Permanent Monitoring of the Reservoir Overburden

Bård Elvik | Weatherford
Weatherford In-Well Sensing

- Full range of electrical & optical sensors
- High quality optical sensors
- Proven track record in Norway
- Experienced local operators and engineers
- Production optimization software and consulting services

Right data, right time, right decisions
OmniWell™ - Optical Sensors

• **Electronic Quartz Gauge Systems**
  – Pressure, Temperature and Vibration Sensing
  – *Subsea* IWIS/ ISO 13628-6 compatible interface card

• **Optical Sensing**
  – *Clarion™* - Multi-component In Well Seismic System
  – *Enables Distributed Acoustic Sensing (DAS)*
  – *CanePT™* - Pressure / Temperature Gauges
  – *CaneATS™* - Multi-Point Temperature Arrays
  – *RehosX™* - Full Bore Multiphase Flowmeter
  – Distributed Temperature Sensing (DTS)
Why Optical?

High Reliability
- No Downhole Electronics
- No Moving Parts
- Nominal Part Count

Ideally Suited For Harsh Environments
- High Temperature Capability
- Vibration and Shock Tolerant

High Data Transmission Capability
- Multiple Sensors on one Optical Cable
- Technological Advances Driven by Telecom

Rigorously Qualified

All Sensors - Field Proven!
Perforating Test
Monitor gas lift valve operation

Gas Lift Valve Operation
In-Well Flow Measurement

- Reduced need for well testing against test separator
  - Production optimization by ~5%
- Can be install below gas lift valves eliminatin need to compensate for injected gas
- Not affected by salinity
Clarion In-Well Seismic System

- **Life of Well Permanent Seismic Monitoring System**
  - Can be installed in:
    - Production Wells
    - Injection Wells
    - Monitor/Observation Wells
  - Integrated part of the Weatherford optical system
  - Can be combined with PT, DTS & Flow on the same cable
Clarion™ - Application

- Reservoir imagine
  - On demand high resolution imaging of target horizon and fluid interfaces

- Micro seismic monitoring
  - Map naturally occurring fractures caused by formation subsidence or fluid migration
Microseismic Results
Microseismic Results

- Monitor Well
- Production Well

Bypassed areas

125 Events
Microseismic Events

Plan View of Microseismic Events

Depth View of Microseismic Events

Data Courtesy of Tengizchevroil & Partners
Cuttings Re-Injection Well

- **Operator**: ConocoPhillips
- **Location**: Norway - Offshore
- **Date**: September 2013

**Installation**
- 3 Station Seismic Array (3C) – System
- Seismic Array Spacing 300ft in 60 degree deviation - Deepest Seismic Sensor 10100ft
- Pressure Temperature Gauge at 10215ft
  - Maximum Temp & Pressure 73°C & 6256psi
- Distributed Temperature Sensing
- DAS Capable Fibre Available
- Cuttings Re-injection Injection Well
- Installed on 5” tubing inside 7-3/4” casing (6-1/2” ID)

**Results**
- Combined continuous monitoring Seismic, P/T and DTS data during the cuttings re-injection process
- Microseismic events recorded during well injection testing
Offshore 4D In-Well Seismic

Operator: BP Norway
Location: Valhall Field - North Sea
Date: March 2006

Installation
- 5 Level Optical Seismic Array (3C) in combination Optical PT Gauge
- Seismic Array Spacing 13.5m – Deepest Seismic Sensor 2408m
- Water Injector Well
- Installed on 5-1/2” tubing inside 9-5/8” casing

Results
- First successful multi-station, multi-component, tubing conveyed optical seismic array in an offshore environment
- Optical seismic sensors interfaced to existing permanent OBS system
- In-well seismic imaging data was successfully acquired during scheduled 4D seismic shooting in May 2006 7 April 2007
**Instrumentation Topside**
*(Fiber In Umbilical)*
- Preferred option where practical
- Full in-well monitoring capabilities

**Instrumentation Subsea**
- Optical P/T and Array Temperature Sensors
- ISO 13628-6, IWIS
Optical Connectors – X-tree

Vertical Trees
• Single-pin connector: 150 °C, 15kpsi

Horizontal Trees
• Single-pin connector: 150 °C, 15kpsi,
• 3-pin connector: 10kpsi, 120°C
• 3-pin connector: 15kpsi, 177°C
Fiber in lower completion

- In Well Wet Mate optical connector
  - Secures optical connection between upper and lower completion
RedEye ® Watercut Meter

- OTC technology award 2015
- Non-nuclear
- 0-100% watercut detection
- Accurate in 0-to 99.5% GVF
- Tree or flow line mounting
Thank you!

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