



Nozzle Examination Using Phased Array Ultrasonics

by Chris Chartier

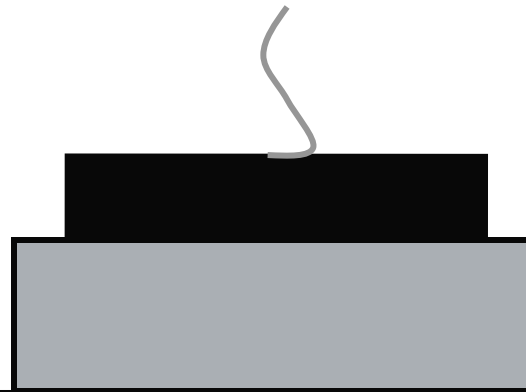
Outline

- Introduction to Phased Array, with comparison to conventional UT.
- Introduction to Phased Array and ultrasonic testing of nozzles.
- Presentation of data from recent heavy wall reactor nozzle in-service Phased Array examination.

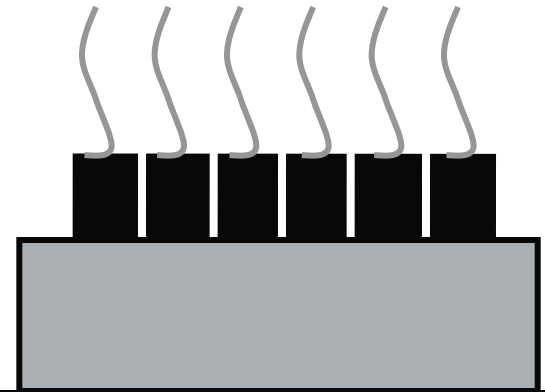


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Probe comparison



Conventional

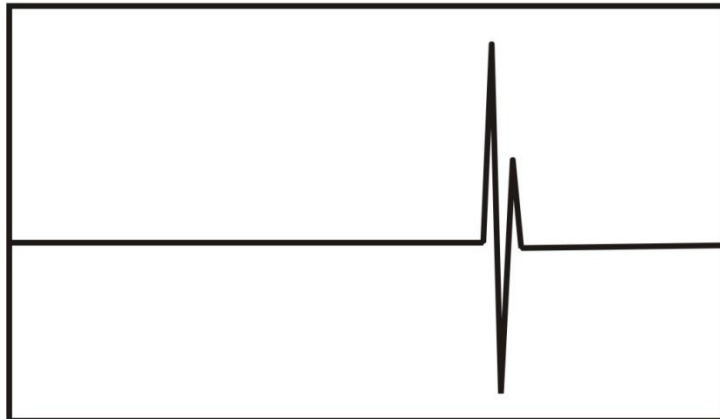
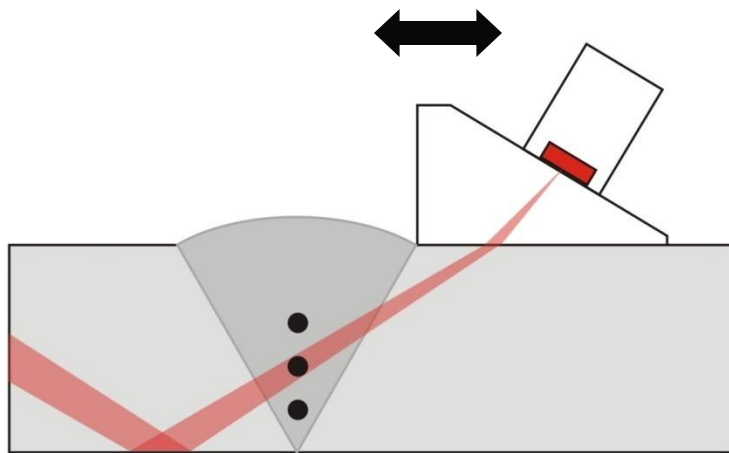


Phased Array

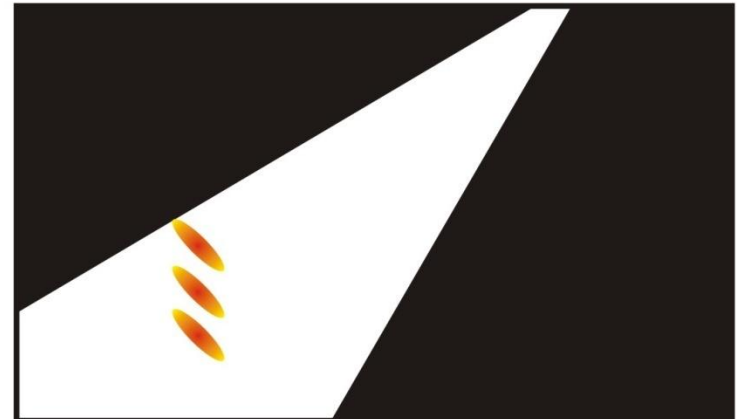
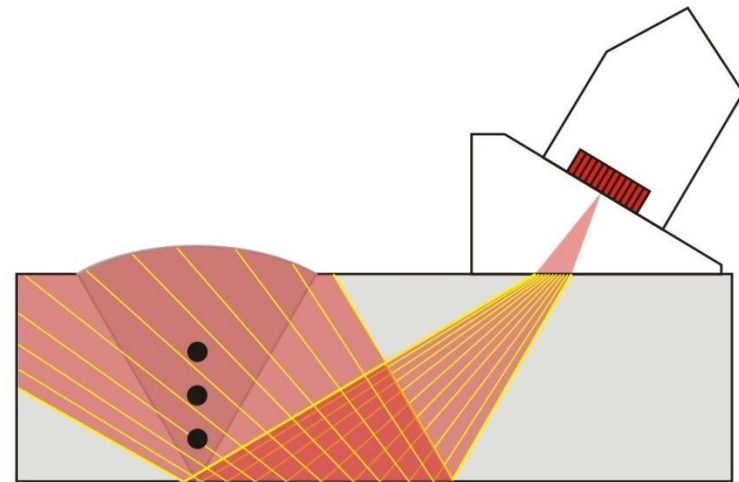


Beam and data comparison

Conventional UT

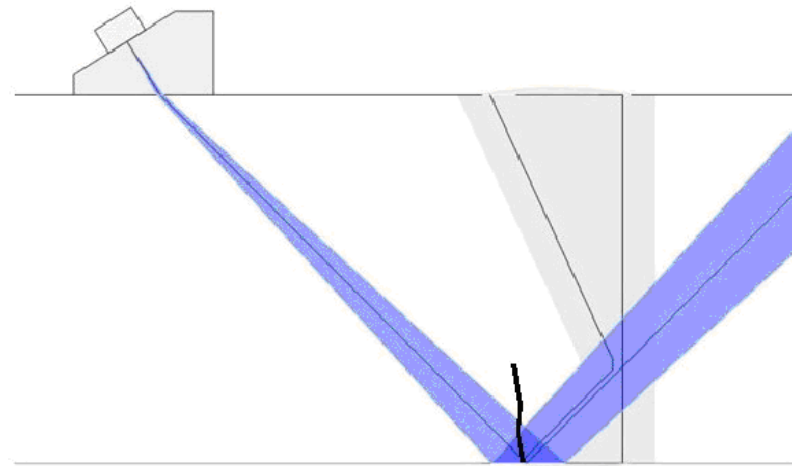


Phased Array

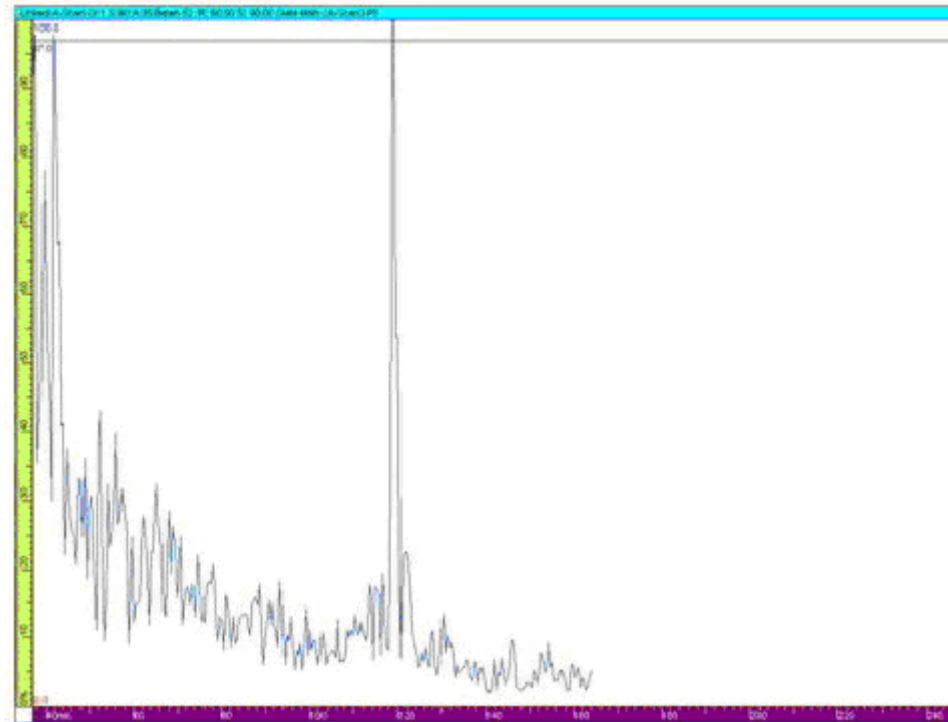


Conventional UT

Shear wave
beam from
single crystal

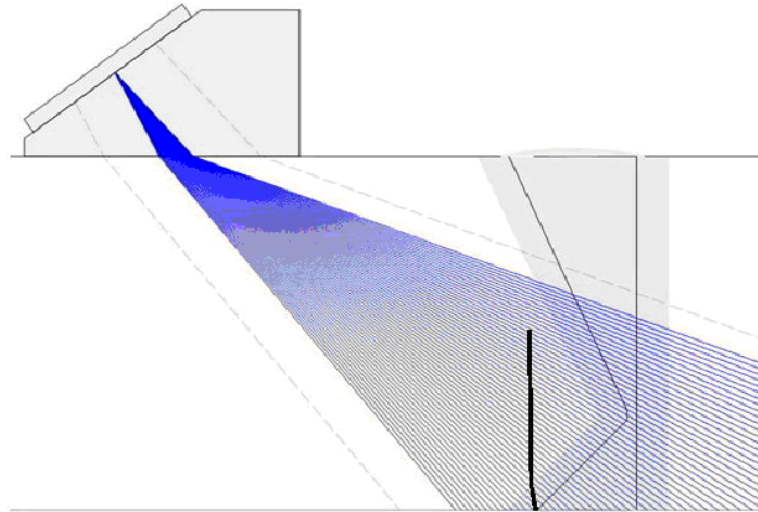


Crack
indication
(A-scan)

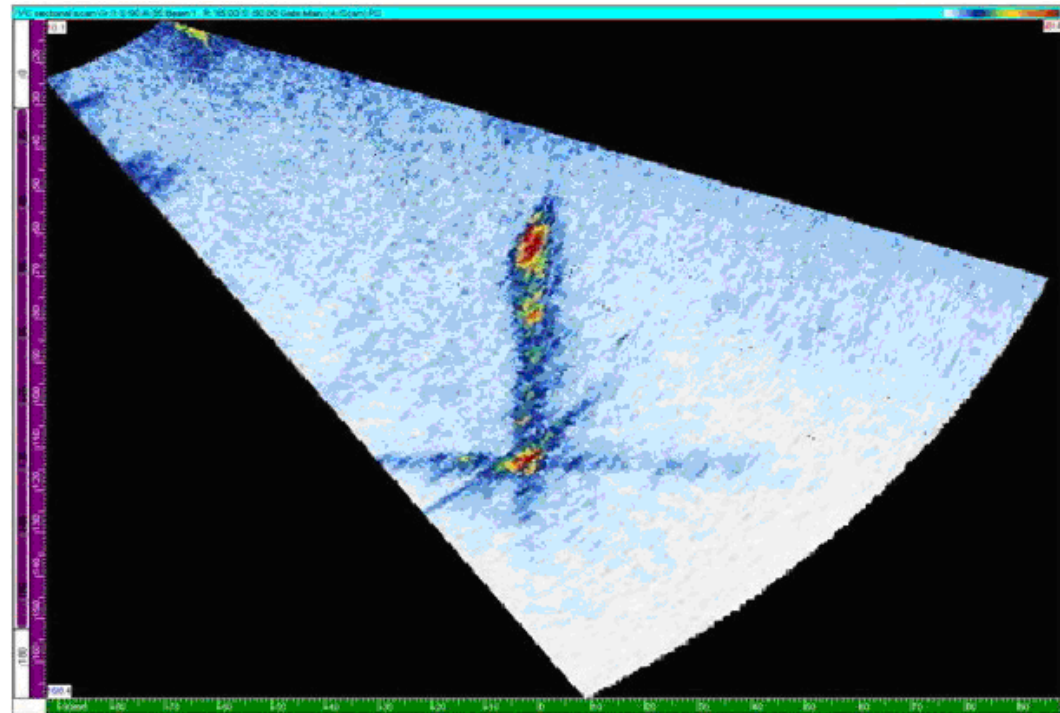


Phased Array

Multiple shear wave beams

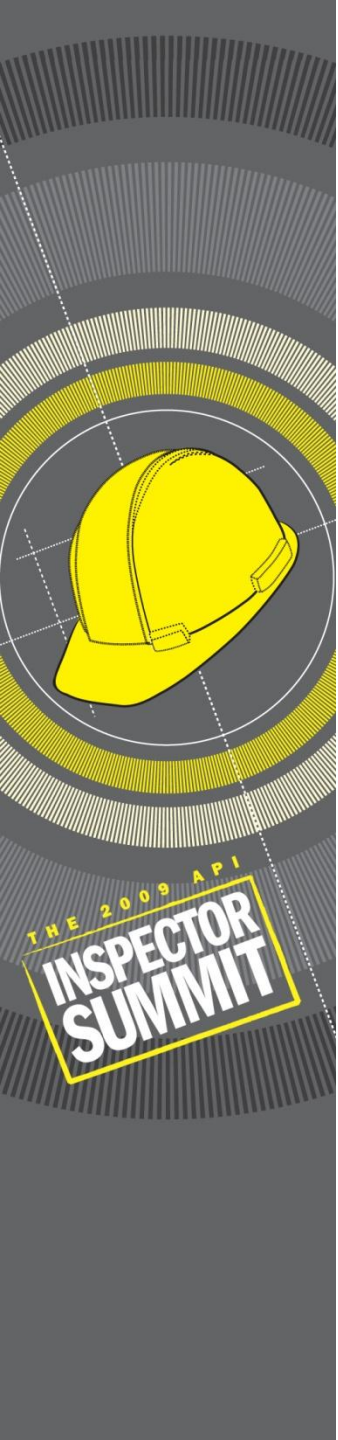


Crack indication (S-scan)



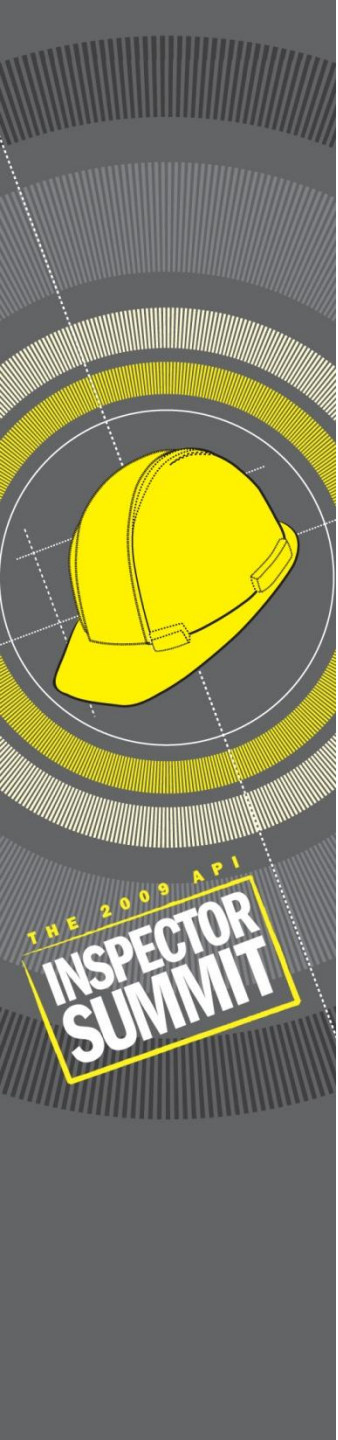
Advantages of Phased Array

- Beams can be steered and focused. Re-focus on areas of interest.
- Electronically cover a large volume from one probe position, nearly instantaneously.
- 2D representation of data allows visualization of features within test object. (Crack sizing by manual UT requires plotting by hand on paper.)

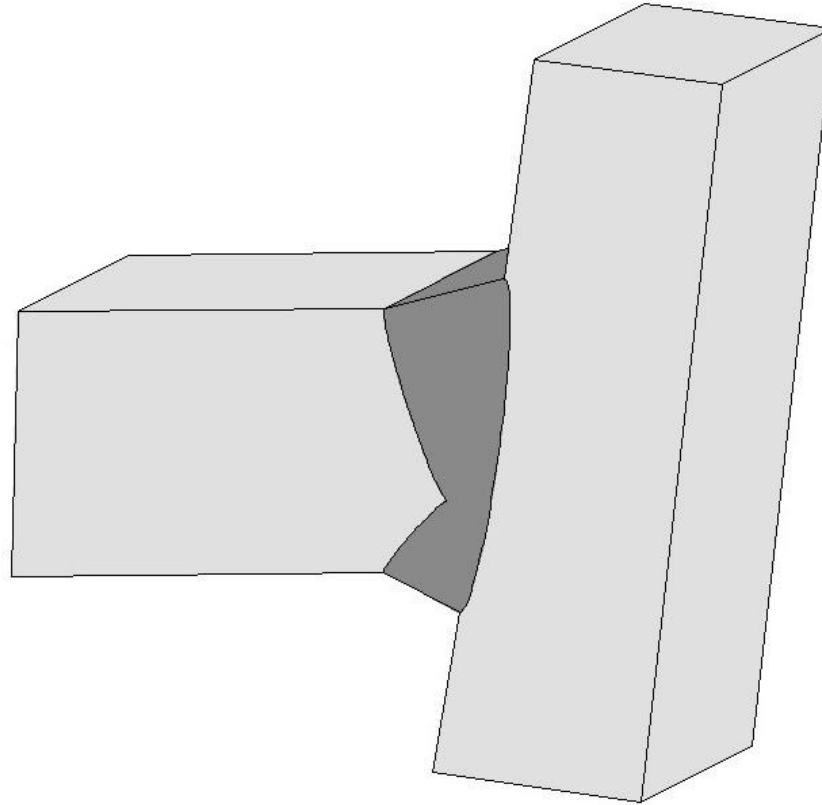


Application of Phased Array to nozzles

- Phased Array used in combination with advanced crack sizing techniques.
- Sizing accomplished by using
 - last significant tip
 - delta time-of-flight
 - time-of-flight



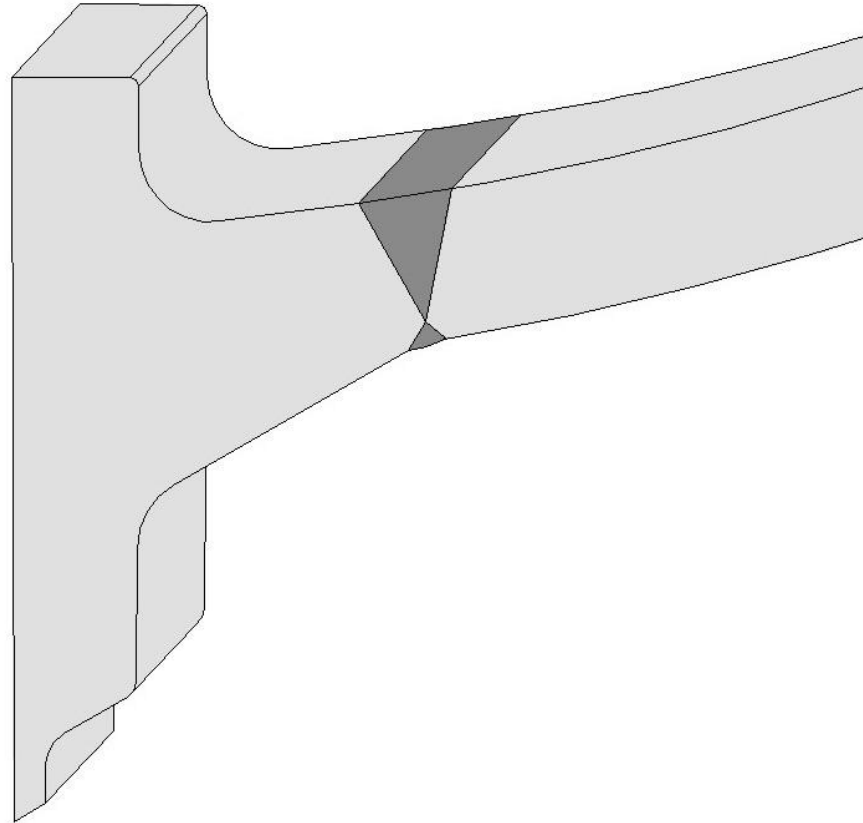
Part descriptions



Typical "Cat D" Nozzle



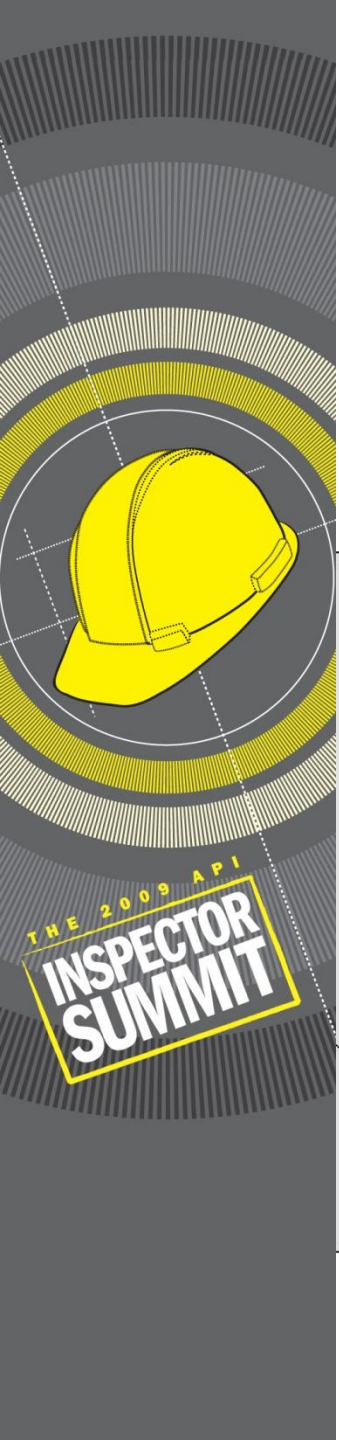
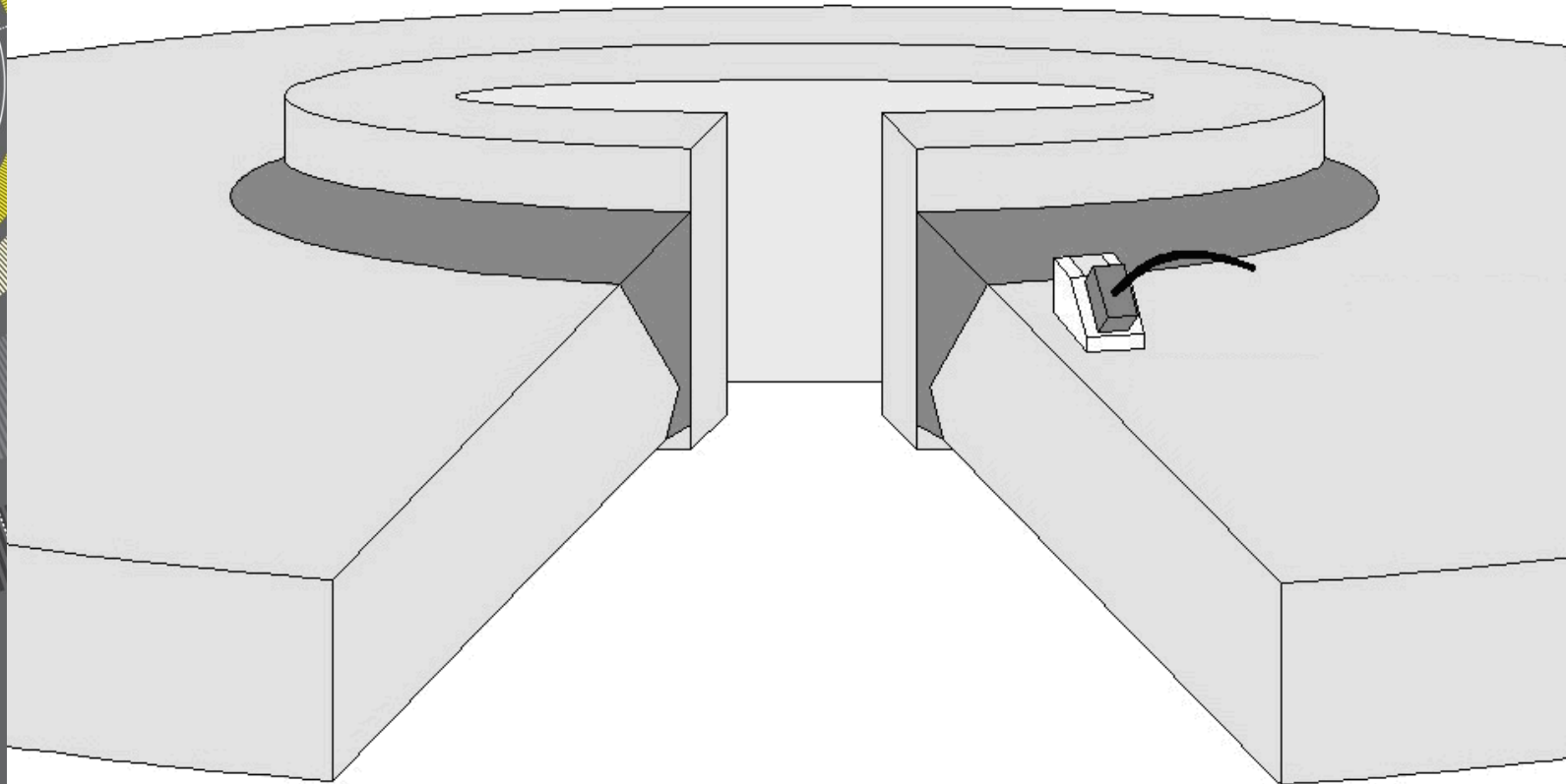
Part descriptions



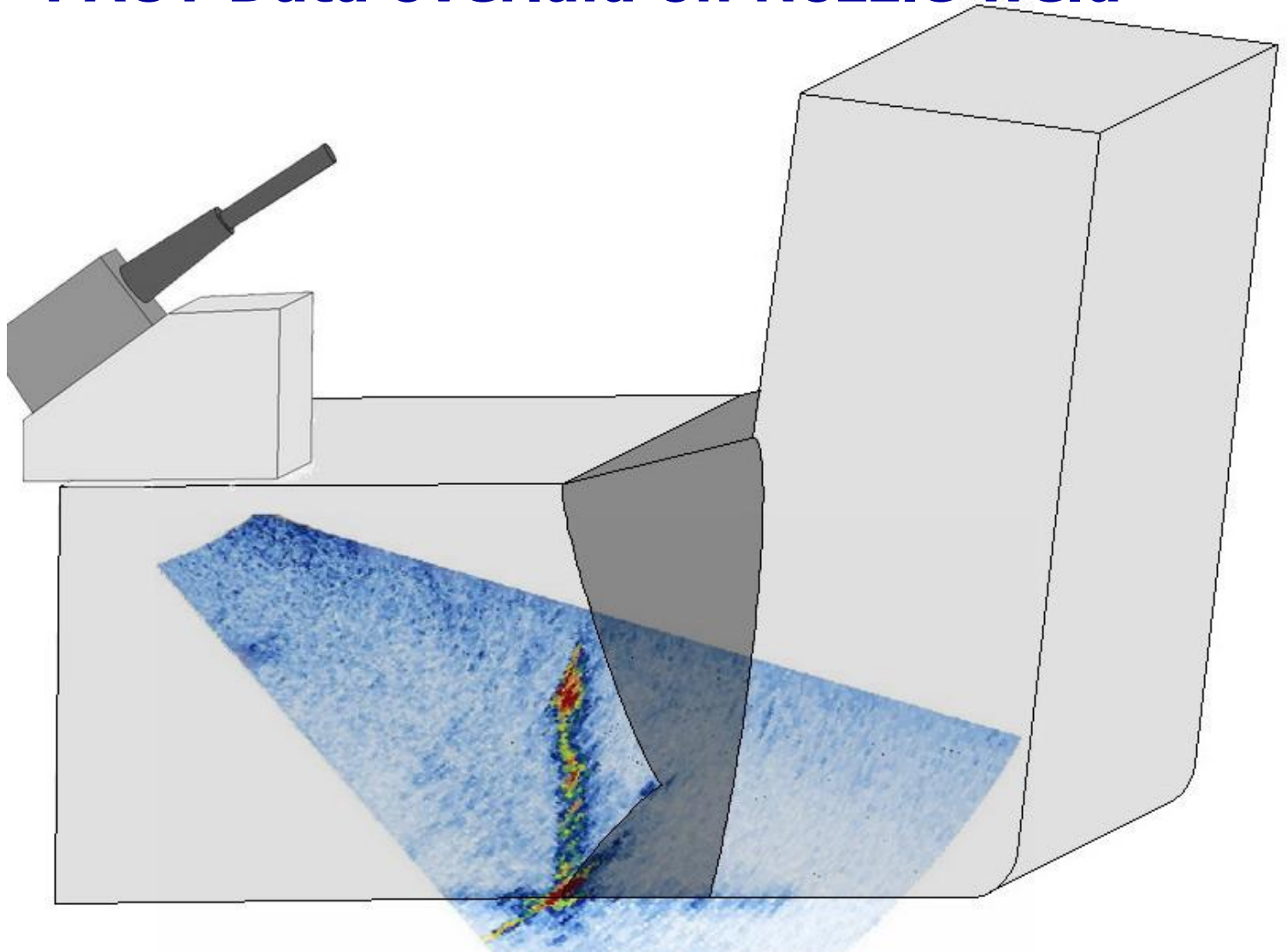
Nonparallel Complex Geometry
- Nozzle with Butt Groove Weld



PA probe placement on Cat D nozzle



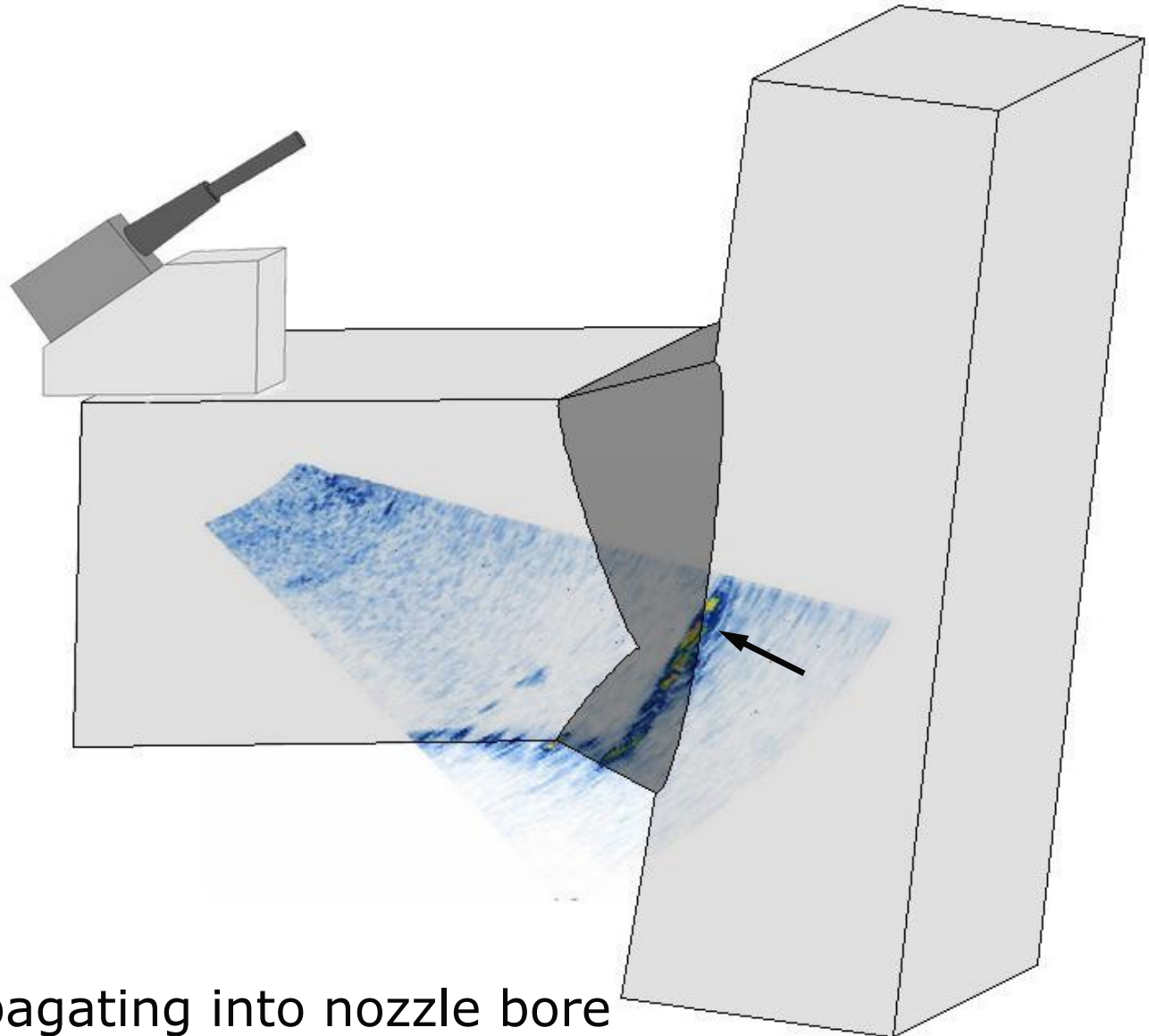
PAUT Data overlaid on Nozzle weld



Fillet weld toe crack. Direction of propagation is perpendicular, towards head.



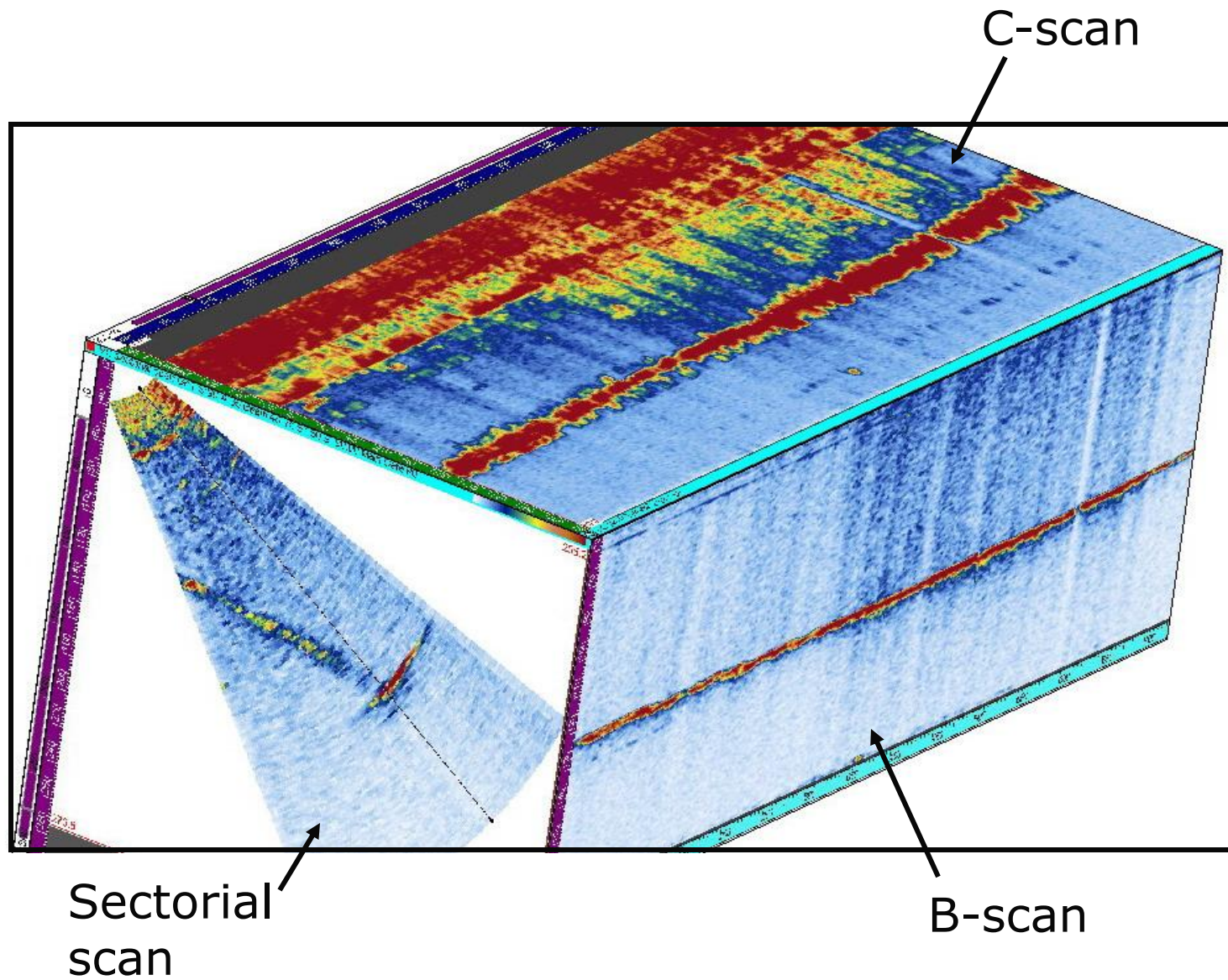
PAUT Data overlaid on Nozzle weld



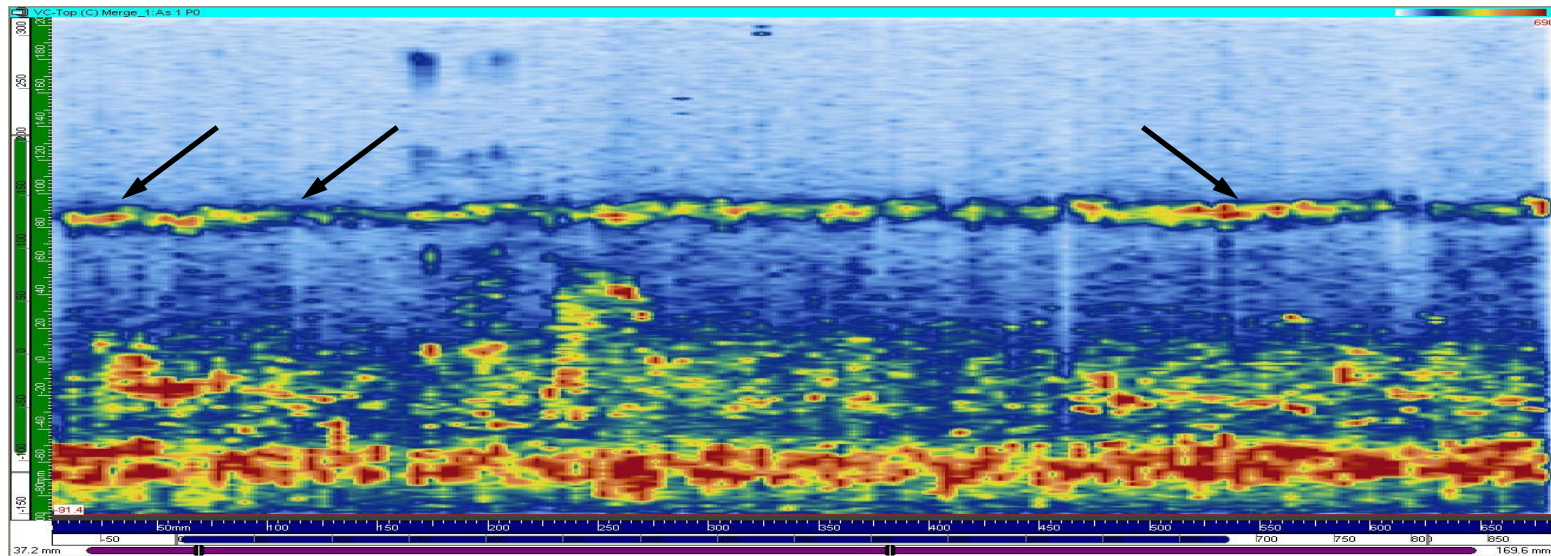
Propagating into nozzle bore



Phased Array views



C-Scan (top view) of bottom nozzle radius scan



Intermittent shallow cracking around the circumference.

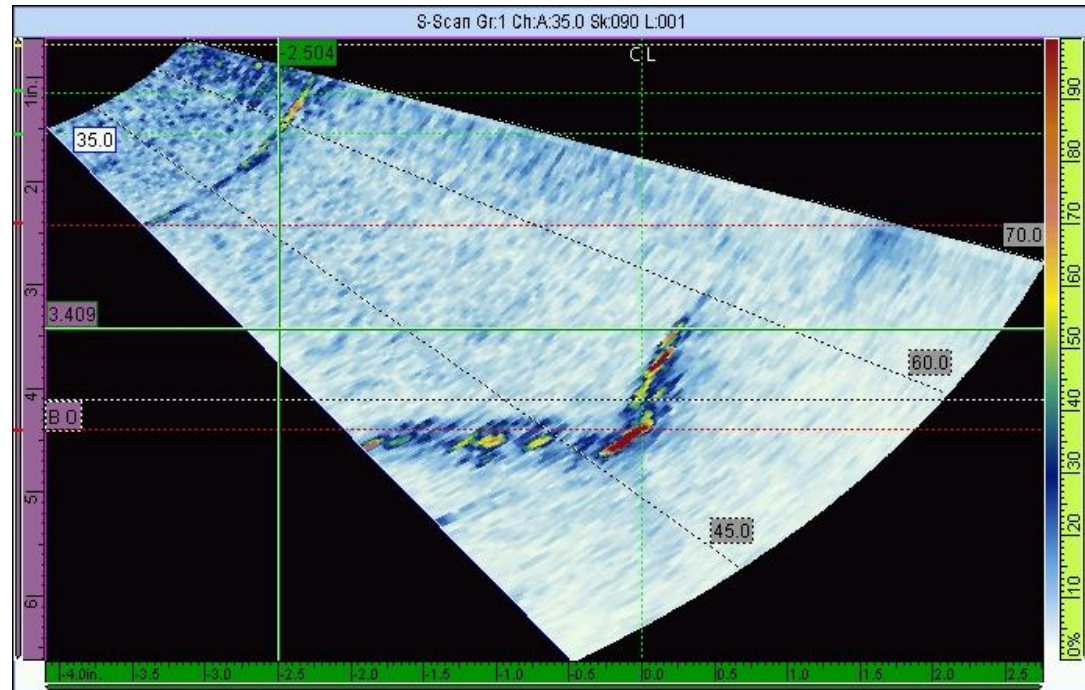
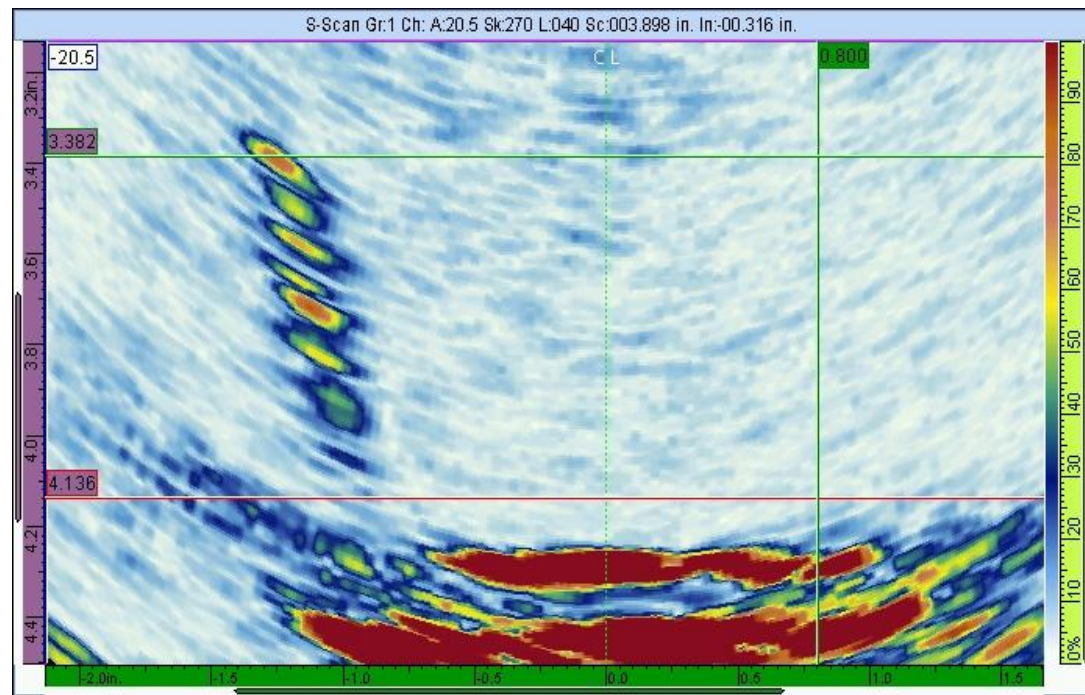


Images of Cracks in Cat D nozzles

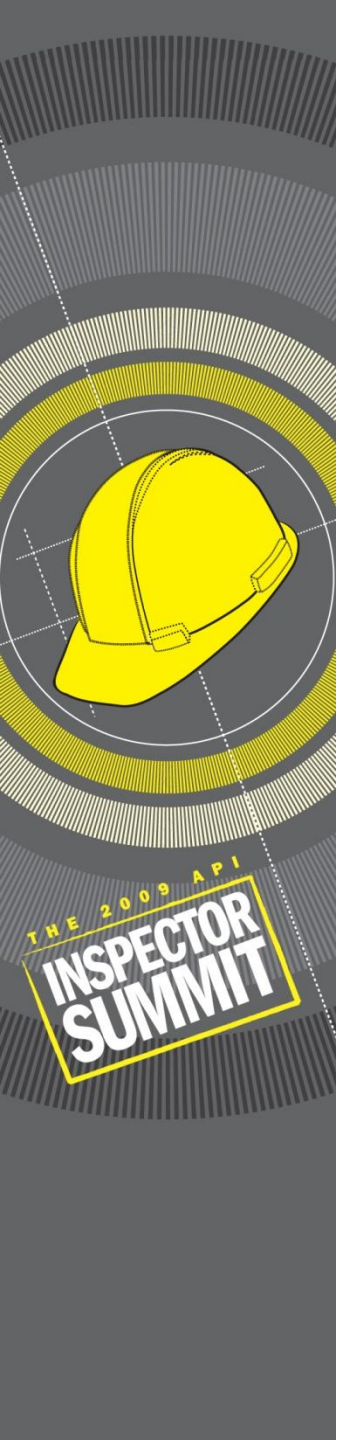
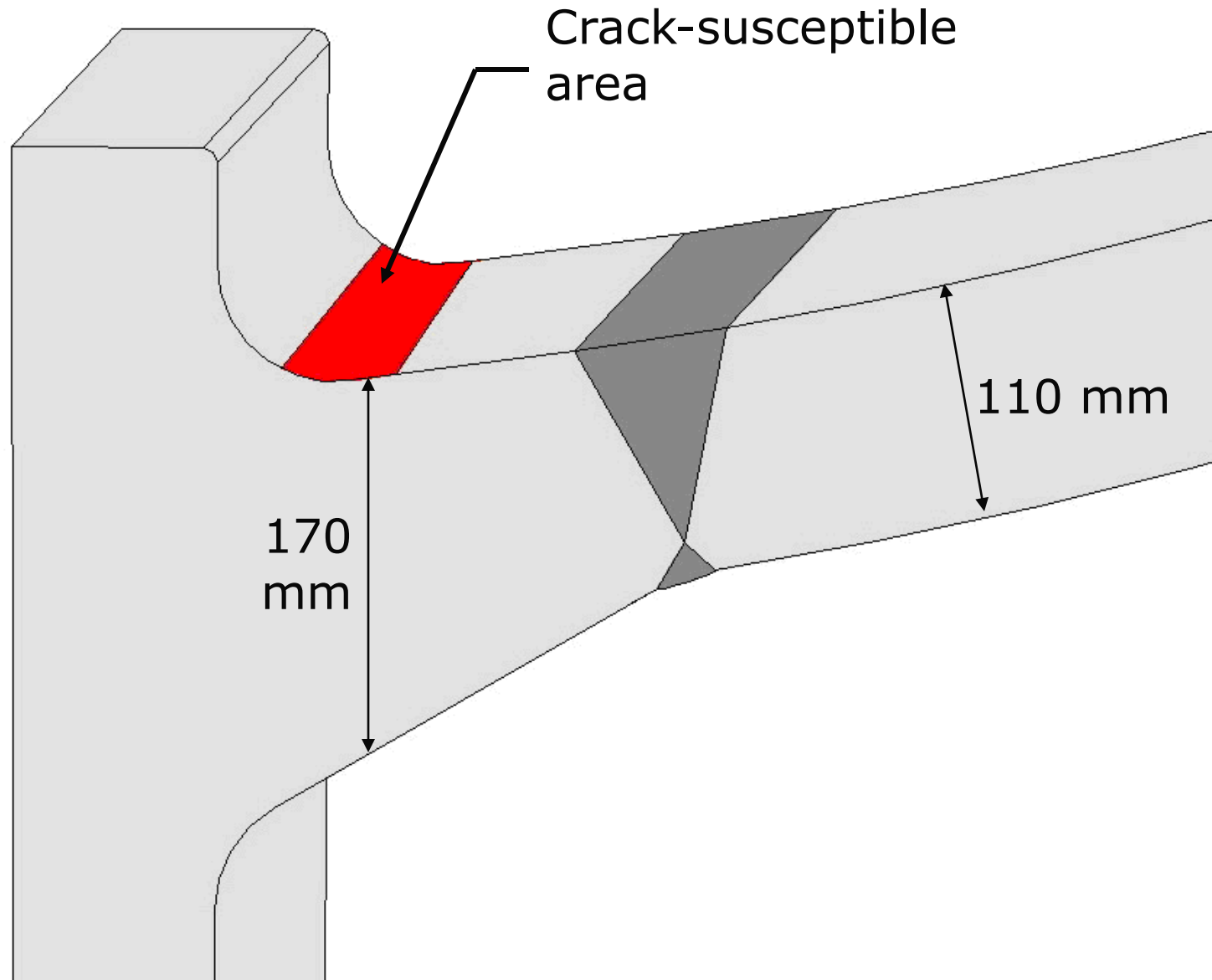
Visible:

- crack facets
- tip signals
- orientation

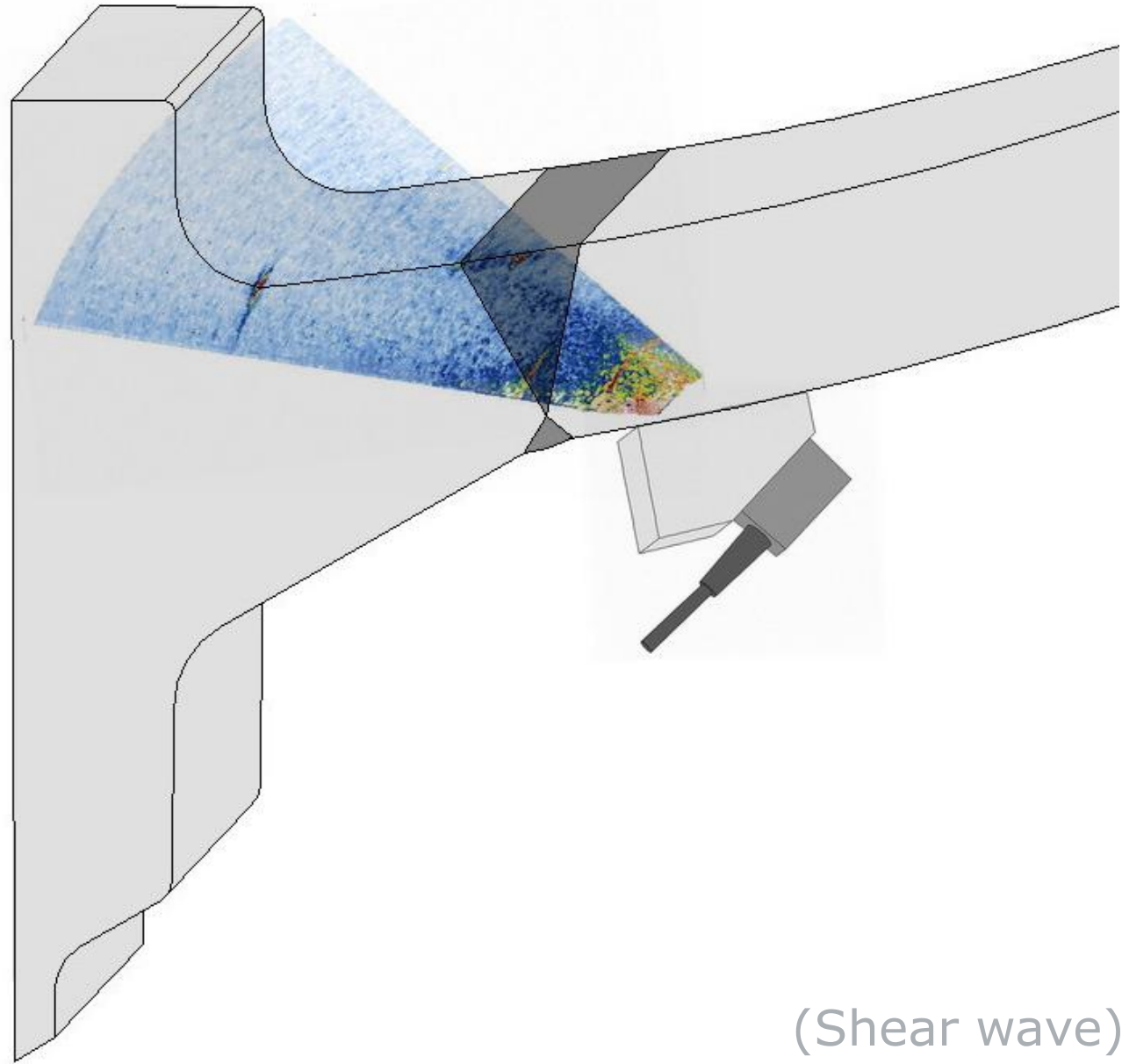
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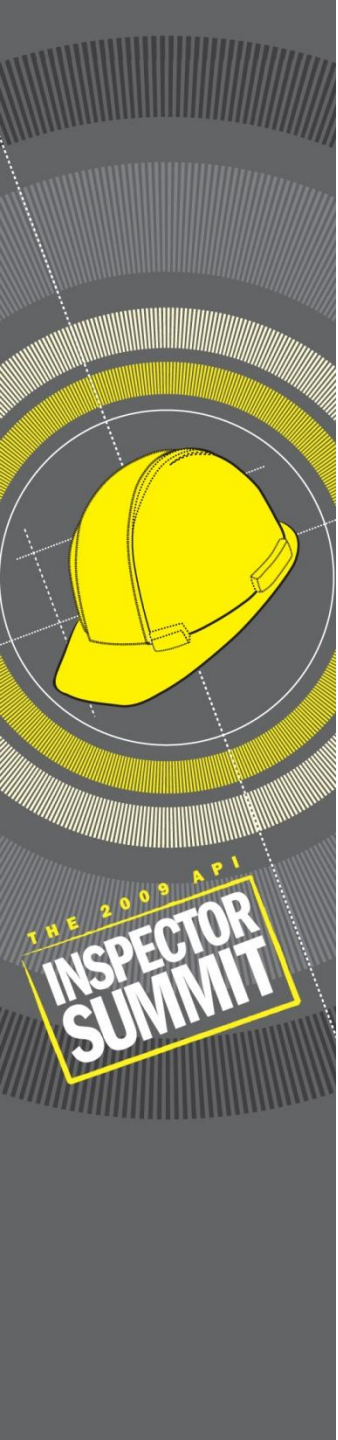
Examination focused on high-stress area



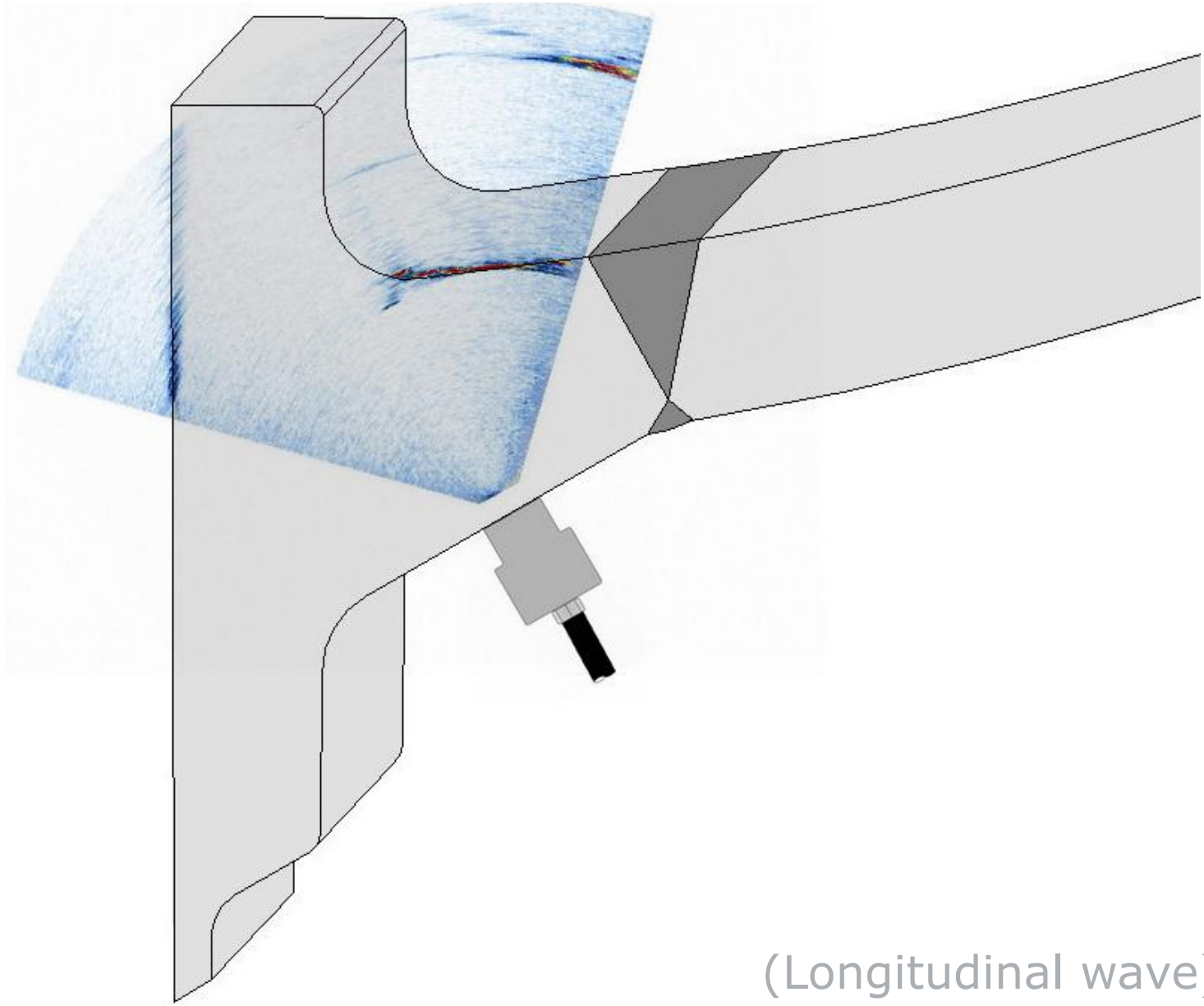
ID Connected crack on complex geometry



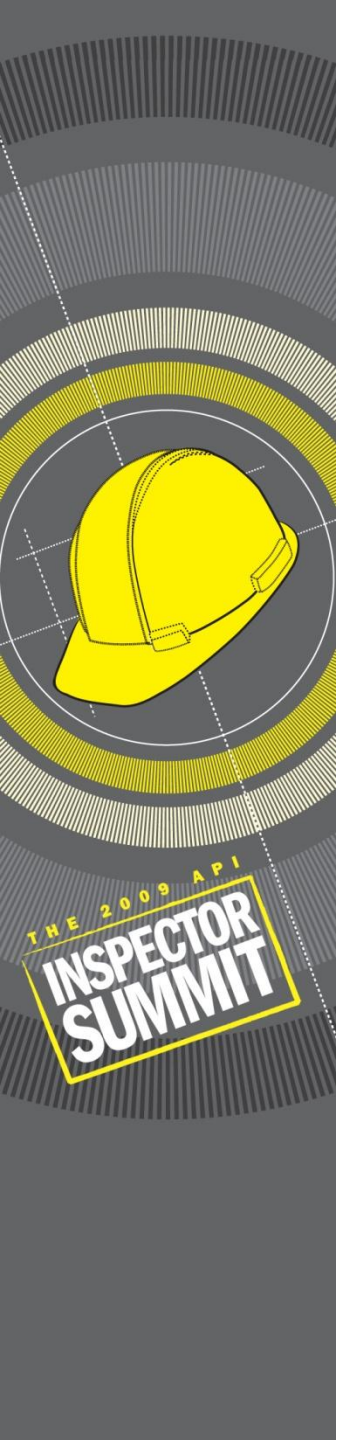
(Shear wave)



ID Connected crack on complex geometry

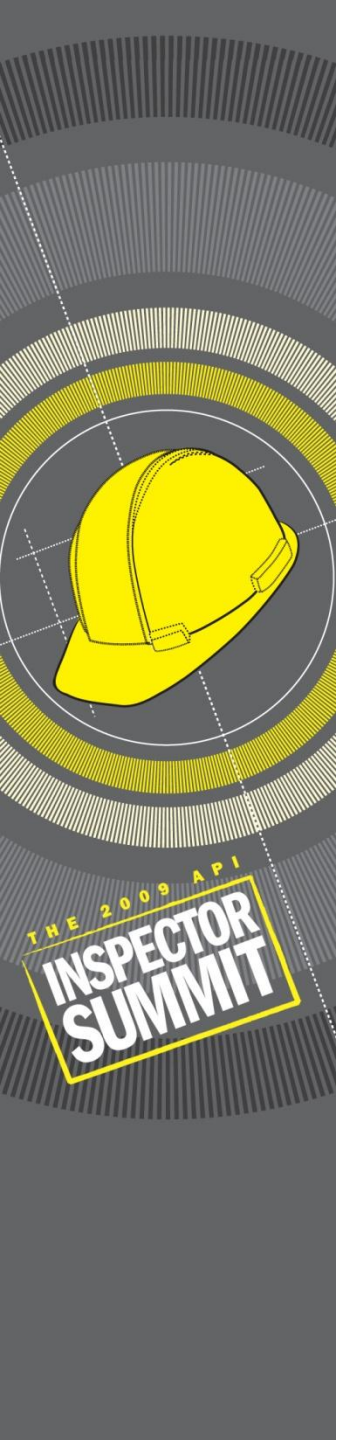


(Longitudinal wave)



Conclusions

- For nozzle application, Phased Array approximately one half scanning time of conventional UT.
- Data is stored for trending, reporting, peer review and comparison purposes.
- Focal laws can be changed for each situation, thus optimizing tip signals and depth measurements.
- 2D imaging shows the crack face, tip and direction of propagation — all valuable information for engineering critical analysis.





Questions ???



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