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Aberdeen Section
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Wireless monitoring reduces reservoir uncertainties in suspended and abandoned subsea wells

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Agenda

- Introduction
- Wireless Well Technology & Equipment
- Case Study – Total, Norvarg - SPE-1800080-MS
- Conclusions
- Questions

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.

Introduction
Reducing Reservoir Uncertainties

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**

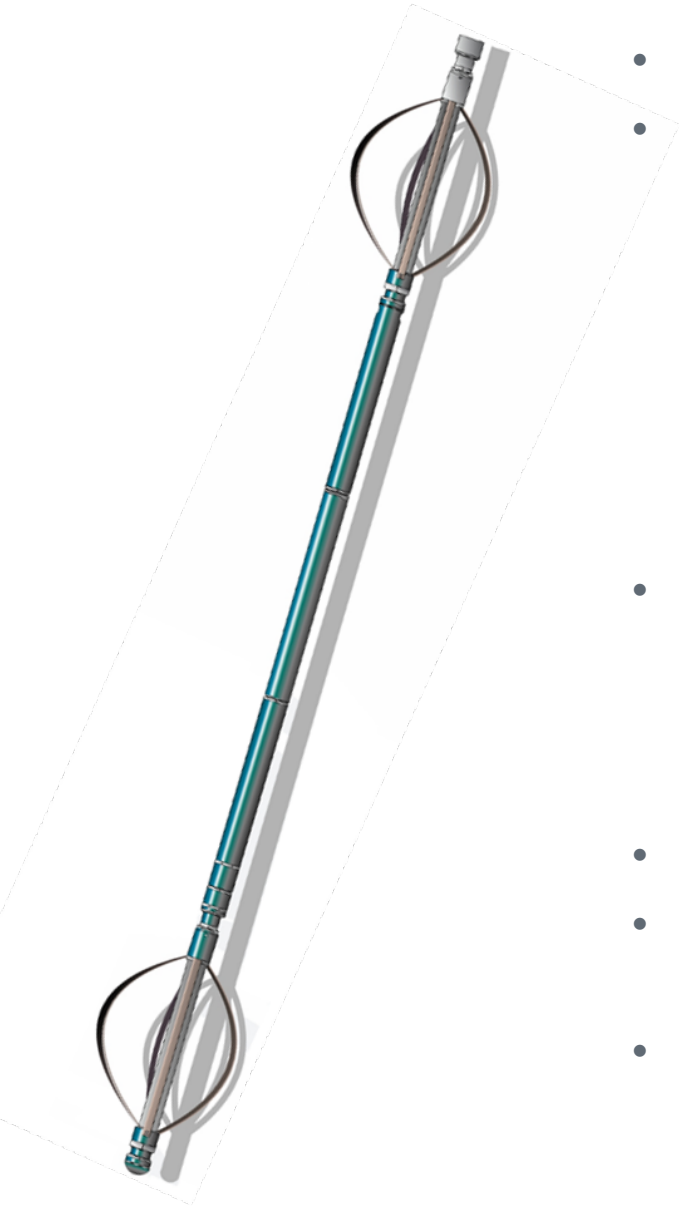
- **By the application of wireless monitoring technology, well testing no longer has to end at well suspension / abandonment**

Introduction
Wireless Technology

- A **Ca**bleless **T**elemetry **S**ystem 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

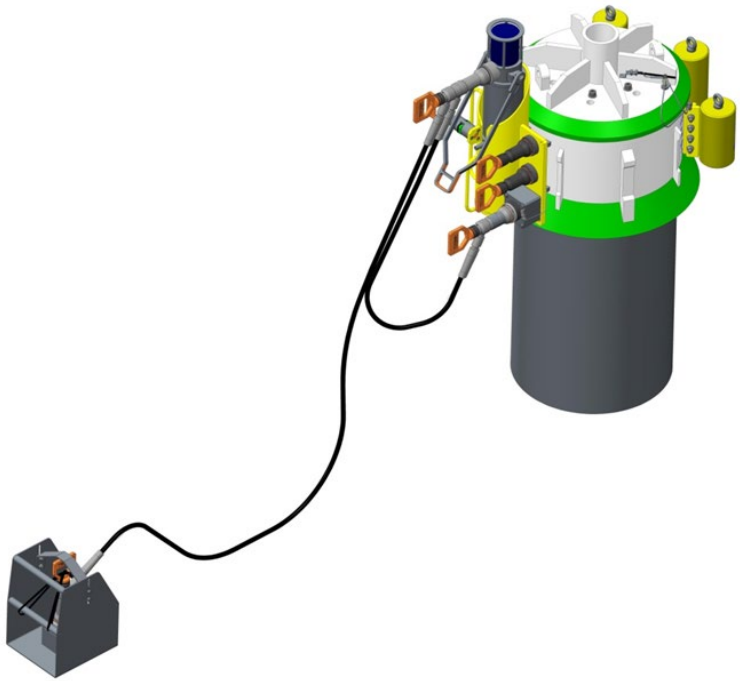
Wireless System Overview

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 / **125°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

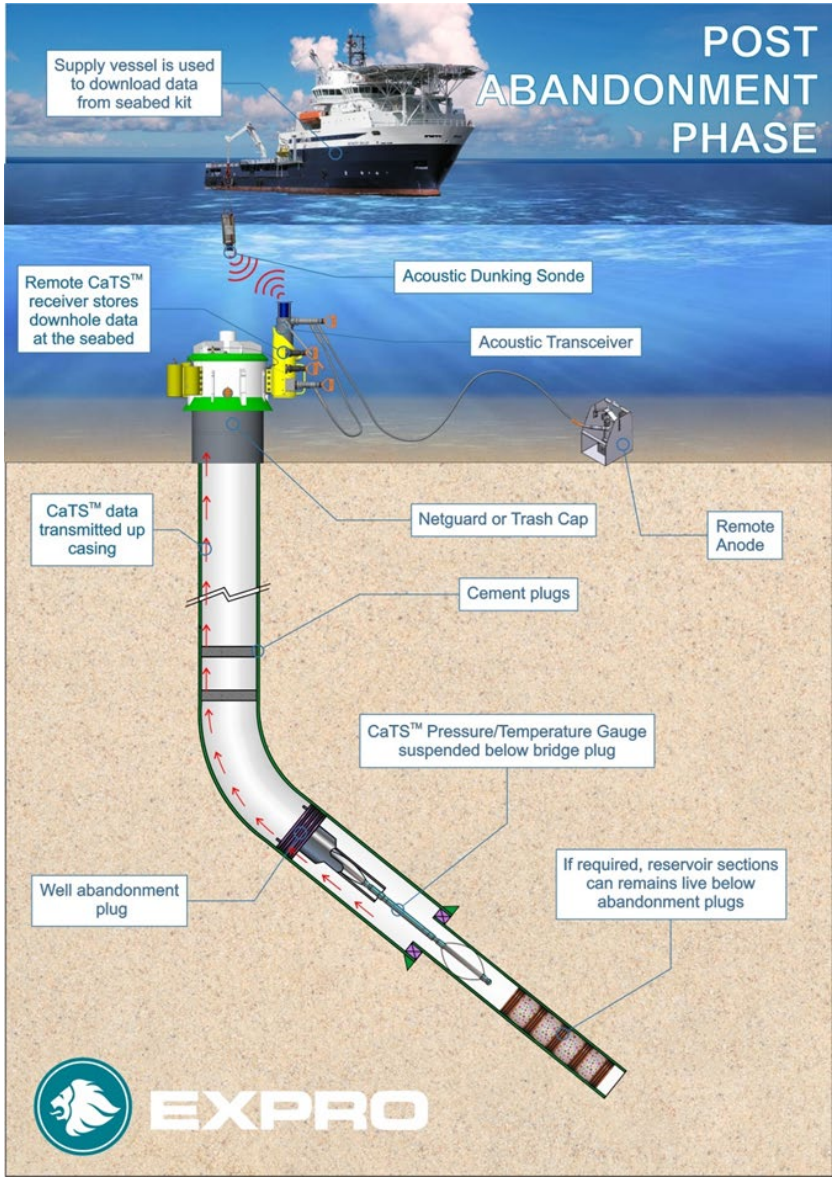
Wireless System Overview
Downhole & Subsea



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 **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



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

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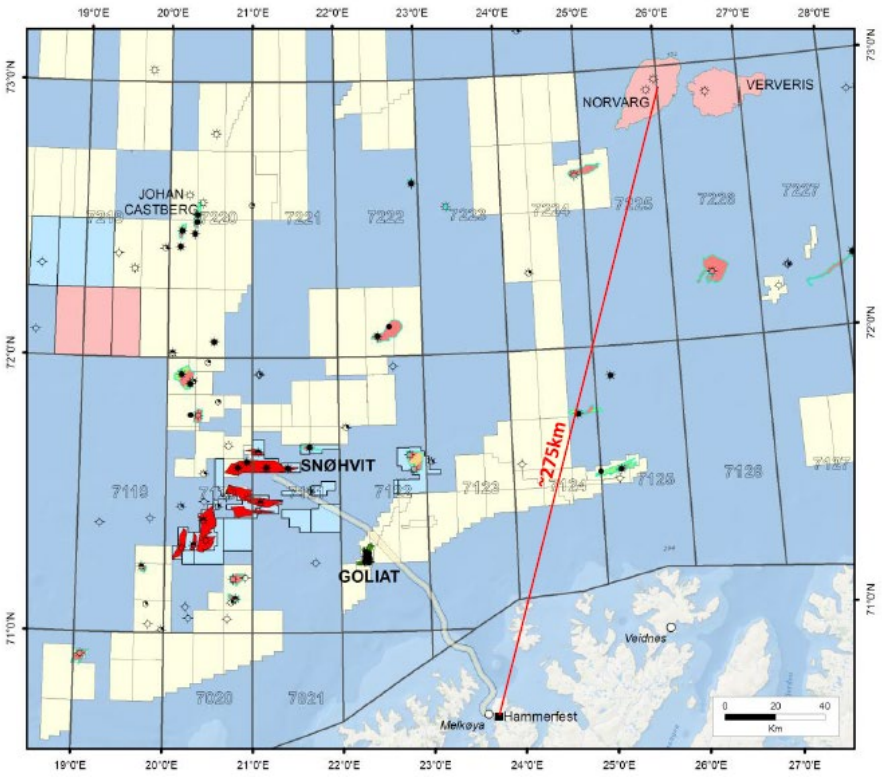
Background

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

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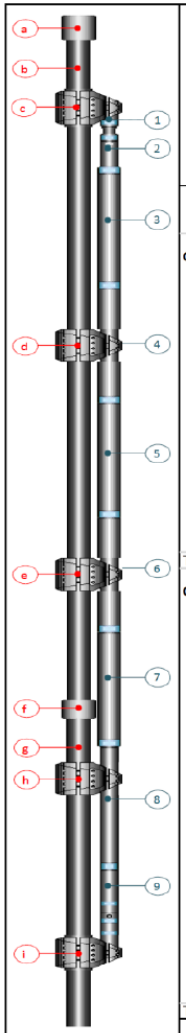
In-well Configuration

- **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



EM Wireless Gauge Toolstring For Post-Abandonment Monitoring

Client	Total	Field	Norvarg	
Well No.	7225/3-2	Location	Norwegian Barents Sea	
Date		Job No		
Tool No.		Expro Rep		

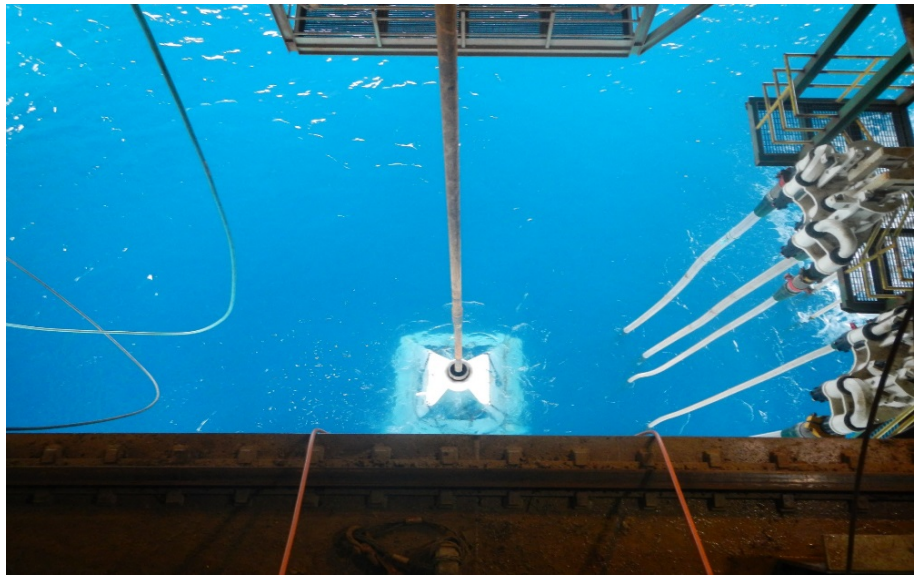
Item No.	Description	OD (in)	length (ft)	cum. Length (ft)	weight (lb)
Gauge assembly					
1	Telemetry section clamp adapter	1.688	0.46	0.46	2.00
2	Telemetry section	1.688	0.99	1.45	6.80
3	High capacity battery	2.125	5.91	7.36	51.35
4	High capacity battery	2.125	5.91	13.27	51.35
5	High capacity battery	2.125	5.91	19.17	51.35
6	High capacity battery	2.125	5.91	25.08	51.35
7	High capacity battery	2.125	5.91	30.99	51.35
8	Electronics section	1.688	5.58	36.57	39.00
9	Quartz gauge section	1.688	2.33	38.90	13.00
Total Weight: 317.55 lb		Total Length: 38.9 ft		Max OD: 2.125 in	
Completion					
a	Coupling	TBA	0.62	-	TBA
b	2-7/8" Tubing joint	2.875	30.00	30.00	600.00
c	Gauge clamp	5.700	0.66	-	31.00
d	Gauge clamp	5.700	0.66	-	31.00
e	Gauge clamp	5.700	0.66	-	31.00
f	Coupling	TBA	0.62	-	TBA
g	2-7/8" pup joint	2.875	15.00	45.00	200.00
h	Gauge clamp	5.700	0.66	-	31.00
i	Gauge clamp	5.700	0.66	-	31.00
Total Weight: 955 lb		Total Length: 45 ft		Max OD: 5.7 in	

Notes:

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

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

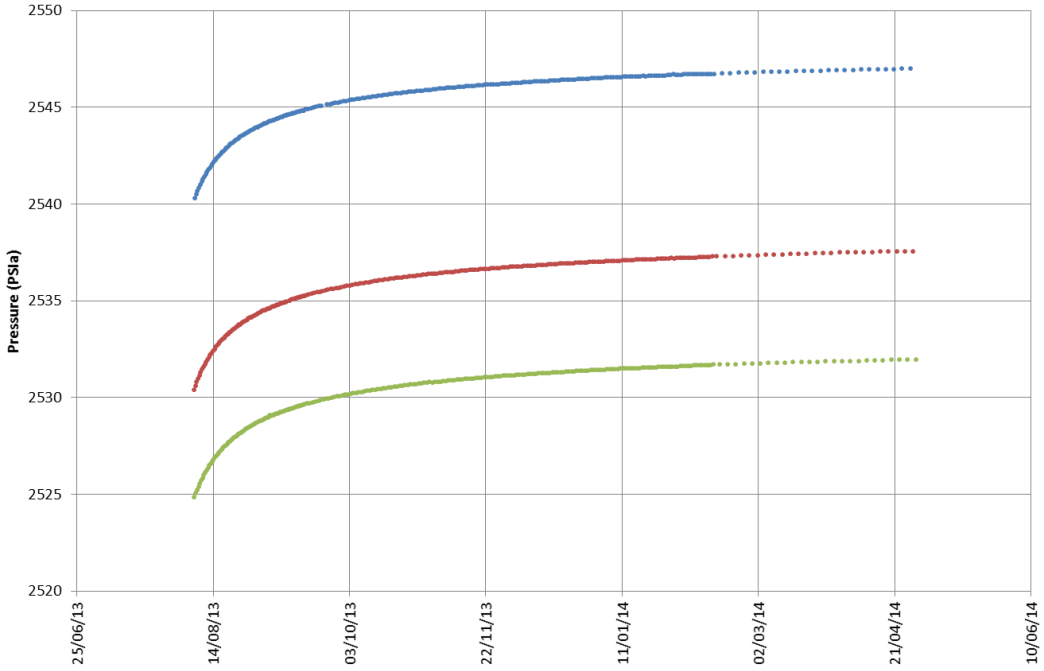


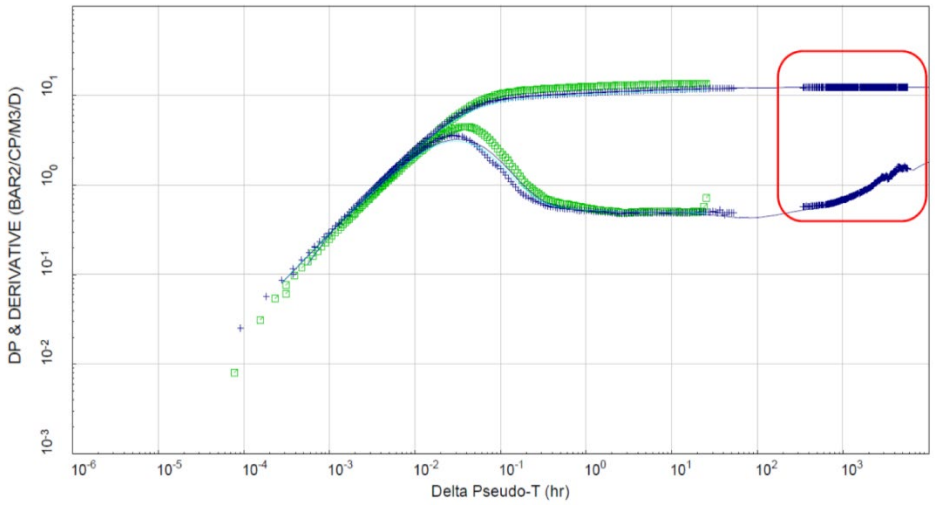
- The rig departed location with the well abandoned and PBU monitoring ongoing
- System recovered earlier than expected in April 2014

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

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

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Thank you for you 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