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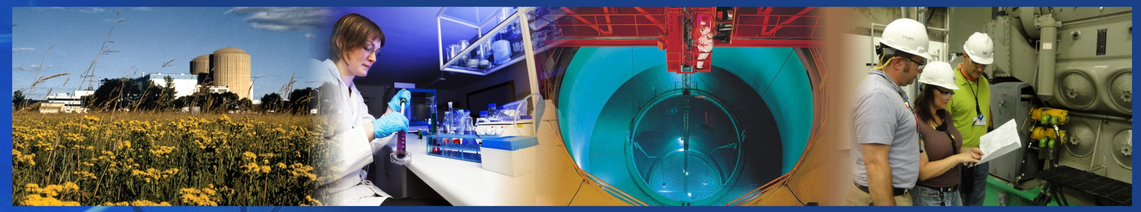


Phased-Array Ultrasonics Looking Below the Surface

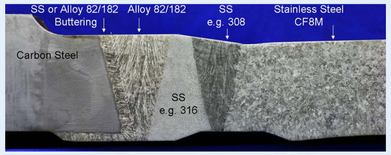
Introduction

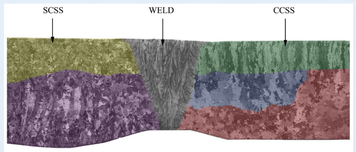
Nondestructive examinations (NDE) evaluate materials without causing damage.

Nuclear power plants have a mandate for effective nondestructive examination technologies for inspection of important safety systems, such as pipe welds within the primary coolant systems.

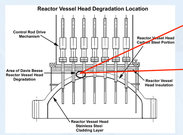
Phased-array ultrasonic testing (PA-UT) uses multiple transducer elements designed to interact constructively and provide improved insonification, focusing, beam steering, and imaging.

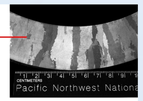
Nondestructive examination inspection challenges include access/geometry and vintage materials used.

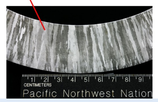




Digital photograph illustrating geometry, grain growth and orientation, ID/OD contour, metallurgical interfaces and other inspection challenges provided by a standard PWR steam generator nozzle DMW configuration.







Why Phased Array?

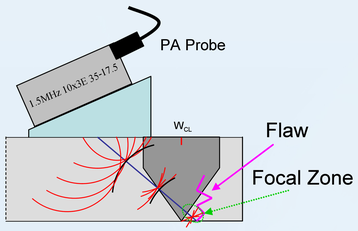
Phased-array ultrasonic systems provide inspection advantages such as rapid volumetric imaging over a multitude of angles, and advanced focusing capabilities with spacially encoded data when used in combination with an encoded scanning system.

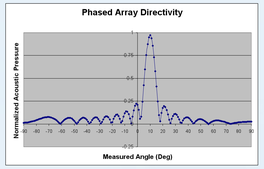
Conventional ultrasonic techniques can be limiting in angle and focus.

Other nondestructive examination methods can be costly, cumbersome and require significant safety protocols.

Phased-Array Approach

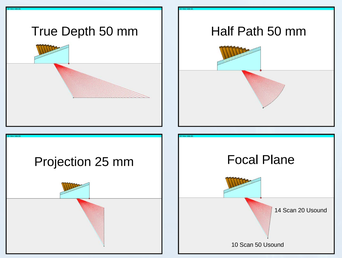
Successful phased array UT begins with careful probe design...

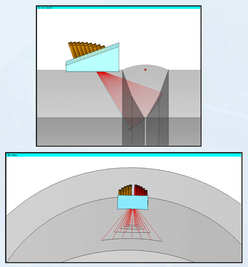




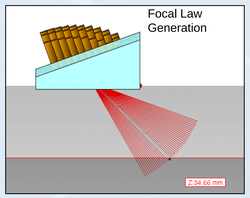
2D Azimuthal Plane Directivity Model

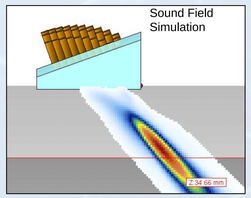
...combined with a fitting and fully adjustable focusing style...

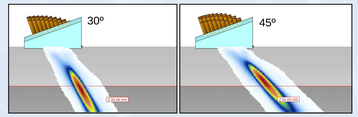




...to generate optimum tailored focal laws for inspection of specific components and material microstructures.



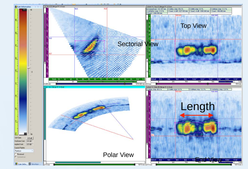




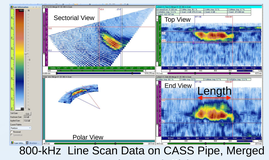
*Acoustic pressure equation:

$$H(\theta,\phi)=\left|sinc\left(\frac{\pi a\sin\theta\cos\phi}{\lambda}\right)\right| \times sinc\left(\frac{\pi L\sin\theta\sin\phi}{\lambda}\right)\times\frac{\left|sinc\left\{(\pi l/\lambda)(\sin\theta-\sin\theta\cos\phi)\right\}N\right|}{\left|sinc\left\{(\pi l/\lambda)(\sin\theta-\sin\theta\cos\phi)\right\}\right|}$$

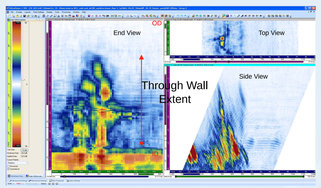
Phased-Array Visual Data



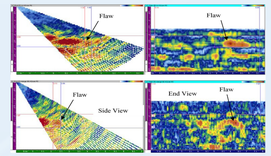
1.5-MHz Line Scan Data, Merged Image for Length Sizing



800-kHz Line Scan Data on CASS Pipe, Merged Image for Length Sizing



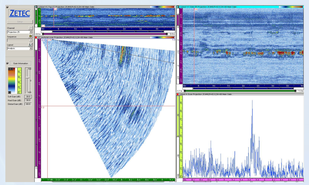
1.5-MHz Raster Scan Data



Phased Array Data at 500-kHz (top) and 800 -kHz (bottom). Multiple signals show the importance of signal discrimination.

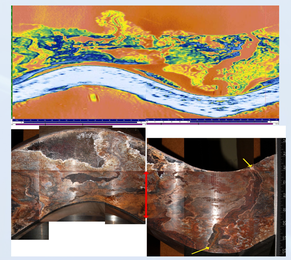
Additional NDE Applications

High-Density Polyethylene Pipe



PA Data using Custom Wedge Design

Nozzle Leak Path Detection



Above: PA-UT Upper Head Penetration Nozzle Leak Path Assessment
Below: Destructive Evaluation of Nozzle

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