Compact multiphase meters take tradition to task

Three of the industry's largest service companies are now offering or perfecting three-phase meters for use in the upstream oil industry. Each has taken an approach fundamentally different from the others. **Rick von Flatern** talks with experts from the three about these compact devices and their potential to change how offshore wells are tested.

Halliburton's FastQ system has been commercial for about a year and there are currently eight mobile units working in various parts of the world.

In today's offshore business environment, the unflagging demand from operators is for smaller, less costly equipment and smart processes to replace the 'way things have always been done'. Well testing is a pointed example of a process that stubbornly resists updating. It is as cumbersome as it is indispensable and has changed very little since long before 300ft was considered deep water.

Well testing requires lots of large pieces of equipment – separators, heaters, piping, flare booms – that consume deck space, add weight and cost significant amounts of time and money.

At the same time, it remains the only practical method for acquiring data of sufficient accuracy to justify the risks associated with very expensive development plans or to properly allocate production income to share holders.

Well testing hardware requirements stem from the need to first separate the flowstream into its three constituent parts, or phases, of oil, water and gas before each can be measured. The alternative, self-contained multiphase meters to measure phase fraction without having separation, has long been in the industry's theoretical sights but until recently has eluded it. It has long been possible to get two-phase measurements, that is, a determination of the relative fractions of gas and liquid, but until recently it has not been possible to directly measure which fraction of the liquid phase was water and which oil.

Now Schlumberger and Halliburton are offering commercial versions of three-phase meters and Weatherford, which has a downhole two-phase system on offer, is field testing its three-phase downhole flowmeter.

The three service and supply giants have taken very different tacks to deliver the third measurement. Schlumberger and Halliburton use modified Venturi technology to deliver the two phases but differ fundamentally in how they derive the third phase.

Weatherford meters, by virtue of the company's fiber optics approach, are configured in yet a third way as the company builds on the successful development of its downhole two-phase fiber optic meter.

While no-one is predicting the demise of traditional testing methods and all concede multiphase meter limits such as very high gas cut or very low production rates, it is plain proponents are optimistic about their market. And as they predictably argue the virtues of their own system they generally agree that the advantages of multiphase meter testing centers around those things that are dearest to the hearts of offshore operators: they save time, space and money.

A familiar source

In 2000, Schlumberger introduced its Vx multiphase well testing technology as PhaseTester and PhaseWatcher. Developed as an adaptation of work done by Norway's Framo Engineering, the former is designed as a well testing system while the latter is for remote, permanent installation on sales lines. Both work by coupling Venturi mass flowrate and dual-energy gamma ray holdup measurements and use high-speed detectors that obtain a measurement at 45Hz to calculate gas, oil and water fractions. The two are essentially the same pieces of kit with different applications.

'PhaseTester is our mobile well testing application,' explains Schlumberger's product champion Trey Lowe of the unit with a 2.5m^2 footprint. 'PhaseWatcher is also used for testing operations but in almost all applications it is permanently

installed. The advantage that multiphase measuring brings to the table is not only continuous measurement but also a measurement that is very maintenance free. And so they are ideal for remote applications like unmanned platforms and other places where a small footprint is needed or that have weight limitations.'

The choice to wed Gamma Ray measurement to Venturi technology, says Lowe, traces to Schlumberger's long history with downhole logging tools, flow dynamics and modeling and a longtime relationship with Framo. 'We experimented through the early 1990's with a lot of different techniques and we looked at several methods and theories,' recalls Lowe. 'While we felt that measuring a pressure differential across a Venturi remained the best method for determining mass flowrate, Schlumberger focused its efforts on developing a very accurate phase fraction measurement using a dual energy gamma ray source.'

Schlumberger says concerns over use of a radioactive source – that it can hinder mobility across international boundaries, create operator concerns over source ownership and accuracy questions related to decay – are unfounded. Schlumberger has been importing sources into nearly every country in the world for more than 20 years, Lowe points out, and, at any rate, since the company usually has considerable infrastructure in place wherever it works the sources are already in place.

'We investigated all these different types of measurement and techniques and we decided we are going to pursue the one that works best,' says Lowe. 'That is the reason we chose the dual gamma ray. And one of the key things about the source we pick is that it is very well predicted so we use a computer algorithm that associates with the expected decay rate and it compensates over time. It is very straightforward. If one of these days we find a way to do a more accurate measurement then we will do that.'

To date, Lowe says, the company has sold more than 150 permanent-style PhaseWatchers and has about 50 PhaseTesters at work.

The Schlumberger PhaseWatcher installed on an unmanned platform offshore Australia.

Conductance/capacitance

Halliburton's Alex Ogilvie says his company began its foray into the multiphase meter market also around 2000, initially using systems from Roxar that also contained radioactive sources. 'We took them to Algeria for field trialing and it became obvious to us that even if we started to sell multiphase meters to customers, we were still the owners and the customer did not want to own sources,' he says. 'So we started looking for non-nuclear solutions and that is when we came up with the company Flowsys.'

Flowsys had devised a non-radioactive solution that is the basis for the current Halliburton offering and which Ogilvie describes as a Venturi that has been 'highly modified with electrodes for conductance and capacitance measurements'.

The system, called the FastQ, works by first getting the differential across the Venturi throat, which is then cross-correlated to velocity through the meter with respect to time and distance to deliver mass density. That result is then coupled with the conductance or capacitance measurements and fed into complex algorithms and models that work out the fraction of gas, oil and water.

'We do high-speed sampling and the cross-correlation is being taken eight times per second and with that 1/8 second window there has to be a dominant velocity whether it is liquid or gas,' notes Ogilvie. 'High speed sampling allows us to get that.'

A 6in meter is only 40in tall and a 2in one only 20in tall. When packed into a mobile frame it still weighs in at something like 1500 kilos and can be installed in permanent or temporary configuration.

'The non-radioactive approach had a big appeal to Halliburton,' says Ogilvie. 'It is part of our HSE policy to introduce services friendly to the environment and

At the heart of the mobile Halliburton FastQ multiphase meter, pictured below in a recent onshore application, is a series of sensors mounted on a small venturi.

we have also found that radioactive sources present problems of import licenses from various countries, some countries took us three or four months, others would take us 12 months and then time for clearing personnel for radioactive awareness.'

The FastQ system has been commercial for about a year with eight mobile units working in various spots around the world. Ogilvie says that while the systems can be installed as a permanent installation, the company prefers to offer it as a service. 'We normally have two people on location and one of our FastQ engineers, based here in Scotland, travels to location for initial deployment and to work with the local people to train them. Then we can back off and let them run the operations themselves as we have done in Algeria and Indonesia.'

Fiber optics

With a continuing commitment to fiber optics as a downhole enabler, Weatherford is developing a three-phase, downhole multiphase meter on the back of its already field-proven two-phase version.

The company's two-phase system, installed for 18 months at BP's Mahogany field offshore Trinidad, consists of two modules. The upper assembly consists of a gauge carrier that houses a fiber optic pressure and temperature transducer while a lower assembly contains optical flow and phase sensors. The meter assembly consists of a fullbore inner sensor tube and an outer sleeve with fiber optic flow and phase fraction sensors in between. An optical bulkhead connector provides optical communication to the surface.

The flowmeter measures the bulk velocity and the speed of sound in the flowstream to determine two-phase composition. With sufficient knowledge of the fluid PVT data, oil-water or gas-liquid flow rates can be determined. To get to direct three-phase measurement, Weatherford is adding a vertically separated second pressure-temperature mandrel to determine mixture density.

'The additional measurement of mixture density, combined with the measurements of fluid velocity and speed of sound, enable us to uniquely determine gas, oil and water flow rates,' says Weatherford project manager Steve Mathias. He adds that the three-phase version 'is now in field tests with a major operator and is being benchmarked with well tests using traditional test separators at the surface and it is going very well'.

Delivering the goods

In the end well testing is about delivering usable data. And the compactness of the multiphase meters as well as the very nature of downhole meters tied to the surface via fiber optics, means data of sufficient quality to support critical operator decisions can be delivered faster than when the same data is gathered through traditional separator systems.

'All the sensors are mounted around a small Venturi and the signals go to a central processing unit that is also right there on the meter,' explains Schlumberger's Lowe. 'So all processing happens right at the meter.'

During a mobile operation, that is temporary installation using PhaseTester, technicians gather the data to be used in reports. PhaseTester and the permanent PhaseWatcher installations can send the data directly to client offices through any SCADA-type system or through Schlumberger's InterACT system built especially for delivering and monitoring realtime data over distances. Halliburton's FastQ can do likewise as well as through its proprietary Incite data transmission system.

'With all this data we are trying to provide information to the operators that they can do something about,' says Schlumberger marketing manager Lorne Simmons. 'All this information is transmitted directly to the client offices and so if there is, for instance, too much gas in the flow, we help them decide what to do about it and when. Obviously the convenience of measuring at the surface is attractive.'

Industry seems to agree. In 2003, Schlumberger estimates it will do more than 1000 jobs with its two systems compared to about 300 a year earlier. 'To be quite honest, the way the industry has begun to accept this technology kind of speaks for itself,' believes Lowe. 'Whenever it can be used, it is. Today, in many parts of the world, almost every well test job is done with a PhaseTester or they are using it upstream of the separator.'

Part of the increasing industry uptake is likely due to mounting evidence the systems are accurate within their appropriate operating parameters, more than about 100b/d of liquid and less than about 96% gas fraction.

'Inside the ideal envelope accuracy rivals traditional separators,' asserts Halliburton's Ogilvie. 'And traditional separators have their problems with liquid-liquid separation and can have carry-over or carry-under and they have problems with heavy oils and emulsions and foaming that are not a problem with multiphase meters.'

And as to industry attitudes, he says: 'Some places are better than others but overall industry interest has been very good and customers are making up their minds as to what they are going to take up. Hopefully the deepwater and subsea market is going to be good. The next logical step is meters at the seabed as permanent installations.'

No-one suggests the traditional separator is about to be retired from the field any time soon, particularly as gas exploration and production activity increases worldwide. But there also can be little doubt that compact multiphase meters are here to stay and have only begun to stake out their share of the well testing market. OE