Wireless monitoring reduces reservoir uncertainties in suspended and abandoned subsea wells

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Agenda

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• Subsea Applications
  ▪ Exploration & Appraisal Monitoring
  ▪ Suspended Completion Monitoring
• Case Study – Total, Norvarg - SPE-1800080-MS
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Introduction

Reducing Reservoir Uncertainties

• How continuous are the reservoir layers and what are the connected volumes?

• What is the drainage area and shape?

• What is the recovery factor and size of reserves?

• How many wells are required to drain the reservoir and where should they be located?

• Making the wrong decision now may have a significant commercial impact later on.
A key objective of well testing is to **investigate Reservoir Continuity** – what is the drainage area, are there any nearby boundaries, is the reservoir compartmentalised?

- There is often time / cost pressure for well testing operations to be conducted in the shortest time frame, meaning that **testing operations may be terminated early, before pressure transient testing has been fully utilised to investigate the reservoir**

- By the application of wireless monitoring technology, well testing no longer has to end at well suspension / abandonment
Introduction

Wireless Technology

• A **Cableless Telemetry System** transmitting pressure and temperature **data from downhole to surface in real time using electromagnetic (EM) signals**.

• It **uses the metallic structure of the well as a conduit** to transmit the electromagnetic signals.

• Uses standard completion hardware, there is no requirement for a tubing string in the well, data transmission is **not affected by cement plugs or bridge plugs**.

• System addressability enables **multi-zone monitoring** in a well.

• Flexible deployment options via wireline, coil, tubing mounted / casing conveyed or via a large bore gauge mandrel.

• The telemetry is **duplex** and thus also capable of transmitting commands from surface to a downhole receiver.
Wireless System Overview
Technical Overview

• System life of up to **7 years in reservoir**
• **Duplex functionality** with the ability to:
  • Change gauge data schedule / sampling frequency from surface
  • Request historical data to maintain data plots or in-fill periods of interest
  • Request on demand readings
  • Upload seabed pressure data, logged every hour
• **15k psi** downhole gauge / **135°C** housings and **quartz sensor**
  • Hi-res P (0.01psi)
  • Hi-res T (0.1°C)
• Full metal-metal primary sealing
• Subsea transceiver with integral **pressure sensor for monitoring tidal data**
• Relay Station means no limit to achievable transmission range
Example of Wireless Gauges Clamped to tubing and Wireless Subsea Receiver installed onto the debris cap.
Wireless System Overview

Data Recovery Overview

- Data from the seabed transceiver is uploaded using the through *seawater dunking transceiver system*

- **Duplex commands** are sent down to the subsea transceiver and confirmation of the change is received

- Offshore the transceiver can be **deployed through the moonpool or over the side or the rig** on a winch or crane line approx. **10m below the surface**

- A support or supply vessel is normally used for routine data uploads
Advanced Reservoir Testing

Exploration & Appraisal Monitoring

- Subsea transceiver & reference anode
- Casings cut below seabed
- Repeaters
- Bi-directional duplex communication
- Cap rock cement plug (casing cut & open-hole section)
- Gauges set in side-track (non-cemented liner)
- Gauges in pilot hole

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Advanced Reservoir Testing
Suspended Completion Monitoring

Subsea transceiver mounted on tree cap
Subsea Xmas Tree
Reference anode positioned on seabed
Bi-directional duplex communication
Temporary suspension plug
Gauges externally mounted on tubing

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Case Study
Total Norvarg, Norway (SPE-1800080-MS)

Background
The Norvarg field in the Barents Sea was discovered by Total in 2011 via wildcat well 7225/3-1. A DST was performed in the Upper Kobbe formation with non-commercial productivity resulting. After revaluation using new seismic data, the vision for Norvarg was for large channel sands having better reservoir properties than tested in the discovery well.

- Bjarmeland Platform area
- 275km north of Hammerfest
- 385m water depth
- Jurassic & Triassic formations
- PL535 licence
Case Study
Total Norvarg, Norway (SPE-1800080-MS)

Objectives of the Norvarg-2 appraisal well

• Verifying the presence of the channel sands defined from the new seismic data
• Quantifying channel productivity and contributions from other Kobbe facies by performing an extended pressure build-up
• Pressure build-up envisage to last many months or even years so had to be performed using a wireless gauge technology that did not require the rig to be on location

Operations

• Norvarg-2 was drilled in the north east part of the structure in 2013 using the Leiv Eiriksson
• DST #1 was performed on the deeper Kobbe Channel D sands, followed by DST #2 on the Channel A sands (Long term PBU)
• 3x CaTS wireless gauges installed for monitoring of the long term PBU for 3.5 years
• Given the location remoteness, 2 subsea receivers for 100% redundancy
• Pre-job modelling concluded that single-hop post-abandonment wireless communications from reservoir to seabed was possible - no relay stations required
• Data was also required from the long term gauges during the initial DST period
In-well Configuration

- **Three CaTS wireless gauges** mounted on 2 7/8” tubing inside 7” liner

- Only 44m range from top of the TCP guns to the deepest wireless gauge - **auto gun disconnect sub** used to minimise shock transfer to gauges

- **Two relay stations** were installed on the DST string to access real time data from the long term gauges **during the DST phase only**

- EM signal pick-up with umbilical deployed on the landing string

- As a contingency against problems with wireless data transfer to surface whilst rig on location, an **EM memory logger tool** was installed above the packer
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Subsea Configuration

- **2 CaTS receivers** and acoustic seawater modems integrated into net-guard structure
- **ROV operated contact screws** for electrical connection from receiver to wellhead
- Reference anode positioned 50m away from well on seabed
- **System was commissioned as an offline activity** whilst the rig was busy preparing to handle anchors
- Acoustic dunking sonde was deployed through the moon pool to a depth of ~15m below sea level
- A single P/T transmission was received from each gauge and the data confirmed as being repeatable in each subsea receiver
- The rig departed location with the well abandoned and PBU monitoring ongoing
- System recovered earlier than expected in April 2014
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Results

- 9 months of **high quality and repeatable post-abandonment pressure / temperature data**
- Extended PBU identified **2 internal flow barriers in the seismic channel** at 130m and 280m from the wellbore that were not revealed during the standard DST period. The seismic channel is most likely a channel belt with individual smaller channels having internal flow barriers
- **Limited connected volumes** from this interpretation and the lower than expected productivity
- **Additional development wells would be required**
- Provided supporting information to relinquish the PL535 licence
Conclusions

- Reservoir connectivity and compartmentalisation are key uncertainties when planning any new field development; reducing reservoir uncertainty carries significant value.

- Advances in wireless monitoring technology now enables abandoned or suspended wells to be cost effectively converted into high value, long term monitoring assets post-final abandonment.

- Post-abandonment data is being used for far-boundary investigation, inter-well connectivity and vertical transmissibility determination.

- Using a wireless monitoring system in reservoir surveillance will provide the opportunity to gather qualitative reservoir data from future exploration, appraisal and development wells to allow operators to make informed appraisal and field development decisions.
Thank you for your attention

Any Questions?

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SPE 175075: Reducing Reservoir Uncertainty During Appraisal and Development – Novel Application of a new Wireless Reservoir Monitoring Technology in Santos Basin Pre-Salt

SPE 102745: Tight gas monitoring – delivering a dual purpose well to satisfy monitoring and production objectives

SPE 108435: Clair Field – Reducing uncertainty in Reservoir Connectivity during reservoir appraisal

SPE 124100: Mungo Platform – A New Wireless Retrofit Solution to restore real time BHP/BHT data after a permanently installed monitoring system has failed

SPE 130427: Development and Qualification of a New Wireless Controlled Retrofit Safety Valve

SPE 145581: Ormen Lange: Delivering Production Optimisation and an improved Reservoir Understanding using new cableless sandface monitoring system