Finn Erik Mohn Berge, Emerson Process Management, discusses meeting platform and multiphase metering challenges in the North Sea and beyond.

UP TO THE challenge

Many oil and gas operators today are faced with limited deck space on their existing platforms and rigs. There are a number of reasons for this, from the growth of small, satellite offshore platforms through to the increased number of wellheads, Xmas trees, piping arrangements and other equipment that operators must incorporate into their production systems.

This growth of satellite platforms and production facilities is only likely to increase. In the North Sea, for example, the latest licensing round for the UK Continental Shelf revealed bids for 356 blocks, the largest number since the first licensing round in 1964.

Activity is also every bit as busy on the Norwegian Continental Shelf where, according to the Norwegian Petroleum Directorate (NPD), there were 16 new discoveries during 2010 and 41 new exploration wells completed. The NPD estimates that 50% of the oil still remains in place in Norway's fields and this despite the country having one of the world's best recovery rates.

One product that is contributing to increased recovery rates but can take up substantial amounts of deck space is the topside multiphase meter.

Multiphase meters have a vital role to play in flow assurance and production optimisation, providing critical information on a well's capabilities and the flowrates of oil, gas and water. Information such as water saturation and break through, gas coning, permeability and flow characteristics (and their impact on choke settings) can all be fed through to the operator to help optimise production.

At a time when operators are producing from ever-more challenging fields and are under pressure to make smaller, older fields more economically viable, the need to measure complex flowrates in real-time and with greater accuracy has never been more important.

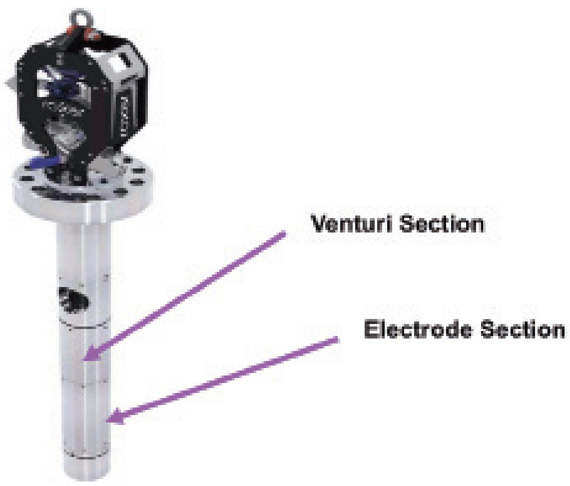

Figure 1. The Roxar Wellhead Insert meter.

As mentioned, however, the typical topside multiphase meter does take up space, weighing approximately 800 kg and being around 1.5 - 2 m tall. Our largest ever meter at 3.65 m was installed on Statoil's Norne field on their Floating Production, Storage and Offloading (FPSO) in 2005.

While we have brought the size down substantially with our third generation multiphase meter, which, at 110 kg and 650 mm is 80% lighter and 50% shorter than previous Roxar multiphase meters, space continues to remain an issue on many platforms.

This article will examine how the twin needs of maximising deck space and generating more accurate measurements of flow can be met through a new Roxar wellhead insert meter that we have been working on in partnership with a leading operator. This article will look at the development of the meter, the measurement technology behind it, and will also provide the results of North Sea pilot installation.

The article will also provide an overview of how the meter operates and is installed through a process that ensures minimal downtime for production and reduces risk during retrofit interventions.

Early beginnings and key drivers

The idea of an insert multiphase meter goes back as far as 1997 when we considered developing a design where the meter could be inserted into a T-bend. At the time, we generated a proposal based on our main meter at the time, the Fluenta SMFM 1000.

Taking this a step further, it was in 2004 that one of our leading customers came to us with the idea of inserting a

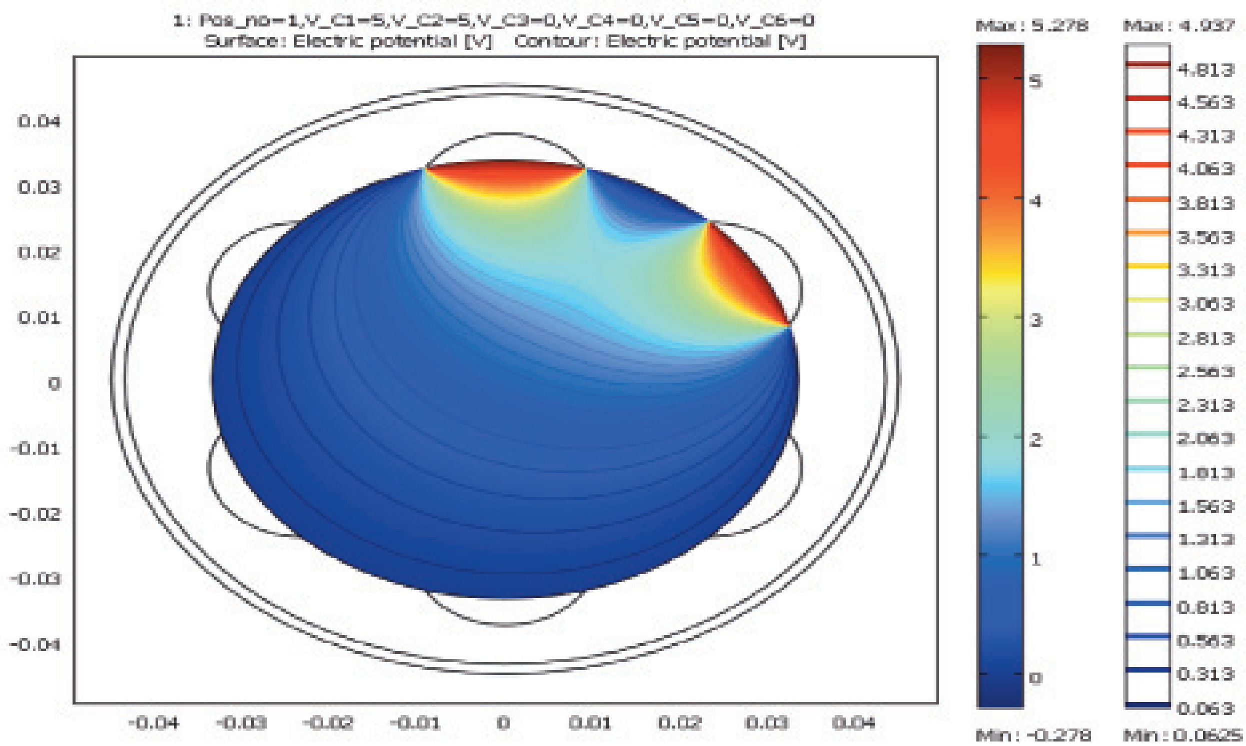

Figure 2. The new measurement principle behind the meter with red indicating high sensitivity and blue low sensitivity.

Figure 3. Taking the meter out of the shipping/calibration frame.

Figure 4. The fully installed meter.

multiphase meter into an Xmas tree. The main rationale behind this was to offset the high cost of retrofitting a multiphase meter onto existing pipelines - a process that involves the cutting of pipe and other modifications and can cost several million US dollars.

Another driver was the need to be able to generate more information on flowrates from the reservoir – a factor which especially applicable in older wells where pressure and temperature transmitters had not been installed or were no longer in operation.

The brief

The brief set for us was to develop a Roxar multiphase meter that could be installed in all the operator's Xmas trees without modification of flowlines or any changes in Xmas tree functionality. Other objectives were to improve production optimisation and control from each well and save space on crowded platforms.

The use of a non-gamma multiphase version to avoid nuclear sources was also discussed. This was important as a means of meeting environmental and HSE requirements, where the use of nucleonic sources was unacceptable due to legislation or company policy.

The meter design

The design (Figure 1 shows the full meter) was based on a number of existing components of our third generation meter and its new measurement principle.

The new measurement principle is based on an electrode geometry sensor, which allows for measurements in separate sectors, in addition to the full cross-sectional area. This results in more combinations and more accurate fraction measurements and velocities for each segment. The measurement principle is shown below in Figure 2 with red indicating high sensitivity, and blue low sensitivity,

The new measurement principle allows for the conducting of both rotational near wall measurements and cross-volume measurements, thereby providing a comprehensive mapping of the flow regimes.

Whereas previous meters had been based on a velocity model consisting of two discrete velocities, the new meter also had a multi-velocity system. This improves accuracy and performance in less than perfect flow conditions. The field electronics system also allows for capacitance and conductance measurements to be combined in one unit.

As well as the existing components of the third generation meter – for example, capacitive, inductive and pressure sensors – a number of new components were incorporated into this new wellhead insert version. This included new housing for the temperature transmitter, with the design optimised to ensure maximum sensitivity to temperature changes and erosion; a new venturi section with a 90° outlet; and a tree cap with cable feed troughs and pressure tapping.

The design was based around ISO 10423 guidelines in relation to Wellhead and Xmas tree equipment. A

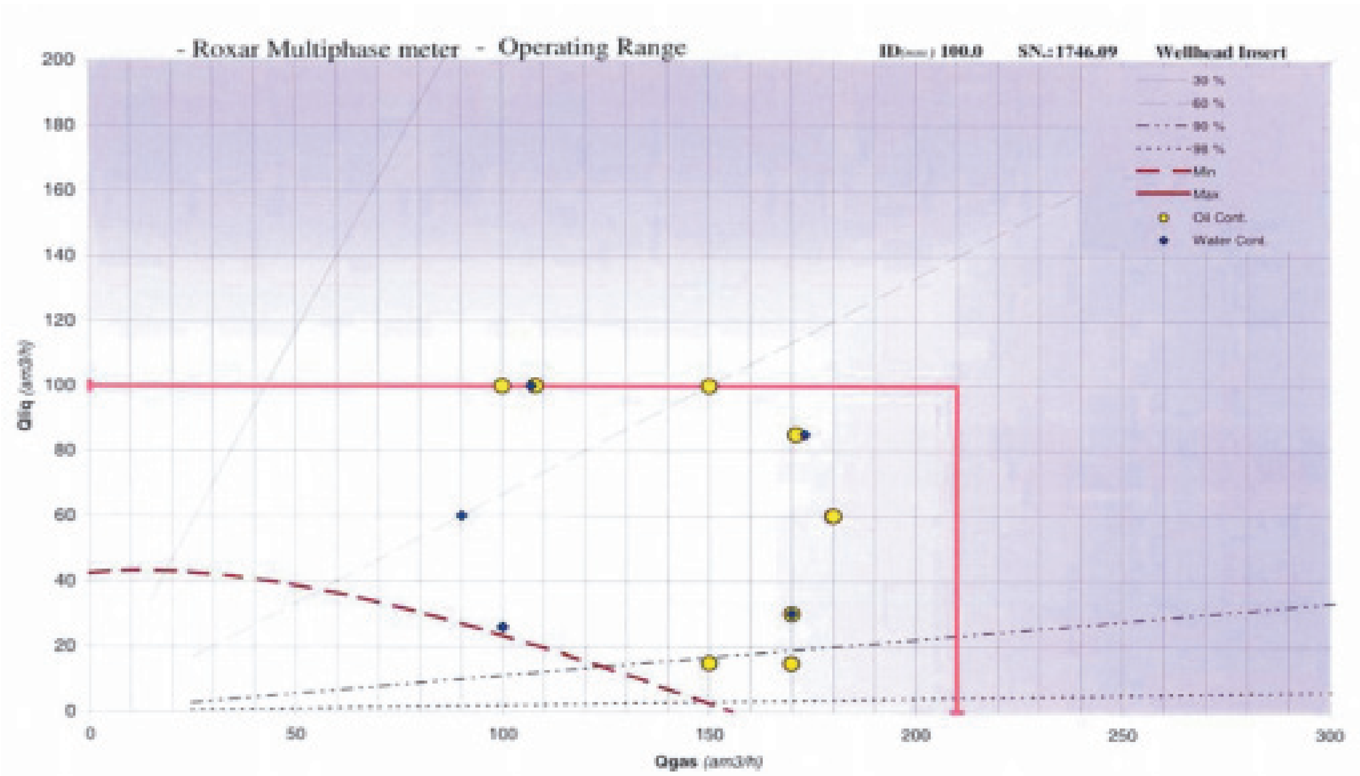

Figure 5. The operating range of the meter with CMR test points included.

cage with a lifting lug was also bolted to the tree cap to protect the valves, transmitters and electronics. With this new design, the new wellhead insert meter can be mounted onto a specially made tree cap. By replacing the original tree cap with the wellhead insert, the meter is then positioned inside the wellhead.

This mechanical solution for fitting the meter into the wellhead does not, however, allow for the positioning of the gamma-ray densitometer in the standard position in the electrode cross-section. The gamma-ray densitometer will therefore have to be positioned after the outlet of the wellhead. If for some reason this is not possible or if a non-gamma version is preferred, this is achievable simply through a software upgrade.

The testing

The new measurement principle has been extensively tested, both statically and dynamically in partnership with CMR (Christian Michelsen Research AS) and at the TUV NEL Multiphase Flow Test.

In November 2010, the meter in wet gas mode was tested at the Colorado Experiment Engineering Station Inc. (CEESI). At CEESI, the meter was tested in the range of 90 - 100 GVF with the meter set up in wet gas mode in two different ways to calculate water volume fraction and hydrocarbon mass flowrate. Two models were tested – one using an inputted WLR (water-liquid ratio) based on a sample and one using the meter's own measured WLR based on its electrode sensors. The results, which were measured at pressures of 30, 55 and 70 bar, showed that overall performance is better than ±5%, hydrocarbon mass flowrate.

The North Sea pilot

Having tested the effectiveness of the measurement principle, the next step was to pilot the new wellhead insert meter to determine the effectiveness of the installation and retrieval processes.

The platform selected in the North Sea had become increasingly crowded but was also a platform where there were limited opportunities for oil, gas and water flow measurement, due to many defect sensors. The objective was therefore to establish improved production optimisation and better control from each well, while at the same time maximising space on the platform.

The installation procedure consisted of a number of steps – firstly, the installation of a new gasket into the ring groove on the Xmas tree; the removal of pad studs and the making up of four installation bars which were incorporated into the Xmas tree pad stud threads. The installation bars were designed so as to ensure they did not interfere with the meter's electronics on top of the tree cap during installation. A nylon tree protector bushing was also installed over the ring gasket.

Once the meter was out of the shipping/calibration frame (Figure 3 shows this happening), the dovetail O-rings on the outside diameter of the meter were inspected to ensure they were in good condition. The meter was then lifted straight up above the Xmas tree by an overhead crane and lowered into the bore of the Xmas tree with the installation bars lowered into the corresponding bolt holes to ensure the alignment of the production outlet. Finally, the tree cap was lowered until it had securely landed on the ring gasket in the Xmas tree ring groove. Figure 4 shows the meter fully installed.

The retrieval of the meter was achieved through the connecting of the overhead crane to the meter at the lift point on top of the meter's electronics cage. The meter was then lifted straight out of the Xmas tree and, once out of the Xmas tree carry, taken immediately over to the shipping/calibration frame, lined up directly above the frame and installed into it for safe storage. The ring groove in the Xmas tree was then cleaned and inspected for any damage (there was none).

The whole process went without incident with three main findings that will simplify the installation and retrieval processes in the future - that the installation bars are not needed for the guiding of the meter into the tree; that the nylon tree protector is not required to offer protection during this procedure; and that no additional insertion force is needed for integration.

As part of the pilot, a dynamic Factory Acceptance Test (FAT) for the Roxar Wellhead Insert meter was performed in the multiphase flow loop at CMR in June 2010.

The test consisted of 15 test points of which 10 were in an oil continuous regime and five in a water continuous regime. In addition, two randomly selected points were tested (but not recorded), having been selected by the operator.

The meter was positioned higher (~1.5 m) above the T-section than for a traditional flow test in order to have a long vertical pipe section before the meter in an attempt to simulate the flow conditions in the pilot field in question. Figure 5 illustrates the operating range of the meter with CMR test points included.

The test compared the meter's measurements with a reference measurement, the purpose being to test the meter in the relevant range of water cut and GVF (Gas Void Fraction) according to specification. The comparisons of the test results from our meter with the reference instruments in the CMR loop gave a good correlation for almost all the points, with the flow test considered successful.

Conclusion

As this article demonstrates, the new well insert multiphase meter has undergone an extensive testing and qualification process.

As the pilot continues and we prepare for widespread roll-out, Emerson Process Management is confident that the new meter will play an important role in future production operations – particularly in smaller fields and unmanned platforms where deck space is limited and in meeting operator demands for production optimisation.

The fact that all the main features of the third generation meter, such as a new measurement principle and field electronics, are incorporated into the meter and that its installation is very effective, ensuring minimal downtime for production and minimising the risk during a retrofit intervention, is also of significant benefit to operators.

We are confident that the meter will have a strong application for operators in the North Sea and beyond over the coming years. WP