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Simplicity | Capability | Reliability

Shaft Inspection using Phased Array Compared to other Techniques

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NDT in Canada
NDTiC 2017
Canada's NDT Conference
June 6 - 8
Centre des congrès de Québec
Québec City, Québec

Presentation Overview

- Introduction
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- Suggested Approach
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  - Radial inspection using CSC
- Results
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  - Sizing capability
  - Screening efficiency
  - Suggested Workflow
- Conclusion
  - Summary & Other applications
  - Complete solution

François Lachance
Application Engineer
Sonatest

Founded in the UK in 1958

- 3rd largest manufacturer UT – NDT equipment
- Simple to use, rugged & portable instruments
- Offices
- Over 100 distributors network
- Service points on 5 continents

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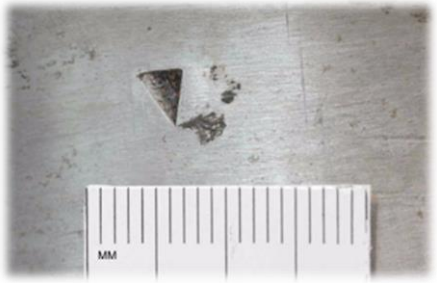
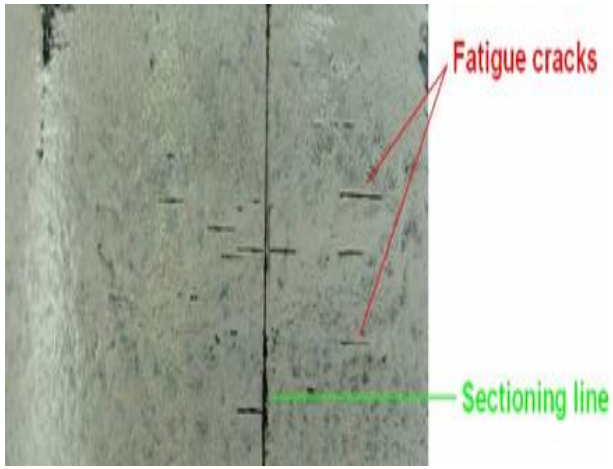
Introduction
Shaft Inspection Application

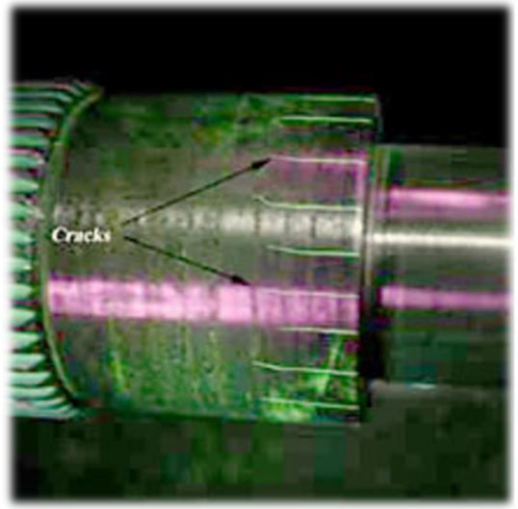
- Train axle
  - Mechanical Damage
  - Corrosion Cracking
  - Fatigue Crack
- Billet (Forging)
  - Porosity
  - Steam
  - Cooling crack
- Drive shaft
  - Crack
  - Other in service flaw
- Spline shaft
  - Crack
  - Other in service flaw





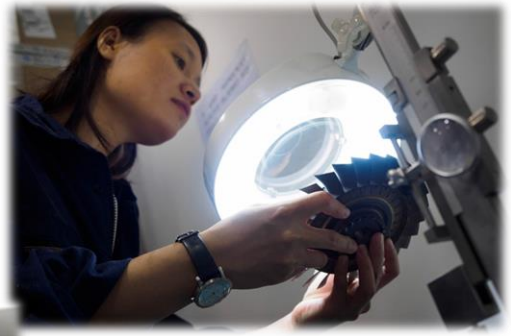
Introduction
Current Inspection Technique

- Magnetic particle limitations
  - Indications can sometime be hard to size
  - Could produce false call due to scratch
  - Need an access to all the surface
  - Shaft disassembly required
  - No traceable information
  - Hardly catch deeper Subsurface flaw than 2–2.5 mm

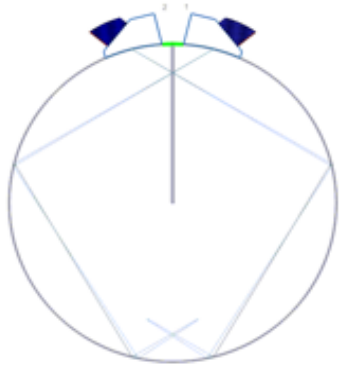


Introduction
Current Inspection Technique

- Visual inspection limitations
  - By definition a qualitative inspection
  - No traceable information
  - Need an access to all the surface
  - Shaft disassembly required
  - Hard or impossible to detect small crack



Introduction
Current Inspection Technique



- Conventional Ultrasonic limitations
  - Surface is covered with only one angle at the time
  - The probe must be move to obtain 100% coverage
  - The localization, visualization and sizing of a flaw is quite challenging for most inspector
  - There is only one fix focus point
  - Most of the time, no traceable information is generated

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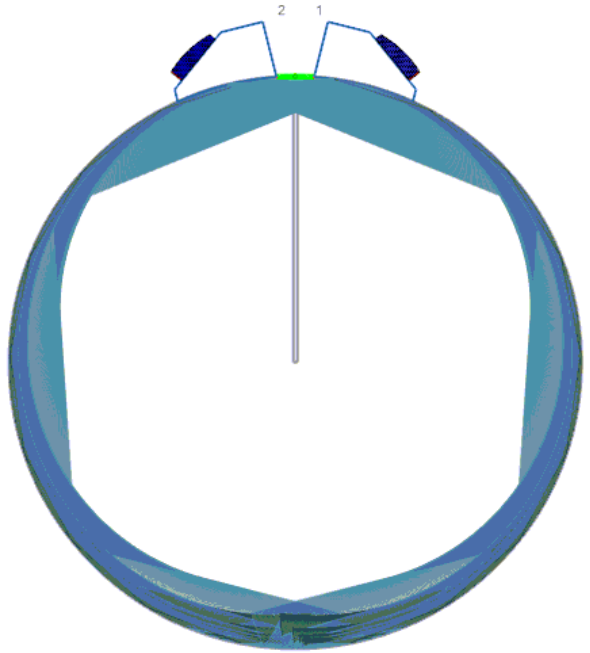
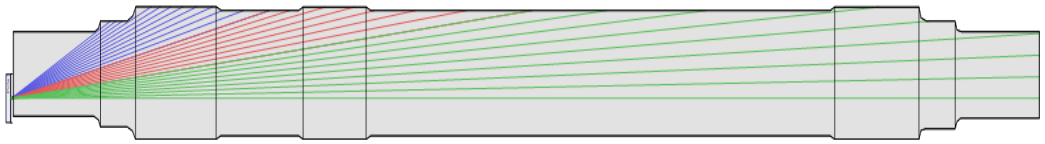
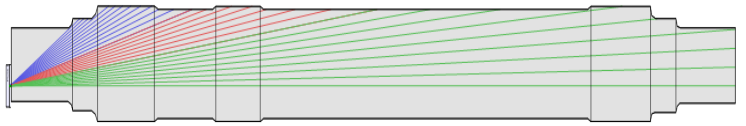
Suggested Approach

- Multi oriented Phased Array inspection
  - Axial orientation
    - PA inspection from extremities
  - Radial orientation
    - PA inspection from surface
  - Characterization and sizing advantages of the PA Curved Surface Correction



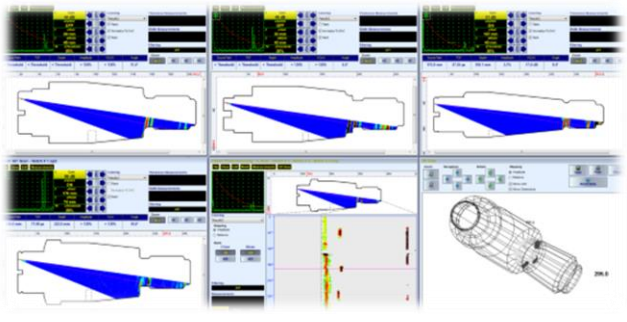


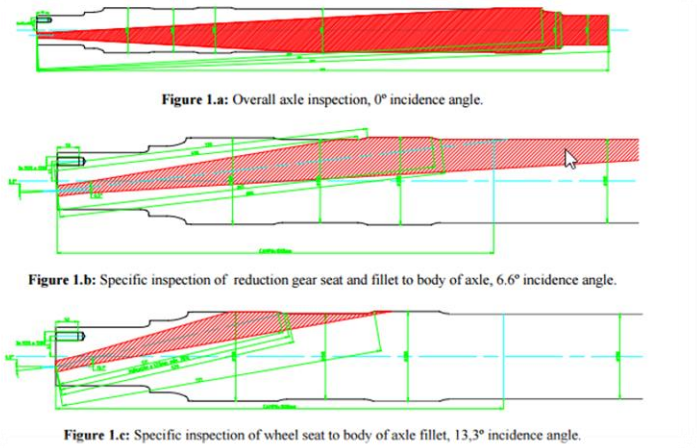
Suggested Approach
Axial Inspection



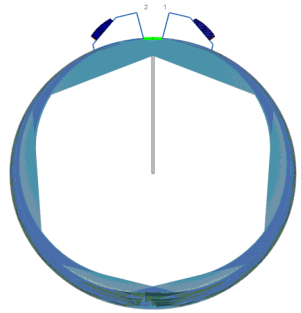
- Already well documented especially for train axle inspection
- Would detect all Radial flaw orientation
- Some References:
  - AQTr (Association Quebecoise des transports)
  - New Generation of Test Benches for Ultrasonic Testing of Solid Axles, Uwe VÖLZ 1 , Peter HEILMANN 1 , Henry SCHOLZ 2

Divergence effect after ID reflection

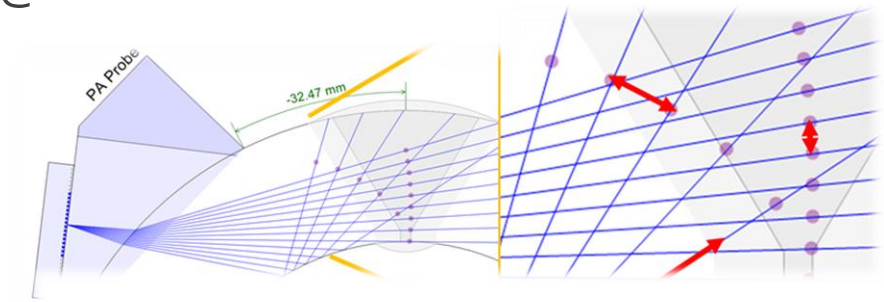




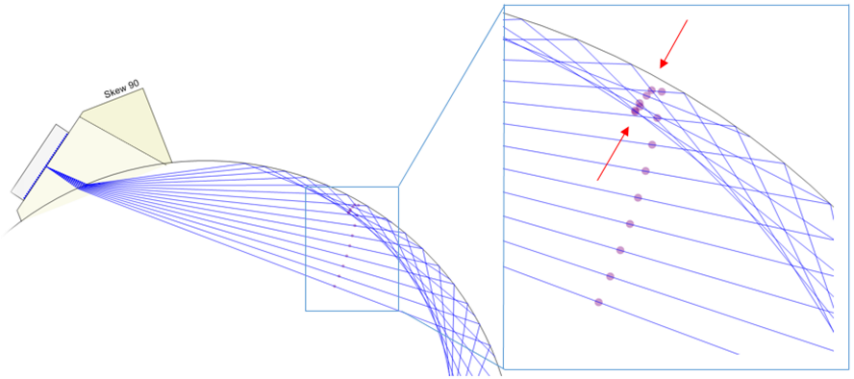
Suggested Approach
Radial Inspection using PA-CSC



- Natural Beam convergence effects on cylindrical component
  - Limit beam spread
  - Increase Spatial covering
  - Increase Resolution
  - Energy retention

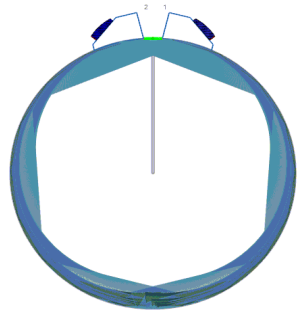


Divergence effect after ID reflection

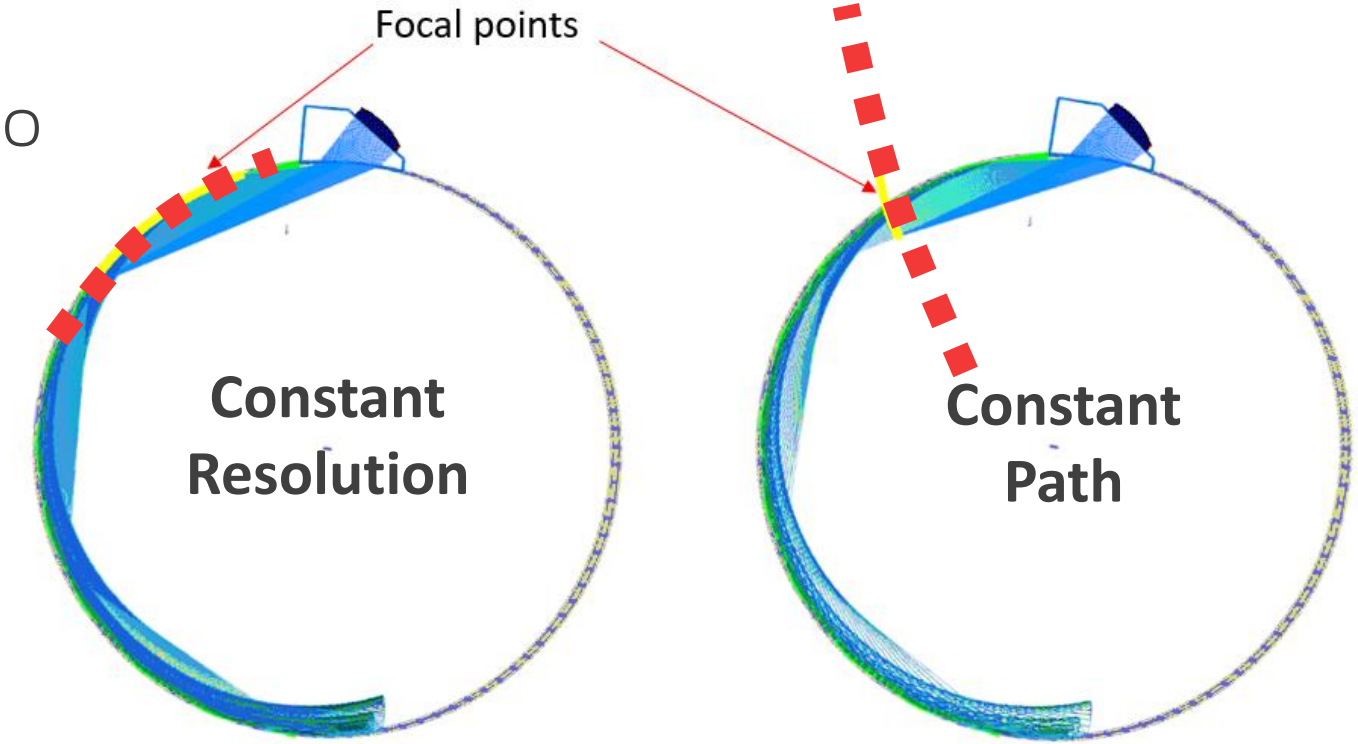


Convergence effect after OD reflection

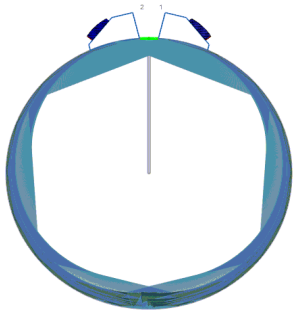
Suggested Approach
Radial Inspection using PA-CSC



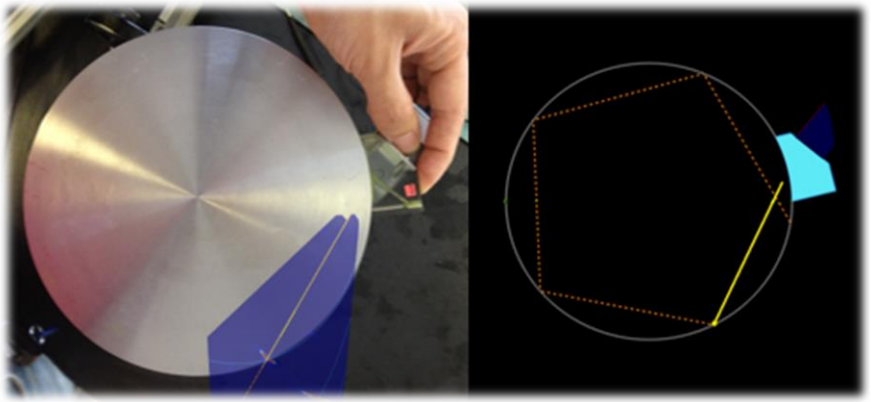
- There is a natural beam convergence effects due to the cylindrical component
  - Limit beam spread
  - Increase Spatial covering
  - Increase Resolution
  - Energy retention

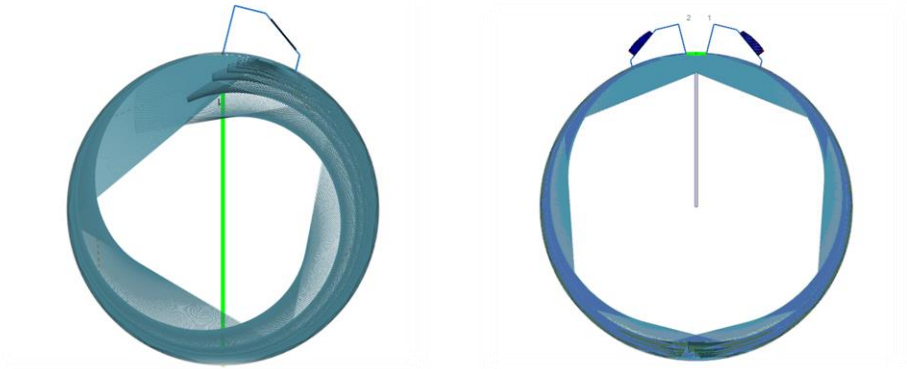


Suggested Approach
Radial Inspection using PA-CSC



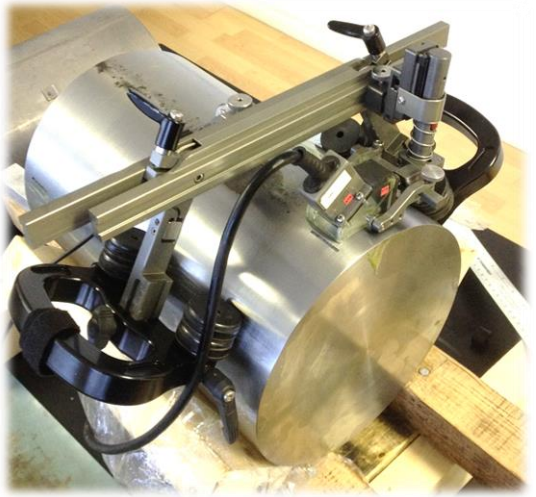
- 3D view Representation
  - Define inspection coverage
  - Precise surface localization and representation
  - Curved part overlay showing rebond lines in the S-Scan view
- One point acquisition Inspection
  - Require a small contact area to inspect a component
  - Ensure traceability
  - Fast and reliable





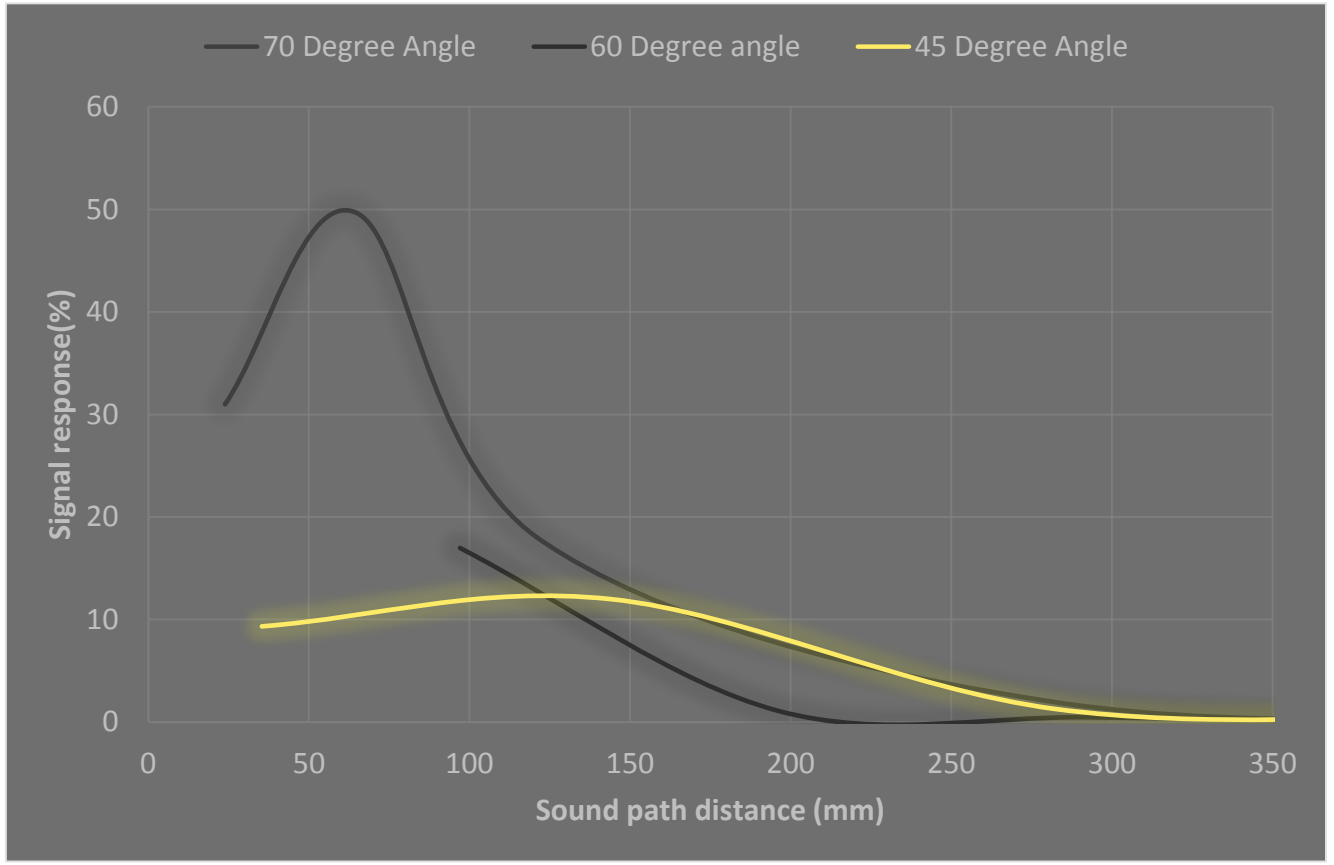
Results
Test Sample & Calibration

- Sample
  - 8" diameters shaft
  - 6 Notches
  - From 0.5 mm to 3 mm, with constant depth increment of 0.5 mm
- Calibration
  - All velocity, wedge delay and sensitivity done using a curved calibration block
  - TCG @ a constant dB of 0.08 dB/mm
  - Sensibility done on a 0.5m Notch @ 80% FSH and 600 mm of sound path



Results
Sizing Capability

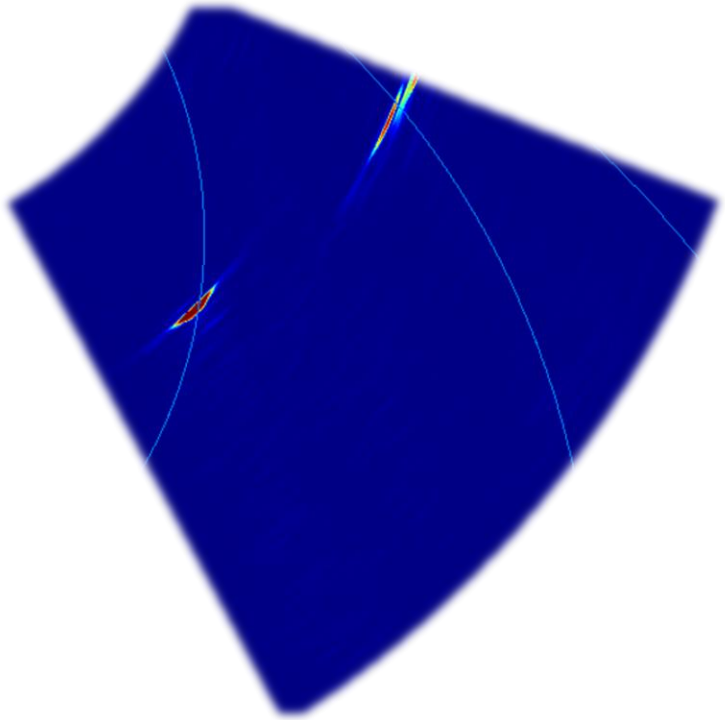
- At 70° angle nearfield is ≈ 70 mm
- At 45° angle nearfield is ≈ 150 mm
- At lower angle nearfield is longer… hence a better focusing capability



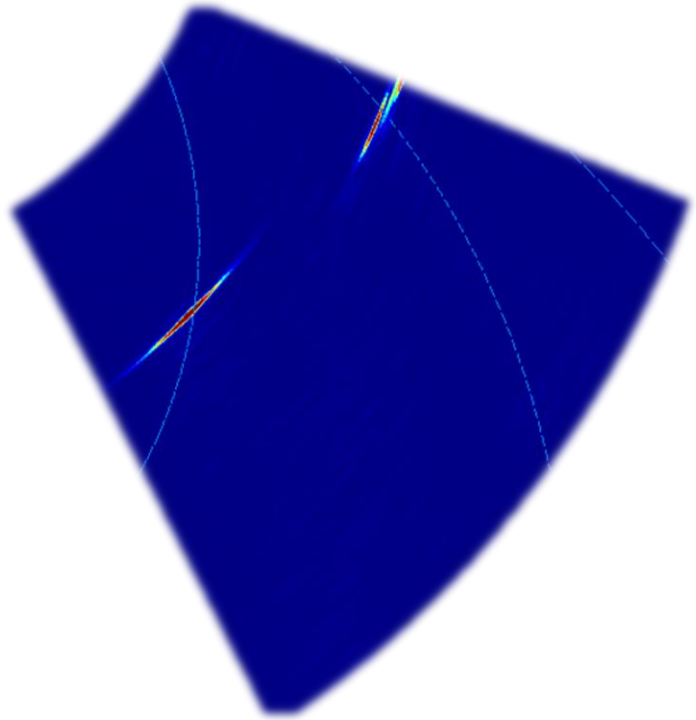
Results
Sizing Capability

- Constant Resolution Advantages
  - Focal point directly on the outside surface
  - Optimized signal response
  - Better sizing

Constant Resolution



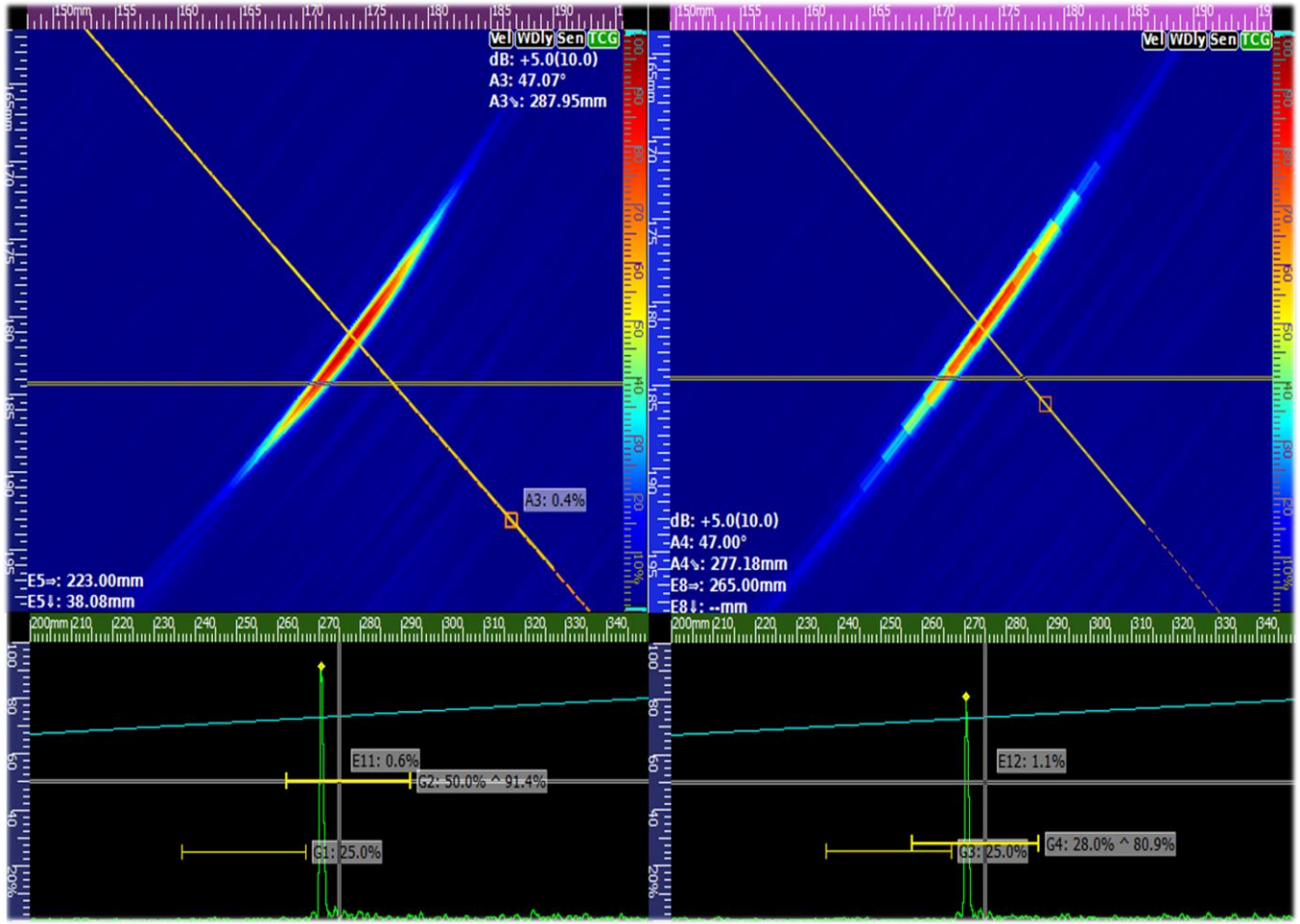
Constant Path



Results

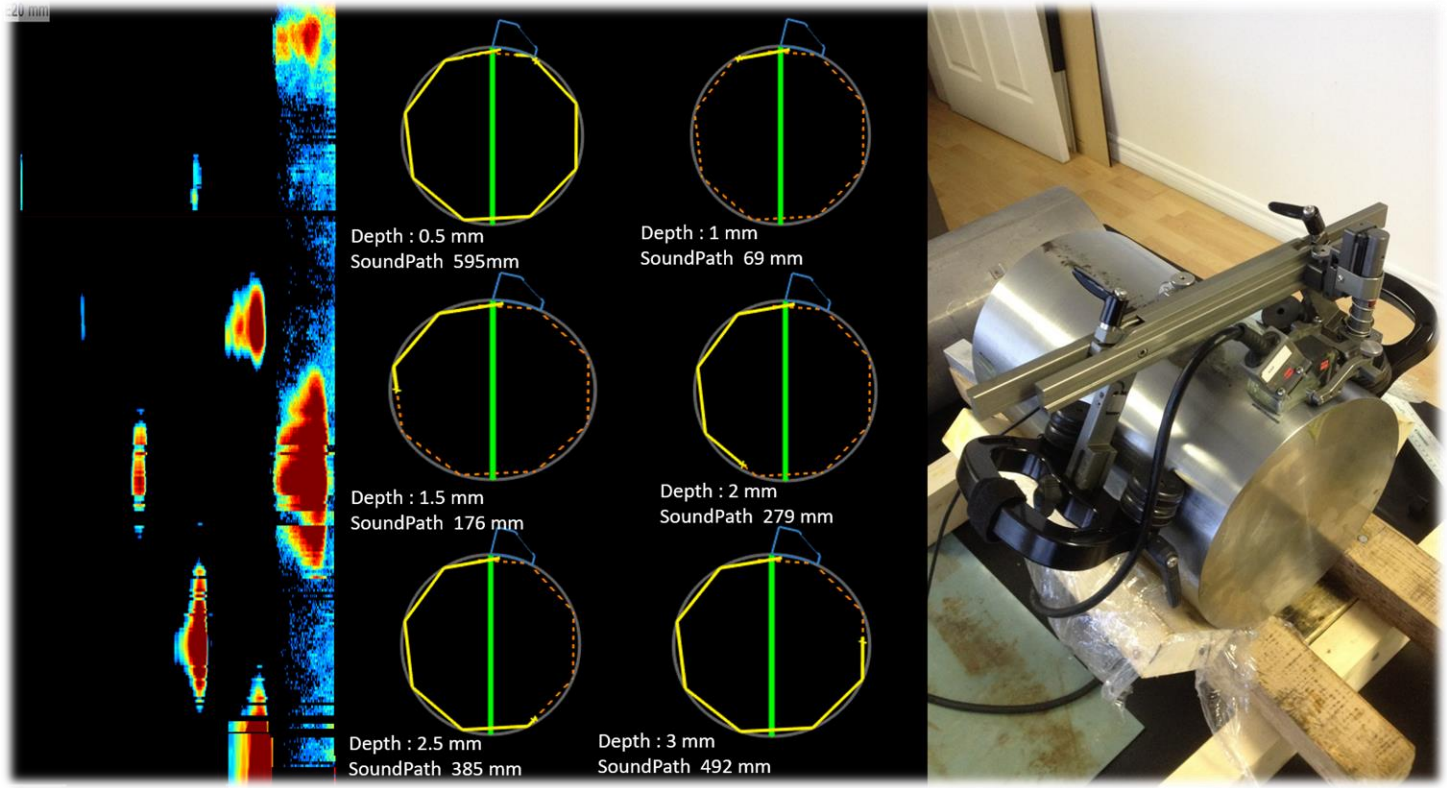
Sizing Capability

- Constant Resolution Advantages
  - Ensure a precise resolution at a specific sound path
  - Counter the lost resolution caused by the beam diffraction
  - Ability to push electronic to a maximum resolution (1024 beams / scan)



Results
Screening Efficiency

- From one contact point and a 360° coverage:
  - All flaws are detected with only one scan
  - Up to a 0.5 mm notch at 595 mm travel path
  - SNR > than 12 dB
  - ! Presence of L-wave mode conversion !

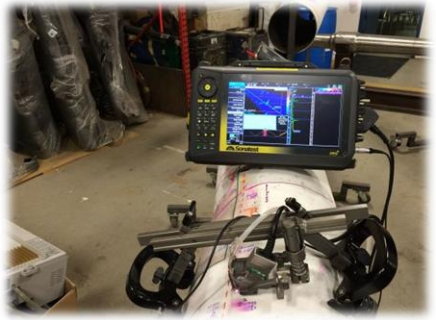


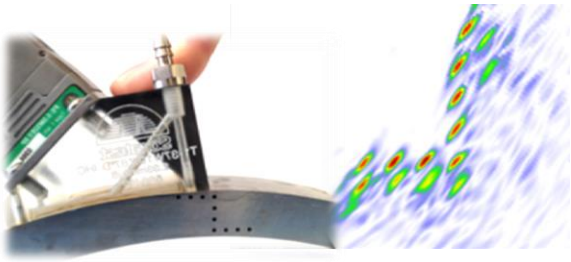
Results
Suggested Work Flow

1. Evaluate the required sensibility
2. Select the required equipment (Probe(s), Scanner, Wedge) according to scan plan

3. Do the screening inspection (recorded)

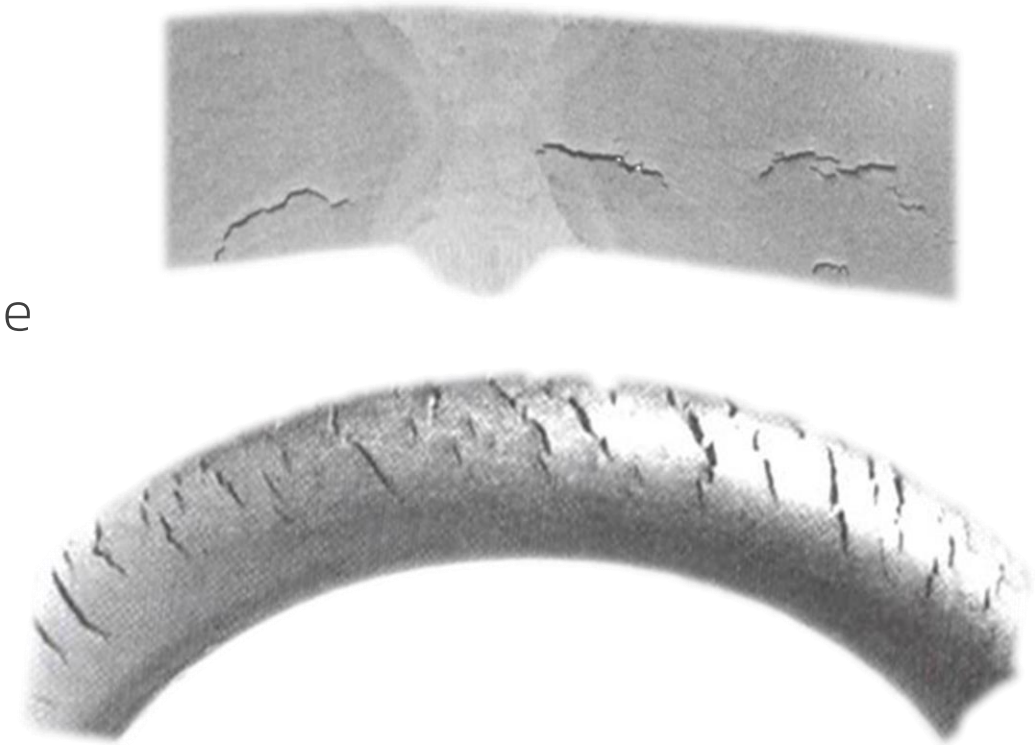
4. Localized and Characterize flaw found in previous step





Conclusion
Summary & Other Applications

- Multi oriented Phased Array inspection with PA-CSC advantages
  - Excellent sizing & characterization capability
  - Excellent SNR (good for screening)
  - Fast, traceable, reliable, adaptive & intuitive approach thanks to 3D ray tracing
- Other potential applications using the PA-CSC solution
  - Stress corrosion cracking
  - SOHIC and HIC



Conclusion – A Complete Solution

With PA-CSC option

Long Seam Weld Scanner

PA Probe
Curved Wedge

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