Eddyfi®

Eddy Current Array Crack Detection and Sizing in Carbon Steel Welds

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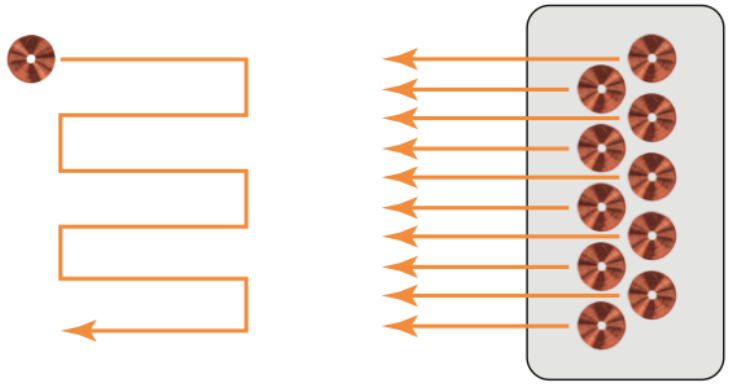
1. Eddy Current Arrays

- An eddy current array (ECA) is composed of several individual coils, grouped together in one probe
- The coils are excited in a specific sequence to eliminate interference from mutual inductance (channel multiplexing)
- Arrays can be made flexible or shaped to any geometry
- Software provides graphical display (2D and 3D C-scans)

Typical benefits:

- Reduced Inspection Time
- Improved Flaw Detection
- More Intuitive Interpretation
- Full Inspection Records



Slow raster scan (single-coil ECT)

Fast single-pass (ECA)

2. Background

- Background on Carbon steel welds
  - Variety of applications & critical (safe operation of assets)
  - Prone to cracking (fatigue and/or stress corrosion)
  - Challenging for any examination method (sometimes coated)



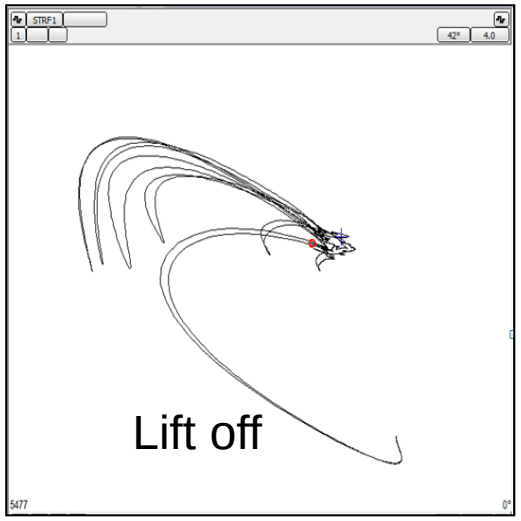

- Current methods and their limitations
  - Dye Penetrant and MPI
    - Long, Surface Preparation, No depth sizing, Etc.
  - ECT (pencil probes)
    - Basic Signals, Operator dependent, No reliable depth sizing, Etc.
  - Advanced Techniques
    - Limited availability / marginal, expensive

3. Objectives

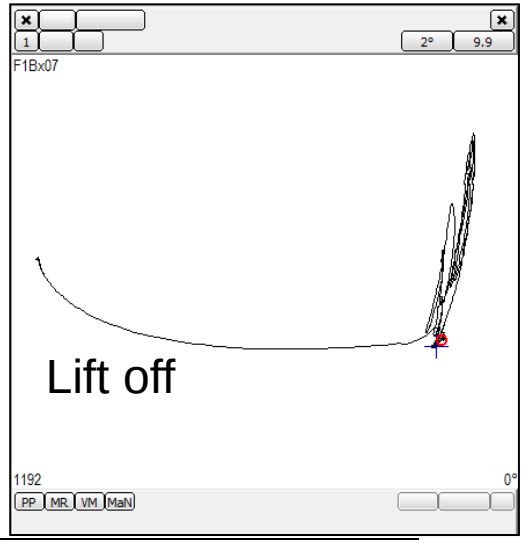
- Detect surface-breaking cracks in CS joints
- Length and depth sizing
- Accommodate weld crown in the ”as is” condition
- Lift-off tolerance: coating/paint up to 2-3mm (0.080”-0.120”)
- Maximize coverage and speed
- Leverage advanced imaging capabilities (C-Scan, 2D/3D)

4.1. Preliminary Studies

- Tests with a Transmit/Receive configuration using pancake coils side-by-side
  - Surprisingly, defects within a range of 0.5mm to 15mm in depth were easily distinguishable.
  - However, defects signals curvature could complicate depth sizing using either vertical or horizontal component of signals.
  - As lift-off occurs during weld scans, the operating point moves along this hooked curve producing significant phase changes.

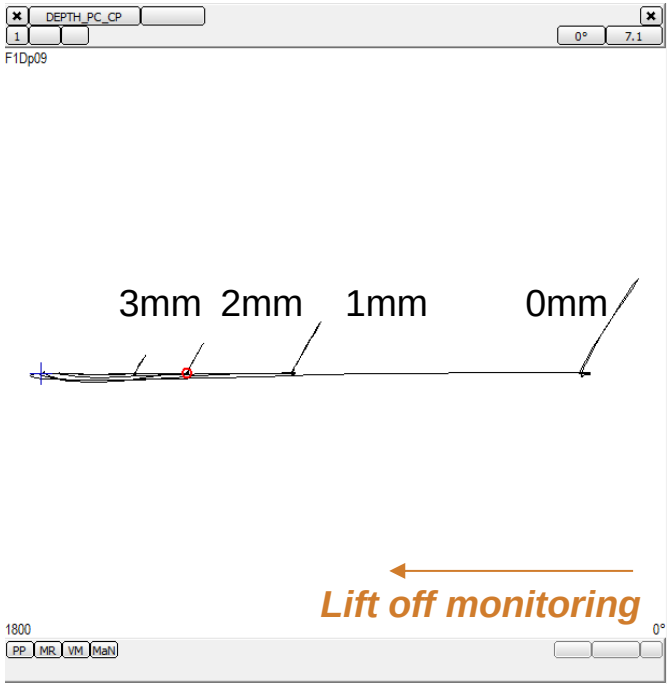


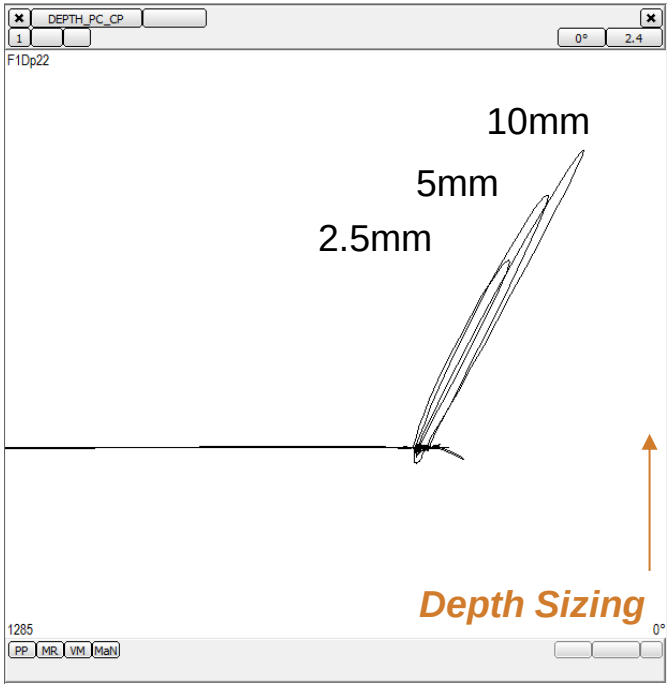
- Tests with new ECA configuration
  - Defects at 90 degrees with lift-off
  - All defects have the same phase shift
  - Lift-off “flatness”



4.2. Lift Off & Depth Sizing

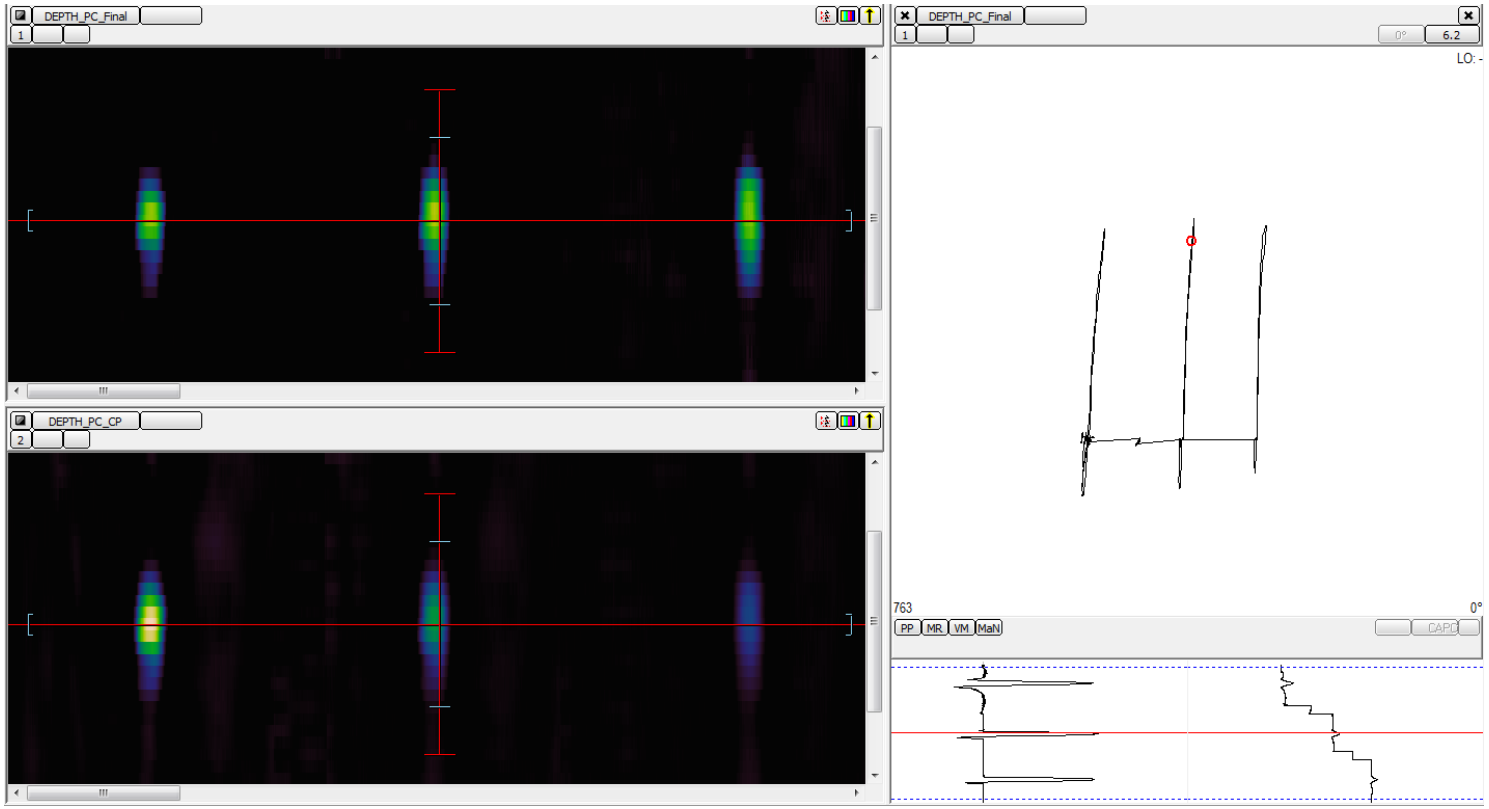
- Horizontal operating point movement is linked with lift-off
- Signal vertical component is linked with crack depth
- Sizing curves lift-off vs horizontal & depth vs vertical amplitude enable sizing capabilities





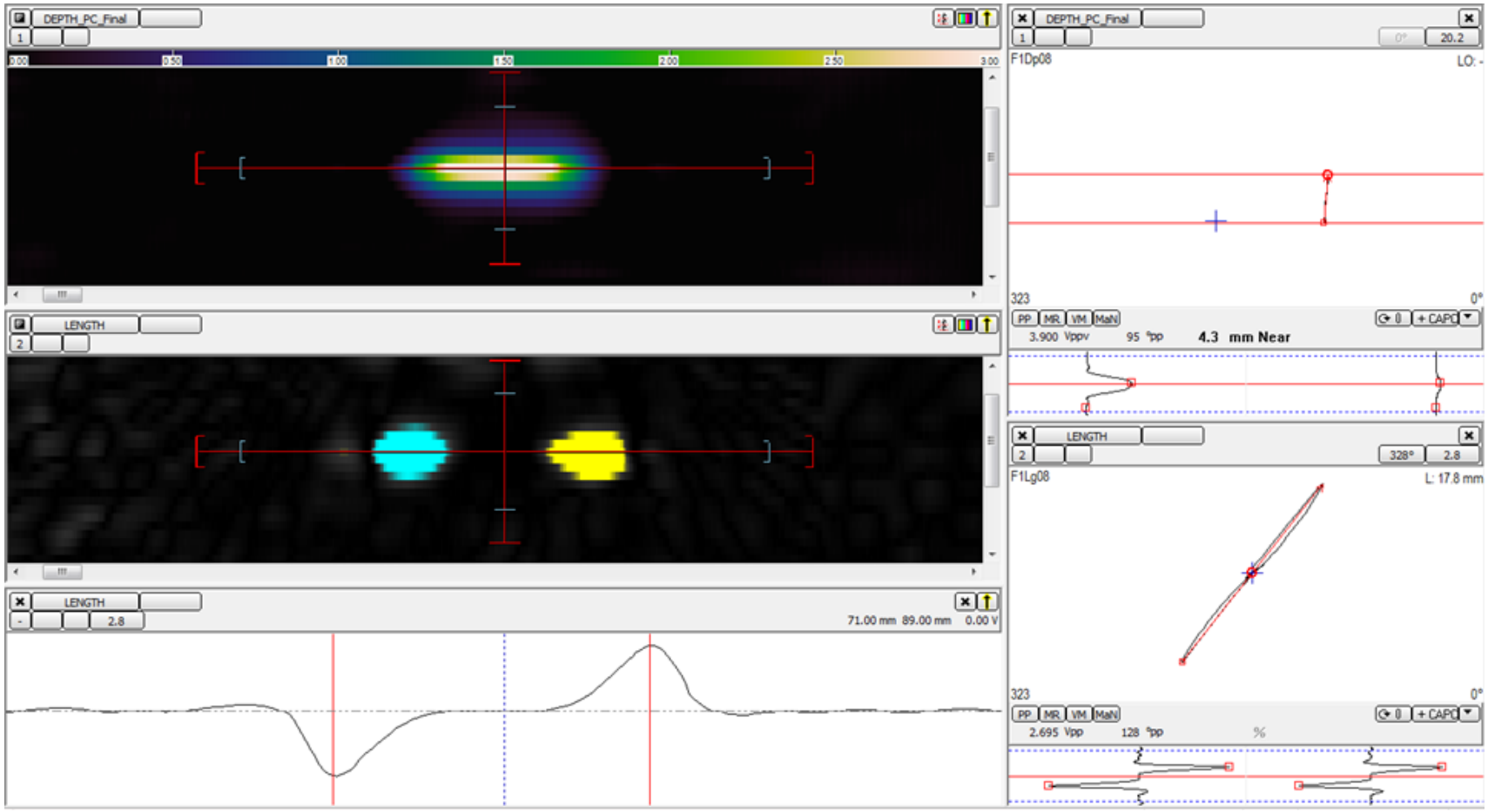
4.3. Lift Off Correction

- The idea was to correct depth sizing depending on lift-off variations without any loss of information on the C-Scan mapping



4.4. Example - Detection & Sizing

- Here is how a sizing is made on a 4.5mm deep defect with 1mm of lift-off



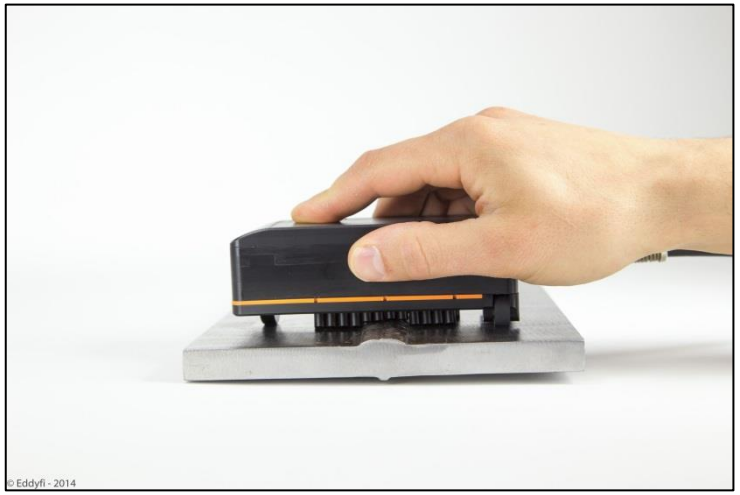
5.1. Our Solution

Patent-pending

5.2. Probe Specification

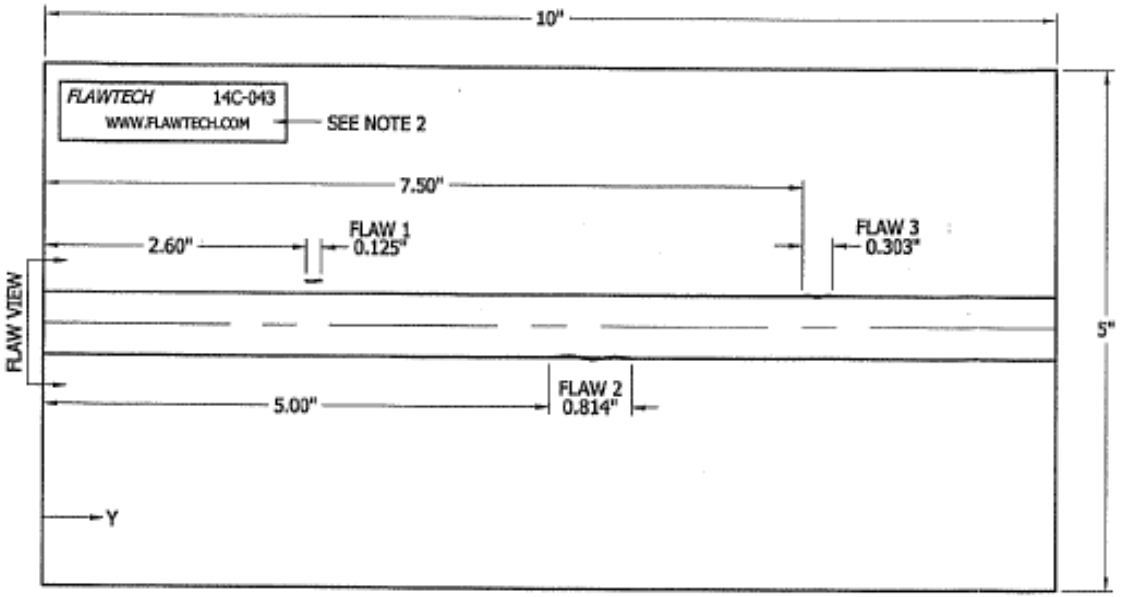
- Rigid body for manual or semi-automatic handling
- Spring-loaded fingers conforming to the weld crown
- Integrated encoder and guiding wheels, removable for cleaning and repair
- 53mm coverage (crown + HAZ)
- Minimum detectable depth: 0.5mm
- Maximum measurable depth: 10mm
- Minimum detectable length (HAZ): 2mm
- Possibility to detect transverses defects
- Spring-loaded fingers have been tested for durability and can withstand over 10 kilometers of scanning

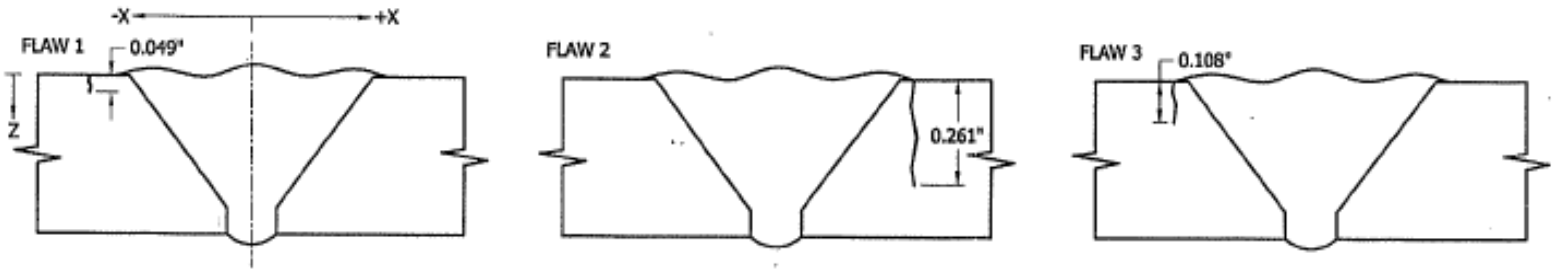
(Patent pending)



6.1. Trials on dedicated weld

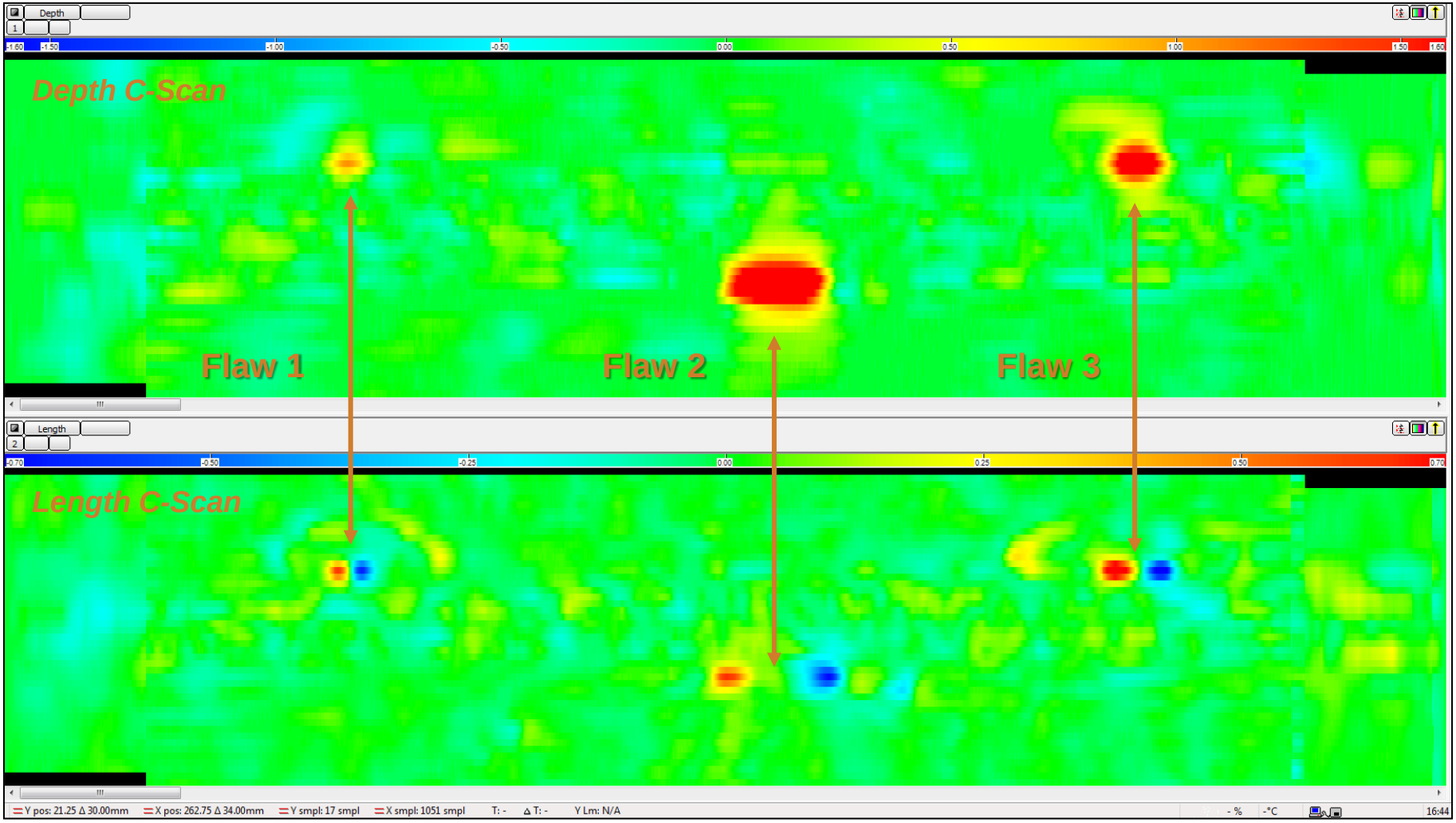
- 9.5mm thick carbon steel welded plate (“as welded”)
- Single V weld with toe and HAZ cracks





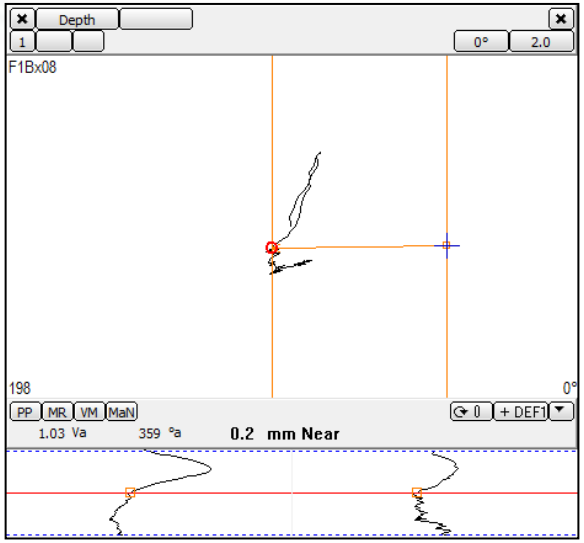
6.2. Trials on dedicated weld

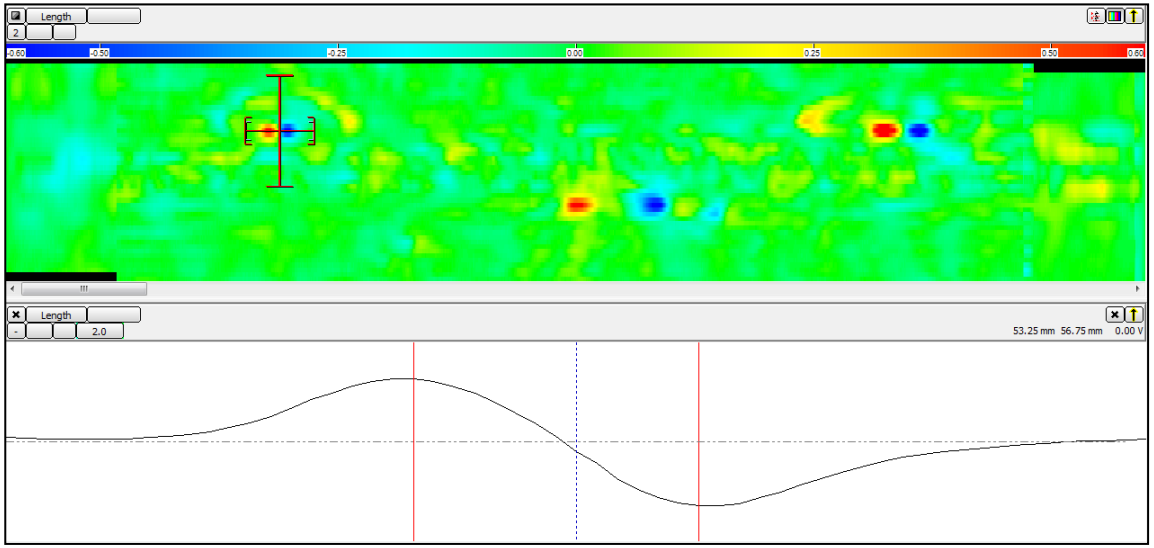
- 3 axial surface breaking defects detected in one single pass

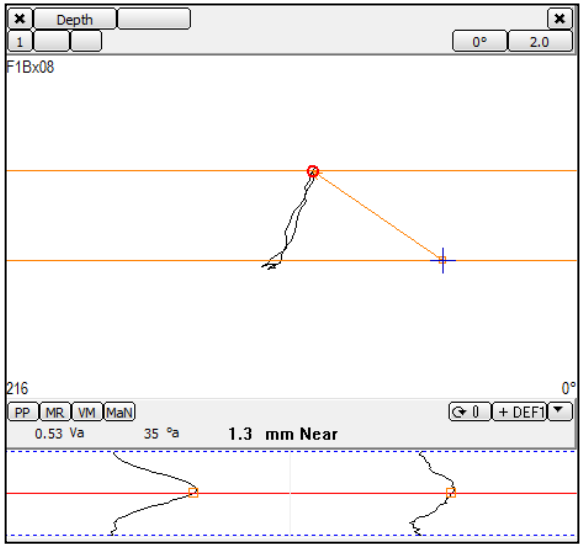


6.3. Trials on dedicated weld

- Defect #1 sizing
  - 1st step: lift-off sizing
    - 0.2mm measured
    - Selection of the 0mm lift-off curve
  - 2nd step:
    - Vertical amplitude measurement
    - Depth measured: 1.3mm (1.25mm real)
  - 3rd step: length sizing
    - Length measured: 3.5mm (3.2mm real)

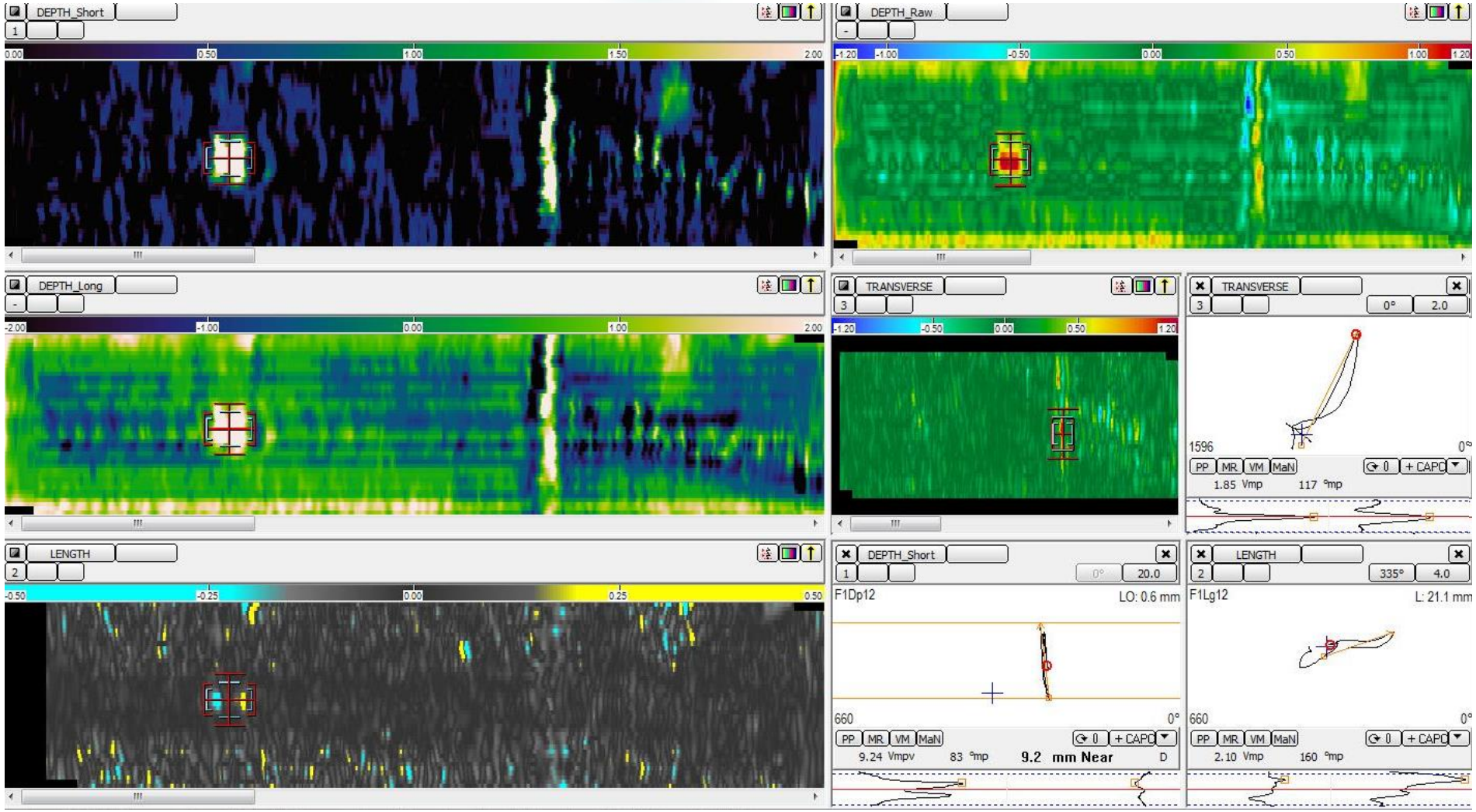






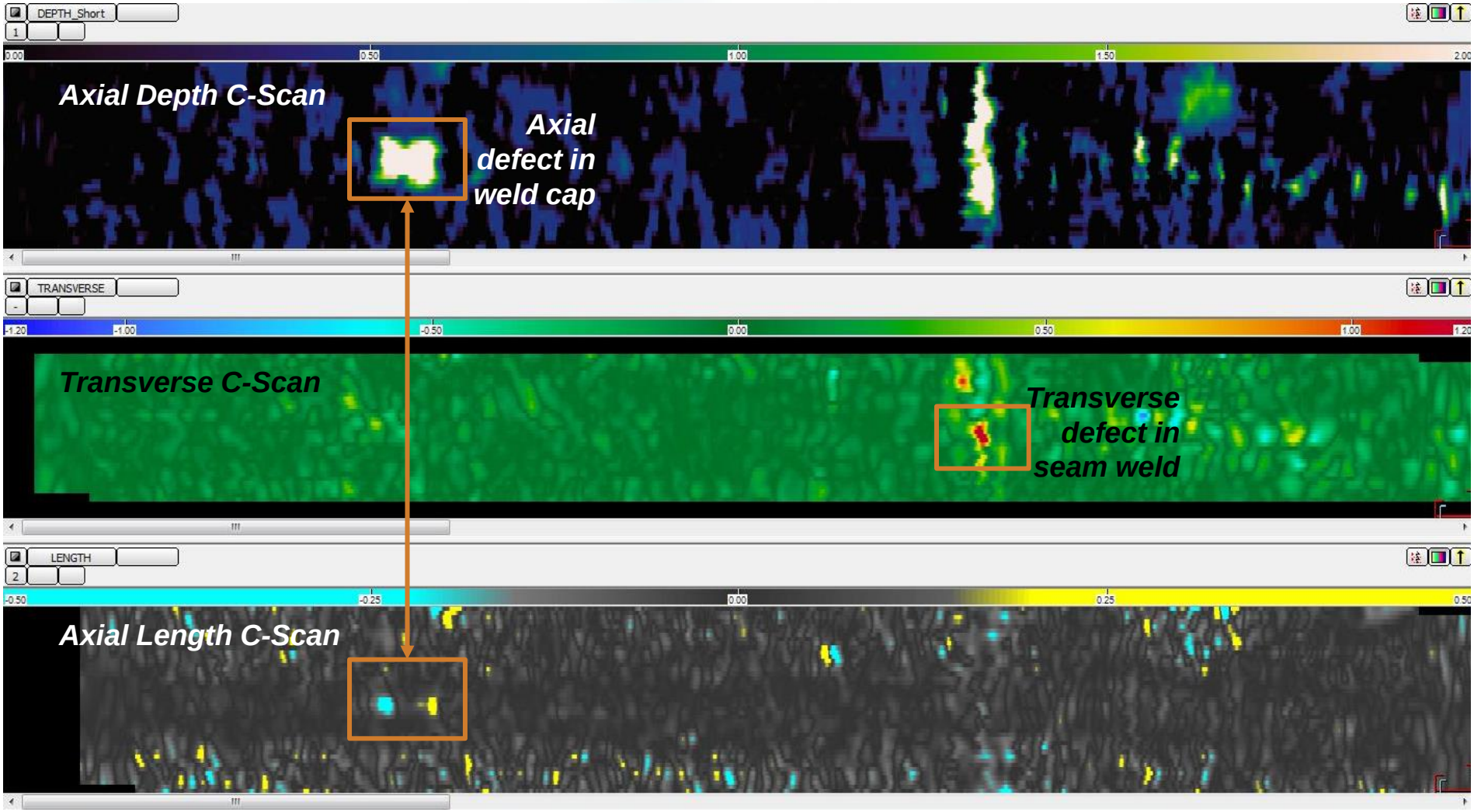
6.4. Trials on real cracked weld

- Axial and transverse defects detected in one single pass



6.5. Trials on real cracked weld

- Zoom in



7. Development & Testing

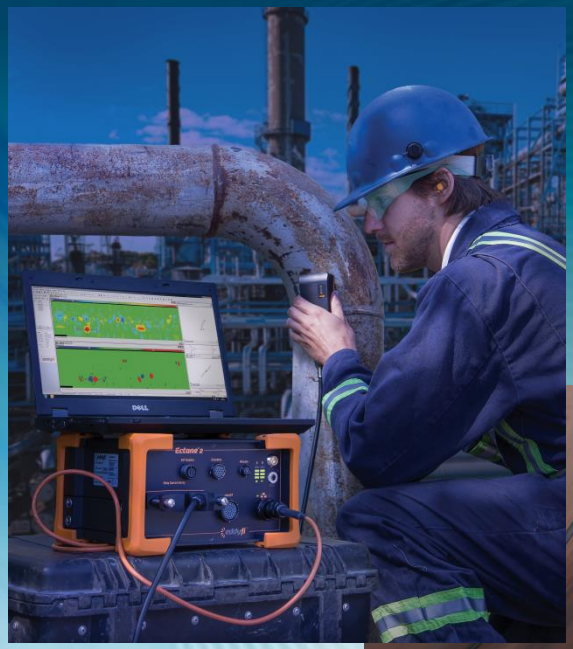
- Extensive tests on various welded specimens
  - Various steel grades
  - Various coatings
  - Various surface states

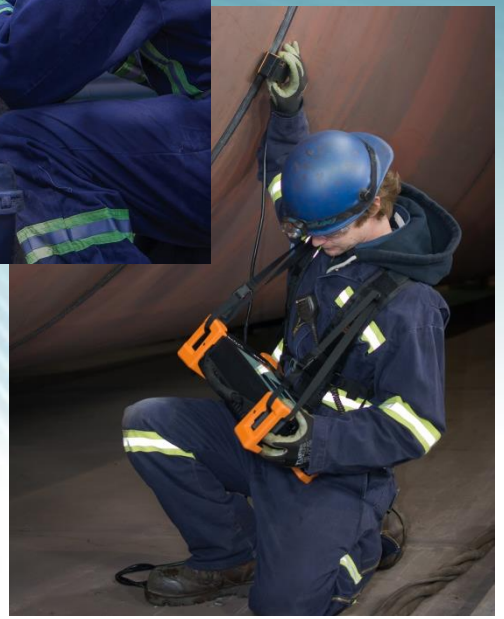
- Dedicated software tools
  - Matrix sizing curves
  - New filtering process
  - Global and Local permeability correction
  - Automated sizing capabilities
  - Basic calibration method

8. Conclusions

- An eddy current array technique has been developed for the detection and sizing of surface-breaking cracks in carbon steel welds
- Results show that the probe is capable of sizing defects in depth and in length with a certain lift-off tolerance
- The probe is also capable of detecting transverse defects
- Additional works are undergoing to thoroughly assess the capabilities of the TECA technology for specific type of flaws (cluster of cracks, oblique cracks, increased resolution, etc.)

Thank you for your attention





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