Flexible Riser Inspection Tool

Innospection Group Ltd.
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CONTENT

– Short overview Innospection

– Background : Eddy Current for Inspection of Flexible Risers

– Eddy Current Base inspection technique principle

– Feasibility Test ,

– Phases of Development

– Conclusion and Discussions
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Innospection Ltd.

Advanced Electromagnetic Inspection Solutions

- Heat Exchanger Tube Inspection
  - (MF-ET, Mag Biased ET, RFET, Iris)

- SLOFEC
  - External Pipe scanning
  - Storage Tank Inspection
  - Vessel Inspection

- Inspection with marinised Systems
  - Internal & external Caissons
  - Risers

- Electromagnetic Inspection Solutions
  - Advanced crack detection

R&D - Application Developments

Locations: Aberdeen, Rugby, Stutensee (Germany)
AbuDhabi, Al-Khobar, Melbourne, Singapore
Due to the principle and inspection capabilities the target of the SLOFEC™ technique is:

- fast screening of good accessible areas
- detection of corrosion (isolated pits, corrosion areas) & other defects
- analysis of defects with wall loss severity classifications
- colored mapping of inspected area
- low inspection preparations
CONTENT

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Background of Eddy Current for Flex Pipes

Inspection

- *Tube Inspection:* e.g. Multiple Layer / cladded tube inspection
- *Tank Inspection:* e.g. inspecting through GRP liner (8-10mm)
- *Pipe/Vessel Inspection:* e.g. inspecting WT up to 33mm, inspecting through cladd layer
- *Riser Inspection:* e.g. inspecting high WT through cladd, through Neoprene

Potential for Inspection of Flexible Risers
Background of Eddy Current for Flex Pipes

Experiences with Eddy Current based techniques:

- a wall penetration of up to 33mm was achieved
- through 15mm (liner) stand off was possible
- through cladded layers possible to penetrate
- Differential Mode sensitive detection of localised defects
- Absolute Mode to be used analysing Material changes

Decision to run a Feasibility Study
CONTENTS

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The depth at which eddy current density has decreased to $1/e$, or about 37% of the surface density, is called the **standard depth of penetration** ($\delta$).
Principle of SLOFEC™

Eddy Current Field Line Distribution in ferromagnetic material with no DC magnetisation

Eddy Current Field Line Distribution in ferromagnetic material with DC magnetisation

Principle of SLOFEC™
**PRINCIPLE OF SLOFEC™**

Induced voltage for probe in non-defect area

Induced voltage for probe in defect area

- **MAGNET**
- **EDDY CURRENT SENSORS**
- **EDDY CURRENT FIELD LINES**
- **TEST PIECE**
- **MAGNETIC FIELD LINES**
- **DEFECT**
- **COMPRESSED MAGNETIC FIELD LINES**
SLOFEC™ - A COMPARISON METHOD

Calibration with artificial reference defects

Evaluation of indications in comparison to calibration
Artificial defect (diam. 10mm) at the underside side depth 40%

Topside corrosion Corrosion pit diameter 15mm, depth 20%
SLOFEC™ - AMPLITUDE & PHASE ANALYSIS

The eddy current differential signal phase in colour imaging background for color reporting.

Selecting color image window

Top Side

Under Side

top side phase to defect depth analysis window
underside phase to defect depth analysis window

COLOUR PALETTE – DEFECT CLASSIFICATION:

- < 20%
- 20 - 30%
- 30-40%
- 40-50%
- >50%
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Feasibility Test and further stages

Target of the feasibility tests at flexible risers with existing Pipe scanners

performing the tests with existing external pipe scanner.

Analysing:
- penetration depth with the existing scanners and sensors.
- detectability of various type of inhomogenities
- distinction capabilities between defects and other caused signals
- capabilities of signal pattern distinction defects / armour layer edge effects.
- capabilities of fatigue detection & analysis
### Sample for Flex Pipe Inspection Test

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Material</th>
<th>T [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interlocked Carcass (72.0 x 1.5)</td>
<td>304 L (Fe 02)</td>
<td>8.7</td>
</tr>
<tr>
<td>2</td>
<td>Rislan P40 TL TP01 Pressure Sheet</td>
<td>Rislan</td>
<td>7.5</td>
</tr>
<tr>
<td>3</td>
<td>Zeta Wire</td>
<td>FM35 (FI 11) (Carbon Steel)</td>
<td>8.0</td>
</tr>
<tr>
<td>4</td>
<td>First Armour layer</td>
<td>FM35 (FI 11) (Carbon Steel)</td>
<td>3.0</td>
</tr>
<tr>
<td>5</td>
<td>Second Armour layer</td>
<td>FM35 (FI 11) (Carbon Steel)</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>Fabric Tape</td>
<td>Type PVC</td>
<td>2.3</td>
</tr>
<tr>
<td>7</td>
<td>Polyethylene External Sheet</td>
<td>Polyethylene</td>
<td>10.0</td>
</tr>
</tbody>
</table>
### Test Setup – 10” Flex Riser sample

<table>
<thead>
<tr>
<th>Test Sample</th>
<th>SLOFEC Scanner PS200 &amp; specific Sensors</th>
<th>ET SLOFEC Computer System &amp; E-magnet power supply</th>
</tr>
</thead>
</table>

![Image of 10” Flex Riser sample with test setup equipment]
Feasibility Test - Step 1: Calibration?

Setting equipment up at 14inch x WT 18mm CS cal-sample

Unknown settings in comparison to full wall cal sample:
- magnetisation,
- how sensitive,
- Signal Phase,
- how the signal phase setting is in comparison to possible defects
Feasibility Test - Step 2: Scanning with unknown setting

- Scanning with the typical settings (as 1.) the complete pipe (except later known defect area),
  Result: clean signal, no indication detected

- Variation of ET Frequency, major (+24dB) increase of sensitivity, full magnitisation
  Result: 2 areas with indications (later analysed as light deformation at outer armour layer)
  > Result (in step 1.b): not indicated as here in 1.a-4 too high sensitivity
Feasibility Test - Step 3: Penetration Analysis

Putting a piece of ferromagnetic material from inside between the gaps of SS Carcass. Target: analyzing if the external scanner receives an indication due to magnetic field line changes if sufficient magn. field line penetration.

Result: full penetration with the existing pipe scanner
Feasibility Test - Step 4:
Armoured layer edge disturbance running scanner in longitudinal axial direction

Analyzing the influence of armoured layer individual End Effect to the ET Signal

Result: no significant influence
Feasibility Test - Step 5:
Artificial Defect detection

Artificial defects (slots) produced in the zeta wire by cut out and re-welded armour layers
Feasibility Test - Step 5: Artificial Defect detection

Setting equipment up to be able to run defect area, putting a rubber coating on top of defect area.

Limitation: due to cut edges of external sheet, scanner can’t run continuous over the edge (wheels hit edge/jump)
Result:
The reachable and less influenced defects “B” & “D” have shown indications. A slight indication of “C” can be recognized below misaligned armour layer.
Feasibility Test - Step 6:
Defect detection

Analysis of penetration into the Zeta Wire from outside without damaged armour layers.

A Ø10mm hole drilled from inside trough SS Carcass, 3mm deep into the (8mm) Carcass.

Result: Detected
Conclusion Phase 1

• Penetration into the different layers by the (existing) external pipe scanner was deeper than expected. (3mm hole in Zeta wire detected, ferromagn. Material in Carcass gap gave indication)

• No significant influence due to armour layer individual band end effect

• Defects (localized) in armour layers and Zeta Wire possible to detect

• The used scanner PS200 was used at its limits, as the warmer the electromagnetic coil got, the less magnetic field line strength was produceable. (Proposing to use a stronger magnetic field inducing scanner – SLOFEC maranised Riser Pipe Scanner)

• .......

Feasibility Test Performance Phase
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Following Steps

(using SLOFEC Maranised Scanner with higher magnetic field)

- Analysis of minimum defect detection
  (different type, different layer, ...)

- Evaluation of the way of equipment Setting & Calibration
  with a matching or similar cal sample

- With variation of settings, analysis of the capability to
  identifying the layer in which the defect is located

- Using ET absolute mode (available with Maranised
  Scanner) to analyse Fatigue status & growth monitoring

- Evaluation of ideal scanner arrangement

- .........................
From feasibility study used scanners to stronger marinised riser/caisson tools
Started development of the full encircling Flex Riser Inspection Tool
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Conclusion

• Penetration into the different layers
• Defect detection in armoured layer and zeta wire
• No significant influence due to armour layer individual band end effect
• Successful feasibility study with limited scanner capabilities
• Fast scanning
• Monitoring possible
• Use of different modes will allow defect detection and material change monitoring
• Etc.

Discussions ……
Started development of the full encircling Flex Riser Inspection Tool

Support required

- Most likely type defects (experience) ?

- Defect detection criteria ?

- Most typical Pipe Dimensions  ?

- Access along the Pipe ?

- Requirements / Experience for fatigue monitoring ?

- Available test samples (with defects) ?

etc.
<table>
<thead>
<tr>
<th>Aberdeen Office</th>
<th>Abu Dhabi Office</th>
<th>Melbourne Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Howemoss Avenue</td>
<td>Sector M-41, Plot 93-94B</td>
<td>2 Mercier Street</td>
</tr>
<tr>
<td>Kirkhill Industrial Estate</td>
<td>Abu Dhabi Industrial City</td>
<td>Coburg</td>
</tr>
<tr>
<td>Dyce - Aberdeen - AB21 0GP</td>
<td>PO Box 4030</td>
<td>Victoria 3058</td>
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