Subsea Asset Monitoring using Distributed Fiber Optic Sensing

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Agenda

- Who is Omnisens?
- Distributed Fiber Optic Monitoring
- Power Umbilicals
- Flow Assurance (Heated Flowlines)
  - Direct Electrical Heating (DEH)
  - Indirect Heating (PiP)
Omnisens is a world leader in high performance fiber optic monitoring. Our fiber-optic solutions help organizations protect critical resources and avoid the escalating consequences of delayed incident detection protecting people, places and reputations along the way.

- Privately-owned Swiss company, established in 1999
- Spin-off from Swiss Federal Institute of Technology in Lausanne (EPFL)
- Headquarters in Morges, Switzerland
- Offices in USA and Brazil
- Highly educated team
- Worldwide customer base
- Distributors/Integrators in:
  - South America
  - Middle East
  - Europe
  - Asia (Malaysia)
  - Russia
  - Africa
Broad Range Of Capabilities

- Engineering and design
- Project management
- Procurement
- Manufacturing
- Systems integration and testing
- Installation and commissioning
- Offshore intervention
- Service, support and training
- Software design and licensing

Omnisens operates according to the following industry standards:

- ISO 9001
- ISO 14001
- OHSAS 18001

Omnisens is certified by Achilles
Industries served
Our Technology

A fiber optic distributed sensing system with capabilities that are considerably ahead of the market

Turning optical fibers into fully distributed sensors

One interrogator connected
...to one fiber to monitor thousands of locations

Remote sensing
One cable, one monitor

Local temperature or strain
The physics behind the monitoring

Scattering processes

Laser, $\lambda_o$
Scattering processes used for sensing applications:

**Rayleigh**
Detects loss variations
(OTDR and Fault location)

**Raman**
Scattered magnitude is temperature dependent

**Brillouin**
Scattered frequency is temperature and strain sensitive (leakage, ground movement, deformation)
The physics behind the monitoring

Scattering analysis applied to sensing applications

- Brillouin lines are temperature and strain sensitive
- Rayleigh detects loss variations (OTDR and fault location)

Changes in the fiber introduce frequency changes of Brillouin scattered light.
The activating signal is a propagating pulse and the position is given by the time of flight. Spatial resolution is given by the pulse width.

The frequency shift is computed by recording the Brillouin spectrum at different frequencies and extracting the maximum peak location.
Why monitor Power Umbilicals?

- Sunlight - temperature
- Bend stiffener - strain and fatigue
- Shock/abrasion/crashing - temperature
- Buoyancy modules - temperature
- Weight - fatigue
- Touch-down point - abrasion, friction, temperature
- Geohazard - landslide, seismic - strain/temperature
Umbilical: Sensor Design and Integration
Dynamic bending

6 days Flex fatigue test - no power

Evolution of temperature in the middle section

6 days to T stabilisation
Bending strain monitoring

Instrumented power umbilical

Monitoring of:
- Bending, tension, torsion strain
- Temperature

Strain/Temp Sensing Cable

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How would the umbilical respond to the increased load imposed by new pumps?

- Successful temperature measurement during operation, despite:
  - Attenuation: 17 dB
  - High reflexing peak of 13 dB
  - Fiber optic rotary joint
Flowline - Flow assurance solutions

Direct Electrical Heating (DEH)

Flowline bundles

Electrically Heated Pipe in Pipe
What does monitoring offer?

- Leak detection
  - alert with location

- Flow assurance
  - alert with location
  - historic temperature evolution

- Heating system control
  - closed-loop real time feedback
  - overhear detection
  - heating performance

- Damage detection
  - fiber optic break detection alert within 50 ms

- Condition monitoring
  - alert with location
  - historic temperature evolution
  - actual temperature versus model prediction

Measure ----> Monitor ----> Manage

Asset ----> Fiber optic sensing cable ----> Event monitoring software ----> Operator

Sensor ----> Data ----> Information ----> Action

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The Challenge

to maintain temperature above a critical threshold during long shut down and start-up periods.
Heated Pipe-in-Pipe (ETH-PiP)

The Solution

Fully Distributed Sensing:

- provides the temperature of the heated elements
- helps optimise the heating with respect to the targeted pipeline temperature
Temperatures measured during first ETH-PiP heating and cooling

Pipe elevation profile

Pipe temperature profiles
Chemical injection points
Direct Electrical Heated Cable System

- Some 5 installations with up to 44 km DEH subsea flowline monitored, including with riser and feeder cable.
Temperature profile example from one project

- DEH Topside transformer
- Power cable
- Rock dump
- Thermally insulated well stream pipe/flowline
- Hotspot at KP28 - Gravel dumping prevents heat dissipation

Field
Profiles during DEH cable energization

- HS 3
- HS 1
- HS 2

Energization without water cooling
Energization with water cooling

Temperature [°C]

Time [hh:mm]

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Summary

Subsea Umbilical Riser and Flowline (SURF) monitoring…

- Flow assurance – temperature evolution and alerts with location for flowlines, pipelines
- Leak detection and location in flowlines, umbilicals, risers.
- Umbilical fatigue (strain) and condition (temperature and strain) monitoring
- Validation of design and operation models
- Heating control for DEH and ETH-PiP flowline,
  - Closed loop, real time feedback
  - Overheat detection
  - Heating performance
- Damage warning thanks to fiber optic break detection

… for subsea structure integrity.