Corrosion Monitoring system through 'surf-board' communication by satellite

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Presentation Layout
Corrosion-Erosion Monitor - CEM

- Subsea
- Introduction and Background
- System properties
- System layout
- Subsea Installation Options
- Conclusion
Going Subsea means new **Challenges**

- Subsea Trees
- Subsea Pumps/Processing
- Subsea Manifolds/Templates
- ROV Tie-in Systems
- Pipelines/Risers

**Brown field life extension**

This requires more Monitoring
System in the field - *Topside*

 ClampOn CEM Electronic Unit

 Protection Cover

 (Transducers under the Protection Cover)
The Corrosion Monitoring System

Data Communication

System in the field - Subsea
Working Principle - Lamb Waves
Corrosion-Erosion Monitor

- AGLW = Acoustic Guided Lamb Waves
- Named after Horace Lamb, who discovered the waves in 1916
- Also called Long Range NDT
- The pipe wall will force the transmitted signal into a given shape and form (mode generation)
- Analytical inversion of acoustic data to obtain relevant thickness information
• Transducers can be mounted on the outside of coating <1mm /0.04” thickness

• Measures WT between the transducers in “line of sight”
• Resolution/sensitivity better then 1% of WT
• Signal is Robust and will not break down
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ULTRASONIC INTELLIGENT SENSORS

CEM Coverage area

- The figure illustrates the area covered by a pair of transducers
- Beam divergence allows the CEM to "see" a large area
- A matrix of transducers deployed on a region of pipe can provide comprehensive coverage
- The larger WT the larger the coverage area is
ULTRASONIC INTELLIGENT SENSORS

CEM - Coverage Area

- OD pipe – 8"
- Separation 700 mm
- 6 Transducers set-up

Total Coverage:
- ≈ 90% (of inspected area)
- Each path width is 70mm
ULTRASONIC INTELLIGENT SENSORS

CEM - Coverage Area

- OD pipe – 8”
- Separation 700 mm
- 6 Transducers set-up

Total Coverage:
- ≈ 90% - topline corrosion
- Can be calculated by Software
ClampOn Corrosion Erosion Monitor

Coverage

- Example with 8 transducers – 28 paths.
- Many paths are crossing each other – covering the same area.
- We want to compare the data to get more information
  → Can we localize a defect if it is covered by several paths?
**CEM - Tomography**

- The more transducers that is used - better coverage and depth measurement
- CEM can then "**Measure**" minimum wall thickness and locate the defects.
- Has been simulated, tested and demonstrated → ...... software upgrade

**Min thickness = 9.64mm**
Comparison – Coverage Area

**COVERAGE AREA –**
THE MEASURED AREA THAT THE SYSTEMS ARE COVERING:

a) 2 x CEMAT Transducer separated by 600mm.
   Coverage area = 35 000 mm²

b) Alternative 14 spots (el 5mm) each covering 19,5mm² = 273 mm²
   c) Alternative 8 spots (el 12mm) each covering 113mm² = 904 mm²

**OR**

d) 8 CEMAT Transducer distributed over the selected surface: <65% of
   the surface, which equals to: 187 000 mm².

= Large coverage with less transducers/equipment
Uniform thickness loss
CEM demonstration – uniform thickness reduction
General Wall loss
ClampOn DSP Corrosion-Erosion Monitor

Milling out a wide defect
9 milling operations

Witnessed by:
BP, Statoil,
Hydro and Shell
Example – Detecting general corrosion

- General corrosion was simulated by grinding on a 1 x 1 m and approximately 22 mm thick plate.
- Corresponded well with results obtained from handheld UT gauge.
- Figure showing 2 grinding runs, showing an average loss of 3.3% and 1.2%.

![General Corrosion – Wear rate in % change of WT](image)
Example – Detection “pitting corrosion”

- Pitting corrosion was simulated by drilling small holes in a 1x1m and approximately 22mm (0.87”) thick steel plate.
- The ClampOn CEM shows a average loss of about 1%
- UT measurements conducted in a thorough manner at 14 points along the measurement path showed no corrosion.
CEM Test – 6” bend

ConocoPhillips Technology Center, Bartlesville, OK

Test A Results - Absolute Thickness

Path 1 of 1: "6inchStraight"

Covered area

Correct average thickness [mm]

Measured thickness [mm]

RUN NUMBER

1 2 3 4 5

mm

6.36
6.34
6.32
6.30
6.28
6.26
6.24
6.22
6.20
6.18
6.16
ULTRASONIC INTELLIGENT SENSORS
Verification of Stability
CEM system tested with heating & cooling

Standard deviation: 0.02mm
Temp. range 10 - 170°C
EMAT

- **Electromagnetic Acoustic Transducers**
- The wave is generated inside the pipe, not in the transducer itself like with classic piezoelectric.

Advantages over piezoelectric transducers:
- Better thermal stability
- No need for acoustic couplant such as silicon → easier to install
- Makes the system relocateable.

Drawbacks:
- Lower sensitivity → need more averaging
- Larger transducer size

Conclusion:
- Proper measurements
CEM Subsea System

Main Parts

- Transducers
- Electronic w/CEM Controller
- Power

- UP TO 32 Transducers can be CONNECTED to the Canister

Transducers: 4 Transducers

Electronic up to 7 meters from transducers

Electronic w/CEM Controller: DSP, Flash, Power

PAC Unit: Programmable Automation Controller

Power: ROV Battery Pack

4 Transducers

Split box

Split box
Fully ROV CEM Subsea configurations

- Pre Installed - Green field
- ROV Installed - Brown field
- Fully interfaced
- Internal data storage
- Battery or SCM powered
- Low power Consumption
- Wireless Communication
ROV – CEM - The BP System

- Electronic Canister
- Transducer Clamp
- Battery Pack
- Acoustic Modem
Natural Energy Conversion Enables *Sustained* Unmanned Ocean Operations

Proven platform with Over 150K combined miles At Sea

*Uploading CEM data takes approx. 3 minutes / month*

Image courtesy of Liquid Robotics Oil+Gas
Data collection - Wave Gliders

- Monitors on every well
- Acoustic link between CEM and wave glider
- Satellite link between wave glider and office (web)
- Data retrieval can be every day
Wave Glider Propulsion

Fundamentals of Wave Glider Operation

Both upward and downward motions produce thrust
Acoustic Communications

Data Harvesting via Acoustic Modem and Satellite Radio and/or Broadband Wireless or Cellular Link

Service multiple locations with one Wave Glider.
One or more wave gliders will navigate the field relaying data from the equipment.
Proven All Weather, Long Range Performance

Wave Glider
Long Range Capability

August-Sept. ’09
Wave Glider “Red Flash”
Monterey – Alaska
Wave Glider experienced
22ft seas and 50 kt winds for
multiple days offshore of BC,
Canada

April-June ’09
Wave Glider “Red Flash”
Monterey - San Diego - Eureka

June-August ’09
Two Wave Gliders transit from Hawaii to San Diego
Average speed > 1 kt. Both vehicles “like new” after crossing.
Image courtesy of Liquid Robotics Oil+Gas
PacX CHALLENGE
Unprecedented Journey of Marine Robots X the Pacific

150,000 Combined Miles Traveled To Date

New World Record Set
Oceanic Robotic Transit Distance
3,200 nautical miles
March 13, 2012
Heavy Weather - US West Coast

22ft (6.7m) SEAS AND 50kt WINDS AT THE ALASKA / CANADIAN BORDER

- Heavy Weather over 7 Days
- As Part of a 3,500+ nmi Tour of the West Coast

Data courtesy of Liquid Robotics Oil+Gas
THE LEADER IN SAND, PIG AND CORROSION-EROSION MONITORING
CEM Subsea

Corrosion-Erosion Monitor

- 3 Models alternatives for CEM -

- CEM for ROV installation

- CEM under insulation/coating

- CEM w/mechanical cover
Conclusion

Clampon DSP Corrosion-Erosion Monitor

• Excellent correlation between measured and actual average thickness values, for a wide variety of defect types demonstrated with witness from independent observers (Shell, Statoil, BP, Hydro, Saudi Aramco, etc)
• Sensitivity of the CEM to changes in wall thickness demonstrated
• Generic defect, groove and pits were machined and detected
• Extremely high unevenness still gave far better results than initially predicted
• Robust nature of thickness evaluation method illustrated and monitored over a long time
• Temperature, flow is not affecting the Guided Waves
• Dry contact transducers have been developed to increase flexibility and stability of the CEM system
• Subsea CEM System qualification w/BP have been demonstrated.
• Tomography under development and very promising results providing **MINIMUM** wall thickness and location.
Thank you for your attention!

Any questions?

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