Operational Experience Roxar Wetgas Meters, Offshore Egypt

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Executive Summary

Customer: Burullus Gas Corporation

Challenge: To accurately measure all produced fluids on a well-by-well basis within the West Delta Deep Marine (WDDM) concession for production optimization, high availability, production allocation and history matching purposes.

Solution: Burullus went through a rigorous selection processing assessing the relative merits of Inference Systems, Differential Pressure Meters, Multiphase Meters, and Wet Gas Metering. Working on evaluation criteria of reliability, accuracy, water measurement, and ease of installation, Burullus opted for the Roxar Wetgas meter. The Roxar Wetgas meter is a compact, state of the art meter for the inline measurement of wet gas flow. The meter provides real-time, accurate measurement of hydrocarbon flow rates and water production - highly valuable for reservoir management, flow assurance and for optimizing the production process.

Results: Installation of the Roxar Wetgas meter has helped Burullus to monitor water production profiles in real-time. By providing early warnings of the water produced, the wet gas meters installed on the field have helped Burullus and its partners save several wells from water breakthrough. It has also provided Burullus with the necessary information to optimize the performance of its wells, leading to increased availability. Moving forward, it is hoped that Burullus will be able to create a dynamic simulation model of the reservoir continually updated with production data. In this way, production and pressure data from the simulation model can be matched to historical pressure data and daily production data by adjusting any number of reservoir parameters. The result would be reduced uncertainty, and a better understanding of reservoir behavior.

The Challenges of Wet Gas Fields

Oil and gas operators today are facing a number of significant challenges in their efforts to optimize production and generate more from their reservoirs – particularly in wet gas fields.

The ability to predict and measure the water production profile for a subsea well has become critical for optimizing production, preventing hydrate, scale and corrosion in pipelines, and ensuring reliability of supply. Water and formation water in particular, can lead to scaling and corrosion of the pipelines and chokes leading to a significant reduction in well production.

The growth in subsea tiebacks has only exacerbated the challenge with it taking longer to detect a water breakthrough in the well which, by the elapsed time, could lead to severe consequences and pipeline damage.

It is therefore essential for operators to be able to measure the early onset of formation-water production in real time in order that preventative or remedial action (adjusting the pH in the MEG/water mixture or controlling the hydrate inhibitor added to the produced fluids, for example) can be taken.

Availability Challenges

Operators are also facing availability challenges. They require accurate estimates of the timing of future developments including: infill wells, new field developments, and production facility requirements.

Poor estimates will lead to the premature advances of development phases to avoid any shortfalls in production, leading to significant potential financial losses. To this end, accurate predictive tools are required.

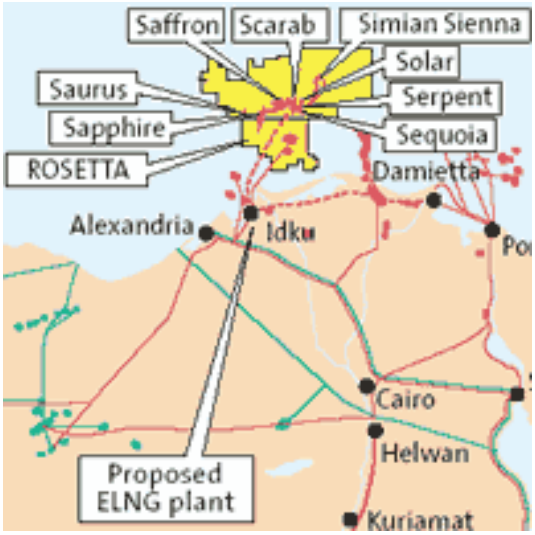
The Rise of Wet Gas Metering

The challenges of wet gas have led to the emergence of specialised wet gas meters, providing real-time, accurate measurement of hydrocarbon flow rates and water production. Yet, how does one opt for a wet gas metering solution and what are the benefits compared to other solutions?

The West Delta Deep Marine (WDDM) Concession

The West Delta Deep Marine (WDDM) concession is situated offshore Egypt in the Mediterranean Sea, about 130 kilometers north east of Alexandria. Burullus Gas Corporation is developing and operating the fields on behalf of its partners.

The WDDM is Egypt’s largest known gas-bearing block offshore and is producing gas for both domestic consumption and to feed the country's growing LNG industry.



There are three principle fields in the WDDM concession: the Simian/Sienna field and the Sapphire field which is tied back to the Scarab/Saffron field. From the Scarab/Saffron field the gas is commingled before transferred to Burullus' onshore processing facilities at Idku near Alexandria.

Specific production characteristics from the fields' wells include high gas rate wells with low water gas ratios (0.3-10 bbl/mmscf) and water depths of between 400 and 1,400 meters.

Formation water production is also expected to increase with both the Simian/Sienna and Sapphire developments anticipated to produce both condensed water and increasing volumes of formation water over their production lifetime.

Reservoir Management Challenges Facing Burullus

Burullus had two immediate reservoir management challenges - the need to be able to detect water in real-time so that immediate corrections can be made to production operations; and the high availability requirements to meet obligations to provide gas for both export and the domestic Egyptian market.

There were also a number of future reservoir management challenges which Burullus wished to address. This included the need to optimize future development phases focusing on the timing and locations of the next drilling phases.

To address these challenges, it was essential for Burullus to be able to accurately measure all produced fluids on a well-by-well basis for production optimization, production allocation and history matching purposes.

The Decision to Opt for Wet Gas Metering

Burullus had a number of requirements for any metering solutions it selected. The solution needed to be able to continuously measure flow on a well by well basis; have the ability to detect water breakthrough for the controlling of chemical injection; ensure high availability; and result in the accurate measurement of all produced fluids on a well-by-well basis.

Burullus assessed a number of metering options - Inference Systems, Differential Pressure Meters, Multiphase Meters, and Wet Gas Meters.

The estimated uncertainty from the inference measurement systems was considered by Burullus to be well outside the acceptable range.

Differential pressure meters were considered to be unsuitable because of the changing composition especially as a result of water breakthrough.

Multiphase flow meters were also considered unsuitable because of high liquid flow uncertainty in the case of high GVF as exists in the WDDM fields.

The conclusion was that wet gas meters offer the only acceptable solution to the water flow rate measurement of high Gas Void Fraction (GVF) wellstreams in remote subsea locations.

Having made the decision to opt for wet gas meters, Burullus compared Roxar's Wetgas Meter with a rival meter. It was determined that the Simian/Sienna and Sapphire flow regimes were within the operating envelope of the Roxar Wetgas Meter except at the highest water production rates. The Simian/Sienna flow regimes were outside the rival meter's operating envelope except at the highest water production rates (the Sapphire flow regime was within the operating range).

The Roxar Wetgas meter

The Roxar subsea Wetgas meter *(figure 1)* is a compact, state of the art meter, which provides real-time, accurate measurement of hydrocarbon flow rates and water production. The meter has an operating range of 90 to 100 per cent GVF, a hydrocarbon mass flow relative uncertainty of +/- 5%, a water fraction measurement uncertainty of 0.1abs vol. % and water fraction sensitivity < 0,0008 abs. vol.%.

Figure 1

The Roxar Wetgas meter is being utilized in some of the world's best known offshore gas fields, including the Independence Hub in the Gulf of Mexico and the Ormen Lange field in the North Sea.

There are three key attributes to the Roxar Wetgas meter – its robustness and low maintenance requirements, its accuracy, and its ability to measure water fraction in a wet gas flow in real-time.

The Roxar Wetgas meter is qualified for high-pressure/high-temperature applications to water depths of 3,000 meters with the meter body constructed of UNS S31803 Duplex. The meter can operate at up to 10,000 psi and 150 °C.

The Roxar Wetgas meter provides online and direct, accurate measurements of water fraction in a wet gas flow, utilizing microwave-based dielectric measurements. In combination with a V-cone based differential pressure measurement this also generates accurate water, gas and condensate flow rates.

Implementation

Today, eight Roxar Wetgas meters are installed in the Simian-Sienna field and eight on the Sapphire field, providing real-time, accurate measurements of hydrocarbon flow rates and water production.

Water production monitoring started almost immediately. *Figure 2* shows the gas rate of each field with purple corresponding to the Sapphire field, red the Simian Sienna field, and yellow Scarab/Saffron. The blue curve represents the saline water coming from the reservoir, measured on shore.

Figure 2 illustrates the challange of determining sources and causes for changing salinity levels, as there are no Wetgas meters on the Scarab wells.

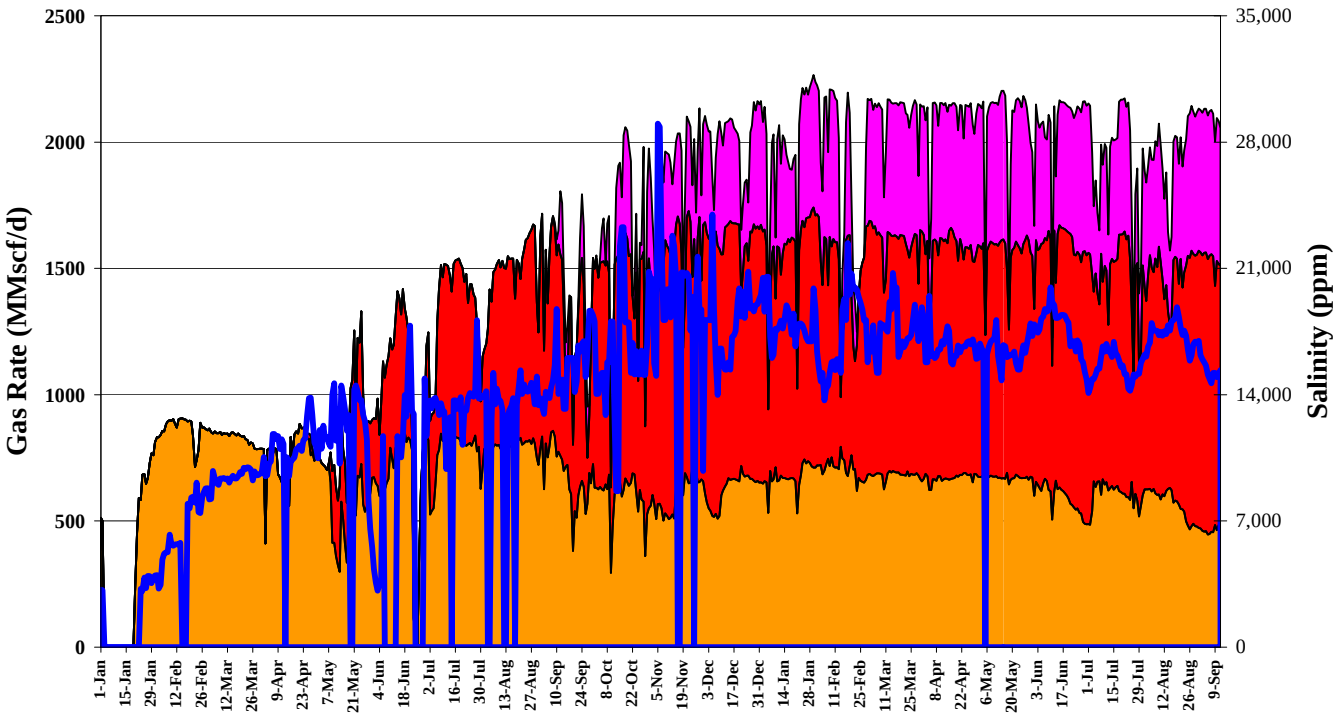


Figure 2

Each meter delivered to Burullus for the Simian/Sienna and Sapphire fields was equipped with the formation water detection functionality which in combination with

the high water fraction sensitivity allows for early identification of potential water breakthrough.

In *Figure 3*, the red line shows the water and the blue line the gas flow rates from one specific well. On 25th May 2006, a water breakthrough was detected. Burullus decided to reduce the choke size in order to lower the water produced and recover and generate better production profiles.

After approximately three weeks producing at lower rates, Burullus decided to open the upper zone of the smart completion.

Another two weeks later the water production started to increase rapidly again.

In an effort to stabilize the well, it was shut in for a week in early August 2006.

When production started again, however, the water starting to increase dangerously and a decision was taken to decrease the lower inflow control valve position. Water then started to decrease, indicating increased water production coming from the lower zone.

Burullus then went into a period of tuning the lower inflow control valve position to find the optimum gas production at an acceptable water rate.

By providing early warnings of the water produced, the wet gas meters installed on the field has helped Burullus and its partners to save several wells from water breakthrough in a similar manner. It also gave Burullus the necessary information to optimize the performance of its wells at acceptable and controlled water rates.

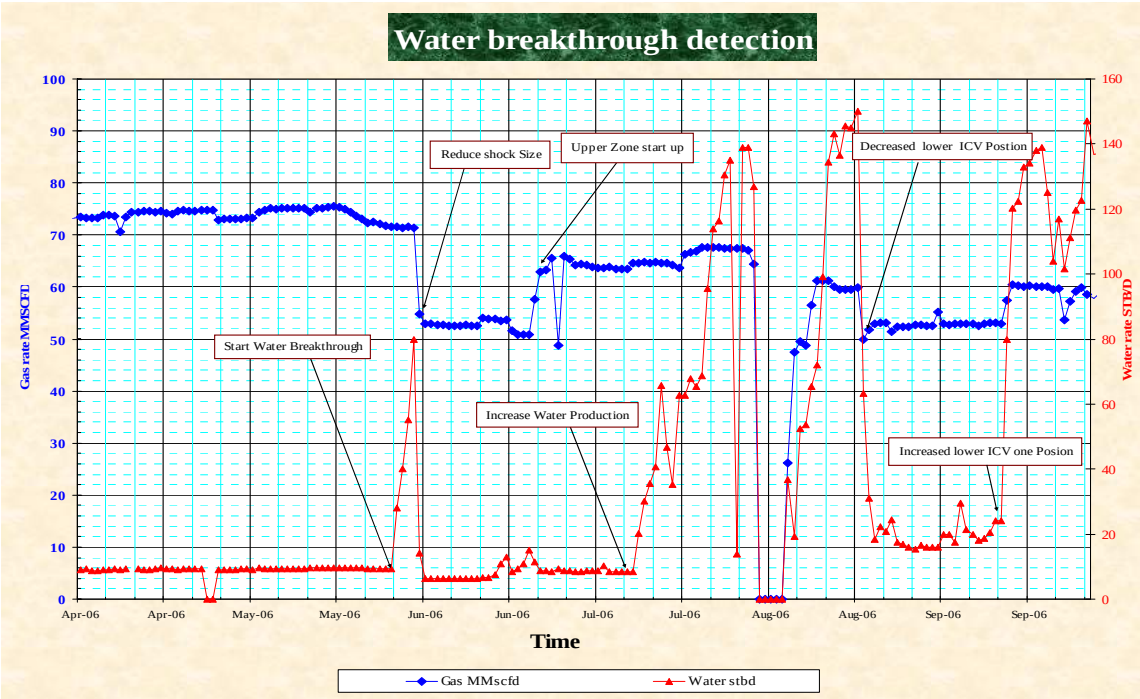


Figure 3

Moving forward, it is hoped that Burullus will be able to create a dynamic simulation model of the reservoir continually updated with production data. In this way, production and pressure data from the simulation model can be matched to historical

pressure data and daily production data by adjusting any number of reservoir parameters. The result will be reduced uncertainty, and a better understanding of reservoir behavior.