



PII-PAUT-01

Phased Array Ultrasonic Examination Piping Systems

PNDT-PAUT

Revision 02

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Revision / Change Summary

Revision/Change	No.	Date	Description
Initial	0	6/15/2020	Initial Issue
Revision	01	12/11/2025	ASME Code Review; new template format; updated for ASME Section V 2025 Edition
Revision	02	9/6/2026	Complete rewrite to audit-ready format; added API 1104 21st Edition Section 12 reference for UT acceptance of pipeline welds; added ASME Section V Article 23 reference for phased array ultrasonic techniques; expanded equipment, calibration, examination, and evaluation sections; added definitions, responsibilities, safety, and procedure qualification sections; expanded appendices with acceptance criteria tables; aligned with ASNT SNT-TC-1A 2020 Edition

Table of Contents

1.0 SCOPE

2.0 REFERENCED DOCUMENTS

3.0 DEFINITIONS AND ABBREVIATIONS

4.0 RESPONSIBILITY

5.0 PERSONNEL QUALIFICATIONS

6.0 EQUIPMENT AND MATERIALS

7.0 SURFACE PREPARATION

8.0 SCAN PLANNING

9.0 CALIBRATION

10.0 EXAMINATION

11.0 EVALUATION

12.0 ACCEPTANCE CRITERIA

13.0 PROCEDURE QUALIFICATION

14.0 DOCUMENTATION AND RECORDS

15.0 SAFETY

16.0 REVISION HISTORY

APPENDICES

Appendix I – ASME B31.3 Workmanship Acceptance Criteria

Appendix II – ASME B31.3 Fracture Mechanics Acceptance Criteria

Appendix III – ASME B31.1 Workmanship Acceptance Criteria

Appendix IV – ASME B31.1 Fracture Mechanics Acceptance Criteria

Appendix V – ASME Section I Workmanship Acceptance Criteria

Appendix VI – ASME Section IX Workmanship Acceptance Criteria

Appendix VII – API 1104 Section 12 UT Acceptance Criteria for Pipeline Welds

Appendix VIII – PAUT Scan Plan Template

1.0 SCOPE

1.1 This procedure establishes the minimum requirements for performing phased array ultrasonic examination (PAUT) of welds and the dimensioning of indications for comparison with acceptance standards when required by the referencing Code Section. The technique described herein utilizes phased array transducers with electronic beam steering and focusing to provide full volumetric coverage of pipe and vessel welds.

1.2 This procedure applies to the application of Phased Array Ultrasonic Testing (PAUT) on both carbon steel and stainless steel piping welds using manual, semi-automated, or fully automated scanning techniques with computer-based data acquisition and analysis capabilities per applicable appendices and piping inspection codes referenced herein. Piping diameters covered range from 2 in. (50 mm) NPS through 56 in. (1420 mm) NPS with wall thickness from 0.125 in. (3 mm) through 2.500 in. (63.5 mm).

1.3 This procedure is applicable to weld joint configurations per ASME B31.3, B31.1, ASME Section I, and ASME Section IX; typically weld type is single-V, however other weld types such as single bevel, double-V, and compound bevel welds such as J or U prep designs are included. Other joint configurations may be covered with scan plans approved by a UT Level III and/or client representative. Smaller diameter piping may be inspected if a successful mock-up and demonstration is approved by the UT Level III.

1.4 This procedure covers the general method for contact scanning from the I.D. or O.D. surfaces with equipment and techniques utilizing phased array transducers and wedges capable of generating shear wave and longitudinal waves between 0° and 75° as detailed in approved scan plans.

1.5 This procedure is qualified for use based on successful calibration on an acceptable calibration block (typical for carbon steel and low-nickel stainless steel); or satisfactory demonstration on a mock-up (typical for high-nickel austenitic, bimetallic welds); and/or upon acceptance for use by the fabricator and/or the owner/user along with the PII UT Level III.

1.6 Smaller diameters or thicknesses may be inspected as long as approved scan plans and satisfactory calibration for the piping or tubing is achieved on a calibration block of the same NPS diameter and thickness is within $\pm 25\%$.

1.7 For pipeline girth weld acceptance, ultrasonic testing shall be performed in accordance with API 1104, 21st Edition, Section 12 (Ultrasonic Testing of Welds). Acceptance criteria for UT examination of pipeline welds shall be in accordance with API 1104 21st Edition Section 12 as detailed in Appendix VII of this procedure.

1.8 PAUT techniques employed under this procedure shall conform to the requirements of ASME Section V, Article 4 (Ultrasonic Examination Methods for Welds), Article 5 (Ultrasonic Examination Techniques), and Article 23 (Phased Array Ultrasonic Examination Techniques), 2025 Edition. Where mandatory appendices to Article 4 or Article 23 apply, those requirements shall be met.

1.9 Note: This procedure is not applicable for High Energy Piping Creep Damage Assessments.

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 BPVC Section V, Nondestructive Examination, 2025 Edition — Article 4 (Ultrasonic Examination Methods for Welds), Article 5 (Ultrasonic Examination Techniques), Article 23 (Phased Array Ultrasonic Examination Techniques), Article 14 (Calibration Blocks)

2.2.2 ASME B31.3, Process Piping, 2024 Edition, including Mandatory Appendix R (Fracture Mechanics Acceptance Criteria) and Mandatory Appendix IX (Procedure Qualification)

2.2.3 ASME B31.1, Power Piping, 2024 Edition, including Mandatory Appendix O (Fracture Mechanics Acceptance Criteria)

2.2.4 ASME BPVC Section I, Power Boilers, 2025 Edition, PW-52 (Ultrasonic Examination of Welds)

2.2.5 ASME BPVC Section IX, Welding and Brazing Qualifications, 2025 Edition

2.2.6 API 1104, Welding of Pipelines and Related Facilities, 21st Edition — Section 12 (Ultrasonic Testing of Welds) for UT acceptance of pipeline girth welds

2.2.7 ASNT SNT-TC-1A, Recommended Practice No. SNT-TC-1A, 2020 Edition — Personnel Qualification and Certification in Nondestructive Testing

2.2.8 PII-WP-1, Prime Inspections Inc. Written Practice for NDT Personnel Qualification, Latest Revision

2.2.9 ASME Section V, Nonmandatory Appendices S and U, as applicable, for transfer correction techniques

2.2.10 ASME Section V, Mandatory Appendix VII and Mandatory Appendix VIII (UT Procedure Qualification), as applicable

3.0 DEFINITIONS AND ABBREVIATIONS

3.1 The following definitions and abbreviations apply throughout this procedure:

3.2 Definitions

A-Scan — A display of signal amplitude versus time (distance) representing the ultrasonic response at a single beam path.

S-Scan — A sectorial scan display showing multiple A-scan signals at incremented beam angles, displayed as a cross-sectional image.

C-Scan — A planar top-down display of signal amplitude or time-of-flight data mapped over the scanned area.

E-Scan — An electronic scan in which the active aperture is electronically stepped across the array to produce a linear scan at a fixed angle.

PAUT — Phased Array Ultrasonic Testing — an ultrasonic technique using multi-element transducers with electronic beam steering and focusing.

TOFD — Time-of-Flight Diffraction — an ultrasonic technique using diffracted signals from flaw tips for detection and sizing.

TCG — Time Corrected Gain — a calibration function that equalizes signal amplitudes from reflectors at different depths.

VPA — Virtual Probe Aperture — the effective aperture defined by the number of active elements in a focal law.

Focal Law — The set of electronic delays applied to individual array elements to steer and focus the ultrasonic beam.

Scan Plan — A documented plan specifying the transducer, wedge, beam angles, scan positions, and coverage required for a specific weld configuration.

Reference Level — The ultrasonic response amplitude from a specified calibration reflector, set at 80% of full screen height (FSH) during calibration.

Scanning Sensitivity — The gain level used during data acquisition, typically set at a minimum of 6 dB above the reference level.

Evaluation Level — The amplitude threshold above which indications must be evaluated for acceptance, typically 20% of reference level for distance–amplitude techniques.

Relevant Indication — An indication caused by a discontinuity requiring evaluation per the applicable acceptance criteria.

Geometric Indication — An indication caused by component geometry or metallurgical configuration rather than a flaw; not considered a relevant indication.

FSH — Full Screen Height — the maximum display amplitude on the ultrasonic instrument screen.

Calibration Block — A reference block with known reflectors used to establish and verify system calibration.

Mock-Up — A test piece representative of the production weld, containing known flaws, used for procedure qualification and demonstration.

3.3 Abbreviations

PAUT — Phased Array Ultrasonic Testing

UT — Ultrasonic Testing

TOFD — Time-of-Flight Diffraction

NDE / NDT — Nondestructive Examination / Nondestructive Testing

ASME — American Society of Mechanical Engineers

API — American Petroleum Institute

ASNT — American Society for Nondestructive Testing

SNT-TC-1A — ASNT Recommended Practice for NDT Personnel Qualification

NPS — Nominal Pipe Size

OD / ID — Outside Diameter / Inside Diameter

SDH — Side-Drilled Hole

FBH — Flat Bottom Hole

EDM — Electrical Discharge Machining

TCG — Time Corrected Gain

PRF — Pulse Repetition Frequency

dB — Decibel

MHz — Megahertz

FSH — Full Screen Height

PII — Prime Inspections Inc.

CQM — Corporate Quality Manager

PDQ — Performance Demonstration Qualification

4.0 RESPONSIBILITY

4.1 The Corporate Quality Manager (CQM) is responsible for the overall administration, maintenance, and control of this procedure, including ensuring that it is reviewed at intervals not to exceed one year and that it remains compliant with the latest editions of all referenced codes and standards.

4.2 The designated ASNT NDT Level III (UT/PAUT) is responsible for the technical content of this procedure, the qualification and certification of personnel, the review and approval of scan plans, and the resolution of technical issues arising during examination. The Level III shall also be responsible for procedure qualification demonstrations and performance demonstration qualification (PDQ) when required by the referencing code or client.

4.3 The NDT Level II technician is responsible for performing examinations in accordance with this procedure, performing and documenting calibrations, collecting and evaluating data, preparing examination reports, and identifying indications that require evaluation by the Level III.

4.4 The NDT Level I technician may perform calibrations and data acquisition under the direct supervision of a Level II or Level III technician but shall not perform final evaluation or acceptance of indications.

4.5 The client or owner/user is responsible for providing applicable design drawings, weld joint details, material specifications, and any specific examination requirements beyond those covered by this procedure. The client shall also be responsible for providing or approving mock-up or demonstration blocks when required for procedure qualification.

4.6 The responsible fabricator or manufacturer shall be responsible for the review, interpretation, evaluation, and acceptance of completed scan data to assure compliance with the requirements of ASME Section V, Article 4, Mandatory Appendix VII, Mandatory Appendix VIII (as applicable), and the referencing Code Section. Acceptance shall be completed prior to presentation of the scan data and accompanying documentation to the Inspector.

5.0 PERSONNEL QUALIFICATIONS

5.1 Personnel performing phased array examinations in accordance with this procedure shall be qualified and certified in accordance with the requirements of ASNT SNT-TC-1A, 2020 Edition, and PII-WP-1, Prime Inspections Inc. Written Practice, latest revision.

5.2 Personnel certified to PAUT Level II may collect and evaluate data and make interpretation as to the acceptability of indications. This includes performing all required data analysis and preparing the reports. A PAUT Level III shall review and approve all final examination reports.

5.3 In addition to the training requirements established above, technicians shall have documented additional training for operating the specific manufacturer or model of phased array equipment being used. This is specific hardware and software training on the equipment being utilized. Documentation of this training shall be maintained in the personnel certification file.

5.4 When required by client or referencing code, the technicians shall have participated in and successfully demonstrated detection and evaluation of flaws in mock-up(s) or other client test standards prior to performing production examinations.

5.5 Additional specific requirements related to performance demonstration qualification (PDQ) are addressed in applicable Appendices of this procedure and in ASME Section V, Mandatory Appendix VIII, when required by the referencing Code Section.

5.6 All personnel shall maintain current near-vision acuity (Jaeger J-1 or equivalent) and color vision certifications as required by SNT-TC-1A. Annual vision examinations shall be documented and maintained in personnel files.

5.7 Personnel certification records shall be available for review by the client, Inspector, or jurisdictional authority upon request.

6.0 EQUIPMENT AND MATERIALS

6.1 Instrument Requirements

6.1.1 A pulse-echo type of ultrasonic instrument shall be used. The instrument shall be capable of operation at frequencies over the range of at least 1 MHz to 10 MHz and shall be equipped with a stepped gain control in units of 1.0 dB or less. The instrument shall be a phased array instrument capable of controlling a minimum of 16 elements per probe with a minimum of 64 active channels.

6.1.2 If the instrument has a damping control, it may be used if it does not reduce the sensitivity of the examination.

6.1.3 The reject control shall be in the "off" position for all examinations unless it can be demonstrated that it does not affect the linearity of the examination.

6.1.4 The instrument shall have both send and receive jacks for operation of dual search units or a single search unit with send and receive transducers.

6.1.5 The Olympus MX2, OmniScan SX, or equivalent in a minimum 16:64 configuration (0–80 dB dynamic range) within the latest two revisions or equivalent shall be used. The instrument shall support both S-scan and E-scan modes with full focal law programmability.

6.1.6 The instrument shall be capable of recording and saving raw, unprocessed A-scan data with no thresholding at a minimum digitization rate of 5× the examination or probe frequency.

6.2 Search Units (Phased Array Probes)

6.2.1 General: A linear array with a nominal frequency from 1 MHz to 10 MHz shall be used unless variables, such as production material grain structure, require the use of other frequencies to assure adequate penetration or better resolution.

6.2.2 Probes shall have a minimum of 8 elements. More elements may be used when increased sensitivity or coverage is required. Typical configurations include 16, 32, and 64 element arrays.

6.2.3 The overall performance of the phased array technique is dependent on the search unit type, number of elements, size (height/width), pitch, and gap distances. Search units shall be capable of adequate detection and sizing as per this procedure.

6.2.4 Contact Wedges: Examinations performed on a curved component having a diameter less than 14 in. (350 mm) at the examination surface shall be performed using a contoured wedge that meets the following requirements to ensure sufficient ultrasonic coupling and to limit potential rocking of the search unit as it is moved along the circumference:

(a) Search units shall meet the following equation: $A \leq D/4$, where A = length of search unit footprint during circumferential scanning or the width when scanning in the axial direction, and D = the component diameter at inspection surface (I.D./O.D.). The footprint is defined as the physical dimension of the search unit in the curved direction of the component.

(b) The search unit contoured dimension shall be selected from manufacturer tables and shall be determined using the same component dimension from which the examination is being performed (I.D. or O.D.). Maximum contour for examinations performed from O.D.; minimum contour for examinations performed from I.D.

(c) Wedge cut, height, and material shall be capable of producing angular sweeps as per the manufacturer's recommendations.

6.3 Couplant

6.3.1 General: The couplant, including additives, shall not be detrimental to the material being examined. Typical couplants include water or cellulose-based gels watered down sufficiently to be directed into the transducer using a pump-type delivery system. Other couplants may be used as needed, including Ultragel grades, gels, pastes, and commercially prepared formulations.

6.3.2 Control of Contaminants

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

6.4 Scan Plans

6.4.1 This procedure is to be used with scan plans documenting expected beam coverage including any additional essential variables not addressed in this procedure. When requested, scan plans shall be submitted for approval to the client prior to commencement of examinations. Scan plans shall include, as a minimum: probe identification, wedge angle, beam range (S-scan) or fixed angles (E-scan), scan positions, skip distances, gate settings, and coverage zones.

6.5 Scanners

6.5.1 Examinations shall be performed using encoded scans or data collection with one of the listed apparatuses below:

6.5.2 Automated Scanner: A fully mechanized scanner (e.g., Jireh Navic or equivalent) that, after being attached to the component, maintains the index and offset position of the search unit. The scanner is manipulated by an independent motor controller and requires no manual handling during operation.

6.5.3 Semi-Automated Scanner: A manually adjustable scanner (e.g., Jireh Rotix or equivalent) that has mechanical means to maintain the index of the search unit while maintaining the search-unit offset position, but which must still be propelled manually by the operator. This scanner has mechanical means to retain its position while attached to the component once released by the operator.

6.5.4 All scanners shall use appropriate search unit holders and guides as per manufacturer guidelines. Encoders shall be verified per the requirements of Section 9.0 (Calibration).

6.6 Calibration Blocks

6.6.1 "Calibration Blocks" such as a NAVSHIP or equivalent blocks shall be used to establish the initial calibration parameters for the transducers and the system (wedge delay, velocity, TCG, etc.). "Reference Blocks" are used to establish the required examination sensitivity (gain) or primary reference response, e.g., "Piping Calibration Block" identified in paragraph 6.7.

6.6.2 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) produces a sensitivity equal to or greater than the specified reflector(s).

6.6.3 Material

- (a) Similar Metal Welds: The material from which the block is fabricated shall be of the same product form and material specification or equivalent P-Number grouping as one of the materials being

examined. For the purposes of this paragraph, P-Nos. 1, 3, 4, 5A through 5C, and 15A through 15F materials are considered equivalent.

(b) 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.

(c) Transfer Correction: When the block material is not of the same product form or has not received the same heat treatment, it may be used provided it meets all other block requirements and a transfer correction for acoustical property differences is used. ASME Section V, Nonmandatory Appendices S and U (as applicable) may be used. Transfer correction shall be determined by noting the difference between the signal response, using the same transducers and wedges to be used in the examination, received from either: (1) the corresponding reference reflector (same type and dimensions) in the applicable calibration block and in the component to be examined; or (2) two search units positioned in the same orientation on the basic calibration block and component to be examined. The examination sensitivity shall be adjusted for the difference.

(d) Coarse-Grained Materials: Ultrasonic examination of high alloy steels and high alloy nickel alloy weld deposits and dissimilar metal welds between carbon steels and high nickel alloys are usually more difficult than ferritic weld examinations. It is necessary to modify and/or supplement the provisions of this procedure in accordance with ASME Section V T-150(a) when examining welds in these materials. Additional items required include weld mockups with reference reflectors in the weld deposits and utilizing single or dual search element units producing refracted longitudinal waves.

6.6.4 Quality

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

6.6.5 Cladding

(a) Block Selection: The material from which the block is fabricated shall be from a component prolongation, or material of the same material specification, product form, and heat treatment condition as the material to which the search unit is applied during 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 $\pm 1/8$ in. (3 mm). Deposition of clad shall be by the same method as used to clad the component. When the cladding method is not known or is impractical for block cladding, deposition may be by the manual method.

6.6.6 Heat Treatment

The calibration block shall receive at least the minimum tempering treatment required by the material specification for the type and grade. If the calibration block contains welds other than cladding, and the component weld at the time of the examination has been heat treated, the block shall receive the same heat treatment.

6.6.7 Surface Finish

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

6.6.8 Block Curvature

(a) Materials With Diameters Greater Than 20 in. (500 mm): For examinations in materials where the examination surface diameter is greater than 20 in. (500 mm), a block of essentially the same curvature, or alternatively, a flat basic calibration block, may be used.

(b) Materials With Diameters 20 in. (500 mm) and Less: For examinations in materials where the examination surface diameter is equal to or less than 20 in. (500 mm), a curved block shall be used. A single curved basic calibration block may be used for examinations in the range of curvature from 0.9 to 1.5 times the basic calibration block diameter.

6.7 Piping Calibration Blocks

6.7.1 The basic calibration block configuration and reflectors shall be as shown in ASME Section V, Figure T-434.3-1, or the alternate provided in Figure T-434.3-2 where curvature and/or wall thickness permits. The basic calibration block curvature shall be in accordance with 6.6.8. Thickness, T, shall be $\pm 25\%$ of the nominal thickness of the component to be examined.

6.7.2 Scanner Block: A block shall be fabricated meeting the requirements of 6.6 and ASME Section V, Figure T-434.2.1, except that its thickness, T, shall be within the lesser of 1/4 in. (6 mm) or 25% of the material thickness to be examined, and the number and position of the side-drilled holes shall be adequate to confirm the sensitivity of each probe. The scanner block is in addition to the reference block required per 6.7.1. When the required blocks are not part of the calibration set, the client shall provide the required scanner blocks.

7.0 SURFACE PREPARATION

7.1 Surface Condition: The examination surfaces (I.D. and/or O.D.) shall be free of paint, oil, dirt, scale, rust, weld spatter, and other contaminants that could interfere with the ultrasonic coupling or scanning operation. Surfaces shall be prepared as needed to permit proper coupling and unimpeded scanner movement.

7.2 Weld Reinforcement: The weld reinforcement (weld cap) shall be evaluated per the scan plan. When the scan plan requires examination of the weld cap area, the cap shall be ground sufficiently smooth to allow transducer contact without rocking. If the cap is not ground, the scan plan shall account for the geometry limitation and document the reduced coverage area.

7.3 Surface Finish: The surface finish on the component shall be such that the search unit can maintain consistent coupling. Typical surface finish requirements are 250 μin (6.3 μm) RMS or better. When surface finish is not adequate, grinding or machining may be required.

7.4 Temperature: The examination surface temperature shall be within the operating range of the ultrasonic instrument and couplant. For contact examination, the temperature differential between the calibration block and examination surfaces shall be within 25°F (14°C). Couplant suitable for the examination temperature range shall be used.

7.5 Access: The examination area shall provide sufficient access for the scanner, probe, and technician to perform the examination per the scan plan. Where physical obstructions prevent full coverage, the limitations shall be noted in the examination report.

8.0 SCAN PLANNING

8.1 A scan plan shall be prepared for each weld configuration to be examined. The scan plan shall document the expected beam coverage and all essential variables not addressed in this procedure. When requested, scan plans shall be submitted for approval to the client prior to commencement of examinations.

8.2 Scan Plan Contents

- (a) Probe identification (manufacturer, model, serial number, frequency, number of elements, element pitch and gap)
- (b) Wedge identification (manufacturer, model, wedge angle, material)
- (c) Beam mode (shear wave, longitudinal wave, or both)
- (d) Scan type (S-scan, E-scan, or combination)
- (e) Beam angle range (minimum and maximum angles for S-scan; fixed angle(s) for E-scan)
- (f) Active aperture (number of elements) and focal law parameters
- (g) Scan positions (number of scan lines, offset from weld centerline, stand-off distance)
- (h) Skip distances and beam coverage zones
- (i) Gate settings (gate start, gate end, gate threshold)
- (j) Expected beam coverage of the weld volume and HAZ
- (k) Couplant type to be used
- (l) Calibration block or mock-up identification

8.3 Coverage Requirements

- (a) The scan plan shall ensure that the required volume of the weld and adjacent base material is fully covered by the ultrasonic beam. The required volume typically includes the weld metal and the heat-affected zone (HAZ) on both sides of the weld.
- (b) When multiple linear scans are required to cover the required volume of weld and base material, overlap between adjacent linear scans shall be a minimum of 10% of the effective aperture height for E-scans or beam width for S-scans.
- (c) For examination from both sides of the weld, beam coverage shall be designed such that the full weld volume is covered from at least one side. When single-sided access is required, the scan plan shall document the extent of coverage and any limitations.

8.4 Scan Plan Approval

Scan plans shall be reviewed and approved by the designated UT/PAUT Level III prior to use. When required by the referencing code or client specification, scan plans shall also be submitted to the client or Inspector for approval. Any deviations from an approved scan plan shall be documented and approved prior to implementation.

9.0 CALIBRATION

9.1 Instrument Linearity Checks

9.1.1 General: The requirements of 9.1.2 and 9.1.3 below shall be met at intervals not to exceed one year for digital type instruments, or prior to first use thereafter.

9.1.2 Screen Height Linearity

The ultrasonic instrument's screen height linearity shall be evaluated as follows: Position an angle beam search unit on a calibration block so that indications from both the 1/2T and 3/4T holes give a 2:1 ratio of amplitudes. Adjust the sensitivity (gain) so that the larger indication is set at 80% of full screen height (FSH). Without moving the search unit, adjust sensitivity to successively set the larger indication from 100% to 20% of FSH, in 10% increments (or 2 dB steps if a fine control is not available), and read the smaller indication at each setting. The reading shall be 50% of the larger amplitude, within 5% of FSH. The settings and readings shall be estimated to the nearest 1% of full screen.

9.1.3 Amplitude Control Linearity

The ultrasonic instrument's amplitude control linearity shall be evaluated as follows: Position an angle beam search unit on a calibration block so that the indication from the 1/2T side-drilled hole is peaked on the screen. Adjust the sensitivity (gain) as specified and verify that the indication falls within the specified limits. Alternatively, any other convenient reflector from any calibration block may be used with angle or straight beam search units. The settings and readings shall be estimated to the nearest 1% of full screen.

9.2 General Calibration Requirements

9.2.1 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.

9.2.2 Calibration Surface: Calibrations shall be performed from the surface corresponding to the surface of the component from which the examination will be performed. The finish on the scanning surface of the block shall be representative of the scanning surface of the component to be examined.

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

9.2.4 Contact Wedges: The same contact wedges to be used during the examination shall be used for calibration.

9.2.5 Instrument Controls: Any control which affects instrument linearity (e.g., filters, reject, pulse width, pulse type, voltage, or clipping) shall be in the same position for calibration, calibration checks, instrument linearity checks, and examination.

9.2.6 Temperature: For contact examination, the temperature differential between the calibration block and examination surfaces shall be within 25°F (14°C).

9.2.7 Beam: Scan type shall be either S- or E-scan; elements used, maximum and minimum beam angles according to the examination plan including start/stop elements which are dictated in the scan plans. The focal law to be used during the examination shall be used for calibration.

9.2.8 Overlap: Maximum increment between beams shall be 1°. For E-scans, overlap between adjacent active apertures shall be a minimum of 50% of the aperture length. The focal law used during calibration shall be used for examination.

9.2.9 Focus Length and Plane: Focal range shall be set to unfocused for the initial examination. Alternatives are acceptable for specific examinations of particular zones. The focal law used during calibration shall be used for examination.

9.2.10 Digitization: The A-Scan shall be set up to record data in an unprocessed form with no thresholding, at a minimum digitization rate of $5\times$ the examination or probe frequency and controlled by "scale factor."

9.2.11 PRF (Pulse Repetition Frequency): The PRF shall be set small enough to ensure that a signal from a reflector located at the maximum distance in the examination volume will arrive back at the probe before the encoder triggers the next pulse in the transducer.

9.3 Initial Calibration

9.3.1 Array Operability Check

- (a) The transducer shall be separated from the wedge material and coupled to the ASME Basic Block or similar to produce a full backwall response at 80% FSH. This reflection shall be displayed in a linear scan.
- (b) The Linear scan shall be displayed with the VPA (one element per VPA) set to match the number of elements in the array transducer. Each VPA or beam in the linear scan represents a corresponding element. The phased array specialist shall scroll through these VPAs while monitoring the linear scan backwall reflection. Any reflection that is not present or > -12 dB from 80% FSH should be considered inoperable.
- (c) If a prepackaged program is available for checking element activity, this can be used as an alternative to (a) and (b) above.
- (d) Seventy-five percent of all elements shall be considered operable. If less than 75% of the elements are operable, or if two elements directly adjacent to each other are inoperable, the transducer shall be considered unacceptable for use.
- (e) Element operability shall be performed at each period of extended use or every 3 months, whichever is less.

9.3.2 Wedge Delay

- (a) Using a block as described in 6.6.1, position the probe to observe a response from a reflector of known thickness, target depth, or curved face radius and set gates to bracket the indications.
- (b) Move the probe back and forth to build the wedge delay envelope for all beams in the S-scan or E-scan.

9.3.3 Sensitivity

- (a) Using a block as described in 6.6.1, position the probe to observe a response from a reflector at the target depth of the first TCG point.
- (b) Move the probe back and forth to build the sensitivity envelope for all beams in the S-scan or E-scan.

9.3.4 TCG (Time Corrected Gain)

- (a) TCG calibration shall be based on a minimum three-point curve.
- (b) Using a block as described in 6.6.1, obtain indications from the reflectors, and set gates to bracket the indications.
- (c) Move the probe back and forth to build the gain compensation envelope for all beams in the S-scan or E-scan.

- (d) Set the primary reflector at 80% full screen height.
- (e) Repeat the same steps for the remaining reflectors to cover 1T for 1/2 V setups and 2T for full V setups and acknowledge acceptance of the TCG.
- (f) Scan the reflectors one more time to verify the accuracy within $\pm 5\%$ (75%–85%).

9.3.5 Encoder

- (a) A calibration check shall be performed at intervals not to exceed one month or prior to first use thereafter, by moving the encoder a minimum distance of 20 in. (500 mm). The display distance shall be within 1% of the actual distance moved.

9.4 Calibration for Piping

9.4.1 System Calibration for Distance–Amplitude Techniques

- (a) Calibration Block(s): Calibrations shall be performed utilizing the calibration block shown in ASME Section V, Figure T-434.3-1 or the alternate provided in Figure T-434.3-2.
- (b) Angle Beam Calibration with Notches: The angle beam(s) 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. Separate calibrations shall be established for both the axial and circumferential notches.
- (c) Calibration With Side-Drilled Holes: The angle beam(s) 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. Separate calibrations shall be established for both the axial and circumferential scans.
- (d) Straight Beam Calibration: When required, straight beam calibrations shall be performed in accordance with the latest revision of "UT-2."
- (e) Transfer Value (Additional gain compensation): A transfer correction is required when using pipe calibration standard blocks that have not been heat treated to the same conditions of the piping being examined. When used, the transfer value shall be determined using standard 45° manual UT transducers: position the transducers facing each other and maximize the pitch-catch response on the calibration block and then on the piping requiring examination. The transfer value is the difference in net result gain setting between the two. The transfer value in dB shall be added to the reference gain obtained from the calibration block and noted as "transfer gain" in the report.

9.5 Calibration Confirmation

9.5.1 System Changes: When any part of the examination system is changed, a calibration check shall be made on the basic calibration block to verify that distance range points and sensitivity setting(s) satisfy the requirements of 9.5.4.

9.5.2 Calibration Checks

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 completion of each examination or series of similar examinations, and when examination personnel (except for automated equipment) are changed. The distance range and sensitivity values recorded shall satisfy the requirements of 9.5.4.

9.5.3 System Confirmation Scan

The scanner block shall be scanned, and the reference reflector indications recorded to confirm system calibration prior to and at the completion of each examination or series of similar examinations, when examination personnel are changed, and if the scan plan is modified. When the scanner block is not used, both of the following shall be used to verify the scan plan and examination calibration:

(a) Simulator Checks: A simulator check shall be used prior to and at the end of each examination or series of exams. Any simulator checks used shall be correlated with the original calibration on the basic calibration block. The simulator checks may use different types of calibration reflectors or blocks (such as IIW) and/or electronic simulation provided that amplitude and time base signals can be identified and correlated to the original examination calibration. 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.

(b) Search Unit Position Verification: An adjustable scanner or search unit positioning system capable of measuring and securing the search unit shall be used. If the search unit position within the scanner has changed more than 1/16 in. (1.5 mm), all data since the last valid search unit position check shall be marked void and the area covered by the voided data shall be reexamined.

9.5.4 Confirmation Acceptance Values

(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 rerecorded.

(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 reexamined. 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 rerecorded.

10.0 EXAMINATION

10.1 General Examination Requirements

10.1.1 Examination Coverage: The required volume of the weld and base material to be examined shall be scanned, as per the scan plan, using a linear scanning technique with an encoder. Each linear scan shall be parallel to the weld axis at a constant stand-off distance with the beam oriented perpendicular to the weld axis.

- (a) Each pass of the search unit shall overlap a minimum of 10% of the transducer (piezoelectric element) dimension parallel to the direction of scan indexing.
- (b) Oscillation of the search unit is permitted if it can be demonstrated that overlapping coverage is provided.
- (c) The search unit shall be maintained at a fixed distance from the weld axis by a fixed guide or mechanical means.
- (d) The examination angle(s) for E-scan and range of angles for S-scan shall be appropriate for the joint to be examined.
- (e) Scanning speed shall be such that data drop-out is less than 2 data lines/in. (25 mm) of the linear scan length and that there are no adjacent data line skips.
- (f) When multiple linear scans are required to cover the required volume of weld and base material, overlap between adjacent linear scans shall be a minimum of 10% of the effective aperture height for E-scans or beam width for S-scans.

10.1.2 Rate of Search Unit Movement

The rate of search unit movement (scanning speed) shall not exceed 6 in./s (150 mm/s), unless: (a) the ultrasonic instrument pulse repetition rate is sufficient to pulse the search unit at least six times within the time necessary to move one-half the transducer (piezoelectric element) dimension parallel to the direction of the scan at maximum scanning speed; or (b) a dynamic calibration is performed on multiple reflectors which are within 2 dB of a static calibration and the pulse repetition rate meets the requirements of 9.2.11.

10.1.3 Scanning Sensitivity Level

Distance–Amplitude Techniques: The scanning sensitivity level shall be set a minimum of 6 dB higher than the reference level gain setting or, when a semi-automatic or automatic technique is used, it may be set at the reference level.

10.1.4 Surface Preparation

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.

10.1.5 Recording of Ultrasonic Data

The ultrasonic data for the semi-automatic and automatic techniques shall be recorded and saved electronically per the increments below in an unprocessed form with no thresholding. Gating of the data solely for the recording of the examination volume is permitted, provided a scan plan is utilized to determine the gate and range settings to be used.

- (a) 0.02 in. (0.5 mm) for material < 0.200 in. (5 mm) thick
- (b) 0.04 in. (1 mm) for material < 3 in. (75 mm) thick and $\geq$ 0.200 in. (5 mm) thick
- (c) 0.08 in. (2 mm) for material $\geq$ 3 in. (75 mm) thick

10.2 Weld Joint Distance Amplitude Technique

10.2.1 General: When the referencing Code Section 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. 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.

10.2.2 Angle Beam Technique

- (a) Beam Angle: The search unit and beam angle selected shall be 45° or an angle appropriate for the configuration being examined and shall be capable of detecting the calibration reflectors over the required angle beam path.
- (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: As an alternate to line scanning, a manual angle beam examination may be performed for reflectors transverse to the weld axis unless the referencing code section specifies it also shall be by automated or semi-automated scans. When scanning with weld reinforcement present, the examination shall be performed from the base material on both sides of the weld cap, with the angle beam directed from 0° to 60° with respect to the weld axis. When scanning without weld reinforcement (cap ground flat), the examination shall be performed on the weld with the angle beam directed essentially parallel to the weld axis.

10.2.3 Single-Sided Access Welds

Welds that cannot be fully examined from two directions per 10.2.2 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 pipe-to-fitting or branch connections. The area(s) of single-sided access and, if applicable, the extent of the limit coverage shall be noted in the examination report.

10.2.4 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.

10.3 Post Examination Cleaning

10.3.1 Post-examination cleaning should be conducted as soon as practical after evaluation and documentation using a process that does not adversely affect the part. All couplant residue shall be removed from the component surface.

11.0 EVALUATION

11.1 General

11.1.1 Final flaw evaluation shall only be made after all display parameter adjustments such as contrast and brightness have been completed.

11.1.2 Offboard analysis may be done by using additional software such as OmniPC within the latest two revisions or equivalent.

11.1.3 Electronic or soft gain may be used to aid in characterization and sizing as needed.

11.2 Evaluation Level

11.2.1 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 acceptance criteria of the referencing code section found in this procedure's appropriate appendix.

11.3 Evaluation of Laminar Reflectors

11.3.1 Reflectors evaluated as laminar reflectors in base material which interfere with the scanning of examination volumes shall require the angle beam examination technique to be modified such that the maximum feasible volume is examined and shall be noted in the record of the examination.

11.4 Supplemental Manual Techniques

11.4.1 Flaws detected during the automated or semi-automated scan may be alternatively evaluated, if applicable, by supplemental manual techniques.

11.5 Alternative Evaluations

11.5.1 Reflector dimensions exceeding the referencing Code Section requirements may be evaluated to any alternative standards provided by the referencing Code Section.

11.6 Characterization and Sizing

11.6.1 Geometric Indications: It is recognized that not all ultrasonic reflectors indicate flaws, since certain metallurgical discontinuities and geometric conditions may produce indications that are not relevant. Indications determined to originate from surface conditions (such as weld root geometry) or variations in metallurgical structure may be classified as geometric indications. The identity, maximum amplitude, location, and extent of the reflector causing a geometric indication shall be recorded. The following steps shall be taken to classify an indication as geometric:

- (a) Interpret the area containing the reflector in accordance with this procedure.
- (b) Plot and verify the reflector coordinates. Prepare a cross-sectional sketch showing the reflector position and surface discontinuities such as root and counterbore.
- (c) Review fabrication or weld preparation drawings. Other ultrasonic techniques or non-destructive examination methods may be helpful in determining a reflector's true position, size, and orientation.

11.6.2 Flaw Characterization

All indications produced by reflectors that exceed the evaluation levels described above within the volume to be examined that cannot be clearly attributed to the geometry of the weld configuration shall be considered as discontinuities. Characterization should be done prior to sizing since appropriate selection of sizing technique is dependent upon flaw characteristics. Critical features to be noted during characterization are: (a) shape of A-scan signal (smooth, rough-edged, multi-faceted, multiple); (b) orientation of indications in S-scan image (location with reference to weld fusion faces and/or centerline); and (c) visible pattern (solid pure red full-height indication, spotted multi-colored diffused response, or faint cloud-like multiple low-amplitude indications).

11.6.3 Flaw Size

The dimensions of the flaw shall be determined by the rectangle that fully contains the area of the flaw.

11.6.4 Flaw Length Sizing

- (a) When length sizing smooth reflectors such as lack of fusion where the signal response is not saturated, a 6 dB drop method should be used. The flaw signal should be maximized, then using the scan axis data cursor, move across the flaw noting scan distance where the indication amplitude reduces by 50%. The delta between the two ends will be the flaw length. This method is only accurate when the flaw is equal to or larger than the beam width at the sound path.
- (b) When length sizing multiple and multi-faceted reflectors such as cracks, porosity, and slag, a max amplitude method should be used. Set the scan axis data cursor to a point a short distance off the end of the flaw. Slowly increment the cursor towards the flaw. Maximize the first facet and record the scan distance. Repeat for the other end. The delta between the two ends will be the flaw length.

11.6.5 Flaw Height Sizing

The height of the flaw shall be the dimension of the rectangle that is normal to the inside pressure-retaining surface of the component. Height sizing is required to establish the aspect ratio between the length and height to determine accept/reject per the applicable tables. Indication through-wall height shall be determined using the following in order of priority:

- (a) Height sizing shall be determined by identifying the "top" and "bottom" or extreme boundaries of the flaw in the through-wall dimension (tip diffraction). If this cannot be accomplished, alternative techniques such as TOFD or PAUT with larger aperture probes may be used.
- (b) When the above is ineffective and the indication signal response is between 80%–200% (not saturated), use cursors to establish the 6 dB drop points (50% drop), establish the delta, and divide by 2 to get a height value. The resultant value should be between the values shown below for the respective probe frequency. If the value is larger, re-evaluate looking for flaw boundary responses.
- (c) When flaw height boundaries cannot be determined, the following maximum flaw heights may be used based on transducer frequency: 2.25 MHz = 0.075"–0.125", 5 MHz = 0.050"–0.075", or 10 MHz = 0.025"–0.050".

11.6.6 Flaw Positioning

- (a) Indication distance from surface shall be determined by the separation between the shortest distance of the flaw's top/bottom to the surface.
- (b) Indication distance to other indications shall be determined by the separation between outermost extremities of the flaws.

11.6.7 Flaw Categorization

- (a) If the space is equal to or less than one-half the height of the flaw, then the flaw shall be categorized as a surface flaw.

- (b) If the space is greater than one-half the height of the flaw, then the flaw shall be categorized as a subsurface flaw.

11.7 Evaluation by Manufacturer

11.7.1 The Manufacturer shall be responsible for the review, interpretation, evaluation, and acceptance of the completed scan data to assure compliance with the requirements of ASME Section V, Article 4, Mandatory Appendix VII, Mandatory Appendix VIII, and the referencing Code Section. Acceptance shall be completed prior to presentation of the scan data and accompanying documentation to the Inspector.

12.0 ACCEPTANCE CRITERIA

12.1 The acceptance criteria applicable to a given examination shall be determined by the referencing Code Section specified in the engineering design, drawings, or contract documents. The applicable acceptance criteria are detailed in the Appendices of this procedure.

12.2 For pipeline girth welds acceptance under API 1104, 21st Edition, ultrasonic testing acceptance criteria shall be in accordance with API 1104 21st Edition Section 12 (Ultrasonic Testing of Welds). The specific acceptance criteria are detailed in Appendix VII of this procedure.

12.3 For ASME B31.3 process piping, the workmanship acceptance criteria in Appendix I shall apply unless the fracture-mechanics-based criteria of Appendix II (Mandatory Appendix R) are specified.

12.4 For ASME B31.1 power piping, the workmanship acceptance criteria in Appendix III shall apply unless the fracture-mechanics-based criteria of Appendix IV (Mandatory Appendix O) are specified.

12.5 For ASME Section I power boiler welds, the workmanship criteria in Appendix V (PW-52) shall apply.

12.6 For ASME Section IX welder performance qualification, the workmanship criteria in Appendix VI shall apply.

12.7 Discontinuities evaluated as being cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length under all ASME workmanship criteria referenced above.

12.8 When a client or contract specification specifies acceptance criteria other than those listed above, the client-specified criteria shall be used, provided they are approved by the designated UT/PAUT Level III and documented in the examination records.

13.0 PROCEDURE QUALIFICATION

13.1 This procedure shall be qualified by successful demonstration on a mock-up or demonstration block containing known flaws representative of the production weld configuration. Qualification shall be performed in accordance with the requirements of ASME Section V, Mandatory Appendix VIII (as applicable) and the referencing Code Section.

13.2 For ASME B31.3 and B31.1 fracture-mechanics-based acceptance criteria, procedure qualification shall be performed in accordance with ASME Section V, Mandatory Appendix IX, which provides requirements for the qualification of ultrasonic examination procedures when flaw sizing and categorization are specified.

13.3 Demonstration Blocks: Mock-ups or demonstration blocks are the responsibility of the client. PII can provide acceptable blocks as needed. The parameters associated with diameters, material, etc. apply to the demonstration blocks. The demonstration block shall be prepared by welding or, provided the acoustic properties are similar, the hot isostatic process (HIP) may be used.

13.4 Thickness: Demonstration block thicknesses shall be within 25% of the thickness to be examined. For welds joined of two different thicknesses, demonstration block thickness shall be based on the thinner.

13.5 Weld Joint Geometry: The demonstration block(s) weld joint geometry shall be representative of the production joint's details.

13.6 Flaw Requirements: The demonstration block shall contain a minimum of 3 planar flaws or 3 EDM notches oriented to simulate flaws parallel to the weld axis and major groove faces. The flaws shall be located at or adjacent to the block's weld groove faces as follows: (a) one surface flaw on the side representing the O.D.; (b) one surface flaw on the side representing the I.D.; (c) one sub-surface flaw. When the scan plan subdivides a weld into multiple examination zones, a minimum of one flaw per zone is required.

13.7 Flaw Sizes: Flaw sizes shall be based on the block thickness and shall be no larger than that specified by the referencing code section.

13.8 Dual Surface Access: When the demonstration block can be scanned from both surfaces (I.D. and O.D.), has similar detail, diameter of curvature greater than 20 in. (500 mm), and no cladding or weld overlay is present, then only one surface flaw is required.

13.9 Single Side Access: When the weld can only be examined from one side due to obstructions, the demonstration block shall contain 2 sets of flaws; one set on each side of the weld.

13.10 Acceptable Performance: Acceptable performance is defined as detection of all the flaws in the demonstration block and: (a) recorded response or imaged lengths, as applicable, exceed the specified evaluation criteria; (b) flaws are sized as being equal to or greater than their actual size (both length and height); (c) flaws are properly categorized (surface or subsurface).

13.11 Documentation: The following shall be documented for the demonstration block: (a) the procedure used; (b) demonstration block details (thickness, joint design, cladding, flaw data); (c) scanning sensitivity and inspection speed used; (d) qualification data (the raw data); (e) flaw sizing data; (f) supplemental manual technique(s) sizing data, if applicable. A report similar to the final report for a production weld scan shall be provided.

13.12 For API 1104 pipeline weld applications, procedure qualification shall additionally meet the requirements of API 1104 21st Edition Section 12 as applicable.

14.0 DOCUMENTATION AND RECORDS

14.1 Recording Indications

14.1.1 Nonrejectable Indications: Nonrejectable indications shall be recorded as specified by the referencing Code Section.

14.1.2 Rejectable Indications: 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. ASME Section V, Nonmandatory Appendices D and K provide general recording examples for angle and straight beam search units. Other techniques may be used.

14.2 Examination Records

14.2.1 For each ultrasonic examination, the following information shall be recorded:

- (a) Date of the examination
- (b) Name and/or identity and certification level (if applicable) for personnel performing the examination
- (c) Examination method, technique, procedure identification, and revision
- (d) Results of the examination
- (e) Ultrasonic instrument identification (including manufacturer's serial number)
- (f) Instrument settings: excitation pulse type, duration and voltage settings, digitization rate, rectification, pulse repetition rate, range start and stop, band pass filters, smoothing, focal type and length
- (g) Search unit(s) identification (manufacturer's serial number, frequency, element size, number, pitch/gap, and size)
- (h) Wedge natural refracted angle
- (i) Focal law parameters: beam angle or angular range, element numbers used, angular or element increment change, start and stop element numbers
- (j) Scan plan variables
- (k) Couplant used, brand name or type
- (l) Search unit cable(s) used, type and length
- (m) Special equipment when used (search units, wedges, shoes, automatic scanning equipment, recording equipment, etc.)
- (n) Computerized program identification and revision when used
- (o) Calibration block identification
- (p) Simulation block(s) and electronic simulator(s) identification when used
- (q) Instrument reference level gain and, if used, damping and reject setting(s)
- (r) Calibration data [including reference reflector(s), indication amplitude(s), and distance reading(s)]
- (s) Data correlating simulation block(s) and electronic simulator(s) with initial calibration
- (t) Identification and location of weld or volume scanned
- (u) Surface(s) from which examination was conducted, including surface condition
- (v) Map or record of rejectable indications detected, or areas cleared

(w) Areas of restricted access or inaccessible welds

14.3 Report

14.3.1 A report of the examinations shall be made. The report shall include those records indicated in 14.1 and 14.2. The report shall be filed and maintained in accordance with the referencing Code Section.

14.4 Storage Media

14.4.1 Storage media for computerized scanning data and viewing software shall be capable of securely storing and retrieving data for the period specified by the referencing Code Section. A copy of any software necessary to view the data shall be retained with the stored data.

15.0 SAFETY

15.1 All personnel performing ultrasonic examinations shall comply with applicable site-specific safety requirements, including but not limited to OSHA regulations, client safety procedures, and PII safety policies.

15.2 Personal Protective Equipment (PPE): All personnel shall wear appropriate PPE including hard hats, safety glasses, safety shoes, and hearing protection where required. When working in industrial environments, additional PPE such as high-visibility vests, fire-resistant clothing, and gloves may be required.

15.3 Electrical Safety: All ultrasonic equipment shall be inspected for damage to cables, connectors, and housings prior to use. Equipment shall be used in accordance with manufacturer's instructions. Ground fault circuit interrupters shall be used where required.

15.4 Chemical Safety: Couplants and cleaning materials shall be handled in accordance with the manufacturer's Safety Data Sheets (SDS). Personnel shall be aware of the location of SDS documents and emergency eyewash stations. Couplant disposal shall be in accordance with local environmental regulations.

15.5 Elevated Work: When examinations are performed at elevation, appropriate fall protection measures shall be implemented. Scaffolding, lifts, or platforms shall be inspected and approved prior to use.

15.6 Confined Space: When examinations are performed inside piping, vessels, or confined spaces, confined space entry permits shall be obtained, atmospheric testing shall be performed, and a standby attendant shall be present.

15.7 Heat Stress: When examinations are performed in high-temperature environments, personnel shall take appropriate precautions including hydration, work/rest cycles, and monitoring for signs of heat stress.

15.8 Manual Lifting: Phased array equipment, scanners, and calibration blocks can be heavy. Personnel shall use proper lifting techniques and mechanical lifting aids where necessary.

16.0 REVISION HISTORY

16.1 This procedure shall be reviewed at intervals not to exceed one year. Any changes shall be documented in the revision history table below and approved by the Corporate Quality Manager and the designated ASNT NDT Level III.

Revision	Date	Description of Changes
0	6/15/2020	Initial Issue
01	12/11/2025	ASME Code Review; new template format; updated for ASME Section V 2025 Edition
02	9/6/2026	Complete rewrite to audit-ready format; added API 1104 21st Edition Section 12 reference for UT acceptance of pipeline welds; added ASME Section V Article 23 reference for phased array techniques; added Sections 3 (Definitions), 4 (Responsibility), 13 (Procedure Qualification), 15 (Safety), and 16 (Revision History); expanded all sections with full detail; added Appendix VII (API 1104 Section 12 UT acceptance); aligned with ASNT SNT-TC-1A 2020 Edition

APPENDIX I — ASME B31.3 WORKMANSHIP ACCEPTANCE CRITERIA

SCOPE

ASME B31.3 requirements for Ultrasonics can be found in Chapter VI, paragraph 344.6 (Ultrasonic Examination) with the acceptance criteria in paragraph 344.6.2. In addition to the general requirements provided for within this procedure, the following addresses additional requirements if not previously addressed.

Manual PAUT

When engineering design or drawings call out for ultrasonic examination that does NOT reference radiography nor list radiography or ultrasonic as the required examination, manual UT and/or manual non-encoded UT (i.e., manual Phased Array) may be performed for piping welds subject to workmanship acceptance.

ACCEPTANCE CRITERIA

Wall Thickness (T)	Maximum Acceptable Indication Length
$T \leq 3/4$ in. (19 mm)	1/4 in. (6 mm)
$3/4$ in. (19 mm) $< T \leq 2-1/4$ in. (57 mm)	T/3
$T > 2-1/4$ in. (57 mm)	3/4 in. (19 mm)

A discontinuity is unacceptable if the amplitude of the indication exceeds the reference level and its length exceeds the values shown in the table above. The fracture-mechanics-based ultrasonic examination acceptance criteria in ASME B31.3 Mandatory Appendix R may be used if all requirements of Appendix R are met (see Appendix II).

APPENDIX II — ASME B31.3 FRACTURE MECHANICS ACCEPTANCE CRITERIA

SCOPE

ASME B31.3 requirements for Ultrasonics can be found in Chapter VI, paragraph 344.6 (Ultrasonic Examination) with the acceptance criteria in Mandatory Appendix R. This appendix provides alternative acceptance criteria based on ultrasonic fracture mechanics that may be used for code piping in lieu of those described in Appendix I.

The acceptance criteria within this Appendix are applicable to **T** having a thickness equal to or greater than 1.0 in. (25 mm). The acceptance criteria of Appendix I shall be used for all thicknesses less than 1.0 in.

EVALUATION

(1) A flaw shall be characterized as surface or subsurface. The flaw shall be characterized as a surface flaw if the separation (S) of the indication from the nearest surface of the component is equal to or less than 1/2 the through-wall dimension (h).

(2) Multiple Flaws: Discontinuous flaws that are oriented primarily in parallel planes shall be considered to lie in a single plane if the distance between the adjacent planes ≤ 0.50 in. (13 mm) or $0.5t$, whichever is less. If the space between 2 flaws aligned along the axis of the weld is less than the height of the flaw of greater height, the 2 flaws shall be considered a single flaw. If the space between 2 flaws aligned in the through-thickness dimension is less than the height of the flaw of greater height, the 2 flaws shall be considered a single flaw. The height, h, of the flaw shall be drawn normal to the inside pressure-retaining surface of the component.

ACCEPTANCE CRITERIA

(1) Relevant indications shall be evaluated against the applicable acceptance criteria Table R308.1 or Table R308.2, except that flaw length (l) shall not exceed $4T$, regardless of height (h) or calculated aspect ratio. (2) Per R-300(b), for materials under 1.0 in. the workmanship criteria (Appendix I) applies.

PROCEDURE QUALIFICATION

Mandatory Appendix IX provides requirements for the qualification of ultrasonic examination procedures when flaw sizing and categorization determination are specified for fracture mechanics-based acceptance criteria. See Section 13.0 of this procedure for full qualification requirements.

APPENDIX III — ASME B31.1 WORKMANSHIP ACCEPTANCE CRITERIA

SCOPE

This appendix is to be used when performing examinations in accordance with ASME B31.1 (Workmanship Based Acceptance Criteria). The requirements of this procedure shall apply except as modified by this appendix. Where physical obstructions prevent the use of systems capable of recording UT data, manual UT may be used with the approval of the owner.

ACCEPTANCE CRITERIA

Relevant indications shall be evaluated against the applicable acceptance criteria in accordance with (1) and (2) below.

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

(2) Other discontinuities are unacceptable if the indication exceeds the reference level, and their length exceeds the following:

Wall Thickness (t)	Maximum Acceptable Indication Length
$t \leq 3/4$ in. (19 mm)	1/4 in. (6 mm)
$3/4$ in. (19 mm) $< t \leq 2-1/4$ in. (57 mm)	$t/3$
$t > 2-1/4$ in. (57 mm)	3/4 in. (19 mm)

Where t is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses. As an alternate, the fracture-mechanics-based ultrasonic examination acceptance criteria in Mandatory Appendix O may be used if all requirements of Appendix O are met (see Appendix IV).

APPENDIX IV — ASME B31.1 FRACTURE MECHANICS ACCEPTANCE CRITERIA

SCOPE

ASME B31.1 requirements for Ultrasonics can be found in Chapter VI, paragraph 136.4.6 (Ultrasonic Examination) with the acceptance criteria in Mandatory Appendix O. This appendix provides alternative acceptance criteria based on ultrasonic fracture mechanics that may be used in lieu of those described in Appendix III (136.4.6(b)).

EVALUATION

(1) A flaw shall be characterized as surface or subsurface. The flaw shall be characterized as a surface flaw if the separation (S) of the indication from the nearest surface of the component is equal to or less than 1/2 the through-wall dimension (h).

(2) Multiple Flaws: Discontinuous flaws that are oriented primarily in parallel planes shall be considered to lie in a single plane if the distance between the adjacent planes ≤ 0.50 in. (13 mm) or $0.5t$, whichever is less. If the space between 2 flaws aligned along the axis of the weld is less than the height of the flaw of greater height, the 2 flaws shall be considered a single flaw. The height, h, of the flaw shall be drawn normal to the inside pressure-retaining surface of the component.

ACCEPTANCE CRITERIA

(1) Relevant indications shall be evaluated against the applicable acceptance criteria Tables O-9-1, O-9-2, and O-9-3, except that flaw length (l) shall not exceed $4T$, regardless of height (h) or calculated aspect ratio.

PROCEDURE QUALIFICATION

See Section 13.0 of this procedure for full qualification requirements per ASME Section V, Mandatory Appendix IX.

APPENDIX V — ASME SECTION I WORKMANSHIP ACCEPTANCE CRITERIA

SCOPE

This appendix is to be used when performing examinations in accordance with ASME Section I, PW-52.3 (Workmanship Based Acceptance Criteria). The requirements of this procedure shall apply except as modified by this appendix. Where physical obstructions prevent the use of systems capable of recording UT data, manual UT may be used with the approval of the owner.

ACCEPTANCE CRITERIA

- (1) Discontinuities evaluated as being cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.
- (2) Other discontinuities are unacceptable if the indication exceeds the reference level, and their length exceeds the following:

Wall Thickness (t)	Maximum Acceptable Indication Length
$t \leq 3/4$ in. (19 mm)	1/4 in. (6 mm)
$3/4$ in. (19 mm) < $t \leq 2-1/4$ in. (57 mm)	$t/3$
$t > 2-1/4$ in. (57 mm)	3/4 in. (19 mm)

Where t is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses. As an alternate, the fracture-mechanics-based ultrasonic examination acceptance criteria in Nonmandatory Appendix E may be used. This is not covered within this procedure.

APPENDIX VI — ASME SECTION IX WORKMANSHIP ACCEPTANCE CRITERIA

SCOPE

This appendix is to be used when performing examinations in accordance with ASME Section IX (Workmanship Based Acceptance Criteria) for groove welds and welder performance qualification welds on tube or pipe. The requirements of this procedure shall apply except as modified by this appendix. Material thickness shall be ≥ 0.250 in.

Where physical obstructions prevent the use of systems capable of recording UT data, manual UT may be used with the approval of the owner.

ACCEPTANCE CRITERIA

- (1) Discontinuities evaluated as being cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.
- (2) Discontinuities exceeding $1/8$ in. (3 mm) in length are considered relevant, and are unacceptable if their length exceeds the following:

Wall Thickness (t)	Maximum Acceptable Indication Length
$t \leq 3/8$ in. (10 mm)	$1/8$ in. (3 mm)
$3/8$ in. (10 mm) $< t \leq 2-1/4$ in. (57 mm)	$t/3$
$t > 2-1/4$ in. (57 mm)	$3/4$ in. (19 mm)

- (3) Acceptance Criteria for Production Welds: The acceptance criteria for welders or welding operators who qualify on production welds by ultrasonic examination as permitted shall be the same as (1) and (2) above. Where t is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses.

APPENDIX VII — API 1104 21st EDITION SECTION 12 UT ACCEPTANCE CRITERIA FOR PIPELINE WELDS

SCOPE

This appendix is to be used when performing ultrasonic examination of pipeline girth welds in accordance with API 1104, 21st Edition, Section 12 (Ultrasonic Testing of Welds). The requirements of this procedure shall apply except as modified by this appendix.

GENERAL

Ultrasonic testing of pipeline welds shall be performed in accordance with API 1104, 21st Edition, Section 12. This section covers the use of manual and automated UT including phased array and TOFD techniques for the examination of girth welds in pipelines. The acceptance criteria of Section 12 shall apply when specified by the referencing code, contract, or client specification.

ACCEPTANCE CRITERIA

Acceptance criteria for ultrasonic testing of pipeline welds shall be in accordance with API 1104 21st Edition Section 12. The acceptance criteria are based on the length and height of indications as determined by ultrasonic examination. The specific acceptance limits shall be as specified in the contract documents or as agreed between the purchaser and contractor. Indications shall be evaluated for acceptability based on the following:

Indication Type	Acceptance Criterion
Crack	Unacceptable regardless of length
Lack of fusion (LOF)	Unacceptable if length exceeds limits per Section 12
Incomplete penetration	Unacceptable if length exceeds limits per Section 12
Slag inclusion	Unacceptable if length exceeds limits per Section 12
Porosity (cluster/elongated)	Evaluated per Section 12 limits
Wall thickness reduction	Evaluated per Section 12 limits

EVALUATION

All indications exceeding the evaluation level shall be investigated to determine their type, location, length, and through-wall height. The acceptance or rejection of each indication shall be based on the criteria in API 1104 21st Edition Section 12 and any additional criteria specified in the contract documents.

PROCEDURE QUALIFICATION

For pipeline weld applications, this procedure shall be qualified in accordance with API 1104 21st Edition Section 12 requirements. Demonstration of procedure effectiveness shall be performed on mock-ups or qualification blocks representative of the production weld configuration. See Section 13.0 of this procedure for additional qualification requirements.

APPENDIX VIII — PAUT SCAN PLAN TEMPLATE

The following template shall be used as a minimum guide for documenting PAUT scan plans. Additional information may be added as required by the specific weld configuration or client requirements.

Parameter	Value
Project / Job No.	
Weld ID	
Material Specification	
Pipe Diameter (NPS / mm)	
Wall Thickness (in. / mm)	
Weld Joint Design	
Weld Process	
Probe Model / Serial #	
Probe Frequency (MHz)	
Number of Elements	
Element Pitch (mm)	
Wedge Model / Angle	
Scan Type (S-scan / E-scan)	
Beam Angle Range (deg)	
Active Aperture	
Scan Positions (1, 2, 3, ...)	
Stand-off Distance (mm)	
Couplant Type	
Calibration Block ID	
Scan Speed (in./s)	
Data Recording Increment (mm)	
Prepared By / Date	
Approved By (Level III) / Date	