NDT Procedure for Ultrasonic Testing of Forgings as per ASME, API, AWS codes

NDT Procedure No: TNWSPL-DOC-PT-12 Rev '0'

A Nondestructive testing (NDT) Procedure suitable for Ultrasonic Testing. Includes acceptance criteria as per ASME Section IX, AWS D1.1 and ASME B31.1, ASME B31.3 and API 650 & API 653 standards. This is a sample UT procedure and may be required to be modified as per specific requirements. For more specific NDT procedure preparation as per customer need, contact Trinity NDT, ASNT/ISO9712/NAS410 Level III Expert Consulting services.

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PROCEDURE FOR ULTRASONIC EXAMINATION AS PER ASME, AWS, API CODES

Procedure No. TNWSPL-DOC-UT-12 Rev '0'

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No.	Date	Description of Revision	Revised by	Approved by

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PROCEDURE FOR ULTRASONIC EXAMINATION AS PER ASME, AWS, API CODES

1. Scope

This procedure provides the operation procedure to be applied for performing Ultrasonic examination by using the manual ultrasonic flaw detector of materials and complete joint penetration of groove welds with thickness between 8 mm to 200.0 mm for Piping and Pressure Vessel fabrication. Additional procedure / instruction for material thickness below 8.0 mm. shall be approved by client engineering and surveyor. When being exam on austenitic steel materials.

2. Reference Documents

2.1. ASME BPV Codes Section I : Rules for Construction of Power Boilers
2.2. ASME BPV Codes Section II : Material
2.3. ASME BPV Codes Section V : Nondestructive Examination
2.4. ASME BPV Codes Section VIII Div.1 : Rules for Construction of Pressure Vessels
2.5. ASME BPV Codes Section VIII Div.2 : Rules for Construction of Pressure Vessels-Alternative Rules
2.6. ASME BPV Codes Section IX : Welding and Brazing Qualification
2.7. ASME B 31.1 : Power Piping
2.8. ASME B 31.3 : Process Piping
2.9. ASNT, SNT-TC-1A; 2011 edition with 2006 addendum
2.10. NAS 410 : NAS Certification & Qualification of Nondestructive Test Personnel
2.11. ISO 9712 : Non-destructive Testing – Qualification and Certification of NDT Personnel
2.12. RCI Qualification and Certification of NDT procedure
2.13. Applicable referencing code section or project specification

3. Abbreviation

3.1. NDT : Non-Destructive Testing
3.2. UT : Ultrasonic Testing
3.3. ASME: American Society for Mechanical Engineers

3.4. ASNT: American Society for Non-destructive Testing
3.5. NAS: National Aerospace Standard
3.6. ISO: International Standards Organization
3.7. SNT-TC: Society for Non-destructive Testing- Testing Council

4. Personnel Qualification

Personnel performing the test shall be qualified and certified in accordance with one of the following.

4.1. SNT-TC-1A : Personnel Qualification and Certification in Nondestructive
4.2. ANSI/ASNT CP-189 ASNT : Standard for Qualification and Certification of Nondestructive Testing
4.3. EN ISO 9712 : Qualification and Certification of NDT Personnel
4.4. NAS 410 : NAS Certification & Qualification of Nondestructive Test Personnel

5. Equipment's and Materials

Pulse-echo ultrasonic instrument with A-scan display shall be used with a Frequency range of at least between 1 to 5 MHz. *The instrument shall be calibrated at interval not to exceed 1 year* or prior the use thereafter. Brand: Kraukrâmer such USM 35X S and USM 35X DAC, NDT Systems such Avenger and Raptor or approved equivalent

5.1. Screen Height Linearity, The ultrasonic instrument shall provide linear vertical presentation within ± 5% of full screen height for 20% to 100% of the calibrated screen height. The evaluating procedure shall be performed in accordance with Mandatory Appendix I of ASME Sec V Article 4.
5.2. Screen Height Linearity, Amplitude Control Linearity, The ultrasonic instrument shall utilize an amplitude control, accurate over its useful range to ±20% of the nominal amplitude. Amplitude control evaluation will be performed in accordance with Mandatory Appendix II of ASME Sec V Article 4. Search Units or Probe**,** Search units may contain either single or dual transducer elements and shall be straight beam or angle beam type with frequency range between 1 to 5 MHz.

5.3. Search units may contain either single or dual transducer elements and shall be straight beam or angle beam type with frequency range between 1 to 5 MHz.

5.4. Couplant

5.4.1. A couplant having well wetting properties and acoustic properties such as starch paste, oil or any other commercial available shall be used.

5.4.2. The couplant must be compatible with the temperature of the specimen.

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

5.5. Calibration Blocks

5.5.1. The calibration blocks shall be flat or have curved surfaces. A basic calibration block in Fig.T-434.2.1 for non-piping and Fig.T434.3 for pipe of ASME Sec V shall be used for DAC construction

5.5.2. For examination of circumferential and longitudinal welds in vessels with contact surface curvatures greater than 20 inches (508 mm) in Diameter, flat basic calibration blocks may be used.

5.5.3. The basic calibration block contact surface shall be curved for vessel contact surface curvature less than 20 inches/508 mm. in diameter. A single curved basic calibrate block may be used to calibrate the examination on vessel contact surfaces in the rage of curvature from 0.9 to 1.5 times the basic calibration block diameter.

5.5.4. Calibration blocks shall be of the same product form and the same or Equivalent P number groupings as the materials to be inspected. For purposes of this procedure requirement, P-Nos. 1, 3, 4 and 5 are considered equivalent.

6. Surface preparation

6.1. Contact surfaces area minimum of one half skip-distance or more in order to be sure and allow complete weld examination from edge of the weld on both sides. It shall be smooth and free of irregularity such as spatter, dirt, rust, grease, oil (other than that used as a couplant), any

other roughness that will interfere with the free movement of the search unit or would prevent

6.2. Weld surface shall also be adequately smooth to prevent interference with the interpretation of the examination.

7. Extent of Examination

The extent of Ultrasonic examination shall be as specified by the referencing Code section.

8. Calibration

Calibration shall include the complete ultrasonic examination system. Calibration shall be performed prior to use of the system in the thickness range under examination. Sweep range calibration shall be performed on the basic calibration block in accordance with Non mandatory Appendix B and C of ASME Section V Article 4.

8.1. General

8.1.1. A change in operator, power supply, search unit, frequency, cables, couplant, or other components shall require calibration check of the system.

8.1.2. The calibration shall be done prior to examination, after each 4 hours of work and at the completion of the examination.

8.1.3. A calibration check shall verify the sweep range calibration and distance amplitude correction (DAC) as defined in T-466.

8.1.4. The temperature differential between the calibration block and examination surface shall be within 25 ° F (14 °C)

8.2. Straight Beam Calibration

8.2.1. Any suitable calibration block may be used for sweep range calibration such as V1, V2, V3 or equivalent.

8.2.2. A (DAC) curve shall be used in examination for weld or cast defect. For base metal testing (i.e. for lamination etc.), sensitivity setting is to bring the second back wall echo up to full screen height.

8.3. Angle Beam Calibration

8.3.1. The beam angle in the production material shall be in the range of 40 to 75 degrees inclusive.

8.3.2. Any suitable calibration block may be used for sweep range calibration such as V1, V2, V3 or equivalent.

8.3.3. A (DAC) curve shall be used in examination by calibration block in 5.5.1.

8.3.4. When two or more base material thickness ate involved, the calibration block thickness shall be determined by the average thickness of the weld. The block used shall be acceptable covering range of weld thickness of the weld thickness by plus or minus 1 inch of the block.

9. Examination

The test technique shall be by contact with normal or angle beam. The qualification of essential variables for technique used shall limit within Qualification of variables in Appendix of this procedure. When the test requires variable outside those stated, requalification is required.

9.1. Probe Selection

9.1.1. Straight beam probe shall be used for detecting of lamination in base metal prior to using angle beam examining wells.

9.1.2. For the welds which the reinforcement ground flush to the base metal, straight beam probe can be used.

9.1.3. The 70 degrees angle probe shall be used for the sweep range not greater than 200 mm. For sweep range greater than 200 mm. either 45 degrees probe or 60 degrees probe can be used but the operator shall pay more careful interpretation of indication when using 60 degrees probe because mode conversion is easily occurred.

9.2. Examination Area

9.2.1. The Volume of base material through which ultrasound will travel in angle beam examination shall be scanned using the straight beam method. If any reflectors are detected that could interfere with the interpretation of angle beam examination results, one of the alternate examination methods specified in Para 9.2.3 shall be used

to examine the weld and heat affected zone for which angle beam examination is masked or partially masked.

9.2.2. The weld shall be examined for discontinuities within the weld and adjacent heat affected zone. This examination shall be performed using the angle beam method from two directions. In cases where Geometry or angle beam method from two directions. In cases where Geometry or the inability of the rest specimen to allow transmission of ultrasound makes the angle beam examination from both sides of the weld impractical, either a combination of angle beam and straight beam or angle beam in two directions at 90 degree to each other shall be used.

9.2.3. Base material shall not be accepted or rejected on the results of the base material scan specified in 9.2.1 The areas are to be noted on the examination report and the angle beam examination shall require modify.

9.3. Scanning

9.3.1. The scanning pattern for straight beam examination shall be to move the search unit along and across a sufficient contact area of the test specimen so as to scan the entire volume of the weld and heat affected zone.

9.3.2. When reject table indications are detected, a map or drawing shall be prepared showing the location and depth of indications.

9.3.3. To scan for discontinuities parallel to the weld using the angle beam method, the search unit shall be placed on the surface with the sound beam at an approximate right angle to the center line of the weld from two directions where possible. The search unit shall be manipulated laterally and longitudinally so that the sound beam passes through the entire volume of the weld and heat affected zone from both sides of the weld.

9.3.4. To scan for discontinuities transverse to the weld using angle beam method, angle beam shall be directed essentially two directions parallel to the weld axis. The search shall be manipulated so that the angle beam passes through the required volumes of weld or heat affected zone.

9.3.5. Scanning shall be done at a gain setting of least twice the primary reference level (100% DAC) sensitivity or plus 6 dB.

9.3.6. Each pass of search unit shall overlap at least 10% of the transducer dimensions measured perpendicular to the direction of scan.

9.3.7. The rate of scanning shall not exceed 6 inches (150 mm) per second or unless.

10. Interpretation

10.1. All indications which produce a response greater than 20% of the reference level (100% DAC) 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 of the applicable Code.

10.2. Evaluation of discontinuities shall be done at the reference level.

10.3. When the material or weld is not acceptable to the requirement, the items shall be marked with words by marker as appropriated by the NDT examiner.

11. Evaluation and Acceptance Criteria

The acceptance standard shall be in accordance the referencing Code section. Appendices of this procedure describe the acceptance criteria of some Codes as below.

Acceptance Criteria for ASME BPV Section VIII Div. I

All Imperfections which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine their shape, identity, and location of all such imperfections and evaluate them in terms of the standards given in (a) and (b) below.

(a) Indication characterized as cracks, lacks of fusion, or incomplete penetration are unacceptable regardless of length.

(b) Other imperfections are unacceptable if the indication exceed the reference level amplitude and have lengths which exceed;

(1) ¼ in.(6 mm) for t up to 3/4 in. (19 mm)

(2) 1/4 t for t from 3/4 in. to 2 1/4in. (19 mm to 57 mm)

(3) 3/4 in.(19 mm) for t over 2 1/4 in.(57 mm)

Where 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.

Acceptance Criteria for ASME B31.3

A linear-type discontinuity is unacceptable if the amplitude of the indication exceeds the reference level and its length exceeds

(a) 6 mm (1⁄4 in.) for Tw ≤ 19 mm (3⁄4 in.)
(b) Tw/3 for 19 mm < Tw ≤ 57 mm (2 1⁄4 in.)
(c) 19 mm for Tw > 57 mm

12. Documentations

12.1. Ultrasonic examination result shall be recorded in the report as per attach in Appendix II

12.2. Repaired area shall be noted on the report and the results of the re-examination for the repaired area shall be recorded and indicated as indication number with R1, R2,….Rn on the new line of the original report or by addition report number with R number of repaired time.

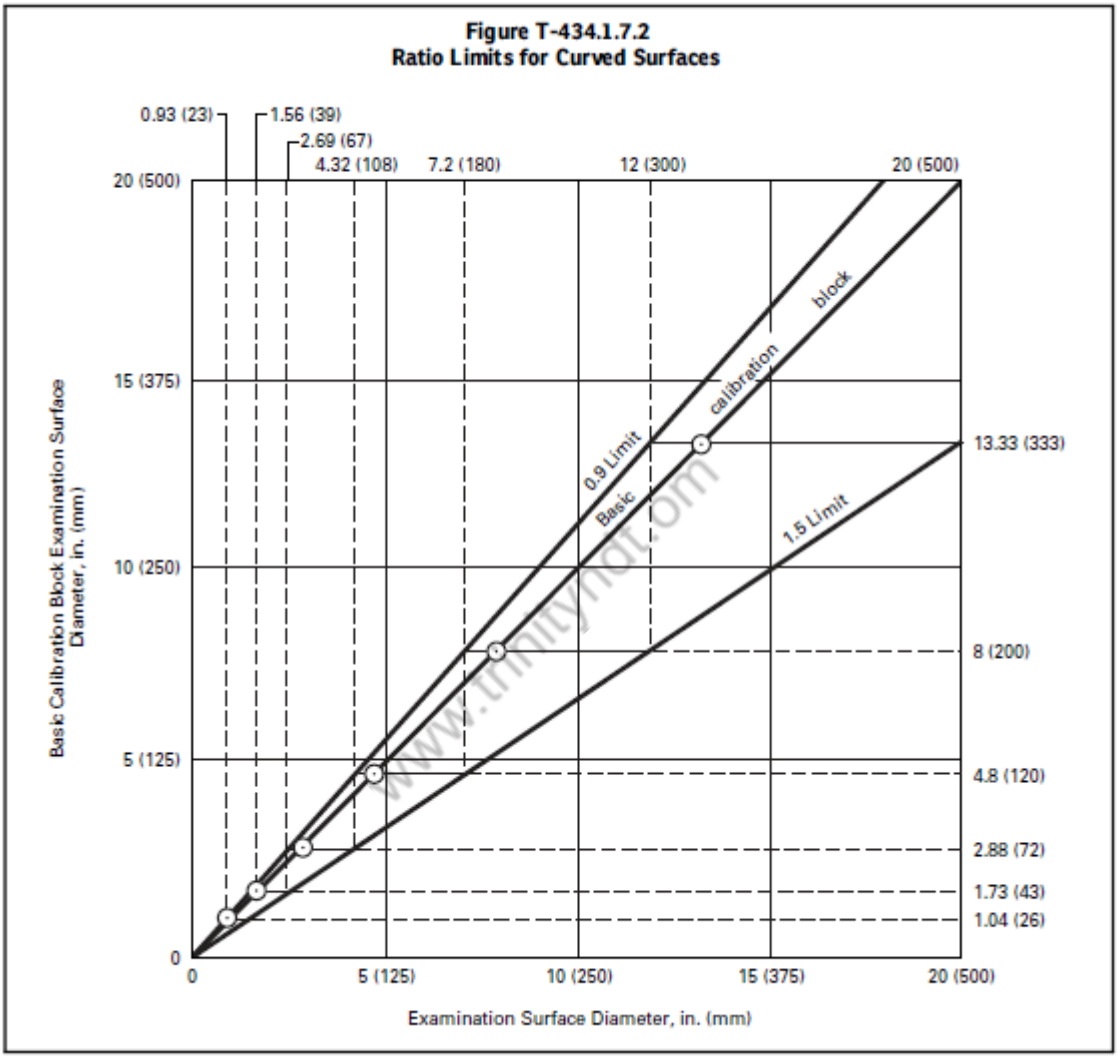
12.3. All the restrictions that limit the effectiveness of the examination shall be noted on the report.

13. Safety and Environment

Prior to handling test materials, performing equipment setups, and/or conducting this method, Operators are required to read "SAFETY AND HEALTH" of EQUIPMENT's Manufacturer.

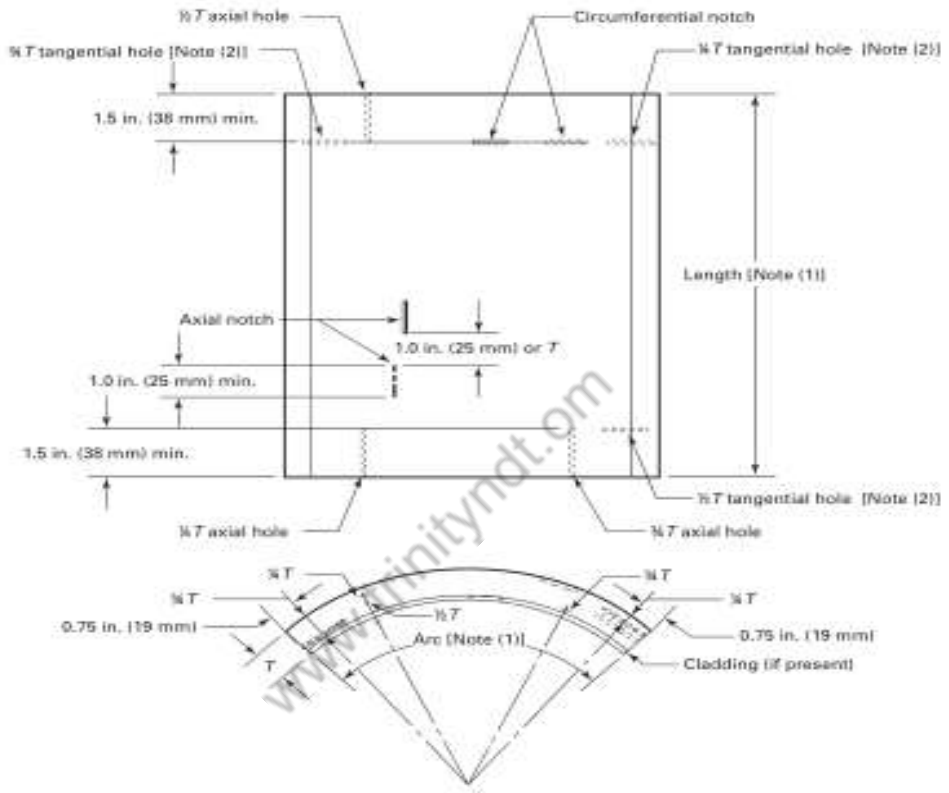
Appendix I Calibration Blocks

Figure T-434.1.7.2
Ratio Limits for Curved Surfaces



Appendix I Calibration Blocks (Cont'd)

Figure T-434.3-2
Alternate Calibration Block for Piping

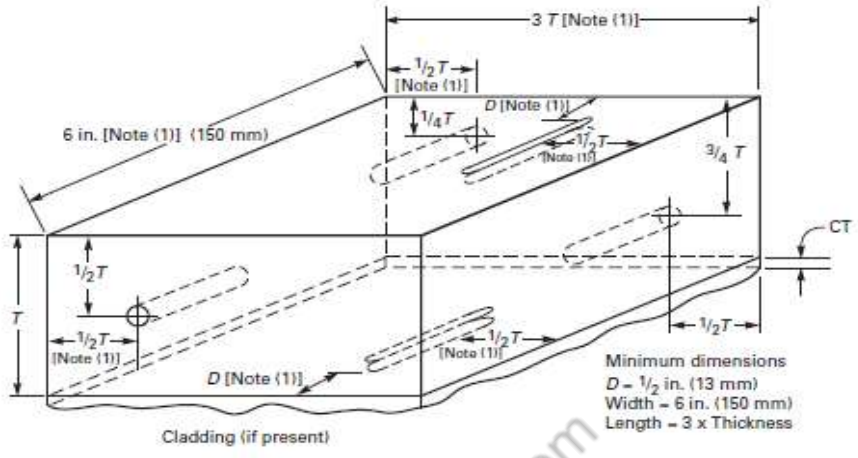


GENERAL NOTES:
(a) For blocks less than $^{3}/_{4}$ in. (19 mm) in thickness, only the $^{1}/_{2}T$ side drilled hole is required.
(b) Inclusion of notches is optional. Notches as shown in Figure T-434.3-1 may be utilized in conjunction with this calibration block.
(c) Notch depths shall be from 8% T 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-464.1.2. 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.

Appendix I Calibration Blocks (Cont'd)

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.

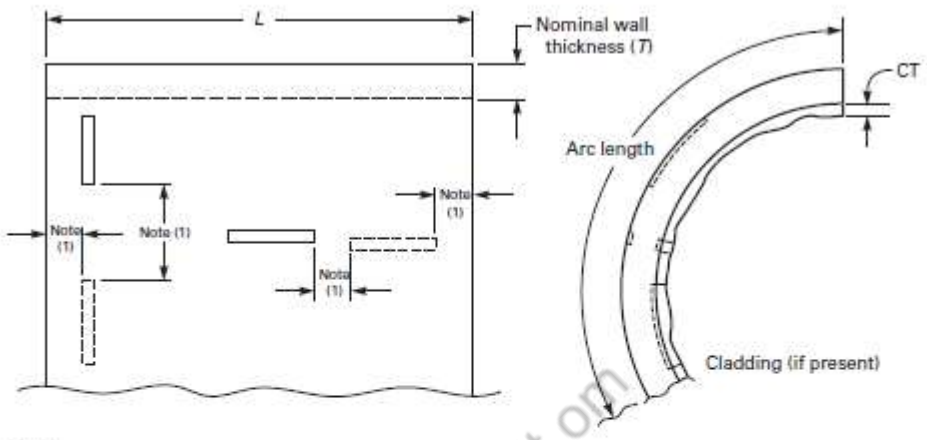
Weld Thickness (t), in. (mm)	Calibration Block Thickness (T), in. (mm)	Hole Diameter, in. (mm)
Up to 1 (25)	3/4 (19) or t	3/32 (2.5)
Over 1 (25) through 2 (50)	1 1/2 (38) or t	1/8 (3)
Over 2 (50) through 4 (100)	3 (75) or t	5/16 (5)
Over 4 (100)	t ±1 (25)	[Note (2)]

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 3/4 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 3/4 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).

Appendix I Calibration Blocks (Cont'd)

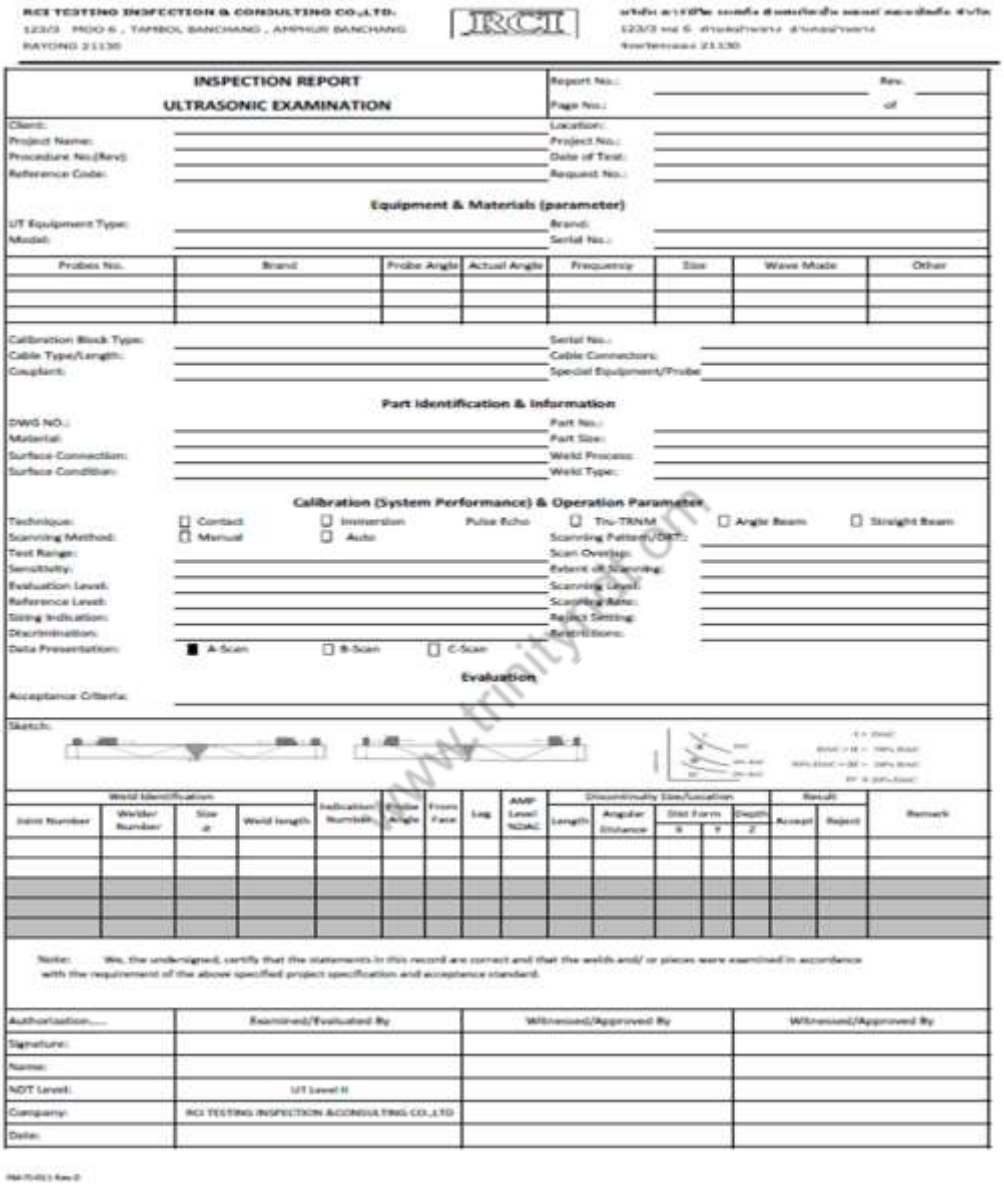
Figure T-434.3-1
Calibration Block for Piping



GENERAL NOTES:
(a) The minimum calibration block length, *L*, shall be 8 in. (200 mm) or 8*T*, whichever is greater.
(b) For O.D. 4 in. (100 mm) or less, the minimum arc length shall be 75% of the circumference. For O.D. greater than 4 in. (100 mm), the minimum arc length shall be 8 in. (200 mm) or 3*T*, whichever is greater.
(c) Notch depths shall be from 8% *T* minimum to 11% *T* maximum. When cladding is present, notch depths on the cladding side of the block shall be increased by the cladding thickness, CT (i.e., 8% *T* + CT minimum to 11% *T* + CT maximum). Notch widths shall be $\frac{3}{4}$ in. (6 mm) maximum. Notch lengths shall be 1 in. (25 mm) minimum.
(d) Maximum notch width is not critical. Notches may be made with EDM or with end mills up to $\frac{1}{4}$ 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) Two blocks shall be used when a weld joining two different thicknesses of material is examined and a single block does not satisfy the requirements of T-434.3.
(g) When a flat block is used as permitted by T-434.1.7.1, the two axial notches may be omitted and the block width may be reduced to 4 in. (100 mm), provided the I.D. and O.D. notches are placed on opposite examination surfaces of the block. When cladding is not present, only one notch is required provided each examination surface is accessible during calibrations.

NOTE:
(1) Notches shall be located not closer than $\frac{1}{2}T$ or $\frac{1}{2}$ in. (13 mm), whichever is greater, to any block edge or to other notches.

Appendix – II Ultrasonic Examination UT Report Format



INSPECTION REPORT
ULTRASONIC EXAMINATION

Report No.: Rev.
Page No.: of

Client: Location:
Project Name: Project No.:
Procedure No.(Rev): Date of Test:
Reference Code: Request No.:

Equipment & Materials (parameter)

UT Equipment Type: Brand:
Model: Serial No.:

Probes No.	Brand	Probe Angle	Actual Angle	Frequency	Size	Wave Mode	Other

Calibration Block Type: Serial No.:
Cable Type/Length: Cable Connectors:
Couplant: Special Equipment/Probe:

Part Identification & Information

DWG NO.: Part No.:
Material: Part Size:
Surface Connection: Weld Process:
Surface Condition: Weld Type:

Calibration (System Performance) & Operation Parameter

Technique: ☐ Contact ☐ Immersion Pulse Echo ☐ Thr-TRNM ☐ Angle Beam ☐ Straight Beam
Scanning Method: ☐ Manual ☐ Auto Scanning Pattern/ DIRT.:
Test Range: Scan Overlap:
Sensitivity: Extent of Scanning:
Evaluation Level: Scanning Level:
Reference Level: Scanning Rate:
Sizing Indication: Reject Setting:
Discrimination: Restrictions:
Data Presentation: ■ A-Scan ☐ B-Scan ☐ C-Scan

Evaluation

Acceptance Criteria:

Sketch:

Weld Identification: Joint Number	Welder Number	Size of	Weld length	Indication Number	Probe Angle	From Face	Leg	AWS Level %DAC	Discontinuity Size/Location: Length	Angular Distance	Dist From X	Dist From Y	Depth Z	Result: Accept	Reject	Remark

Note: We, the undersigned, certify that the statements in this record are correct and that the welds and/ or pieces were examined in accordance with the requirement of the above specified project specification and acceptance standard.

Authorization	Examined/Evaluated By	Witnessed/Approved By	Witnessed/Approved By
Signature:			
Name:			
NDT Level:	UT Level-II		
Company:	RCI TESTING INSPECTION &CONSULTING CO.,LTD		
Date:			