This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

INTERNATIONAL

Designation: E2700 − 20

Standard Practice for Contact Ultrasonic Testing of Welds Using Phased Arrays[1]

This standard is issued under the fixed designation E2700; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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.

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.

1.3 *Units*—The values stated in SI units are to be regarded as standard.

NOTE 1—This practice is based on experience with ferrous and aluminum alloys. Other metallic materials can be examined using this practice, provided reference standards can be developed to demonstrate that the particular material and weld can be successfully penetrated by an ultrasonic beam.

NOTE 2—For additional pertinent information, see ASME BPVC Section V, Article 4, Guide E2491, Practice E317, and Practice E587.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E164 Practice for Contact Ultrasonic Testing of Weldments

E317 Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems without the Use of Electronic Measurement Instruments

E543 Specification for Agencies Performing Nondestructive Testing

E587 Practice for Ultrasonic Angle-Beam Contact Testing

E1316 Terminology for Nondestructive Examinations

E2192 Guide for Planar Flaw Height Sizing by Ultrasonics

E2491 Guide for Evaluating Performance Characteristics of Phased-Array Ultrasonic Testing Instruments and Systems

2.2 *ASME Standard:*[3]

ASME BPVC Section V, Article 4

2.3 *ISO Standards:*[4]

ISO 2400 Reference Block for the Calibration of Equipment for Ultrasonic Examination

ISO 9712 Nondestructive Testing—Qualification and Certification of NDT Personnel

ISO 19675 Nondestructive Testing—Ultrasonic Testing—Specification for a Calibration Block for Phased Array Testing (PAUT)

2.4 *ASNT Documents:*[5]

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

ANSI/ASNT CP-189 Standard for Qualification and Certification of NDT Personnel

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[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Method.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

***A Summary of Changes section appears at the end of this standard**

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2.5 *AIA Standard:*[6]

NAS-410 Certification and Qualification of Nondestructive Testing Personnel

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology E1316.

4. Summary of Practice

4.1 This practice provides procedural guidance for both manual and mechanized scanning of welds using phased array systems, including a discussion of general requirements for standardization of range, angular and depth sensitivity and reference blocks for same; coupling considerations; examination procedures, including development of scan plans for common butt and tee weld configurations; basic indication evaluation; and reporting requirements.

5. Significance and Use

5.1 Phased array ultrasonic testing (PAUT) is an advanced examination technique used for enhanced flaw detection, sizing, and imaging as compared to conventional UT employing single-element transducers. PAUT utilizes multi-element (array) probes in which groups of elements are pulsed with pre-calculated time delays ("focal laws") for each element ("phasing"). The resulting constructive and destructive interference allows for electronic steering, shaping, and focusing of the sound beam.

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.

5.3 Phased arrays can be used in different ways: manual or encoded linear scanning; and different displays or combinations of displays. In manual scanning, the dominant display will be an S-scan with associated A-scans. S-scans have the advantage over E-scans in that all the specified examination angles can be covered at the same time.

5.4 The main advantages of using phased arrays for ultrasonic weld examinations are:

5.4.1 Increased control of beam characteristics, including capability for focusing and steering the beam;

5.4.2 Faster scanning and increased probability of detection due to multiple lines/angles acquired and displayed in a single pass;

5.4.3 Increased ability to examine complex geometries and areas with limited access;

5.4.4 Better imaging from the true depth S-scan;

5.4.5 Digital data storage capability, which is intended to enable auditing, archiving, and off-line post-processing, reprocessing, and comparison of data from different examinations;

5.4.6 Rapid and reproducible set-ups with electronic instruments.

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.

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

[6] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

13.1, unless otherwise specified. Since acceptance criteria are not specified in this standard, they shall be specified in the contractual agreement.

6.9 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this standard and, if required, shall be specified in the contractual agreement.

7. Equipment

7.1 *Phased Array Instruments:*

7.1.1 The ultrasonic phased array instrument shall be a pulse echo type with multiple independent pulser/receiver channels equipped with a standardized dB gain or attenuation control stepped in increments of 1 dB minimum. The system shall be capable of generating and displaying both B-scan and S-scan images (ideally C-Scan image capability should also be available), which can be stored and recalled for subsequent review.

7.1.2 The phased array system shall have on-board focal law generation software that permits direct modification to ultrasonic beam characteristics. Specific delay calculations may be performed by the system itself or imported from external calculations.

7.1.3 The phased array system shall have a means of data storage for archiving scan data. An external storage device, flash card, or USB memory stick can be used for data storage. A remote portable PC connected to the instrument may also be used for this purpose. If instruments do not inherently store A-scan data, such as some manual instruments, the final image only may be recorded.

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7.1.4 The phased array system shall be standardized for amplitude and height linearity in accordance with Guide E2491 annually, at a minimum.

7.1.5 The instrument shall be capable of pulsing and receiving at nominal frequencies of 1 MHz to 10 MHz. For special applications, higher frequencies can be used, but may require special instrumentation with appropriate digitization capability.

7.1.6 The instrument shall be capable of digitization of A-scans at a minimum of five times the nominal frequency of the probe used. Amplitude shall be digitized at a resolution of at least 8-bit (that is, 256 levels).

7.1.7 The instrument shall be capable of equalizing the amplitude response from a target at a fixed sound path for each angle used in the technique (angle corrected gain (ACG)), thereby providing compensation for wedge attenuation variation and echo-transmittance.

7.1.8 The instrument shall also be equipped with facilities to equalize amplitudes of signals across the time-base (time-corrected gain (TCG)).

7.2 *Phased Array Probes:*

7.2.1 The application requirements will dictate the design, including number of elements, element dimensions, and pitch, of the phased array probe used.

7.2.2 The probe selected shall not have more elements than the number of elements addressable by the pulser-receivers available in the phased array instrument being used.

7.2.3 Phased array probes used for weld examination may be of 1D, 1.5D, or 2D design. For manual scanning techniques, 1D arrays or dual arrays configured with side-by-side transmitter-receiver arrays (as in Transmit-Receive Longitudinal wave probes) are recommended. For 2D arrays, standardization should be performed at all skewed angles.

7.2.4 Phased array probes may be used with a removable or integral wedge, delay-line, or in an immersion or localized bubbler system mode. In some cases, a phased array probe may be used without a refracting wedge or delay-line (that is, just a hard wear-face surface).

7.2.5 When refracting wedges are used to assist beam steering, the natural incident angle of the wedge shall be selected such that the angular sweep range of the examination technique used does not exceed the manufacturer's recommended limits for the probe and mode (compression or transverse) used; this will minimize spurious indications/interference due to grating lobes.

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. Standardization

8.1 *General:*

8.1.1 A baseline assessment of probe element activity shall be made in accordance with Annex A3 of Guide E2491.

8.1.2 Standardization shall include the complete ultrasonic phased array system and shall be performed prior to use of the system in the thickness range under examination.

8.1.3 Standardization on reference block(s) shall be performed from the surface (clad or unclad; convex or concave) corresponding to the surface of the component from which the examination will be performed.

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.

8.2.3 Commercial reference blocks such as the PAUT IIW Block (ISO 19675), the IIW Block (ISO 2400), or other reference blocks discussed in Practice E164 may be used to facilitate the adjustment and standardization of the PAUT equipment.

8.3 *Range:*

8.3.1 The instrument display shall be adjusted using the A-scans for each focal law used to provide an accurate indication of sound travel in the test material. Range standardization shall include correction for wedge travel time so that the zero-depth position in the test piece is accurately indicated for each focal law.

8.3.2 Time base linearity and accuracy shall be verified in accordance with the guidelines in Guide E2491 or Practice E317, or both.

8.3.3 Volume-corrected B-scan or S-scan displays shall indicate the true depth to known targets to within 5 % of the physical depth or 3 mm, whichever is less.

8.3.4 Range standardization shall be established using the radius surfaces in reference blocks such as those noted in 8.2.

8.4 *Angular Sensitivity:*

8.4.1 Sensitivity standardization, also referred to as angle corrected gain (ACG), equalizes the amplitude at all angles or focal laws in the active group on a single reference target (see 8.2.2). Consistency in coupling and pressure is crucial for accurate standardization.

8.4.2 The instrument sensitivity shall be standardized using the manufacturer's recommended procedure; or alternatively, by first choosing the desired standardization amplitude (usually 80 % FSH), then sliding the probe back and forth over the selected target so that the raw target amplitude for each angle is captured, and finally, invoking the instrument's automatic ACG calculation feature to generate and save required gain correction factors for each angle.

8.4.3 Successful angular sensitivity standardization shall be verified by sliding the probe over the reference block and visualizing all focal laws corrected to the chosen standardization amplitude (usually 80 % FSH), within tolerance.

9. Coupling Conditions

9.1 *Preparation:*

9.1.1 Where accessible, prepare the surface of the deposited weld metal so that it merges into the surfaces of the adjacent base materials; however, the weld may be examined in the as-welded condition, provided the surface condition does not interfere with valid interpretation of indications.

9.1.2 Clean the scanning surfaces on the base material of weld spatter, scale, dirt, rust, and any extreme roughness on each side of the weld for a distance equal to several times the thickness of the production material, this distance to be governed by the size of the search unit and refracted angle of the sound beam. Where scanning is to be performed along the top or across this weld, the weld reinforcement may be ground to provide a flat scanning surface. It is important to produce a surface that is as flat as possible. Generally, the surfaces do not require polishing; light sanding with a disk or belt sander will usually provide a satisfactory surface for examination.

9.1.3 The area of the base material through which the sound will travel in the angle-beam examination should be completely scanned with a straight-beam search unit to detect reflectors that might affect the interpretation of angle-beam results by obstructing the sound beam. Consideration must be given to these reflectors during interpretation of weld examination results, but their detection is not necessarily a basis for rejection of the base material.

9.2 *Couplant:*

9.2.1 A couplant, usually a liquid or semi-liquid, is required between the face of the search unit and the surface to permit transmission of the acoustic energy from the search unit to the material under examination. The couplant should wet the surfaces of the search unit and the test piece, and eliminate any air space between the two. Typical couplants include water, oil, grease, glycerin, and cellulose gum. The couplant used should not be injurious to the material to be examined, should form a thin film, and, with the exception of water, should be used sparingly. When glycerin is used, a small amount of wetting agent is often added, to improve the coupling properties. When water is used, it should be clean and de-aerated if possible. Inhibitors or wetting agents, or both, may be used.

9.2.2 The coupling medium should be selected so that its viscosity is appropriate for the surface finish of the material to be examined.

9.3 For contact examination, the temperature differential between the reference block and examination surface shall be within 15 °C.

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.

10.2 Alternative methods of distance-amplitude of correction of sensitivity may be used, provided the results are as reliable as those obtained by the acceptable method. In addition, the alternative method and its equipment shall meet all the performance requirements of this standard.

10.3 *Reference Reflectors:*

10.3.1 *Straight-Beam Standardization*—Correction for straight beam examination may be determined by means of a side drilled hole reflector at ¼ and ¾ of the thickness. For thickness less than 50 mm, the ¼-thickness reflector may not be resolved. If this is the case, drill another hole at ½ thickness and use the ½ and ¾-thickness reflectors for correction.

10.3.2 *Angle-Beam Standardization*—Correction for angle-beam examination may be determined by means of side-drilled hole reflectors at ¼ and ¾ of the thickness. The ½-thickness depth to a side-drilled hole may be added to the standardization or used alone at thicknesses less than 25 mm. For certain combinations of thin wall and small diameter pipe, side drilled holes may not be practical and surface notches may be used with agreement between contracting parties.

10.3.3 The size of the side-drilled hole used for setting sensitivity shall be agreed upon by the contracting parties.

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Other targets may be substituted for side-drilled holes if agreed upon by the contracting parties.

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. Therefore, it is necessary that the display used provide a uniform color code related to amplitude at all sound path distances. This method can be used only if the instrument is provided with electronic distance amplitude compensation circuitry (TCG). Use is made of all reflectors in the standardization range. The examination equipment, probe(s), focal law(s), couplant, etc., to be used in the ultrasonic examination shall be used for this attenuation adjustment.

10.4.2 With the instrument display in time or sound path (not true depth), locate the focal law that provides the maximum response from the reference targets. Set the signal from the reference reflector that gives the highest response to a screen height of between 40 % to 80 % full screen height (FSH). This target may be considered the primary reference reflector.

10.4.3 Using the same focal law, maximize each of the other reference reflectors at other distances over the range to be used for examination, adjusting the electronic distance amplitude correction controls to equalize the screen height from these reference reflectors to the primary reflector. Apply the correction to all focal laws used for the examination.

10.4.4 Other methods of accomplishing the equalization of amplitude for all focal laws used from equal-size reflectors over the examination distance range may be used. The method for the system used is best described for each instrument in the operating manual for that instrument.

10.4.5 An example of sensitivity standardization for weld examination using side-drilled holes is shown in Fig. 1. Note the amplitude responses from the side drilled holes is the same for each hole even though the angle used to detect the hole and the sound path to the hole are different in each instance. The modeled coverage in the upper portion of Fig. 1 illustrates the beams as if they were projected instead of reflected off the opposite wall. The weld profile overlay allows visualization sound path to the side drilled holes.

10.5 Periodic checks of the sensitivity shall be made at a frequency agreed upon by the contracting parties. If the equipment has changed by more than the agreed upon tolerances, it shall be re-standardized. If the source of sensitivity change is a result of change in the number of active elements compared to the baseline assessment, it may require probe replacement.

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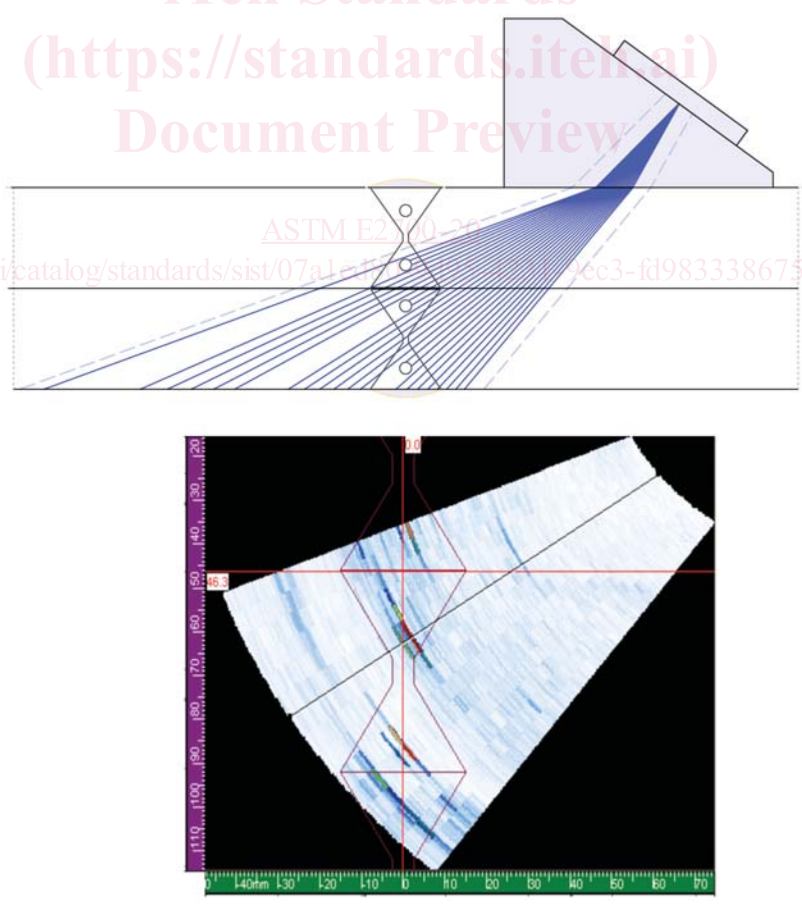

FIG. 1 Modeled S-scan and S-scan Display of Side-Drilled Holes Corrected to 80 % Screen Height Using TCG

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.

11.3 In addition, if cross-cracking (transverse cracking) is suspected, a supplementary technique shall be used that directs the beam parallel or essentially parallel to the weld centerline. The technique used will depend on whether or not the weld reinforcement has been ground flush or not.

11.4 Typically, scanning is carried out from the surfaces where the plate has been machined with the weld bevel. Alternative scanning techniques shall be used for different weld profiles. Sample illustrations are shown in Figs. 2-7. Not all possible configurations are illustrated; illustrations are examples only. Volume coverage afforded by multiple stand-off positions of probes are illustrated for encoded linear scans. This can be replaced with raster scanning where the stand-offs are continuously varied to the limits required using manual movement of the probes.

11.5 Scanning may be by manual probe motion or automated or semi-automated motion.

11.6 For manual scanning, the primary scan pattern is a raster motion with the beam directed essentially perpendicular to the weld axis. The distance forward and backward that the probe is moved is determined by the scan plan to ensure full volume coverage. The lateral movement on each raster step shall not exceed half the element dimension in the lateral direction. Scanning speed (speed at which the probe is manually moved forward and backward) will be limited by the system update capabilities. Generally, using more focal laws requires more processing time so update rates of the B-scan or S-scan displays are slower as more focal laws are used.

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 frames or magnetic strips are used to ensure that the probe moves at a fixed distance from the weld centerline. Data, in the form of A-scans from each focal law used, shall be collected at increments of not greater than 2 mm (with at least three increments for the length of the smallest required detectable defect, that is, a defect length of 3 mm would require increments of not greater than 1 mm) along the scan axis. Note that this interval should be reduced when length sizing of flaws is critical with respect to the acceptance criteria. If laterally focused beams are used, this can be considered for data collection increments as above.

11.8 For encoded scanning only, multiple probes and multiple focal law groups (for example, two S-scans from the same probe but having difference start elements) may be used simultaneously if the system has the capability. Probe placement will be defined by the details of the scan plan with confirmation of coverage confirmed using notches that may be incorporated into the reference block.

12. Indication Evaluation

12.1 The method of evaluation used will, to some extent, depend on whether manual or encoded scanning was used.

12.2 *Manual Scanning:*

12.2.1 For manual scanning using phased arrays, examination personnel shall use a real-time C-Scan, S-scan, or B-scan display during scanning to monitor for coupling quality and signals exceeding the evaluation threshold.

12.2.2 Evaluation of indications detected using manual phased array methods shall require the operator to assess all indications exceeding the evaluation threshold when the indication is detected during the scanning process. Some phased-array systems may include options for entering some items into a report format and incorporating C-Scan, S-scan, or B-scan images as part of the report.

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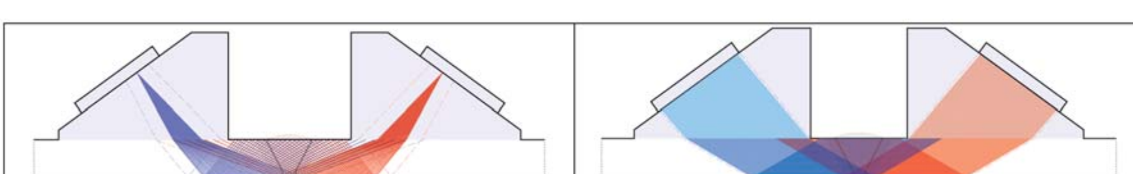
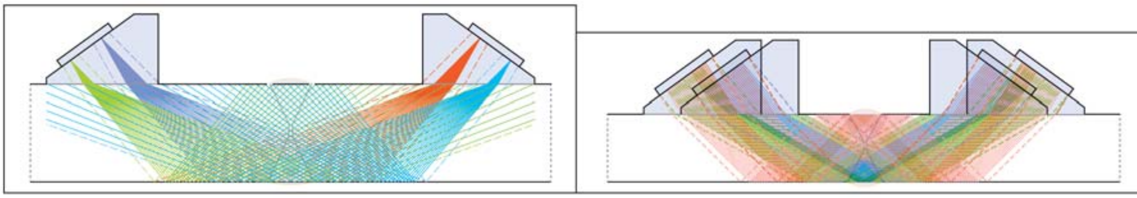


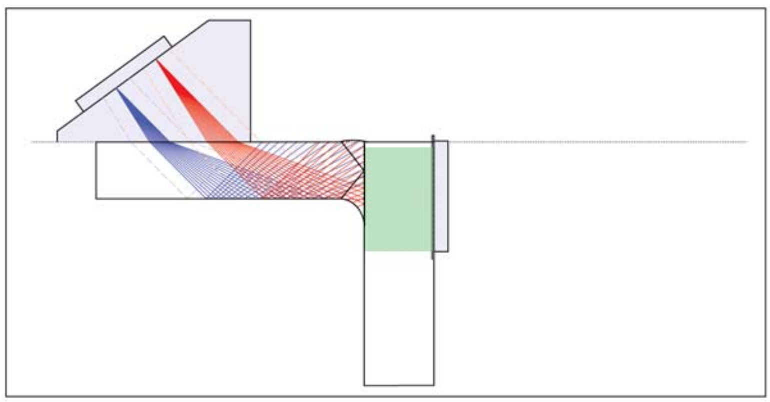
NOTE 1—Butt welds should be examined from both sides of the weld and preferably from the bevel opening side (when access permits). For thin wall sections, a single probe stand-off may be possible for linear scanning if the probe parameters are adequate for full volume coverage.

FIG. 2 Thin Butt Weld (S and E Scans)



NOTE 1—Butt welds should be examined from both sides of the weld and preferably from the bevel opening side (when access permits). For thick wall sections, multiple probe stand-offs or multiple focal law stand-offs will be required for linear scanning to ensure full volume coverage.

FIG. 3 Thick Butt Welds (S and E Scans)



NOTE 1—Corner welds are to be addressed using a combination of angle beams and straight beams. The preferred probe placement for the angle beam is on the surface where the weld bevel opening occurs. For double Vee welds, angle beam examinations should be carried out from both surfaces when access permits. In most cases, the surface from which the straight beam is used needs no further examination using angle beams.

FIG. 4 Corner Welds (Combined S and E Scans)

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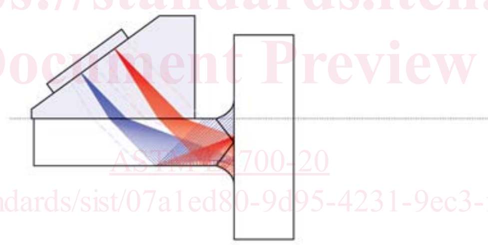
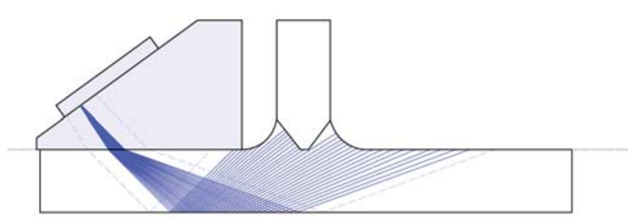


NOTE 1—T-weld examinations may be treated similarly to butt welds. For thin sections, it may be possible to use a single stand-off position with either E-scans or S-scans. Examination from both surfaces of the web-plate plate should be used when access permits.

FIG. 5 T-Weld (from Web)



NOTE 1—An alternative to the technique illustrated in Fig. 5 for T-welds is to use refracted shear wave S-scans or E-scans from web-side of flange surface. More than one stand-off position may be required for thicker sections. Examination from both sides of the web plate should be used when access permits. This technique is not generally considered to be as effective as the technique described in Fig. 5.

FIG. 6 Tee Welds (from Flange)

12.3 *Encoded Scanning:*

12.3.1 Encoded scanning methods rely on assessment of data displays produced from stored A-scans.

12.3.2 Encoded systems may be equipped with real-time displays to display one or more views of data being collected during the scan. This feature will be used only for assessment of data quality as the scan is progressing and may allow for one or more channels to be monitored.

12.3.3 Evaluation of indications detected by encoded phased array scanning shall be made using the digitized waveforms underlying the S-scans or B-scans collected during the data acquisition process.