Increased performance and safety by means of subsea instrumentation

Olav Brakstad
ClampOn AS
Agenda

• Introduction
• Integrity/condition monitoring
  • Corrosion/erosion
  • Vibration
Introduction

Industry focus on safety and integrity
Subsea requirements
• More information
• Reliability
• Long lifetime
ClampOn
• “Sand monitoring experts”
• Wide range of ultrasonic instruments and capacities
One technology, different applications

• Sand Monitor
• PIG detector
• Leak Monitor
• Well Collision Detector
• Cracking detector
• Wall Thickness Monitor
• Corrosion Under Insulation
• Vibration Monitor
• Corrosion-Erosion Monitor
Corrosion-erosion monitoring
Background

Subsea corrosion & erosion
- Integrity damage
- Production stop
- Expensive
- Spill
- Pollution
- Major problems
Background

Corrosion
- Cause; sour gas/condensate
- Effect; loss of integrity
- Remedy; anti corrosion agents

Erosion
- Cause; Sand production
- Effect; loss of integrity
- Remedy; reduce sand production
Continuous monitoring

Maintaining system integrity
- No loss of containment
- Avoid safety hazards
- No environmental damage
- Maintain uptime
- Minimize inspection & repair costs
ClampOn Corrosion-Erosion Monitor

AKA:
Continuous area wall thickness monitoring
What is it?

Permanent active acoustic, non intrusive wall thickness monitoring system
What does it provide?

Continuous monitoring of changes in wall thickness on a defined pipe section.
How does it work?

- Guided waves
- Change in WT -> change in signal shape
Why guided waves?

Conventional manual gauge:
- Limited spot coverage

Guided wave transducer rings:
- Full volume coverage
Guided wave propagation in pipe structures is complicated by the presence of wave-paths that wrap around the structure. In the case of a circular cylinder the paths are helixes

Helical signal paths

Signal Paths:
- Direct
- Helical Clockwise
- Helical Counter clockwise
- Double Helical Clockwise
- Double Helical Counter clockwise

5 Signal Paths per transducer
Reconstructed wall thickness loss map

The reconstructed maximum depth is in excellent agreement with the maximum depth estimation from ultrasonic spot measurements at 20MHz which yielded 0.78±0.05mm.

Maximum Depth 0.79 mm
Tomography Results w/EDM

Defect #1

EDM = Electrical Discharge Machining

A copper electrode was machined to pipe surface shape and we eroded out in 12 different steps with increasing steps of 20um, 40um etc steps

Defect #12
Transducer set-up

EDM Erosion – “Slot” with oil & copper 115mm wide

535mm

315mm

220mm

115mm

115mm
Defect #7

Maximum Corrosion Depth 0.41 mm

Result 2D-view
Defect #12

Maximum Corrosion Depth 0.95 mm

Result 2D-view
CEM Subsea

3 main alternatives

- CEM® for ROV installation
- CEM® non-ROV
- CEM® w/ ROV electronics
Retrofit/Brownfield

- Fully ROV installable
- Battery powered
- Wireless comms
non-ROV

Non-ROV retrievable electronics
Preinstalled ROV electronics

- Transducers under insulation
- ROV retrievable electronics
System components:

- ROV CEM electronics
- Wet-mate connectors
- Transducers
Technical data

- Pipe outer diameter (OD): min 4” (100mm)
- Pipe wall thickness (WT): 2 mm to 35 mm (0.08” to 1.38”)
- Distance between transducers: 0.15 m – 2 m (78”) typical
- Temperature: -40 to 180 °C (-40 to 356 °F)
- Power consumption: Max 2.5 Watt
- Sensitivity: better than 1% of the pipe wall thickness (typical 0.1%)
- Repeatability: ±0.04%
- Operation life: 220 000 hours
- Frequency range: 30 to 300 kHz
- Power Consumption: Avg 6 Watt – Max 10 Watt (during operation)
- Sensor electronics: DSP 66-MIPS, A/D con. 24bit, 25-Years
- Water depth: 3000 Meters
- Test pressure: 345 BarA
Case example

**BP - GOM**

Application: corrosion
Type: standalone

Standalone, battery powered, onboard data storage, acoustic coms by Sonardyne modem, fully retrofit.
Case example

Total – Laggan - Tormore
Application: Erosion
Type: Integrated

Integrated Non retrievable configuration, erosion monitoring
Case example

Statoil – Mikkel Åsgard & SVAN

Application: erosion
Type: standalone
QTY: 12

Fully integrated, frequent measurement trough bend
Murphy - Kikeh
Application: corrosion
Type: integrated

Integrated, connected to subsea controls.
Case example

Burullus – WDDM Ph 9a
Application: corrosion
Type: standalone
QTY: 8

Standalone, battery powered, onboard data storage
Case example

Total - Edradour
Application: corrosion
Type: standalone
QTY: 1

Standalone, battery powered, onboard data storage. Installed on pipeline prior to “reel out” 180 deg pivot.
Case example

Total - Edradour
Application: corrosion
Type: standalone
QTY: 1

Mechanical interface testing, pivoting
Vibration monitoring
Background

Topside causes of pipework failure

Source: UK Health & Safety Executive

- Degradation of material properties: 29%
- Operator error: 4%
- Inadequate procedures: 4%
- Corrosion: 4%
- Inadequate isolation: 2%
- Procedural violation: 6%
- Erosion: 9%
- Incorrect installation: 21%
- Fatigue/vibration: 21%
Modes of vibration - subsea

- VIV – Vortex Induced Vibration
  - Low frequency – 0.01-2Hz
- FIV – Flow Induced Vibration
  - Medium frequency – 2-50Hz
- FLIP – Flow Line Induced Vibration
  - High frequency – 50-1000Hz
- Pumps, compressors etc.
Working principle

- MEMS accelerometer
- Acceleration in three dimensions
- Digital Signal Processor (DSP)
- Numerical integration
- Convert acceleration to velocity or displacement
Data processing
ClampOn vibration monitors

1. Accelerometer
2. Analog low-pass filter
3. Analog to digital conversion
4. Digital decimation

- Anti-aliasing

- RMS calculation
- Unit conversion
- FFT spectrum analysis

- RMS output
- Spectrum output
- Raw data output
Integrated/permanent solution

- Real-time data
- Instant alarm
- Always present
- Data from 0-day
- Fatigue estimate
- No running costs
- SIIS L2 and 3
Integrated/permanent solution

**Pros:**
- Real-time data
- Always present
- No running cost
- ASVD

**Cons:**
- Limited bandwidth (SIS L2 & RTU)
- Difficult to retrofit
Temporary / inspection

- Stand-alone
- No integration
- Internal battery
- 6 month operation per charge
- Local indication
- Light weight
- Mechanical and magnetic fixtures
- No bandwidth restrictions
- Continuous raw data logging
Temporary / inspection

- USB interface
- "Flash drive" mode
- Internal processing
Analysis of vibration data

- Precise analysis based on spectra or raw data typically performed by a third party
- Simplistic approach: RMS Velocity is approximately proportional to fatigue. Rules of thumb apply.
Field Case – Statoil – Visund Nord

Potential risk of Vibration on flex loop
Field Case – Statoil – Visund Nord
Field Case – Statoil – Visund Nord

<table>
<thead>
<tr>
<th>Vibration 3D Monitor w/Clamp</th>
<th>Split Box</th>
<th>20mm Jumper W/12 Pin Tronic Stab w/Power &amp; RS485 interface</th>
<th>Controller with interface to SCM and Split box &gt;&gt; up to 50M cable length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed installed</td>
<td>Fixed</td>
<td>&gt;&gt; 1,000M</td>
<td></td>
</tr>
</tbody>
</table>

THE LEADER IN SAND, PIG AND CORROSION-erosion MONITORING
Field Case – Statoil – Visund Nord
Field Case - BP - Azerbaijan

Flow back ESD Valve

- Flow conditions creates vibration - why
- Can it be monitored and bandwidth
- Type of mounting fixture?
- Installation locations

Scenario
- Valve in vibration
- How often and amplitude
- Under what operation conditions
- Valve WILL wear out …
in worst case stop the production from the platform
Valve flapping movement
Field Case – Statoil - Skuld

Flex loop vibrations
- Calibrate calculation model
- Find maximum safe flow rate
- Direct cable communication
Conclusions

Online monitoring of corrosion/erosion;
- Greater control
- Increased uptime
- Reduced risk

Vibration monitoring;
- Complement vibration modelling
- Actual situation report
- Online/permanent
- Standalone/inspection
Questions?

Olav Brakstad
ClampOn

www.clampon.com