TES-NDT-UT1 Mechanized Ultrasonic Examination of Pipeline Girth Welds		Document Type: Specification
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PURPOSE

This Specification details the requirements for the ultrasonic system (transducers, ultrasonic instrument, and recording system), calibration standards, system set-up and performance, field inspection and records for the examination of pipeline girth welds using a mechanized ultrasonic examination system.

The pipeline contractor should be aware of these inspection requirements and work with the NDE contractor to ensure that welds are inspected as required by the Company

SCOPE

This Specification establishes minimum requirements for ultrasonic examination of qualification welds, production welds and repair welds. Notwithstanding the requirements set forth herein, ultrasonic examination shall comply with the requirements of the latest approved edition CSA Z662.

This Specification applies to welds made in pipe having a nominal wall thickness 7.2 mm and greater.

BRIEF DESCRIPTION OF CHANGE

This Specification has been fully revised to capture new AUT technologies, update system requirements, and performance monitoring. Data interpretation and flaw marking protocols for weld removal have been added. Specifications TES-NDT-UTS, TES-NDT-UTG, and TES-NDT-UT2 have been revised and consolidated into this Specification.

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1 SCOPE

This Specification establishes minimum requirements for ultrasonic examination of qualification welds, production welds and repair welds. Notwithstanding the requirements set forth herein, ultrasonic examination shall comply with the requirements of the latest approved edition of CSA Z662, and any amendment, supplement, or errata issued by CSA; and the Company Environment, Occupational Health and Safety standards. This Specification applies to welds made in pipe having a wall thickness 7.2 mm and greater.

2 REFERENCES

a) CSA Standard Z662-07 Oil and Gas Pipeline Systems (referred to as CSA Z662)

b) British Standard BS EN 12668 Characterization and Verification of Ultrasonic Examination Equipment; Part 1 Instruments, part 2 Probes, Part 3 Combined Equipment

c) ASTM E164, Practice for Ultrasonic Contact Examination of Welds

d) ASTM E317, Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments

e) BS EN 583-6:2008, Non-destructive testing. Ultrasonic examination. Time-of-flight diffraction technique as a method for detection and sizing of discontinuities

f) Canadian General Standards Board, CAN/CGSB 48.9712 Qualification and Certification of Nondestructive Testing Personnel

g) Electrical Supply Industry Standard ESI 98-2 Issue 1 Dec 1979/R1998, Ultrasonic Probes: Medium Frequency Miniature Shear Wave, Angle Probes

h) ASTM E 1316 Standard Terminology for Nondestructive Examinations

i) ASME Section V, Nondestructive Examination

j) Applicable TransCanada specifications

3 DEFINITIONS

Definitions contained in ASME Section V, Article 5, Mandatory Appendix III apply to this Specification; in addition the following definitions shall be added:

Company	TransCanada Pipelines Limited (Company) including their engineering agencies, inspectors and other authorized representatives.
Contractor	The ultrasonic inspection contractor engaged to perform work covered by this Specification.
Operator(s)	Operators of ultrasonic equipment. Ultrasonic operators shall be qualified and certified in accordance with the requirements of Level II Canadian General Standards Board, CAN/CGSB 48.9712 Qualification and Certification of Nondestructive Testing Personnel.
Pipeline	A pipeline for the transmission of natural gas or hazardous liquids including laterals, branch connections, extensions, compressors, pumps, and related facilities as defined by CSA Z662.

4 GENERAL

All documents listed in the tender shall apply to and govern all phases of the Work hereinafter specified.

4.1 General Conditions

4.1.1 The Company will only use Contractors who have been pre-approved using the system performance qualification process detail in Clause 6.2 of this Specification.

4.1.2 The Company shall have the right to nondestructively examine any weld; the examination shall be used to assess compliance with CSA Z662. The Company shall also have the right to require the removal of any weld for the purpose of destructive tests. The Company is the final authority for the acceptance of welds.

4.1.3 The Contractor shall provide ultrasonic examination services for all welds designated by the Company during the construction of a pipeline or facility, as described in Clause 6.

4.1.4 The pipe coating shall be cutback for a minimum distance of 125 mm from the original bevel face; spiral or long weld seams shall be ground within 0.5/-0 mm of the pipe surface for a distance measured along the length of the pipe of 125 mm from the original bevel face to ensure that no transducers are lifted from the pipe surface during the scanning operation.

4.1.5 No transducers shall operate on the coating.

4.1.6 Pulse-echo and pitch-catch techniques, using either focused transducers or phased array transducers, in combination with a minimum of A-scan, stacked A-scan presentations, and a fully automatic recording system shall indicate accurately the circumferential location, circumferential length, and through-thickness location of indications as well as the continuity of acoustic coupling. The system analysis software shall be capable of determining the through-thickness height of indications with an accuracy $\leq$ 1.5 mm. System resolution shall be 1 mm of circumferential distance, and the system shall provide for encoder accuracy verification. Circumferential distance markers shall be provided at intervals not exceeding 1 cm of weld length.

4.1.7 Each system shall incorporate a Time of Flight Diffraction (TOFD) configuration, this shall augment, but not replace, the pulse echo system. A single TOFD configuration shall be used for wall thickness $\leq$ 25 mm, whereas a dual TOFD configuration shall be used for wall thickness greater than 25 mm.

4.1.8 In addition to an analog strip recording for all sequences/channels, a stacked A-scan mapping display shall be provided or each root and volumetric sequence/channel. For any selected analog strip sequence/channel, there shall be an A-scan presentation of the gated period available for viewing in the display during scanning when required.

4.1.9 The Contractor shall provide the Company with an electronic copy of the raw data and a hard copy recording of the inspection, together with the judgment of acceptability of each weld examined and the recordings of the calibration standard scans. The raw data shall capture the A-scan signal within the gated period of each sequence at a sampling rate allowing proper reconstruction of the signal. The Contractor shall supply a viewer program to enable the Company to view the raw data in the same manner used by the system operator at the time of inspection, and the program shall allow the Company to verify amplitude or TOFD indication height values from the raw data.

4.1.10 The inspection shall be carried out using an automatic ultrasonic system capable of maintaining production rates established by the pipeline construction contractor, which can be as many as 150 welds/day. The system shall be self-contained, have its own independent power supply, and be mounted on a suitable all-terrain vehicle. The Contractor shall have necessary spare equipment to ensure continuance of the work without interruption or delays.

4.1.11 The Contractor shall designate one person as the NDE Supervisor, and this person shall be responsible for the conduct and performance of all ultrasonic personnel and for maintaining all equipment and supplies in reliable condition. The NDE Supervisor shall work closely with the Company's Senior Welding Inspector in the documentation of inspections completed and shall be responsible for all reports, interpretations and evaluation. The Contractor Job Supervisor shall audit daily results to ensure that interpretations are consistent, informative, and concise, and this supervisor shall be capable of technical support for automated UT operations. The extent of data audit shall be approved by the Company. The NDE Supervisor shall be approved by the Company for duties to be performed.

4.1.12 The Contractor shall have sufficient equipment and personnel on site to maintain a production rate which ensures that any weld completed prior to 4:30 PM shall be inspected, interpreted and included in the Ultrasonic Inspection Report for that working day, unless otherwise directed by the Company.

5 VISUAL INSPECTION

At suitable intervals, the Contractor or designate should confirm by visual inspection and with a slip gauge that the pipe bevel dimensions and alignment prior to welding conform to the dimensional tolerances of the ultrasonic testing procedure. Any differences in dimensions or alignment observed during setup and scanning should be reported to the appropriate Company representative.

6 ULTRASONIC INSPECTION

6.1 Introduction

6.1.1 Mechanized mainline girth welds shall be fully examined by an automated ultrasonic inspection system for 100% of the circumference, in accordance with CSA Z662. The inspection system shall be capable of locating and accurately predicting the through wall height and circumferential length of defects, in a manner that permits the use of acceptance criteria defined by the Company in accordance with CSA Z662, Annex "K".

6.1.2 Girth welds made in a factory bevel or repairs made to welds produced using automatic welding shall be fully examined by an automated ultrasonic inspection system for 100% of the circumference in accordance with CSA Z662. The inspection system shall be capable of locating and accurately assessing circumferential length of defects, in a manner that permits the use of CSA Z662 "Workmanship Acceptance Standards".

6.1.3 Girth welds made in a factory bevel which cannot be inspected by automated ultrasonic inspection may where practicable, and with permission of the Company be inspected by manual ultrasonic inspection according to Appendix C of this Specification.

6.2 System Performance Qualification

The Contractor shall be pre-approved prior to bidding the work. During the pre-approval process the Contractor must successfully demonstrate system performance by examining a minimum of five welds supplied by the Company. The demonstration shall include integration of hardware, software, and personnel in a manner that permits reliable detection and accurate height sizing of weld imperfections to CSA Z662. The Company shall be the sole judge of the adequacy of system performance for the intended use. Systems failing the performance test requirements shall not be re-evaluated until it is proven that all previous non-performance issues have been addressed. The Company reserves the right to require the Contractor be re-approved if the Company is of the opinion that the Contractor's system has changed with respect to technology, or requires modification to correct non-performance issues.

6.3 Operator Qualification

6.3.1 Ultrasonic operators shall be qualified and certified as a Level II in the "Ultrasonic" method in accordance with CAN/CGSB 48.9712, and shall submit their current records of certification. In addition, operators shall have completed a minimum of 40 hours training in automatic testing, including practical and theoretical aspects pertinent to the equipment and general configurations to be examined. This training shall be documented and the records shall be provided to the Company. An operator's project experience shall include stand-alone automated ultrasonic testing of a minimum 1000 pipeline girth welds.

6.3.2 The Company reserves the right to assess the competency of system operators for pipeline inspection by demonstrating their ability to detect and characterize typical weld indications and determine their acceptance. The Company will provide qualification test welds containing known defects, for operator qualifications. The qualification test will be administered and witnessed by the Company prior to production welding. This process may be waived in lieu of an alternate approach, at the discretion of the Company. The Company shall be sole judge of operator performance.

6.3.3 The Company reserves the right to assess the competency of ultrasonic operators for manual inspection using qualification welds containing defects. Operators must demonstrate their ability to detect and characterize typical indications and determine their acceptance according to the CSA workmanship criteria, and shall be approved by the Company. This process may be waived in lieu of an alternate approach, at the discretion of the Company. The Company shall be sole judge of operator performance.

6.3.4 Only ultrasonic operators/systems qualified in accordance with this Specification shall be permitted to inspect welds using the ultrasonic method.

6.4 Procedure and Technique Qualification

6.4.1 Ultrasonic inspection shall be performed in accordance with a documented, detailed procedure, technique approved by the Company. Approved procedures shall contain as a minimum the applicable information stated in this Specification, information stated in ASME Section V, Article 4 paragraph T.421, and a description of the methodology used to investigate indications.

6.4.2 If not issued by the Company, project-specific inspection designs shall be developed by the Contractor following the requirements of Appendix A of this Specification for automated GMAW, and Appendix B for welds produced in a standard factory bevel. Using either the design information provided by the Company or derived from the relevant Appendix, the Contractor shall prepare a detailed technique for each wall thickness to be inspected by automated ultrasonic

inspection. The Contractor shall prepare a detailed technique(s) for manual ultrasonic inspection. only when required by the Company.

6.4.3 The Contractor shall demonstrate the effectiveness of all proposed procedures and techniques to the Company prior to mobilizing each system to the project. The specific technique for each wall thickness will be assessed according to the performance requirements contained in Section 7 of this Specification. All project procedures/techniques must be approved prior to mobilization to the project. The Contractor shall not use any procedure or technique in the performance of the work that has not been approved by the Company. The Company shall be sole judge of the adequacy of the technique for the intended use.

6.4.4 Further procedure/technique validation may be required by the Company during welder training and qualification testing.

6.4.5 The Contractor shall provide an automatic ultrasonic inspection procedure and specific techniques which permit full volumetric examination of the weld in a single pass from both sides of the weld. The procedure shall provide tolerance for pipe misalignment and weld shrinkage; it shall provide for characterization of imperfections, their location in the weld thickness direction, through-wall defect height, and circumferential imperfection length and location. Imperfection location and sizing must be adequate to permit use of Company defined acceptance criteria based on the Engineering Critical Assessment provisions of CSA Z662 Annex "K". It should include but not be limited to describing the following requirements:

a) an automatic variable speed scanner mounted on automatic welding bands or other tracking devices;
b) an encoder capable of accurately indicating any defect location within the girth weld;
c) independently loaded ultrasonic transducers mounted in a configuration that provides independent inspection of the weld from both sides;
d) provisions for adjustments and maintaining the alignment of the transducers;
e) provisions for recording the continuity of the coupling;
f) provisions for ensuring the mechanical reliability of the equipment;
g) a technique summary sheet stating beam angles, wave types, transducer frequencies, beam size profiles and sketches for each geometry to be examined, and other relevant information;
h) a record of analog and/or digital signals from the multiple channels to a common circumferential distance;
i) provisions for a permanent copy of the scans in an easily interpretable format to meet archival and audit needs;
j) construction and accuracy details of the calibration piece; calibration procedures to be used in the field;
k) calibration checks that shall be established and verified on a time or weld cycle defined by the Company, with system performance between calibration checks continually monitored for degradation;
l) area of inspection; and
m) marking defects for repair.

6.4.6 The Company will notify the Contractor of its approval of each procedure and/or technique. Upon approval from the Company, the procedure becomes a mandatory requirement and changes are only permitted with further approval from the Company.

6.5 Calibration Standards

6.5.1 The number of calibration reflectors shall be adequate to provide better than 1.5 mm height sizing accuracy, and clearly discriminate buried from surface breaking imperfection, as well enable classification of imperfection type, planar and volumetric.

6.5.2 Calibration standards shall be used to qualify the system for field inspection and to monitor ongoing system performance.

6.5.3 Calibration standards shall be manufactured from a section of project specific line pipe supplied by the Company and designed such that the target reflectors simulate the bevel geometry to be inspected.

6.5.4 The acoustic velocity of each pipe material shall be determined in the same plane as the pipe axis using SH shear waves polarized to simulate particle displacement during actual inspection conditions. Measurements shall be made using parallelograms machined to represent the lowest and highest inspection angles. Two complete sets of parallelograms shall be taken from each pipe section; sets shall be separated by 180°. This data shall be considered during transducer selection or design and be recorded in the procedure submitted to the Company.

6.5.5 Calibration standards shall be designed with sufficient surface area so that the complete transducer array will traverse the target areas in a single pass. The lateral position of calibration reflectors shall be such that there will be no interference from adjacent reflectors, or the edges of the block.

6.5.6 Calibration standards shall be identified with a unique serial number providing traceability back to the project for which they were manufactured. Records of the serial number, wall thickness, diameter, and acoustic velocity shall be kept. Calibration standards remain the property of the Company.

6.5.7 For stress based pipeline design in wall thickness of 25 mm or less, and for all wall thicknesses used in a strain based pipeline design the principal calibration reflectors for fusion defects shall be 2 mm diameter flat bottom holes (FBH) and 1 mm deep surface notches. The principal reflector for porosity detection shall be a 1.5 mm FBH. For stress based pipeline design in wall thickness greater than 25 mm the principal calibration reflectors for fusion defects shall be 3 mm diameter flat bottom holes (FBH) and 1 mm deep surface notches, and the principal reflector for porosity detection shall be a 2 mm FBH. The central axis of each FBH calibration reflector shall coincide with the central axis of the sound-beam interrogating it. For inspection of welds made with a standard bevel (e.g., the shielded metal arc [SMAW], gas metal arc [GMAW/PGMAW] or flux-cored arc [FCAW] welding process, two transverse notches are required, each measuring 10 mm long and 2 mm deep, with one on the ID and one on the OD surface. TOFD notches shall not be deeper than 2 mm for the inside surface and 3 mm for the outside surface.

6.5.8 Machining tolerances for all calibration reflectors shall be less than or equal to the following:

a) Hole diameter ± 0.1 mm
b) Flatness of FBH ± 0.2 mm
c) Angles ± 1 degree
d) Notch Depth ± 0. 2 mm
e) Notch Length ± 10%
f) Center location ± 0.2 mm

g) Hole depth ± 0.2 mm

6.5.9 Calibration standards shall be certified by the machine shop and a report shall be provided to the Company verifying the tolerance to design actual for each of the calibration reflectors. In addition, the Contractor shall ultrasonically verify the signal response from like kind reflectors on upstream versus downstream sides; a report shall be provided to the Company.

6.5.10 Holes and notches shall be protected from degradation by filling them with a suitable silicone sealant.

6.5.11 Project pipe will normally be available for procedure development and calibration block design 60 days before construction.

6.6 Ultrasonic Equipment General

6.6.1 The instrument shall provide a linear A-scan presentation for each channel selected. A selectable A-scan presentation shall be available during scanning. The inspection channels shall allow assessment of the full volume of the weld scanned, and all defects present detected, located and sized in the through-wall direction. Instrument linearity shall be determined according to ASTM E317, within 3 months of the intended end use date and not deviate by more than 5% from ideal. The Contractor shall retain a current copy of the calibration certificate at the worksite.

6.6.2 Each inspection channel shall provide:

a) Pulse echo or through transmission modes;
b) Two gates, each adjustable for start position and length;
c) Gain adjustment independent of the other inspection channels;
d) Recording threshold between 5 and 100% of full screen height for A-scan and transit time recording and 0% to 100% for stacked A-scan mapping;
e) For TOFD waveforms, a recording threshold of 100% to -100%;
f) Recording of the first or the largest signal in the gated region; and signal outputs representing signal amplitude and time of flight

6.6.3 All transducers shall be contoured to match the curvature of the pipe surface.

6.6.4 The acoustic focus shall occur at the target ±10 mm of steel path and the beam height shall be within ±25% of that required by the inspection design; the -6 dB horizontal dimension of the beam at the target shall not be greater than two times the -6 dB vertical dimension of the beam.

6.6.5 Transducers shall be certified as meeting the performance requirements of British Electrical Supply Industry Standard ESI 98-2.

6.6.6 Each transducer's performance shall be documented before use on a Contractor developed form approved by the Company.

6.7 Phased Array

6.7.1 When phased array technology is used as an alternative to a focused multi-transducer array, the Contractor shall apply the following additional requirements:

6.7.2 Phased array systems will simulate the focused multi transducer array system function for weld volume inspection. Azimuthal scans are permissible when required to provide enhanced defect height sizing.

6.7.3 Phased array equipment shall meet the requirements of Part 1, 2 &3 of BS EN 12668.

6.7.4 Phased array transducers shall have a minimum of 48 elements. Due to the large wedge footprint and therefore sensitivity to surface waviness, care must be taken to ensure the contact surface of the transducer is properly dressed to match the contour of the pipe surface. The permissible gap between pipe and wedge shall not exceed 0.25 mm.

6.7.5 Phased array transducers shall contain shaped elements in the passive none steered direction, radius of curvature 75 to 125 mm. Alternatively phased array transducers shall contain a suitable lens in the passive none steered direction.

6.7.6 Each array will be assessed at intervals not exceeding 500 welds or 1 week of production whichever comes first to confirm continued element integrity and performance within the manufacturers acceptable tolerance. The Contractor shall follow the manufacturer's performance tolerances with respect to sensitivity across the array, number of non-active elements.

6.7.7 Each focal law will provide for the maximum sound pressure at the target defined in the inspection design. The focus shall occur at the target ±10 mm of steel path and the beam height shall be within ±25% of that required by the inspection design.

6.7.8 Software locks shall be active for each focal law to limit changes by the system operator which will alter the system configuration once approved by the Company Representative. Changes will only be permitted by the Contractor Job Supervisor with approval of the Company Representative. The Contractor shall demonstrate the tolerance to ideal for each focal law. With permission from the Company a software feature which identifies in the display that a focal law is outside the tolerance set for that focal law may be substituted for software locks. This out of range condition shall appear in the display continuously until corrected and recorded in the raw data for welds examined with this out of range condition.

6.8 Time of Flight Diffraction

6.8.1 Time of flight diffraction TOFD shall be configured following BS EN 583-6:2008 guidelines.

6.8.2 The receiver bandwidth shall have a range 0.5 to 2 times the nominal transducer frequency at -6dB.

6.8.3 The system shall have an electronic gate with both start and lengths within the digitized, un-rectified A-scan.

6.8.4 The gate shall be set starting 1 microsecond prior to the arrival of the lateral wave and extend to ensure that the complete reflected back wall signal is recorded.

6.8.5 The digitization rate shall be at least 4 times the nominal transducer frequency.

6.8.6 The system shall be able to acquire and digitize and display at least one A-scan for each 1mm of scan length.

6.8.7 The system shall be capable of displaying D-Scan images in at least 128 grey scale levels.

6.8.8 If pre amplifiers are used then the bandwidth of the pre amplifier at -3dB shall be similar to that of the system. The preamplifier shall be low noise better than 20μV peak to peak.

7 SYSTEM SET-UP

7.1 Transducer Positioning and Primary Reference Sensitivity

7.1.1 Primary Reference Level

The system shall be optimized for field inspection using the calibration standard established in Clause 6.5 of this Specification. Each transducer shall be positioned at its operating distance away from the simulated weld centerline on the calibrated standard and adjusted to provide a peak signal from its target reference reflector in its inspection zone. The peak signal response shall be adjusted to approximately 80% of the full screen height for each channel. This gain level shall be the primary reference level for that transducer, and shall be recorded in the procedure (see Clause 6.3 of this Specification). Variation and corrective actions to maintain calibration shall be recorded on a Company pre-approved form. The noise shall be at least 20 dB weaker than the signal at the target path, and the electronic noise 40 dB weaker. The transducer operating distance relative to a marked index point shall also be recorded on the form. Signal discrimination between adjacent zones shall be a minimum 6 dB but not exceed 12 dB.

7.1.2 Gate Settings

Using the calibrated standard, each detection gate shall be set to cover a sound path which starts at least 3 mm before the weld preparation in the hot pass and fill /cap zones, and 5 mm before for the root and cross-penetration zones, and ends at least 1 mm past the weld centerline. The gate start position and gate length with respect to the weld preparation for each detection channel shall be recorded in the procedure. For mapping (stacked A-scan) the gate shall mimic the start positions above and extend past the weld geometry.

7.1.3 Gate Recording Threshold

The recording threshold of each planar detection channel shall be 40% of full screen height when on the peak signal response from the target FBH or surface notch is set at 80% of full screen height. The recording threshold of each porosity detection channel shall be 20% of full screen height when the 1.5 mm diameter FBH is set at 80% of full screen height and 6 dB is added. Alternatively, the recording threshold of each porosity detection channel shall be 10% of full screen height when the 1.5 mm diameter FBH is set at 80% of full screen height.

7.1.4 Data Display

Channel output signals shall be arranged in the data display and hard copy record in an order acceptable to the Company In addition, time delays shall be applied to the signals to compensate for different transducers circumferential positions relative to the circumferential zero point and subsequent distance markers. Details of the delays applied and the chart arrangement shall be recorded in the procedure. Variations and corrective actions to maintain calibration shall be recorded on a Company pre-approved form.

7.1.5 Circumferential Scanning Velocity

$Vc \leq Wc * PRF / 3$ - Where Vc is the scanning velocity and Wc, is the narrowest -6dB beam width at the appropriate operating distance(s) of all transducers in accordance with the design requirements and PRF is the pulse repetition frequency per transducer.

7.1.6 Circumferential Scanning Direction

The circumferential scanning direction shall be clockwise when the pipe axis is viewed in the direction of construction. Drag sections and other instances when the pipe is scanned in reverse shall be documented "REVERSE SCAN" on the weld chart and NDE Weld Form

7.1.7 Operating Log

A log shall be kept of adjustments; changes to measurements, dB changes or other changes from those stated the original technique. Replacements will be documented i.e.: major system components, transducer wedge change-outs, transducer change-outs. Transducer details shall include angle, frequency, serial number, diameter, and focal position (if focused).

8 CALIBRATION QUALIFICATION

8.1 Detection Channels

8.1.1 With the system optimized, the calibration standard shall be scanned in the multiplexed mode. The recording medium shall indicate 70-100% (within specified tolerance) of full screen height signals from each calibration reflector recorded in their correct position assigned on the recorder chart. The circumferential positional accuracy of the recorded reflectors relative to each other shall be within ± 2 mm. A calibration acceptable to the Company shall be used as the inspection quality standard to which subsequently produced calibration charts shall be judged for acceptability.

8.1.2 Calibrations shall be performed at the same scanning speed as the weld examination – no stop/starting or rocking will be allowed, as this intended to be a representative dynamic scan.

8.2 Coupling Monitor Channels

8.2.1 Amplifier gain shall be adjusted when the system is mounted on the calibration standard to produce a maximum echo height of 80% from the full "vee" path, when using separate coupling monitors, or 80% FSH and up to a maximum of +12dB transmitted signal for the through transmission mode. The recording gate threshold level shall be a minimum of 20% of full screen height to a maximum 80% of full screen height.

8.2.2 The re-inspection of the calibration standard with its surface wiped dry shall produce a record showing a lack of coupling (i.e., absence of recording signal). This shall be performed at least twice a day; once at the start of the day and once at midday..

8.3 Measurement to Assess Transducer Wear

8.3.1 The Contractor shall provide baseline height measurement for the transducer case prior to the start of field weld examinations. An accurate (± 0.1 mm) measurement shall be made of the case height at each of the corners of each transducer. These measurements shall be recorded on a Company approved form for a comparison of periodic measurements taken throughout the project to assess transducer wear. The frequency of checks shall be defined in the procedure. An ongoing transducer performance monitoring process may be used as a substitute for physical measurements, if approved by the Company.

9 INSPECTION OF PRODUCTION WELDS

9.1 Weld Marking

9.1.1 The Contractor shall permanently identify each weld with a unique weld number following the weld number system provided by the Company.

9.1.2 The weld number shall be positioned on the pipe surface on the work side of the pipe in a manner agreed by the Company.

9.1.3 Weld numbers shall be large enough to be clearly and visually identified from a distance of 3 metres.

9.2 Surface Condition

The scanning surfaces shall be free of weld spatter and other irregularities, which may interfere with the movement of the transducers, the coupling or the transmission of acoustic energy into the material.

9.3 Reference Line

9.3.1 Prior to welding, the Contractor shall scribe a reference line on the pipe surface at 40 mm from the weld centerline with an accuracy of ± 0.5 mm from the centerline of the weld preparation and on the inspection band side.

9.3.2 The reference line shall be used to ensure that the band is adjusted to the same distance from the centerline as to replicate the calibration standard. The tolerance to ideal positioning shall not exceed ± 0.5 mm. The 12 o'clock position shall also be clearly marked on the pipe to indicate the start position (0 cm) position of the scan.

9.3.3 The Contractor shall take into account the circumferential shrinkage of the girth weld during the design and calibration sequences. Shrinkage is determined by scribing a reference line on both pipe ends for the first 10 welds, then measuring the distance in between them after welding.

10 SYSTEM PERFORMANCE MONITORING

10.1 Sensitivity

10.1.1 The calibration standard shall be used daily before beginning pipe weld inspections, after repairs to the system, and thereafter at intervals not exceeding 1 hour or 10 welds, whichever comes first, and again at the conclusion of the shift.

10.1.2 When changes are made to the setup, for example a change of wall thickness, transducer or wedge, then six acceptable consistency calibration scans are required.

10.1.3 The hard copy record of the calibration standard scan shall be included sequentially with the weld inspection charts. The last weld number inspected and time at which it was performed shall appear on each calibration chart. These charts shall be made available to the Company when requested.

10.2 Circumferential Position Accuracy

The position accuracy of the chart distance markers shall be validated twice during each working shift. The scanner shall travel from the zero position with the scanning frame coincident with the pipe. At all o'clock positions, the index marks on the scanning frame and the pipe must be aligned. The chart shall then be compared to circumferential distance measured with a diameter tape; chart accuracy shall be within ±1 cm or better. The results shall be recorded on a Company approved form.

10.3 Transducer Surface Position Accuracy

Shifts in the refracted angle resulting from the change in velocity within the wedge line materials or pipe due to temperature, for example when scanning cold welds, shall be corrected for by adjustment of the transducer surface position. Care shall be taken to ensure that the gate start, and length positions are still set as required by paragraph 7.1.2 following any such adjustment. .

10.4 Temperature Control

10.4.1 It shall be the Contractor's responsibility to maintain a stable transducer wedge temperature between the calibration scan and scanning the weld. This shall be monitored using a thermocouple embedded in a dummy transducer within the transducer array, or in one of the active transducer wedges used in conjunction with a digital temperature gauge. The difference between the temperature of the transducers on the production weld and the temperature of the transducers when scanning the calibration block shall be monitored, and must be within 10 Celsius degrees. The temperature shall be recorded on all the hard copy printouts and be present in the electronic data.

10.4.2 For testing at temperature extremes, in very hot or very cold conditions, the calibration block may need to be heated or cooled so that the array is maintained within a 10 Celsius degrees variance when completing calibration in, weld scan, and calibration out cycles. The need for heating or cooling of the calibration standard shall be documented on all the hard copy calibration and weld printouts.

11 SCANNING SENSITIVITY

An additional 2 dB of gain shall be added globally to the system for weld examination to compensate for differences in coupling efficiencies between the calibration standard and the production pipe. This additional gain shall be removed during calibration. During production weld inspection, with the Company's approval, the system may be operated at a higher gain to ensure detection of defects, or to account for excessive pipe surface roughness.

12 RE-INSPECTION

12.1 Sensitivity

Welds examined at a sensitivity varying more than 2 dB from the scanning sensitivity shall require re-calibration of the system and re-examination, with no additional compensation to the Contractor.

12.2 Coupling Losses

Welds examined exhibiting coupling losses with a length exceeding the acceptable defect length for that channel shall be re-inspected.

12.3 Scanner Slippage

Scans shall not be acceptable where any slippage occurs. Where slippage is noted, the scanner shall be adjusted to correct the problem and the scan shall be repeated, with no additional compensation to the Contractor.

12.4 Weld Repairs

Welds examined by automatic ultrasonic inspection requiring repair shall be re-tested by automated ultrasonic inspection, or if not practicable, by using manual ultrasonic testing per Appendix C (of this document) after the repair has been completed.

12.5 Temperature Variance

Welds examined with wedge temperature difference greater than 10 Celsius degrees from the temperature used for calibration shall be re-tested with no additional compensation to the Contractor.

12.6 Other Conditions

When conditions exist where data collection is impaired or data is lost, the weld shall be retested with, no additional compensation to the Contractor. The operator shall write down the reason for impaired data and relay that to the Company on the daily report.

13 TRANSDUCER PERFORMANCE

Transducers shall be examined for wear as per Clause 8.3 of this Specification, whenever wear is apparent, but not greater than an interval of 500 welds. The signal to noise value for each transducer shall also be compared to the value obtained in accordance with Clause 7.1.1 at the start of the project. Case heights and the signal to noise value for each transducer shall be recorded on Company approved forms. The transducer contact face shall be re-surfaced, or the transducers replaced to correct any of the following.

13.1.1 Beam angle changes of ±1.5 degrees for angles less than 45 degrees or ±2 degrees for angles greater than 45 degrees.

13.1.2 Squint angles exceeding 1.5 degrees for single crystal transducers and 2 degrees for twin crystal transducers.

13.1.3 A signal-to-noise value 6 dB less than the value obtained at the start of the project

13.1.4 Scores in the transducer wear faces which exceed 0.2 mm in depth.

14 EVALUATION OF INDICATIONS

14.1 Imperfections

14.1.1 Weld imperfections shall be evaluated according to the defect acceptance criteria defined by the Company; evaluations shall be completed immediately after inspection of the weld.

14.1.2 When evaluating imperfections following the CSA Z662 Annex "K" length interaction criteria, the ends of the indications are to be determined from the points where the signal reduces in amplitude to two times the background noise level. Imperfections are considered to interact when the space between adjacent imperfections is smaller than the length of the shortest imperfection.

14.2 SMAW Root Zone Buried versus Open to the Surface Classification

Indications in the 70 degree root sequence must have a corresponding signal > 40% FSH in 60 degree root sequence to be interpreted as surface breaking, in addition to meeting the following requirement. Indications occurring simultaneously in root 60 and root 70 degree sequences must have the transit times compared to the calibration notch transit times to aid correct classification as buried or surface breaking. Indications occurring >0.5 mm prior to the respective notch transit time must be reviewed in the A-scan map display. The indication must to be classed as buried if there is a simultaneous signal evident from the face of the root bead.

15 WELD INSPECTION RECORD & REPORTS

15.1 Weld Inspection Record

A hard copy record of each weld and calibration scan shall be provided to the Company. In addition the Contractor shall supply the Company the raw data for both calibration and weld scans every 300 welds or 3 days, whichever comes first, for ongoing audit purposes. Before the start of the project, the Contractor shall supply the Company with a viewer program with full functionality to view the raw data files.

15.2 Interpretation of Weld Inspection Record

Areas in the AUT data with a corresponding pulse echo response will be evaluated and given a disposition by the operator as to whether it is a relevant or non-relevant indication. This area will be highlighted on the strip chart and have associated comment in the comments section of the AUT data.

15.3 Weld Acceptance from the Inspection Record

15.3.1 A weld shall be considered acceptable when the weld inspection shows imperfections that do not exceed the acceptable values, as given by the Company.

15.3.2 The Contractor shall submit ultrasonic weld interpretation reports to the Company daily, as directed by the Company, using forms approved by the Company. Contractor shall ensure that all electronic data files and hard copy graphs are further identified with the following:

a) Project Name
b) Work Order Number
c) Date
d) Inspector's Name
e) Inspection Unit Number
f) Weld Number

15.3.3 All hard copy charts shall be catalogued by consecutive weld number in binders.

15.3.4 Clear and legible interpretation records shall be included inside the binders.

15.4 Data Management

Back-ups of all digital data shall be made for audit purposes on a daily basis with a minimum of two back-ups of each file on separate mass storage media. The working computer system disk shall not be considered as a back-up.

15.5 Archives

No later than 3 months after completion of the project, a copy of all of the raw weld and calibration data shall packaged together with a weld interpretation log and a raw data viewer program to provide an archive record. The viewer software shall allow reconstruction of the weld data files in an identical manner to that viewed by the system operator at the time of inspection.

16 ADDITIONAL REQUIREMENTS

16.1 Weld Repair List

16.1.1 Weld repair lists shall be provided to the Company in electronic and hard copy format each working day by 6:00 PM.

16.1.2 Repair lists shall report the weld quality, including outstanding weld repairs and/or weld cutouts, of all welds completed by the prime Contractors mainline welding crew, by 4:30 PM each day.

16.1.3 The Contractor shall have sufficient equipment and personnel on site to maintain a production rate that ensures any weld completed prior to 4:30 PM on any working day shall be inspected, interpreted and included in the Ultrasonic Report for that working day.

16.2 Weld Cut –outs

16.2.1 Prior to removal of the suspect weld it must be rescanned using the system which identified the rejected defect.

16.2.2 The system operator must maximize the signal from the longest/ highest amplitude signal in the rejected area.

16.2.3 With the transducer positioned for maximum signal response mark with a metal punch at the weld cap edge the centreline of the phased array transducer, one centre punch mark on the upstream side and two on the downstream.

16.2.4 Mark with a metal marker the overall defect length.

16.2.5 The section of weld removed for analysis must be under direct control of the Company at all times.

16.2.6 When the weld is metallographically examined the bottom of the centre punch marks must be evident on the macro section.

16.2.7 Samples removed for analysis will be tracked and verified by the Company.

16.3 Training

If required by the Company, the Contractor shall provide training (one day minimum) for Company Inspectors on the techniques of ultrasonic inspection. This training shall be at a date and location determined by the Company and shall occur prior to the start of production welding.

17 RECORDS

The following records shall be kept:

Scanning Calibration	*material and manufacture
Standard Records	*date of manufacture of the standard *actual dimensions and angles of reference *reflectors *actual surface roughness and outer profile
Transducer records	*make, date of manufacturing & serial number *nominal dimensions *nominal frequency *height & wear
Ultrasonic System Records	*system description *make & model number of units *operating procedure *technique detail *operator log

17.1 Report Format

17.1.1 Equipment performance logbooks, daily reports (Weld Log) and Repair Lists will be presented to the Company in both hard copy and electronic format. The format shall be comma delimited ASCII, and be capable of displaying and printing the Electronic Report, Daily Repair Summary and Repair List.

17.1.2 Evaluation of the acceptability of every weld inspection shall be reported on the "NDE Daily Report". The NDE Daily Report form will be the only form used for NDE (UT, VT, RT, MT, and PT) for weld accepted/reject status. The Contractor will ensure that GPS coordinates are recorded applicable weld information on NDE Daily Report for all Tie-ins, repair welds and every 650 feet (200m) intervals for main and poor boy, if applicable.

17.1.3 The NDE Supervisor will collect all reports from the system operators and document weld status in a database. The reports shall include weld identification, description, position, and length of indications recorded from weld imperfections; identification of indications recorded from sources other than weld imperfections; date; time, signature of qualified ultrasonic inspectors, spread identification, project name, inspection unit number, chainage and upstream and downstream pipe unique number, pipe material and thickness, pipe diameter and manufacturer, and AUT technique/procedure.

17.1.4 All completed weld inspection and calibration charts shall be catalogued and packaged on a daily basis. The Repair List shall consist of the following fields, date, weld identification, imperfection type, and length in mm, and position in mm from zero, upstream or down stream, depth in mm to the bottom of the imperfection and GPS. The Repair List shall retain all non-status welds, weld repairs until the repair is cleared or status is determined.

APPENDIX A – INSPECTION DESIGN REQUIREMENTS GAS METAL ARC WELDS

A1 PURPOSE

This appendix details the inspection design requirements for automated ultrasonic inspection of gas metal arc welds produced in the specified weld bevel.

A2 SCOPE

This appendix applies to mechanized ultrasonic inspection of gas metal arc welds made with an internal root bead or with all passes deposited externally, in pipe having a nominal wall thickness 7.2 mm and greater.

A3 APPLICABLE STANDARDS

Ultrasonic examination to this procedure shall also meet the requirements of CSA Z662 and any amendment, supplement, or errata issued by CSA.

A4 APPLICABLE WELD BEVEL

This design is applicable to mechanized gas metal arc weld bevel designs shown in Figure A1.

A5 ULTRASONIC PARAMETERS

Ultrasonic parameters (transducer number, angle, frequency, beam size and position) shall be selected for each zone of the specified weld bevel, beginning in the weld root and finishing at the weld cap.

A5.1 Root Zone

A5.1.1 Welds with an Internal Root Bevel (37.5° Internal Bevel) and a weld pass deposited internally, see Figure A1 (a) One transducer shall be required with the following parameters:

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 8	52.5 ± 2.5	min. 4 max. 8	min. 2.0 max. 2.5	1.5 skip
> 8	52.5 ± 2.5	min. 4 max. 8	min. 2.0 max. 2.5	0.5 skip

A5.1.2 Weld with all Passes Deposited Externally (0° Land) All weld passes deposited externally, see Figure A1 (b). One transducer shall be required with the following parameters:

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 8	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	1.5 skip
> 8	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	0.5 skip

A5.2 Cross Penetration Zone

(0° Bevel - Welds with an Internal Root Bevel only) refer to Figure A1 (a) for bevel sketch. One transducer shall be required with the following parameters:

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 8	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	1.5 skip
> 8	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	0.5 skip

A5.3 Hot Pass Zone

A5.3.1 Welds with an Internal Root Bevel (45° or 52° Hot Pass Bevel)
For a hot pass with a bevel offset less than 2.5 mm one transducer is required with a -6dB beam size of 3.5 mm.
For a hot pass with bevel offset of 2.5 mm and greater this zone shall be divided in 2 sub-zones (refer to Figure A1 (a)) two transducers shall be required with the following parameters.

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 10	min. 50 max. 55	min. 4 max. 5	min. 2.5 max. 3.0	1.5 skip
> 10	min. 50 max. 55	min. 4 max. 5	min. 2.5 max. 3.0	0.5 skip

A5.3.2 Weld with all Passes Deposited Externally (Radius Hot Pass)
Refer to Figure 1 (b) for bevel sketch. One transducer shall be required with the following parameters:

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 10	min. 50 max. 55	min. 4 max. 5	min. 2.0 max. 2.5	1.5 skip
> 10	min. 50 max. 55	min. 4 max. 5	min. 2.0 max. 2.5	0.5 skip

A5.4 Fill(s) and Cap Zones

The number of transducers for the fill(s) and cap zones, and their parameters, are linked directly to the pipe wall thickness. Typical bevel sketches are shown in Figure A1.

A5.4.1 For wall thickness smaller than 8 mm one focused 70 ±2° transducer shall be used.

A5.4.2 Wall thickness larger than 8 mm, but smaller than 11.7 mm,

Two focused 70 ±2.5° transducers, or a combination of one focused 70 ±2.5° transducer for the cap zone, and a single tandem arrangement for the fill zone shall be used.

The -6 dB beam height selected for the cap zone shall have a dimension equal to or greater than the fill zone intimately below it.

The preferred tandem configuration is shown in Figure A2 and acceptable tandem combinations are specified in Table A1.

A5.4.3 Wall thickness 11.7 mm and larger

The cap zone shall be considered as having a 3 mm vertical extent and be inspected using a 65° to 70 ° pulse echo, or creeping wave transducer, typically with a -6 dB beam height of approximately 3.0 mm.
The remaining bevel dimension extending from the top of the hot pass to the bottom of the cap zone (outside pipe surface minus 3 mm) shall be divided equally into fill sub-zones, with the following conditions:
The fill sub-zone intimately below the cap zone shall have a -6 dB beam height equal to or less than the cap zone dimension; and
No individual -6 dB beam size shall exceed 3.5 mm.
Each sub-zone shall be inspected using one of the suitable tandem combinations specified in Table A1.

Table A1 – Tandem Configurations

Fill Bevel Angle °	Transmitter Angle °	Receiver Angle °
4	38 - 50	Transmitter Angle + 8 (46 - 58)
5	38 - 48	Transmitter Angle + 10 (48 - 58)
6	38 - 46	Transmitter Angle + 12 (50 - 58)
7	38 - 44	Transmitter Angle + 14 (52 - 58)
8	38 - 42	Transmitter Angle + 16 (54 - 58)
9	38 - 40	Transmitter Angle + 18 (56 - 58)
10	38	58

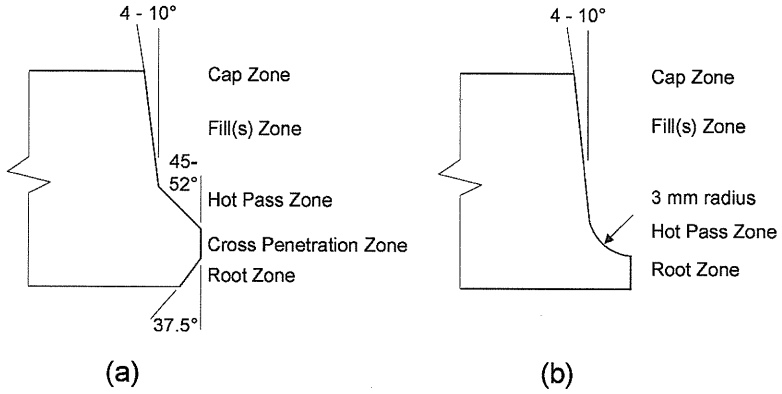
A6 POROSITY TRANSDUCERS

For the detection of porosity, the weld shall be divided into equal zones each not exceeding 3.5 mm, and examined using transducers with the following angles and frequency.

Root zone: One 72° transducer having a center frequency between 5 and 6 MHz.
All other zones: 45 to 50° transducer/s having a center frequency of 4 MHz.*

* Phased array transducers of higher centre frequency are permitted provided the -6 dB bandwidth includes a frequency of 4 MHz.

FIGURES



Figures A1: Bevel Designs
(a) Weld with Internal Root (b) Weld with all Passes Deposited Externally

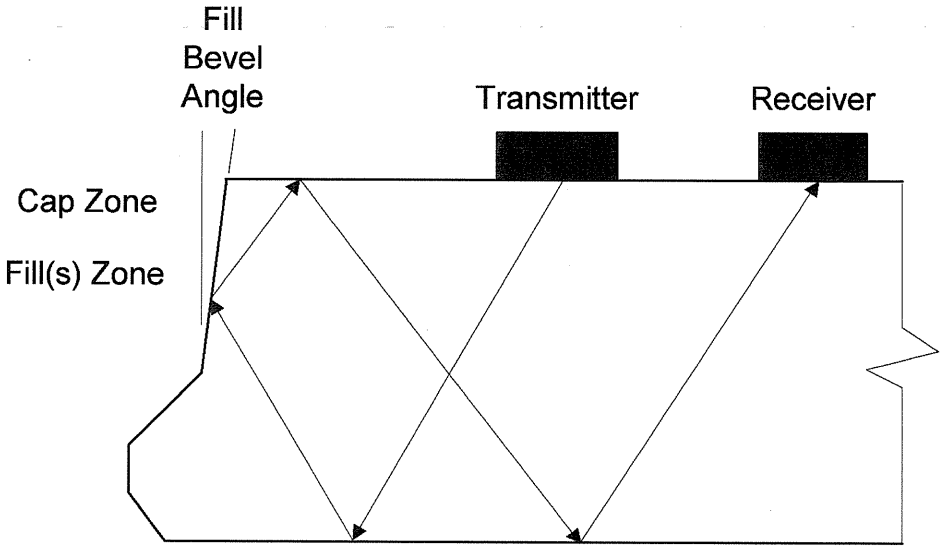


Figure A2: Typical Tandem Sound Path for W.T. < 20 mm
(Shown for a weld with an internal root pass,
same sound path for a weld with all passes deposited externally)
When mechanically achievable the sound path should as short as practical; in the example above the receiver could be in front of the transmitter.

APPENDIX B – INSPECTION DESIGN REQUIREMENTS WELDS IN FACTORY BEVEL

B1 PURPOSE

This appendix details the inspection design requirements for automated ultrasonic inspection of welds produced in the standard bevel.

B2 SCOPE

This appendix applies to mechanized ultrasonic inspection of arc welds made in pipe having a nominal wall thickness 7.2 mm and greater.

B3 APPLICABLE STANDARDS

Ultrasonic examination to this procedure shall also meet the requirements CSA Z662 and any amendment, supplement, or errata issued by CSA.

B4 APPLICABLE WELD BEVEL

This design is applicable to the standard end preparation of pipe as shown in Figure B1 of this document.

B5 ULTRASONIC PARAMETERS

Ultrasonic parameters (transducer number, angle, frequency, beam size and position) shall be selected for each zone of the specified weld bevel, beginning in the weld root and finishing at the weld cap.

B6 ROOT ZONE (0° BEVEL)

Two transducers shall be required with the following parameters:

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 8	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	1.5 skip
	60.0 ± 2.5			
> 8	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	0.5 skip
	60.0 ± 2.5			

B7 HOT PASS ZONE (30° BEVEL)

One transducer shall be required with the following parameters:

Wall thickness mm	Angle °	Frequency MHz	Beam Size mm	Surface position
≤ 8	60.0 ± 2.5	min. 4 max. 6	min. 3.0 max. 4.0	1.5 skip
> 8	60.0 ± 2.5	min. 4 max. 6	min. 3.0 max. 4.0	0.5 skip

B8 FILL(S) AND CAP ZONES

The number of transducers for the fill(s) and cap zones, and their parameters, are linked directly to the pipe wall thickness.

B8.1 Wall thickness smaller than 9 mm

Three focused 60±2.5° transducers shall be used. The –6 dB beam height selected for the cap zone shall have a dimension equal to or greater than the fill zone intimately below it.

B8.2 Wall thickness larger than 9 mm

The number (n) of sub-zones and focused 60±2.5° shear wave transducers and their -6 dB beam height shall be determined by the formula;
$n = (WT - RH) / (\cos(A)*h) = (WT - 3) / (0.866*h)$

Where, A is the bevel angle (30° for a standard bevel),
WT is the wall thickness in mm,
RH is the vertical displacement to account or the root and hot pass (assumed as 3 mm), and
h is -6 dB beam height such that:

No individual -6 dB beam size shall exceed 3 mm, and the –6 dB beam height selected for the cap zone shall have a dimension equal to or greater than the fill zone intimately below it.

B9 POROSITY TRANSDUCERS

For the detection of porosity, the weld shall be divided into equal zones each not exceeding 3.5 mm, and examined using transducers with the following angles and frequency.

Root zone: One 60 or 70° transducer having a center frequency between 5 and 6 MHz.
All other zones: 45 to 55° transducer/s having a center frequency of 4 MHz.*

* Phased array transducers of higher centre frequency are permitted provided the -6 dB bandwidth includes the frequency 4 MHz.

B10 TIME OF FLIGHT DIFFRACTION (TOFD)

For a given pipe wall thickness, the transducer angle, frequency and damping characteristics shall be selected to optimize detection and to limit the depth of the lateral wave below the surface to a maximum of 4 mm, giving consideration to the index-to-index spacing and the maximum width of the weld reinforcement.

B11 TRANSVERSE CRACK DETECTION (SEE FIGURE B2)

Two pair of 50° to 70° transducers positioned at 20° from the weld axis in a cross configuration shall be used to detect transverse cracks. The signal shall be sent from the transducer on the upstream side of the weld and received by the downstream transducer. One pair of transducers shall interrogate the upper half of the weld while the other pair interrogates the lower half. Coupling shall be monitored by sensing through-transmission diagonally across the weld.

FIGURES

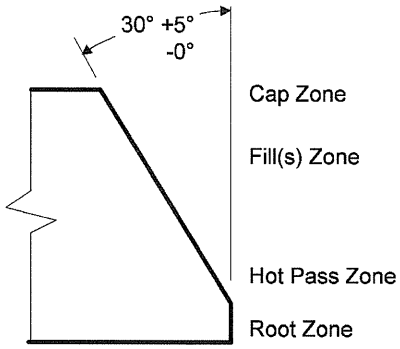


Figure B1: Standard Bevel Design

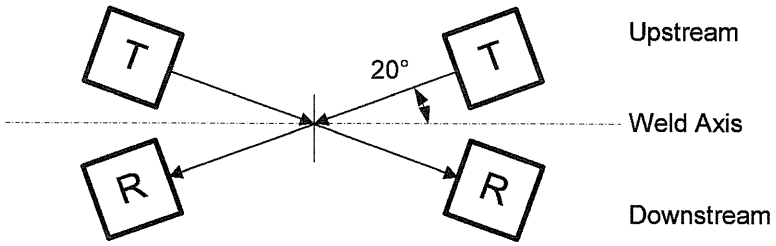


Figure B2: Sound Paths for Transverse Crack Detection

APPENDIX C – SPECIFICATION FOR MANUAL ULTRASONIC INSPECTION OF PIPELINE WELDS

C1 SCOPE

This Specification establishes the requirements for manual ultrasonic examination of pipeline GMAW weld repair verifications, mainline SMAW repair girth welds and welds in test heads. The referenced clauses in this appendix are from the main body of the Ultrasonic Specification.

C2 PERSONNEL

Personnel performing manual ultrasonic inspection shall be certified to Level II in the "Ultrasonic" method in accordance with Canadian General Standards Board, CAN/CGSB 48.9712 "Qualification and Certification of Nondestructive Testing Personnel", and shall submit their records of certification. Personnel must have an additional 16 hours of in-house training on manual inspection of pipeline girth welds. Personnel must demonstrate proficiency in calibrating the portable A-scan instrument on the sensitivity calibration blocks with the selection of transducers to be used to inspect the different zones. Personnel must demonstrate proficiency in setting and interpreting both the amplitude scale and the time gates to determine the location within the weld of received indications. Personnel must demonstrate proficiency to recognize linear versus volumetric echo dynamic pattern recognition and differentiate between geometry and actual weld anomalies. This training shall be documented and accompanied by an in-house certifying exam.

The Company reserves the right to approve operators as described by Clause 6.3.3. Manual ultrasonic operators shall be required to take the manual qualification test only.

C3 PROCEDURES

A procedure, specific techniques and instructions for each thickness and variation shall be prepared (see Clauses 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.6 of this Specification). The procedure shall meet the requirements of CSA Z662.

C4 EQUIPMENT

C4.1 Ultrasonic equipment shall meet the requirements of ASME Section V, Article 4.

C4.2 Instrument A-scan presentation shall meet the requirements of ASME Section V, Article 4.

C4.3 Instrument linearity shall meet requirements of Clause 6.6.1 of this Specification.

C4.4 Ultrasonic transducers shall meet the requirements of Clause 6.6.5 of this Specification.

C4.5 Sensitivity calibration blocks shall meet the requirements of CSA Z662

C4.6 Reference blocks for angle beam distance calibration shall meet the requirements of ASTM E164 Appendix 1.

C4.7 Coupling shall be a water-based product. Water or gel (provide MSDS sheet) may be used but shall be completely removed upon completion of the test.

C5 CALIBRATION

C5.1 Calibration shall meet the requirements of Clause 7 of this Specification, except that individual transducers shall be set up according to the parameters used by the automatic ultrasonic unit. The "standoff distances" shall be noted if different from the technique detail. Transfer value shall be checked and documented for each weld.

C5.2 GMAW setup shall mimic automated ultrasonic system sensitivities when verifying all GMAW indications and ensuring all GMAW defects have been removed in designated repair areas. The SMAW manual ultrasonic setup sensitivities shall be set using the 2.4 mm side drilled hole.

C6 SCANNING

C6.1 The repaired area shall be scanned ± 50 mm either side of the repaired area. Tested areas shall be marked to indicate acceptance or rejection status.

C6.2 The repairs scans and verifications shall be raster or fixed scans (i.e., the standoff distance for the transducer and zone shall be determined and the transducer shall then be set at this distance). For fixed position scans a magnetic strip shall be used to keep the transducer at the set distance for the length of repair. The transducer shall be moved continuously along the area of interest. The transducer may be adjusted back and forth slightly to maximize the signal. The adjacent zones shall be examined in the same way.

C6.3 The transducers used shall be the same transducer specification as the original mechanized test (i.e., transducer beam angle shall be ±1.5 degrees for angles less than 45 degrees or ± 2.0 degrees for angles greater than 45 degrees, transducer frequency, focus, crystal size and configuration).

C6.4 Where volumetric scanning of a repair weld is required, focused transducers shall not be used. The test shall be conducted with a minimum of two (2) different angles to a procedure based on ASME Section V, Article 4 and acceptable to the Company.

C6.5 Ensure that the scan raster provides for a minimum 30 percent overlap of the beam width.

C7 RECORDING

C7.1 All indications above 40% of DAC or zonal designated threshold shall be recorded.

C7.2 All interpreted indications shall be recorded on the report sheet.

C7.3 The acceptance criteria for GMAW/ SMAW repair areas performed by manual ultrasonic shall be defined by CSA Z662 workmanship criteria.

C7.4 Recordable indications and defects shall be noted numerically and diagrammatically on the report. Reports shall be pre-approved prior to fieldwork.

C8 REPORTING

C8.1 The report shall include as a minimum:

a) Operator Name and Date of Test
b) Technique number or unique ID
c) Zone(s) examined
d) Thickness
e) Gate start and length
f) Repair or verification or other detail
g) Position(s) & length(s)
h) Coupling used (and removed)
i) Transducer(s) used (type, size, frequency) and standoff & gain setting
j) Unique number of calibration (sensitivity) block used
k) Defect/Discontinuity description, depth, location, size length, zone, and amplitude
l) UT instrument serial number

C8.2 All welds tested shall be reported on a separate report sheet(s) approved by the Company. The reports shall be handed to the Contractor NDE Supervisor on a daily basis to meet the requirements of Clause 15.1. The Contractor NDE Supervisor shall verify the areas scanned against the interpretations made by both automatic ultrasonic inspection and manual ultrasonic inspection. The Contractor NDE Supervisor shall then endorse the report. The Contractor NDE Supervisor shall record and store them for review and transmittal to the Company. Reports shall be kept current and up to date with the weld repair production.