photos: Tendeka

## *Tendeka's Technology in Norway –*

# Proving Where There is a Well There is a Wireless Way

The Norwegian oil and gas industry has always supported innovation and a disproportionate number of very successful technologies have their origins here. This longstanding commitment to research and development (R&D) is increasing further as operators, suppliers, universities and research institutes rise to the challenge of maintaining high production levels on the Norwegian Continental Shelf (NCS) long into the future.

BY ANNABEL GREEN

Statoil alone has increased R&D investment by 27% to nearly NOK 3 billion in order to enable an increase in its production to 2.5 million barrel of oil equivalent per day by 2020. With support from the government and activity from international oil companies also high, these are vibrant times on the NCS.

### Core Challenges

I believe there are three core challenges faced by the region that are driving technology development. The first of these is to increase the production rates and extend the lives of the mature field developments. Hydrocarbon recovery in Norway is already world leading in some fields but investment in reservoir characterisation and improved oil recovery (IOR) technology is designed to delivery recover factors as high at 70% in some areas.

The second challenge is to develop small marginal discoveries in a rapid and cost-effective manner with more efficient well construction in terms of both time and overall cost. Three out of four discoveries fall into this category and the aim is to reduce costs by 30% and half the time from discovery to production.

The final technology challenge is to support the exploration and development of the largely untapped resources that lie in the Barents Sea. The on-going development of the Goliat field and the recent massive discoveries of Havis and Skrugard in this challenging operating environment are increasing focus in this area.

### Wireless Technology

One development to have benefitted from the Norwegian support of innovation in recent years is Tendeka AS's wireless technology which is initially targeted towards mature fields both for reservoir characterisation and improving recovery factors.

Accurate reservoir pressure data is a valuable tool for the driller, the reservoir engineer and the petroleum engineer in extending field life whether infilling drilling through depleted zones to target bypassed reserves, monitoring the effectiveness of pressure support, flow assurance or planning tertiary recovery techniques.

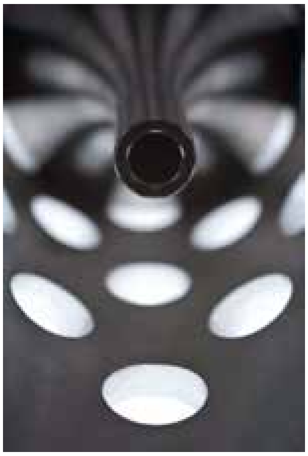
In many mature and marginal fields permanent pressure monitoring systems were not installed when the wells were completed. Other fields have experienced the systemic failure of permanent downhole gauges due to poor installation practices, historical weaknesses in the control lines and control lines connection or simply the gauges exceeding their design life as the field matures. In either case the available options to obtain real-time data from the well without the major expense of well recompletion and/or wellhead modification are very limited.

### Retrofit Monitoring

The coupling of a pressure pulse telemetry system with a quartzdyne pressure and temperature (PT) gauge provides the required retrofit monitoring capability. It includes the flexibility to be installed anywhere in the well using standard intervention techniques or tools with no further modifications or additional equipment required.

The pressure and temperature data from the gauge is compressed and transmitted via a pressure pulse telegram to surface. The intelligent pulse telemetry system uses a novel down-hole piston and choke design with hydraulic actuator to cause a small reduction in flowing wellhead pressure (FWHP), just long enough to be detected on the surface pressure gauge. A short-series of pulses, typically six a day, is sufficient for pressure and temperature data to be obtained. The wireless gauge functions independently of any other well components and the system requires no signal boosters or additional surface hardware, since the size of the required pulse can be programmed into the tool and an existing tubing head pressure gauge can be used to detect the pulse train.

For most operators, the system can be deployed by a single interven



*Tendeka monitoring technologies give accurate real-time data, enabling an operator to make informed decisions that optimise asset performance and reduce costs*

tion using standard intervention techniques and anchored in the well using a standard retrievable bridge plug or flow control system. The added advantage of using a bridge plug is that the gauge can be set in blank pipe, giving optimal freedom for installation depth, and it can be installed close to or within the producing interval as required.

## Or Pre-Installed

Alternatively, the wireless gauge, or multiple wireless gauges, can be deployed pre-installed into a new well or completion to allow pressure or temperature data to be obtained where conventional permanent monitoring systems cannot be used. For example, within the laterals of multi-lateral wells or in slimhole wells where there is no room for control lines.

Compared with a memory gauge system, it allows data to be collected in real time and provides a continuous confirmation of operation, while the internal memory allows high frequency data to be recorded in a similar way, to be downloaded when the wireless gauge is eventually retrieved.

The simplicity of the intelligent pulse telemetry system and the ease of installation make this an ideal technology for retrofit at a fraction of the cost and technical complexity of alternative solutions.

## Multiple Field Trial Opportunities

Norwegian sector support for development of the wireless gauge has meant that multiple field trial opportunities were provided, demonstrating the robustness of the telemetry function in a number of applications, from high rate oil producers to low rate gas wells. It has been possible to prove that the wireless gauge can function in wells with slug flow and high levels of pressure/noise variations on surface. By predicting and comparing the results using transient flow analysis it is now possible to evaluate future installations using modelling techniques. Poor reliability in early commercialisation will hinder the uptake of any new technology and the ability to trial and test all elements of the system accelerates technology acceptance and allows the value that technology brings to be realised sooner.

On-going support and uptake for the technology has meant a further five gauges are now either installed and transmitting data, retrieved, or are in the process of being installed. In a recent campaign wireless gauges were installed into different reservoir segments in the same field to monitor depletion and establish the extent of reservoir connectivity. The gas condensate field was originally developed in the mid-nineties without any in-well monitoring hardware and in many wells downhole pressure has not been measured since the late nineties.

In preparation for the campaign, in 2009 the wireless gauge was installed in a single low-pressure gas well offshore Norway to demonstrate pressure pulse telemetry under low rate, low-pressure condition and to prove the tool performance in the well environment. The application was especially challenging as the well was a marginal producer and the wellhead pressure had large background pressure variations due to the limited well deliverability. Despite these conditions, pressure pulse transmission proved effective.

Following the successful conclusion of that trial the current campaign was planned. The data will ultimately be used to help determine whether in-fill drilling would be beneficial in the field and the placement of any new wells.

## Water Injection Wells

The downhole pressure temperature gauge can also operate in water injection wells, where a back pressure is created instead on the injection fluid, which generates a pressure pulse train on the surface. For these applications wireless technology now also offers the measurement of injection rate. By measuring the pressure drop across a modified venturi an accurate flow rate can be calculated.

Flow loop testing has verified the method is extremely accurate when used in single phase fluids, such as with water injection applications. This allows the gauge to be run between injection intervals, reporting on the pressure, temperature and rate split between zones. The information is then transmitted to the surface using wireless telemetry.

The retrofit wireless gauge makes valuable use of pressure pulse telemetry but marks only the starting point for this high potential technology.

## Intelligent Wells

Advanced completions or intelligent wells use valves or chokes in the reservoir section of wells that can be operated from the surface. They have been used extensively in the NCS over the last fifteen years for the more effective exploitation of resources through shut-off of unwanted production, improved water injection placement and modification to hydrocarbon inflow profiles to increase recovery factors. They form an integral part of the technology strategy for both extending the life of existing fields and the development of marginal field developments.

Currently available advanced completion technology is controlled from surface using multiple electric and/or hydraulic control lines which must pass through the wellhead into the completion annulus, along the length of the completion, through any packers and into the reservoir section were the interval control valves are located.

*The wireless PT Gauge is the first to transmit accurate downhole measurements back to the surface via the fluids in the wellbore*

While this technology has been used with great success there are a number of limitations associated with the use of control lines which weaken well barriers, which affect reliability and which mean the technology is not always compatible with the well architecture.

Wireless intelligent well technology will extend the operating envelope for the advanced completion to allow interval control where currently this cannot be achieved. Independent valve assemblies without control lines can be rotated in the well during deployment and function autonomously without physical connection to the surface. Single critical point failure modes are eliminated and inflow control can be achieved in the lateral of multi-lateral wells or at the furthest extent of a long open hole lateral.

Well construction costs are reduced as cost savings in control lines, downhole connection and completion times are made, and simple top hole work-overs can be performed more simply and cheaply without affecting the advanced completion functionality. A further benefit of eliminating control lines is that open hole zone isolation is more effective with standard packers compatible for deployment and zonal isolation in the system.

## Wireless Interval Control Valves

Development work on wireless interval control valves (ICVs) is already well advanced with initial design configurations targeted at mature areas. The value of downhole flow control in mature fields can be more immediate and significant with water breakthrough, large differential pressures between zones and gas capacity management problems already commonly existing.

***The PT Gauge system uses innovative intelligent pulse technology to choke well flow intermittently so that existing sensors at the wellhead can receive the signals***

The use of ICVs can simplify re-perforation strategies and reduce intervention for shut-off, treatment and production logging. The application of advanced completion technology into existing wells has been hindered not only by the suitability of tools for the well architecture but by the significant challenges in interfacing with existing wellheads and topside infrastructure.

With wireless ICV technology it is possible to install systems both during re-completion operations or retrofit solutions using standard intervention techniques. With fully open, fully closed and zonal choking positions available in the valves, the flexibility exists to provide the operator with the tools for well optimisation without intervention. Two-way communications with the downhole devices is achieved using pressure pulse technology, allowing adjustment of the valve position from the surface and to confirm the valve position along with pressure and temperature data for each ICV.

## The Future

Each mature asset poses a unique set of challenges in the drive to meet production targets and minimise well operating costs. As every wireless ICV unit, inclusive of hanging device and zonal isolation, functions entirely independently it can provide the full modular flexibility required, from a low cost single zone solution to full multi-zone, multi-lateral measurement and control.

The future will see wireless technology used in a wider variety of downhole tools, ICVs for all applications, integration with fracturing and stimulation sleeves and adjustable inflow control devices. As the technology matures it has the potential to change the way operating companies design, test, stimulate, and operate complex and maximum reservoir contact wells, and demonstrate once again Norway's world leading position on technology and innovation. ■

## The Author:

Annabel Green is the product line director, wireless technologies, Tendeka. Based in Norway, she has a leading role in driving forward Tendeka's business through strategic marketing, technical collaboration and product development. Ms. Green joined Tendeka from Weatherford where she spent more than 14 years in numerous technical and R&D roles, and she previously worked for Schlumberger as an open hole-logging engineer in the North Sea. She holds a degree in mechanical engineering, several patents and is the co-author of a number of sand control-related SPE papers.