Phased-Array Techniques for Inspection of Repair Welds

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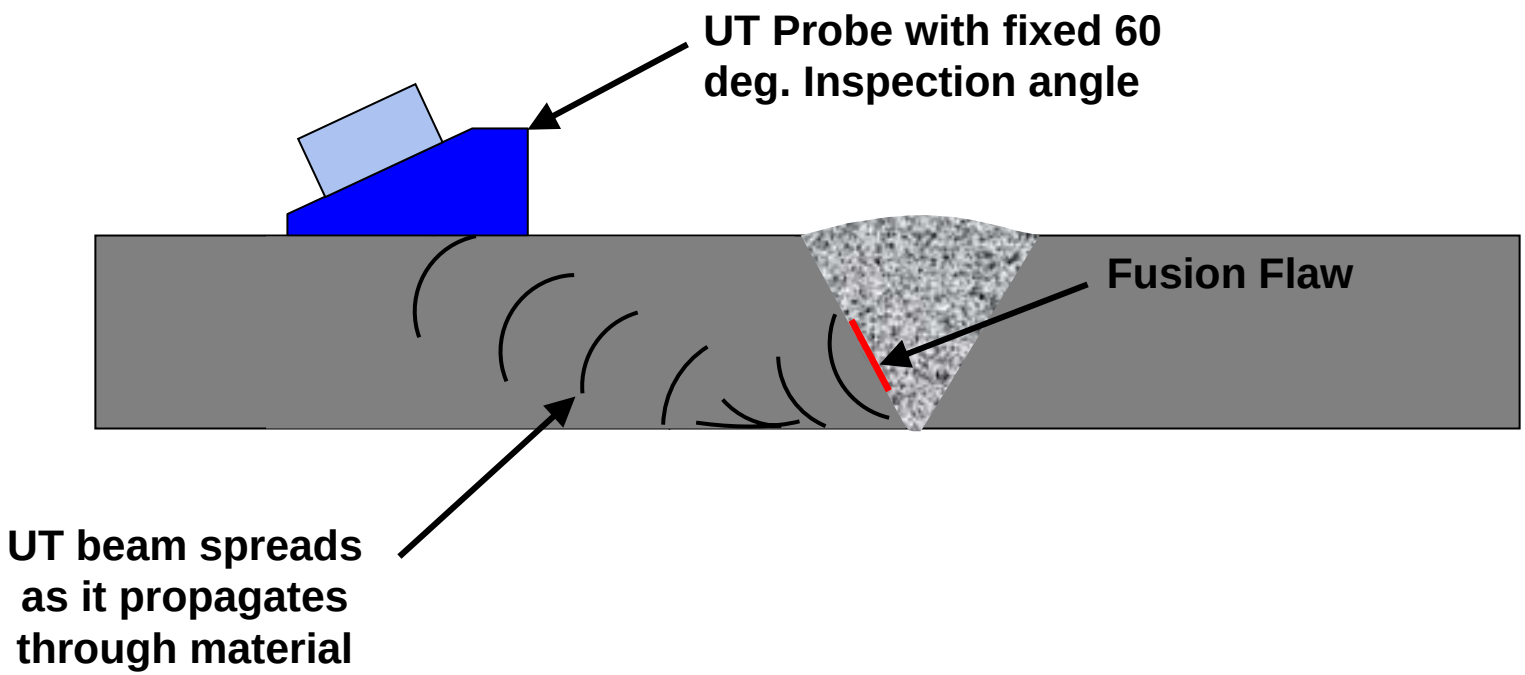
THE MATERIALS JOINING EXPERTS

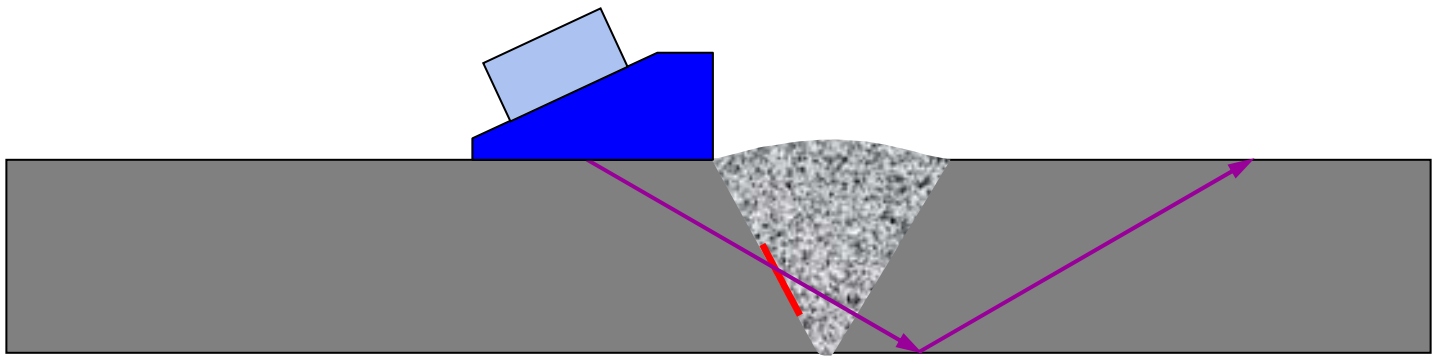
Overview

- Ultrasonic Testing (UT) of welds
- Challenges faced when performing UT of repair welds
- Basics of Phased-Array (PA) UT
- Use of UT modeling and simulation tools for inspection technique development
- Application of PA UT to sleeve repairs and hot tap welds
- Discussion and questions

Conventional UT Weld Inspection

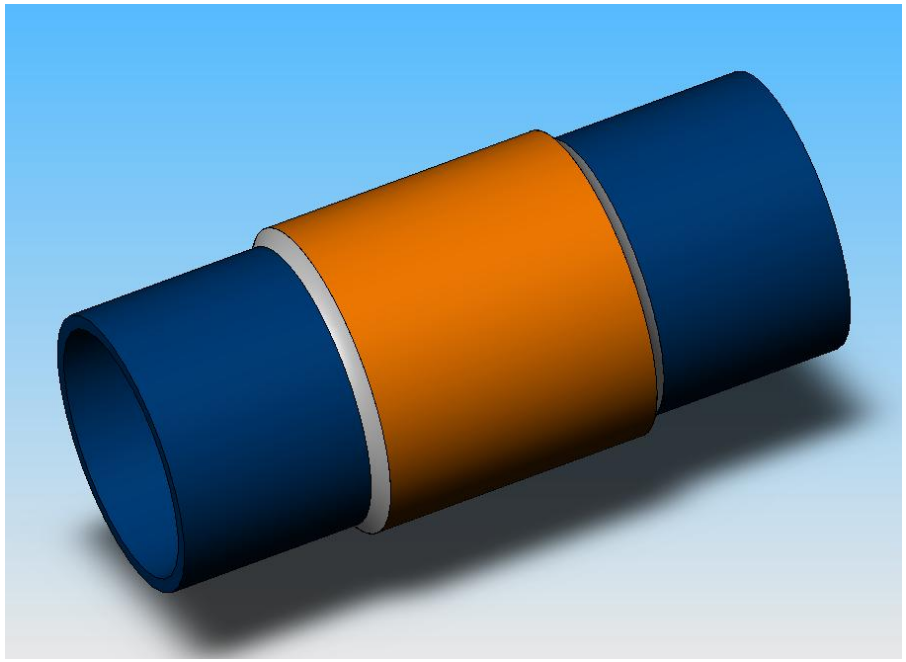


Conventional UT Weld Inspection Scan

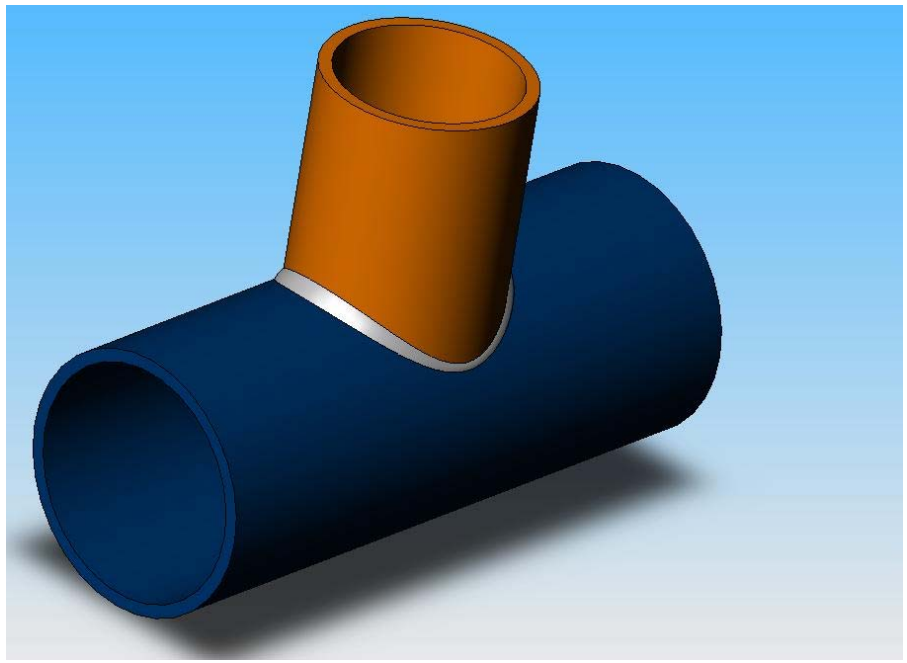


Mechanical movement of probe provides good coverage of weld

Examples of In-Service Repair Welds



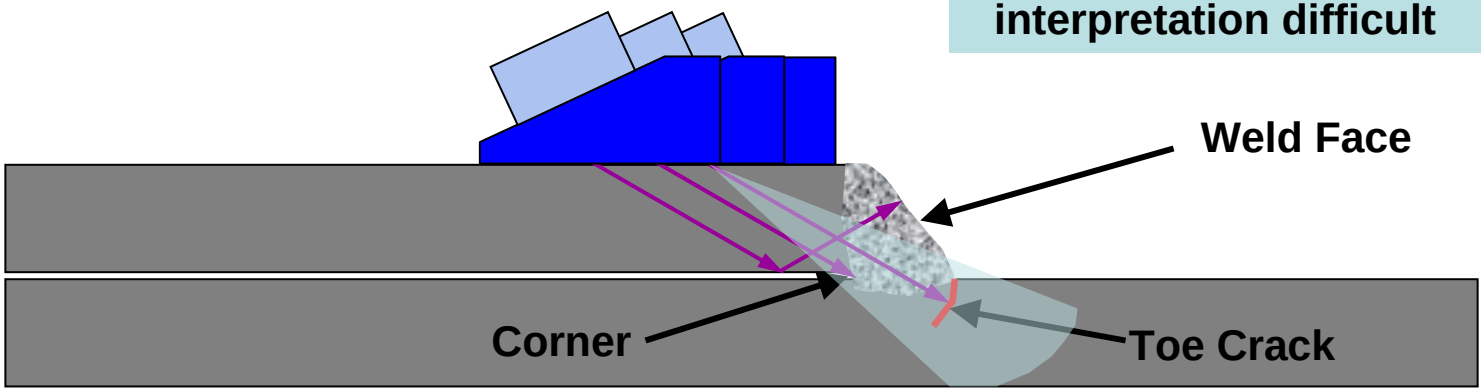
Sleeve Repair

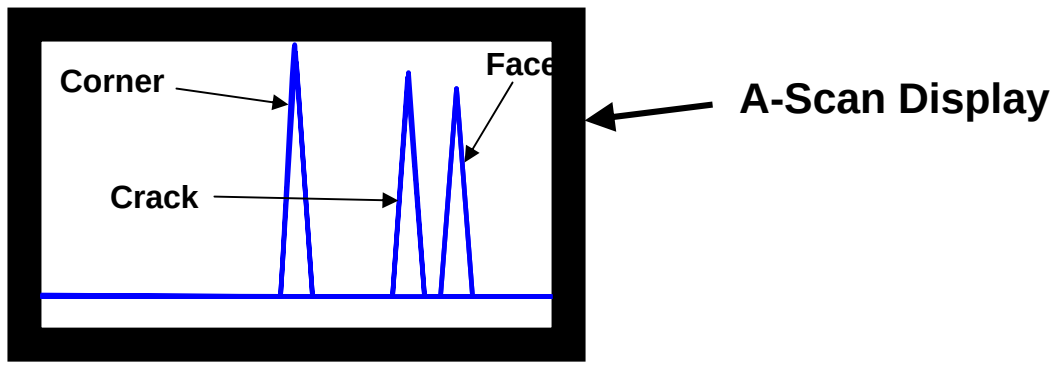


Hot Tap Branch Connection

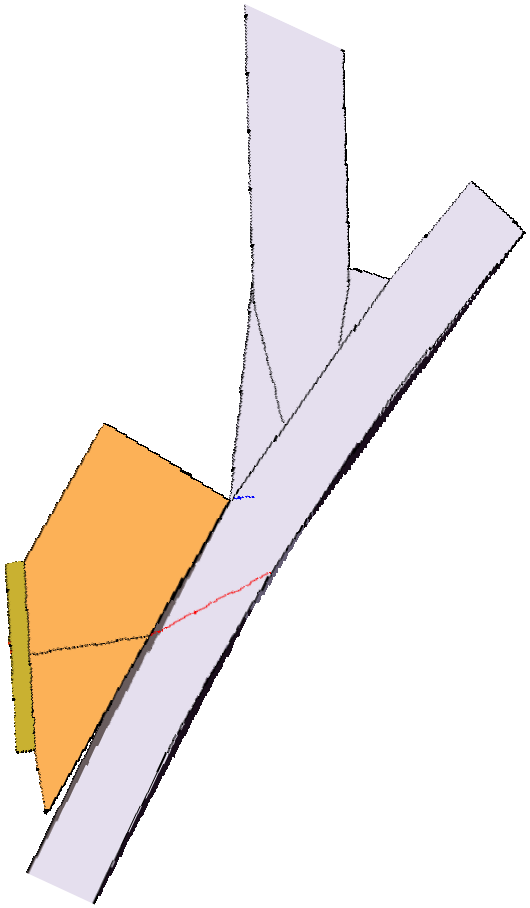
UT Inspection of Sleeve Repair Weld from Sleeve

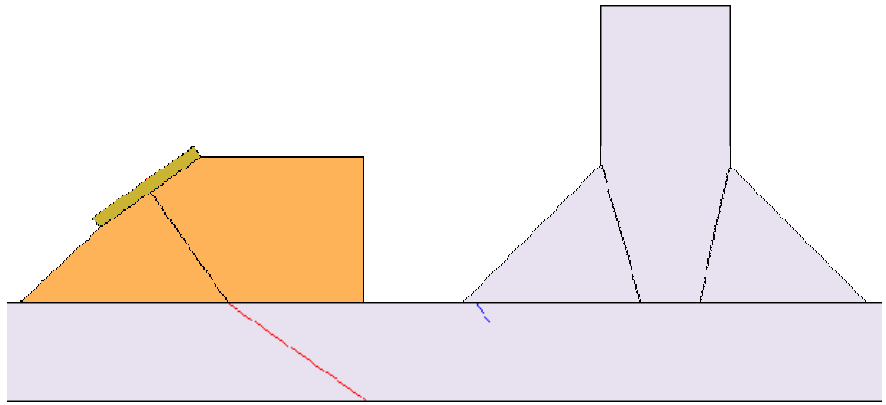
UT beam reflects from face of weld, corner, and crack making interpretation difficult

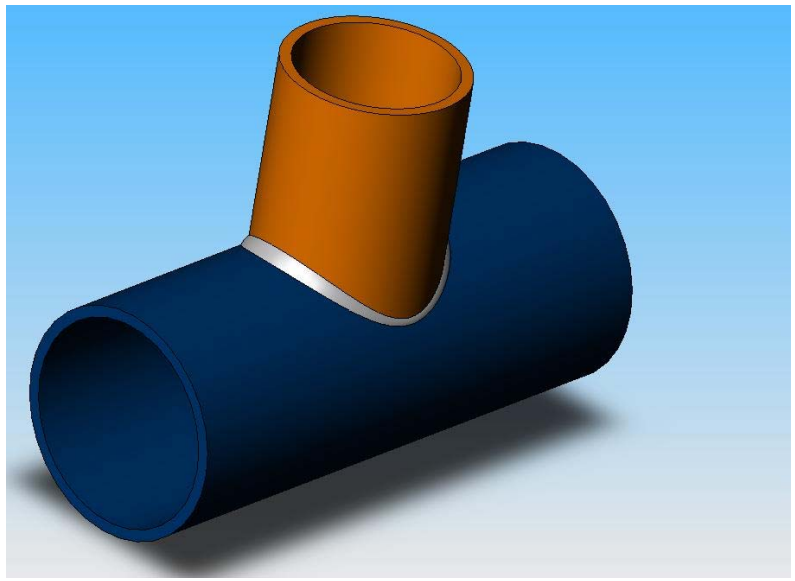




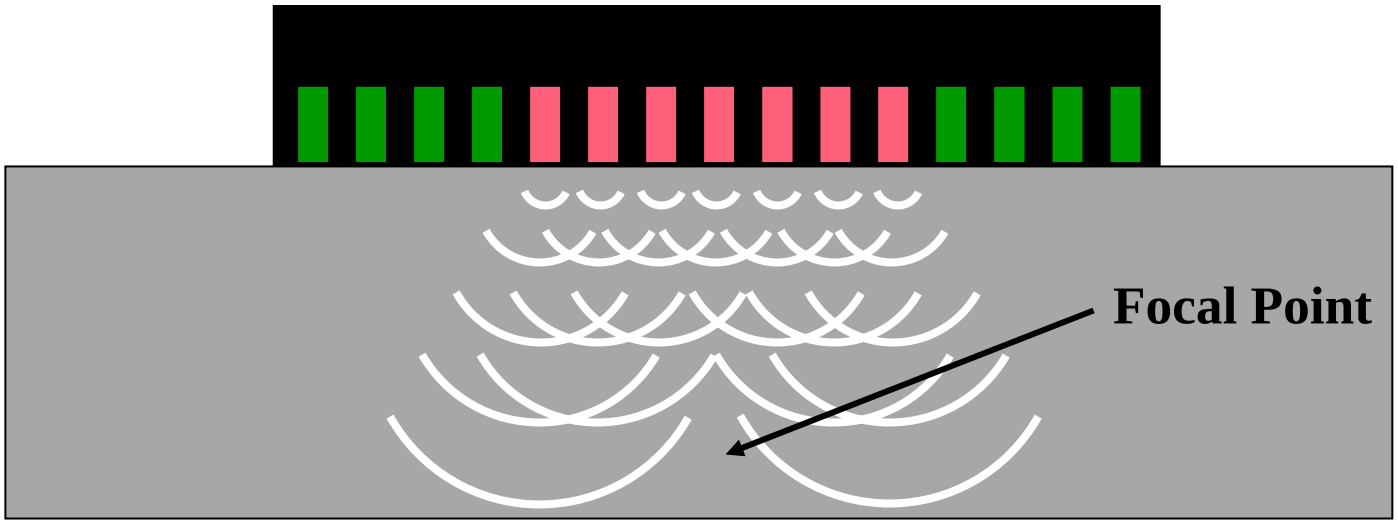
Branch Connection Scan Geometries





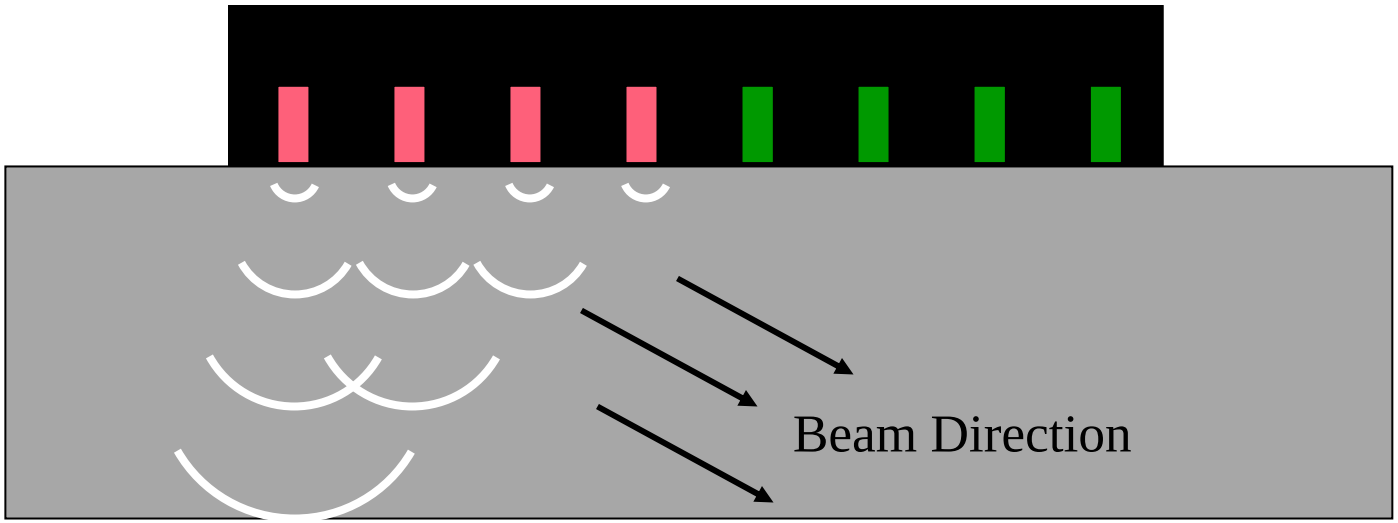


Phased-Array – Beam Focusing



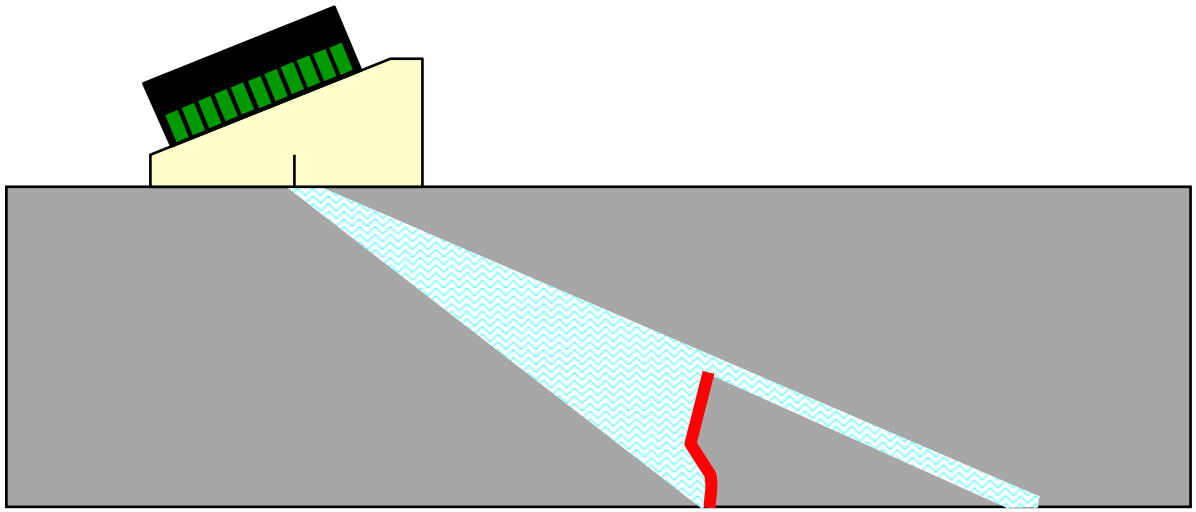
- ***<u>Electronic Beam Focusing</u>*** **can be accomplished by delaying the pulsing of elements in a symmetrical combination**

Phased-Array – Beam Steering

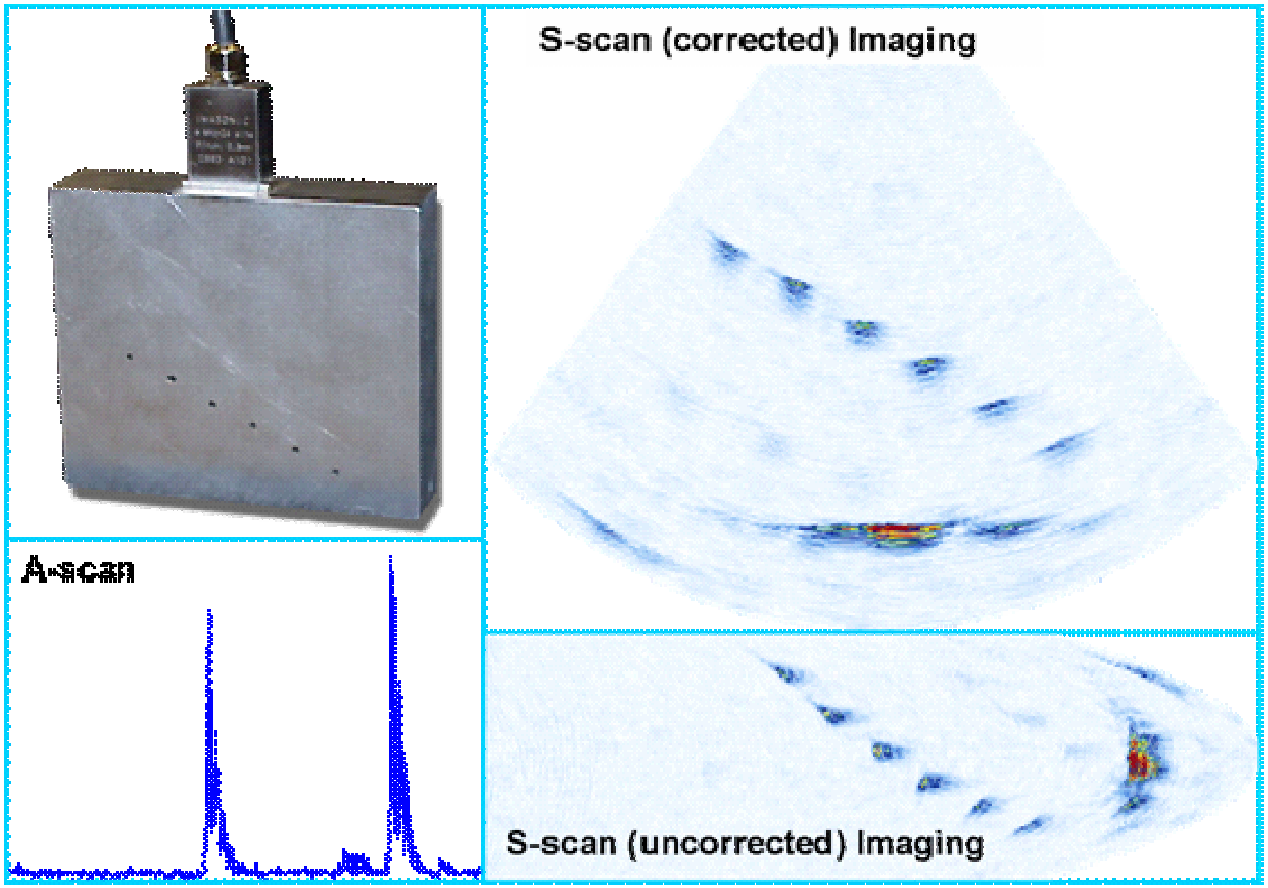


- ***<u>Electronic Beam Steering</u>*** **can be accomplished by delaying the pulsing of each element in a sequentially increasing rate**

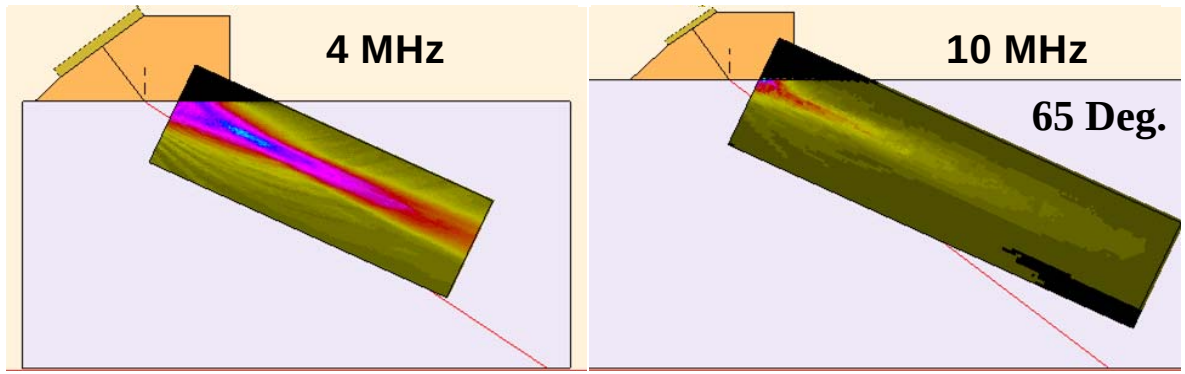
Angle Sweep

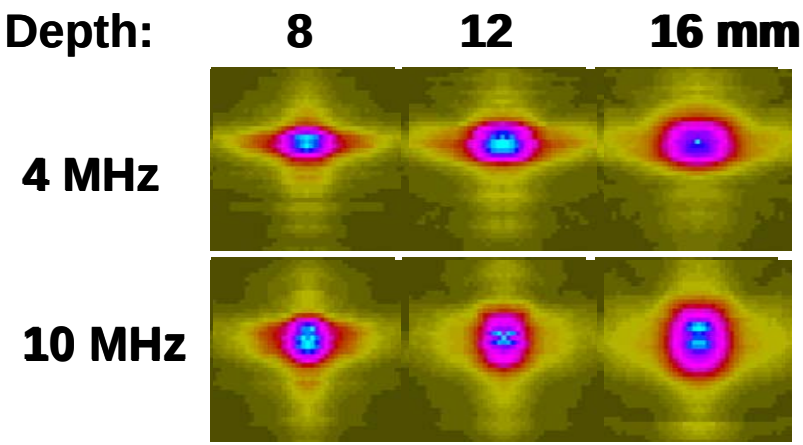


PA Sector Scan Imaging



Modeling and Simulation for Optimization

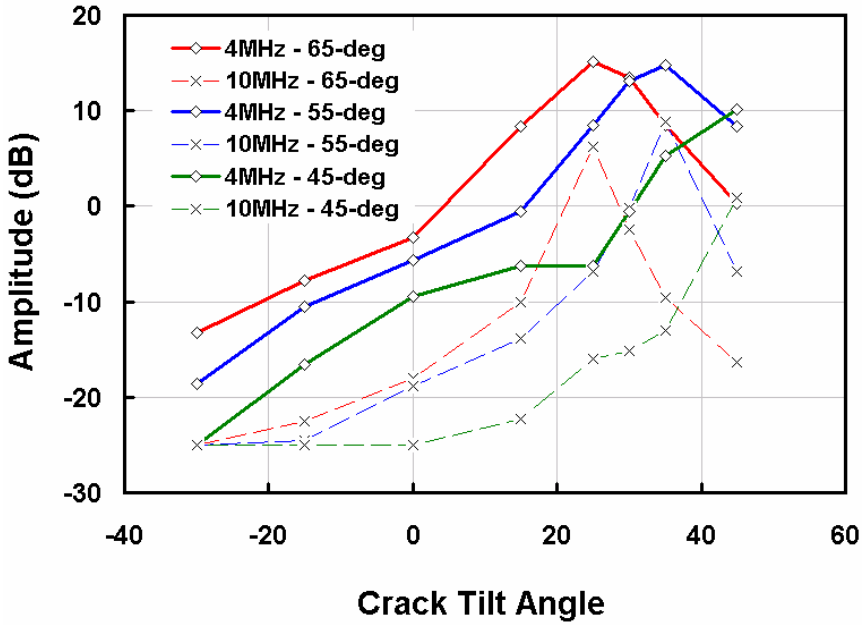


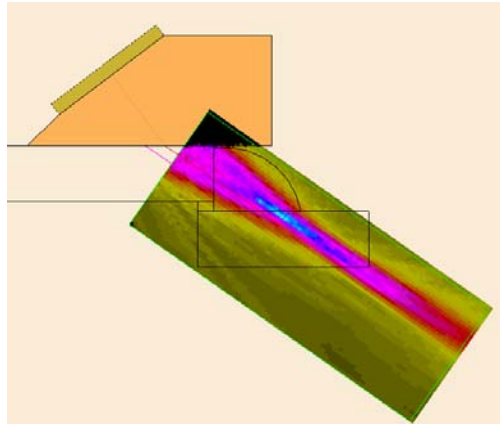


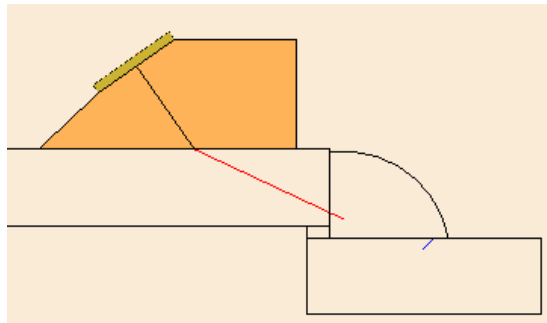
Simulation of Inspection from Sleeve

Notes:

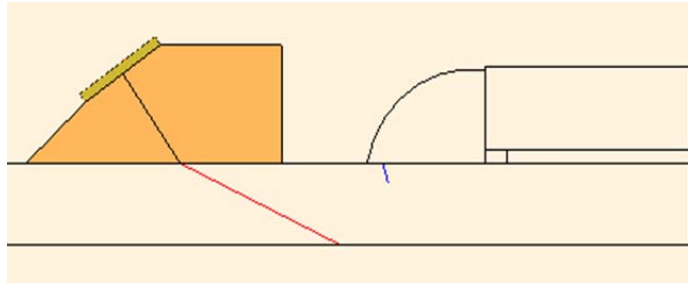
- 45 degrees cannot quite reach peak signal before sliding off edge of sleeve
- This measurement may not work, depending on the geometry and structure of the weld

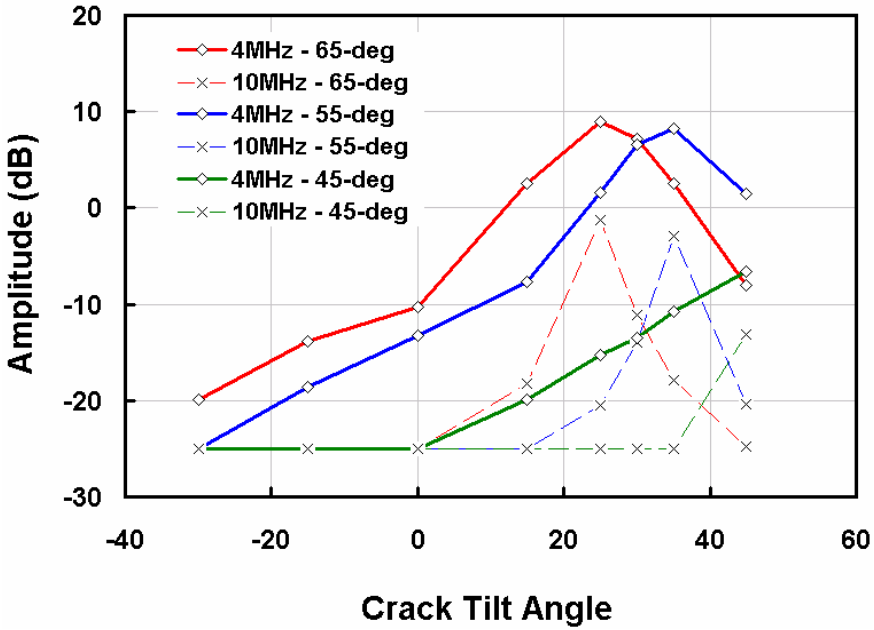






Simulation of Inspection from Pipe

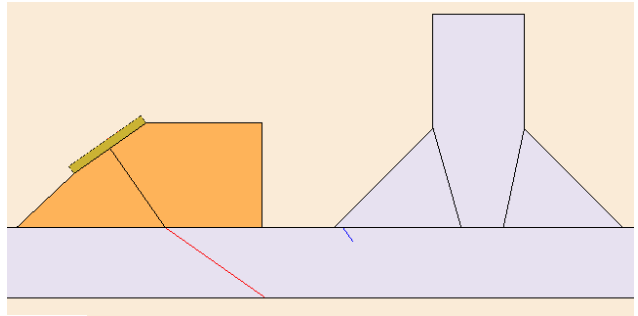


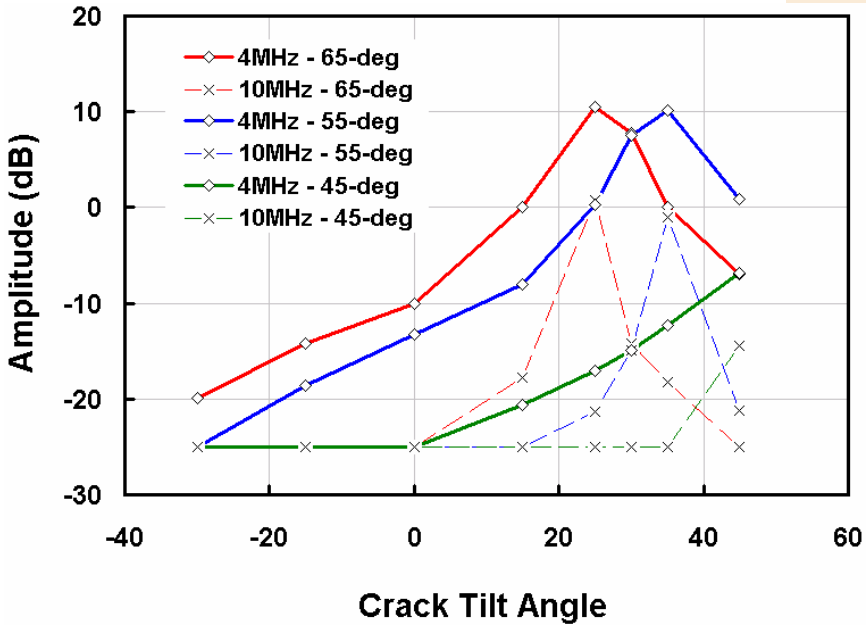


Notes:

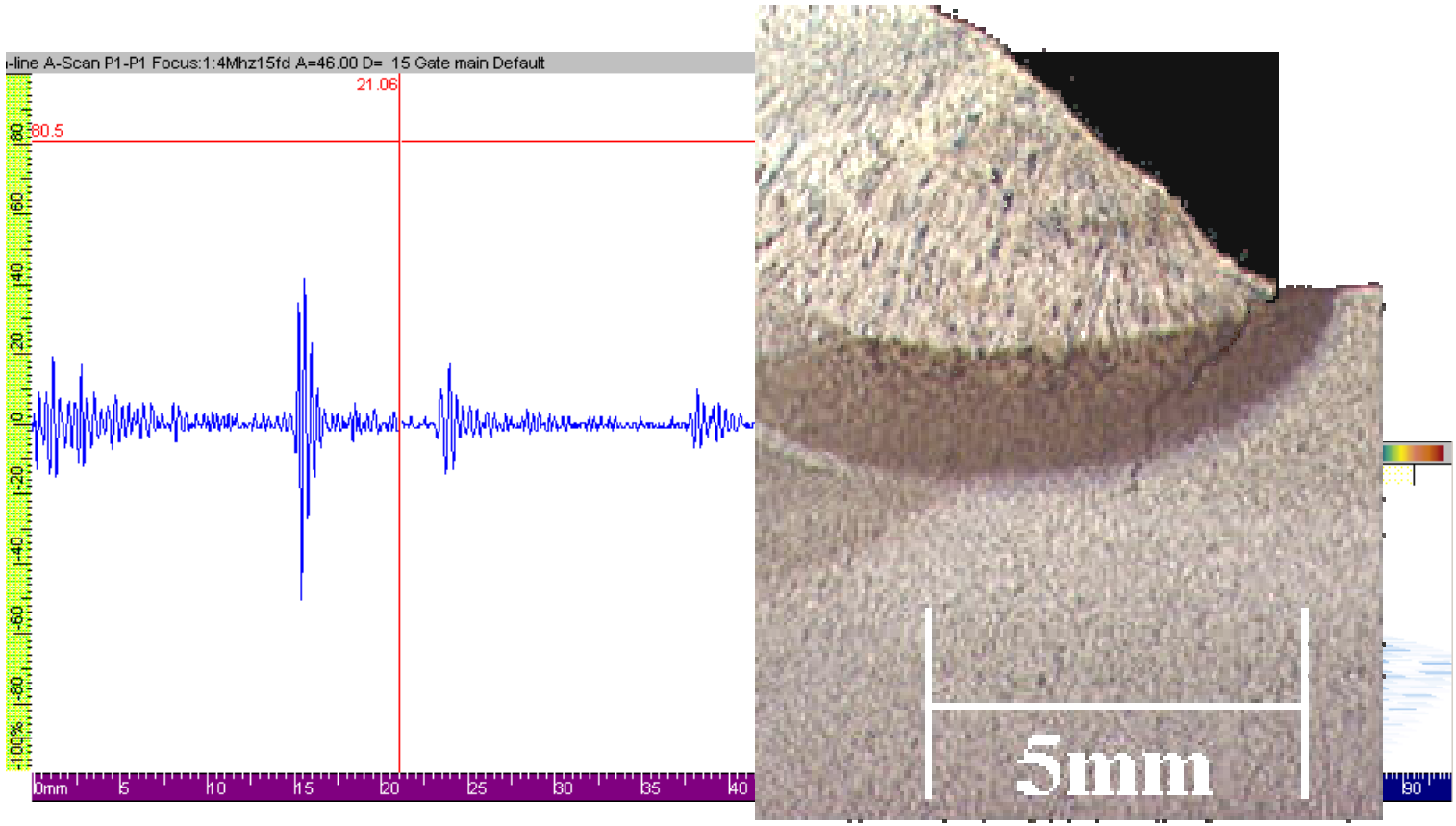
- Peak of 45 degrees cannot reach flaw due to geometry

Simulation of Toe Crack in Branch Connection





Detection of Toe Crack in Branch Connection



Flaw Height Measurements

Mock-up	Flaw #	Flaw Tilt (degrees)	Height					
			Measured		Actual		Error	
			in	mm	in	mm	in	mm
Hot Tap	H1	0	0.119	3.0	0.198	5.0	-0.079	-2.0
	H2	38	0.039	1.0	0.135	3.4	-0.096	-2.4
	H3	38	0.069	1.8	0.114	2.9	-0.045	-1.1
	H4	25	0.111	2.8	0.084	2.1	0.027	0.7
	H5	31	0.078	2.0	0.054	1.4	0.024	0.6
Sleeve	S1	35	0.102	2.6	0.076	1.9	0.026	0.7
	S2	20	0.231	5.9	0.204	5.2	0.027	0.7
	S3	27	0.085	2.2	0.109	2.8	-0.024	-0.6
	S4	18	0.072	1.8	0.074	1.9	-0.002	-0.1
	S5 (toe)	73	0.063	1.6	0.046	1.2	0.017	0.4
	S5 (root)	13	---	---	0.190	4.8	---	---
	S6	30	0.114	2.9	0.052	1.3	0.062	1.6

Flaws were generally undersized due to the probe contacting the weld before the full extent of the flaw could be measured. This could be improved by the use of smaller probes or wedges.

Conclusions

- The 4-MHz PA probe was superior to the 10-MHz probe for crack detection and sizing at non-ideal (unknown) tilt angles.
- Angle and focus control of the 4-MHz PA probe was superior to the 10-MHz PA probe.
- Optimum inspection angle is perpendicular to the flaw (i.e., for a flaw tilt of 35 degrees, peak response on second leg is at 55-degree inspection angle.