Passive Acoustic Leak Detection

Jens Abrahamsen
Business Manager
GE Digital Solutions – Naxys

SEMINAR: LEKKASJEDETEKSIJON
PETROLEUMSTILSYNET, 04.05.207, STAVANGER
TECHNOLOGY DESCRIPTION – PASSIVE ACOUSTICS

SOURCE

- LEAKAGE
- ROTATING MACHINERY
- STRUCTURAL VIBRATIONS
- CHOKES & VALVES

+ more

Acoustic Source

Loud high-freq. broadband noise from leakage

RECEIVER

PASSIVE ACOUSTIC SENSOR

- Electric Signal
- Processing & Analysis

DUAL USE

- LEAK DETECTED
- VIBRATION DETECTED

DUAL USE (Passive Acoustic Vibration Monitoring)

- OK
- WARNING
- ALARM
PASSIVE ACOUSTICS – PROS & CONS

PROS

HIGH SENSITIVITY
✓ Oil, Gas, Water - leaks from process to sea
✓ Detection behind obstructions – no requirement for line of sight
✓ Inward/reverse leaks – water leaks from sea to process

WIDE AREA COVERAGE
✓ Subsea installation (template / cluster) & adjacent infrastructure

DIRECTIVITY
Using an array of 10 Acoustic Sensors
✓ Enhances sensivity
✓ Improves detectability
✓ Enables spatial resolution

DUAL USE
✓ Vibration monitoring
✓ Rotating machinery monitoring
✓ Valve & Chokes

CONS

REQUIRES A MINIMUM DIFFERENTIAL PRESSURE
✗ «Silent leaks» are not possible to detect

BACKGROUND NOISE LEVEL
✗ ....but system automatically adapts to changes in background noise level

ROV NOISE (High pressure cleaning, thruster noise)
✗ ....but system avoids false alarming by detecting presence of ROV

PASSIVE ACOUSTIC SUBSEA LEAK DETECTION: COVERS LARGE AREA

WIDE AREA COVERAGE
Leakage sound propagates very well in water

DIRECTIVITY
HIGH SENSITIVITY

DUAL USE

CONS

REQUIRES A MINIMUM DIFFERENTIAL PRESSURE
✗ «Silent leaks» are not possible to detect

BACKGROUND NOISE LEVEL
✗ ....but system automatically adapts to changes in background noise level

ROV NOISE (High pressure cleaning, thruster noise)
✗ ....but system avoids false alarming by detecting presence of ROV

Acoustic emissions from subsea leak
Leakage sound propagates very well in water

Subsea Vibration Monitoring
Subsea Processing Monitoring (Pumps, Compressors)
SYSTEM DESCRIPTION - NAXYS ACOUSTIC LEAK DETECTOR

Operator acts according to Alarm Handling Procedure (ref. DNV RP)

Minimal use of bandwidth (approx. 1 bit/sec)

Continuous monitoring
- Spatial presence (no movement of leak)
- Presence over time (user defined)
- Frequency content
- Presence of ROV
TECHNOLOGY DEVELOPMENT & READINESS LEVEL

TRL 0: Unproven Idea  
Passive acoustics for condition monitoring of subsea installations  
Initial testing (tank testing)

TRL 1: Concept demonstrated  
Inshore deep water testing  
Sintef testing

TRL 2: Concept validated

TRL 3: Prototype tested  
Troll Pilot: Leak detection & Condition Monitoring

TRL 4: Technology qualified for first use

TRL 5: Integration tested with full interface and functionality tests

TRL 6: Installed

TRL 7: Proven technology

2000

2015

1st GENERATION  
Electronics: ISO 13628-6

2nd GENERATION  
Electronics & Sensors: ISO 13628-6

PROVEN TECHNOLOGY  
Technology Readiness Level 7

QUALIFIED

• ISO 13628-6 | API 17F
• Statoil TR1233
• 30 years design life
• 3000m water depth

RECENT TECHNOLOGY DEVELOPMENTS

• ROV detection – reduces false positives related to ROV activity (2014)
• Inward leak detection capability (2014)
• Improved leak detection capability (2014)
• Improved Condition Performance Monitoring (2014)
• Improved sensitivity utilizing all sensors (2015)
• Improved system redundancy (2015)
• Engineering re-design (2015)

MEETING INDUSTRY DEMAND FOR COST REDUCTION (2017)
More than 80 passive acoustic system installed on NCS

<table>
<thead>
<tr>
<th>System</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ormen Lange A&amp;B</td>
<td>2006</td>
</tr>
<tr>
<td>Tordis SSBi</td>
<td>2007</td>
</tr>
<tr>
<td>Vbildz Extension</td>
<td>2007</td>
</tr>
<tr>
<td>Vega</td>
<td>2010</td>
</tr>
<tr>
<td>Tordis/Vbildz Retrofit</td>
<td>2010</td>
</tr>
<tr>
<td>Pazoflo</td>
<td>2010</td>
</tr>
<tr>
<td>Ormen Lange Ph II</td>
<td>2010</td>
</tr>
<tr>
<td>Goliat</td>
<td>2010</td>
</tr>
<tr>
<td>Marulk</td>
<td>2011</td>
</tr>
<tr>
<td>Vbildz NE</td>
<td>2012</td>
</tr>
<tr>
<td>Stjermie</td>
<td>2012</td>
</tr>
<tr>
<td>Hyme</td>
<td>2012</td>
</tr>
<tr>
<td>Brynhild</td>
<td>2012</td>
</tr>
<tr>
<td>Skuld</td>
<td>2012</td>
</tr>
<tr>
<td>Knorr</td>
<td>2012</td>
</tr>
<tr>
<td>Svalin</td>
<td>2012</td>
</tr>
<tr>
<td>Frøya H Nord</td>
<td>2012</td>
</tr>
<tr>
<td>Åsgard SSM</td>
<td>2013</td>
</tr>
<tr>
<td>Ormen Lange Mid-North</td>
<td>2013</td>
</tr>
<tr>
<td>Gullfaks Sar Oje</td>
<td>2013</td>
</tr>
<tr>
<td>Gullfaks Subsea Compression</td>
<td>2013</td>
</tr>
<tr>
<td>Oseberg Delta 2</td>
<td>2013</td>
</tr>
<tr>
<td>Smarbuuki</td>
<td>2014</td>
</tr>
<tr>
<td>Aasta Hansteen</td>
<td>2014</td>
</tr>
<tr>
<td>Gullfaks Rimfaksdalen</td>
<td>2014</td>
</tr>
<tr>
<td>Visund Sar</td>
<td>2014</td>
</tr>
<tr>
<td>Mario</td>
<td>2015</td>
</tr>
</tbody>
</table>

FEEDBACK FROM OPERATORS:
Statoil: Discussion with operation teams (Oct-Nov 2016)
- Most systems installed and commissioned
- Operating as intended
- Low level of false alarms
- Some alarms related to rig or ROV activity (but this only tells that the system is functioning – comfort feeling)
- 1 installation down due to comms- problems

Shell:
- Systems are operating as intended (leak & vibration)
- Monthly follow up through Service & Support Agreement

SUPPLIER’S OPERATIONAL EXPERIENCE:
- Operational engagement to Leak Detection seems in many cases to be based on personal initiatives
- Is there a lack of Operational Procedures & Alarm Handling?

LEAKS DETECTED
Information rarely communicated to supplier (sensitive information)....

....but this real case demonstrated detection of leakage and correct sector indication for water injection leakage (NCS)
Thanks for your attention