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Limitations and Disadvantages of Advanced Techniques in Ultrasonic Method !!

Such as [Phased Array (PAUT), and Full Matrix Capture FMC/TFM]

Introduced by

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ASNT UT Level III, CWI, API (570, 510, 653), ISO9001, PMP, TOT

Table A-110
Imperfection vs. Type of NDE Method

	Surface [Note (1)]		Subsurface [Note (2)]		Volumetric [Note (3)]				
	VT	PT	MT	ET	RT	UTA	UTS	AE	UTT
Welding Imperfections									
Burn Through	◉	...	...	...	◉	⊛	...	...	◎
Cracks	◎	◉	◉	⊛	⊛	◉	◎	◉	...
Excessive/Inadequate Reinforcement	◉	...	...	...	◉	⊛	◎	...	◎
Inclusions (Slag/Tungsten)	...	...	⊛	⊛	◉	⊛	◎	◎	...
Incomplete Fusion	⊛	...	⊛	⊛	⊛	◉	⊛	⊛	...
Incomplete Penetration	⊛	◉	◉	⊛	◉	◉	⊛	⊛	...
Misalignment	◉	...	...	...	◉	⊛	...	...	...
Overlap	⊛	◉	◉	◎	...	◎	...	...	...
Porosity	◉	◉	◎	...	◉	⊛	◎	◎	...
Root Concavity	◉	...	...	...	◉	⊛	◎	◎	◎
Undercut	◉	⊛	⊛	◎	◉	⊛	◎	◎	...

Legend:
- AE — Acoustic Emission
- ET — Electromagnetic (Eddy Current)
- MT — Magnetic Particle
- PT — Liquid Penetrant
- RT — Radiography
- UTA — Ultrasonic Angle Beam
- UTS — Ultrasonic Straight Beam
- UTT — Ultrasonic Thickness Measurements
- VT — Visual

◉ — All or most standard techniques will detect this imperfection under all or most conditions.

⊛ — One or more standard technique(s) will detect this imperfection under certain conditions.

◎ — Special techniques, conditions, and/or personnel qualifications are required to detect this imperfection.

Standard Practice for Contact Ultrasonic Testing of Welds Using Phased Arrays

1. Scope

1.1 This practice describes ultrasonic techniques for examining welds using phased array ultrasonic methods (see Note 1 and Note 2).

1.2 This practice uses angle beams, either in S-scan or E-scan modes, primarily for butt welds and Tee welds. Alternative welding techniques, such as solid state bonding (for example, friction stir welding) and fusion welding (for example, electron beam welding) can be examined using this practice, provided adequate coverage and techniques are documented and approved. Practices for specific geometries such as spot welds are not included. The practice is intended to be used on thicknesses of 9 to 200 mm. Greater and lesser thicknesses may be examined using this practice if the technique can be demonstrated to provide adequate detection on mockups of the same wall thickness and geometry.

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1.2.1 Extreme caution should be used when attempting to size indications using phased array. It is likely that without proper procedures, indications can be oversized due to beam divergence, multiple virtual probes returning signals from the same indication, etc. For more guidance, see 12.4.

5.2 Though primarily a method of generating and receiving ultrasound, phased arrays are also a method of scanning and imaging. The two basic types of scans are the Linear or Electronic scan (E-Scan) and the Sectorial or Azimuthal scan (S-Scan). In the E-Scan, which emulates a manual scan, multiple sound beams are created at the same refracted angle. The beam is electronically translated along the active axis of the array by sequentially adding an element on one end and dropping an element off the other end of the active group of elements within the probe, with time multiplexing coordinated by the instrument's on-board processor. In the S-Scan, which is unique to phased arrays, the sound beam is electronically swept through a range of user-defined angles by sequentially changing the time delays applied to each element. Because the beam angle is no longer solely dependent upon the wedge angle, more complete data can be obtained and more complex geometries can be examined versus conventional UT. With their distinct features and capabilities, phased arrays require special set-ups and standardization, as addressed by this practice. Commercial software permits the operator to easily make set ups without detailed knowledge of the phasing requirements.

6. Basis of Application

6.1 The following items are subject to contractual agreement between the parties using or referencing this standard.

6.2 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, ISO 9712, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6.2.1 In addition, there should also be training or knowledge and experience related to phased array equipment and techniques. Personnel performing examinations to this standard should list the qualifying credentials in the examination report.

6.3 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Specification E543. The applicable edition of Specification E543 shall be specified in the contractual agreement.

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MANDATORY APPENDIX II
SUPPLEMENTAL PERSONNEL QUALIFICATION REQUIREMENTS FOR NDE CERTIFICATION

II-110 SCOPE

This Appendix provides the additional personnel qualification requirements that are mandated by Article 1, T-120(g), and which are to be included in the employer's written practice for NDE personnel certification, when any of the following techniques are used by the employer: computed radiography (CR), digital radiography (DR), phased array ultrasonic (PAUT), ultrasonic time-of-flight diffraction (TOFD), and ultrasonic full matrix capture (FMC).

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II-121 LEVEL I AND LEVEL II TRAINING AND EXPERIENCE REQUIREMENTS

The following tables shall be used for determining the minimum hours for personnel without prior qualification in film; CR or DR techniques in radiography; and PAUT, TOFD, and FMC techniques in ultrasonics to be included in the employer's written practice. See Tables II-121-1 and II-121-2.

For the CR and DR techniques, personnel shall first meet the training and experience requirements in Table II-121-1 for a Level I in that technique as a prerequisite for being eligible for qualification as a Level II in that technique. See Table II-121-1, General Notes for modifications to the number of training and experience hours required.

For TOFD, PAUT, and FMC, see the prerequisite requirements in Table II-121-2.

II-123 LEVEL III REQUIREMENTS

Level III personnel shall be responsible for the training and qualification of individuals in the NDE techniques described in this Mandatory Appendix. As a minimum, the requirements of Level III personnel shall include each of the following:

(a) hold a current Level III certification in the Method

(b) meet the Level II requirements per II-121 (training and experience) and II-122 (examinations) in the technique

(c) have documented evidence in the preparation of NDE procedures to codes, standards, or specifications relating to the technique

(d) demonstrate proficiency in the evaluation of test results in the technique

A Level III who fulfills the above requirements may perform examinations in the applicable technique.

Table II-121-2
Additional Training and Experience Requirements for PAUT, TOFD, and FMC Ultrasonic Techniques

Examination Method	NDE Level	Technique	Training Hours	Experience: Minimum Hours in Technique	Experience: Total NDE Hours
Ultrasonic	II	PAUT	80	320	UT Level I and Level II training and experience required as a prerequisite [Note (1)], [Note (2)]
Ultrasonic	II	TOFD	40	320	
Ultrasonic	II	FMC	80	320	

NOTES:
(1) Level II personnel holding a current Ultrasonic method certification are eligible for certification in the PAUT, TOFD, and FMC techniques.
(2) In addition to the training specified in Table II-121-2, supplemental specific hardware and software training shall be required for automated or semiautomated technique applications. The employer's written practice shall fully describe the nature and extent of the additional training required for each specific acquisition or analysis software and instrument/system used. The employer's written practice shall also describe the means by which the examiner's qualification will be determined for automated and semiautomated techniques.

6.4 *Procedures and Techniques*—The procedures and techniques to be used shall be as specified in the contractual agreement. Guide E2491 recommends methods of assessing performance characteristics of phased array probes and systems.

6.5 *Surface Preparation*—The pre-examination surface preparation criteria shall be in accordance with 9.1, unless otherwise specified.

6.6 *Timing of Examination*—The timing of examination shall be determined by the contracting parties and in accordance with the stage of manufacture or in-service conditions.

6.7 *Extent of Examination*—The extent of examination shall be suitable to examine the volume of the weld plus the heat affected zone, unless otherwise specified.

6.8 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with

7.2.6 Refracting wedges used on curved surfaces shall require contouring to match the surface curvature if the curvature causes a gap between the wedge and examination surface exceeding 0.5 mm at any point.

8.1.4 The same couplant to be used during the examination shall be used for standardization.

8.1.5 The same contact wedges or immersion/bubbler systems used during the examination shall be used for standardization.

8.1.6 The same focal law(s) used in standardization shall be used for examination.

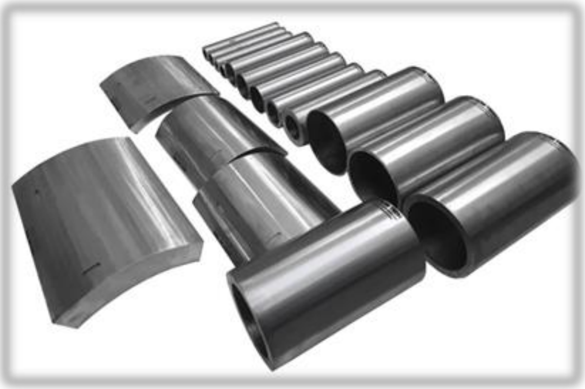
8.1.7 Any control which affects instrument amplitude response (for example, pulse-duration, filters, averaging, etc.) shall be in the same position for standardization and examination.

8.1.8 Any control which affects instrument linearity (for example, clipping, reject, suppression) shall not be used.

8.2 *Reference Blocks:*

8.2.1 Reference blocks shall be made of the same material as the test piece or an acoustically similar material acceptable to the customer.

8.2.2 Reference standards for sensitivity-amplitude standardization should be designed so that sensitivity does not vary with beam angle when angle beam examination is used. Sensitivity amplitude reference standards that accomplish this are side-drilled holes parallel to the major surfaces of the plate and perpendicular to the sound path, flat-bottomed holes drilled at the examination angle, and equal-radius reflectors. Surface notches may be used under some circumstances but are not generally recommended.

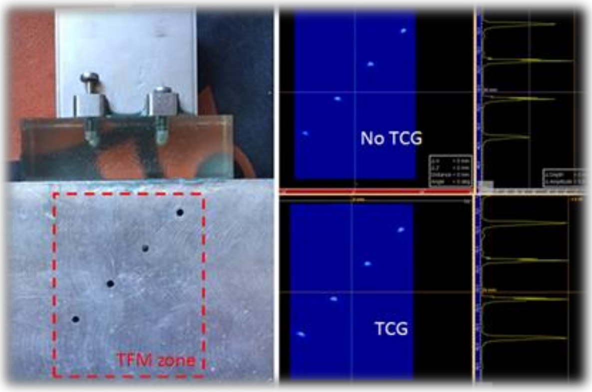


10. Distance-Amplitude Correction (DAC)/Time-Corrected Gain (TCG)

10.1 Reference standards for distance-amplitude standardization should be constructed of materials with similar surface finish, nominal thickness and metallurgically similar in terms of alloy and thermal treatment to the weldment.

10.4 *Acceptable Technique:*

10.4.1 *Time-Corrected Gain (TCG)*—TCG balances all focal laws at multiple depths to a reference setting (usually 80 % FSH). Assessment of phased array examinations uses color-coded B-scans or S-scans as the initial evaluation method.



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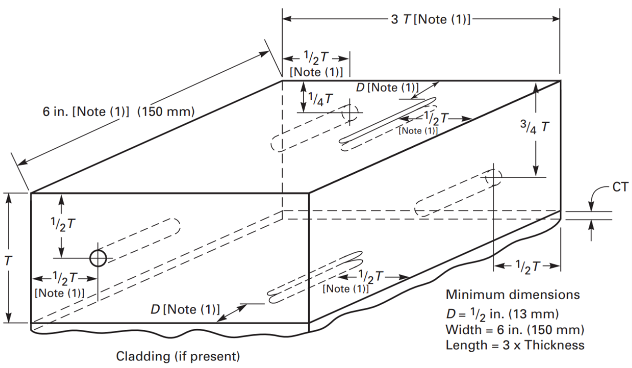
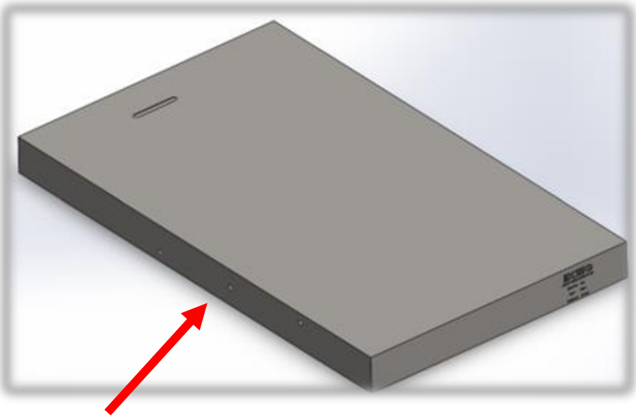
T-434.1.7 Block Curvature.

T-434.1.7.1 Materials With Diameters Greater Than 20 in. (500 mm). For examinations in materials where the examination surface diameter is greater than 20 in. (500 mm), a block of essentially the same curvature, or alternatively, a flat basic calibration block, may be used.

Figure T-434.2.1
Nonpiping Calibration Blocks

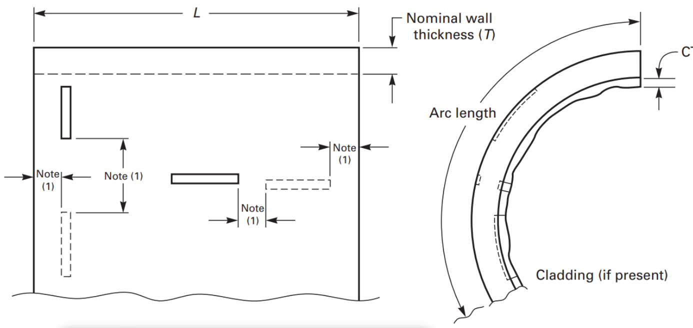


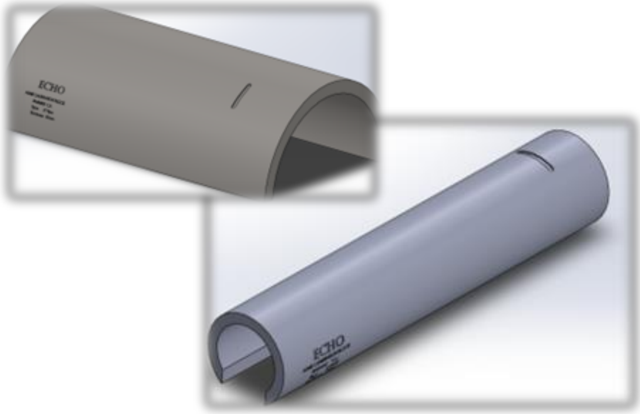


T-434.1.7.2 Materials With Diameters 20 in. (500 mm) and Less. For examinations in materials where the examination surface diameter is equal to or less than 20 in. (500 mm), a curved block shall be used. Except where otherwise stated in this Article, a single curved basic calibration block may be used for examinations in the range of curvature from 0.9 to 1.5 times the basic calibration block diameter. For example, an 8 in. (200 mm) diameter block may be used to calibrate for examinations on surfaces in the range of curvature from 7.2 in. to 12 in. (180 mm to 300 mm) in diameter. The curvature range from 0.94 in. to 20 in. (24 mm to 500 mm) in diameter requires six curved blocks as shown in Figure T-434.1.7.2 for any thickness range.

T-434.3 Piping Calibration Blocks. The basic calibration block configuration and reflectors shall be as shown in Figure T-434.3-1 or the alternate provided in Figure T-434.3-2 where curvature and/or wall thickness permits. The basic calibration block curvature shall be in accordance with T-434.1.7. Thickness, *T*, shall be ±25% of the nominal thickness of the component to be examined. The block size and reflector locations shall be adequate to perform calibrations for the beam angle(s) and distance range(s) to be used.

Figure T-434.3-1
Calibration Block for Piping





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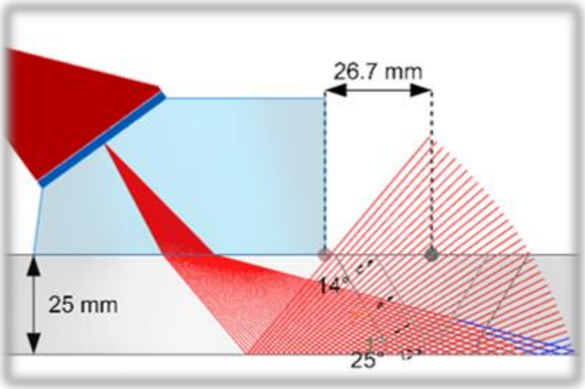
11. Examination Procedures

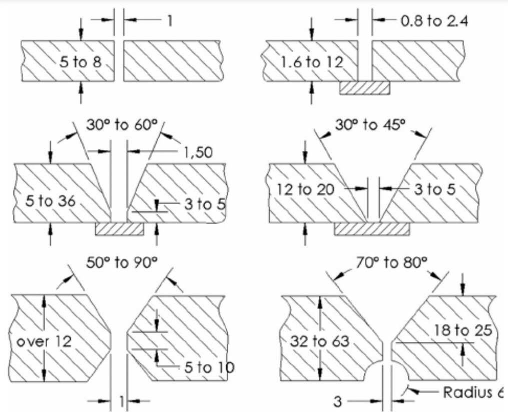
11.1 Phased array examination procedures are nominally identical to conventional ultrasonic procedures in coverage, angles etc. Examination procedures recommended for common weld configurations are detailed in Practice E164. Variations in specifics of the procedures for phased array methods are required depending on whether manual or encoded scanning is used.

11.2 *Scan Plans:*

11.2.1 A scan plan is a documented examination strategy designed to facilitate optimal weld coverage, ensure examination repeatability, and aid in interpretation of indications. Scan plans may be hand drawn or computer generated using appropriate software.

11.2.2 Phased array scanning procedures for welds shall be established using scan plans that indicate the part and weld geometry, probe and wedge (including number of groups and elements per group), required stand-off positions for the probe to ensure volume coverage required, number and direction of scans, and appropriate beam angles. Volume coverage required may include the full volume of weld plus a specified region either side (such as the heat affected zone). Welds shall be examined from both sides, where possible.





11.7 For automated or semi-automated scanning, the probe will be used with a positional encoder for each axis in which probe motion is required (for most applications, a single encoder is used). The encoder shall be calibrated to provide positional information from a reference start position and shall be accurate to within 1 % of total scan length or 10 mm, whichever is less. Guide mechanisms such as probe holding

V-467 ENCODER CALIBRATION

A calibration check shall be performed at intervals not to exceed one month or prior to first use thereafter, by moving the encoder a minimum distance of 20 in. (500 mm). The display distance shall be within 1% of the actual distance moved.

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