Calibration Methods and Accuracy in Detecting Defects in flexible Riser Pipe

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What is so difficult about the inspection of flexible riser pipe?

• **Material is not homogeneous through the thickness of the wall**
• **Electrically conductive and insulating material is present**
• **Ferromagnetic and stainless steel (or duplex) is present**
• **Every pipe is different in its structure**
• **There is a pronounced anisotropy due to the helical winding**
Layers of a flexible riser

Carcass (Stainless or Duplex)

Pressure Sheath (Polymer)

Pressure Armour (Carbon Steel)

Inner Tensile Armour (Carbon Steel)

Outer Tensile Armour (Carbon Steel)

Outer Sheath (Polymer)
Magnetically Biased Eddy Current (SLOFEC™)

MAGNETIC CIRCUIT

EDDY CURRENT SENSORS

EDDY CURRENT PROBE FIELD

TEST PIECE

MAGNETIC FIELD LINES

DEFECT

Increased Magnetic Flux Level

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What is a sizing/grading method in electromagnetic non-destructive testing?

- A signal is related to the size of a defect. A curve establishing this relation is derived based on experimental evidence.
- This is a calibration curve
- For methods like Magnetic flux leakage and other electromagnetic methods this is too simple to fulfil requirements on defect accuracy levels.
- A more sophisticated methods is required. An “Inverse Problem” has to be solved
- Artificial defects and FEM-calculation is required to find a map a complex relationship Defect Signal $\rightarrow$ Defect Size
How to make defects into flexible riser pipe

• **Remove Outer PE Sheath. Do not open too large an area**
• **For near side defects produce defects. If a wire is cut, it will spring out due to internal tension**
• **For internal defects:**
  – **Cut out the outer wires to allow access the inner layers. Introduce defects and tick-weld wires back.**
  – **Produce a trough-hole from the opposite side and drill from inside into the layers**
  – **Rearrange outer wires to allow for a small access area to the inner layer**
The art of producing artificial defects in flexible pipe

Metal loss defect

Crack like defect

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Outer layer defects

Gradual metal loss

Pin-hole defects

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Larger area cut and replaced

Statoil 2008
Cutting through the rear

Through-holes from rear

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Cutting into a slit

Introduction of „internal“ defects
Signals from various outer layer defects

Signals from various types of surface defects. Only amplitude of specific phase with magnet off is shown
On the issue of defect classification

- **First and most important step is to correctly classify Signals**
  - Spurious/errornness Signal
  - Crack-like defect in first layer
  - Metal loss defect in second layer
  - Etc

- **Then calculate size of defect**
How to classify defects based on Signal for SLOFEC?

Distinction of defects in standard pipe

Typical signal of defect in Flexible riser

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Phase Selection 1: Wire-gaps

Magnet Off

0°  90°  180°  270°
Phase Selection 2: Wire-gaps hidden
Phase selection; Magnet on
Defects visible
Signal development with change in Magnetisation level

Magnet on

Magnet off
Change of magnetisation level

Patented magnetisation System for MEC-FIT™

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Signal Amplitude vs. Magnetisation level

Classification by behaviour of signal under change of magnetisation
Example: Calibration Curves for FBH-defects

Amplitudes of Flat Bottom Defect

- Defect Depth [% of wall thickness]
- Amplitude [Screen Div.]

- Single wire
- Multiple wires

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Deployment of the tool from top-site
Conclusion

• Various kinds of defects can be detected in flexible riser pipe.
• A defect classification scheme was set up.
• The analysis of the data is quite complex and requires many parameter and signal components to be investigated.
• One of the parameters is the magnetisation level. This, for instance, will allow distinguishing internal and external defects.
• With the proper defect characterisation methods, the MEC-FIT™ is a suitable tool for flexible pipe inspection.