IWEX 3D AUT Inspection Methodology

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Applus + RTD
Content of presentation

- Presently used AUT inspection principle
- Introduction of New AUT inspection methodology
- Explanation of the IWEX inspection principle and imaging approach
- Examples of IWEX inspection result presentation capabilities
- Field trial in Canada
Automated Ultrasonic Testing

Current AUT inspection philosophy with ultrasonic waves:

- Detection based on reflection (like sonar)
- Detection based on directional ultrasonic beams
- Sizing based on amplitudes requires calibration procedure
Zonal approach, typical height typically 2.0mm - 3.0mm

Ultrasonic Probe angles are selected perpendicular to weld bevel profile

Assumption is made that:
- Defects are positioned at the theoretical weld bevel configuration
- Defects are present within the zone
- Defect height and depth

The weld bevel configuration is dictating the AUT inspection concept
Extensive training is required to interpret the AUT inspection result in view of the applicable codes and standards and related ECA acceptance criteria.
Exploring new ways……..

Why are such images not possible in NDT?

- Difficult to read
- Need calibration blocks
- Huge subjective factor

Medical sector......

NDT (industrial) sector

Straight forward interpretation
no calibration blocks required
What are we expecting from new methodology?

Generate a (3-D) image from defects in pipeline girth welds

- The image must present the defects’ orientation, position and size
- Straight forward result display (no strip charts)
- Interpretation inspector independent and with minimal experience
- Detection ability independent on defect shape and orientation
Seismic imaging, and potential for AUT

- **Vibrator truck**
- **Array of recorders**

Based on measurement and data processing concepts applied in *seismic exploration*

Algorithm processes the information into **2D and 3D images**

**New AUT methodology is based upon same principles**

Original earth's crust
The IWEX imaging process

- Imaging area consist out of pixels
- Back propagate wave field to each pixel: Inverse Wave field EXtrapolation
- The value of the pixel is the amplitude from the back propagated wave field
IWEX inspection concept

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  - Transmit with 1\textsuperscript{st} element
  - Receive with all elements
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IWEX inspection concept

 IWEX: Inverse Wave field EXtrapolation
 Concept:
 Transmit with 1\textsuperscript{st} element
 Receive with all elements
 Transmit with 2\textsuperscript{nd} element
 Receive with all elements
IWEX inspection concept

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  - And so on until all elements have been used as a source
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- Obtained data for N elements: N sources x N receivers = N\textsuperscript{2} A-scans

DATA
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- Obtained data for N elements: N sources x N receivers = N\^2 A-scans
- Process with IWEX algorithm (based on Rayleigh integral)
IWEX concept

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- Obtained data for N elements: N sources x N receivers = N^2 A-scans
- Process with IWEX algorithm (based on Rayleigh integral)
- Result: Cross-sectional image of inspected object
IWEX algorithm

Correct phase & amplitude

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Defects at bevel position locations

- **B4** = BN -10°
- **B2** = BN -5°
- **BN**
- **B1** = BN +5°
- **B3** = BN +10°

IWEX - 0  IWEX - 2  IWEX – 1 & 3
Defects at Weld Centerline locations

BS4 = BS -10°
BS2 = BS -5°
BS = BS
BS1 = BS +5°
BS3 = BS +10°

IWEX - 0  IWEX - 2  IWEX – 1 & 3
Results in 3D: Lack of Fusion

- 3D result of Lack of Sidewall Fusion welding defect
  - After software rendering
Example Crack detection

- Wide Plate result from crack

- IWEX analyzer raw data result

- IWEX visualization after rendering process
Resolution capabilities

Diameter: 0.5 mm

Resolution is determined by the wave length

Ideal transducer 8 to 10 MHz -> 0.4 to 0.3 mm for transversal mode converted waves
The 2013 IPLOCA New Technologies Award sponsored by BP was presented during the annual Convention held in Washington, D.C.

The 3D IWEX inspection methodology received the Runner-up award.
Canada Field introduction
Inside view of the cabin from IWEX AUT inspection vehicle
Scanner in operation
IWEX on-line Pipeline girth Weld Inspection
The IWEX 3D inspection methodology offers;

- Improved POD and Sizing accuracy (depth & height)
  - Reduced/eliminate dependence on defect orientation
  - Eliminate the dependency on weld bevel geometry (single system setup for J, V, X, or I bevels)
  - Visualization of weld profile (cap & root profile)

- Simplified visualization of imperfections 2D and 3D images will improve the AUT inspection confidence factor and reduce the subjective interpretation error

- Improved defect discrimination/visualization in the “shadow” area behind large defects.

- A performance/verification block is used, replacing standard calibration blocks.
Thank you for your input!

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What is more in the pipeline?