MCE Deepwater Development 2017 =

Computed Tomography for Deepwater Pipelines Integrity







NH GRAND HOTEL KRASNAPOLSKY • AMSTERDAM • 3-5 APRIL 2017

Agenda:

- Tracerco Discovery[®]: technology & field experience
- Objectives of the qualification program
- Test protocol:
 - Pipes samples and Defects types
 - Probability of Detection
 - Sizing accuracy
- Data acquisition and processing: key steps
- Achievements (PoD, Sizing...)
- Conclusions:
 - Tool performance
 - Use case
 - Opportunities for further improvement



Tracerco Discovery[®] technology

- by TRACERCO (Johnson Matthey)
- based on Computed Tomography
- sealed source ; mono-energetic gamma ray (¹³⁷Cs)
- deployed by ROV (<3000m water depth)
- for subsea pipeline inspection:
 - Tool rotating around the pipe
 - Data acquisition
 - Data processing & Image reconstruction
 - Real time visualisation
 - > 2D view of a pipe slice (15mm thick)









Tracerco Discovery[®] field experience

- A number of field experiences since 2014:
- Non-intrusive inspection of subsea systems:
 - Flowline, Jumper, Riser, Pipe-in-Pipe, Bundle
 - 4" to 12"
 - Through coating & insulation (<75mm)
- For flow assurance purpose:
 - Detection & characterisation of deposits (hydrate, wax, scale...)
- For integrity purpose:
 - Detection & sizing of pipe defects (metal loss)
 - Detection of water in PiP annulus



Asphaltene @1.2g/cc

Scale @2.3g/cc



Objectives of this qualification program

- Assess the tool performance with regard to pipeline inspection:
 - Detectability of crack like defects (weld defects (lack of fusion...), notches)
 - Detectability of metal loss defects (pinhole, pitting, general, circ. grooving)
 - Sizing accuracy
 - Compare with performance of In-Line Inspection tools (MFL, UT)
- Assess the tool performance with regard to pipeline defects assessment:
 - Using advanced Finite Element software (Empreinte[®]) (software developed by Total and Tecnitas)

Note: Discovery[®] tool was the 15-T340 type with standard collimator





Test protocol: Pipes samples & Defects types

• Real and Machined defects on Pipes samples:

Samples	Pipes	Defects	Notes
Seamless pipes samples	OD: 10.75" WT: 18.6 mm	N5 notches 25 x 0.5 x 1mm Axial, circumferential	16 defects
Girth weld pipes samples	OD: 10.75" WT: 21.4 mm	Weld defects (linear, lack of fusion)	> 100 defects
Metal loss pipes samples	OD: 10" & 20" WT: 18.6 to 21.9 mm	Machined slots of various sizes (internal, external, side drilled)	26 defects









Test protocol: Pipes samples & Defects types

- In addition, simulated defects were considered to have a large population for PoD and Sizing evaluation
- The Discovery Scanning Simulator was used to produce **1310** defects
- The Simulator was checked comparing tomograms from simulated defects vs tomograms from machined defects
- The defects were created to cover the full range referring to POF* classification (3 groups were considered)



*POF (Pipeline Operators Forum):

Specifications and requirements for intelligent pig inspection



Test protocol: Probability of Detection (PoD)

- PoD detailed assessment:
- Referring to Nordtest TR 394*
- PoD 90% at 95% confidence level with regard to defect depth (i.e. minimum depth to meet PoD = 0.9)
- PoD estimated separately for:
 - Group 1, Group 2, Group 3 defects
 - Machined defects (small population)
 - Simulated defects (large population)





*Nordtest Technical Report 394:

Guidelines for NDE reliability determination and description

Test protocol: Sizing accuracy

- Sizing accuracy assessment:
- Referring to Nordtest TR 394*
- Calculated for defect depth and width in term of:
 - Systematic deviation (Mean error mm)
 - and Standard deviation (+/- Δ mm) at 80% certainty
- Sizing accuracy estimated separately for:
 - Group 1, Group 2, Group 3 defects
 - Machined defects (small population)
 - Simulated defects (large population)
 - Inner, Outer defects





*Nordtest Technical Report 394: Guidelines for NDE reliability determination and description

Data acquisition and processing:

- SNR (Signal to Noise Ratio) used to define the scanning time required in term of CT image stabilisation and quality (*):
 - **17 min** for 10" pipes **30 min** for 20" pipes (Inner and outer surfaces stabilise quicker)
- CDD (Contrast Detail Dose) used to define detectability & resolvability limits based on human visual inspection:
 - Expected contrast is 200% for metal loss features on water background
 - 3mm Ø features can be detected & resolved
 - (valid for features with length \geq 15mm)



(*) as per ISO 15708-1&2:

NDT – Radiation Methods – Computed Tomography



Findings: Probability of Detection (with auto. pattern recognition algorithm)

- Crack-like defects cannot be reliably detected.
- Metal loss defects: 90%PoD is achieved with defect depth 2 mm (detectability limit based on CDD (human visual detection) slightly improved)



Findings: Sizing accuracy (with automatic pattern recognition algorithm)

- Depth accuracy:
 - Standard deviation (at 80% certainty) was found less than +/- 1.5 mm
 - Systematic undersizing (mean error) was noted for Group1: -1 to -2 mm
- Width accuracy:
 - Standard deviation (at 80% certainty) was found significant: +/- 5 to +/- 13 mm
 - Systematic oversizing (mean error) was noted for all Groups: 3 to 8 mm



Comparing Discovery[®] performance with MFL & UT in-line tools

	Discovery®	MFL	UT
Min. Depth at 90%PoD	2 mm	10 to 15% WT (2 to 3mm for a 20mm thick pipe)	1 to 1.5 mm
Depth accuracy (at 80% certainty)	-1 to -2 +/- 1.5 mm	+/- 10 to 15% WT (+/-2 to 3mm for a 20mm thick pipe)	+/- 0.5 mm
Width accuracy (at 80% certainty)	3 to 8 +/- 13 mm	+/- 10 to 20 mm	+/- 10 mm
Length accuracy (at 80% certainty)	+/- 15 mm (considered = to CT slice thickness)	+/- 10 to 20 mm	+/- 10 mm

- Performance of Discovery[®] (15-T340) was found equivalent to MFL (not UT)
- Performance may be affected for short (L<15mm) & narrow defects (W<3mm)
- Tool configuration can be enhanced with collimator leading to 5mm CT slice.



Conclusions:

- Some limitations of Discovery[®] tool are highlighted:
 - Crack-like defects cannot be reliably detected.
 - Metal loss sizing accuracy cannot improve further the defects assessment process (3D imaging not accurate enough for Empreinte[®] Finite Element software).
- Performance of Discovery[®] was found equivalent to MFL In-Line Tools in term of PoD and Sizing accuracy for metal loss defects.
- Discovery[®] is confirmed to be helpful in the following use cases (integrity related):
 - Perform local external inspection to cross-check intelligent pigging findings (metal loss),
 - Provide inspection solution for non-piggable lines (spot random checks),
 - Can tackle challenging pipe systems (Pipe in Pipe, Bundles, Thick coating/insulation...).
- Opportunities for further improvement are being assessed with TRACERCO.

