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Technical Basis of Weld Overlay Indication Evaluation and Disposition Based on Advanced Technology Assessments

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Performance Demonstration

Examination Goals

- Overlay Examination
  - Performed after initial application of overlay only
    - Workmanship standard
  - Purpose of examination
    - Assure quality of the overlay itself
      - No unacceptable welding flaws
      - Bonded to original base material
      - Assure no conditions would affect the examination of the upper 25% of the original base material

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Examination Goals

- Inservice Examination
  - Performed directly after application of overlay (PSI)
  - Subsequent examinations dictated by relief request commitments and MRP-139 requirements
  - Purpose of examination
    - Detect and size any flaws that may have propagated into the outer 25% of the original base material
      - Critical attribute
        - Assure no propagation into overlay
        - No new flaws appear

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Reported Indications

- Types of flaws detected to date in most recent applications of overlays
  - Inter-bead lack of fusion (laminar and planar)
  - Lack of bond (laminar)
  - High concentrations of solidification defects

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Flaw Evaluations

- Currently a multi-level evaluation must be performed on any flaw that is detected during examination
- These evaluations are quite complex and time consuming
  - Must consider
    - Real planar flaws
    - Postulated planar flaws
    - Laminar flaws
    - Loss of coverage due to laminar flaw

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Ultrasonic Techniques

- Sizing accuracy for laminar flaws
  - Currently, the techniques used for determining the width of laminar flaws are not part of the Appendix VIII qualification process
    - No documented acceptance criteria for sizing is available to judge the accuracy of these techniques
    - Currently, width determination is same process as measuring length of flaw
      - 0.75” RMS
      - Tends to oversize width of very small flaws

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Ultrasonic Techniques

- Sizing planar embedded flaws
  - Currently, the techniques used for depth sizing embedded planar flaws are not part of the Appendix VIII qualification process
    - No documented acceptance criteria for sizing is available to judge the accuracy of these techniques
    - Currently the same techniques used for measuring upper extremity (qualified to 0.125” RMS) of embedded planar flaws used for measuring lower extremities
      - Tip diffraction
      - Believed to be accurate

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Ultrasonic Techniques

- Projects approved evaluate these techniques
  - ***"Proposed Code Case Criteria for Technical Basis of Weld Overlay Indication Evaluation and Disposition Based on Advanced Technology Assessments Report*** *1015148*
  - Funded by EPRI NDE
    - Addresses sizing of embedded planar flaws and laminar flaws

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Laminar Flaw Sizing Improvements

- Phased Array Technique
- There are two Phased Array approaches evaluated to increase the accuracy of a laminar width measurement
  - The first approach is to minimize the width of the ultrasonic beam at the flaw location.
    - Dynamic focusing capability readily available using phased array technology
  - The second approach is to modify the focal depth by adjusting focal law to focus at the depth of a detected flaw prior to sizing
    - Significantly increases sizing accuracy for small flaw dimensions

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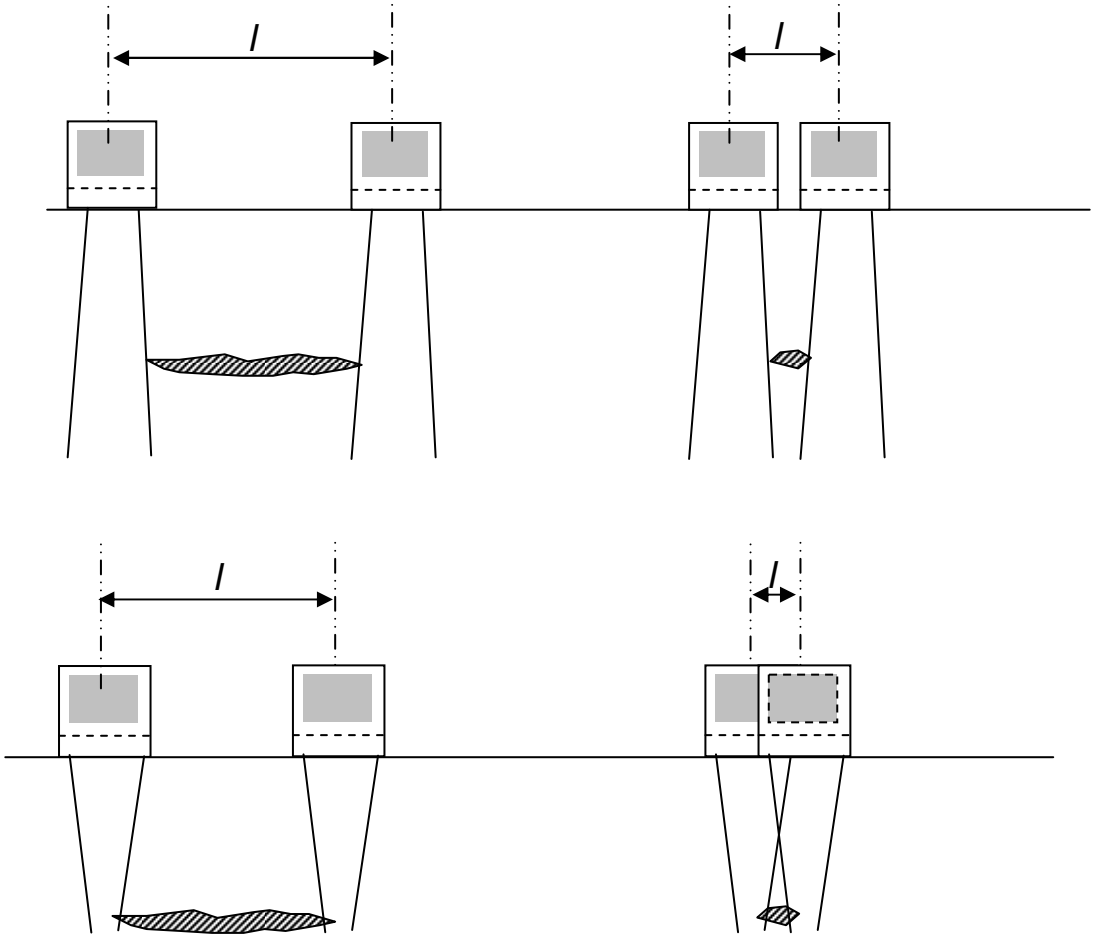
Laminar Flaw Sizing Improvements



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Laminar Flaw Sizing Improvements

- Phased Array Width Measurements taken on 0.25” flaws

	Measured Width	
	Unfocused (inch)	Focused at Flaw (inch)
Flaw 4	0.400	0.250
Flaw 5	1.100	0.300

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Laminar Flaw Sizing Improvements

- Conventional Technique Improvements
- The current technique for identifying flaw end positions in all EPRI PDI overlay procedures is to mark locations where the flaw signal diminishes into the back ground noise.
  - Techniques were modified by adjusting the amplitude based criteria for determining width of the flaw
  - Several measurements taken using different dB drop values to determine most accurate values

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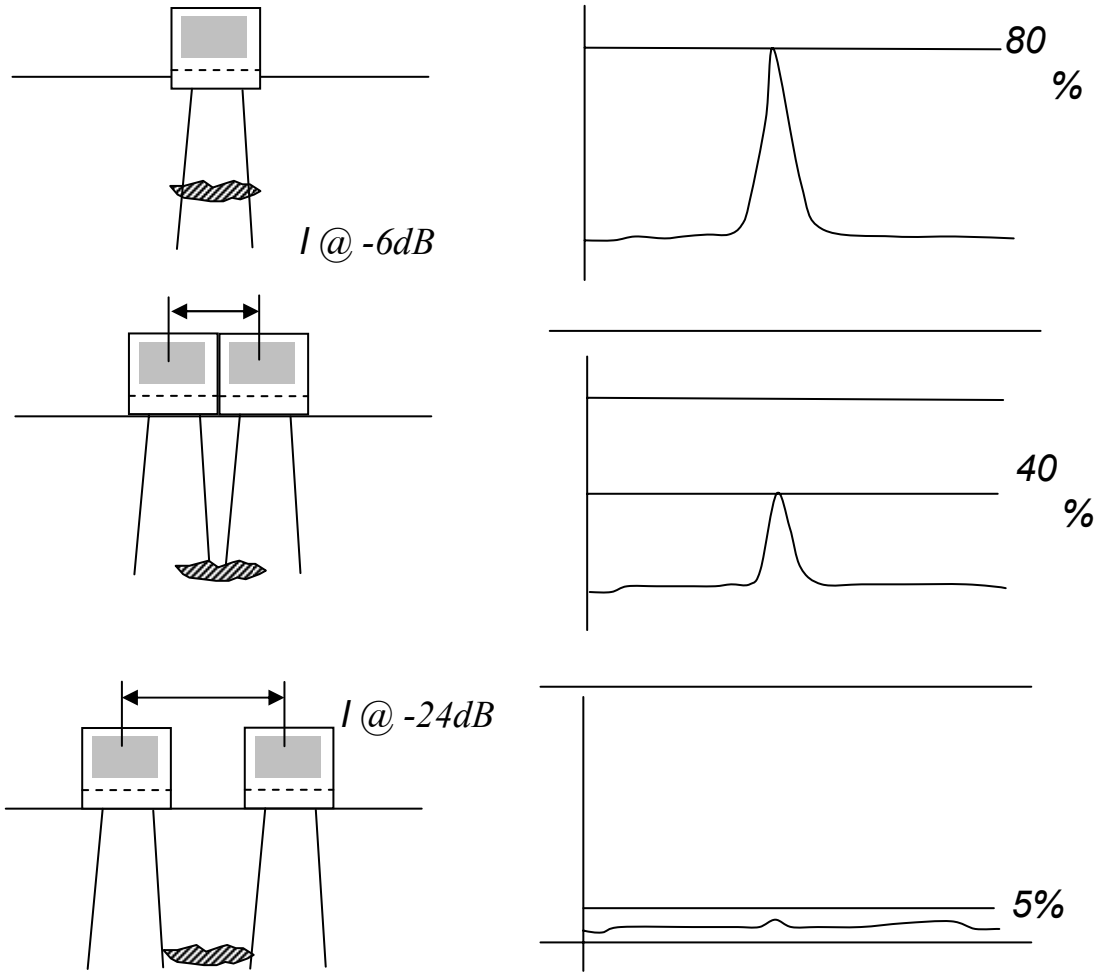
Laminar Flaw Sizing Improvements



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Laminar Flaw Sizing Improvements

- Conventional Measurements

Deviations in Width Measurements Using Different Techniques (inch)				
	-3 dB Drop	-6 dB Drop	-12 dB Drop	Full Amplitude Drop
Flaw 1	0.006	0.041	0.183	0.431
Flaw 2	.0.020	0.018	0.339	0.419
Flaw 3	0.011	0.024	0.165	0.341
Flaw 4	0.021	0.014	0.127	0.232
Flaw 5	0.028	0.098	0.204	0.416
Flaw 6	0.028	0.135	0.240	0.417
Flaw 7	0.028	0.106	0.205	0.463
Flaw 8	0.028	0.178	0.250	0.321
Flaw 55[1]	0.064	0.047	0.195	0.269
Flaw 51	0.028	0.08	0.270	0.344

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Laminar Flaw Sizing Improvements

- Conventional Width Determination Methodology to be added to PDI Guidelines

Laminar Flaw Width Sizing Methodology			
Flaw Type	**Ultrasonic Signature**	**Signature Characteristics**	**Width Sizing Method**
Round, Volumetric	Distinct, rather sharp response	• Relatively stable and repeatable peak amplitude • Smooth amplitude envelope as the probe is scanned across the width • Relatively low signal amplitude/BW ratio • Very good signal-to-noise ratio with defined start and stop points in both the length and width directions.	- 3dB drop
Small, Singular	Distinct, rather sharp response	• Relatively stable and repeatable peak amplitude • Smooth amplitude envelope as the probe is scanned across the width • Relatively low signal amplitude/BW ratio • Very good signal-to-noise ratio with defined start and stop points in both the length and width directions.	-3dB drop
Large, Singular	Distinct, sharp response	• Stable and repeatable peak amplitude • Relatively smooth amplitude envelope as the probe is scanned across the width • Relatively high signal amplitude/BW ratio • Excellent signal-to-noise ratio with defined start and stop points in both the length and width directions.	-6dB drop
Cluster	Broad, multi-peaked response	• Difficult to peak amplitude • Variable amplitude envelope as the probe is scanned across the width • Relatively low signal amplitude/BW ratio • Good signal-to-noise ratio (>2:1) with less definitive start and stop points in both length and width directions.	Full amplitude

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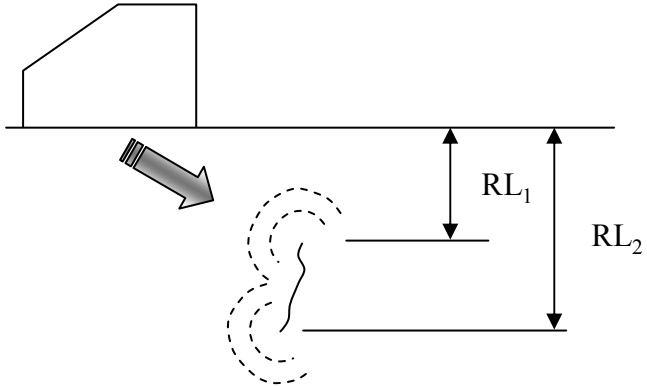
Planar Flaw Sizing Improvements

- Tip Diffraction Depth Sizing Techniques Were Evaluated
  - Same techniques for measuring remaining ligament of flaw



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Planar Flaw Sizing Improvements

- 12 embedded planar flaws were measured using these techniques
- The results of this exercise concluded the following
  - The ability to measure within a RMS of 0.125-inch seemed reasonable
  - As the flaw heights decrease, the upper and lower tip signals moved closer together on a ultrasonic A-scan presentation resulting in a minimum height where these two signals are no longer distinguishable
    - Based on the above experiments the use of tip diffracted methods for the sizing of embedded planar flaws in overlay with thickness less than ½ -inch, is not practical when evaluating flaws to the ASME IWB 3514-2 acceptance criteria
      - Rejectable flaw size is smaller than what can be accurately sized

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Future Work

- EPRI is in the process of fabricating additional test samples containing such flaws with an emphasis on overlays with thicknesses ranging from 0.6 to 1.4 inch
- Samples will contain a wider range of laminar widths and embedded planar flaws with varying heights.

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Summary

- The application of acceptable overlays is possible
- PDI ultrasonic techniques being used today are not significantly different from those used in the past
- Significant amount of work underway to expand the application of weld overlays
- Significant improvements have been made in measuring the width of laminar flaws
- Planar flaw sizing of embedded defects is possible
- PDI Guideline being developed to address enhanced sizing techniques

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