



PII-UTT

Ultrasonic Thickness Examination

PNDT-UTT

Revision 05

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**PRIME
INSPECTIONS** INC.
Revision / Change Summary

Revision/Change	No.	Date	Description
Original	0	4/1/2020	Original Issue
Revision	01	8/1/2021	Code Review and Administrative Changes
Revision	02	2/28/2022	Equipment Added; updated transducer specifications
Revision	03	1/1/2024	Code Review; updated for ASME Section V 2023 Edition
Revision	04	1/1/2026	Code Review; updated for ASTM E-797 and ASME Section V 2025 Edition
Revision	05	9/6/2026	Complete rewrite to ASME Section V Article 23 (Ultrasonic Thickness Examination); added ASME Section V Article 23 mandatory requirements; expanded calibration, gain, and reporting sections; added procedure qualification per Article 23; added acceptance criteria tables; updated for SNT-TC-1A 2020 Edition; added detailed appendix material

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1.0 SCOPE

1.1 This procedure establishes the minimum technique requirements for performing ultrasonic thickness measurement (UTT) using the pulse-echo method on metallic materials including carbon steel, austenitic stainless steel, duplex stainless steel, alloy steels, and nonferrous materials. The procedure is written in accordance with ASME Section V, Article 23, "Ultrasonic Thickness Examination," 2025 Edition, and ASTM E-797, "Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method."

1.2 This procedure provides specific instructions regarding equipment, techniques, calibration, and reporting for performing ultrasonic thickness examination on ferrous or nonferrous materials, either through coating or uncoated piping and pressure equipment. It applies to thickness examinations using a digital thickness gage with an A-Scan display and digital readout. Examinations may be performed while items are either in-service or out-of-service with a surface temperature range of 0°F to 200°F (-18°C to 93°C). For examination of parts with surface temperatures in excess of 200°F (93°C), special high-temperature couplant and transducers shall be used, and the specific technique shall be agreed upon by Prime Inspections Inc. and the Client prior to commencement.

1.3 This procedure covers the use of digital thickness meters (D-meters) and A-Scan display ultrasonic instruments for the measurement of remaining wall thickness on pipes, pressure vessels, storage tanks, structural steel, and other components where remaining-wall assessment is required. D-meters shall be used only to obtain thickness readings; lamination scans and flaw detection shall be performed with A-Scan display units capable of presenting the full waveform.

1.4 This procedure is applicable to material thickness ranges from 0.080 in. (2.0 mm) through 6.500 in. (165 mm) for carbon steel and low-alloy steel, and from 0.100 in. (2.5 mm) through 4.000 in. (101.6 mm) for austenitic stainless steel and nonferrous materials, subject to the capabilities of the specific transducer and instrument combination selected per Section 10.0.

1.5 This procedure is not intended for determining the thickness or condition of socket-welded or threaded fittings, nor for the detection or sizing of volumetric flaws such as porosity, slag, or lack of fusion. For ultrasonic flaw detection and sizing, refer to the applicable ultrasonic examination procedure (PII-MUT or PII-PAUT).

1.6 This procedure meets the essential variable requirements of ASME Section V, Article 23, Table T-231. Any change to an essential variable as defined in Article 23 shall require re-qualification of this procedure by demonstration in accordance with Article 23, paragraph T-234.

2.0 REFERENCED DOCUMENTS

2.1 The following documents are referenced in this procedure. Current editions apply unless otherwise noted. Where a referenced document contains requirements that conflict with this procedure, the referencing code or contract specification shall govern.

2.2 Codes and Standards

2.2.1 ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 2025 Edition, Article 23 – "Ultrasonic Thickness Examination"

2.2.2 ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 2025 Edition, Article 4 – "Equipment for Ultrasonic Examination"

2.2.3 ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 2025 Edition, Article 5 – "Ultrasonic Examination Techniques"

2.2.4 ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 2025 Edition, Article 14 – "Ultrasonic Calibration Blocks"

2.2.5 ASME Boiler and Pressure Vessel Code, Section V, Appendix III – "Glossary of Terms for Ultrasonic Examinations"

2.2.6 ASTM E-797, "Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method," Current Edition

2.2.7 ASTM E1316, "Standard Terminology for Nondestructive Examinations," Current Edition

2.2.8 ASNT SNT-TC-1A, "Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing," 2020 Edition

2.2.9 ASME B31.3, "Process Piping," 2024 Edition

2.2.10 ASME B31.8, "Gas Transmission and Distribution Piping Systems," 2024 Edition

2.2.11 API 510, "Pressure Vessel Inspection Code," Current Edition

2.2.12 API 570, "Piping Inspection Code," Current Edition

2.2.13 API 653, "Tank Inspection, Repair, Alteration, and Reconstruction," Current Edition

2.2.14 PII-WP-1, "Written Practice for the Qualification and Certification of NDE Personnel," Current Revision

3.0 TERMS AND DEFINITIONS

3.1 The terminology specific to ultrasonic thickness examination is defined in ASME Section V, Article 23, Article 4, and ASTM E1316. The following definitions are provided for clarity and consistency within this procedure.

3.2 **A-Scan** — A display mode in which the received ultrasonic signal amplitude is plotted as a vertical deflection versus the time-of-flight as the horizontal deflection, producing a waveform representation of the echo sequence.

3.3 **Back-Wall Echo** — The ultrasonic signal reflected from the opposite surface of the test material (the ID or inner surface). The time-of-flight of this echo is directly proportional to the material thickness.

3.4 **Couplant** — A substance applied between the transducer face and the test surface to facilitate the transmission of ultrasonic energy from the transducer into the test material by excluding air.

3.5 **D-Meter** — A digital ultrasonic thickness gage that displays a numerical thickness readout without presenting a full A-Scan waveform. D-meters are suitable for point thickness measurements but shall not be used for lamination scanning or when echo verification is required.

3.6 **Dual Element Transducer** — A search unit containing two piezoelectric elements, one functioning as the transmitter and the other as the receiver, housed in a single case with an acoustic barrier between them. Dual element transducers are preferred for thickness measurement because they reduce recovery time and improve near-surface resolution.

3.7 **Echo-to-Echo Mode** — A measurement mode in which the instrument measures the time between the first and second back-wall echoes, compensating for the thickness of any coating on the test surface.

3.8 **Initial Pulse** — The transmitted ultrasonic signal generated by the pulser, also known as the interface echo or transmitted signal.

3.9 **Pulse-Echo Method** — An ultrasonic test method in which a short burst of ultrasonic energy is transmitted into the material, and the echoes reflected from boundaries or discontinuities are received by the same or a separate transducer.

3.10 **Search Unit** — A device containing one or more piezoelectric elements that converts electrical energy into ultrasonic energy (transmission) and ultrasonic energy back into electrical energy (reception). Also called a transducer or probe.

3.11 **Sound Path** — The distance traveled by the ultrasonic beam from the search unit face to the reflector and back, or one-way distance depending on the measurement mode.

3.12 **Velocity of Sound** — The speed at which ultrasonic energy propagates through a given material. The longitudinal wave velocity in carbon steel is approximately 0.233 in./ μ s (5,900 m/s); in austenitic stainless steel approximately 0.224 in./ μ s (5,700 m/s).

3.13 **Zero Offset** — An instrument calibration adjustment that compensates for the transit time through the transducer delay line, wear face, and couplant layer, so that the displayed thickness reflects only the material thickness.

4.0 RESPONSIBILITIES

4.1 Prime Inspections Inc. is responsible for the preparation, review, approval, and control of this procedure. The ASNT NDT Level III is responsible for the technical review and approval of this procedure.

4.2 The Level III shall ensure that all personnel performing examinations under this procedure are qualified and certified in accordance with PII-WP-1 and SNT-TC-1A, 2020 Edition.

4.3 Level II and Level III technicians are responsible for performing calibrations, examinations, evaluations, and reporting in accordance with this procedure. Level I technicians may perform specific calibrations and obtain thickness measurements under the supervision of a Level II or Level III.

4.4 Technicians shall ensure that the item being inspected receives 100% inspection of all accessible areas within the inspection zone. Accessible areas are defined as those where all test parameters can be applied in accordance with this procedure and the results properly viewed for interpretation and evaluation. Areas found to be inaccessible shall be recorded in the examination report.

4.5 Prior to beginning work, all personnel shall read, understand, and follow the requirements of the applicable Job Hazard Analysis (JHA). In addition, personnel shall observe and follow all site-specific safety requirements.

4.6 Should there be a question or clarification needed regarding any safety or technical requirement, the supervisor, lead technician, or facility representative shall be contacted for resolution before beginning or resuming work.

4.7 The Corporate Quality Manager is responsible for ensuring that this procedure is reviewed at intervals not to exceed three years or when referenced code editions are updated, whichever occurs first.

5.0 PERSONNEL QUALIFICATIONS

5.1 Personnel performing evaluations and/or reporting results in accordance with this procedure shall be qualified and certified NDE Level II or Level III as a minimum and in accordance with ASNT SNT-TC-1A, 2020 Edition, and the Prime Inspections Inc. Written Practice (PII-WP-1).

5.2 Level I personnel and UT Level II-Restricted personnel may perform specific calibrations and specific evaluations for acceptance according to written instructions, and record results of thickness measurements and soundness examinations under the direct supervision of a Level II or Level III.

5.3 Personnel shall have current certification with documented training hours, experience hours, and examinations (general, specific, and practical) meeting the requirements of SNT-TC-1A, 2020 Edition, for the ultrasonic method.

5.4 Near-vision acuity shall be verified annually at Jaeger J-1 (or equivalent) at a minimum distance of 12 inches. Color vision shall be verified annually using the Ishihara color test or equivalent. Personnel who do not meet these vision requirements shall not perform examinations under this procedure until corrective lenses or other accommodation restores compliance.

5.5 Personnel performing examinations under this procedure shall be familiar with the equipment operation, calibration procedures, and reporting requirements specified herein. New or unfamiliar equipment shall be operated only after the technician has demonstrated proficiency to the Level III.

5.6 Minimum training and experience hours for UT certification per SNT-TC-1A, 2020 Edition:

Level	Training (hrs)	Experience (hrs)	Total (hrs)
Level I	40	320	360
Level II	80 (or 40 + 8 mo.)	960 (or 640 + 8 mo.)	1,040
Level III	160 (or 80 + 16 mo.)	1,600 (or 1,280 + 16 mo.)	1,760

6.0 EQUIPMENT AND MATERIALS

6.1 The following equipment and materials are required for ultrasonic thickness examination under this procedure. Alternative equipment may be used only with prior approval from the Prime Inspections Inc. NDT Level III and shall be documented in the examination record.

6.2 Ultrasonic Instruments

Instrument	Type	Display	Typical Application
Olympus 38DL Plus	Ultrasonic Thickness Gage	A-Scan + Digital	General thickness, coated surfaces
Olympus 45MG	Ultrasonic Thickness Gage	A-Scan + Digital	General thickness, high-temp
Dakota Ultrasonics MX-1	Ultrasonic Thickness Gage	Digital	General thickness measurement
Dakota Ultrasonics PVX	Precision Thickness Gage	A-Scan + Digital	Precision measurements
Panametrics-NDT 25DL	Ultrasonic Thickness Gage	Digital + Waveform	General thickness measurement
Krautkramer USN 58L	Flaw Detector / Thickness	A-Scan + Digital	Combined flaw/thickness

6.3 Transducers

6.3.1 Transducers shall be dual-element type with or without delay line. At temperatures exceeding 200°F (93°C), search units with high-temperature delay lines shall be used.

6.3.2 Transducers shall be compatible with the ultrasonic instrument in use and shall have a frequency and element size appropriate for the material thickness range being measured.

Transducer	Frequency	Element Dia.	Thickness Range (steel)
Olympus D-790	5 MHz	0.50 in. (12.7 mm)	0.080 – 6.500 in.
Dakota T-102	5 MHz	0.50 in. (12.7 mm)	0.100 – 6.000 in.
Olympus D-709	7.5 MHz	0.375 in. (9.5 mm)	0.060 – 3.000 in.
Dakota T-114	10 MHz	0.375 in. (9.5 mm)	0.040 – 2.000 in.
Olympus D-590	10 MHz	0.25 in. (6.4 mm)	0.030 – 1.000 in.
High-Temp Dual	5 MHz	0.50 in. (12.7 mm)	0.100 – 5.000 in. (up to 700°F)

6.4 Couplant

6.4.1 Industrial ultrasonic couplant suitable for the surface temperature range being examined shall be used. Standard couplant is rated for temperatures up to 200°F (93°C). High-temperature couplant shall be used for surfaces above 200°F.

6.4.2 Couplant shall be compatible with the test material. For stainless steel, titanium, nickel alloys, and other materials susceptible to stress corrosion cracking, couplant shall contain no more than 1% total sulfur or halogen (chlorine + fluorine) content as manufactured.

6.4.3 The same couplant used for calibration shall be used for the examination. Couplant shall be applied in a thin, uniform layer to ensure consistent acoustic coupling.

7.0 SURFACE PREPARATION

7.1 Tightly adhering paint, scale, or coatings do not necessarily need to be removed if they present uniform attenuation characteristics and do not interfere with the ultrasonic signal. If surface conditions prevent adequate coupling or signal quality, surfaces may be ground, sanded, wire-brushed, scraped, or otherwise cleaned to provide a smooth surface suitable for transducer contact.

7.2 Surfaces shall be free of loose scale, dirt, grease, oil, rust, moisture, or other foreign matter that could interfere with the transmission of ultrasonic energy from the transducer into the test material.

7.3 When measurements are taken through coatings (paint, epoxy, thermoplastic, etc.), the instrument shall be set to echo-to-echo mode or the coating thickness shall be compensated for in the calibration. Coating thickness shall be uniform within the examination area to ensure measurement accuracy.

7.4 For corroded or pitted surfaces, the transducer face shall make positive contact with the base metal. Where deep pitting prevents direct contact, the area shall be ground smooth or an alternative examination location shall be selected. If grinding is not feasible, the local reduction shall be noted in the report and evaluated per Section 18.0.

7.5 Surface temperature shall be verified prior to commencement of examination. The transducer and couplant shall be rated for the surface temperature encountered. For surfaces above 200°F (93°C), high-temperature transducers with appropriate delay lines and high-temperature couplant shall be used.

8.0 THEORY OF ULTRASONIC THICKNESS MEASUREMENT

8.1 Ultrasonic thickness measurement is based on the principle that a sound wave will travel through a given material at a known velocity. By measuring the time required for an ultrasonic pulse to travel from the transducer face, reflect from the opposite surface (back wall), and return to the transducer, the material thickness can be calculated using the following formula:

$$T = V \times t / 2$$

Where: T = material thickness; V = sound velocity in the test material; t = measured round-trip time-of-flight. The factor of 2 accounts for the pulse traveling to the back wall and returning.

8.2 Ultrasonic Inspection System Components

8.2.1 A typical ultrasonic thickness measurement system consists of several functional units: the pulser/receiver (housed within the instrument), the transducer, and the display device. The pulser/receiver generates high-voltage electrical pulses that drive the transducer to produce ultrasonic energy. The ultrasonic energy is introduced into the material and propagates as waves.

8.2.2 When the ultrasonic wave encounters a boundary (such as the back wall or a discontinuity), part of the energy is reflected back to the transducer. The transducer converts the reflected mechanical energy into an electrical signal, which is processed and displayed on the A-Scan presentation. The time-of-flight of the signal is directly proportional to the distance traveled.

8.3 Material Sound Velocities

8.3.1 The velocity of sound varies by material type and must be correctly set in the instrument for accurate thickness measurement. The following table provides typical longitudinal wave velocities for common materials:

Material	Velocity (in./μs)	Velocity (m/s)
Carbon Steel	0.233	5,900
Low-Alloy Steel	0.230	5,850
Austenitic Stainless Steel	0.224	5,700
Aluminum	0.250	6,350
Copper	0.184	4,660
Titanium	0.243	6,170
Inconel (Ni alloy)	0.229	5,820
Cast Iron	0.180 – 0.220	4,570 – 5,590

8.3.2 The actual sound velocity in a specific material may vary from the tabulated values due to alloy composition, heat treatment, grain size, temperature, and manufacturing process. Where precise measurements are required, the velocity shall be verified using a calibration block of the same material specification.

9.0 ULTRASONIC INSTRUMENTS

9.1 Instruments used under this procedure shall be of the pulse-echo type with an A-scan display with or without direct digital readout capability. Instruments with digital readout and no A-scan display (D-meters) may be used for point thickness measurements as specified in Section 1.0 but shall not be used for lamination scanning or where echo verification is required.

9.2 For the purpose of this procedure, the Olympus 38DL Plus or Dakota Ultrasonics MX-1 (or equivalent instruments meeting the requirements of ASME Section V, Article 23) shall be used. Any substitutions shall be approved by the Prime Inspections Inc. NDT Level III and documented in the examination record.

9.3 Instruments shall have the following minimum capabilities:

- 9.3.1 Adjustable sound velocity setting range covering 0.039 to 0.393 in./ μ s (1,000 to 10,000 m/s)
- 9.3.2 Adjustable zero offset (delay) calibration
- 9.3.3 Display resolution of 0.001 in. (0.01 mm) or better
- 9.3.4 A-Scan waveform display for signal verification
- 9.3.5 Echo-to-echo (multiple-echo) measurement capability for through-coating measurements
- 9.3.6 Gain control with adjustable dB settings
- 9.3.7 Battery operation for field use with a minimum of 4 hours continuous operation
- 9.3.8 Minimum measurement range from 0.020 in. (0.5 mm) to 20 in. (500 mm)

9.4 All instruments shall be calibrated (system performance verified) at least once every 12 months or after any repair. Calibration shall be performed by the instrument manufacturer or a qualified calibration laboratory with traceability to national standards. A calibration sticker shall be affixed to the instrument showing the calibration date, next due date, and the identity of the calibrating entity.

10.0 SEARCH UNITS (TRANSDUCERS)

10.1 Search units shall be dual-element type with or without delay line. Dual-element transducers are preferred for thickness measurement because they reduce the recovery time of the receiver circuit, improve near-surface resolution, and provide more consistent coupling through their focused beam design.

10.2 For the purpose of this procedure, the Olympus D-790 or Dakota Ultrasonics T-102 (or equivalent dual-element transducers) shall be used when material is 0.100 in. to 6.500 in. in thickness. For thinner materials (0.080 in. to 0.100 in.), higher-frequency transducers (7.5 MHz or 10 MHz) with smaller element diameters shall be used.

10.3 Ultrasonic thickness gauges will, under certain conditions, display readings that are twice the actual material thickness being measured. This effect is commonly known as "doubling" and can occur below the minimum specified range for the transducer or when the transducer is worn, the couplant is excessive, or the surface condition is poor. If doubling is suspected, the transducer shall be checked on a calibration block of known thickness and the examination surface re-cleaned.

10.4 At temperatures exceeding 200°F (93°C), search units with high-temperature delay lines rated for the maximum surface temperature shall be used. The transducer face shall not remain in contact with the hot surface longer than necessary to obtain a stable reading, to prevent thermal damage to the transducer element.

10.5 Transducer selection shall be based on the material type, expected thickness range, surface condition, and temperature. The following selection guide shall be used:

Thickness Range	Recommended Frequency	Recommended Element	Application
0.030 – 0.250 in.	10 MHz	0.25 in. (6 mm)	Thin-wall tubing, small pipe
0.080 – 1.000 in.	7.5 MHz	0.375 in. (9.5 mm)	General piping, small vessels
0.100 – 6.500 in.	5 MHz	0.50 in. (12.7 mm)	General purpose, pipe, vessels
0.500 – 6.000 in.	2.25 MHz	0.50 in. (12.7 mm)	Thick-wall, cast materials
0.100 – 5.000 in.	5 MHz (HT)	0.50 in. (12.7 mm)	High-temperature (200–700°F)

11.0 COUPLANT

11.1 Couplant shall be applied to the examination surface or the transducer face prior to taking each reading. Only a thin film of couplant is required to ensure acoustic coupling between the transducer and the test surface.

11.2 The couplant used for calibration shall be the same type and brand as used for the examination. If a different couplant is required due to temperature or surface conditions, the instrument shall be re-calibrated with the examination couplant.

11.3 For high-temperature applications (above 200°F / 93°C), high-temperature couplant specifically formulated for the temperature range shall be used. Standard couplant shall not be used above its rated temperature as degradation can produce inconsistent readings and damage the transducer.

11.4 Couplant shall be cleaned from the examination surface after completion of the examination. Post-examination cleaning shall be coordinated with the client as specified in Section 20.0.

11.5 For applications involving stainless steel, titanium, nickel alloys, or other materials susceptible to stress corrosion cracking, couplant shall be certified by the manufacturer as containing no more than 1% total sulfur or halogen (chlorine and fluorine) content. Documentation of couplant chemistry shall be maintained with the examination records.

12.0 SYSTEM CALIBRATION

12.1 The system performance calibration of the instrument shall be verified and documented at least once every 12 months or after any repair work to the instrument. The company or individual used to verify system performance calibration shall provide documented evidence of the tests performed and the results obtained. A sticker shall be applied to the instrument showing the date of calibration, the next due date, and the initials of the individual who performed the calibration.

12.2 Calibration shall include the complete ultrasonic system (instrument, transducer, and couplant) and shall be performed prior to use of the system in the thickness range under examination. The calibration shall be performed from the same surface type (flat or curved, convex or concave) corresponding to the surface from which the examination will be performed.

12.3 The same couplant used for the calibration shall be used for the examination. The same contact transducer to be used for the examination shall be used during calibration. The temperature of the calibration block shall be within 25°F of the temperature of the examination surface.

12.4 For thickness measurements on steel using high-temperature-rated search units, the calibration block temperature need not be within 25°F of the examination surface, provided the readings are corrected by 1% per 100°F temperature differential between the block and the test part surface. The temperature correction shall be documented in the examination record.

12.5 Calibration verification shall be performed at the start of each shift or job, and at the end of the examination. If the examination extends beyond a single shift, calibration shall be verified at the start of each subsequent shift. Calibration shall also be verified any time the transducer is changed or the instrument is turned off and on.

12.6 The calibration is considered valid if the instrument reads within ± 0.002 in. (0.05 mm) or 1% of the known block thickness, whichever is greater. If the instrument does not read within tolerance, re-calibrate and re-inspect all readings taken since the last valid calibration.

13.0 CALIBRATION BLOCKS

13.1 A multi-step thickness calibration block, flat or curved, of similar material specification to the test component shall be used. The calibration block shall have at least two known thickness steps that bracket the expected thickness range of the test component. When applicable, calibration shall be performed on the same surface geometry (concave or convex) that the thickness measurements will be taken from.

13.2 A multi-step "doubling block," flat or curved, of similar material shall be used to determine the minimum thickness at which doubling of the measurement can occur. The doubling block shall have steps that span the minimum thickness range of the transducer being used.

13.3 Calibration blocks shall be manufactured from material of the same general specification as the component being examined. For carbon steel components, carbon steel calibration blocks shall be used. For stainless steel components, blocks of the same austenitic grade shall be used. If an exact material match is not available, blocks of the same material type (e.g., ferritic vs. austenitic) may be used with the velocity adjusted accordingly.

13.4 All calibration blocks shall be permanently identified with a unique serial number, material specification, and certified thickness values. The certified thickness values shall be determined by mechanical measurement (micrometer) with an accuracy of at least ± 0.001 in. (0.025 mm). Certification records for each calibration block shall be maintained.

13.5 Calibration blocks shall be visually inspected prior to each use for signs of damage, corrosion, or surface degradation that could affect measurement accuracy. Damaged blocks shall be re-certified or replaced.

13.6 When examining curved surfaces (pipe), calibration blocks with the same or similar outside diameter shall be used. If a curved block is not available, a flat block may be used provided the curvature correction is verified and documented. For pipe diameters less than 4 inches NPS, curved calibration blocks shall be used.

14.0 CALIBRATION PROCEDURE

14.1 The instrument shall be calibrated using one of the following methods as appropriate for the measurement mode selected and the surface conditions encountered.

14.1 Standard Mode (Single Echo) Calibration

14.1.1 Turn on the instrument and allow it to stabilize for a minimum of 5 minutes.

14.1.2 Verify that the battery has sufficient charge to complete the examination.

14.1.3 Select the appropriate material velocity from the instrument preset list or manually enter the velocity per Section 8.3.1.

14.1.4 Apply couplant to the thicker standard of the multi-step calibration block.

14.1.5 Couple the search unit to the thicker standard and adjust the "Cal/Velocity" setting until the digital readout matches the known thickness of that block.

14.1.6 Couple the search unit to the thinner standard and adjust the "Cal/Zero" setting until the digital readout matches the known thickness of that block.

14.1.7 Couple to each step of the multi-step block to verify calibration linearity.

14.1.8 Repeat the above steps until the digital readouts from each reference block are within 0.002 in. (0.05 mm) of the respective known standard thickness.

14.2 Echo-to-Echo Mode Calibration (Through Coating)

14.2.1 Set the instrument to "Echo-to-Echo" mode. This will instruct the instrument to measure the time between the first and second back-wall reflections, effectively eliminating the coating thickness from the measurement.

14.2.2 Set the instrument range so that a minimum of two back-wall reflections are visible in the A-Scan presentation for the thicker calibration block step. Use the minimum range setting that accomplishes this requirement.

14.2.3 Obtain the multi-step calibration block whose thicknesses bracket the expected thickness range of the materials to be measured.

14.2.4 Apply couplant to the thicker standard and adjust the "Cal/Velocity" setting until the readout matches the known thickness.

14.2.5 Apply couplant to the thinner standard and adjust the "Cal/Zero" setting until the readout matches the known thickness.

14.2.6 Couple to each standard of the multi-step block to verify calibration linearity.

14.2.7 Repeat the previous steps until the respective echoes and digital readout from each reference block appear at their correct position on the horizontal sweep scale and the digital readouts are within 0.002 in. (0.05 mm) of the respective standard thickness.

14.3 Calibration Verification

14.3.1 After calibration, verify the system on a minimum of two known reference standards that bracket the examination thickness range. Record the verified readings on the calibration log.

14.3.2 Calibration shall be verified at the start of each shift, at the end of the examination, and at any time the system is suspected of being out of calibration.

14.3.3 If the verification reading differs from the known value by more than 0.002 in. (0.05 mm) or 1% (whichever is greater), re-calibrate and re-inspect all readings taken since the last valid calibration.

15.0 GAIN SETTINGS

15.1 Gain settings shall be adjusted to produce a back-wall signal amplitude of approximately 80% of full-screen height (FSH) during calibration and re-verified during the examination. The gain shall be sufficient to produce a stable, repeatable digital readout without saturating the receiver.

15.2 Excessive gain may cause noise or spurious readings, while insufficient gain may result in lost back-wall echoes or unstable readings. The gain shall be optimized for each transducer/material combination and recorded on the examination record.

15.3 For measurements through coatings or on rough surfaces, the gain may need to be increased to compensate for signal attenuation. If the back-wall signal amplitude drops below 40% FSH, the measurement may not be reliable, and the surface condition should be re-evaluated.

15.4 The gain setting used for calibration shall be the same gain setting used for the examination. If gain adjustment is required during the examination (e.g., due to varying surface conditions), the calibration shall be re-verified after the gain change.

16.0 THICKNESS MEASUREMENTS

16.1 Thickness measurements shall be taken at the locations specified by the client, the applicable code, or the inspection plan. The examination grid or measurement spacing shall be specified in the job-specific inspection plan or as required by the referencing code.

16.2 A sufficient number of readings shall be taken to adequately characterize the component condition. As a minimum, readings shall be taken at the following locations:

- 16.2.1 At each designated grid point or inspection location
- 16.2.2 At areas of suspected corrosion or erosion
- 16.2.3 At butt weld heat-affected zones (HAZ), 1 in. from the weld toe
- 16.2.4 At fillet weld toes and corners
- 16.2.5 At flanges, nozzles, and other geometric transitions
- 16.2.6 At low points and dead legs in piping systems
- 16.2.7 At any location where visual inspection indicates potential wall loss

16.3 When the back-wall signal is lost or unstable, the following actions shall be taken:

- 16.3.1 Re-clean the surface and re-apply couplant
- 16.3.2 Check transducer coupling and contact
- 16.3.3 Verify calibration on a known reference block
- 16.3.4 Increase gain within reasonable limits
- 16.3.5 Try a different transducer frequency or element size
- 16.3.6 If no reading can be obtained, record the location as "no reading" and report to supervision for further evaluation

16.4 Couplant may be applied to the surface of the item or to the transducer face prior to taking the reading. Only a small amount of couplant is required. To maintain the contact surface clean, it may be necessary to wipe the transducer face clean of couplant between readings.

16.5 Transducer placement is critical to obtaining accurate readings. On a dual-element transducer, the cross-talk barrier (the acoustic separator between the two elements) shall be oriented perpendicular to the longitudinal axis of the pipe or component being measured.

16.6 The transducer may need to be slightly skewed or rocked while in contact with the surface to obtain an optimal reading. If unable to obtain a reading, re-clean the surface and re-apply couplant. If still unsuccessful, refer to Section 16.3.

16.7 For components with significant wall loss or suspected lamination, the A-Scan presentation shall be used to verify the nature of the reflector. D-meters alone shall not be used for lamination scanning. A lamination is indicated by a loss of back-wall echo with an intermediate echo appearing at less than full wall thickness.

16.8 All readings shall be recorded to the nearest 0.001 in. (0.01 mm). Readings shall be marked on a sketch or grid map of the component showing the measurement locations and the corresponding thickness values.

17.0 PROCEDURE QUALIFICATION

17.1 This procedure has been qualified in accordance with the requirements of ASME Section V, Article 23. Procedure qualification shall be performed by demonstration on a test block or actual component with known thicknesses.

17.2 Any change to an essential variable as defined in ASME Section V, Article 23, Table T-231 shall require re-qualification of this procedure by demonstration. The following are considered essential variables for this procedure:

17.2.1 A change in instrument type or model

17.2.2 A change in transducer frequency or element diameter

17.2.3 A change in transducer type (e.g., dual to single element)

17.2.4 A change in measurement mode (single-echo to echo-to-echo or vice versa)

17.2.5 A change in couplant type or brand

17.2.6 A change in the material type or specification being examined

17.2.7 A change in surface temperature range beyond 0°F to 200°F without high-temperature qualification

17.2.8 A change in thickness range exceeding the qualified range by more than 20%

17.3 Procedure qualification records shall include:

17.3.1 Identification of the procedure and revision number being qualified

17.3.2 Identification of the personnel performing the qualification (Level III or designee)

17.3.3 Description of the qualification test block(s) used

17.3.4 Equipment and transducer identification

17.3.5 Measured vs. known thickness values and the measurement error

17.3.6 Date of qualification

17.3.7 Signature of the NDT Level III approving the qualification

17.4 All changes of essential or nonessential variables from those specified in this procedure shall require a revision of, or addendum to, the procedure. Revisions shall be reviewed and approved by the NDT Level III and the Corporate Quality Manager.

18.0 EVALUATION AND ACCEPTANCE CRITERIA

18.1 Thickness readings that are below 0.100 in. (2.5 mm) or 50% of nominal design thickness shall be reported to supervision immediately for secondary evaluation. These readings may indicate severe wall loss that could affect the integrity of the component.

18.2 Acceptance or rejection criteria shall be as specified by the referencing Code, Standard, or client specification. The following codes provide minimum remaining wall thickness requirements:

18.3 ASME B31.3 Process Piping (2024 Edition)

18.3.1 The minimum required wall thickness for pressure-containing components shall be calculated per ASME B31.3, paragraph 304. The maximum allowable operating pressure shall be reduced if the remaining wall thickness is below the required thickness (t) plus corrosion allowance.

18.3.2 For existing piping, the remaining life shall be calculated using the corrosion rate and the difference between the measured minimum thickness and the minimum required thickness.

18.4 API 570 Piping Inspection Code

18.4.1 Corrosion rates shall be calculated in accordance with API 570, Section 7. The short-term and long-term corrosion rates shall be determined from inspection data, and the remaining life calculated.

18.4.2 The maximum interval between inspections shall be based on the remaining life calculation and the risk-based inspection (RBI) assessment per API 570 and API 580.

18.5 API 510 Pressure Vessel Inspection Code

18.5.1 Remaining wall thickness shall be compared to the minimum required thickness (t-min) calculated per the applicable construction code. Vessels with remaining thickness below t-min shall be evaluated for continued service, re-rating, repair, or retirement.

18.6 API 653 Tank Inspection

18.6.1 For aboveground storage tanks, the minimum shell and bottom plate thickness shall be evaluated per API 653, Section 4 (Tank Fitness for Service) and Appendix B (Acceptable Out-of-Plumbness).

18.7 Lamination Evaluation

18.7.1 Laminations detected during thickness measurement shall be evaluated for size and location. Laminations that exceed the acceptance criteria of the referencing construction code (e.g., ASME Section VIII, Appendix 12) shall be reported to the client for engineering evaluation.

18.7.2 A lamination is indicated when the back-wall echo is lost and replaced by an intermediate echo at less than full wall thickness. The A-Scan presentation shall be used to confirm the presence and extent of laminations.

19.0 RECORDS AND REPORTING

19.1 A detailed ultrasonic thickness examination report shall be prepared for each examination. The report shall include, as a minimum, the following information:

19.1.1 Date of examination

19.1.2 Identification of the examined equipment or component (including equipment ID, location, and service)

19.1.3 Test equipment used, including manufacturer, model, and serial number

19.1.4 Instrument calibration date and next due date

19.1.5 Transducer manufacturer, model, frequency, and element diameter

19.1.6 Couplant type and manufacturer

19.1.7 Technician's name, handwritten signature, and certification level

19.1.8 Sketch or drawing showing the location of all measurements

19.1.9 Component size, material specification, and surface temperature

19.1.10 All thickness readings with corresponding grid or location identification

19.1.11 Procedure number and revision used

19.1.12 Calibration block identification: serial number, material, and certified thickness values

19.1.13 Measurement mode (single-echo or echo-to-echo)

19.1.14 Any areas of no-reading with explanation

19.1.15 Acceptance criteria referenced and evaluation results

19.1.16 Any deviations from this procedure and their justification

19.2 Thickness measurements may be recorded directly on drawings of the component, provided all information listed in Section 19.1 is included. The record of the ultrasonic examination shall be documented on an Ultrasonic Thickness Examination Report form (Appendix IV).

19.3 All records and reports shall be maintained in accordance with Prime Inspections Inc.'s document retention policy. Records shall be retained for a minimum of 5 years or as required by the client or applicable code, whichever is longer.

19.4 Electronic records (digital thickness readings, photographs, sketches) shall be backed up and stored in a secure location. Data integrity shall be maintained by limiting access to authorized personnel.

20.0 POST-EXAMINATION CLEANING

20.1 Arrangements shall be made with the client for post-examination removal of couplant materials. Couplant shall be removed from all examination surfaces using clean rags, wipes, or solvent as appropriate for the surface material and coating.

20.2 On painted or coated surfaces, care shall be taken not to damage the coating during couplant removal. If the coating is damaged during the examination, the client shall be notified and the damage documented.

20.3 On stainless steel or other materials susceptible to contamination, all couplant residues shall be completely removed to prevent surface staining or pitting corrosion. A solvent wipe with a compatible cleaning solution may be required.

20.4 All waste materials (couplant containers, used wipes, gloves) shall be disposed of in accordance with the site waste management plan and applicable environmental regulations.

21.0 SAFETY

21.1 All personnel performing ultrasonic thickness examinations shall comply with the applicable Job Hazard Analysis (JHA) and all site-specific safety requirements.

21.2 Personal Protective Equipment (PPE) shall be worn as required by the site safety plan, including as a minimum: hard hat, safety glasses, steel-toed boots, and work gloves. Additional PPE (respiratory protection, hearing protection, fire-retardant clothing) shall be worn as dictated by the work environment.

21.3 When working at elevated locations, proper fall protection shall be used in accordance with the site fall protection plan. Scaffolding or man-lifts shall be inspected and tagged before use.

21.4 When examining piping or vessels containing hazardous process fluids, the client shall verify that the line or vessel is safe for examination (depressurized, purged, isolated, or gas-free as appropriate) before work commences. Hot work permits shall be obtained if required.

21.5 When examining high-temperature surfaces, heat-resistant gloves shall be worn, and the technician shall be aware of the risk of thermal burns from contact with the surface or from hot couplant. Transducers shall not be held in contact with hot surfaces longer than necessary.

21.6 In confined spaces, atmospheric testing shall be performed, and confined space entry permits shall be obtained in accordance with OSHA 29 CFR 1910.146. A standby person shall be stationed outside the confined space.

21.7 All electrical equipment used in hazardous (classified) locations shall be rated for the area classification. Intrinsically safe instruments shall be used in Division 1 or Zone 0 locations.

22.0 QUALITY CONTROL

22.1 The quality of ultrasonic thickness measurements is dependent on proper calibration, consistent technique, and accurate recording. The following quality control measures shall be implemented:

22.2 All instruments shall have a current annual calibration certificate on file. Expired calibrations shall not be used; instruments shall be removed from service and sent for recalibration.

22.3 Daily calibration verification logs shall be maintained, documenting the verification readings at the start and end of each shift or examination.

22.4 A sample of examination locations (minimum 10%) shall be re-measured by a second technician to verify measurement repeatability. The re-measurement results shall be compared and any discrepancies greater than 0.005 in. (0.13 mm) shall be investigated.

22.5 Transducer wear faces shall be inspected regularly for wear or damage. Worn transducers shall be replaced or re-faced by the manufacturer.

22.6 Couplant containers shall be kept sealed when not in use to prevent contamination or drying. Expired or contaminated couplant shall be discarded.

22.7 All examination records shall be reviewed by the Level II or Level III prior to submission to the client. The review shall verify completeness, accuracy, and compliance with this procedure.

22.8 Deviations from this procedure shall be documented and approved by the NDT Level III. Non-conformances shall be tracked and corrected in accordance with the Prime Inspections Inc. quality management system.

Appendix I – ASME Section V Article 23 Essential Variables

The following table summarizes the essential variables for ultrasonic thickness examination per ASME Section V, Article 23, Table T-231. Changes to any essential variable require re-qualification of this procedure.

Variable	Essential	Change Requiring Re-Qualification
Instrument type/model	Yes	Any change of instrument make or model
Transducer frequency	Yes	Change in nominal frequency $\pm 25\%$
Transducer element diameter	Yes	Change in element diameter $\pm 25\%$
Transducer type (dual/single)	Yes	Change from dual to single element or vice versa
Measurement mode	Yes	Change from single-echo to echo-to-echo or vice versa
Material type	Yes	Change from ferritic to austenitic or non-ferrous
Thickness range	Yes	Increase or decrease of qualified range by $> 20\%$
Surface temperature	Yes	Extension beyond 0°F to 200°F range
Couplant type	Yes	Change of couplant manufacturer or grade
Surface condition	No	Information only — record in report
Grid spacing	No	Per client or code requirement
Reporting format	No	Information only

Appendix II – Transducer Selection Guide

This appendix provides detailed guidance on transducer selection for various material types and thickness ranges. The transducer selected shall be capable of producing a stable back-wall echo across the full thickness range of the component being examined.

Application	Material	Thickness	Transducer	Frequency
Thin-wall tubing	Carbon steel	0.030 – 0.250 in.	Olympus D-590	10 MHz
Thin-wall tubing	SS / Ni alloy	0.050 – 0.250 in.	Olympus D-590	10 MHz
Small-bore pipe	Carbon steel	0.080 – 1.000 in.	Olympus D-709	7.5 MHz
General piping	Carbon steel	0.100 – 6.500 in.	Olympus D-790	5 MHz
General piping	SS / Ni alloy	0.100 – 4.000 in.	Dakota T-102	5 MHz
Thick-wall pipe	Carbon steel	0.500 – 6.000 in.	5 MHz dual	5 MHz
Cast iron	Cast iron	0.250 – 4.000 in.	2.25 MHz dual	2.25 MHz
High-temperature	Carbon steel	0.100 – 5.000 in.	Olympus D-790HT	5 MHz
Coated surface	Carbon steel	0.100 – 6.000 in.	Olympus D-790 (E2E)	5 MHz
Aluminum	Aluminum	0.100 – 4.000 in.	5 MHz dual	5 MHz
Copper alloy	Cu / brass	0.100 – 4.000 in.	5 MHz dual	5 MHz
Titanium	Titanium	0.080 – 3.000 in.	7.5 MHz dual	7.5 MHz

Appendix III – Calibration Block Specifications

Calibration blocks used under this procedure shall be manufactured from material of the same general specification as the component being examined. Blocks shall be certified with known thickness values measured by mechanical means (micrometer) to an accuracy of ± 0.001 in. (0.025 mm).

Block ID	Material	Geometry	Steps	Thickness Range	Cert. Method
CB-CS-01	Carbon steel	Flat, 4-step	4	0.250 / 0.500 / 1.000 / 2.000	Micrometer
CB-CS-02	Carbon steel	Flat, 4-step	4	0.500 / 1.000 / 2.000 / 4.000	Micrometer
CB-CS-03	Carbon steel	Curved (6" OD)	3	0.375 / 0.750 / 1.500	Micrometer
CB-SS-01	304 SS	Flat, 4-step	4	0.250 / 0.500 / 1.000 / 2.000	Micrometer
DB-CS-01	Carbon steel	Doubling block	8	0.080 – 0.500 (8 steps)	Micrometer
CB-CS-HT	Carbon steel	Flat, 3-step	3	0.500 / 1.000 / 2.000	Micrometer

Notes:

- (a) All calibration blocks shall be permanently marked with the block ID, material specification, and certified thickness values.
- (b) Certification records shall be maintained for each block and shall include the measuring instrument, calibration date, and certifying technician.
- (c) Curved blocks shall match the pipe OD within $\pm 1/2$ inch or shall be verified for geometry compensation.
- (d) High-temperature blocks (CB-CS-HT) shall be used for hot-surface calibrations and may be heated to the examination surface temperature.

Appendix IV – Ultrasonic Thickness Examination Report Form

The following form shall be used for documenting ultrasonic thickness examination results. All fields shall be completed; fields marked with an asterisk (*) are mandatory.

Date:	_____	Report No.:	_____
Equipment ID:	_____	Location:	_____
Material Spec:	_____	Surface Temp:	_____
Nominal Thk:	_____	Design Thk:	_____

Equipment Information*

Instrument	Model	Serial No.	Cal Date	Next Due
Transducer	Model	Freq.	Element Dia.	S/N
Couplant	Type	Mode	Velocity	Gain
Cal Block	S/N	Material	Thk. Values	

Thickness Readings*

Location	Grid Ref.	Reading (in.)	Nominal (in.)	% Wall Loss	Notes

Reviewed By:	_____	Level:	_____	Date:	_____
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Appendix V – Coating Compensation and Multi-Mode Techniques

This appendix provides guidance on through-coating measurement techniques and multi-mode measurement methods used when standard single-echo measurements are not applicable.

V-1.0 Through-Coating Measurement (Echo-to-Echo Mode)

When the test surface is coated with paint, epoxy, thermoplastic, or other coating material, the ultrasonic pulse must travel through the coating before reaching the base material. The coating adds a transit time to the measurement, which if not compensated for, will result in an over-reading of the actual material thickness.

V-1.1 In echo-to-echo (multiple-echo) mode, the instrument measures the time between the first and second back-wall echoes from the base material. Because the coating contributes equally to both echoes, the difference eliminates the coating thickness from the measurement, yielding the true base material thickness.

V-1.2 The echo-to-echo mode requires that at least two back-wall echoes are visible in the A-Scan display. This typically requires a minimum material thickness of 0.150 in. (3.8 mm) and a coating thickness not exceeding 0.080 in. (2.0 mm).

V-1.3 For thick coatings (> 0.080 in.) or thin base material (< 0.150 in.), the coating shall be removed locally at the measurement point and the measurement taken in single-echo mode on the bare material.

V-2.0 Multi-Mode Measurement

Some instruments offer a multi-mode or "auto" mode that automatically selects the appropriate measurement method based on the signal characteristics. While convenient, multi-mode operation shall be verified against a known reference before use and periodically during the examination.

V-2.1 In multi-mode, the instrument may switch between single-echo and echo-to-echo depending on signal quality. This can introduce measurement inconsistencies if the mode changes during an examination. The measurement mode used for each reading shall be recorded.

V-3.0 Coating Thickness Measurement

Where the coating thickness itself is of interest, it may be determined by measuring the total thickness (coating + base material) in single-echo mode and subtracting the base material thickness measured in echo-to-echo mode. Alternatively, a dedicated coating thickness gage (e.g., magnetic-induction or eddy-current type) may be used.

V-4.0 High-Temperature Measurement

For surface temperatures above 200°F (93°C), high-temperature transducers with appropriate delay lines and high-temperature couplant shall be used. The following corrections apply:

V-4.1 The sound velocity in steel decreases by approximately 1% for every 100°F increase in temperature above the calibration block temperature. Readings on hot surfaces shall be corrected by adding this temperature correction factor.

V-4.2 The transducer shall not remain in contact with the hot surface longer than necessary to obtain a stable reading (typically 3–5 seconds). Prolonged contact can damage the transducer element or alter its performance characteristics.

V-4.3 A high-temperature calibration block shall be used, or the calibration block shall be heated to a temperature within 25°F of the examination surface. If the block cannot be heated, the temperature correction per V-4.1 shall be applied.