



Ultrasonic Techniques for Testing Transportation Containers and Pipelines

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NDT

- Ultrasonic techniques are used in NDT.
- NDT: Non-destructive Testing
 - Group of analysis techniques used in industry (or medical) to detect flaw in welds and materials without causing damage to the item tested.
 - NDT methods include visual test, radiographic test, **ultrasonic test**, magnetic particle test, liquid penetrant test, **acoustic emission test**, thermal infrared test, eddy current test, ...



Purpose of NDT

- Increase reliability of equipment operating
- To detect defects in welds and materials, quantify their size and evaluate according the applicable construction Codes or standards.
 - During construction
 - On Stream
 - After service
- To sizing and locating of existing defect, e.g., crack, wall loss, in order to monitoring its integrity, plan for repair or fitness-for-service assessment

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LPG Tanks



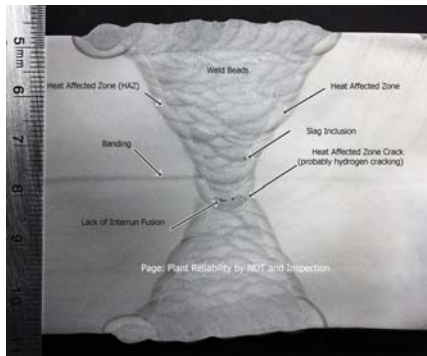
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Welding Defects



Macro view of cross-section of the steel fusion weld

- The flaw or defects include cracks, gas cavities (porosity, worm holes, isolated pores), slag inclusion, incomplete penetration, lack of fusion, ...

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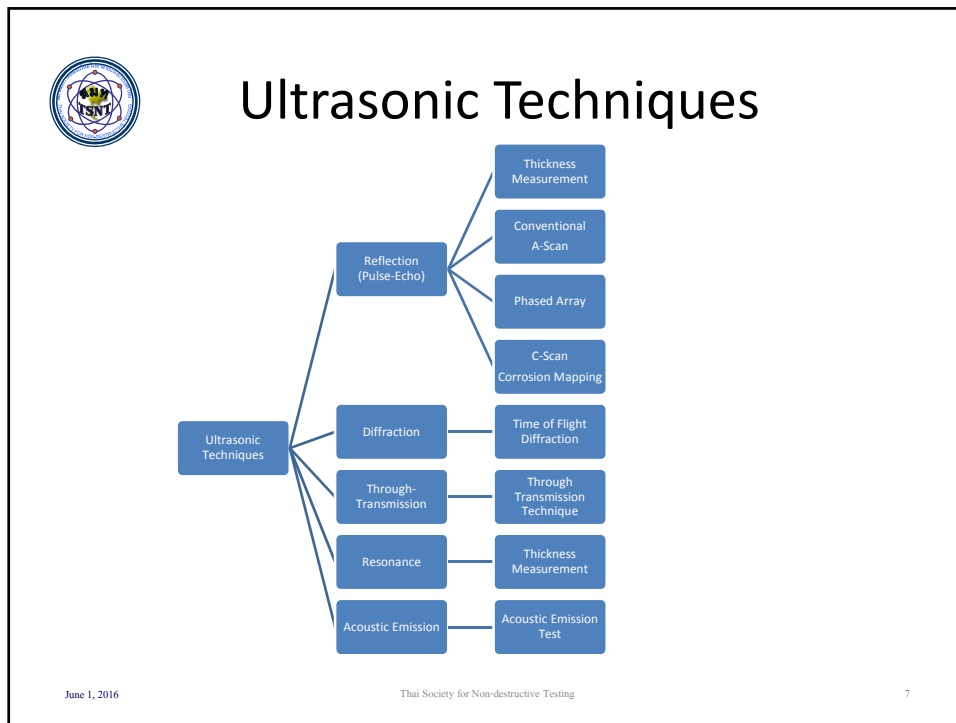
Ultrasonic Techniques used in NDT

- Reflection: Pulse-Echo Technique
- Diffraction: Time of Flight Diffraction Technique (TOFD)
- Interference: Phased Array Technique, Resonance Technique
- Refraction: Control direction of ultrasound according to Snell's law

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Thickness Measurement

- Very common in pressure vessel and pipeline inspection.
- Pulse-echo technique, frequency 4-10 MHz
- a digital read out and A-scan display.
- Accuracy typically 0.1 mm

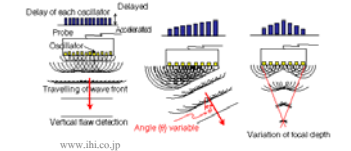
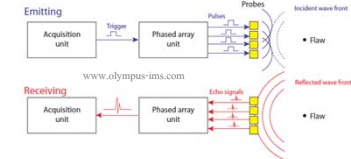

www.worcesterndt.com

www.stawtest.com 03/04/2015 08:18


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Phased Array UT (PAUT)






- Array of transducer in a single housing
- Phasing >>sequentially pulse of those element in program pattern

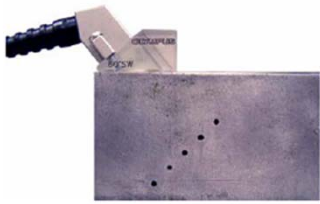
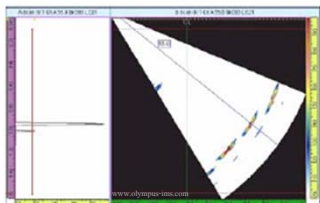


www.olympus-ims.com

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PAUT-Sectorial Scan

- Cross-section view display
- Continuous firing with control of delay (focal law) forming sweep scan in an angle range
- Processing of individual A-scan (amplitude-time display)

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PAUT for Weld Inspection



- Test a pipeline weld for defects.
- The scanner consists of a frame with magnetic wheels, holds the probe in contact with the pipe by a spring.
- The wet area is the ultrasonic couplant that allows the sound to pass into the pipe wall.

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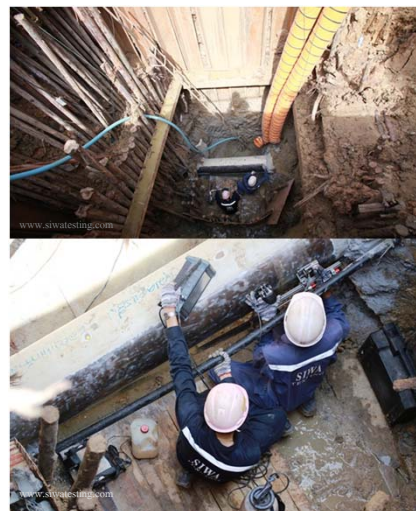
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PAUT Corrosion Mapping

- The indication of wall loss was found in an underground transferred pipeline material after inspection by intelligent pig using magnetic flux leakage (MFL).
- Excavate to pipeline. PAUT C-Scan corrosion mapping (Plan view) to confirm and sizing the existing wall loss.
- The result was satisfactory. Measurement of remaining thickness and exact location can be provided.



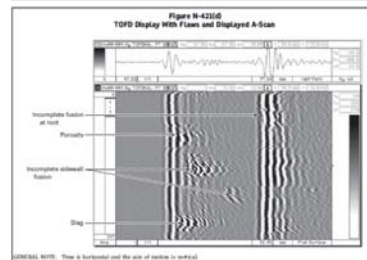
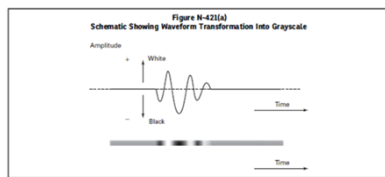
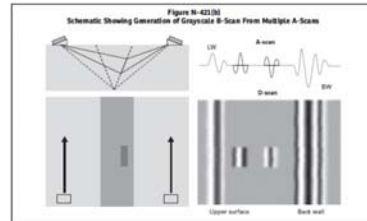
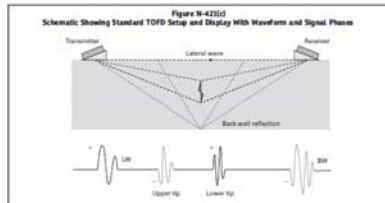
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Time of Flight Diffraction, TOFD




Ref: ASME Code for Boiler and pressure Vessel, Section V, 2015 Edition

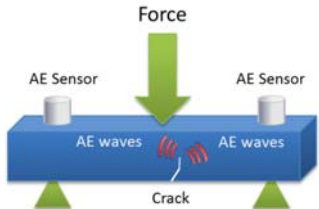


Acoustic Emission Test, AET


- AE is commonly defined as transient elastic waves within a material, caused by the rapid release of localized stress energy.
- Most of the released energy is within the 1 kHz to 1 MHz range.
- Applications of AE techniques are to detect crack and leak of materials/structures; and monitor the safety operation of a structure, i.e. bridges, pressure containers, and pipe lines, etc.




AET for Tank and Pipeline



Acoustic emission due to crack growth in a solid material under stress.

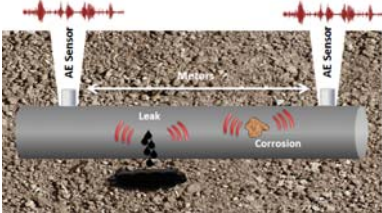




$$d = \frac{1}{2}(D - \Delta T \cdot V)$$

d = distance from first hit sensor
 D = distance between sensors
 V = wave velocity

Calculation of AE source location based on the detected time difference between wave arrivals to sensors and known wave velocity.




AE sources related to corrosion development and a leak in an underground pipeline

www.idinspections.com


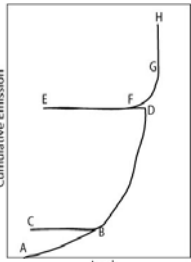
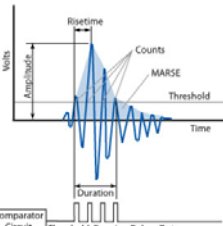
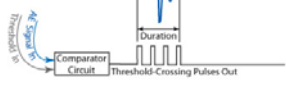
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AE System and AE Plot

www.nde-ed.org

- Kaiser Effect
- Felicity Effect
- AE Signal Feature
 - Amplitude (A), Rise Time (R), Duration (D), Count (N) and MARSE (Measured Area under the rectified Signal Amplitude)

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AET for CNG Cylinder



Source: Kingwelds (King Mongkut University Thonburi)

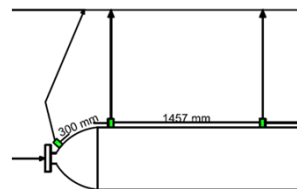
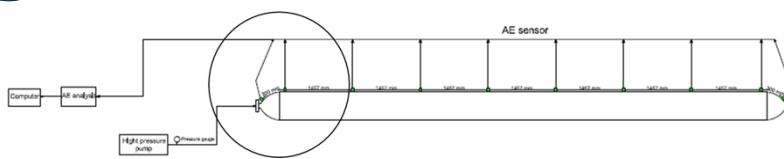
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AET Set up



Source: Kingwelds (King Mongkut University Thonburi)

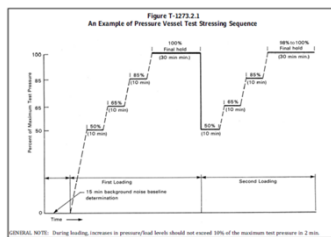
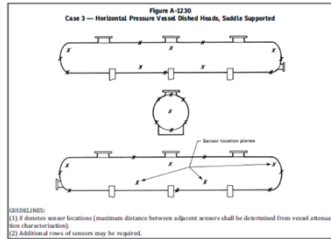
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Sample of Sensors Placement and Stressing



- Sensors installation and pressurizing steps
- Each sensor cover area around where the ultrasound intensity from breaking of pencil lead is high enough.

Table T-1281
An Example of Evaluation Criteria for Zone Location

Enterion During Load	Method	Count Rate	Number of Hits	Large Amplitude Hits	MSRSE or Amplitude	Activity	Evaluation Threshold
(First Loading)	Not more than F_u hits beyond time T_u	Not applied	Not applied	Not more than F_u hits above a specified amplitude	MSRSE or amplitude do not increase with increasing load	Activity does not increase with increasing load	F_u
(Pre-Loading)	Not more than F_u hits other than those allowed above	Low than F_u counts per second for a specified load increase	Not more than F_u hits above a specified amplitude	Not more than F_u hits above a specified amplitude	MSRSE or amplitude do not increase with increasing load	Activity does not increase with increasing load	F_u

GENERAL NOTES:
(1) F_u , N_u , and F_u are specified acceptance criteria values specified by the referencing Code Section.
(2) T_u is the specified evaluation threshold.
(3) T_u is the specified hold time.

Ref.: ASME Code for Boiler and pressure Vessel, Section V, 2015 Edition

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Intelligent Pig



- Intelligent pigs measure pipe wall thickness and metal loss.

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Long Range UT, LRUT



- Multi transducers, use low frequency in order of 10 KHz
- For unpiggable and difficult-to-inspect pipelines
- Up to several 10-meter deep in soil
- Typically 3-9% loss of cross-sectional area can be detected

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Thank you for your attention

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