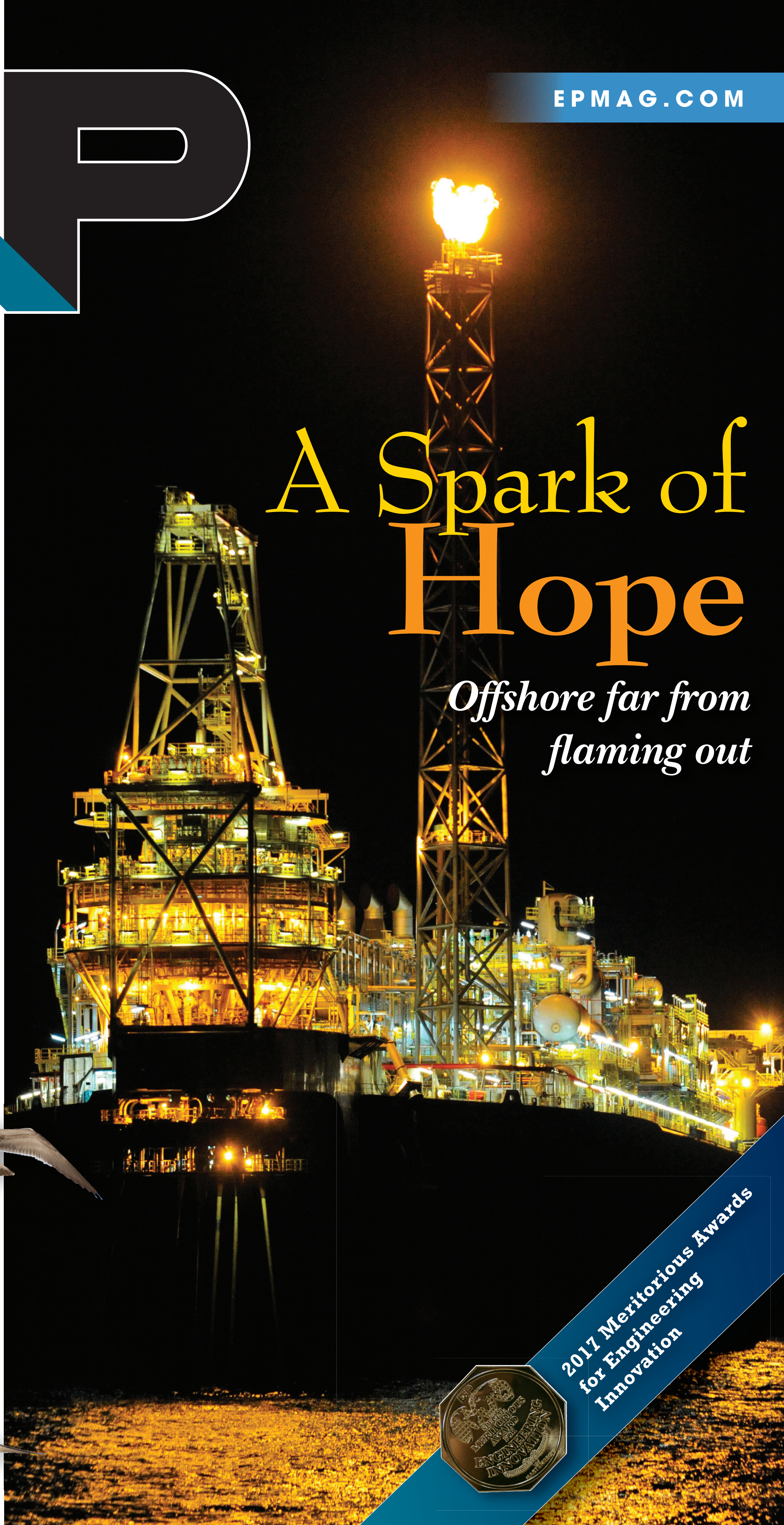

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Salinity measurement system identifies production threats

A new salinity system was designed for increased flow assurance on subsea wet gas field developments.

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Many oil and gas wells are being produced over a broad range of process conditions with more liquid and water present in the wellstream.

With varying process conditions, however, come different production threats. In wet gas fields, formation water and water coning—where water infiltrates the perforation zone in the near-wellbore area—can lead to scaling, hydrate formation and corrosion. In worst-case scenarios this can threaten the integrity of the subsea wells and infrastructure and reduce production. The onset of formation water, if not controlled, also can lead to well shutdowns and have a highly negative impact on field economics.

Additionally, the growth in subsea tieback developments—in some cases up to 400 km (248.5 miles) long—has only exacerbated the danger, leading to potentially hours or even days before the onset of formation water is detected and measured topside. In such cases it might be too late to react and save the well.

Detecting saline water

So how can such challenges be addressed? One means of achieving improved flow assurance and meeting the challenges of different process conditions and formation water is through the accurate and real-time detection of saline water and measuring its conductivity.

Measuring water conductivity has become a key operational parameter for reservoir management and flow assurance. The real-time continuous measurement of water conductivity can tell the operator whether formation water is entering the flow and in what amounts. Such information also can help the operator adjust injection rates of scale, corrosion inhibitors and hydrate prevention using monoethylene glycol. Other remedial action might include adjusting the choke setting or instigating zonal isolation.

The detection of the onset of formation water and its conductivity also must take place quickly. Hydrate formation can accelerate at an alarming pace in the right conditions, with the critical time window when preventative action needs to take place being as little as 20 minutes. Hydrate formation also can take place with fresh/condensed water.

Therefore, it is critical to detect and measure total water and its conductivity in real time.

New salinity measurement system

Traditionally, formation water detection was based on an indication value that remained stable if there was no salinity but would increase when more saline water entered the flow. Typical measurement charts would tend to illustrate the horizontal trending of the defined salinity measurement, indicating no change to salinity followed by a signal spike when there was a change in conductivity.

The downside of this form of measurement, however, is that it is only a qualitative indication, not a quantitative measurement.

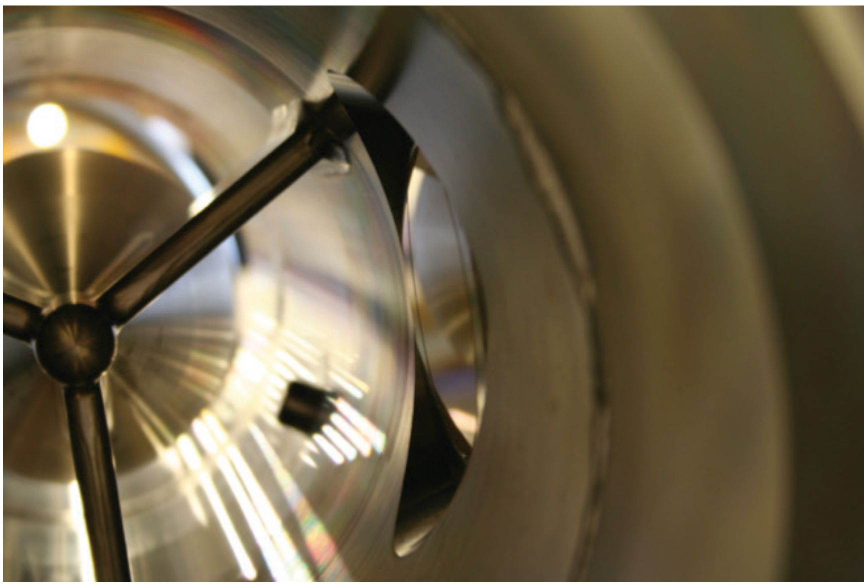

FIGURE 1. The salinity sensor is integrated into the meter. (Source: Emerson Automation Solutions)

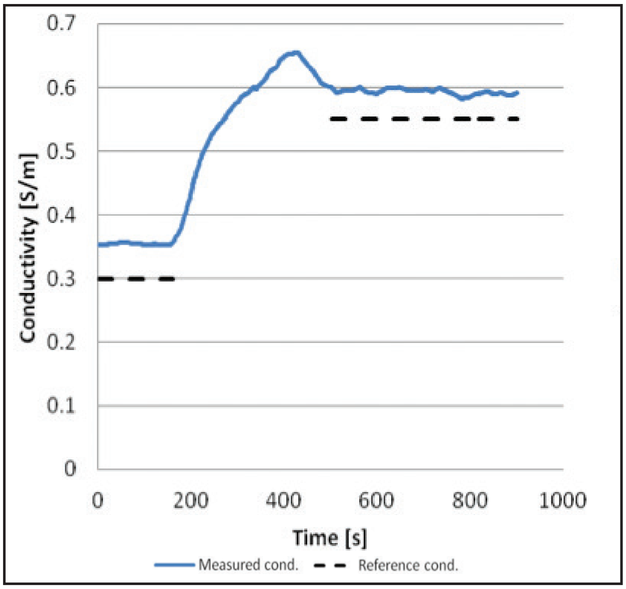

FIGURE 2. Changes to conductivity over a short period between two test levels and the immediate response are measured by the sensor. (Source: Emerson Automation Solutions)

The new Roxar Subsea Wetgas Salinity System developed by Emerson Automation Solutions provides both quantitative and qualitative real-time measurements in many types of field conditions but, in particular, in the high gas void fraction (GVF)/wet gas flows that characterize wet gas fields.

The sensor is extremely sensitive to saline water on the sensor surface and is integrated within the Roxar subsea Wetgas meter. The sensor allows the detection of different cases of formation water breakthrough, including a time-limited small increase of water conductivity from a pocket burst to larger conductivity changes. The system has been designed as a key element of the Roxar subsea Wetgas meter, thereby allowing direct measurements of water conductivity. The Wetgas meter measures the total water content in the gas to provide individual flow rates of gas, condensate/oil and water.

The salinity system itself consists of a ceramic salinity sensor mounted in the wall of the meter body. The ceramic cylinder is metalized on all surfaces except the one facing the flow, with the sensor categorized as a waveguide cavity resonator, shortened in one end and open in the other (the side that is facing the flow).

The ceramic salinity sensor is based on microwave resonance technology. Figure 1 shows the sensor integrated into the meter. Being a microwave resonator sensor comes with several benefits for salinity water measurement. This includes instant response to changes in the flowstream—in seconds, not minutes. The sensor also is highly accurate and can measure small changes in water conductivity down to ± 0.1 Siemens/meter (S/m) and up to 99.99% GVF and measure sensitivity in the range of ± 0.004 S/m. In the field this means that small pockets of formation water leaking into the flow can be detected instantaneously when entering the production flow.

Outputs from the meter enabled by the inclusion of the salinity system include salinity, conductivity, formation water indicator, formation water flow rates and condensed water flow rates.

The conductivity measurements are obtained by measuring the Q-factor shift of the resonance from the

FIGURE 3. The Roxar subsea Wetgas meter measures the total water content in the gas to provide individual flow rates of gas, condensate/oil and water. (Source: Emerson Automation Solutions)

liquid film or droplets of water near the sensor surface. Q-factor is the rate of absorption of microwaves in the sensor where the slower the energy that's absorbed, the higher the Q-factor. Changes to the resonance frequency depend on fluid dielectric properties (permittivity) with a permittivity change within the resonance field changing the resonance frequency and Q-factor.

Testing the system

Extensive testing of the new salinity system took place both internally and at the Colorado Experiment Engineering Station (CEESI). Three separate flow tests were conducted at the CEESI between 2014 and 2016 with close to 700 individual test points run. Testing was conducted along the full range of the subsea Wetgas meter from 85% to 100% GVF, 0-100 water liquid ratio, velocities from 3 m/s to 40 m/s and a wide range of conductivities.

The testing results demonstrated the new salinity system can perform effectively at as low as ± 0.15 S/m uncertainty for water conductivity and can detect ± 0.004 S/m sensitivity in changes in water conductivity. Figure 2 illustrates the changes to conductivity over a short period between two test levels and the immediate response measured by the sensor.

Maximizing production

It's clear that rapid and highly sensitive salinity measurements are needed to capture the critical time window of a hydrate plug forming and to secure flow assurance in oil and gas wells.

With the new Wetgas salinity system integrated into the Roxar subsea Wetgas meter (Figure 3), operators can identify threats to production, improve chemical injection control, reduce opex and maximize oil and gas production. E&P

Have a story idea for Tech Watch? This feature highlights leading-edge technology that has the potential to eventually address real-life upstream challenges. Submit your story ideas to Group Managing Editor Jo Ann Davy at *jdavy@hartenergy.com*.