



# CAN-UT-14P001 REVISION 04



## ULTRASONIC EXAMINATION OF WELDS

ASME V, ARTICLE 4

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**APPENDIX 1: CALIBRATION STANDARDS**

**APPENDIX 2: REQUIREMENTS OF AN ULTRASONIC EXAMINATION PROCEDURE (ESSENTIAL AND NONESSENTIAL VARIABLES)**

**1.0 SCOPE**

- 1.1 This procedure provides instruction to technicians performing ultrasonic examination of welds in materials up to 400 mm (16 in.) in thickness in accordance with ASME Section V, Article 4. This includes, but is not limited to, welds in ferromagnetic and non-ferromagnetic metal pipe, plate, cast and forged products. This procedure is to be applied when ASME V, Article 4 is referenced and may also be used when no inspection protocol is specified.
- 1.2 The techniques described in this procedure are intended for applications where either single or dual element search units are used to produce normal incident longitudinal wave beams, angle beam longitudinal waves and/or angle beam shear waves. Contact or immersion techniques may be used.
- 1.3 Other techniques or technology which can be demonstrated to produce equivalent or better examination sensitivity and detectability may be used if allowed for by the applicable technique, code or standard.

**2.0 PROCEDURE QUALIFICATION**

When procedure qualification has been specified by the client or the applicable code or standard, a change in an essential variable (listed in Appendix 2) from the specified value or range of values shall require re-qualification of this procedure. A change of a requirement identified as a nonessential variable from the specified value, or range of values, does not require requalification of this procedure. All changes of essential or nonessential variables from the value, or range of values, specified by this procedure shall require an addendum to this procedure.

**3.0 REFERENCES**

- 3.1 Acuren Safety Management System
- 3.2 ASME Section V, Article 4 (2013)
- 3.3 CAN-CP-02P001 Acuren Canada SNT-TC-1A Written Practice

**4.0 PERSONNEL**

- 4.1 Inspection shall be carried out by technicians certified to the requirements of the Acuren procedure CAN-CP-02P001. Note: Certain codes or standards may require the use of additional or alternate certification schemes.
- 4.2 A Level I technician may perform inspection when under the direct supervision of a Level II or Level III technician.
- 4.3 A Level II or III technician shall carry out final interpretation and sign the report.
- 4.4 A Level III technician shall approve this procedure.
- 4.5 Personnel qualification and procedure performance demonstrations shall be required when specified by the applicable technique, code or standard.

**5.0 SAFETY**

Personnel shall;

- 5.1 comply with the requirements of the Acuren Safety Management System.
- 5.2 follow all Client and project specific safety requirements.

**6.0 DEFINITIONS**

- 6.1 Angle Beam – where the angle of incidence or refraction is other than normal to the surface of the test object.
- 6.2 Contact Testing – refers to a technique where the search unit makes contact directly with the test piece through a thin layer of couplant.
- 6.3 DAC – distance amplitude correction.
- 6.4 DSC – distance and sensitivity calibration
- 6.5 FBH – flat bottom hole.
- 6.6 FSH – full screen height.
- 6.7 IIW – International Institute of Welding.
- 6.8 Immersion Testing – an ultrasonic examination method in which the search unit and the test part are submerged (at least locally) in a fluid, usually water.
- 6.9 Longitudinal Wave – those waves in which the particle motion of the material is essentially in the same direction as the wave propagation.
- 6.10 Probe – see ‘search unit’.
- 6.11 SDH – side drilled hole.
- 6.12 Search Unit – an electro-acoustic device used to transmit or receive ultrasonic energy, or both.
- 6.13 Shear Wave – wave motion in which the particle motion is perpendicular to the direction of propagation.
- 6.14 Straight Beam – a vibrating pulse wave train traveling normal to the test surface.
- 6.15 Transducer – the piezoelectric element in an ultrasonic search unit.
- 6.16 Wedge – in ultrasonic examination by the contact method, a device used to direct ultrasonic energy into the material (usually at an angle).

**7.0 EQUIPMENT AND MATERIALS**

- 7.1 Test Instrument

- 7.1.1 A pulse-echo-type of ultrasonic instrument operating at a frequency range of at least 1 MHz to 5 MHz and equipped with a stepped gain control of 2.0 decibels (dB) or less.
- 7.1.2 If the instrument has a damping control, it may be used if it does not reduce the sensitivity of the examination.
- 7.1.3 The reject or clipping control shall not be used (turned off).
- 7.1.4 Automatic alarms may be used with electronic gates to aide examinations unless prohibited by the applicable technique, code or standard.
- 7.1.5 Instrument recording features (e.g. data acquisition or screen capture) may be used to record examination data and support the documentation of calibrations or indications.
- 7.1.6 The instrument shall be calibrated in accordance with CAN-CAL-02P004 and display valid calibration identification.
- 7.2 Search Units
- 7.2.1 Search units may be either single or dual transducer elements with a nominal frequency of 1 MHz to 5 MHz. Use of alternate frequencies may be used to assure adequate penetration or better resolution.
- 7.2.2 Search units with flat or contoured contact wedges may be used to aid ultrasonic coupling.
- 7.2.3 Search unit combinations (transducer and wedge materials) shall be selected for the working temperature range.
- 7.2.4 Search unit type, frequency, size and angle shall be selected based on the material thickness and weld access with respect to ensuring complete coverage of the area of interest. Example of recommended search units is listed in the table below. Actual selection shall be based on the specific weld or component to be examined and the applicable technique, code or standard.

Thickness	Angle	Frequency	Transducer Size
Less than 200 mm (8 in.)	0°	1 to 5 MHz	≈13 mm (0.5 in.) Ø
Less than 13 mm (0.5 in.)	70°	5 MHz	≈13 mm (0.5 in.) Ø or less
13 mm to 38 mm (0.5 to 1.5 in.)	60 or 70°	2.25 MHz	≈13 mm (0.5 in.) Ø
38mm to 63 mm (1.5 to 2.5 in.)	45 or 60°	2.25 MHz	≈13 mm (0.5 in.) Ø or greater
Over 63 mm (2.5 in.)	45°	1 to 2.25 MHz	≈13 mm (0.5 in.) Ø or greater

- 7.2.5 Examination of weld metal overlay cladding shall utilize dual element, straight beam search units using an angled pitch-catch technique. The included angle between the search unit's elements shall be such that the effective focal spot distance is centered in the area of interest.

7.3 Couplant

7.3.1 Typical couplants include water, glycerine and cellulose gel.

7.3.2 The couplant, including additives, shall not be detrimental to the material being examined. Consult the product data to ensure material compatibility.

a) Couplants used on nickel base alloys shall not contain more than 250 ppm of sulphur.

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

7.3.3 The temperature rating of the couplant shall be appropriate for the examination surface temperature.

**8.0 CALIBRATION BLOCKS**

8.1 General Requirements

8.1.1 Reflectors

Specified reflectors (i.e. side-drilled holes, flat bottom holes, notches, etc.) shall be used to establish primary reference responses of the equipment. An alternative reflector(s) may be used provided that the alternative reflector(s) has demonstrated or has been documented to produce sensitivity equal to or greater than the specified reflector(s) (i.e. side-drilled holes, flat bottom holes, notches, etc.)

8.1.2 Material

For welds made with similar metals the block material shall be of the same product form and material specification or equivalent P-number grouping as one of the materials being examined. P-numbers 1, 3, 4, 5A through 5C, and 15A through 15F materials are considered equivalent.

For 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.

8.1.3 Quality

a) Prior to fabrication, the block shall be examined using a straight beam search unit. Areas that contain any indications exceeding the remaining back-wall reflection shall be excluded from the beam paths required to reach the various calibration reflectors.

b) Blocks shall be designed to allow calibration on each reflector without interference from other indications.

8.1.4 Cladding

- a) The material from which the block is fabricated shall be from one of the following:
  - nozzle dropout from the component
  - a component prolongation
  - material of the same material specification, product form, and heat treatment condition as the material to which the search unit is applied during the examination
- b) Where the component material is clad and the cladding is a factor during examination, the block shall be clad to the component clad nominal thickness  $\pm 3\text{mm}$  (1/8 in). Deposition of clad shall be by the same method (i.e., roll-bonded, manual weld deposited, automatic wire deposited, or automatic strip deposited) 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.
- c) When the parent materials on opposite sides of a weld are clad by either 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.

#### 8.1.5 Heat Treatment

The calibration block shall receive at least the minimum tempering treatment as 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 the examination has been heat treated, the block shall receive the same heat treatment.

#### 8.1.6 Surface Finish

The surface finish of the block shall be representative of the surface finishes on the component to be examined.

### 8.2 Block Curvature

#### 8.2.1 Materials with Diameters Greater Than 500 mm (20 inch)



- a) For examinations in materials where the examination surface diameter is greater than 500 mm (20 in.) a block of essentially the same curvature or alternately, a flat calibration block, may be used.

#### 8.2.2 Materials with Diameters 500 mm (20 inch) and Less

- a) For examinations in materials where the examination surface diameter is equal to or less than 500 mm (20 in.), a curved block shall be used.
- b) Except where otherwise stated, 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 (see Appendix 1, Figure 1). For example a 200 mm (8 inch) diameter block may be used to calibrate for examinations on surfaces in the range of curvature from 180 to 300 mm (7.2 to 12 in.) in diameter. The curvature range from 24 to 500mm (0.94 in. to 20 in.) would require 6 curved blocks for a particular thickness range.

#### 8.3 Non-Piping Calibration Block

- 8.3.1 The basic calibration block configuration and reflectors shall be as shown in Appendix 1, Figure 2.
- 8.3.2 The basic block size and reflector locations shall be adequate to perform calibrations for the beam angle(s) and distance range(s) to be used.
- 8.3.3 For components equal to or less than 500mm (20 in.) in diameter, calibration block diameter shall meet the requirements of 8.2.2. Two sets of calibration reflectors (holes, notches) oriented 90 degrees from each other shall be used. Alternatively, two curved calibration blocks may be used.
- 8.3.4 When the block thickness  $\pm 25\text{mm}$  (1 in.) spans two weld thickness ranges as shown in Appendix 1, Figure 2, the block's use shall be acceptable in those portions of each thickness range covered by 25mm (1 in.) of the calibration block's thickness. As an example a calibration block with a thickness of 38 mm (1.5 in.) could be used for weld thicknesses of 13 mm (0.5 in.) to 64 mm (2.5 in.).
- 8.3.5 When two or more base material thicknesses are involved, the calibration block thickness 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.
- 8.3.6 Alternative Angle Beam Calibration.
  - a) When a vessel or other component is made with a thickness of 13 mm (0.5 in.) or less and a diameter equal to or less than 500 mm (20 in.), the angle beam system calibrations for distance-amplitude techniques may be performed using the piping calibration block outlined in 8.4 and the

requirements of angle beam calibration for piping, 11.3(ref. ASME V, Art 4, T-463.1.4).

#### 8.4 Piping Calibration Block

- 8.4.1 The basic calibration block configuration and reflectors shall be as shown in Appendix 1, Figure 3 or the alternate shown in Appendix 1, Figure 3A where curvature and/or wall thickness permits.
- 8.4.2 The basic calibration block curvature shall be in accordance with 8.2.
- 8.4.3 Thickness shall be  $\pm 25\%$  of the nominal thickness of the component to be examined.
- 8.4.4 The block size and reflector locations shall be adequate to perform calibrations for the beam angle(s) and distance range(s) to be used.

#### 8.5 Weld Metal Overlay Cladding Calibration Blocks

- 8.5.1 For Technique One – A basic calibration block as shown in Appendix 1, Figure 4, 5 or 6 shall be used. 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.
- 8.5.2 For Technique Two – A basic calibration block as shown in Appendix 1, Figure 7 shall be used. The thickness of the weld metal overlay cladding shall be at least as thick as that to be examined. The thickness of the base metal shall be within 25 mm (1 in.) 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 overaly cladding surface.

#### 8.6 Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal Calibration Blocks

- 8.6.1 The calibration block configuration shall be as per Appendix 1, Figure 8.
- 8.6.2 The block size and reflector locations shall be adequate to perform calibrations to cover the nozzle side weld fusion zone and /or the adjacent 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.
- 8.6.3 The calibration block shall be the maximum thickness of the nozzle wall adjacent to the nozzle weld plus 19 mm (0.75 in.).
- 8.6.4 For examinations of nozzles with an inside diameter (ID) equal to or less than 500 mm (20 in.), the contact surface of the calibration block shall have same curvature or be within the range of 0.9 to 1.5 times the diameter as detailed in Appendix 1, Figure 2.
- 8.6.5 The calibration reflectors shall be side drilled holes that are in accordance with the requirements in Appendix 1, Figure 1 for the nozzle wall thickness.

- 8.6.6 Existing 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 6 mm (0.25 in.) of what is required and the side drilled hole(s) is (are) the same or a smaller diameter than what is required.

## **9.0 TECHNICAL HAZARDS**

- 9.1 Techniques for coarse-grained materials must be approved by a UT level III prior to performing the work.
- 9.2 The technician shall ensure that the equipment selection and examination processes are appropriate for the temperature range to be worked in. Calibration standard and examination surface temperatures shall be as outlined in 10.7.
- 9.3 Transfer correction methods may only be used to correlate the ultrasonic responses between the calibration standard and the component tested when allowed for by the applicable technique, code or standard.

## **10.0 CALIBRATION – GENERAL REQUIREMENTS**

### **10.1 Instrument Linearity Checks**

Instrument linearity checks shall be conducted in accordance with CAN-CAL-02P004 at intervals not to exceed three months for analog type instruments and one year for digital type instruments.

### **10.2 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.

### **10.3 Calibration Surface**

Calibrations shall be performed from the calibration block surface (clad or unclad; convex or concave) corresponding to the surface of the component from which examination will be performed.

### **10.4 Couplant**

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

### **10.5 Search Units and Contact Wedges**

10.5.1 Exit points and angles of contoured or standard search units with or without wedges must be verified prior to use.

10.5.2 The same contact wedges to be used during the examination shall be used for calibration.

### **10.6 Instrument Controls**

Any control which affects instrument linearity (e.g. filters) shall be in the same position for calibration, calibration checks, instrument linearity checks, and examination.

**10.7 Temperature**

- 10.7.1 For contact examination, the temperature differential between the calibration block and the examination surfaces shall be within 25°F (14°C).
- 10.7.2 For immersion examination, the couplant temperature for calibration shall be within 25°F (14°C) of the couplant temperature for examination.
- 10.7.3 Ensure that the temperature differentials remain acceptable throughout the course of examinations.

**10.8 Calibration Confirmation****10.8.1 System Changes**

When any part of the examination system is changed (e.g. search unit, cable, wedge, etc.), a calibration check shall be made on the basic calibration block to verify that distance range points and sensitivity setting(s) are acceptable as follows:

a) 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. 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.

b) 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. 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 re-examined. If the sensitivity setting has increased, 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.

**10.8.2 Calibration Checks**

- a) A calibration check on at least one of the reflectors in the basic calibration block or a check using a simulator shall be performed:
- at the start and completion of each examination or series of similar examinations.
  - when examination personnel (except for automated equipment) are changed.
  - whenever the validity of the calibration is in question.

The distance range and sensitivity values recorded shall satisfy the requirements of 10.8.1.

Interim calibration checks between the required initial calibration and the final calibration check may be performed. The frequency of interim calibration checks should be based on ultrasonic instrument stability (analog vs. digital) and the risk of having to conduct re-examinations.

#### 10.8.3 Simulator Checks

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 reflectors or blocks and/or electronic simulation. However, the simulation used shall be identifiable on the calibration sheet(s). The simulator check shall be made on the entire examination system. Accuracy of the simulator checks shall be confirmed, using the basic calibration block, at the conclusion of each period of extended use, or every three months, whichever is less.

### 11.0 CALIBRATION – TECHNIQUE SPECIFIC

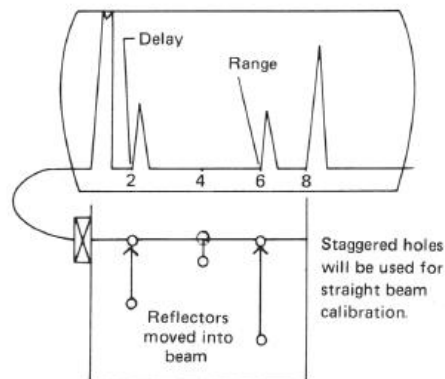
#### 11.1 Straight Beam Calibration – Distance Amplitude Technique

##### 11.1.1 Calibration Block(s).

- a) Non-piping straight beam calibrations shall be performed utilizing the calibration block as outlined in 8.3.
  - In cases such as single sided access welds, the calibration block outlined in 8.3 may not provide the necessary sound path distances to the reference reflectors to provide distance amplitude corrections that will fully cover the area of interest for the straight beam technique. In these cases, a second calibration block is required whose thickness (T) and reference reflector locations are based on the sound path distance that provides for coverage of the area of interest.
- b) Piping straight beam calibrations shall be performed using the side-drilled hole alternate calibration reflectors of 8.1.1(alternate in relation to the piping calibration block notches outlined in 8.4).
- c) Other calibration blocks may be utilized for distance and range calibration (e.g. DSC, IIW, PACS or custom blocks) provided the curvature requirements of 8.2 are met when applicable. If also utilized for distance-amplitude correction the block reflectors must meet the requirements of 8.1.1.

##### 11.1.2 Distance and Range Calibration

- a) Straight beam distance and range calibrations shall be carried out using a minimum of two reference points (e.g. side drilled hole or back wall reflectors).
- b) If using the calibration block as outlined in 8.3,
  - position the search unit for the maximum first indication from the  $\frac{1}{4}$  T SDH. Adjust the left edge of this indication to line 2 on the sweep with the delay zero control.
  - position the search unit for the maximum indication from the  $\frac{3}{4}$  T SDH. Adjust the left edge of this indication to line 6 with the sweep range control.
  - repeat the delay zero and sweep range adjustments until the  $\frac{1}{4}$  T and  $\frac{3}{4}$  T SDH indications start at sweep lines 2 and 6. The back surface indication will appear near sweep line 8. See the following illustration.



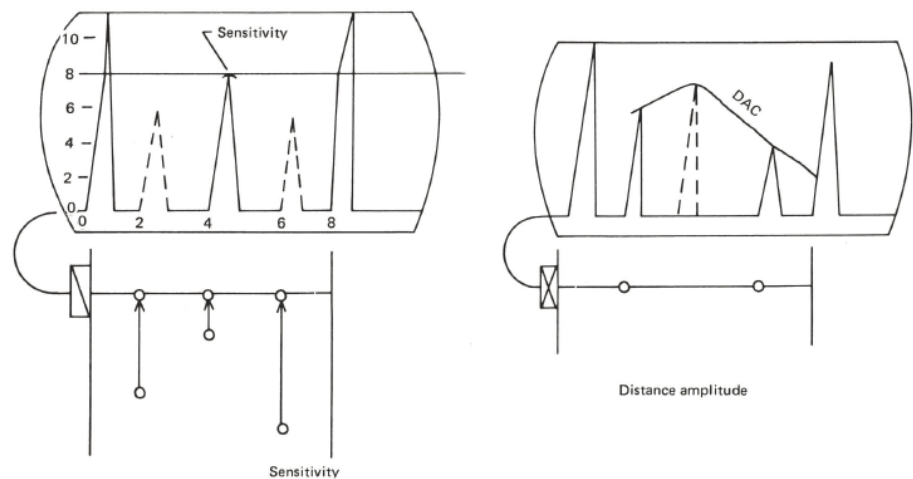
Distance and Range Calibration Using Side Drilled Holes

- c) If necessary, further adjust the sweep range to a value sufficient to cover the required examination volume.

#### 11.1.3 Distance-Amplitude Calibration

- a) When an electronic distance-amplitude correction device is used, the primary reference responses from the calibration block shall be equalized over the distance range to be employed in the examination. The response equalization line shall be at a screen height of 40% to 80% of full screen height.
- b) If establishing distance-amplitude correction,
  - for the sound path range of interest, position the search unit for the maximum indication from the SDH, which gives the highest indication (e.g.  $\frac{1}{4}$  T).

- adjust the sensitivity (gain) control to provide an 80%  $\pm$ 5% of FSH indication. This is the primary reference level. Mark the peak of this indication on the screen.
- position the search unit for maximum indication from another SDH (e.g.  $\frac{1}{2}$  T).
- mark the peak of the indication on the screen.
- position the search unit for maximum indication from the third SDH (e.g.  $\frac{3}{4}$  T) and mark the peak on the screen.
- connect the screen marks for the SDH's and extend through the thickness to provide the distance-amplitude curve. See the following illustration.



Sensitivity and Distance-Amplitude Correction

## 11.2 Angle Beam Calibration for Non-Piping – Distance Amplitude Technique

### 11.2.1 Calibration Block(s)

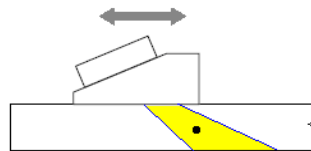
- Calibrations shall be performed utilizing the calibration block as outlined in 8.3.
- Other calibration blocks may be utilized for distance and range calibration (e.g. DSC, IIW, PACS or custom blocks) provided the curvature requirements of 8.2 are met when applicable. If also utilized for distance-amplitude correction the block reflectors must meet the requirements of 8.1.1.

11.2.2 Distance and Range Calibration

- a) Angle beam distance and range calibrations shall be carried out using a minimum of two reference points (e.g. side drilled hole or radius reflectors).
- b) If using the calibration block as outlined in 8.3,
  - position the search unit for maximum first indication from the  $\frac{1}{4}$  T SDH. Adjust the left edge of this indication to line 2 on the sweep with delay zero control.
  - position search unit for maximum indication from  $\frac{3}{4}$  T SDH. Adjust the left edge of this indication to line 6 with the sweep range control.
  - repeat delay and range adjustments until the  $\frac{1}{4}$  T and  $\frac{3}{4}$  T SDH indications start at sweep lines 2 and 6.
  - position search unit for maximum indication of the notch which will appear at sweep line 8.
  - two divisions of the sweep line equal  $\frac{1}{4}$  T of the calibration block.
- c) If necessary, further adjust the sweep range to a value sufficient to cover the required examination volume.

11.2.3 Distance-Amplitude Calibration

- a) The angle beam shall be directed toward the side-drilled hole that yields the maximum response in the area of interest. 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.
- b) The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum responses from the other calibration reflectors at their respective beam paths to generate a minimum three point distance amplitude correction (DAC) curve over the distance range to be employed in the examinations.



- c) When an electronic distance-amplitude correction device is used, the primary reference responses from the basic calibration block shall be equalized over the distance range to be employed in the examination. The response equalization line shall be at a screen height of 40% to 80% of full screen height.



**11.2.4 Alternative Angle Beam Calibration Method**

When a vessel or other component is made with a thickness of 13 mm (0.5 in.) or less and a diameter equal to or less than 500 mm (20 in.), the angle beam system calibrations for distance-amplitude techniques may be performed using the piping calibration block outlined in 8.4 and the requirements of angle beam calibration for piping, 11.8 (ref. ASME V, Art 4, T-463.1.4).

**11.3 Angle Beam Calibration for Piping – Distance Amplitude Technique****11.3.1 Calibration Block(s)**

- a) Calibrations shall be performed utilizing the calibration blocks as outlined in 8.4.
- b) Other calibration blocks may be utilized for distance and range calibration (e.g. DSC, IIW, PACS or custom blocks) provided the curvature requirements of 8.2 are met when applicable. If also utilized for distance-amplitude correction the block reflectors must meet the requirements of 8.1.1.

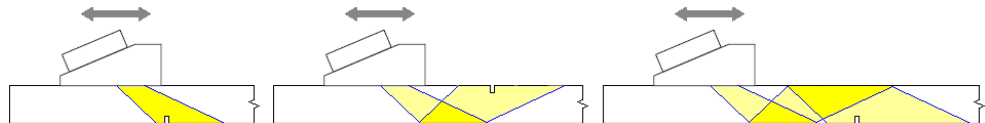
**11.3.2 Distance and Range Calibration**

- a) Angle beam distance and range calibrations shall be carried out using a minimum of two reference points (e.g. ASME pipe block notches/side drilled holes or alternates as described in 11.3.1b)).
- b) If using the notches of the calibration blocks as outlined in 8.4,
  - position the search unit for maximum first indication from the I.D. notch ( $\frac{1}{2}$  V-path). Adjust the left edge of this indication to line 4 on the sweep with delay zero control.
  - position search unit for maximum indication from the O.D. notch (full V-path). Adjust the left edge of this indication to line 8 with the sweep range control.
  - repeat delay and range adjustments until the I.D. and O.D. notch indications start at sweep lines 4 and 8.
  - two divisions of the sweep line equal  $\frac{1}{2}$  T of the calibration block.
- c) Adjust the sweep range to a value sufficient to cover the required examination volume.

**11.3.3 Distance-Amplitude Calibration**

- a) With Notches
  - The angle beam shall be directed toward the notch 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.

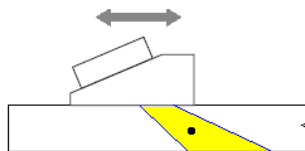
- The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum responses from the other calibration reflectors at their respective beam paths to generate a minimum three point distance-amplitude correction (DAC) curve over the distance range to be employed in the examinations.



- Separate calibrations shall be established for both the axial and circumferential notches.

b) With Side-Drilled Holes:

- 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  $80\% \pm 5\%$  of full screen height. This shall be the primary reference level.
- The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum responses from the other calibration reflectors at their respective beam paths to generate up to a 3T time corrected gain (TCG) curve, where T is the thickness of the calibration block.



- Next, position the search unit for the maximum response for the surface notch positions and mark the peaks on the screen for consideration when evaluation surface reflectors.
- Separate calibrations shall be established for both the axial and circumferential notches.

#### 11.4 Calibration for Weld Metal Overlay Cladding

##### 11.4.1 Distance and Range Calibration

Straight beam distance and range calibrations shall be carried out per the methodology of 11.1.2.

##### 11.4.2 Distance-Amplitude Calibration for Technique One.

- a) Calibrations shall be performed utilizing a Technique One calibration block as outlined in 8.5.1.

- b) The search unit shall be positioned for the maximum response from the calibration reflector. The gain control shall be set so that the response is 80%  $\pm$ 5% of full screen height. This shall be the primary reference level.

#### 11.4.3 Distance-Amplitude Alternate Calibration for Technique One.

- a) Calibrations shall be performed utilizing an alternate Technique One calibration block as outlined in 8.5.1(Specifically - Appendix 1, Figures 5 and 6) The calibration shall be performed as follows:
  - The search unit shall be positioned for maximum response from the reflector, which gives the highest amplitude.
  - When a side drilled hole is used for calibration, the plane separating the elements of the dual element search unit shall be positioned parallel to the axis of the hole.
  - The gain shall be set so that the response is 80%  $\pm$ 5% of full screen height. This shall be the primary reference level. Mark the peak of the indication on the screen.
  - Without changing the instrument settings, position the search unit for maximum response from each of the other reflectors and mark their peaks on the screen.
  - Connect the screen marks for each reflector to provide a DAC curve.
- b) Distance-Amplitude Calibration for Technique Two.
  - Calibrations shall be performed utilizing a Technique Two calibration block as outlined in 8.5.2.
  - The search unit shall be positioned for the maximum response of the first resolvable indication from the bottom of the calibration reflector. The gain shall be set so that the response is 80%  $\pm$ 5% of full screen height. This shall be the primary reference level.

### 11.5 Calibration for Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal

#### 11.5.1 Distance and Range Calibration

Straight beam distance and range calibrations shall be carried out per the methodology of 11.1.2.

#### 11.5.2 Distance-Amplitude Calibrations

- a) Distance-amplitude calibrations shall be performed utilizing the calibration block as outlined in 8.6.
- b) 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.

- 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.
- 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 the response is 80%  $\pm$ 5% of full screen height. This shall be the primary reference level. 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.

#### 11.6 System Calibration for Non-Distance Amplitude Techniques.

Calibration may be by use of basic calibration blocks with artificial or discontinuity reflectors. Other methods of calibration may include sensitivity adjustment based on the examination material, etc.

### 12.0 EXAMINATION – GENERAL REQUIREMENTS

#### 12.1 Work Order

Client information and specific inspection requirements including acceptance criteria shall be provided to the technician in the form of a Work Order (Call Sheet) prior to the start of examination. On projects where work orders are not issued, the supervisor shall provide detailed instructions, preferably written, to the technician.

#### 12.2 Identification of Weld Examination Areas

12.2.1 Weld location and their identification shall be recorded using unique identifiers. This may be by serial number, part number, job number, or any other unique weld identifier.

12.2.2 If the client requests a weld to be permanently marked, the client shall be responsible for providing the means and procedure.

12.2.3 Each weld shall be located and identified by a system of reference points. The system shall permit identification of each weld center line and designation of regular intervals along the length of the weld. This shall include,

- a) a datum point marked to indicate the zero (0) or examination start position and;
- b) an arrow indicating the positive examination direction.

The marking products shall not be detrimental to the material being examined. Consult the product data to ensure material compatibility.

#### 12.3 Base Metal Thickness

Ultrasonic thickness measurements shall be conducted to verify the base metal thickness at either side of the weld or at the applicable scanning surface(s).

**12.4 Examination Coverage**

- 12.4.1 The volume to be scanned shall be examined by moving the search unit over the scanning surface so as to scan the entire examination volume for each required search unit. This shall include, at a minimum, the weld volume and the adjacent heat affected zone (HAZ) unless otherwise specified by the applicable technique, code or standard.
- 12.4.2 For each search unit utilized, the technician shall ensure that the instrument sound path (sweep range) is sufficient for full coverage of the applicable volume.
- 12.4.3 Each pass of the search unit shall overlap a minimum of 10% of the transducer dimension parallel to the direction of scan indexing.
- 12.4.4 Oscillation of the search unit is permitted if it can be demonstrated that overlapping coverage is provided.

**12.5 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.

**12.6 Rate of Search Unit Movement**

The rate of search unit movement (scanning speed) shall not exceed 150 mm/sec (6 in./sec), unless, 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.

**12.7 Scanning Sensitivity Level**

- 12.7.1 Distance amplitude techniques shall be carried out at a scanning sensitivity level set at a minimum of 6dB higher than the reference level gain setting.

When the referencing technique, code or standard requires the detection and evaluation of indications exceeding 20% DAC, the gain should be increased an additional amount so that no calibration reflector indication is less than 40% FSH.

- 12.7.2 For non-distance amplitude techniques the scanning shall be at a gain setting appropriate for the configuration being examined and shall be capable of detecting the calibration reflector(s) at the maximum scanning speed.

**12.8 Surface Preparation**

- 12.8.1 When the base material or weld surface interferes with the examination, the base material or weld shall be prepared as needed to permit the examination.

- 12.8.2 Prior to examination the surface area shall be visually examined for relevant and non-relevant items that may affect the examination (e.g. joint off-set or weld discontinuities visible at the surface).

### **13.0 EXAMINATION – TECHNIQUE SPECIFIC**

#### **13.1 Weld Joint Distance Amplitude Technique**

- 13.1.1 When the referencing technique, code or standard specifies a distance amplitude technique, weld joints shall be scanned with an angle beam search unit in both parallel and transverse directions (4 scans) to the weld axis.

- 13.1.2 Before performing the angle beam examinations, a straight beam examination 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.

#### **13.1.3 Angle Beam Technique**

a) Beam Angle.

The search unit and beam angle selected shall be 45 degrees or an angle appropriate for the configuration being examined and shall be capable of detecting the calibration reflectors over the required angle beam path.

b) 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.

c) Reflectors Transverse to the Weld Seam.

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

d) Single Sided Access Welds.

- Welds that cannot be fully examined from two directions 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 man way neck to shell or head joints, pipe to fittings, or branch connections.
- These area(s) of single-sided access and, if applicable, the extent of the limit of coverage shall be noted in the examination report.

e) 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.

13.2 Weld Metal Overlay Cladding Techniques

13.2.1 The techniques described shall be used when examinations of weld metal overlay cladding have been specified. Technique One shall be used when examination for lack of bond and weld metal overlay cladding flaw indications is required. Technique Two may be used when only the examination for lack of bond is required.

13.2.2 Technique One.

The examination 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.

13.2.3 Technique Two.

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

13.3 Nozzle Side Weld Fusion Zone and/or Adjacent Nozzle Parent Metal Techniques

13.3.1 Search Unit Location.

When it has been specified 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

**13.3.2 Examination.**

The full circumference of the nozzle shall be scanned to cover the entire nozzle side fusion zone of the weld plus 25 mm (1 in.) beyond the weld toes. The search unit may be moved either circumferentially around or axially across the examination zone. The screen range shall cover a minimum of 1.1 times the full thickness of the nozzle wall. Nozzles that cannot be fully examined (e.g., restricted access that prevents hand placement of the search unit) shall be noted in the examination report.

**13.4 Non-Distance Amplitude Techniques**

The number of angles and directions of the scans, for reflectors both parallel and transverse to the weld axis, shall demonstrate the ability to detect the minimum size rejectable discontinuities in the referencing acceptance standards. The detailed techniques shall be in conformance with the requirements of the referencing technique, code or standard.

**14.0 POST-EXAMINATION****14.1 Cleaning**

When the client specifies post-examination cleaning, it should be conducted as soon as practical after evaluation and documentation using a process that does not adversely affect the part.

**15.0 EVALUATION****15.1 Acceptance Criteria**

The Client shall specify the acceptance criteria (e.g. applicable criteria, code or standard).

**15.2 Geometric Indications**

The identity, maximum amplitude, location, and extent of reflector causing a geometric indication shall be recorded. [For example: internal attachment, 200% DAC, 25 mm (1 in.) above weld center line, on the inside surface, from 90 degrees to 95 degrees] The following steps shall be taken to classify an indication as geometric:

15.2.1 Review fabrication or weld preparation drawings and visually examine the part configuration.

15.2.2 Assess the area containing the reflector.

15.2.3 Plot and verify the reflector coordinates. Prepare a cross-sectional sketch showing the reflector position and surface discontinuities such as root and counter bore.

15.2.4 Other ultrasonic techniques or non-destructive examination methods may be helpful in determining a reflector's true position, size, and orientation.



**15.3 Flaw Evaluation Level****15.3.1 Distance Amplitude Techniques.**

All indications greater than 20% of the reference level shall be investigated to the extent that they can be evaluated in terms of the applicable acceptance criteria.

**15.3.2 Non-Distance Amplitude Techniques.**

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 applicable acceptance criteria.

**15.4 Evaluation of Laminar Reflectors**

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 examination report.

**15.5 Flaw Sizing**

Unless otherwise indicated by the applicable technique, code or standard, the length, depth and position of the flaw shall be determined as follows:

**15.5.1 For angle beam examinations determine indication depth and position as follows:**

- a) Maximize on the indication and adjust the amplitude to 80% FSH. Record the sound path distance from the sweep and make a mark on the part at the search unit beam index point.
- b) Plot the data and report the depth and position.

**15.5.2 For angle beam examinations determine indication length using the 6dB drop technique as follows:**

- a) Maximize on the indication and adjust the amplitude to 80% FSH.
- b) Move the search unit laterally until the signal response drops to 40% FSH (- 6 dB). Record the travel distance and make a mark on the part at the search unit center line.
- c) Move the search unit laterally back past the 80% FSH position until the signal once again drops to 40% FSH (- 6 dB) in the opposite direction. Record the travel distance and make a mark on the part at the search unit center line.
- d) Plot the distance between the data points and report the length.

**15.5.3 For straight beam examinations determine indication depth by plotting the depth measurement from the sweep.**

15.5.4 For straight beam examinations determine indication length and width as follows:

- a) Use the angle beam length measurement methodology above and repeat for both opposing axis (e.g. for laminar indications).
- b) Plot the distances between the data points for both axis and report the length and width.

15.5.5 Notes:

- a) When sizing for length, where the signal does not drop off completely when moving beyond the 6dB drop limits referenced, the indication should be considered continuous.
- b) For sizing the length of indications smaller than the beam width, alternative sizing techniques may be employed (e.g. plotting of the flaw using a beam spread profile). The lateral beam spread shall be plotted at the half maximum amplitude limits (- 6 dB) of the primary lobe using round bottom holes or equivalent and the projected beam spread angle documented. The 6 dB indication boundaries can then be plotted in relation to the established beam spread.

## **16.0 REPORTS**

### **16.1 Reporting**

16.1.1 Complete all fields of the Acuren supplied report form in either the electronic or hard copy format.

- a) Non-rejectable indications shall be recorded as specified by the referencing technique, code or standard.
- b) Rejectable indications shall be recorded. As a minimum, the type of indication (i.e., crack, non-fusion, slag, etc.), location, and extent (i.e., length) shall be recorded.

16.1.2 For each examination the following information shall be recorded as a minimum. Where the item is not applicable to the examination the field shall be completed as N/A:

- a) Date of examination
- b) Client information
- c) Acuren job number
- d) Work location
- e) procedure identification and revision;
- f) ultrasonic instrument identification (including manufacturer's serial number);

- g) search unit(s) identification (including manufacturer's serial number, frequency, and size);
- h) beam angle(s) used;
- i) couplant used, brand name or type;
- j) search unit cable(s) used, type and length;
- k) special equipment when used (search units, wedges, shoes, automatic scanning equipment, recording equipment, etc.);
- l) computerized program identification and revision when used;
- m) calibration block identification;
- n) simulation block(s) and electronic simulator(s) identification when used;
- o) instrument reference level gain and, if used, damping and reject setting(s);
- p) calibration data [including reference reflector(s), indication amplitude(s), and distance reading(s)];
- q) data correlating simulation block(s) and electronic simulator(s), when used, with initial calibration;
- r) identification and location of weld or volume scanned;
- s) surface(s) from which examination was conducted, including surface condition;
- t) map or record of rejectable indications detected or areas cleared;
- u) areas of restricted access or inaccessible welds;
- v) examination personnel identity and qualification level;

Items 16.1.2f) through 16.1.2q) may be included in a separate calibration record provided the calibration record identification is included in the examination record.

## 16.2 Marking

- 16.2.1 Indications shall be marked directly on the item examined. (e.g. indication #, length, depth and characterization). Unless otherwise directed, only rejectable indications are required to be marked.
- 16.2.2 The marking products shall not be detrimental to the material being examined. Consult the product data to ensure material compatibility.

APPENDIX 1: CALIBRATION STANDARDS

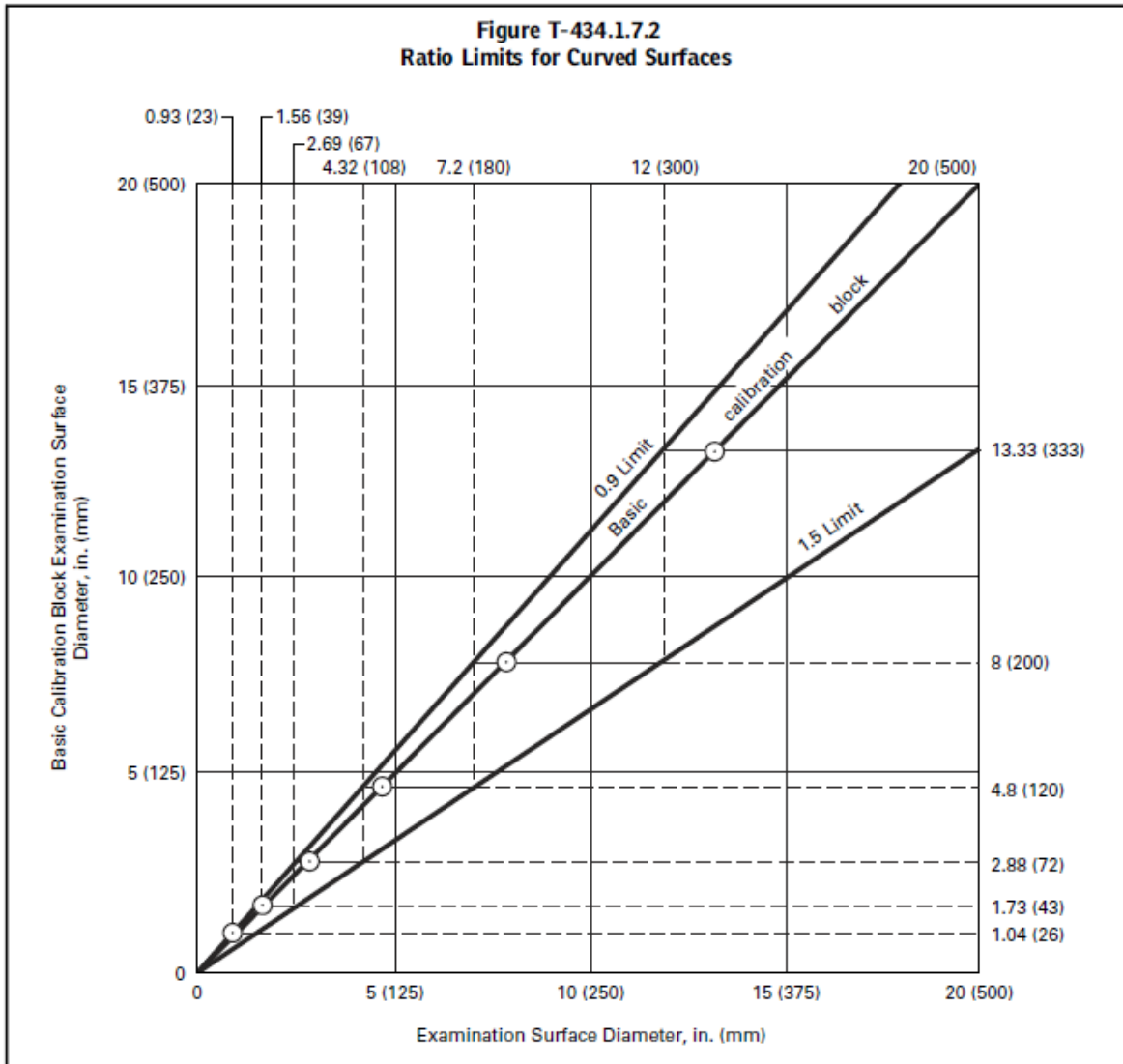


Figure 1 - Ratio Limits For Curved Surfaces  
(Figure Fig T-434.1.7.2 from ASME Section V, Article 4)

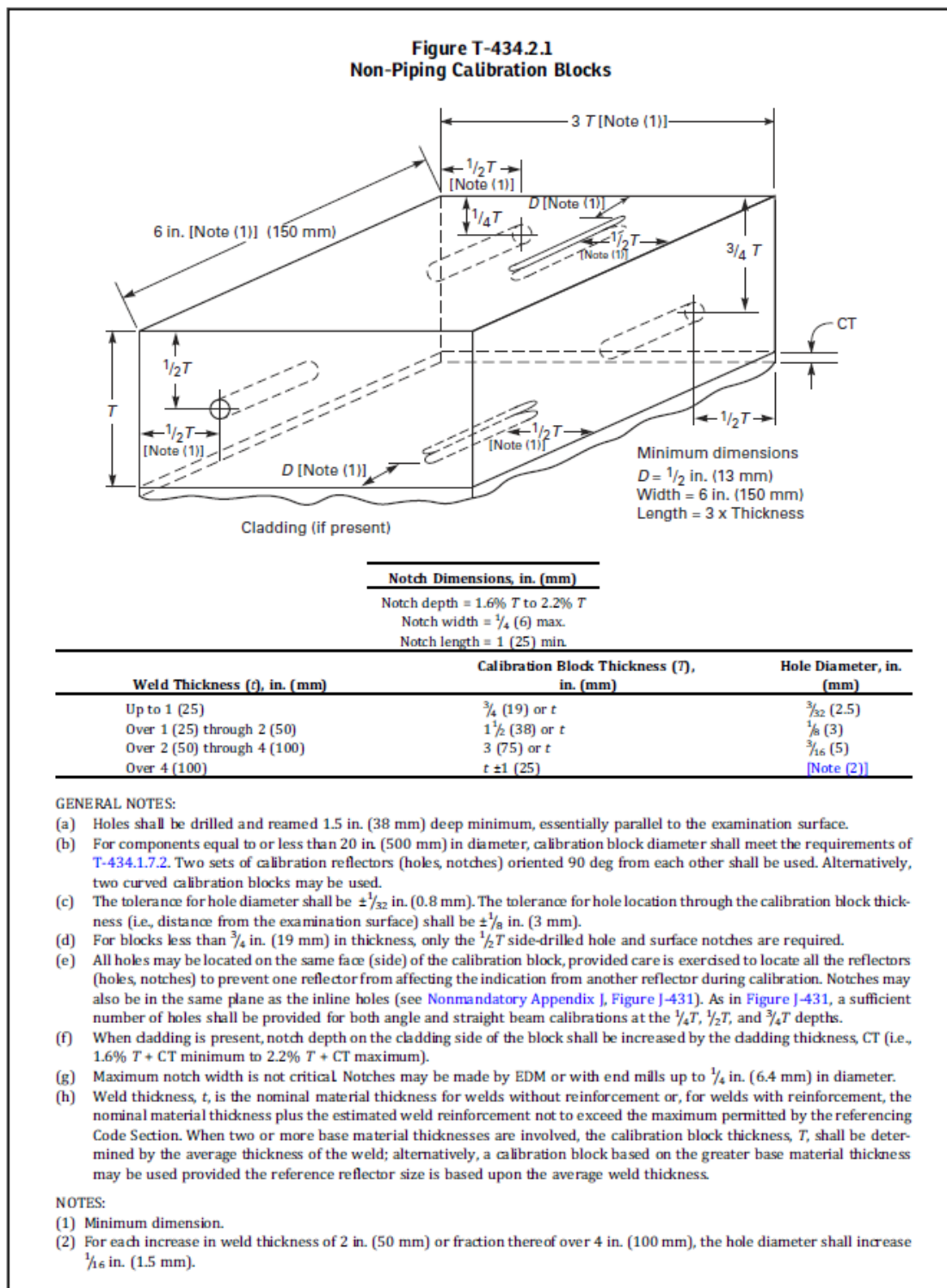


Figure 2 - Non-Piping Calibration Block  
(Fig T-434.2.1 from ASME V Article 4)

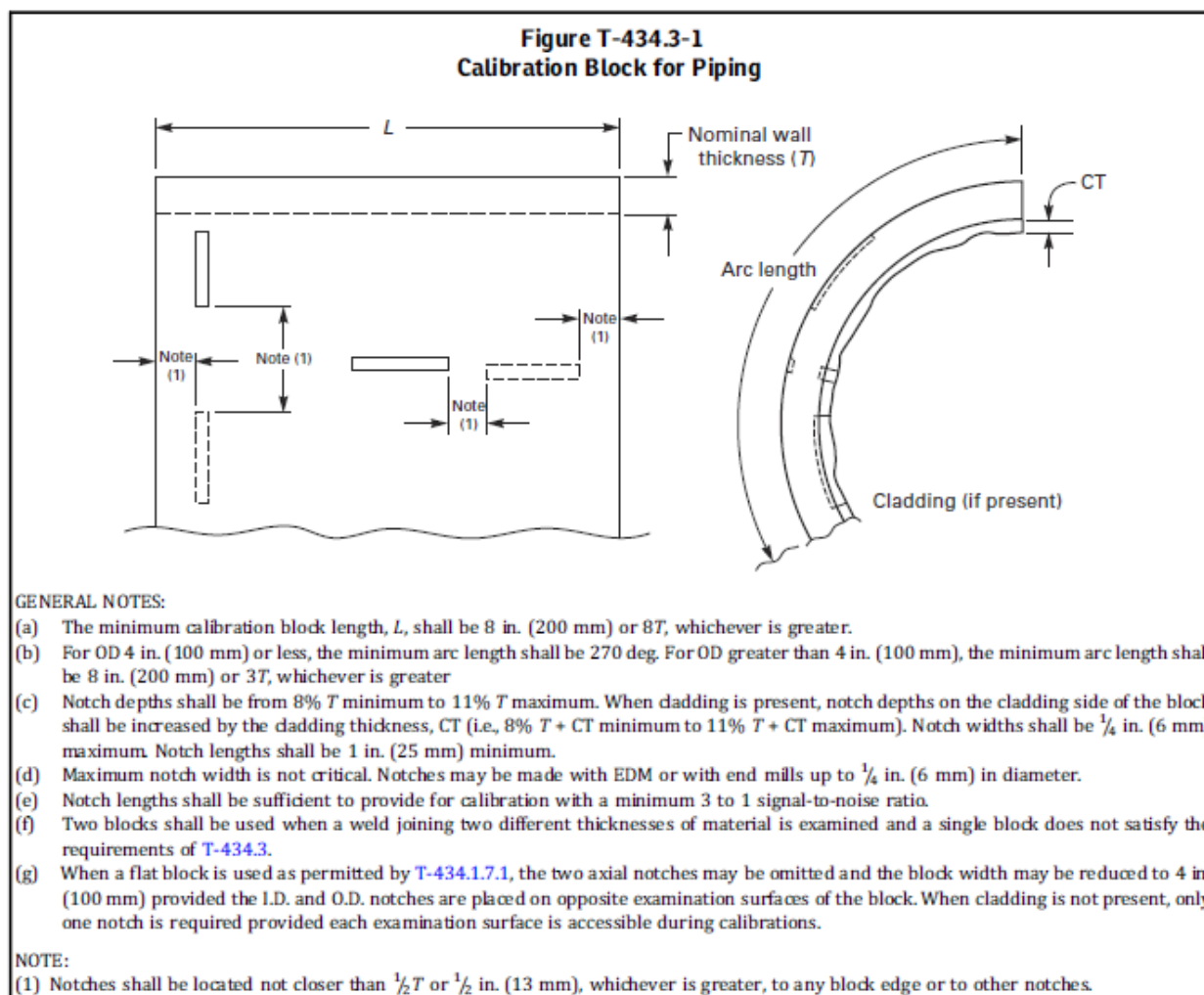


Figure 3 - Piping Calibration Block  
(Figure Fig T-434.3-1 from ASME Section V, Article 4)

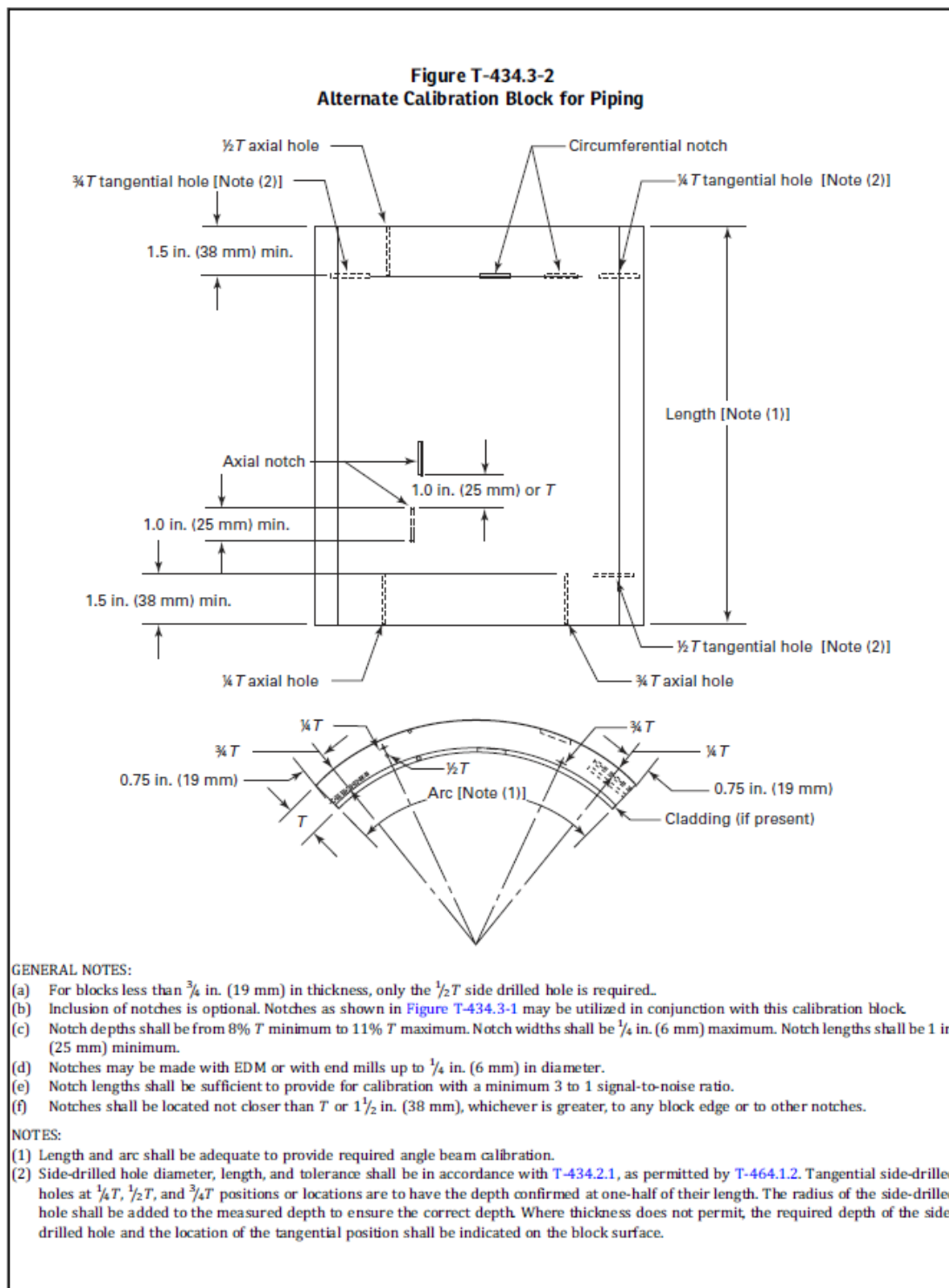


Figure 3A – Alternate Piping Calibration Block  
(Figure Fig T-434.3-2 from ASME Section V, Article 4)

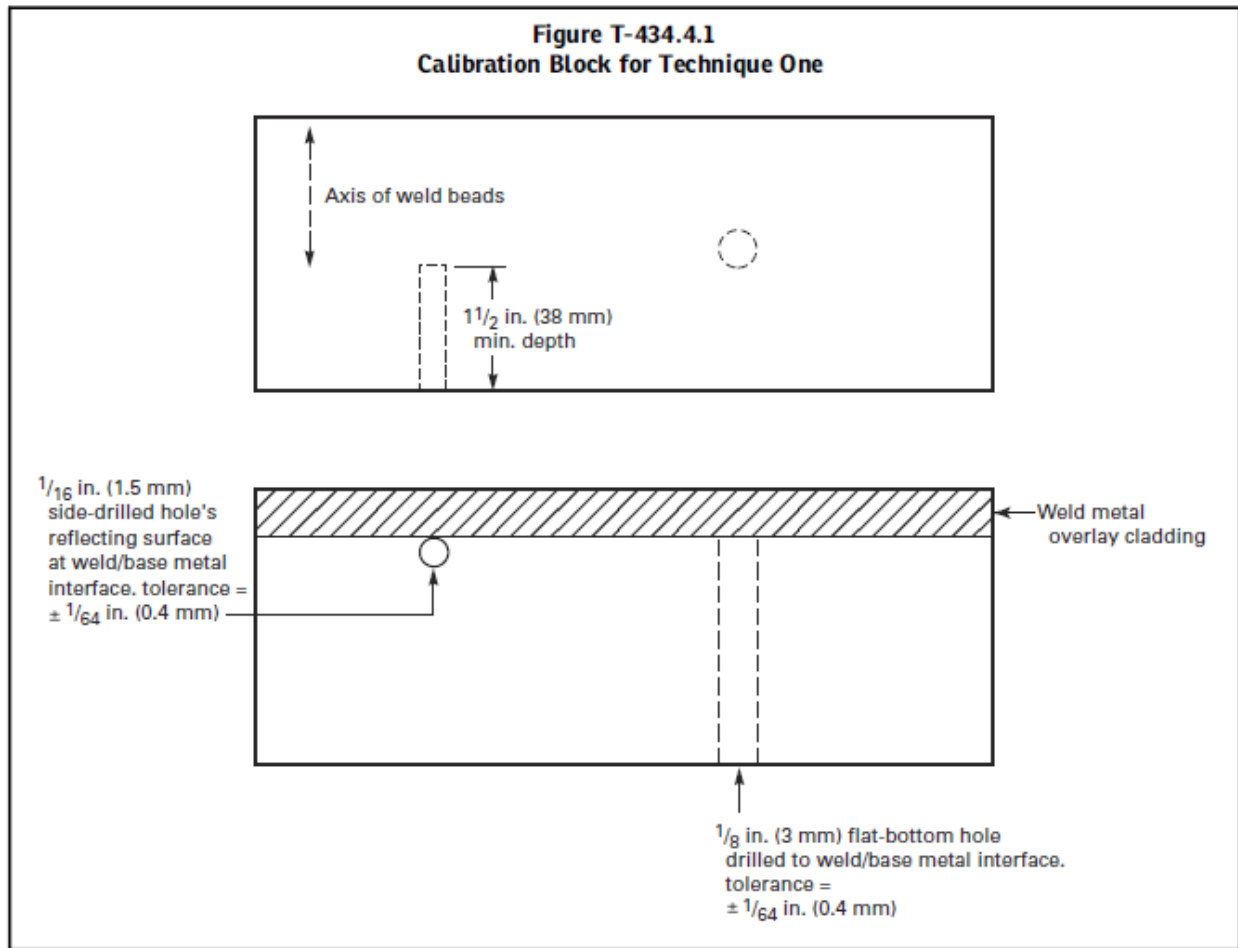


Figure 4 - Cladding Calibration Block – Technique One  
(Figure Fig T-434.4.1 from ASME Section V, Article 4)



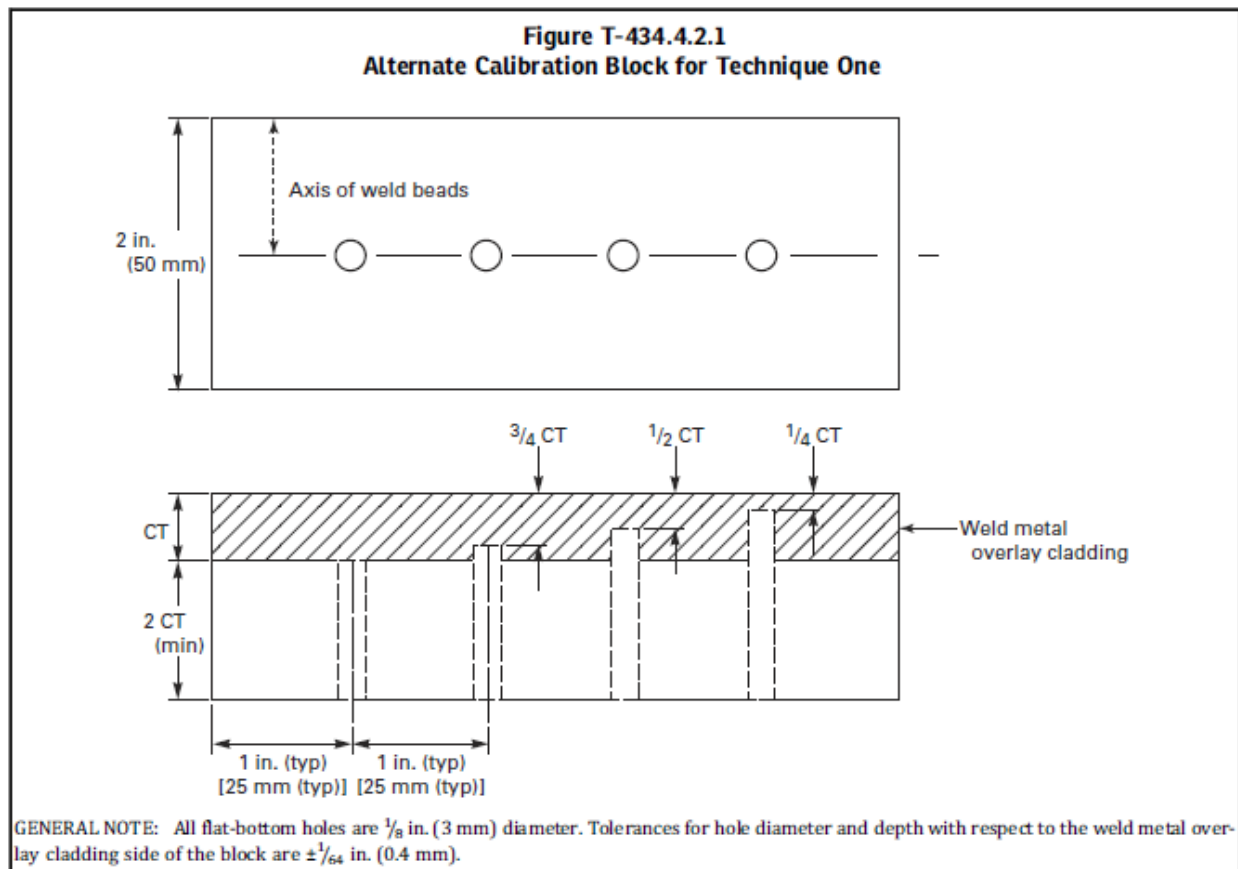


Figure 5 - Cladding Calibration Block – Alternate For Technique One  
(Figure Fig T-434.4.2.1 From ASME Section V, Article 4)

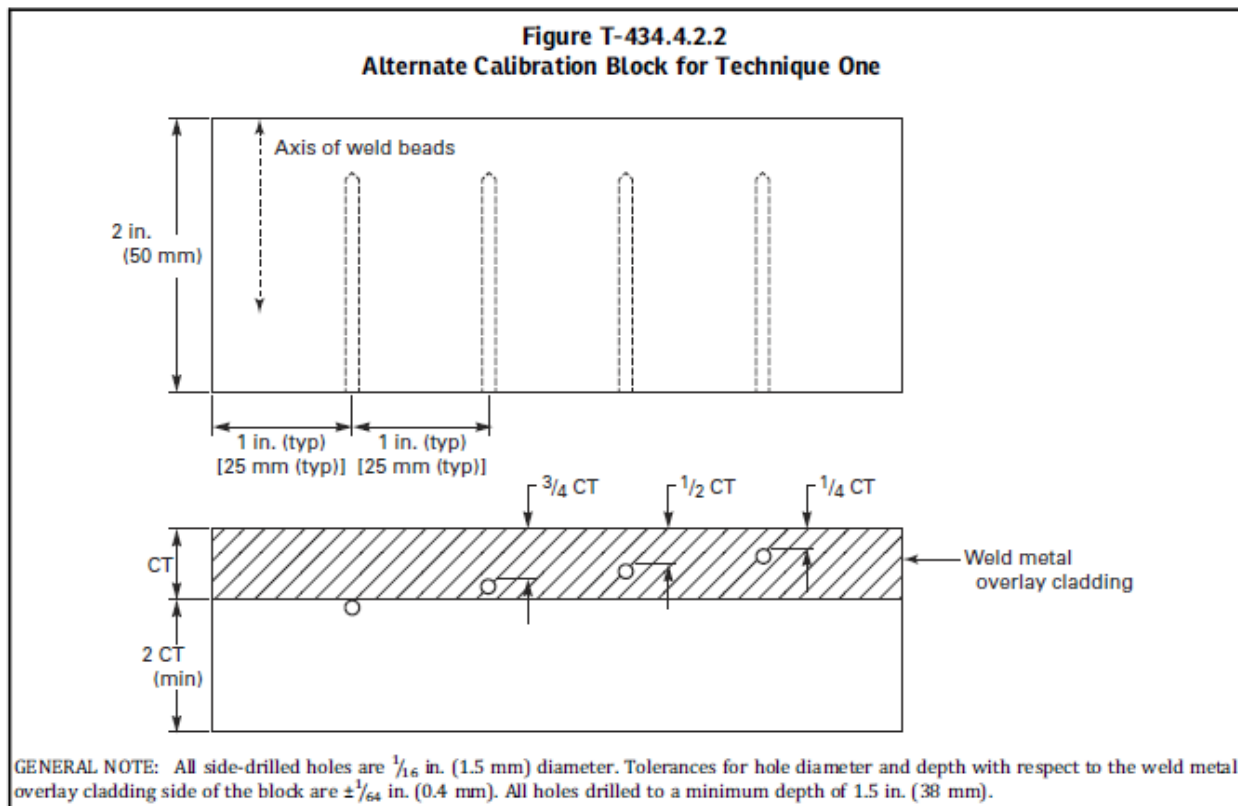


Figure 6 - Cladding Calibration Block – Alternate for Technique One  
(Figure Fig T-434.4.2.2 from ASME Section V, Article 4)

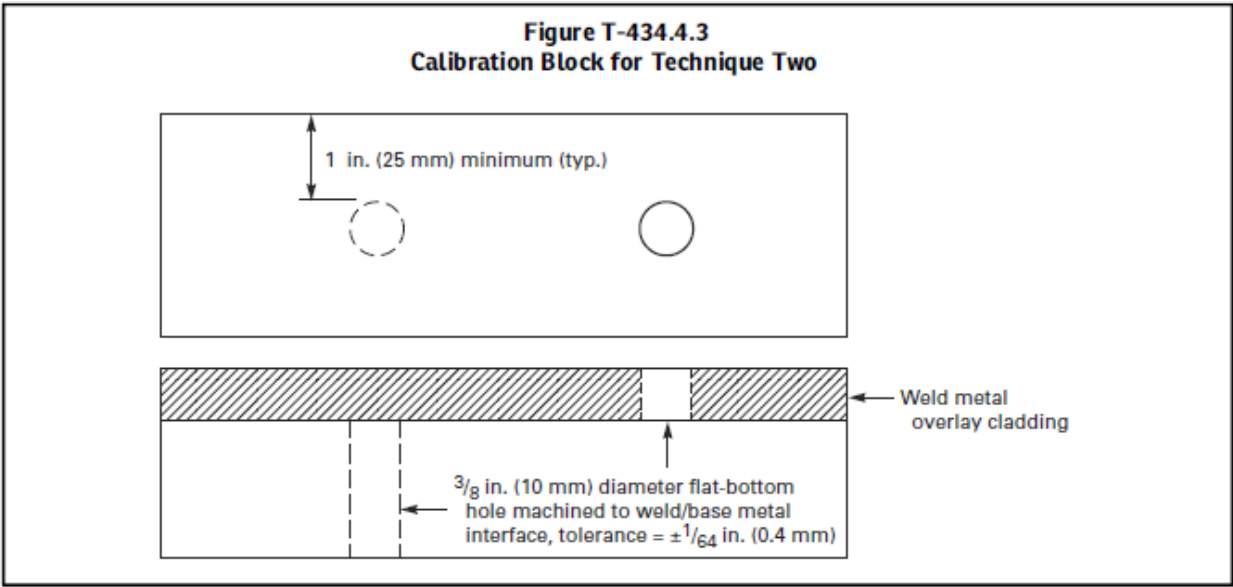
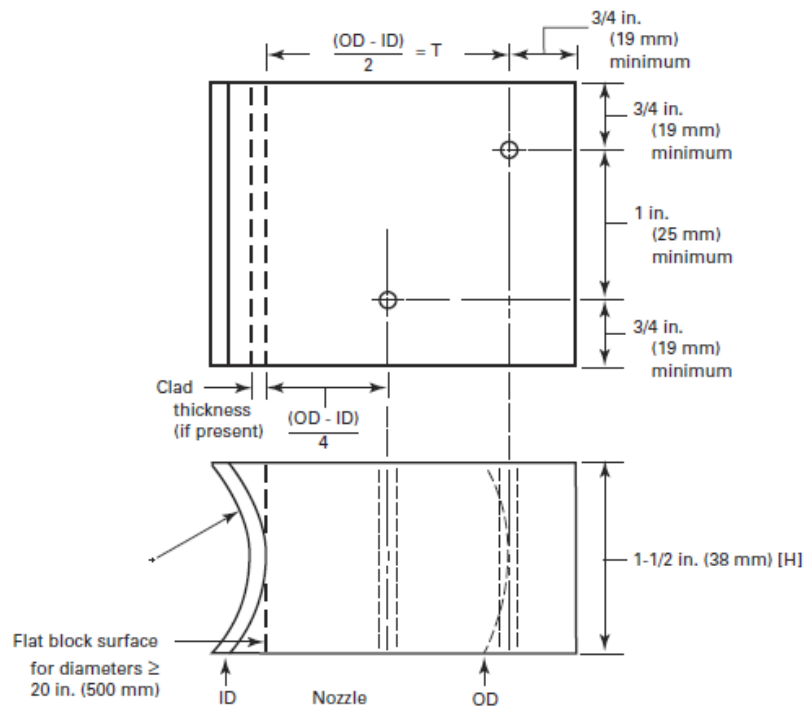


Figure 7 - Cladding Calibration Block – Technique Two  
(Figure Fig T-434.4.3 from ASME Section V, Article 4)

**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  $(OD - ID)/2$  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

Figure 8 - Nozzle Calibration Block  
(Fig T-434.5.1 from ASME Section V, Article 4)

## APPENDIX 2: REQUIREMENTS OF AN ULTRASONIC EXAMINATION PROCEDURE (ESSENTIAL AND NONESSENTIAL VARIABLES)

(Table T-421 from ASME V, Article 4)

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