Echo NDE Procedure: UT-9 – Phased Array Ultrasonic Examination of Butt Welds

1.0 Scope

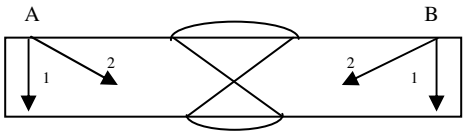
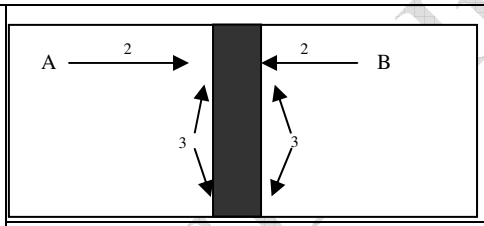
1.1 This procedure describes the method for ultrasonically inspecting welds utilizing phased array instruments and equipment.

1.2 ASME Code Section V makes specific considerations for computerised imaging techniques (CITs). Within the CITs category, the suitability of phased array techniques and automated data acquisition techniques are described. These provisions are incorporated into this procedure and the special adaptations unique to their implementation are described in this procedure and the associated Standard Practices referenced by this Procedure. Qualification of this procedure and associated Standard Practices and techniques is unique to the OmniScan phased array instrument. This procedure is not valid with any other instrument.

2.0 Procedure

2.1 Table 9.1 through to 9.5 summarize the procedure requirements.

1. Table UT-9.1 – (UT 9A) – Phased Array Ultrasonic Examination of Buttwelds (NPS 20 or greater)
2. Table UT-9.2 – (UT-9B) – Phased Array Ultrasonic Examination of Buttwelds (NPS 2 to 18 pipe)
3. Table UT-9.3 – (UT-9C) – Phased Array Ultrasonic Examination of Category ‘D’ Nozzles
4. Table UT-9.4 – (UT-9D) – Phased Array Ultrasonic Examination of Lap Welds
5. Table UT-9.5 – (UT-9E) – Phased Array Ultrasonic Examination of ‘T’ Joints

TABLE – UT-9.1 – Phased Array Ultrasonic Examination of Butt Welds							
Specific Procedure:	**UT-9A**		**Description**		**Butt Welds**		
Product Form	Single or Double Vee			**Thickness Range**	½" to 3" (12.7 to 76.2mm)		
Base metal form	Pipe NPS 20 or greater / All Plates			**Heat treatment**	Any[1]		
Material Type	Carbon & low alloy steels (ASME P-1 through P-5)						
Qualification of Personnel & performance evaluation	Any personnel performing examination to this specific procedure shall have satisfactorily performed at least one examination to this procedure; this examination may have been carried out on a production piece or on a test piece used for such qualifications. The performance shall have been verified and evaluated by the UT Level III Examiner. Such performance qualification shall be retained on file.						
Scanning Surface(s) Direction & Extent of Scans	 As a minimum, scanning shall be from surface A & B wherever access allows				 Direction of sound travel		
Surface Condition	All scanning surfaces may remain in the "as is" form but shall be free of all loose scale, paint and any other dirt or foreign material that may affect the effectiveness of the test. The ASME calibration block(s) shall have essential the same type of surface as that of the part being tested.						
Technique	Contact	**Couplant**	See below	**Method**	Manual / semi auto	**Instrument**	See below

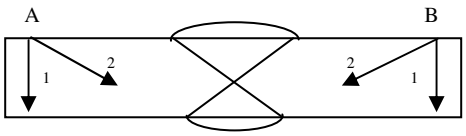
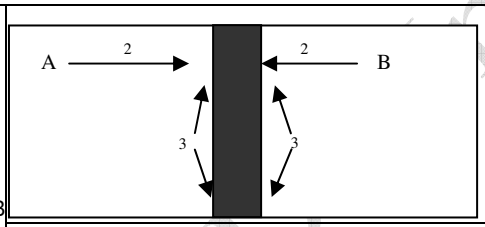
Scan #	**Angle**	**Wave**	**Probe type**	**Freq MHz**	**Size**	**Calibration Blocks & Technique**
1	0°	Long	Dual	2 ¼ – 5	¼" – ½"	Standard step wedge
OR 1	0°	Long	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
2	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
3	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block

Notes

[1]The calibration blocks shall have the same heat treatment as the part under examination.

Where angle beam testing is used, a straight beam 100% scan of the entire area over which the angle beam testing is to be conducted shall be performed to ensure no inherent defects in base metal will affect the geometry of the intended test(s).

All length sizing of indications shall be by the 6dB drop method. Sizing of vertical extent shall be with phased array linear / sectorial scans utilizing the tip diffraction method.

TABLE – UT-9.2 – Phased Array Ultrasonic Examination of Butt Welds							
Specific Procedure:	**UT-9B**		**Description**		**Butt Welds**		
Product Form	Single or Double Vee			**Thickness Range**	1/4" to 2" (6 to 51mm)		
Base metal form	NPS 2 to 18 pipe (inclusive)			**Heat treatment**	Any[1]		
Material Type	Carbon & low alloy steels (ASME P-1 through P-5)						
Qualification of Personnel & performance evaluation	Any personnel performing examination to this specific procedure shall have satisfactorily performed at least one examination to this procedure; this examination may have been carried out on a production piece or on a test piece used for such qualifications. The performance shall have been verified and evaluated by the UT Level III Examiner. Such performance qualification shall be retained on file.						
Scanning Surface(s) Direction & Extent of Scans	 As a minimum, scanning shall be from surface A & B wherever access allows			 Direction of sound travel			
Surface Condition	All scanning surfaces may remain in the "as is" form but shall be free of all loose scale, paint and any other dirt or foreign material that may affect the effectiveness of the test. The ASME calibration block(s) shall have essential the same type of surface as that of the part being tested.						
Technique	Contact	**Couplant**	See below	**Method**	Manual / semi auto	**Instrument**	See below

Scan #	**Angle**	**Wave**	**Probe type**	**Freq MHz**	**Size**	**Calibration Blocks & Technique**
1	0°	Long	Dual	2 ¼ – 5	¼" – ½"	Standard step wedge
OR 1	0°	Long	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
2	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
3	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block

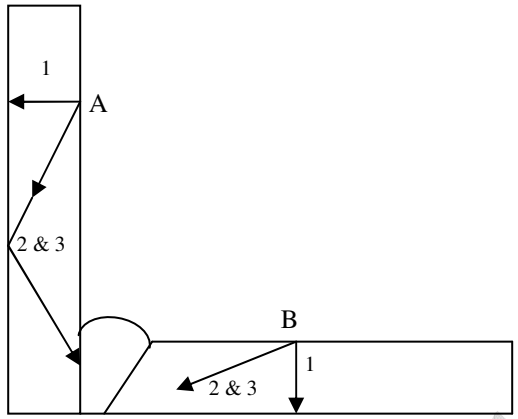
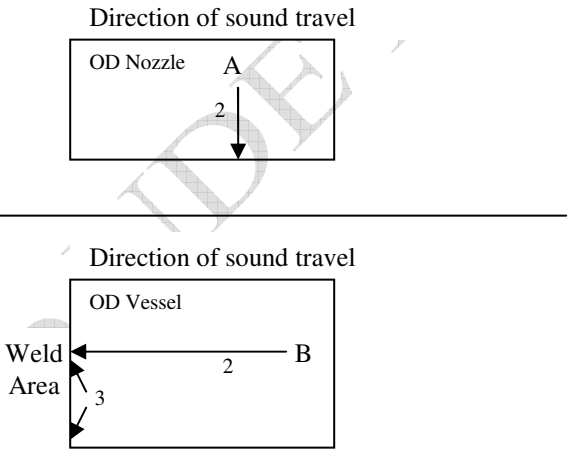
Notes

[1]The calibration blocks shall have the same heat treatment as the part under examination.

Where angle beam testing is used, a straight beam 100% scan of the entire area over which the angle beam testing is to be conducted shall be performed to ensure no inherent defects in base metal will affect the geometry of the intended test(s).

All length sizing of indications shall be by the 6dB drop method. Sizing of vertical extent shall be with phased array linear / sectorial scans utilizing the tip diffraction method.

TABLE – UT-9.3 – Phased Array Ultrasonic Examination of Category 'D' Nozzles

Specific Procedure:	**UT-9C**	**Description**		**Category D Nozzles**	
Product Form	Single Vee		**Thickness Range**	1/4" to 2" (6 to 51mm)	
Base metal form	NPS 20 or greater		**Heat treatment**	Any[1]	
Material Type	Carbon & low alloy steels (ASME P-1 through P-5)				
Qualification of Personnel & performance evaluation	Any personnel performing examination to this specific procedure shall have satisfactorily performed at least one examination to this procedure; this examination may have been carried out on a production piece or on a test piece used for such qualifications. The performance shall have been verified and evaluated by the UT Level III Examiner. Such performance qualification shall be retained on file.				
Scanning Surface(s) Direction & Extent of Scans	 As a minimum, scanning shall be from surface A & B.				
Surface Condition	All scanning surfaces may remain in the "as is" form but shall be free of all loose scale, paint and any other dirt or foreign material that may affect the effectiveness of the test. The ASME calibration block(s) shall have essential the same type of surface as that of the part being tested.				

Technique	Contact	**Couplant**	See below	**Method**	Manual / semi auto	**Instrument**	See below

Scan #	**Angle**	**Wave**	**Probe type**	**Freq MHz**	**Size**	**Calibration Blocks & Technique**
1	0°	Long	Dual	2 ¼ – 5	¼" – ½"	Standard step wedge
OR 1	0°	Long	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
2	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
3	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block

Notes

[1]The calibration blocks shall have the same heat treatment as the part under examination.

Where angle beam testing is used, a straight beam 100% scan of the entire area over which the angle beam testing is to be conducted shall be performed to ensure no inherent defects in base metal will affect the geometry of the intended test(s).

All length sizing of indications shall be by the 6dB drop method. Sizing of vertical extent shall be with phased array linear / sectorial scans utilizing the tip diffraction method.

TABLE – UT-9.4 – Phased Array Ultrasonic Examination of Lap Welds

Specific Procedure:	**UT-9D**	**Description**	**Lap Welds**

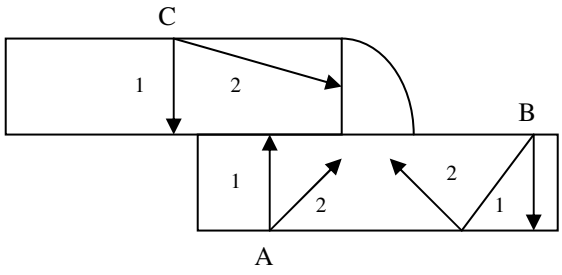
PHASED ARRAY ULTRASONIC EXAMINATION PROCEDURES

REVISION: 1

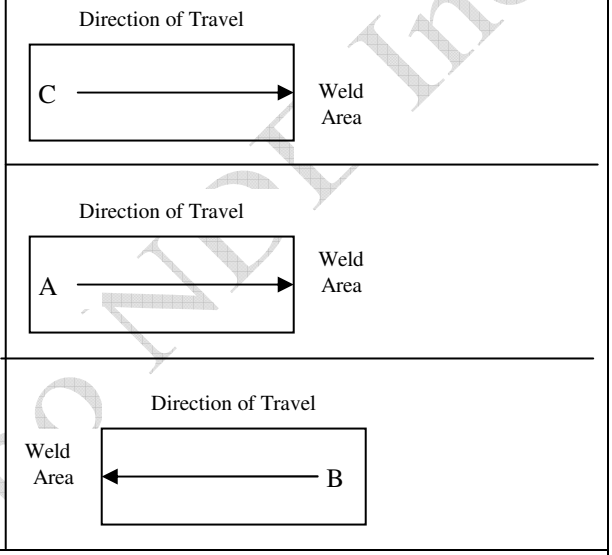
DATE: 2008.12.05

Product Form	Fillet Welds	**Thickness Range**	1/4" to 2" (6 to 51mm)
Base metal form	NPS 20 or greater and plate material	**Heat treatment**	Any[1]
Material Type	Carbon & low alloy steels (ASME P-1 through P-5)		
Qualification of Personnel & performance evaluation	Any personnel performing examination to this specific procedure shall have satisfactorily performed at least one examination to this procedure; this examination may have been carried out on a production piece or on a test piece used for such qualifications. The performance shall have been verified and evaluated by the UT Level lll Examiner. Such performance qualification shall be retained on file.		

Scanning Surface(s) Direction & Extent of Scans



As a minimum, scanning shall be from surface B & C. Whenever access allows, scanning from surface A shall also be performed.



Surface Condition	All scanning surfaces may remain in the "as is" form but shall be free of all loose scale, paint and any other dirt or foreign material that may affect the effectiveness of the test. The ASME calibration block(s) shall have essential the same type of surface as that of the part being tested.

Technique	Contact	**Couplant**	See below	**Method**	Manual / semi auto	**Instrument**	See below

Scan #	**Angle**	**Wave**	**Probe type**	**Freq MHz**	**Size**	**Calibration Blocks & Technique**
1	0°	Long	Dual	2 ¼ – 5	¼" – ½"	Standard step wedge
OR 1	0°	Long	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
2	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block

Notes

[1]The calibration blocks shall have the same heat treatment as the part under examination.

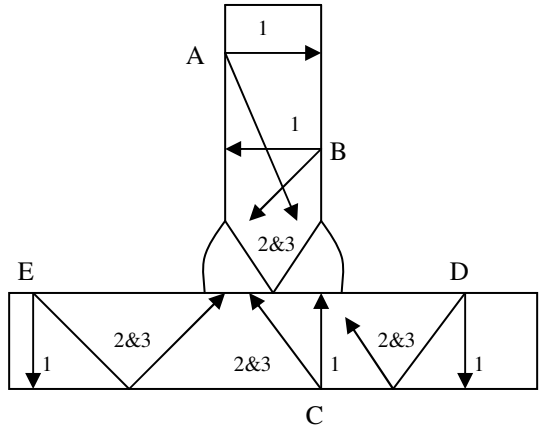
Where angle beam testing is used, a straight beam 100% scan of the entire area over which the angle beam testing is to be conducted shall be performed to ensure no inherent defects in base metal will affect the geometry of the intended test(s).

All length sizing of indications shall be by the 6dB drop method. Sizing of vertical extent shall be with phased array linear / sectorial scans utilizing the tip diffraction method.

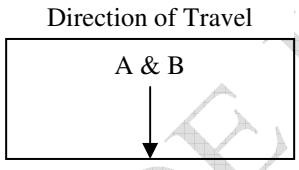
TABLE – UT-9.5 – Phased Array Ultrasonic Examination of 'T' Joints			
Specific Procedure:	**UT-9E**	**Description**	**Lap Welds**
Product Form	Single or Double Vee	**Thickness Range**	1/4" to 2" (6 to

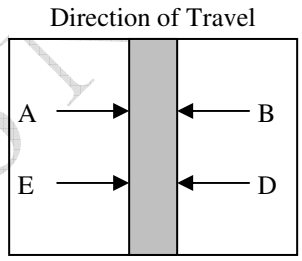
			51mm)
Base metal form	NPS 20 or greater and all plates	**Heat treatment**	Any[1]
Material Type	Carbon & low alloy steels (ASME P-1 through P-5)		
Qualification of Personnel & performance evaluation	Any personnel performing examination to this specific procedure shall have satisfactorily performed at least one examination to this procedure; this examination may have been carried out on a production piece or on a test piece used for such qualifications. The performance shall have been verified and evaluated by the UT Level lll Examiner. Such performance qualification shall be retained on file.		

Scanning Surface(s) Direction & Extent of Scans



As a minimum, scanning shall be from surface A & B. Whenever access allows, scanning from surfaces C, D & E shall be performed.





Surface Condition	All scanning surfaces may remain in the "as is" form but shall be free of all loose scale, paint and any other dirt or foreign material that may affect the effectiveness of the test. The ASME calibration block(s) shall have essential the same type of surface as that of the part being tested.

Technique	Contact	**Couplant**	See below	**Method**	Manual / semi auto	**Instrument**	See below

Scan #	**Angle**	**Wave**	**Probe type**	**Freq MHz**	**Size**	**Calibration Blocks & Technique**
1	0°	Long	Dual	2 ¼ – 5	¼" – ½"	Standard step wedge
OR 1	0°	Long	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block
2	35° to 70°	Shear	Phased Array	2 – 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block

Notes

[1]The calibration blocks shall have the same heat treatment as the part under examination.

Where angle beam testing is used, a straight beam 100% scan of the entire area over which the angle beam testing is to be conducted shall be performed to ensure no inherent defects in base metal will affect the geometry of the intended test(s).

All length sizing of indications shall be by the 6dB drop method. Sizing of vertical extent shall be with phased array linear / sectorial scans utilizing the tip diffraction method.

3.0 Applicable Codes, Standards and References

3.1 This procedure is applicable to the following:

1. ASME V Article 4

2. ASME V Article 5
3. ASME VIII
4. ASME CODE CASE 2235-9
5. B31.3
6. B31 3 Code Case 181
7. B31.1
8. CSA Z662
9. AWS D1.1
10. CSA W59

4.0 Personnel Qualifications

4.1 Technicians completing this procedure must meet the requirements of Part A - Section 2.0 of this procedure and our *Written Practices for the Qualification of NDE Examiners*. Personnel performing this technique must have participated in a procedure demonstration on qualification blocks that meet the requirements of ASME code case 2235-9 and B31.3 code case 181.

5.0 Calibration Blocks

5.1 Standard calibration blocks used by Echo NDE Inc. are:

1. IIW Resolution Block
2. DSC Angle Beam Calibration Block
3. ASME Basic Calibration Blocks (piping and non-piping)
4. Standard thickness calibration block (step wedge)
5. Specialty blocks as required by the client or governing specification.
6. Qualification blocks as per code case 2235-9 and B31.3 code case 181 for demonstration and training

5.2 Calibration block requirements

1. For plate & piping in excess of NPS 20 a basic calibration block may be used.
2. For piping < NPS 20 a block of essentially similar diameter (0.9 to 1.5 ratio) shall be used.
3. Blocks shall be of the same product form, material type and heat treatment as the part under examination.
4. For carbon steel and low alloy steel (ASME P1 through P5) shall be considered as the same basic material.
5. The blocks shall be designed and meet the requirements of T434.2 & T434.3 of ASME Section V Article 4.
6. Blocks shall meet the quality requirements of T-434.1.3 prior to fabrication.
7. Different configurations may be required to reflect various geometries such as Category ‘D’ nozzles and these shall be identified in the specific procedures.
8. Calibration block surface finish shall be representative of the test part to be examined.

6.0 Equipment

6.1 Ultrasonic Test Instruments

6.1.1 This procedure will use the OmniScan phased array ultrasonic inspection unit exclusively. The ultrasonic flaw detection instrument shall be used in the pulse echo or pitch-catch mode with an A-Scan presentation used for calibration. The instrument is equipped with a stepped gain control calibrated in units of 1dB or less. The equipment is capable of amplitude control over its useful range and time corrected gain (TCG)

will be used in lieu of a simple Distance Amplitude Correction curve (DAC curve). The reject control shall be in the "off" position for all examinations

6.2 Search Units

6.2.1 Search units used for weld examinations shall operate at a frequency between 2 MHz and 10 MHz. Either phased array or single element probes may be used.

6.2.2 Single element probes shall have element dimensions between 6mm and 25mm.

6.2.3 Phased array linear array configurations shall have 12 elements or more having element width of 6mm to 15mm. Element spacing will be search unit design specific and based on the calculations for element pitch to provide beam steering of +/- 20°. Angles used will range from 35° to 70°.

6.2.4 For typical shear wave applications the phased array probe will be placed on a refracting wedge of suitable material and refracting angle as to be compatible with the requirement to provide beam steering of +/- 20°.

6.2.5 In addition to phased array search units, pulse-echo single element or dual element probes may be used where geometry or resolution or other factors dictate that there is advantage to do so, such as for thickness assessments, transverse scanning and TOFD techniques.

6.3 IIW Calibration Block is used to perform the required calibration.

6.4 ASME basic calibration block of the appropriate size and/or diameter or any other sensitivity calibration block allowed by the governing specification or by the client.

6.5 Couplant

6.5.1 If the couplant is not specified by the referencing code, standard or customer specification, the following shall be used as a guide in couplant selection:

1. The couplant, usually a liquid or semi-liquid is required between the face of the search unit and the examination surface to permit the transmission of ultrasonic waves from the search unit into the material under examination.

2. Typical couplants include, but are not limited to, glycerin, water, cellulose gel, oil, water-soluble oils and grease. Corrosion inhibitors or wetting agents, or both, may be used. Selected couplants shall not be detrimental to the material under examination.

3. The couplant used for calibration shall also be used for the examination.

4. The calibration and examination surface temperatures shall be within 62°F (14°C) of each other to avoid large attenuation and velocity differences in the wedge material.

5. The viscosity of the selected couplant shall be appropriate for the surface finish of the material under examination.

6. At elevated temperatures, above 125 °F (52 °C), heat resistant coupling materials such as silicone oils or greases shall be used.

7. Intermittent contact of the search unit with the surface or auxiliary cooling of the search unit may be necessary to avoid temperature changes that affect the ultrasonic wave transmission properties of the wedge materials or the characteristics of the transducer.

8. At higher temperatures, couplants based on inorganic salts or thermoplastic organic materials, high temperature wedge materials, and transducers that are not damaged by high temperatures shall be used.

9. For nickel base alloys, contaminants of the couplant must not exceed 100 ppm of sulfur; for nickel alloys or titanium and the maximum halide (especially chlorides) content of the couplant cannot exceed 100 ppm for austenitic stainless steels. Certification from the couplant supplier shall be required for these couplants and these certificates shall be kept on record.

6.6 A compatible transducer cable that is free of damage or evidence of deterioration is used to complete the examination.

7.0 Calibration

7.1 Instrument Linearity Checks

7.1.1 All instruments are subject to the following linearity checks before use. Details of the steps involved in the set-up of equipment for calibration can be found in the Standard Guide for Use of OmniScan.

Instrument Linearity Checks are conducted:
1. on initial receipt of equipment
2. at the commencement of an inspection campaign
3. on a twelve month cycle for digital instruments
4. after any electronic repair or physical damage
5. or for any other reason deemed appropriate at intervals less than 12 months

7.1.2 Screen Height Linearity

7.1.2.1 The Omni-scan instrument shall provide vertical amplitude presentation linear to within +/- 3% of full screen height over the range 10% to 100% of full screen height. The method for evaluating screen height linearity is outlined in Standard Practice for Verification of OmniScan Linearity Performance Omni_P2_EchoNDE and as per Mandatory Appendix I.

7.1.3 Amplitude Control Linearity (Calibrated Gain Control)

7.1.3.1 The accuracy of amplitude control on the Omni-scan instrument is verified. The method for evaluating amplitude control linearity is outlined in Standard Practice for Verification of OmniScan Linearity Performance Omni_P2_EchoNDE and as per Mandatory Appendix II.

7.1.4 Sweep Range Linearity (Horizontal Linearity)

7.1.4.1 The ultrasonic instrument must provide sweep range linearity accurate to +/-2% of the total base line. The method for evaluating sweep range linearity is outlined in Standard Practice for Verification of OmniScan Linearity Performance Omni_P2_EchoNDE.

7.2 Search Unit Checks

7.2.1 Because the Omni-scan ultrasonic instrument is a phased array instrument many of the parameters associated with standard single element probes such as exit point and nominal angle do not apply. As well, probes using curved wedges to fit the diameter of pipes, and components will not permit measurements of nominal angle and exit points using the standard calibration blocks (IIW and DIN-54) as they cannot be used on flat surfaces.

7.2.2 Standard Practice for Verification of Performance of Probes used with OmniScan Omni_P3_EchoNDE will be used as appropriate to assess the suitability of the probe and focal laws applied to phased array probes. Guidance for Probe Performance is also found in this Standard Practice for assessment of single element probes when used with the OmniScan phased array ultrasonic instrument.

Search unit Checks are conducted:
1. on initial receipt of equipment
2. at the commencement of an inspection campaign
3. on a one month cycle
4. after any electronic repair or physical damage
5. or for any other reason deemed appropriate at intervals less than 1 month

8.0 Calibration - Weld Examination

8.1 Range and Signal Amplitude (TCG) Calibration

8.1.1 The OmniScan instrument is calibrated for each examination specified on the detailed technique for both range and signal amplitude. Calibrations shall be performed utilizing the calibration block shown in Fig. T-434.2.1

8.1.2 Range setting for both shear and longitudinal wave examination is detailed in Standard Practice for Setting Range using OmniScan Omni_P4_EchoNDE.

8.1.3 Time Corrected Gain is applied as detailed in Standard Practice for Distance Amplitude Correction using OmniScan Omni_P5_EchoNDE.

8.2 Calibration Confirmation

8.2.1 A system calibration confirmation shall be used to verify the sweep range calibration and TCG at the start and finish of each examination and at a minimum of once each day during an examination session using the appropriate calibration block.

8.2.2 Any change in search units, shoes, couplants, cables, ultrasonic instruments, personnel or other parts of the examination system is cause for a calibration check.

8.2.3 Calibration checks are performed as follows:

1) The sensitivity control settings are adjusted to match those recorded for the calibrated reference sensitivity of the middle focal law of a single angle Phased Array scanning technique or the single element probe for non-phased array probe applications. (reference sensitivity is 80% FSH from calibration block side drilled holes)

2) The search unit is positioned to detect the first and last points on the TCG using the reference reflectors on the appropriate basic calibration block. The maximum signal response amplitudes and horizontal sweep positions are observed.

3) If either point along the timebase using the TCG has decreased by greater than 2 dB in amplitude, all recorded data sheets since the last calibration check are marked void. A new calibration is made and recorded and the voided examination areas re-examined.

4) If any point along the timebase using the TCG has increased by greater than 2 dB in amplitude, only recorded indications taken since the last valid calibration check need be re-examined with the correct calibration and their values changed on the data sheets or files rescanned.

5) If during system confirmation of calibration, any point on the timebase has moved on the sweep line more than 5% of the total base line, correct the sweep range calibration. If recordable reflectors are noted on the data sheets, these data sheets are voided, a new calibration is recorded and the voided examination is repeated.

8.3 Transfer Values

8.3.1 Loss of sound transmission due to surface geometry, or surface condition (roughness or coatings), can be compensated using a transfer value. Transfer value shall be determined using Standard Practice for Determining Acoustic Compatibility using OmniScan Standard Practice Omni_P6_EchoNDE.

8.3.2 Calibrations shall be performed from the surface corresponding to the test part surface to be inspected as per T-462.2.

9.0 Probe Wedge Contouring

9.1 For weld examination on curved test surfaces with diameters less than 500mm (20”) and wedge widths less than 30mm, the wedges shall be contoured to a curvature adapted to the test surface.

9.2 Curvature of the wedge shall be greater than or equal to the test surface curvature such that the average gap between the outer edge of the wedge and the surface of the test part does not exceed 0.5mm. Details of the technique used to determine curvatures allowed and the range of curvatures that may be examined with a single wedge curvature are found in OmniScan Standard Practice Omni_P11_EchoNDE. The same contact wedges used during calibration shall be used for examination.

10.0 Temperature Control

10.1 For contact examination, the temperature differential between the calibration block and the examination surface shall be within +/-10C° (ASME Code states 25F or 14C but at 70 the deviation of beam is potentially more than 2°)

11.0 Instrument Controls

11.1 Any controls affecting the linearity of the instrument shall be in the same position for calibration, calibration checks, instrument linearity checks and examinations. The Reject control should remain off.

12.0 Surface Preparation

12.1 The finished contact surfaces shall be free from weld spatter, dirt, rust, loose scale, loose paint or any other roughness that could interfere with free movement of the transducer or impair the transmission of ultrasonic vibrations.

12.2 If needed, surfaces shall be ground, sanded, wire brushed, scraped or otherwise prepared for examining purposes.

12.3 The surface of the calibration block shall be similar to the surface of the item being inspected. If the surfaces do not coincide, a transfer mechanism may be used to correct for the difference.

13.0 Weld Marking and Inspection Area Location

13.1 Numbers allocated to welds being examined shall designate inspection areas.

13.2 Each weld designated for inspection shall be marked with a reference index and/or position numbers marked on the examination surface during initial examination. This will include a method for identifying the location of the weld centreline. If welds are to be permanently marked, low stress stamps or vibra-tools may be used such that the marks are not deeper than 1.2mm.

13.3 Unless specifically noted otherwise, all circumferential measurement will be made clockwise from the zero reference position on the weld when looking in the direction of product flow. When scans are made from a pipe to a flange or fitting where no scan access is had on the flange or fitting, the circumferential measurement will be made clockwise when looking at the flange or fitting from the pipe side.

13.4 All welds examined shall have the designated numbers and locations and associated collected inspection data recorded on the final report.

14.0 Encoding

14.1 Automated scanning shall use position encoders that are verified to provide position accuracy of scans within +/-1mm in 100mm of scan length.

14.2 All encoders shall be verified daily to be correctly calibrated.

14.3 All encoded distances recorded by the data acquisition system shall be accurate to within 2mm over 100mm of actual travel. Encoders failing to maintain this tolerance shall be re-calibrated.

15.0 Motion Control

15.1 Probe motion may be facilitated using motorised probe holders and automated coupling feed systems or motion may be facilitated by manually moving the probe at a fixed standoff. Standoff from the weld centre reference line is best facilitated using a magnetic guide strip when probe movement is made using manual control.

15.2 If manual raster examination is used, the requirements of Art. 4, Mandatory Appendix IV shall be met.

16.0 Examination Criteria

16.1 Weld Examination - General Description

16.1.1 Each weld configuration has its own individual technique or scan plan that describes in detail the type and extent of the examination. The scan plan shall show transducer placement, movement, and component coverage providing a standardized and repeatable methodology for weld acceptance. The scan plan shall also include ultrasonic beam angles used, beam directions with respect to weld centerline, and vessel volume examined for each weld. The documentation shall be made available to the Owner/User upon request. Techniques will be described using the format detailed in Standard Practice for Technique Layout and OmniScan parameters Omni_P9_EchoNDE. Only OmniScan Techniques that have been approved or, where required, qualified in accordance with Standard Practice for qualification of an OmniScan Technique Omni_P10_EchoNDE, shall be used with this Procedure.

16.2 Inspection Area

16.2.1 Each inspection area is identified with a unique "weld" number. The width of the inspection area extends beyond the point of maximum width of the final weld preparation for a minimum distance of the material thickness or 25 mm, which ever is less.

16.2.2 The base material on either side of the inspection area of pipe welds need not be examined for laminations that would interfere with shear wave examination if these materials have been inspected for laminar inclusions at some previous stage in fabrication.

16.3 Inspection Scan Types

16.3.1 When required, automated weld inspection for laminar flaws is carried out using a phased array linear raster scan using focal laws providing a 0° beam in the inspection volume when possible. A standard UT 0° probe may also be used. Restrictions due to geometries of surroundings shall be reported.

16.3.2 Axial Scan

16.3.2.1 Automated weld inspection for axial flaws is carried out using a phased array linear raster or sectorial scan using focal laws providing angled beam examination of the inspection volume. Restrictions due to geometries of surroundings shall be reported. Where possible, the weld is scanned from both sides of the same surface.

16.3.2.2 The speed of scanning is such as to ensure that coupling is maintained. Maximum allowable scanning speed is 6 inches/second.

16.3.3 Parallel or Transverse Scan

16.3.3.1 When required by the referencing Code Section and when access is not restricted, manual or automated transverse scans in two directions either side of the weld cap will also be carried out. Restrictions due to geometries of surroundings shall be reported.

16.3.3.2 Scanning is done in two directions essentially 180° to each other. Swivelling of the probe is not possible when using shaped wedges. For curved surfaces less than 500mm diameter (20 inch), the curvature will prevent proper contact and shall be considered a scanning restriction.

16.3.3.3 Probe motion may be made manually. The speed of scanning is such as to ensure that coupling is maintained. Maximum scanning speed shall not exceed 6 inches/second. Due to weld cap configurations the surface of the weld may not be a suitable scan surface. When the weld cap is not a suitable scan surface the probe will need to be positioned close to the weld cap edge and the beam directed towards the weld centreline (i.e. “essentially” parallel to the weld axis) where curvature permits. Manual transverse scans are not using data acquisition so only operator data entry can be made for indications noted.

16.3.4 All automated scanning shall be position encoded at data collection intervals of 1mm. No more than 5% of data points shall be missed in a weld scan with no more than 2 adjacent samples missing in a single scan. No missing data samples are allowed within an area containing a defect or suspected defect.

16.3.5 The minimum overlap between adjacent scans along the weld axis shall be 25mm.

17.0 Recording

17.1 Scanning shall be done at the Primary Reference level plus 6dB and any gain required for transfer value.

17.2 Recording and plotting – Axial Shear Scan

17.2.1 All A-scan waveforms shall be recorded using a digitisation not less than 5 times the nominal frequency of the probe.

17.2.2 Recording shall be in the form of an OmniScan data file and evaluation of the scan results shall be made using B-scan and C-scan projections with colour pallets that allow the operator to discriminate between signals above or below the evaluation threshold.

17.2.3 All recording shall be in unprocessed form. A complete data set with no gating filtering or threshold for responses from examination shall be included in the data record.

17.2.4 Relevant indications greater than or equal to -6dB reference shall be evaluated against the applicable acceptance criteria. Rejectable indications are plotted showing dimensions, location relative to the weld centre line and vertical extent when required.

17.2.5 Length shall be determined using the 6 dB drop method for signals less than 80% and for flaw signals with amplitudes greater than 80% length shall be determined to the 40% limits.

17.2.6 When vertical extent is required it shall be determined using the tip diffraction sizing technique. Vertical sizing methods are described in Standard Practice for Determining Vertical Extent with OmniScan Omni_P7_EchoNDE.

17.2.6.1 To determine throughwall depth utilizing the tip diffraction sizing technique, data collected via a rastor scan is reviewed to determine if tip diffracted signals are present / associated with defect signals. ID and OD connected indications will have a strong signal from the corner trap and a small signal from the tip (if present). Mid wall defects would have a stronger signal from the center of the defect and smaller tip signals before and after. Depths to the signals are calculated using the equation : depth = sound path x cos θ. The OMNISCAN unit calculates these depths when properly calibrated.

17.2.6.2 Depth to ID connected defects is calculated using the above mentioned equation. Through wall height of defect is wall thickness minus depth to defect.

17.2.6.3 OD connected defects are from OD surface to depth of tip diffracted signal.

17.2.6.4 Internal defects (neither OD or ID connected) are sized by determining depth to both tip diffracted signals. Through wall height is calculated by subtracting depth to top of the defect from depth to defect bottom.

17.2.6.5 When backscatter tip signals are discernable and flaw vertical extent sizing required, flaw size shall be recorded on the inspection data recording sheet. Characterisation of the flaw shall include depth of the upper tip below the inspection surface, vertical extent (distance between upper and lower tips) and the encoded axial position at which the vertical extent assessment was made. Where the tip signals are not possible to discern the fact is noted and an upper limit for flaw extent is used. This shall be the ring-time equivalent distance at the maximum amplitude. For most probes used this will equate to approximately 1 wavelength; e.g. 0.6mm for 5MHz shear mode. Flaw length will be assessed using the encoded position to where the flaw amplitude has dropped to 50% of the reference amplitude.

17.3 Non-Relevant Indications

17.3.1 Signals which are determined to result from metallurgical discontinuities and/or geometrical conditions (such as weld root geometry, or weld to base metal interface) are classified as geometric reflectors. Such reflectors are not characterised as indications nor compared with allowable indication standards. They are clearly identified, located, the maximum amplitude noted, and recorded in the Inspection Record for future reference with any other characteristics specified by the referencing Code section. A plot of reflector coordinates and a cross-sectional sketch showing the reflector position and surface discontinuities such as root and counter bore shall be prepared.

17.3.2 The presence of geometric reflectors is confirmed either by reviewing the fabrication drawings of the weld preparation, reviewing previous inspection records, plotting reflectors on a cross sectional display of the test part or by supplemental inspection results.

17.3.3 Every "root" indication shall be carefully examined to make sure that it is not masking a relevant indication such as lack of fusion or cracking.

18.0 Acceptance Standards

18.1 Acceptance criteria are determined by the governing code, standard, specification, or by the client and is agreed upon prior to beginning the examination.

19.0 Records

19.1 The record of the ultrasonic examination shall be documented on an Echo NDE Inc. Ultrasonic Examination Report and include the following as a minimum:

The final report for each weld will include as a minimum:

1. Project name, contract details
2. Procedure and technique identification and revision

3. All equipment used (UT instrument type and sn, probes [incl. frequency], cables [type and length], wedges [angle and mode], manipulators, couplant, recording equipment, etc)
4. For phased array probes: element size and number, pitch and gap dimensions, as well as focal law parameters including angle, focal depth, and elements used
5. Calibration blocks used, and technique
6. Calibration date and data
7. Computer programme identification and version
8. Instrument gain settings, sensitivity or reference target
9. Weld joint, piping or component number or identification uniquely identifying the examined object
10. Material type, thickness, configuration
11. Surface conditions (scan surface / cal block)
12. Scan plan
13. Scan overlap (decrease only)
14. Record of rejectable indication locations or areas cleared
15. Scan image of entire length of weld/HAZ containing rejectable indications or areas cleared. All rejectable indications shall be marked on the image.
16. Areas of restricted access
17. Personnel and their qualifications
18. Date and Time of the examination
19. Contractor job number (or P.O. number is applicable)
20. Personnel performance requirements (if required)
21. Record of any repaired areas as well as correlation to re-examination of the required areas

Additional inspection results (if any) are also reported and alternate methods of inspection described.

19.2 All records of ultrasonic examination shall be completed by Echo NDE Inc. personnel and submitted to the customer's authorized representative.

19.3 Copies of certification records for the Level I, Level II or Level III ultrasonic examiner shall be maintained in Echo NDE Inc.'s personnel files and a copy shall be submitted to the customer or designated representative

20.0 Approval

20.1 *NDE Procedure: UT-9,* Revision: 0, Dated: 2008.12.05 is approved

Level III Examiner

REVISION LOG

Revision Date	Authority	Reviser	Revision Details
2009.02.24	Level III Examiner	Darryl Coleman	First Issue

Echo NDE Procedure: UT-10 – Phased Array Ultrasonic ID Creep Wave Examination of Butt Welds

1.0 Scope

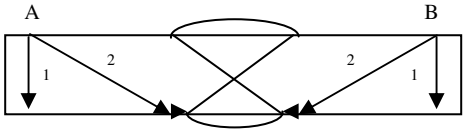
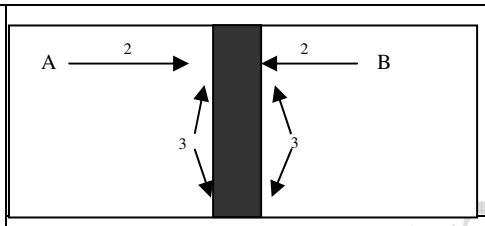
1.1 This procedure describes the method for ultrasonically inspecting butt welds utilizing the ID creepwave technique with phased array instruments and equipment. This procedure is to be used for the detection of ID connected indications focusing on the weld ID toe / root area and ID surface heat affected zone.

1.2 ASME Code Section V makes specific considerations for computerised imaging techniques (CITs). Within the CITs category, the suitability of phased array techniques and automated data acquisition techniques are described. These provisions are incorporated into this procedure and the special adaptations unique to their implementation are described in this procedure and the associated Standard Practices referenced by this Procedure. Qualification of this procedure and associated Standard Practices and techniques is unique to the OmniScan phased array instrument. This procedure is not valid with any other instrument.

2.0 Procedure

2.1 Table 10.1 summarizes the procedure requirements.

TABLE – UT-10.1 – Phased Array Ultrasonic ID Creep Wave Examination of Butt Welds					
Specific Procedure:	**UT-10**		**Description**	**ID Creep Wave-Butt Welds**	
Product Form	Single or Double Vee		**Thickness Range**	½" to 2" (12.7 to 51mm)	
Base metal form	Pipe NPS 20 or greater		**Heat treatment**	Any[1]	
Material Type	Carbon & low alloy steels (ASME P-1 through P-5)				
Qualification of Personnel &	Any personnel performing examination to this specific procedure shall have satisfactorily performed at least one examination to this procedure; this examination may have been carried out on a production piece or on				

performance evaluation	a test piece used for such qualifications. The performance shall have been verified and evaluated by the UT Level III Examiner. Such performance qualification shall be retained on file.
Scanning Surface(s) Direction & Extent of Scans	 As a minimum, scanning shall be from surface A & B wherever access allows
	 Direction of sound travel
Surface Condition	All scanning surfaces may remain in the "as is" form but shall be free of all loose scale, paint and any other dirt or foreign material that may affect the effectiveness of the test. The ASME calibration block(s) shall have essential the same type of surface as that of the part being tested.

Technique	Contact	**Couplant**	See below	**Method**	Manual / semi auto	**Instrument**	See below

Scan #	**Angle**	**Wave**	**Probe type**	**Freq MHz**	**Size**	**Calibration Blocks & Technique**
1	0°	Long	Dual	2 ¼ – 5	¼" – ½"	Standard step wedge
2	31.5°	Shear	Phased Array	2 - 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block, Creep wave cal. blocks
3	31.5°	Shear	Phased Array	2 - 10	12+ elements 6-15mm element width	IIW Block, Basic cal. block, Creep wave cal. blocks
Or 3	CDS wedge	Shear	Single	2 ¼ - 5	¼" – ½"	Basic Calibration Block, Creep wave cal. blocks

Notes
[1]The calibration blocks shall have the same heat treatment as the part under examination.
Where angle beam testing is used, a straight beam 100% scan of the entire area over which the angle beam testing is to be conducted shall be performed to ensure no inherent defects in base metal will affect the geometry of the intended test(s).
All length sizing of indications shall be by the 6dB drop method. Sizing of vertical extent shall be by traditional shearwave method or phased array linear / sectorial scans utilizing the tip diffraction method.

3.0 Applicable Codes, Standards and References

3.1 This procedure is applicable to the following:
1. ASME V Article 4
2. ASME V Article 5
3. ASME VIII

4.0 Personnel Qualifications

4.1 Technicians completing this procedure must meet the requirements of Part A - Section 2.0 of this procedure and our *Written Practices for the Qualification of NDE Examiners*.

5.0 Calibration Blocks

5.1 Standard calibration blocks used by Echo NDE Inc. are:
1. IIW Resolution Block
2. DSC Angle Beam Calibration Block
3. ASME Basic Calibration Blocks

4. Specialty blocks as required by the client or governing specification.
5. Creep Wave Calibration Blocks

5.2 Creep Wave Calibration Blocks

5.2.1 Creep Wave calibration blocks used shall be the same as or similar in thickness to that of the weld / plate being inspected. Calibration blocks shall have EDM notches across the width of the block at 20%, 40%, 60% and 80% throughwall depths. Notch spacing shall be such that the presence of one will not interfere with the detection of the next.

5.3 Calibration block requirements

1. Blocks shall be of the same product form, material type and heat treatment as the part under examination.
2. For carbon steel and low alloy steel (ASME P1 through P5) shall be considered as the same basic material.
3. Blocks shall meet the quality requirements of T-434.1.3 prior to fabrication.
4. Calibration block surface finish shall be representative of the test part to be examined.

6.0 Equipment

6.1 Zero Degree and Traditional shearwave inspection.

6.1.1 An ultrasonic flaw detector that meets the requirements of Part A - Section 4.0 of this procedure manual.

6.1.2 A transducer that meets the requirements of Part A – Section 4.0 of this procedure and can generate an accurate signal in the material. Must have an appropriate frequency, size and angle to the weld that is being inspected.

6.1.3 IIW Calibration Block is used to perform the required calibration.

6.1.4 ASME basic calibration block of the appropriate size or any other sensitivity calibration block allowed by the governing specification or by the client.

6.1.5 The couplant used must meet the requirements of Part A – Section 4.0 of this procedure and is suitable for the examination.

6.1.6 A compatible transducer cable that is free of damage or evidence of deterioration is used to complete the examination.

6.2 Phased Array Creep Wave Inspection

6.2.1 This procedure will use the OmniScan phased array ultrasonic inspection unit exclusively. The ultrasonic flaw detection instrument shall be used in the pulse echo or pitch-catch mode with an A-Scan presentation used for calibration. The instrument is equipped with a stepped gain control calibrated in units of 1dB or less. The reject control shall be in the “off” position for all examinations. The ultrasonic phased array inspection unit must meet the requirements of Part A – Section 4.0 of this procedure manual.

6.2.2 Phased Array transducers shall operate at a frequency between 2 MHz and 10 MHz. Either phased array or single element probes may be used. Single element probes shall meet the requirements of Part A – Section 4.0. Phased array linear array configurations shall have 12 elements or more having element width of 6mm to 15mm. Element spacing will be search unit design specific and based on the calculations

for element pitch to provide beam steering of +/- 20°. For typical shear wave applications the phased array probe will be placed on a refracting wedge of suitable material and refracting angle as to be compatible with the requirement to provide beam steering of +/- 20°.

6.2.3 In addition to phased array search units, pulse-echo single element or dual element probes may be used where geometry or resolution or other factors dictate that there is advantage to do so, such as for thickness assessments and transverse scanning.

6.2.4 IIW Calibration Block is used to perform the required calibration.

6.2.5 ASME basic calibration block of the appropriate size or any other sensitivity calibration block allowed by the governing specification or by the client.

6.2.6 The couplant used must meet the requirements of Part A – Section 4.0 of this procedure and is suitable for the examination.

6.2.7 A compatible transducer cable that is free of damage or evidence of deterioration is used to complete the examination.

7.0 Calibration

7.1 Zero Degree and Traditional shearwave inspection.

7.1.1 Range

7.1.1.1 The flaw detector must be calibrated to a distance that is appropriate to the weld thickness and transducer angle.

7.1.2 Sensitivity

7.1.2.1 Sensitivity is adjusted using the appropriate ASME basic calibration blocks.

7.1.2.2 The reflection from the hole giving the best response is adjusted to about 75% full screen height and marked on the screen.

7.1.2.3 Reflections from at least two other side drilled holes covering the complete range of the examination are also be marked on the screen.

7.1.2.4 These marks are be joined by a smooth line to form the distance amplitude curve.

7.1.2.5 To compensate for differences between the calibration block and the weld being inspected, a transfer value should be obtained and added to the distance amplitude curve gain level.

7.1.2.6 All indications are be evaluated against this gain level.

7.1.2.7 When scanning, at least 6 dB must be added to allow for differences in coupling.

7.1.2.8 Sensitivity calibrations shall be performed each time there is a change in the following:

1. examiner
2. instrument settings
3. pulser or pulser cable

4. change in material
5. change in ambient temperature greater than 25°F
6. at the beginning and end of each shift with no more than 4 hours between calibrations.

7.2 Phased Array Creep Wave Inspection

7.2.1 Phased Array Probe Checks

7.2.1.1 Because the Omni-scan ultrasonic instrument is a phased array instrument many of the parameters associated with standard single element probes such as exit point and nominal angle do not apply. As well, probes using curved wedges to fit the diameter of pipes, and components will not permit measurements of nominal angle and exit points using the standard calibration blocks (IIW and DIN-54) as they cannot be used on flat surfaces. Standard Practice for Verification of Performance of Probes used with OmniScan Omni_P3_EchoNDE will be used as appropriate to assess the suitability of the probe and focal laws applied to phased array probes.

7.2.1.2 Phased Array probe search unit checks are conducted:

1. on initial receipt of equipment
2. at the commencement of an inspection campaign
3. on a one month cycle
4. after any electronic repair or physical damage
5. or for any other reason deemed appropriate at intervals less than 1 month

7.3 Creep Wave Screen Calibration

7.3.1 Screen settings are set utilizing the creep wave calibration block of the same thickness as the weld to be inspected. Using the side of the block, the signal from the ID creep wave is set at the fifth screen division, and the 30-70-70 signal is set at the fourth screen division. Once this relationship has been established, the presence and detection of ID connected indications within the test weld will result in a signal appearing at the 5th screen division. If the indication is midwall in height, then a second signal should appear at the fourth screen division.

7.3.2 Gain level is set to obtain an ID creep wave signal at 80% F.S.H. This is the reference dB level. Scanning is done at 6dB above reference level.

8.0 Surface Preparation

8.1 The finished contact surfaces shall be free from weld spatter, dirt, rust, loose scale, loose paint or any other roughness that could interfere with free movement of the transducer or impair the transmission of ultrasonic vibrations.

8.2 If needed, surfaces shall be ground, sanded, wire brushed, scraped or otherwise prepared for examining purposes.

8.3 The surface of the calibration block shall be similar to the surface of the item being inspected. If the surfaces do not coincide, a transfer mechanism may be used to correct for the difference.

9.0 Weld Marking and Inspection Area Location

9.1 Numbers allocated to welds being examined shall designate inspection areas.

9.2 Each weld designated for inspection shall be marked with a reference index and/or position numbers marked on the examination surface during initial examination. This will include a method for identifying the location of the weld centreline. If welds are to be permanently marked, low stress stamps or vibra-tools may be used such that the marks are not deeper than 1.2mm.

9.3 Unless specifically noted otherwise, all circumferential measurement will be made clockwise from the zero reference position on the weld when looking in the direction of product flow. When scans are made from a pipe to a flange or fitting where no scan access is had on the flange or fitting, the circumferential measurement will be made clockwise when looking at the flange or fitting from the pipe side.

9.4 All welds examined shall have the designated numbers and locations and associated collected inspection data recorded on the final report.

10.0 Encoding

10.1 Automated scanning shall use position encoders that are verified to provide position accuracy of scans within +/-1mm in 100mm of scan length. All encoders shall be verified daily to be correctly calibrated. Moving the scanning apparatus over a fixed distance (e.g. 150mm) and comparing the start and end readings is sufficient to verify the calibration of the encoder.

10.2 All encoded distances recorded by the data acquisition system shall be accurate to within 2mm over 100mm of actual travel. Encoders failing to maintain this tolerance shall be re-calibrated.

11.0 Motion Control

11.1 Probe motion may be facilitated using motorised probe holders and automated coupling feed systems or motion may be facilitated by manually moving the probe at a fixed standoff. Standoff from the weld centre reference line is best facilitated using a magnetic guide strip when probe movement is made using manual control.

12.0 Scanning Method

12.1 Prior to any traditional or phased array shear wave examination, a zero degree scan is conducted on all parent material through which the shear wave ultrasound will be passing to locate any inclusions or laminations that may interfere with the examination.

12.2 Welds are examined from all available surfaces.

12.3 The phased array search unit is offset from the weld centreline at a distance (or as close to as possible) where the front few focal laws are directed at the ID weld edge on the same side as the probe. This ensures coverage of both the weld toe area and the heat affected zone.

12.4 Phased array creep wave scans on the weld are done using a linear scan so that the sound beam is approximately perpendicular to the longitudinal axis of the weld.

12.5 Where necessary, alternative techniques may be used to inspect for defects in difficult to inspect locations.

12.6 A manual creep wave scan must also be done with sound beam parallel to the axis of the weld to inspect for transverse defects.

12.7 Scan restrictions due to geometries of surroundings shall be reported.

12.8 All automated scanning shall be position encoded at data collection intervals of 1mm.

12.9 The minimum overlap between adjacent scans along the weld axis shall be 25mm.

12.10 All scanning shall be at a speed which ensures that coupling is maintained. At no time shall scanning exceed a maximum speed of 6 inches/second.

12.10 Defects may be evaluated using phased array creep wave for length, traditional shearwave techniques (follow procedure UT-4) or by utilizing phased array s-scans / linear scans (follow procedure UT-10). Defect sizing utilizing phased array equipment shall be done with the A-scan presentation

12.11 Defects shall be sized using standard sizing techniques.

12.12 Defects to be repaired must be marked on the weld.

13.0 Acceptance Standards

13.1 Acceptance criteria are determined by the governing code, standard, specification, or by the client and is agreed upon prior to beginning the examination.

13.2 Defect evaluation must be done with the extra scanning gain removed.

14.0 Records

14.1 The record of the ultrasonic examination shall be documented on an Echo NDE Inc. Ultrasonic Examination Report and include the following as a minimum:

The final report for each weld will include as a minimum:

1. Project name, contract details
2. Procedure and technique identification and revision
3. All equipment used (UT instrument type and sn, probes [incl. frequency], cables [type and length], wedges [angle and mode], manipulators, couplant, recording equipment, etc)
4. For phased array probes: element size and number, pitch and gap dimensions, as well as focal law parameters including angle, focal depth, and elements used
5. Calibration blocks used, and technique
6. Calibration date and data
7. Computer programme identification and version
8. Instrument gain settings, sensitivity or reference target
9. Weld joint, piping or component number or identification uniquely identifying the examined object
10. Material type, thickness, configuration
11. Surface conditions (scan surface / cal block)
12. Scan plan
13. Scan overlap (decrease only)
14. Record of rejectable indication locations or areas cleared

15. Scan image of entire length of weld/HAZ containing rejectable indications or areas cleared. All rejectable indications shall be marked on the image.
16. Areas of restricted access
17. Personnel and their qualifications
18. Date and Time of the examination
19. Contractor job number (or P.O. number is applicable)
20. Personnel performance requirements (if required)
21. Record of any repaired areas as well as correlation to re-examination of the required areas

Additional inspection results (if any) are also reported and alternate methods of inspection described.

14.2 All records of ultrasonic examination shall be completed by Echo NDE Inc. personnel and submitted to the customer's authorized representative.

14.3 Copies of certification records for the Level I, Level II or Level III ultrasonic examiner shall be maintained in Echo NDE Inc.'s personnel files and a copy shall be submitted to the customer or designated representative

15.0 Approval

15.1 *NDE Procedure: UT-10,* Revision: 0, Dated: 2008.12.05 is approved

Level III Examiner

REVISION LOG

Revision Date	Authority	Reviser	Revision Details
2009.02.24	Level III Examiner	Darryl Coleman	First Issue

PHASED ARRAY ULTRASONIC EXAMINATION PROCEDURES

REVISION: 1

DATE: 2008.12.05