

Procedure



Ultrasonic Testing Shear Wave Procedure

March 2026

REVISION INDEX

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1.0 PURPOSE

- 1.1 The purpose of this procedure is to provide the specific requirements, methods, and techniques to be used when performing, evaluating, and documenting contact Manual Ultrasonic Testing (MUT) examinations of ASME Section I and Section VIII Pressure Vessel Welds, as well as B31.1 and B31.3 Piping Welds.

2.0 SCOPE

- 2.1 This procedure is applicable to ultrasonic weld examinations in rolled, drawn, forged, or extruded product forms in pressure vessel butt and nozzle welds, as well as piping butt and attachment welds.
- 2.2 Pressure Vessel Welds - This procedure is intended for the use of MUT examinations on pressure vessel butt and nozzle welds with thicknesses ≥ 0.250 " for the detection of fabrication flaws.
- 2.3 Piping Welds - This procedure is intended for the use of MUT examination of piping butt welds and full penetration attachment welds with thicknesses ≥ 0.250 " for the detection of fabrication flaws.
- 2.4 This procedure applies to single vee, double vee, J-bevel joint, single bevel, double bevel configurations of butt weld, as well as sit-in or set-on nozzle welds.
- 2.5 This procedure is to be used only when welds being examined are in the surface temperature range of 40°F to 200°F.
- 2.6 This procedure covers the general method for contact scanning from the O.D. surfaces with equipment and techniques utilizing search units capable of generating shear wave primarily of 45°, 60° and 70°.
- 2.7 Procedure Qualification - When procedure qualification is specified, by an ASME referencing Code Section, a change of an essential variable from the specified value, or range of values listed in Table T-421 of Article 4 in Section V, shall require requalification of this written procedure by demonstration. A change of a nonessential variable from the specified value, or range of values listed in Table T-421 does not require requalification of this written procedure. All changes of essential or nonessential variables specified within this written procedure shall require a revision of, or an addendum to, this written procedure.

| Requirement | Essential Variable | Nonessential Variable |
|---|--------------------|-----------------------|
| Weld configurations to be examined, including thickness dimensions and base material product form (pipe, plate, etc.) | X | ... |
| The surfaces from which the examination shall be performed | X | ... |
| Technique(s) (straight beam, angle beam, contact, and/or immersion) | X | ... |
| Angle(s) and mode(s) of wave propagation in the material | X | ... |
| Search unit type(s), frequency(ies), and element size(s)/shape(s) | X | ... |
| Special search units, wedges, shoes, or saddles, when used | X | ... |
| Ultrasonic instrument(s) | X | ... |
| Calibration [calibration block(s) and technique(s)] | X | ... |
| Directions and extent of scanning | X | ... |
| Scanning (manual vs. automatic) | X | ... |
| Method for discriminating geometric from flaw indications | X | ... |
| Method for sizing indications | X | ... |
| Computer enhanced data acquisition, when used | X | ... |
| Scan overlap (decrease only) | X | ... |
| Personnel performance requirements, when required | X | ... |
| Personnel qualification requirements | ... | X |
| Surface condition (examination surface, calibration block) | ... | X |
| Couplant: brand name or type | ... | X |
| Post-examination cleaning technique | ... | X |
| Automatic alarm and/or recording equipment, when applicable | ... | X |
| Records, including minimum calibration data to be recorded (e.g., instrument settings) | ... | X |

3.0 DEFINITIONS

3.1 Ultrasonic examination definitions and terminology shall be in accordance with Mandatory Appendix I, paragraph I-121 and I-121.2 UT, in Article 1 of the ASME Section V Code.

4.0 REFERENCE DOCUMENTS

4.1 The following National Codes, Standards, and Specifications, were referenced in the preparation of this document:

- 4.1.1 ASME BPVC Section I, Rules for Construction of Power Boilers, 2025 Edition
- 4.1.2 ASME BPVC Section V, Nondestructive Examination, 2025 Edition
- 4.1.3 ASME BPVC Section VIII (Div. 1 & 2), Rules for Construction of Pressure Vessels, 2025 Edition
- 4.1.4 ASME B31.1, Power Piping, 2024 Edition
- 4.1.5 ASME B31.3, Process Piping, 2024 Edition
- 4.1.6 IPS-WP-01, IPS’ Written Practice for the Qualification and Certification of NDE Personnel
- 4.1.7 ASNT, RP No. SNT-TC-1A

5.0 PERSONNEL REQUIREMENTS

- 5.1 Personnel who perform, analyze, interpret data, or report results shall be qualified and certified in accordance with the IPS' Written Practice IPS-WP-01, as a UT Level II or III.

6.0 EQUIPMENT REQUIREMENTS

6.1 Instrument Requirements

- 6.1.1 A pulse-echo-type of ultrasonic instrument shall be used. The instrument shall be capable of operation at frequencies over the range of at least 1 to 5 MHz and shall be equipped with a stepped gain control of 2.0 dB or less.
- 6.1.2 The dampening control may be used if it is proven during calibration/qualification to not reduce the sensitivity of the examination.
- 6.1.3 The reject control shall be in the "off" position for all examinations, unless it can be demonstrated that it does not affect the linearity of the examination.
- 6.1.4 The instrument, when required because of the technique being used, shall have both send and receive jacks for operation of dual search units or a single search unit with send and receive transducers.

6.2 Search Units:

- 6.2.1 General. This procedure applies to single element and dual element transducers with frequencies over a range of 1 to 5 MHz and sizes ranging from .25" to 1.5", and capable of producing longitudinal (straight beam), refracted longitudinal waves, and shear waves.
- 6.2.1.1 The nominal frequency shall be from 1 MHz to 5 MHz unless variables, such as production material grain structure, require the use of other frequencies to assure adequate penetration or better resolution. Search units with contoured contact wedges may be used to aid ultrasonic coupling. If a contoured wedge is used, the calibration block diameter shall also meet the requirements for the selected wedge curvature range (section 6.2.5).
- 6.2.2 The same search unit (transducer and wedge) and nominal frequency used during calibration shall be the same used during the examination.
- 6.2.3 Contact Wedges – When required below, examinations performed on a curved component shall be performed using a contoured wedge, to ensure sufficient ultrasonic coupling is achieved and to limit any potential rocking of the search unit as it is moved along the circumference of the component.
- 6.2.4 Wedges shall be contoured if the component diameter to be examined is equal to or less than D using the calculation below:

$$D \leq \frac{A^2}{0.113 \text{ in. (2.87 mm)}}$$

Where:

A = length of search unit footprint during circumferential scanning or the width when scanning in the axial direction, in.

D = the component diameter at the examination surface (O.D.), in.

The footprint is defined as the physical dimension of the search unit in the curved direction of the component.

6.2.5 When required per above, the wedge contour dimension shall be selected from Table 1 below and shall be determined using the same component dimension from which the examination is being performed (O.D.).

| Table 1 | |
|--|---|
| Maximum contour for examinations performed from O.D. | |
| Actual Component Outside Diameter, in (mm) | Allowable Increase in Contour Diameter Over Component O.D, in. (mm) |
| <4 (<100) | -0 to +1 (+25) |
| ≥4 to 10 (≥100 to <250) | -0 to +2 (+50) |
| ≥10 to <18 (≥250 to <455) | -0 to +4 (+100) |
| ≥18 to <23 (≥455 to <580) | -0 to +6 (+150) |
| ≥23 (>580) | -0 to +10 (+250) |

6.2.6 Weld Metal Overlay Cladding – Search Unit

6.2.6.1 Dual element, straight beam search units using an angled pitch-catch technique shall be used. The included angle between the search unit’s element shall be such that the effective focal spot distance is centered in the area of interest.

6.3 Couplant

6.3.1 Couplants having good wetting characteristics shall be used. Examples are water, glycerin, and cellulose gum solutions. The same couplant shall be used for calibrations and the examination.

6.3.2 Rust inhibitors, softeners and wetting agents may be added to the couplant, if needed.

6.3.3 The couplant, including additives, shall not be detrimental to the material being examined.

6.3.3.1 Couplants used on nickel based alloys shall not contain more than 250 ppm of sulfur.

6.3.3.2 Couplants used on austenitic stainless steel or titanium shall not contain more than 250 ppm of halides (chlorides plus fluorides).

6.4 Calibration and Reference Blocks

6.4.1 Basic Calibration Blocks - Calibration blocks that are used to establish DAC curves and/or sensitivity shall conform to the following requirements.

6.4.2 Block Materials

6.4.2.1 Similar Metal Welds. The material from which the block is

fabricated shall be of the same product form and material specification or equivalent P-Number grouping as one of the materials being examined. For the purposes of this paragraph, P-Nos. 1, 3, 4, 5A through 5C, and 15A through 15F materials are considered equivalent.

6.4.2.2 Dissimilar Metal Welds. The material selection shall be based on the material on the side of the weld from which the examination will be conducted. If the examination will be conducted from both sides, calibration reflectors shall be provided in both materials.

6.4.2.3 Transfer Correction. When the block material is not of the same product form or has not received the same heat treatment, it may be used provided it meets all other block requirements and a transfer correction for acoustical property differences is used. Transfer correction shall be determined by noting the difference between the signal response, using the same transducers and wedges to be used in the examination, received from either:

- A. The corresponding reference reflector (same type and dimensions) in the basic cal block and in the component to be examined, or
- B. Two search units positioned in the same orientation on the basic calibration block and component to be examined.
- C. The examination sensitivity shall be adjusted for the difference.

6.4.3 **Quality. Prior to fabrication, the block material shall be completely examined with a straight beam search unit. Areas that contain an indication exceeding the remaining back-wall reflection shall be excluded from the beam paths required to reach the various calibration reflectors.**

6.4.4 Cladding

6.4.4.1 Block Selection. The material from which the block is fabricated shall be from one of the following:

16 Nozzle dropout from the component.

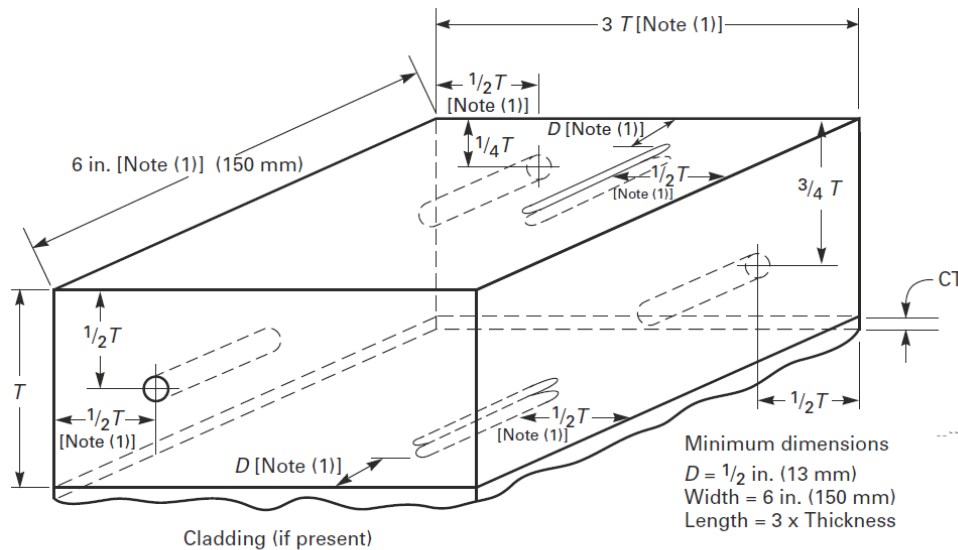
- B. A component prolongation.
- C. Material, including integral clad, of the same material specification, product form, and heat treatment condition as the material to which the search unit is applied during the examination.

6.4.4.2 Where the component material is clad and the cladding is a factor during examination; the block shall be clad to at least the same thickness as the part to be examined. Deposition of clad shall be by the same method as used to clad the component to be examined. When the cladding method is not known or the method of cladding used on the component is impractical for block cladding, deposition of clad may be by the manual method.

- 6.4.4.3 When the parent materials on opposite sides of a weld are clad by different P-, A-, or F-numbers or material designations or methods, the calibration block shall be clad with the same P-, A-, or F-numbers or material designations using the same method used on the side of the weld from which the examination will be conducted. When the examination is conducted from both sides of the weld, the calibration block shall provide for calibration for both materials and methods of cladding. For welds clad with a different material or method than the adjoining parent materials, and it is a factor during the examination, the calibration block shall be designed to be representative of this combination.
- 6.4.5 Heat Treatment - The calibration block shall receive at least the minimum tempering treatment required by the material specification for the type and grade. If the calibration block contains welds other than cladding, and the component weld at the time of examination has been heat treated, the block shall receive the same heat treatment.
- 6.4.6 Surface Finish - The finish on the surface of the block shall be representative of the surface finish on the part to be examined.
- 6.4.7 Block Curvature.
- 6.4.7.1 Materials with Diameters Greater Than 20-inches. For examinations in materials where the examination surface diameter is greater than 20-inches, a single curved basic calibration block may be used to calibrate the examinations on surfaces in the range of curvature from 0.9 to 1.5 times the basic calibration block diameter. Alternatively, a flat basic calibration block may be used.
- 6.4.7.2 Materials with Diameters 20-inches and less. For examinations in materials where the examination surface diameter is equal to or less than 20-inches, a curved block shall be used. Except where otherwise stated in this procedure, 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.
- 6.4.7.3 For example, an 8 in diameter block may be used to calibrate for examinations on surfaces in the range of curvature from 7.2-inches to 12-inches in diameter. The curvature ranges from 0.94-inches to 20-inches in diameter requires 6 curved blocks as shown in Fig. T-434.1.7.2 for any thickness range.
- 6.4.8 Basic Non-Piping Calibration Blocks
- 6.4.8.1 The basic calibration block configuration and reflectors shall be as shown in Figure T-434.2.1.
- 6.4.8.2 The block size and reflector locations shall be adequate to perform calibrations for the beam angle(s) and distance range(s) to be used.

6.4.8.3 Block Thickness. The block thickness (T) shall be per Figure T-434.2.1.

**Figure T-434.2.1
Nonpiping Calibration Blocks**



Notch Dimensions, in. (mm)

Notch depth = 1.6% T to 2.2% T
 Notch width = 1/4 (6) max.
 Notch length = 1 (25) min.

| Weld Thickness (t), in. (mm) | Calibration Block Thickness (T), in. (mm) | Hole Diameter, in. (mm) |
|---------------------------------|--|----------------------------|
| ≤1 (≤25) | 3/4 (19) or t | 3/32 (2.5) |
| >1 (>25) through 2 (50) | 1 1/2 (38) or t | 1/8 (3) |
| >2 (>50) through 4 (100) | 3 (75) or t | 3/16 (5) |
| >4 (>100) | t ±1 (25) | [Note (2)] |

GENERAL NOTES:

- (a) Holes shall be drilled and reamed 1.5 in. (38 mm) deep minimum, essentially parallel to the examination surface.
- (b) For components equal to or less than 20 in. (500 mm) in diameter, calibration block diameter shall meet the requirements of T-434.1.7.2. Two sets of calibration reflectors (holes, notches) oriented 90 deg from each other shall be used. Alternatively, two curved calibration blocks may be used.
- (c) The tolerance for hole diameter shall be ±1/32 in. (0.8 mm). The tolerance for hole location through the calibration block thickness (i.e., distance from the examination surface) shall be ±1/8 in. (3 mm).
- (d) For blocks less than 3/4 in. (19 mm) in thickness, only the 1/2 T side-drilled hole and surface notches are required.
- (e) All holes may be located on the same face (side) of the calibration block, provided care is exercised to locate all the reflectors (holes, notches) to prevent one reflector from affecting the indication from another reflector during calibration. Notches may also be in the same plane as the inline holes (see Nonmandatory Appendix J, Figure J-431). As in Figure J-431, a sufficient number of holes shall be provided for both angle and straight beam calibrations at the 1/4 T, 1/2 T, and 3/4 T depths.
- (f) When cladding is present, notch depth on the cladding side of the block shall be increased by the cladding thickness, CT (i.e., 1.6% T + CT minimum to 2.2% T + CT maximum).
- (g) Maximum notch width is not critical. Notches may be made by EDM or with end mills up to 1/4 in. (6.4 mm) in diameter.
- (h) Weld thickness, t, is the nominal material thickness for welds without reinforcement or, for welds with reinforcement, the nominal material thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing Code Section. When two or more base material thicknesses are involved, the calibration block thickness, T, shall be determined by the average thickness of the weld; alternatively, a calibration block based on the greater base material thickness may be used provided the reference reflector size is based upon the average weld thickness.

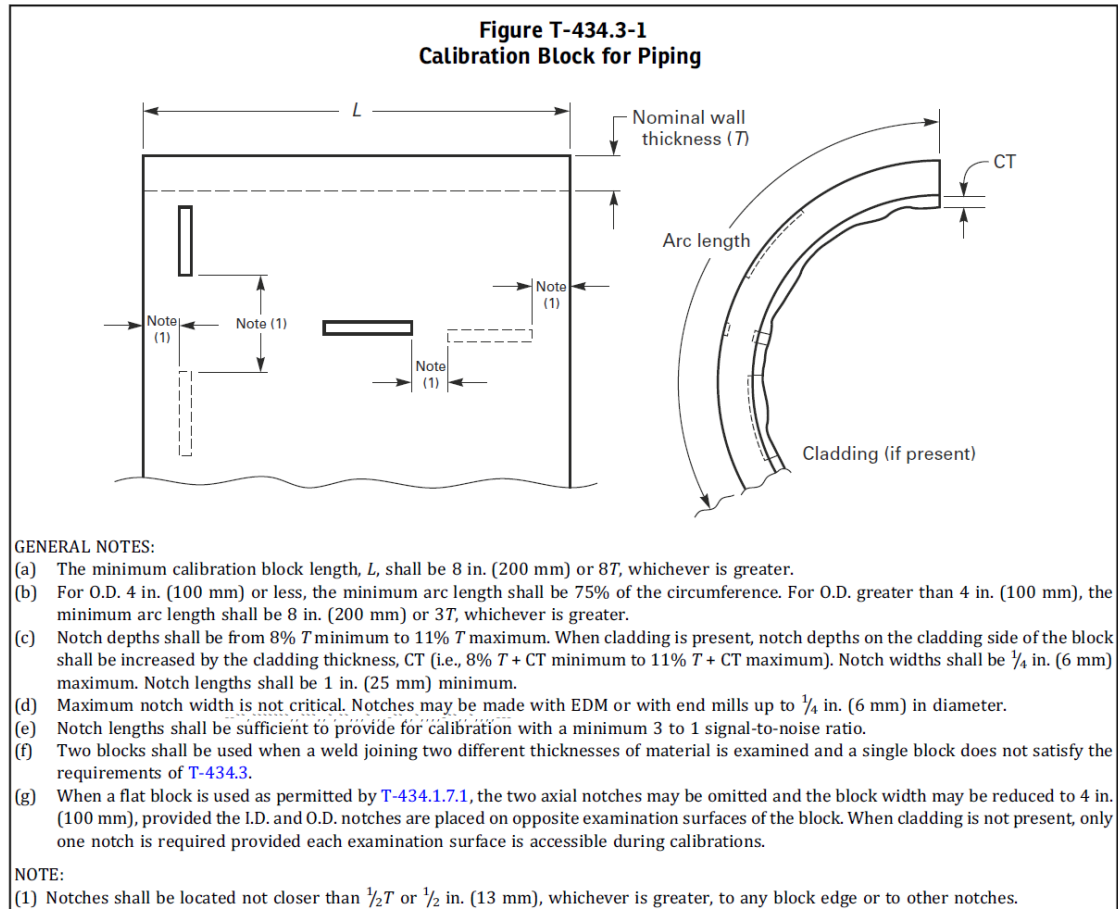
NOTES:

- (1) Minimum dimension.
- (2) For each increase in weld thickness of 2 in. (50 mm) or fraction thereof over 4 in. (100 mm), the hole diameter shall increase 1/16 in. (1.5 mm).

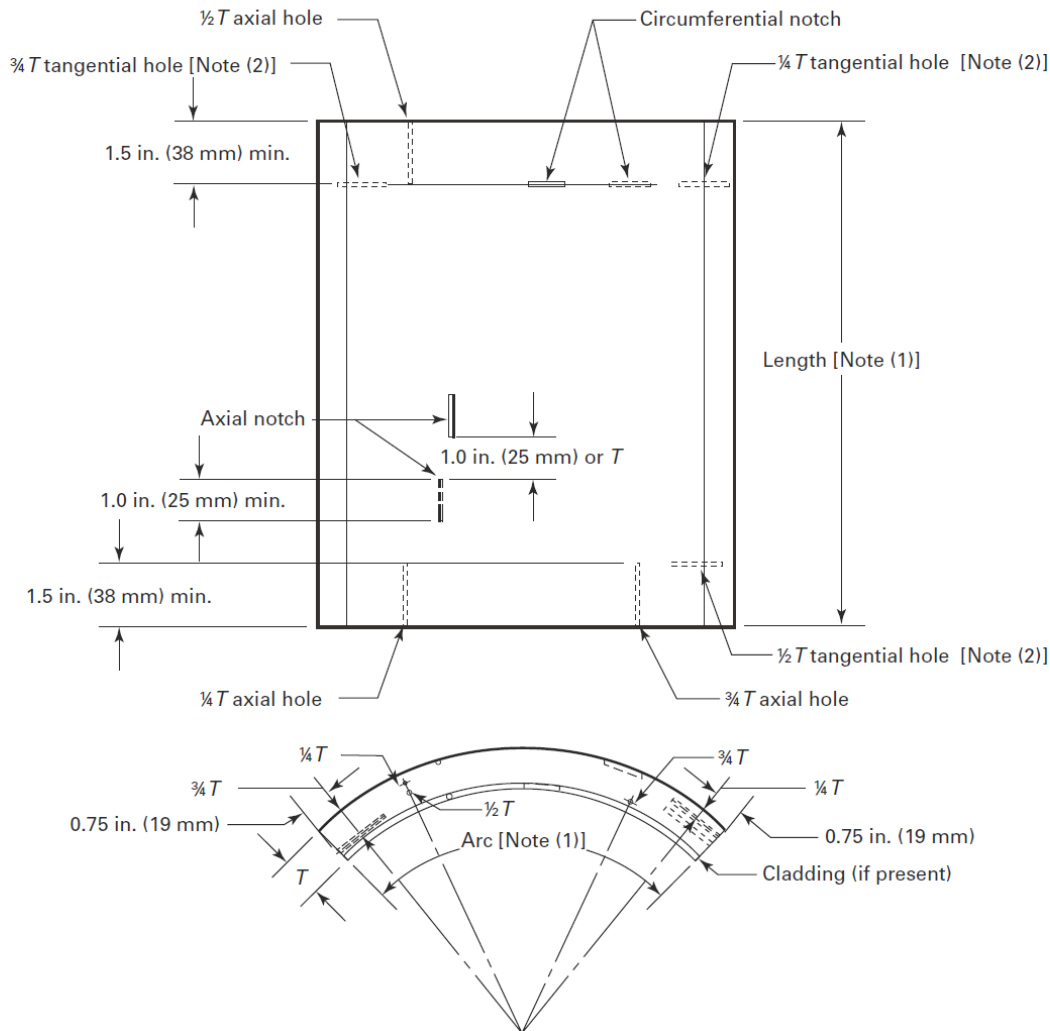
6.4.9 Basic Piping Calibration Blocks.

6.4.9.1 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 paragraph 6.4.7. Thickness, T , shall be $\pm 25\%$ of the nominal thickness of the component to be examined.

6.4.9.2 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-434.3-2
Alternate Calibration Block for Piping**



GENERAL NOTES:

- (a) For blocks less than 3/4 in. (19 mm) in thickness, only the 1/2 T side drilled hole is required.
- (b) Inclusion of notches is optional. Notches as shown in Figure T-434.3-1 may be utilized in conjunction with this calibration block.
- (c) Notch depths shall be from 8% T minimum to 11% T maximum. Notch widths shall be 1/4 in. (6 mm) maximum. Notch lengths shall be 1 in. (25 mm) minimum.
- (d) Notches may be made with EDM or with end mills up to 1/4 in. (6 mm) in diameter.
- (e) Notch lengths shall be sufficient to provide for calibration with a minimum 3 to 1 signal-to-noise ratio.
- (f) Notches shall be located not closer than T or 1 1/2 in. (38 mm), whichever is greater, to any block edge or to other notches.

NOTES:

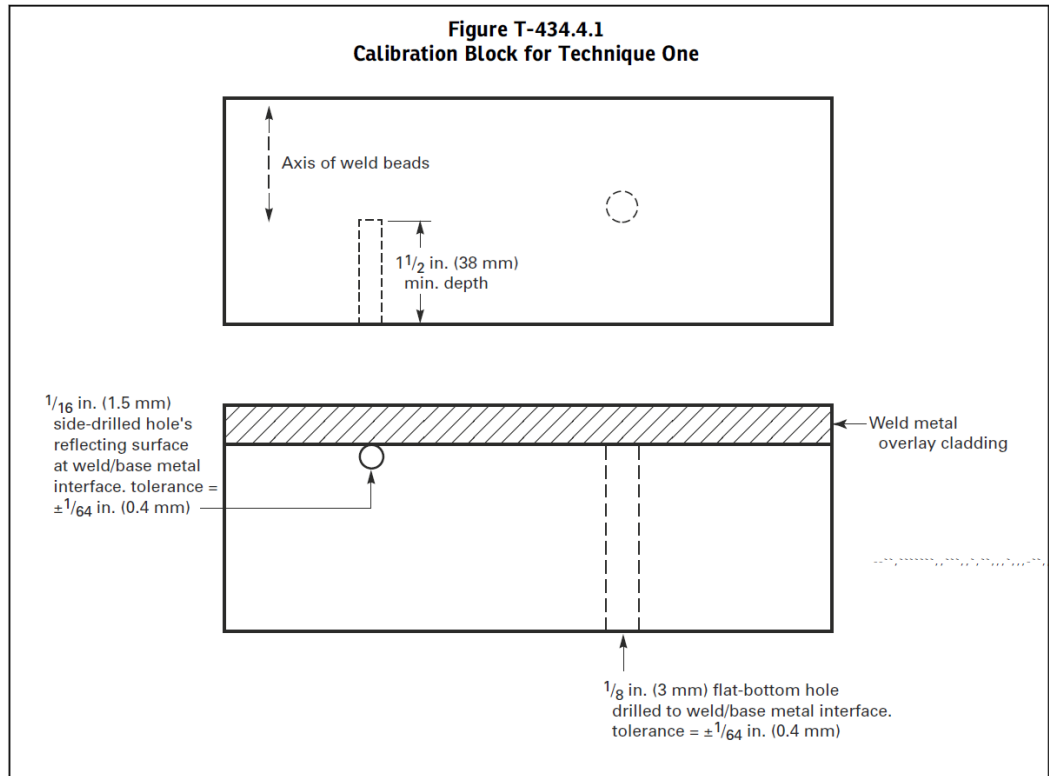
- (1) Length and arc shall be adequate to provide required angle beam calibration.
- (2) Side-drilled hole diameter, length, and tolerance shall be in accordance with T-434.2.1, as permitted by T-464.1.3. Tangential side-drilled holes at 1/4 T, 1/2 T, and 3/4 T positions or locations are to have the depth confirmed at one-half of their length. The radius of the side-drilled hole shall be added to the measured depth to ensure the correct depth. Where thickness does not permit, the required depth of the side-drilled hole and the location of the tangential position shall be indicated on the block surface.

6.4.10 Weld Metal Overlay Cladding Calibration Blocks. (Technique One)

6.4.10.1 The basic calibration block configuration and reflectors shall be as shown in Figure T-434.4.1. Either a side-drilled hole or flat bottom hole may be used.

6.4.10.2 The thickness of the weld metal overlay cladding shall be at least as thick as that to be examined. The thickness of the base material shall be at least twice the thickness of the weld metal overlay cladding.

6.4.10.3 The block curvature shall be in accordance with section 6.4.7.

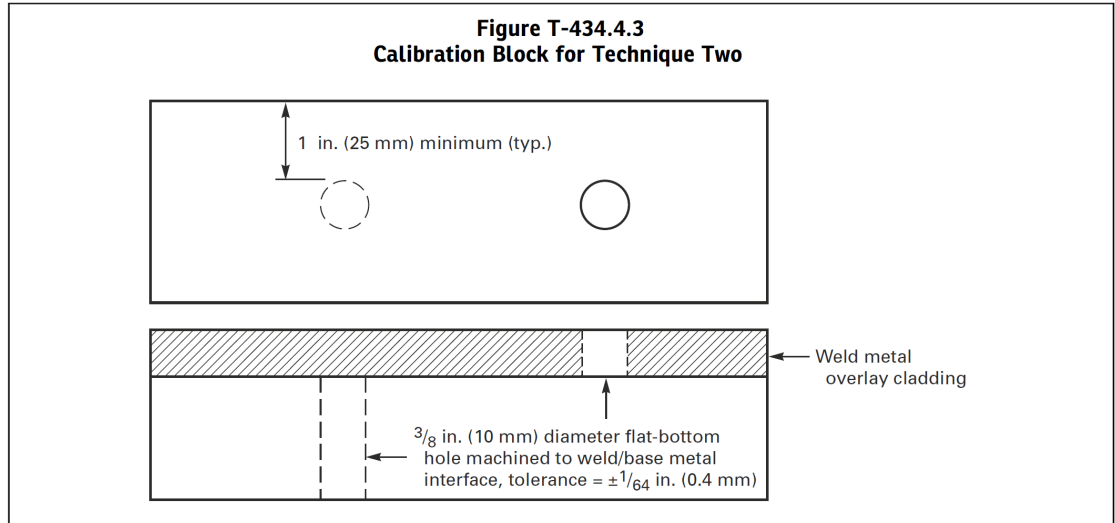


6.4.11 Weld Metal Overlay Cladding Calibration Blocks. (Technique Two)

6.4.11.1 The basic calibration block configuration and reflectors shall be as shown in Figure T-434.4.3. A flat bottom hole drilled to the weld/base metal interface shall be used. This hole may be drilled from the base material or weld metal overlay cladding side.

6.4.11.2 The thickness of the weld metal overlay cladding shall be at least as thick as that to be examined. The thickness of the base material shall be within 1.0 inch of the calibration block thickness when the examination is performed from the base material surface. The thickness of the base material on the calibration block shall be at least twice the thickness of the weld metal overlay cladding when the examination is performed from the weld metal overlay cladding surface.

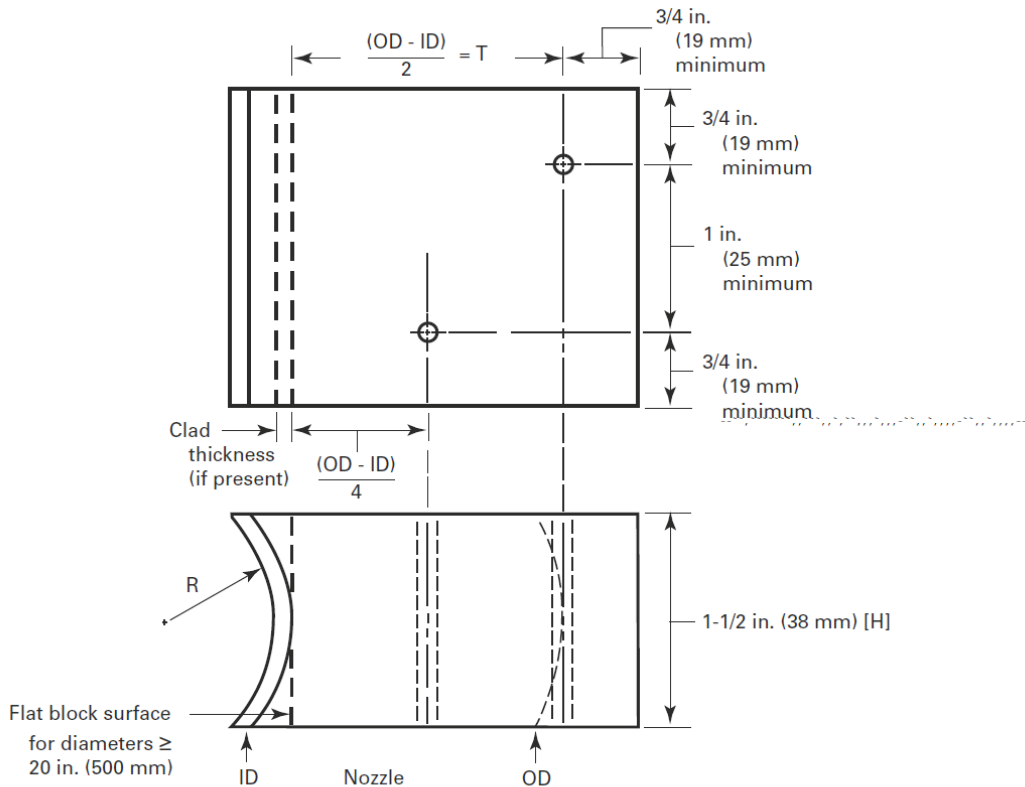
6.4.11.3 The block curvature shall be in accordance with section 6.4.7.



6.4.12 Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal Calibration Blocks.

6.4.12.1 Configuration. The calibration block configuration shall be as shown in Figure T-434.5.1. The block size and reflector locations shall be adequate to perform calibrations to cover the nozzle parent metal. If the internal surface of the nozzle is clad before the examination, the ID surface of the calibration block shall be clad.

Figure T-434.5.1
Calibration Block for Straight Beam Examination of Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal



GENERAL NOTES:

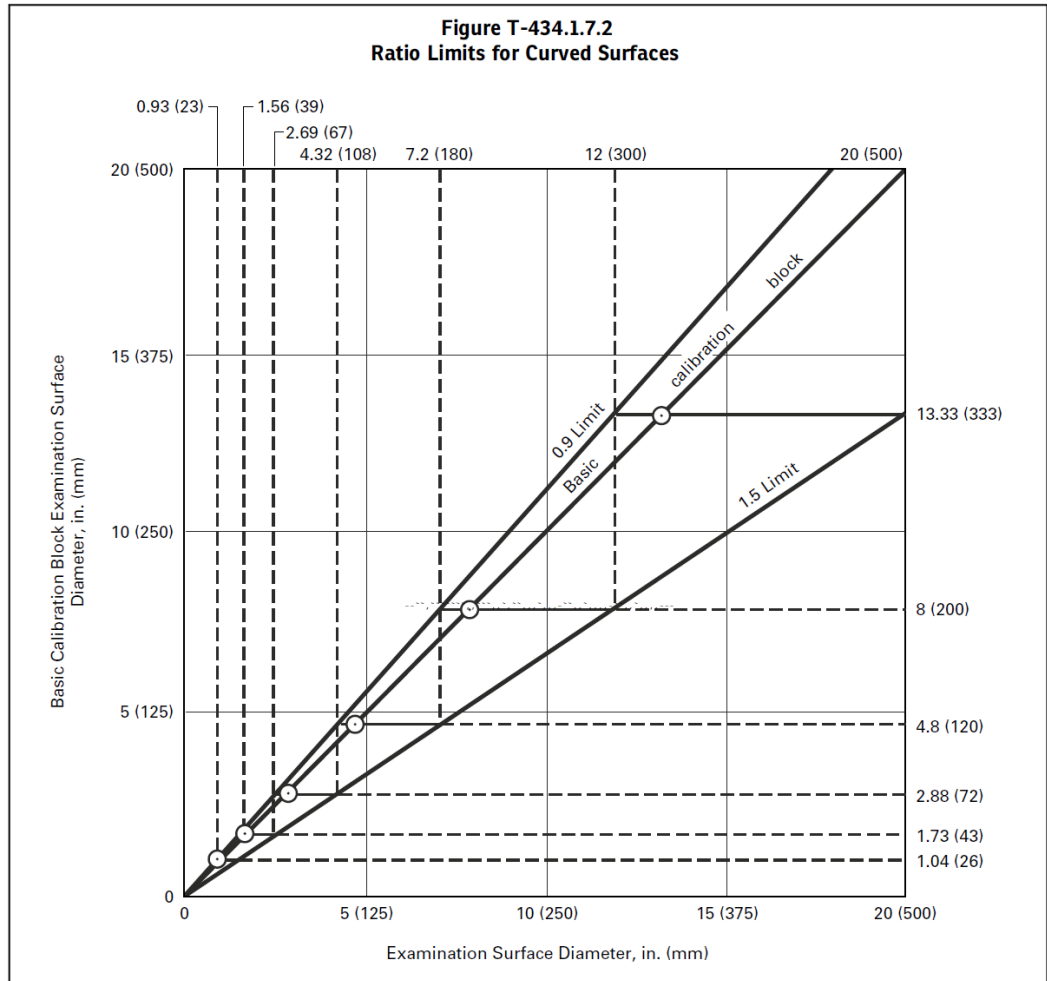
- (a) The thickness, T , of the calibration block $(O.D. - I.D.)/2$ shall be selected for the maximum nozzle wall thickness under the nozzle attachment weld.
- (b) Side-drilled holes shall be drilled and reamed the full height, H , of the block.
- (c) The diameter of the side-drilled holes shall be selected for the maximum nozzle wall thickness per (a) above and [Figure T-434.2.1](#).
- (d) For nozzle side examinations, when the wall thickness of the calibration block exceeds 2 in. (50 mm), additional side-drilled holes shall be placed in the block as required in the table below.

| Calibration Block Wall Thickness, in. (mm) | Hole Location, $\frac{5}{8}T$ | Hole Location, $\frac{3}{4}T$ | Hole Location, $\frac{7}{8}T$ |
|---|----------------------------------|----------------------------------|----------------------------------|
| >2 (>50) through 3 (75) | ... | X | ... |
| >3 (>75) | X | X | X |

6.4.12.2 Block Thickness. The calibration block shall be the

maximum thickness of the nozzle wall adjacent to the nozzle weld plus 3/4 in.

6.4.12.3 Curvature. For examinations of nozzles with an inside diameter (I.D.) equal to or less than 20 in., the contact surface of the calibration block shall have the same curvature or be within the range of 0.9 to 1.5 times the diameter as detailed in Figure 434.1.7.2.



6.4.12.4 Calibration Reflectors. The calibration reflectors shall be side-drilled hole(s) that are in accordance with the requirements of Figure T-434.2.1 for the nozzle wall thickness.

6.4.12.5 Alternative Blocks. Alternative calibration blocks may be used for similar types of examinations provided the sound path distance(s) to the block’s reflector(s) is(are) within 1/4 in. of what is required and the side drilled hole(s) is(are) the same or a smaller diameter than what is required.

6.4.13 Reference Blocks (i.e., IIW, DSC, Rompas, etc.) used for establishing linear screen ranges and determining actual refracted angle and exit

point information shall be made of a material that meets the requirement of paragraph 6.4.2.1.

- 6.4.13.1 Reference blocks used for performing calibration verifications (calibration checks) may be made of any suitable material if adequate sweep and amplitude verification points can be established.

7.0 SURFACE PREPARATION

- 7.1 In general, satisfactory results may be obtained when the surface of the part is in the as-rolled, as-welded or as-forged condition. However, surface preparation by grinding, machining or other methods may be necessary where surface irregularities could mask indications of discontinuities.
- 7.2 Any weld crown condition that prohibits adequate volumetric coverage from the base material surface in either the axial or circumferential directions shall be documented on the Examination Report.
- 7.3 Prior to ultrasonic examinations, the surface to be examined and the adjacent area within 1 inch, shall be cleaned and shall be free of any rust, scale, welding flux, spatter, grease, paint, oily film, dirt, or other extraneous material that could obscure openings or otherwise interfere with the examination.
- 7.4 Mechanical cleaning of test surfaces using power wire brushes, power grinders, or sand or grit blast operations may reduce the sensitivity of the test, and shall be performed with appropriate caution.
- 7.4.1 The use of hand scrapers, plastic abrasive pads, hand brushes, and similar types of mechanical cleaning are permissible, and may be accompanied by the use of solvent Cleaner/Remover.
- 7.4.1.1 When solvent Cleaner/Removers are used, control of contaminants must be observed.
- 20 The Manufacturer' Certification of contaminant content shall be obtained for all Cleaner/Removers materials used on nickel-based alloys, austenitic or duplex stainless steels, and titanium.
- 21 The total residual amount of sulfur and halogens shall not exceed one percent by weight or 1000 ppm.
- 7.4.2 Contour grinding or machining on the weld reinforcement shall only be permitted when approved by the Client.

8.0 CALIBRATION REQUIREMENTS

- 8.1 Instrument Linearity Checks. The requirements of paragraphs 8.1.1 and 8.1.2 shall be met at intervals not to exceed three months for analog type instruments and one year for digital type instruments, or prior to first use thereafter.
- 8.1.1 Screen Height Linearity. The ultrasonic instrument's screen height linearity shall be evaluated and meet the requirements of Mandatory Appendix I in Article 4 of ASME Section V. (See Attachment 3 for details)

- 8.1.2 Amplitude Control Linearity. The ultrasonic instrument's amplitude control linearity shall be evaluated and meet the requirements of Mandatory Appendix II in Article 4 of ASME Section V. (See Attachment 3 for details)
- 8.2 Ultrasonic System. Calibrations shall include the complete ultrasonic system and shall be performed prior to use of the system in the thickness range under examination.
 - 8.2.1 Calibration Surface. Calibrations 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.
 - 8.2.2 Couplant. The same couplant to be used during the examination shall be used for calibration.
 - 8.2.3 Contact Wedges. The same contact wedges to be used during the examination shall be used for calibration.
 - 8.2.4 Instrument Controls. Any control which affects instrument linearity (e.g., filters, reject, or clipping) shall be in the same position for calibration, calibration checks, instrument linearity checks, and examination.
 - 8.2.5 Temperature. For contact examination, the temperature differential between the calibration block and examination surfaces shall be within 25°F (14°C).
 - 8.2.6 Pulse Repetition Rate. The pulse repetition rate shall be small enough to assure that a signal from a reflector located at the maximum distance in the examination volume will arrive back at the search unit before the next pulse is placed on the search unit.
 - 8.2.7 Angle Beam Search Unit Exit Point and Beam Angle Measurements. Actual search unit exit points and beam angles shall be determined prior to calibration using the appropriate reference block, listed in paragraph 6.4.13.
- 8.3 Straight Beam Calibration for Both Pipe and Vessel Exams.
 - 8.3.1 Sweep Range Calibration
 - 8.3.1.1 Position the search unit on the applicable basic calibration block. Set the first back-wall reflection at 40% of Full Screen Width (FSW) and the second back-wall reflection at 80% FSW.
 - 8.3.2 Distance Amplitude Correction (DAC) Calibration.
 - 8.3.2.1 The reference level shall be based on the appropriate back reflection, whichever produces the highest amplitude. Adjust the sensitivity control to produce an amplitude response of 80% +/-5% FSW.
- 8.4 Angle Beam Calibration with Notches for Pipe Weld Examinations
 - 8.4.1 The angle beam shall be toward the notch that yields the maximum response. The gain control shall be set so that this response is 80%

- ± 5% of full screen height. This shall be the primary reference level.
- 8.4.2 The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum responses from the calibration reflectors at the distance increments necessary to generate a three-point distance-amplitude correction (DAC) curve.
- 8.4.3 Separate calibrations shall be established for both the axial and circumferential notches. These calibrations shall establish both the distance range calibration and the distance amplitude correction.
- 8.4.4 All points of the DAC shall be a minimum of 20% FSH. A double DAC or a secondary DAC may be required to properly evaluate the entire examination volume, as detailed in Attachment 2.
- 8.5 Angle Beam Calibration with Side-Drilled Holes for Pipe Weld Examinations
- 8.5.1 The angle beam shall be directed toward the side-drilled hole that yields the maximum response. The gain control shall be set so that this response is 80% ± 5% of full screen height. This shall be the primary reference level.
- 8.5.2 The search unit shall then be manipulated, without changing the instrument settings, to obtain the maximum responses from the calibration reflectors at the distance increments necessary to generate up to a 3T distance-amplitude correction (DAC) curve, where T is the thickness of the calibration block.
- 8.5.3 Separate calibrations shall be established for both the axial and circumferential scans. These calibrations shall establish the distance amplitude correction.
- 8.5.4 All points of the DAC shall be a minimum of 20% FSH. A double DAC or a secondary DAC may be required to properly evaluate the entire examination volume, as detailed in Attachment 2.
- 8.6 Angle Beam Calibration for Vessel Weld Examinations
- 8.6.1 Sweep Range Calibration (Axial Scans)
- 8.6.1.1 Position the search unit on the basic calibration block. Set the ½-V-path response from the ID notch to 30% FSW. Set the full-V-path response from the OD notch to 60% FSW and 1-½-V-path response from the ID notch to 90% FSW.
- 8.6.2 Distance Amplitude Correction (DAC) Calibration (Axial Scans).
- 8.6.2.1 The following steps shall be for examination of components which are greater than 0.500-inches thickness and greater than 20-inches in diameter:
- 8.6.2.2 The reference sensitivity shall be established from the appropriate 1/4T, 1/2T, or 3/4T side-drilled-hole.
- 8.6.2.3 The angle beam shall be directed towards the calibration reflector that yields the maximum response and adjust the sensitivity control to produce an amplitude response of 80% ±5% FSH.

- 8.6.2.4 This shall be the preliminary reference level. The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum response from the other appropriate notches, at their appropriate beam paths, to generate the DAC curve to cover the entire examination volume.
- 8.6.2.5 All points of the DAC shall be a minimum of 20% FSH. A double DAC or a secondary DAC may be required to properly evaluate the entire examination volume, as detailed in Attachment 2.
- 8.6.3 Alternative Angle Beam Calibration. - When a vessel or other component is made with a thickness of 1/2 in. (13 mm) or less and a diameter equal to or less than 20 in. (500 mm), the angle beam system calibrations for distance-amplitude techniques may be performed using the requirements of paragraphs 6.4.9 and 8.3 or 8.4, as applicable.
- 8.7 Calibration for Weld Metal Overlay Cladding
- 8.7.1 Calibration for Technique One
- 8.7.1.1 Calibrations shall be performed utilizing the calibration block shown in Figure T-434.4.1. The search unit shall be positioned for the maximum response from the calibration reflector.
- 8.7.1.2 When a side drilled hole is used, the plane separating the elements of the dual element search unit shall be positioned parallel to the axis of the hole.
- 8.7.1.3 The gain control shall be set so that this response is 80% FSH \pm 5%. This shall be the primary reference level.
- 8.7.2 Calibration for Technique Two
- 8.7.2.1 Calibrations shall be performed utilizing the calibration block shown in Figure T-434.4.3. The search unit shall be positioned for the maximum response of the first resolvable indication from the bottom of the calibration reflector.
- 8.7.2.2 The gain control shall be set so that this response is 80% FSH \pm 5%. This shall be the primary reference level.
- 8.8 Calibration for Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal
- 8.8.1 The number of calibration holes used depends upon the requirements for the examination. If only the nozzle side fusion zone is to be examined, then only a single side drilled hole at the nozzle wall thickness needs to be used.
- 8.8.1.1 Single Hole. The response from a single side drilled hole shall be set at 80% \pm 5% of full screen height. This is the primary reference level.

8.8.1.2 Multiple Holes. The straight beam shall be directed toward the calibration reflector that yields the maximum response. The gain control shall be set so that this response is $80\% \pm 5\%$ of full screen height. This shall be the primary reference level.

8.8.1.3 The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum responses from the other hole position(s) to generate a distance–amplitude correction (DAC) curve.

8.9 Electronic Distance-Amplitude Correction Devices

8.9.1 When an electronic distance-amplitude correction device is used, the primary reference response shall be equalized on the basic calibration block at a screen height between 40% and 80% of full screen height over the distance range to be employed in the examination.

8.9.2 Recording of the calibration data shall be detailed sufficiently to permit subsequent examinations for the purpose of comparison.

8.10 Calibration Checks

8.10.1 Calibration Check on Basic Calibration Block. When any part of the examination system is changed, a calibration check shall be made on the basic calibration block to verify that distance range points and sensitivity setting(s) satisfy the requirements of paragraph 8.10.

8.10.2 Calibration Check on Basic Calibration Block or Simulator Check. A calibration check on at least one of the basic reflectors in the basic calibration block or a check using a simulator shall be made as follows:

8.10.2.1 At the finish of each weld examination or series of similar examinations;

8.10.2.2 When examination personnel are changed, and;

8.10.2.3 Interim calibration checks between the required initial calibration and the final calibration check may be performed. The decision to perform interim calibration checks should be based on ultrasonic instrument stability (analog vs. digital), the risk of having to conduct reexaminations, and the benefit of not performing interim calibration checks

8.10.2.4 The sweep and distance amplitude correction values recorded shall satisfy the requirements of paragraph 8.10.

8.10.3 Simulator Check. Any simulator checks that are used shall be correlated with the original calibration on the basic calibration block during the original calibration. The simulator checks may use different types of calibration reflector or block (such as IIW). The simulator check shall be made on the entire examination system.

8.10.3.1 Accuracy of the simulator checks shall be confirmed, using the basic calibration block, at the conclusion of each period of extended use, or every 3 months, whichever is less.

The requirements for calibration confirmation of paragraph 8.10 shall be met.

8.11 Calibration Confirmation

8.11.1 Distance Range Points. If any distance range point has moved on the sweep line by more than 10% of the distance reading or 5% of full sweep, whichever is greater, correct the distance range calibration, and note the correction in the examination record.

8.11.1.1 All recorded indications since the last valid calibration or calibration check shall be re-examined and their values shall be changed on the data sheets or re-recorded

8.11.2 Sensitivity Settings. If any sensitivity setting has changed by more than 20% or 2 dB of its amplitude, correct the sensitivity calibration and note the correction in the examination record.

8.11.2.1 If the sensitivity setting has decreased, all data sheets since the last valid calibration check shall be marked void and the area covered by the voided data shall be reexamined.

8.11.2.2 If the sensitivity setting has increased, all recorded indications since the last valid calibration or calibration check shall be reexamined and their values shall be changed on the data sheets or re-recorded.

9.0 EXAMINATION REQUIREMENTS

9.1 Prior to the examination, a Scan Plan (weld profile and component thickness information), shall be prepared and compared to the "as-found" configuration.

9.1.1 This review is intended to validate the examination technique and provide information on any changes or limitations to the examination.

9.1.2 Previous examination data (if available) should be reviewed prior to examination in order to identify previously documented limitations or other component information that may assist in examination preparation.

9.2 Identification of Weld Examination Areas

9.2.1 Weld Locations. Weld locations and their identification shall be recorded on a weld map or in an identification plan.

9.2.2 Permanent marking of components should be the responsibility of the manufacturer unless otherwise agreed upon in the contract documents.

9.2.3 Reference Point Marking. All scan start and stop locations (X-circ, & Y-axial) shall be based on absolute coordinates. There shall be only one "O" reference location for each component.

9.3 Examination Surfaces – Examination of pipe welds is normally from the O.D.

9.3.1 Surface Preparation. The base metal on each side of the weld shall be free of weld spatter, surface irregularities, or foreign matter that might interfere with the examination. Where the weld surface interferes with the examination, the weld shall be prepared as needed

- to permit examination.
- 9.4 Scanning Rate. The rate of search unit movement (scanning speed) shall not exceed 6 in./s (150 mm/s), unless:
- 9.4.1 The ultrasonic instrument pulse repetition rate is sufficient to pulse the search unit at least six times within the time necessary to move one-half the transducer (piezoelectric element) dimension parallel to the direction of the scan at maximum scanning speed; or,
- 9.4.2 A dynamic calibration is performed on multiple reflectors, which are within 2 dB of a static calibration and the pulse repetition rate meets the requirements of 9.5.
- 9.5 Pulse Repetition Rate. The pulse repetition rate shall be small enough to assure that a signal from a reflector located at the maximum distance in the examination volume will arrive back at the search unit before the next pulse is placed on the transducer.
- 9.5.1 Overlap - Each pass of the search unit (straight beam and angle beam) shall overlap the preceding pass by a minimum of 10% of the width of the active search unit.
- 9.5.2 Oscillation of the search unit is permitted provided improved coverage is demonstrated.
- 9.5.3 Scanning Sensitivity Level – the scanning sensitivity level (straight beam and angle beam) shall be set a minimum of 6 dB higher than the reference level gain setting.
- 9.6 When the Referencing Code Section requires the detection and evaluation of all indications exceeding 20% DAC, the gain should be increased an additional amount so that no calibration reflector indication is less than 40% Full Screen Height. As an alternate, the scanning sensitivity level may be set at 14 dB higher than the reference level gain setting. This additional gain makes the reference DAC curve a 20% DAC curve so that indications exceeding 20% DAC may be easily identified and evaluated.
- 9.7 Straight Beam Scanning. The scanning of the adjacent base metal shall be performed on the volume of base material through which the angle beams will travel to locate any reflectors that can limit the ability of the angle beam to examine the weld volume. Reflectors evaluated as laminar reflectors in base material, which interfere with the scanning of examination volumes, shall require the angle beam examination technique to be modified such that the maximum feasible volume is examined and shall be noted in the record of the examination.
- 9.8 Angle Beam Scanning
- 9.8.1 Beam Angle. The search unit and beam angle selected shall be 45° or an angle appropriate for the configuration being examined and shall be capable of detecting the calibration reflectors, over the required angle beam path.
- 9.8.2 Reflectors Parallel to the Weld Seam. The angle beam shall be directed at approximate right angles to the weld axis from both sides

of the weld (i.e., from two directions) on the same surface when possible. The search unit shall be manipulated so that the ultrasonic energy passes through the required volume of weld and adjacent base material.

9.8.3 Reflectors Transverse to the Weld Seam

9.8.3.1 Scanning with Weld Reinforcement. If the weld cap is not machined or ground flat, the examination shall be performed from the base material on both sides of the weld cap. While scanning parallel to the weld axis, the angle beam shall be directed from 0° to 60° with respect to the weld axis in both axial directions, with the angle beam passing through the required examination volume.

9.8.3.2 Scanning Without Weld Reinforcement. If the weld cap is machined or ground flat, the examination shall be performed on the weld. While scanning, the angle beam shall be directed essentially parallel to the weld axis in both axial directions. The search unit shall be manipulated so that the angle beam passes through the required examination volume.

9.8.4 Single-Sided Access Welds. Welds that cannot be fully examined from two directions per 9.8.2 and 9.8.3 using the angle beam technique shall also be examined to the maximum extent possible with a straight beam technique applied from an adjacent base material surface. This may be applicable to vessel corner and tee joints, nozzle and manway neck to shell or head joints, pipe to fittings, or branch connections. The area(s) of single-sided access and, if applicable, the extent of the limit coverage shall be noted in the examination report.

9.8.5 Inaccessible Welds. Welds that cannot be examined from at least one side (edge) using the angle beam technique shall be noted in the examination report. For flange welds, the weld may be examined with a straight beam or low angle longitudinal waves from the flange face provided the examination volume can be covered.

9.8.6 Extent of Coverage. Complete examination shall mean 100% for the entire length of the weld. In addition to the weld volume and heat affected zone(s), the amount of adjacent base metal to be examined shall be the lessor of 1T or 1.0 inch. (weld plus 2 inches for B31.3 High Pressure piping)

9.9 Weld Metal Overlay Cladding Techniques

9.9.1 The techniques described below shall be used when examinations of weld metal overlay cladding are required. When examination for lack of bond and weld metal overlay cladding flaw indications is required, Technique One shall be used. When examinations for lack of bond only is required Technique Two may be used.

9.9.1.1 Technique One. The examinations shall be performed from the weld metal overlay clad surface with the plane separating the elements of the dual element search unit positioned

parallel to the axis of the weld bead. The search unit shall be moved perpendicular to the weld direction.

9.9.1.2 Technique Two. The examination may be performed from either the weld metal overlay clad or unclad surface and the search unit may be moved either perpendicular or parallel to the weld direction.

9.10 Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal

9.10.1 Search Unit Location. When the referencing Code section specifies that an ultrasonic examination be performed to examine either the nozzle side weld fusion zone and/or the adjacent nozzle parent metal, a straight beam examination shall be conducted from the inside nozzle surface.

9.10.2 Examination. The general examination requirements of T-471 are applicable. The full circumference of the nozzle shall be scanned to cover the entire nozzle side fusion zone of the weld plus 1.0 inch beyond the weld toes. The search unit may be moved either circumferentially around or axially across the examination zone. The screen range shall cover as a minimum, 1.1 times the full thickness of the nozzle wall. Nozzles that cannot be fully examined shall be noted in the report.

10.0 INTERPRETATION / EVALUATION

10.1 Basic Requirements

10.1.1 Any reflector which causes an indication in excess of 20% DAC, at reference sensitivity, shall be investigated to the extent necessary to provide accurate characterization, identity, and location. All such indications shall be evaluated in terms of the applicable acceptance criteria of the referencing code Section. Additionally, all indications longer than 40% of the rejectable flaw size shall be investigated to the extent that they can be evaluated in terms of the acceptance criteria of the referencing Code Section.

10.1.2 During examination, the sweep range may be adjusted for indication discrimination and characterization. Final recording of indications shall be done utilizing the sweep and DAC settings established during calibration.

10.2 Indication Classification

10.2.1 Flaw Indications. All indications produced by reflectors within the volume to be examined, regardless of amplitude, that cannot be clearly attributed to the geometry of the weld configuration (counter bore, root, metallurgical responses, etc.) shall be considered as flaw indications.

10.2.2 Geometric or Metallurgical Indications. All indications produced by reflectors within the volume to be examined that can be attributed to the geometry of the weld configuration shall be considered as geometric or metallurgical indications.

10.2.2.1 The identity, maximum amplitude, location, and extent of

reflector causing a geometric indication shall be recorded.

10.2.2.2 The following steps shall be taken to classify an indication as geometric:

- 19 Interpret the area containing the reflector in accordance with the Flaw Indications or the Geometric or Metallurgical Indications criteria, listed below in this section.
- 20 Plot and verify the reflector coordinates. Prepare a cross-section sketch showing the reflector position and surface discontinuities such as root, weld crown, and;
- 21 Review radiographs, fabrication or weld preparation drawings, as-built drawings, or any other means available to accurately identify the reflector.

10.3 Indication Discrimination

10.3.1 Flaw Indications. All suspected flaw indications shall be investigated and evaluated taking into account the following indication characteristics. These characteristics should not be considered as mandatory criteria for classifying indications as flaws, but are listed as significant points of interest for the examiner to consider during evaluation of suspect areas:

- a) The indication has a good signal-to-noise ratio (e.g., SN 2:1) with defined start and end points. This characteristic can be supported by observing signal-to-noise ratio variation along the length of the component.
- b) The indication plots to a location susceptible to cracking.
- c) The indication can be detected with multiple search unit angles, and a higher angle provides comparable or greater signal response. This characteristic can be supported with an adequate reference reflector (Inside surface notch or equivalent).
- d) The indication provides substantial and unique echo-dynamic travel (walk). This characteristic can be supported by observing other areas along the length of sample and with an adequate reference reflector (Inside surface notch or equivalent).
- e) Several areas of unique or multiple amplitude peaks are observed throughout the indication length. This characteristic can be supported by observing other areas along the length of sample and by scanning along the indication length laterally.
- f) The indication maintains or provides an increase in signal amplitude when the beam is skewed away from normal. This characteristic can be supported by observing other areas along the length of sample.
- g) Inconsistent time base positions are observed throughout the indication length as the search unit is moved parallel along the length of the reflector. This characteristic can be supported by scanning along the indication length laterally.
- h) The indication shows evidence of flaw tip signals.
- i) Circumferential indications provide axial components while

performing tangential scans.

- j) For circumferential flaws, the indication(s) can be confirmed from the opposite side of the weld.
- k) For axial flaws, the indication(s) can be confirmed from the opposite direction. This characteristic is dependent upon flaw orientation and may not always be available.
- l) The indication is near, or initiates from, a geometrical reflector and distinct signal separation and amplitude fluctuation can be observed. This characteristic may require an increase in signal resolution capability to make this evaluation. Examples include reducing screen size and slower scan speeds.
- m) For components where access is limited to a single side of the component, the following additional information shall be considered:

10.4 Because of the uncertainties associated with the flaw orientation and the actual thickness of the component on the inaccessible side of the weld, an accurate inside surface connection on the far side of the weld may be unobtainable.

10.5 For suspect far side flaw indications several search unit angles should be evaluated to optimize the response.

10.5.1 Geometric or Metallurgical Indications. All suspected geometric or metallurgical indications shall be investigated and evaluated considering the following indication characteristics. These characteristics should not be considered as mandatory criteria for classifying indications, but are listed as significant points of interest for the examiner to consider during evaluation of suspect areas:

- A. The indication appears at or near the centerline of the weld or other documented geometrical condition (eg: counter bore) and can be seen continuously or intermittently along the length of the weld at consistent amplitude and sweep positions. This characteristic can be supported by obtaining localized thickness and surface contour recordings at the location of the indication(s).
- B. The indication provides additional responses, which occur from the same scan position, but at different sweep positions (multiples) along the length of the weld. This may be a sign of mode-converted shear-wave signals from counter bore or similar geometric reflectors. This characteristic may require an increase in time base size in order to observe these responses.
- C. The indication can be seen across the entire length of the scan, either continuously or intermittently, at consistent amplitude and sweep positions. This characteristic can be supported by scanning along the indication length laterally.
- D. When examining with a higher angle search unit, the amplitude response is lower or not detected. This characteristic should consider localized thickness and contour information to ensure that the search unit angles provide comparable examination volume coverage and

sound penetration. This characteristic can additionally be supported with an adequate reference reflector (Inside surface notch or equivalent).

- E. The indication provides minimal echo-dynamic travel (walk). This characteristic can be supported by observing other areas along the length of sample and with an adequate reference reflector (Inside surface notch or equivalent).
- F. The indication provides a rapid and consistent drop in signal amplitude when the beam is skewed away from normal in either direction.
- G. The indication provides a clean, single signal response with minimal to no signal faceting. No discernible tip signals are observable. This characteristic can be supported by optimizing the signal presentation on an adequate reference reflector (Inside surface notch or equivalent).
- H. The signal responses are consistent from each side of the weld for axial scans, or from each direction, clockwise (CW) or counter-clockwise (CCW) for circumferential scans.

10.6 Indication Positioning

10.6.1 Due to geometrical configuration, (tapers, radius, etc.) indication positioning may require detailed evaluation. The following information is provided to assist in proper indication positioning:

10.6.1.1 Perform detailed thickness and surface contour recordings at the location of the indication(s). Attempt to identify any position offset of the weld root in relationship to the weld centerline.

10.6.1.2 Evaluate the flaw signal amplitude responses from each side of the weld, if possible. Observe if the signal response appears reduced due to weld volume sound attenuation from one side or another.

10.6.1.3 Evaluate the ultrasonic responses from each side of the weld in both flawed and unflawed regions. Attempt to identify standard benchmark responses (e.g., weld root, weld noise, counter bore, etc.) and flaw indication responses. Take notice of the ultrasonic and surface distance dimensions from these responses.

10.6.1.4 Coordinate and plot this information on a cross sectional drawing of the weld.

10.7 Sizing. Unless otherwise specified by the client, and with consideration for 10.1.1 above, sizing of indications shall be accomplished by the 6db drop for both straight beam indications and angle beam indications.

10.7.1 Straight Beam. Unless specified by the client, sizing of indications located by the straight beam method shall be accomplished using the 6 dB Drop Method:

10.7.1.1 6 dB Drop Method. A drop in the indication signal equivalent to a 6 dB change, where the length of the indication is measured from the centerline of the transducer at both ends of the indication where this drop occurs with a signal ratio of

2:1.

10.7.2 Angle Beam. Unless specified by the client, sizing of indications located by the shear wave method shall be sized by the following:

10.7.2.1 Length Sizing shall be accomplished using the 6 dB Drop Method.

11.0 POST EXAMINATION CLEANING

11.1 All couplant shall be removed following the completion of the examination as a precaution to reduce risks of corrosive materials remaining in contact with the examination material. Unless otherwise stipulated by contract documents, a simple dry or water dampened cloth wipe will be sufficient. Caution should be taken before using any type of solvent-based cleaner as some materials could have adverse effects on the examined object.

12.0 ACCEPTANCE CRITERIA

12.1 Welds shall be evaluated in accordance with paragraph 10.0 and the applicable Code Appendix to this procedure. Unless otherwise stated in project requirements, the following acceptance criteria type shall be utilized:

12.1.1 ASME Section I and Section VIII, Workmanship Acceptance Criteria (Appendix A) for Manual Ultrasonic Examinations.

12.1.2 B31.3 - Workmanship Acceptance Criteria (Appendix B)

12.1.3 B31.1 - Workmanship Acceptance Criteria (Appendix C)

13.0 EXAMINATION REPORTING

13.1 Ultrasonic examination reports shall be documented thoroughly enough to enable future examinations to be conducted in the same manner and fashion with regards to duplicating the instrument type, search unit type, shape, size, and frequency, calibration blocks, calibration method and set-up, etc.

13.2 Calibration data shall be recorded on an Ultrasonic Calibration Data Sheet, if used (may be part of the UT report) and as a minimum, shall include the following:

13.2.1 Calibration sheet identification, if separate.

13.2.2 Names and certification levels of examination personnel.

13.2.3 Examination procedure number and revision.

13.2.4 Examination method and technique.

13.2.5 Basic calibration block identification and reference blocks.

13.2.6 Ultrasonic instrument serial number, manufacturer, and model identification and essential instrument settings.

13.2.7 Search unit beam angle and mode of wave propagation in the material.

13.2.8 Search unit manufacturer, model, and manufacturer's serial number.

13.2.9 Search unit nominal frequency, size, shape, and number of elements.

13.2.10 Special search units, wedges, shoe type, or saddle's identification, if used.

- 13.2.11 Search unit cable(s) used, type and length.
- 13.2.12 Dates of initial calibration and subsequent calibration checks.
- 13.2.13 Calibration data [including reference reflector(s), indication amplitude(s), and distance reading(s)].
- 13.2.14 Instrument damping and reject setting(s), if used.
- 13.2.15 Couplant type and batch number.
- 13.2.16 Examination sensitivity.
- 13.3 Examination data shall be recorded on an Ultrasonic Examination Data Sheet and as a minimum, shall include the following:
 - 13.3.1 Data sheet identification and date of examination.
 - 13.3.2 Names and certification levels of examination personnel.
 - 13.3.3 Calibration sheet identification.
 - 13.3.4 Identification of the weld, part, or component examined including weld number, serial number, or other identifier.
 - 13.3.4.1 Identification and location of the weld and volume scanned.
 - 13.3.5 Surface from which the examination is conducted, including surface condition.
 - 13.3.6 Examination results including limitations of the volume scanned.
 - 13.3.7 Map or record of rejectable indications detected or areas cleared.
 - 13.3.8 Areas of restricted access or inaccessible welds.
 - 13.3.9 Indication classification of all recordable reflectors.
 - 13.3.10 Rejectable indications shall be recorded.
 - 13.3.10.1 As a minimum, the type of indication (i.e., crack, non-fusion, slag, etc.), location, and extent (i.e., length) SHALL be recorded. Non-mandatory Appendices D and K provide general recording examples for angle and straight beam search units.
 - 13.3.11 Record all indications that exceed 50% of the reference level.
 - 13.3.11.1 The record shall locate each area, the response level, the dimensions, the depth below the surface, and the classification.
 - 13.3.12 Cross-sectional plots of flaws and geometric reflector may be included with the UT Report.

14.0 ATTACHMENTS

- Attachment 1 Ultrasonic Examination Report
- Attachment 2 Example of Split DAC Curve
- Attachment 3 Instrument Linearity Checks
- Attachment 4 ASME VIII – Workmanship Acceptance Criteria.

- Attachment 5 B31.3 – Workmanship Acceptance Criteria.
Attachment 6 B31.1 - Workmanship Acceptance Criteria.

Attachment 1 – Ultrasonic Examination Report

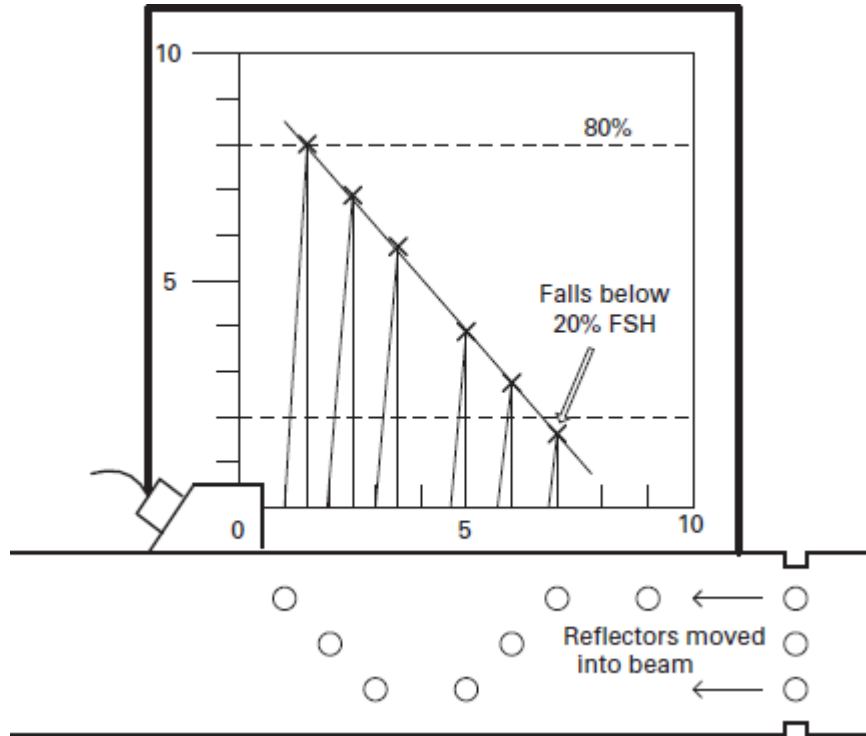
Attachment 2 – Split DAC Curve Example

- 12 This attachment provides an example of a split DAC curve when a single DAC, for the required distance range, would have a portion of the DAC fall below 20% of full screen height [FSH]. See Figure “1”.
- 2.0 Create a DAC curve as normal until a side-drilled hole (SDH) indication peak signal falls below 20% of FSH. See Figure “2”.
- 3.0 Starting with a SDH position prior to the reflector response that falls below

20% of FSH, set the gain so that this response is 80% ± 5% of FSH. Record the reference level gain setting for this second portion of the DAC curve. Mark the peaks of the remaining SDH indications on the screen and connect the points to form the second DAC curve. See Figure “3”.

- 4.0 This technique can also be used on notch reflectors.

Figure 1: Distance-Amplitude Correction



Attachment 2 – continued

Figure 2: First Split Curve

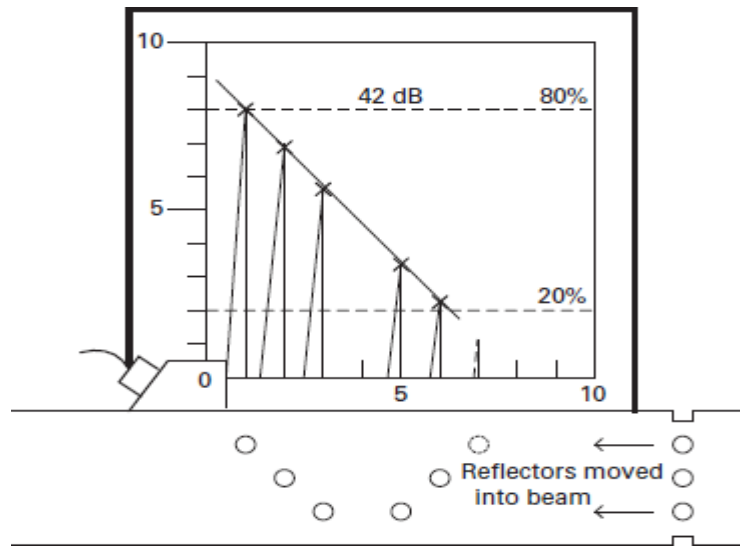
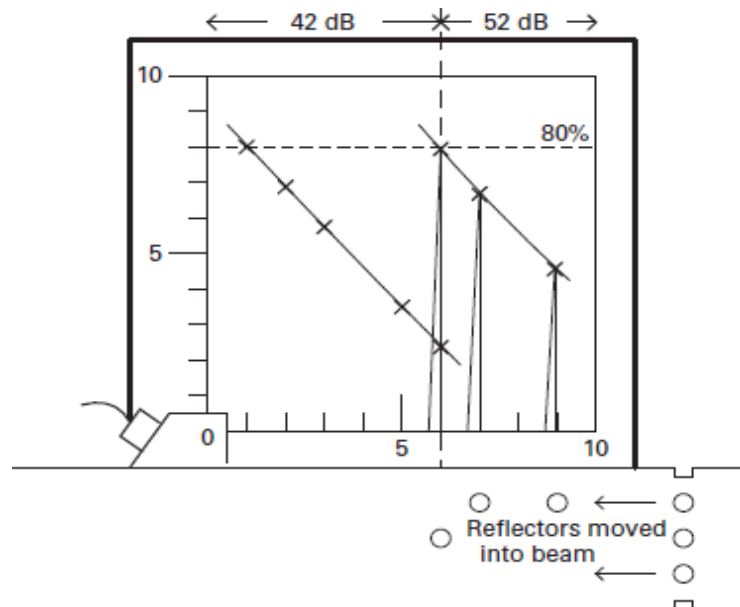


Figure 3: Second Split Curve



Attachment 3 – Mandatory Appendix I Linearity

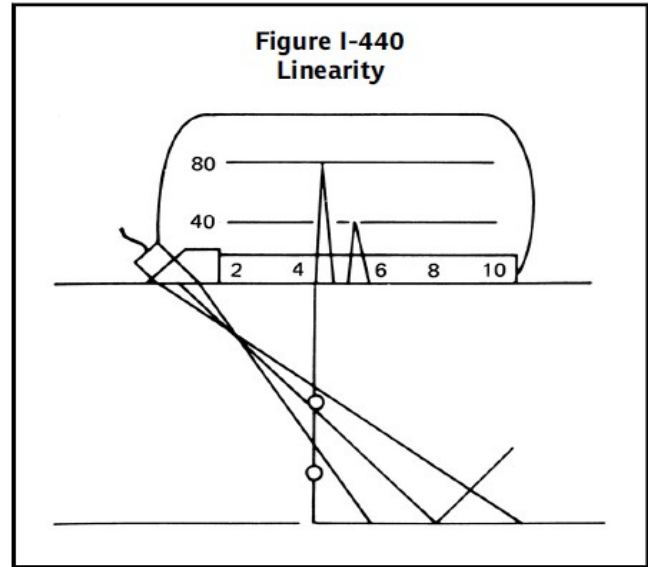
**MANDATORY APPENDIX I
SCREEN HEIGHT LINEARITY**

I-410 SCOPE

This Mandatory Appendix provides requirements for checking screen height linearity and is applicable to ultrasonic instruments with A-scan displays.

I-440 MISCELLANEOUS REQUIREMENTS

Position an angle beam search unit on a calibration block, as shown in [Figure I-440](#) so that indications from both the $\frac{1}{2}T$ and $\frac{3}{4}T$ holes give a 2:1 ratio of amplitudes between the two indications. Adjust the sensitivity (gain) so that the larger indication is set at 80% of full screen height (FSH). Without moving the search unit, adjust sensitivity (gain) to successively set the larger indication from 100% to 20% of full screen height, in 10% increments (or 2 dB steps if a fine control is not available), and read the smaller indication at each setting. The reading shall be 50% of the larger amplitude, within 5% of FSH. The settings and readings shall be estimated to the nearest 1% of full screen. Alternatively, a straight beam search unit may be used on any calibration block that provides amplitude differences, with sufficient signal separation to prevent overlapping of the two signals.



**MANDATORY APPENDIX II
AMPLITUDE CONTROL LINEARITY**

II-410 SCOPE

This Mandatory Appendix provides requirements for checking amplitude control linearity and is applicable to ultrasonic instruments with A-scan displays.

II-440 MISCELLANEOUS REQUIREMENTS

Position an angle beam search unit on a basic calibration block, as shown in [Figure I-440](#) so that the indication from the $\frac{1}{2}T$ side-drilled hole is peaked on the screen. Adjust the sensitivity (gain) as shown in the following table. The indication shall fall within the specified limits.

Alternatively, any other convenient reflector from any calibration block may be used with angle or straight beam search units.

| Indication Set at % of Full Screen | dB Control Change | Indication Limits % of Full Screen |
|------------------------------------|-------------------|------------------------------------|
| 80% | -6 dB | 35% to 45% |
| 80% | -12 dB | 15% to 25% |
| 40% | +6 dB | 65% to 95% |
| 20% | +12 dB | 65% to 95% |

The settings and readings shall be estimated to the nearest 1% of full screen.

Attachment 4 – ASME Section I and Section VIII DIV. 1 and 2 – Pressure Vessels WORKMANSHIP BASED ACCEPTANCE CRITERIA

11 SCOPE

1.1 This Attachment covers the evaluation of welds, 250" thick and greater, to ASME Section I, and Section VIII, Divisions 1 and 2, using the Workmanship Acceptance Criteria and MUT.

2.0 EVALUATION

2.1 Evaluations shall be performed in accordance with Section 10.0 of the base procedure.

2.2 Flaws shall be sized (height and length) in accordance with Section 10.7 of the base procedure.

2.3 Flaws shall be characterized by flaw type. (i.e.: lack of fusion, lack of penetration, cracks)

3.0 ACCEPTANCE CRITERIA

3.1 Welds that are shown by ultrasonic examination to have discontinuities which produce a response greater than 20% of the primary reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such reflectors, and evaluate them in terms of the acceptance standards given below:

3.2 Where discontinuities are interpreted to be cracks, lack of fusion or incomplete penetration, they are unacceptable, regardless of length.

3.3 Other discontinuity types (i.e., slag/porosity) shall be deemed unacceptable if the amplitude exceeds the primary reference level, and lengths that exceed:

3.3.1 1/4" for t less than 3/4".

3.3.2 $t/3$ for t greater than or equal to 3/4" and less than or equal to 2-1/4".

3.3.3 3/4" for t greater than 2-1/4".

" t " is the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t .

4.0 REPORT OF EXAMINATION

4.1 Examination results shall be documented on report form meeting the requirements of Section 13 of the base procedure. All reflectors having responses that exceed 50% of the primary reference level shall be reported. The following minimum information shall be recorded for each reportable indication.

4.1.1 Percent screen height as related to DAC Level.

4.1.2 Discontinuity Type (i.e., lack of fusion, lack of penetration, crack, etc.)

- 4.1.3 Discontinuity length.
- 4.1.4 Depth below the scanning surface.
- 4.1.5 Approximate location along the weld length (X and Y measurement).

**Attachment 5 – ASME B31.3 – Process Piping
WORKMANSHIP BASED ACCEPTANCE CRITERIA**

10 SCOPE

1.1 This Attachment covers the evaluation of welds, 250" thick and greater, to B31.3 Piping welds, using the Workmanship Acceptance Criteria and MUT.

2.0 EVALUATION

2.1 Evaluations shall be performed in accordance with Section 10.0 of the base procedure.

2.1 Discontinuities shall be sized (height and length) in accordance with Section 10.7 of the base procedure.

3.0 ACCEPTANCE CRITERIA

3.1 Welds that are shown by ultrasonic examination to have discontinuities which produce a response greater than 20% of the primary reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such reflectors, and evaluate them in terms of the acceptance standards given below:

3.2 Acceptance criteria shall be as described as specified in section 3.3 below.

3.3 A discontinuity is unacceptable if the amplitude of the indication exceeds the reference level, and its length exceeds:

3.3.1 1/4 in. for T_w 3/4 in.

3.3.2 $T_w/3$ for 3/4 in. $< T_w$ 2-1/4 in.

3.3.3 3/4 in. for $T_w > 2$ -1/4 in.

T_w is the nominal wall thickness of the thinner of two components joined by a butt weld.

4.0 REPORT OF EXAMINATION

4.1 Examination results shall be documented on report form meeting the requirements of Section 13 of the base procedure.

Attachment 6 – ASME B31.1 – Power Piping WORKMANSHIP BASED ACCEPTANCE CRITERIA

9 SCOPE

9.0 This Attachment covers the evaluation of welds, 0.250" thick and greater, to B31.1 Piping welds, using Workmanship Acceptance Criteria and MUT.

2.0 EVALUTION

2.1 Evaluations shall be performed in accordance with Section 10 of the base procedure.

2.2 Discontinuities shall be sized (height and length) in accordance with Section 10.7 of the base procedure.

3.0 ACCEPTANCE CRITERIA

3.1 Welds that are shown by ultrasonic examination to have discontinuities which produce a response greater than 20% of the primary reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such reflectors, and evaluate them in terms of the acceptance standards given below:

3.2 Acceptance criteria shall be as described as specified in section 3.3 below.

3.3 Discontinuities evaluated as being cracks, lack of fusion or incomplete penetration are unacceptable, regardless of length.

3.4 Other discontinuities are unacceptable if the indication exceeds the primary reference level, and lengths exceeds the following:

3.4.1 1/4" for t up to 3/4".

3.4.2 1/3t for t over 3/4" to 2-1/4".

3.4.3 3/4" for over 2-1/4".

Where “ t ” is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, “ t ” is the thinner of these two thicknesses.

4.0 REPORT OF EXAMINATION

- 4.1 Examination results shall be documented on report form meeting the requirements of Section 13 of the base procedure.