Inspection Approaches & Experience for Inspecting Challenging Subsea Assets

- Inspection Approaches & Experience for Inspecting Challenging Subsea Assets

Andreas Boenisch
Group Managing Director Innospection
a.boenisch@innospection.com
Inspection Approaches & Experience for Inspecting Challenging Subsea Assets

CONTENT

- MEC Technique (from SLOFEC to MEC......Background)

- Riser / Conductor / Caisson Inspection

- Flexible Riser Inspection

- Subsea Pipeline inspection

- Mooring Lines

- Hull Inspection

- Deployment Concept in Splash Zone areas
Background Inspection Techniques & Tools

Splash Zone Inspection Tools (Riser / Caisson / Structure)

Subsea Pipelines Inspection Tools

Flexible Riser / Riser / Mooring Line Inspection Tools
Saturation Low Frequency Eddy Current (SLOFEC)

Typical Operation and detection

**Pipe Scanning**
WT range: up to 1”

**Vessel Scanning**
WT range: up to 33mm

**Tank Scanning**
WT range: up to 30mm through coating up to 10mm

- Micro Biological Corrosion (MIC/SRB)
- Amonium Chloride Salt Corrosion
- General Corrosion / CO2 Corrosion
- Corrosion / Cracking
Background Inspection Techniques

Principle MEC (extended from SLOFEC)

Magnetic Field controlled High Frequency Eddy Current

Eddy Current

Eddy Current sensor
EC field

Detection of far side defects
EC field
Magnetic Field Lines

Signal Response

- New Sensor type with field strength measurement
- Field strength control / analysis (retentivity point)
- higher Eddy Current Frequency
- higher sensitivity at increased stand
Background Inspection Technique

Online Analysis – Reporting – Color Mapping Report

EXTERNAL DEFECT ANALYSIS

INTERNAL DEFECT ANALYSIS

COLOUR PALETTE – DEFECT CLASSIFICATION:

- <20%
- 20-30%
- 30-40%
- 40-50%
- >50%

Client: OIL COMPANY
Location: Oil Rundown Lines
Subject: OIL COMPANY
Section: 4
Date: July/August 2000
K-No.: 105/00
Pipe Identifier: P-53

Pipe P-53

Signal of the reference internal defect (50% depth) in the signal Y-component / phase analyser window
Background Inspection Techniques

MEC – Combi Crawler & PipeScanner

- MEC Combi Crawler
- MEC MPS200+
- MEC-Combi Pipe Crawler V1
- MEC-Combi Pipe Crawler V2
- MEC – Hug Crawler

MEC Pole Shoe & Sensor Array
Focus: external/internal corrosion Mapping

Add on Technique for MEC-Combi concept

- UT Array Absolute WT Mapping
- PEC Average WT Mapping
- Eddy Current Sensor Array Crack Detection
- Subsea Laser Geometry Scan
- HD Camera Visual Inspection
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External Scanning of Risers, Conductors, Caissons

External MEC-Combi Tools deployed by ROV, diver, from top side

- Inspecting wall thickness of 1” (1½ “)
- external & internal localised wall loss detection
- inspecting coated or cladded risers
- general marine growth removal (ROV/diver/ integrated cleaning)
- inspection top side, splash zone & subsea
- Corrosion Mapping
Riser Inspection

Coated Riser Inspection – Verification of external & internal & external localized corrosion detection

6” x 18.3mm, 8” x 23mm, 20” x 25.4mm Splashtron coating ½”

External & internal local spherical defect detection results with MEC M-PS200+ scanner

<table>
<thead>
<tr>
<th>Detected Defects</th>
<th>Internal Defects detected from</th>
<th>External Defects detected from</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Ø 20mm</td>
<td>Ø 10mm</td>
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<tr>
<td>6” x 18.3mm Neop. Coating 12.5mm</td>
<td>Class from 10%</td>
<td>Class from 20%</td>
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<td>Visible from 5%</td>
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<td>8” x 23mm Neop. Coating 12.5mm</td>
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<td>Visible from 10%</td>
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<td>20” x 25.4mm Neop. Coating 12.5mm</td>
<td>Class from 20%</td>
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<td></td>
<td>Visible from 10%</td>
<td>Visible from 5%</td>
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</tbody>
</table>

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Riser Inspection

Coated Riser Inspection
MEC-MPS200+ scanner detection capability

Test Riser CP 1
12” x WT 25.4mm
15mm Neoprene

6” x 17mm
10mm Stopaq

6” x 17mm
5mm Epoxy

Scan Direction

1.30m 2.00m 2.70m 3.40m 4.10m 4.80m 5.50m 6.20m 6.90m 7.60m 8.30m 9.00m 9.70m 10.40m 10.50m
Riser Inspection

MEC – Combi crawler

ROV deployed Scanning with MEC & Ultrasonic Sensor arrays

MEC Scan vs UT Array Scan

<table>
<thead>
<tr>
<th>Pos [mm]</th>
<th>Nominal VT [mm]</th>
<th>1</th>
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</table>

Sensor
Riser/Conductor Inspection Report - Assessment support data

External and internal corrosion detection. Isolated defects, areas........
Separate mapping & Wall loss matrix data in 1mm steps per sensor
EXTERNAL COATED RISER INSPECTION
(integrated cleaning head)

M-PS200+ Subsea Scanner system including cleaning head. Rotating Barracuda nozzles at up to 10,000 PSI.
EXTERNAL CLADD RISER INSPECTION
MONEL Clad Riser Scan - Rotational inspection head
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MEC-FIT Flexible Riser Inspection

Experience

MEC-FIT™
Magnetic Eddy Current Flexible Riser Inspection Tool

Wall Loss & Crack detection of steel wire layers
Comparison of different magnetization levels on the wire magnetization
**MEC-FIT TEST / QUALIFICATION**

*Defects – Indication differentiation Crack simulation vs local wall loss*

**Signal Repeatability**
Artificial defect - crack in single wire in second wire layer
wire gap closed for the scan

Test Defect: machined crack in second armour layer

Tight Crack 50% depth of the wire

Magnet on
Magnet off
### MEC-FIT™ Signal Catalogue to date

<table>
<thead>
<tr>
<th>Defect Type</th>
<th>Loop Magnet off</th>
<th>Loop Magnet intermediate</th>
<th>Loop Magnet On</th>
<th>Phase</th>
<th>Change Magnet-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Gap upper level</td>
<td></td>
<td></td>
<td></td>
<td>310°</td>
<td></td>
</tr>
<tr>
<td>2 Cut wire Lower layer</td>
<td></td>
<td></td>
<td></td>
<td>310°</td>
<td></td>
</tr>
<tr>
<td>3 Grinding on upper wire</td>
<td></td>
<td></td>
<td></td>
<td>310°</td>
<td></td>
</tr>
<tr>
<td>4 Cut wire Surface (crack like)</td>
<td></td>
<td></td>
<td></td>
<td>310°</td>
<td></td>
</tr>
<tr>
<td>5 Mat. in-homogeneity</td>
<td></td>
<td></td>
<td></td>
<td>310°</td>
<td></td>
</tr>
<tr>
<td>6 Far side ml in solid Pipe</td>
<td></td>
<td></td>
<td></td>
<td>310° (90° for SLOFEC)</td>
<td></td>
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<tr>
<td>7 Near side ml in solid pipe</td>
<td></td>
<td></td>
<td></td>
<td>310° (90° for SLOFEC)</td>
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</table>

#### Signal amplitude vs defect size

![Graph showing the relationship between defect depth and signal amplitude](image-url)
MEC-FIT Flexible Riser Inspection

MEC-FIT™ - Flexible Riser Pipe Inspection Tool

V1 - ROV adapted

V2 - self crawling: top side or ROV deployed
MEC-FIT Flexible Riser Inspection

Reporting for standard 35° type flexible riser inspection

Riser Section 2 (EL -2.5 m to EL 2.5 m)

Mag off horiz. Phase
Orientation [deg]

Mag on horiz. Phase
Orientation [deg]

Mag off vert. Phase
Orientation [deg]

Mag on vert. Phase
Orientation [deg]
PROJECT:
Subsea Flexible Pipe.
Detection of Wire misalignment & wire defects in area of upheaval buckling

Tasks
- a 15°-flexible pipe structure
- detection of wire misalignment
- differentiation of wire misalignment vs / defects

Comparison of metal loss defect detection for various wire angles
Effects of increased lift-off

- With increases lift-off the signal will get weaker, but not disappear
- The magnetisation will decrease, but the signal does not depend on it

Missing wires in top layer measured with Differential Sensor
Subsea Flex Riser pipe with 15degree wire organisation. Scanning on the horizontal section to detect
- wire misalignment
- wire cracking
- wire corrosion
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Subsea Pipeline Inspection

M-PS200+

e.g. Project:
• 63m length,
• 10 inch pipe, WT 19mm, coated
• 180° coverage = 1 shift

MEC-PipeCrawler V2
Subsea Pipeline Inspection

MEC-Combi Pipe Crawler – ROV deployed

Self crawling systems with Inspection technology adaptations: SLOFEC, UT, Visual, Laser, PEC
Subsea Pipeline Inspection

MEC – Combi Crawler with Laser system for pipe geometry to scan

Scanner with front Laser

Input for FEM calculation

Scratch

Dent
External Subsea Pipescanning R&D work for larger stand off scanning - i.e. heavy coated Flowlines for localized defect detection

Test results of stand off up to 42mm demonstrating detection of the internal defect

<table>
<thead>
<tr>
<th>TEST #</th>
<th>Total stand off to Steel surface [mm]</th>
<th>Detection result of 17mm diameter Defect - 8mm depth</th>
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</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>15.0</td>
<td>very good</td>
</tr>
<tr>
<td>Test 2</td>
<td>21.0</td>
<td>good</td>
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<tr>
<td>Test 3</td>
<td>38.0</td>
<td>good</td>
</tr>
<tr>
<td>Test 4</td>
<td>42.0</td>
<td>low but visible</td>
</tr>
</tbody>
</table>
Subsea Pipeline Inspection

Subsea PEC Deployment

The SUBSEA PEC is a static measurement with capability to inspect through up to 200mm stand off (coating). Two sensors are guided to scan circumferentially and axially along the pipe. Pipe Diameter Range 8” – 36”
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Mooring Line Inspection

High Field Eddy Current Sensors

Mooring Line Inspection – Project

Newly developed Eddy Current sensors to penetrate through 35mm stand off for detection of
- cracks
- localised defects
- galvanisation removal at wires
Mooring Line Inspection

MEC – WireScan  Mooring Line Scanning with High Field Eddy Current Sensors

Flexible Eddy Current Sensor Array System in front of MEC-Combi Pipe Crawler
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MEC-Combi Crawler Robot - deployed for FPSO Hull Inspection

Automatic Position Control
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“MEC-Combi Robot” Concept of the self operating subsea cleaning & inspection system
Specific Subsea Inspections – R&D

Back Side View

- Drive & Location Wheels
- Thruster
- Camera/Light
- Magnet Poles
- Electronic Control Chambers
- Boyancy
- Cleaning Head with swivel device
- Drive & Location Wheels
- Thruster
- Camera/Light
- Eddy Current Sensor Array
- Ultrasonic Sensor Array
- Tether

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THANK YOU FOR YOUR ATTENTION

Innospection Limited
Howemoss Avenue
Kirkhill Industrial Estate
Dyce - Aberdeen - AB21 0GP
United Kingdom

P +44 (0) 1224 724 744
F +44 (0) 1224 774 087

Web: www.innospection.com
info@innospection.com