



MOGAS INDUSTRIES, INC.

Nondestructive Examination Procedure: Ultrasonic Longitudinal & Shear Wave Testing



Specification: **NDT 0400**

Version: 2.0

November 10, 2014

Approved by:

Signature _____

Paul T. Marks
Consulting Level III
ACCP Professional Level III, File #8280

Signature _____

Samuel W. Furman
Certifying Authority
MOGAS Industries, Inc.

Signature _____

Imelda Hernandez
Certifying Agent
MOGAS Industries, Inc.



MOGAS Industries, Inc.
14330 East Hardy Street
Houston, Tx 77039
281-449-0291

**Nondestructive Examination Procedure:
Ultrasonic Examination
NDT – 0400**

Draft: 1.0	Date: October 25, 2012
Version: 1.0	Date: November 05, 2012
Version: 2.0	Date: November 10, 2014
Version: #	Date:
Version: #	Date:
Version: #	Date:

Company Confidential: This document contains information that is confidential and of a proprietary nature and may not be distributed or disclosed in any manner for any reason without the express written consent of MOGAS Industries, Inc.

Table of Contents

Section	Title	Page
1.0	Scope	4
2.0	References	4
3.0	Applications	4
4.0	Responsibility.....	4
5.0	Ultrasonic Equipment and Materials	4
6.0	Reference and Calibration Blocks	5
7.0	Instrument Linearity and Performance	6
8.0	Calibration.....	6
9.0	Sweep Range and DAC Curve Verification.....	7
10.0	Examination	7
11.0	Acceptance/Rejection Criteria.....	8
12.0	Reporting and Documentation.....	8
13.0	Post Examination	8
APPENDIX I	Reference and Calibration Blocks.....	9
APPENDIX II	Sweep Range and DAC Curve Verification	12
APPENDIX III	Accept \ Reject of Examined Items.....	13
APPENDIX IV	Ultrasonic Test Report	15

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

Ultrasonic Examination

1.0 Scope

- 1.1. This procedure provides the information to be used in performing ultrasonic examinations for welds, parts components, materials, and thickness determinations. It is applicable for the examination of components fabricated to ASME Boiler and Pressure Vessel Code Section VIII, Division 1, as well as the ASME B 16.34 Valves – Flanged, Threaded and Welding End, Latest Editions. ASME Boiler and Pressure Vessel Code Section V, articles 4 and 5 provide inspection details and guidelines.

2.0 References

The latest effective editions of the following specification have been used as references in the composition of this procedure:

- 2.1. American Society of Mechanical Engineers (ASME): Section V, Article 4 & 5, Nondestructive Examination, Latest Edition
- 2.2. ASME B 16.34 Valves, Appendix IV – Flanged, Threaded and Welding End. Latest Edition.
- 2.3. ASME Boiler and Pressure Vessel Code Section VIII, Division I, Latest Edition.
- 2.4. **MOGAS Industries, Inc.** Written Practice: WP-QC-1000 Qualification and Certification of NDT Personnel, Latest Edition

3.0 Applications

- 3.1. This procedure has been prepared for the manual contact, pulse-echo, longitudinal and shear wave ultrasonic examination.

4.0 Responsibility

- 4.1. The examiner shall be responsible for implementing the requirements of this procedure.
- 4.2. Personnel performing examinations shall be certified in accordance with the **MOGAS Industries, Inc.** WP-QC-1000 Qualification and Certification of NDT Personnel, Latest Edition, which is in accordance to the guidelines set forth in ASNT Document SNT-TC-1A.
- 4.3. Personnel performing examinations shall have at the minimum of Level II Ltd certification. Personnel evaluating ultrasonic reflectors shall have a minimum Level II certification.

5.0 Ultrasonic Equipment and Materials

5.1. Ultrasonic Equipment

- 5.1.1. A pulse-echo-type of ultrasonic instrument shall be used. The instrument shall have an A-scan display and will be capable of operating at a frequency range from 100 – 3000 Hz with a stepped gain control of 2 db or less.
- 5.1.2. Digital readout instruments for taking thickness measurements will not be used unless it is equipped with an A-scan presentation.

5.2. Transducers

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

- 5.2.1. Longitudinal wave search units will have a nominal frequency of 1 MHz – 10 MHz. Other frequencies may be used if variables such as production material grain structure require the use of other frequencies to assure adequate penetration of better resolution. Transducer size may vary from ¼” to 1 ½” in diameter depending on the referenced section.
- 5.2.2. For parts with a contoured surface it may be necessary to contour the transducer to provide adequate coupling, sensitivity and resolution. [Example: Shear wave evaluations of welds joining curved outside diameter pipe of 4.5” or less will best be examined by use of a transducer wedge that has been ground to the curvature of the pipe surface adjacent to the weld.]
- 5.2.3. Shear wave search units will have a nominal frequency of 2.25 MHz. Other frequencies may be used to ensure adequate penetration, better resolution or for evaluation purposes.
- 5.2.4. The exit point of the sound beam and the actual refracted beam angle of shear wave transducers shall be determined on a IIW block, or equivalent. The exit point of the sound beam shall be marked on the transducer wedge.

5.3. Couplant

- 5.3.1. A high quality Couplant material that meets the requirements of 5.3.2.
- 5.3.2. The Couplant shall be certified for sulfur content and total halogens in accordance with ASTM C-129 and ASTM D-808. The residual amount of total sulfur or halogens shall not exceed 1% by weight.
- 5.3.3. The Couplant used for examinations shall be the same as used for the calibration.

6.0 Reference and Calibration Blocks

- 6.1. Basic Calibration Blocks for Longitudinal wave and Shear wave examinations.
 - 6.1.1. Reflectors such as side drilled holes, flat bottom holes, notches, etc. shall be used to establish primary reference responses of the equipment.
 - 6.1.2. The material from which the block is fabricated shall be of the same product form, and material specification of equivalent P-Number grouping as one the materials being examined. For purposes of this procedure P-Numbers 1, 3, 4, and 5 are to be considered the same. Calibration blocks of dissimilar metal welds; the material selection shall be based on the side of the weld from which the examination will be conducted. If the examination is to be conducted from both sides, calibration reflectors shall be provided in both materials. Where two or more base material thickness is involved, the calibration block thickness shall be determined by the average thickness of the weld. The finish of the scanning surface of the block shall be representative of the surface being examined.
 - 6.1.3. Longitudinal wave calibration blocks shall be used to establish sweep range and distance amplitude correction.
 - 6.1.4. For material requiring heat treatment the calibration block shall receive at least the minimum tempering treatment required by the material specification for the type and grade, and also a post weld heat treatment of at least two hours, if the calibration contains weld other than cladding.
 - 6.1.5. Where the component material is clad, the block shall be clad by the same welding procedure as the production part. Where automatic method is impractical, deposition of clad shall be by the manual method.
 - 6.1.6. The calibration block material shall be completely examined with a longitudinal wave unit to determine block quality. Areas that contain an indication exceeding

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

the remaining back reflection shall be excluded from the beam paths required to reach the various calibration reflectors.

- 6.2. Calibration Block configuration
 - 6.2.1. Calibration block configurations will be per Appendix I.
 - 6.2.2. For examinations in materials where the surface diameter is greater than 20", a block of essentially the curvature, or alternatively, a flat basic calibration block, shall be used.
 - 6.2.3. For examinations of material with diameters 20" and less a single curved basic calibration block may be used for calibration on surface within the curvature range from 0.9 to 1.5 times the basic calibration block diameter. The curvature range from 0.94 inches to 20 inches diameter required six block curvatures as indicated in Appendix I T-434.1.7.2 for any thickness range.
- 6.3. Temperature Requirements
 - 6.3.1. The temperature of the basic calibration block during calibration and verifications shall be within 25 degrees F of the component temperature. The temperature of the basic calibration block shall be recorded on the instrument calibration record, for the initial calibration and each verification of calibration. If the component is at ambient temperature, no measurement is necessary and may be recorded as ambient.

7.0 Instrument Linearity and Performance

- 7.1. Screen Height Linearity
 - 7.1.1. The ultrasonic instrument shall provide linear vertical presentation with + 5% of the Full Screen Height for 20% to 80% of the calibrated screen height (base line to maximum calibrated screen point). Screen height linearity shall be performed at the beginning of each period of extended use or every three months, whichever is less.
 - 7.1.2. A longitudinal wave search unit may be used on any calibration block, which will provide amplitude differences, with sufficient signal separation to prevent overlapping of the two signals.
- 7.2. Amplitude Control Linearity
 - 7.2.1. The ultrasonic instrument shall utilize an amplitude control accurate over its useful range to + 20% of the nominal amplitude ratio, to allow measurement of indications beyond the linear range of the vertical display on the screen. Amplitude control linearity shall be performed at the beginning of each period of extended use or every three months, whichever is less.
- 7.3. Instrument performance shall be evaluated per ASTM E317, or equivalent, on an annual basis.

8.0 Calibration

- 8.1. All ultrasonic calibrations shall be completed prior to the start of the examination. Each calibration shall be performed from the surface, corresponding to the surface of the component from which the examination will be performed.
- 8.2. The REJECT/CLIPPING shall be turned off or to '0' position during calibration and examination.
- 8.3. The Frequency Control shall be set to an appropriate range if applicable.
- 8.4. All spaces on the instrument calibration record shall be filled in.

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

- 8.5. Sweep range and Distance Amplitude Correction (DAC) shall be performed as required. Reference Appendix II.
- 8.6. If it is determined that the Ultrasonic Instrument is not functioning properly during any check or calibration, all material since the last valid calibration shall be re-examined.

9.0 Sweep Range and DAC Curve Verification

NOTE: Sweep range calibration shall be verified on the appropriate reference block. The DAC curve calibration shall be verified on the appropriate basic calibration block. Reference Appendix I and Appendix II.

- 9.1. Calibration shall be performed at the start of the examination. Re-calibration or verification calibration shall be performed if any of the following occur.
 - 9.1.1. Substitution of search unit or cable.
 - 9.1.2. Change in power source.
 - 9.1.3. At least every four hours during the examination
 - 9.1.4. At the finish of a series of examinations.
 - 9.1.5. Whenever the validity of the calibration is considered to be in doubt.
 - 9.1.6. If any point on the DAC curve has changed by more than 20% or 2 dB in amplitude, or moved on the sweep line more than 10% of the sweep reading or 5% of full sweep, whichever is greater:
 - 9.1.6.1. For a decrease in DAC, void all examinations referring to the calibration in question and performed after the last valid calibration verification, perform and record a new calibration, and re-examine the voided area.
 - 9.1.6.2. For an increase in DAC, or a change in sweep range, correct the calibration and note on the data sheets. All recorded indications since the last valid calibration shall be re-examined with corrected calibration, and values changed on the data sheets.
 - 9.1.7. Change in couplant.
 - 9.1.8. Change in examination personnel.

10.0 Examination

NOTE: For Ultrasonic Thickness examinations, reference Appendix IV

- 10.1. The contact surface must be free from weld spatter, roughness, or other condition, which interfere with free movement of the search unit or impair the transmission of ultrasound.
- 10.2. The area to be examined shall be in accordance with the code, standard, or customer specification for the inspection required.
- 10.3. The scanning pattern shall overlap at a minimum of 10% of the search unit element dimension perpendicular to the direction of the scan. Reference figure 10.3 for scanning patterns.
- 10.4. For welds that do not have the weld ground flush scanning patterns "A" and "B" shall be used. For welds that have the weld ground flush scanning patterns "A" and "C" will be used.
- 10.5. The search unit movement rate shall not exceed six linear inches per second unless calibration is verified at scanning speed.

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

11.0 Acceptance/Rejection Criteria

- 11.1. Acceptance/Rejection Criteria shall be based on the referencing Code Section.
- 11.2. If this information is not available or provided this procedure shall govern the acceptability of the item being examined. Reference Appendix III.

12.0 Reporting and Documentation

- 12.1. Ultrasonic Inspection reports shall be completely filled out. The report shall include, but is not limited to: Ultrasonic equipment and search units, identification of parts, drawing reference, calibration block(s), surface condition, couplant, frequency, date, personnel and certifications, procedure, and referencing Code Section or Customer Specifications.
- 12.2. A copy of the ultrasonic examination report shall be retained as specified by the referencing Code Section.

13.0 Post Examination

- 13.1. All couplant should be removed from examination area upon completion of examination.

APPENDIX I

Reference and Calibration Blocks

1.0 Reference blocks

- 1.1. Reference blocks used for screen distance calibration and verification shall be of the same basic material, P-number as the production material, and shall be one of the following types: Half-round, IIW Type 1 or 2, DSC, shear wave calibration blocks or step type longitudinal wave calibration blocks.
- 1.2. Other reference blocks may be used for specific application and shall be documented as to type and flaw location.

2.0 Basic Calibration blocks

- 2.1. Known reflectors such as side-drilled holes, flat bottom holes, notches etc. shall be used to establish primary reference responses of the equipment.
- 2.2. The basic calibration block configuration and reflectors for non-pipe and pipe 20" diameter or greater shall be as shown in Fig. T-434.2.1.
- 2.3. The basic calibration block configuration and reflector for pipe with a diameter less than 20" shall be as shown in Fig T-434.3. The curvature shall range from 0.9 to 1.5 times the basic calibration block diameter.
- 2.4. When two or more base material thickness is involved, the calibration block thickness shall be determined by the average thickness of the weld.
- 2.5. When the block thickness + 1 in. spans two weld thickness ranges as shown in Fig T-434.2.1, the block's use shall be acceptable in those portions of each thickness range covered by 1 in.

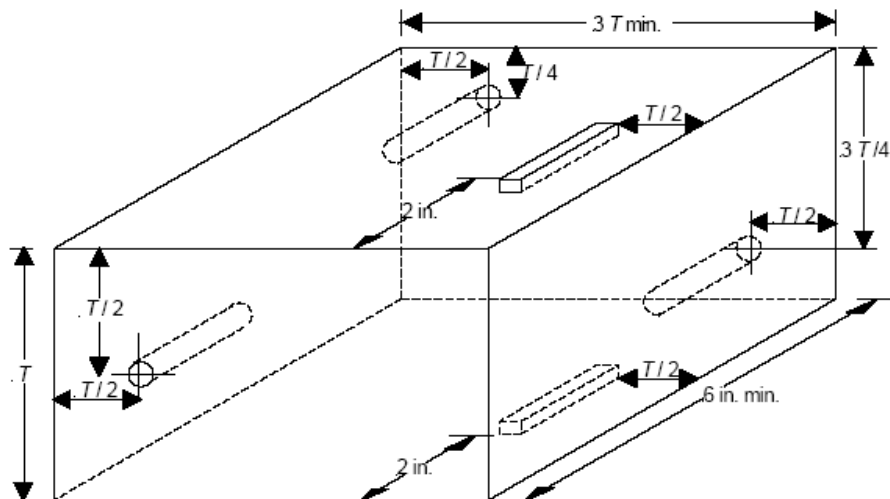


Fig. T-434.2.1 Basic Calibration Blocks

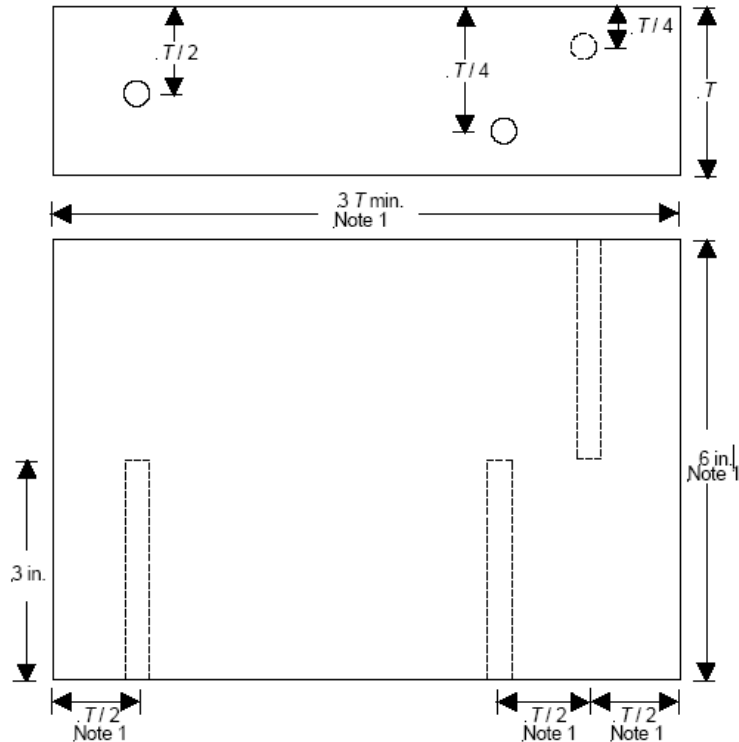


Fig. T-434.2.1 Basic Calibration Blocks

Weld Thickness t	Basic Calibration Block Thickness T	Hole Diameter	Notch Dimensions
1" or less	3/4 " or t	3/32"	(for any thickness)
Over 1" through 2"	1-1/2" or t	1/8"	Notch Depth = 2% T
Over 2" through 4"	3" or t	3/16"	Notch Width = 1/4" max.
Over 4"	$t \pm 1$ "	**	Notch Length = 1" min.

** For each increase in weld thickness of 2 in. or fraction thereof over 4 in. the hole diameter shall increase 1/16 in.

GENERAL NOTES:

- Holes shall be drilled and reamed 1.5 in deep min., essentially parallel to the examination surface.
- For curved surfaces, two sets of calibration reflectors (holes, notches) oriented 90 deg from each other shall be used. Alternatively, two curved calibration blocks may be used. (Reference components of 20 inch or less diameter, see T- 434.3)
- The tolerance for hole diameter shall be + 1/32 in. The tolerance for hole location through the calibration block thickness shall be + 1/8 inch.
- For blocks less than 3/4 inch in thickness, only the 1/2 T side drilled hole and surface notch is required.
- All three holes may be located on the same face (side) of the calibration block provided care is exercised to locate the holes far enough apart to prevent one hole from masking the indication of another hole during calibration.
- Minimum notch depth shall be 1.6%T and maximum notch depth shall be 2.2%T plus the thickness of cladding, if present.

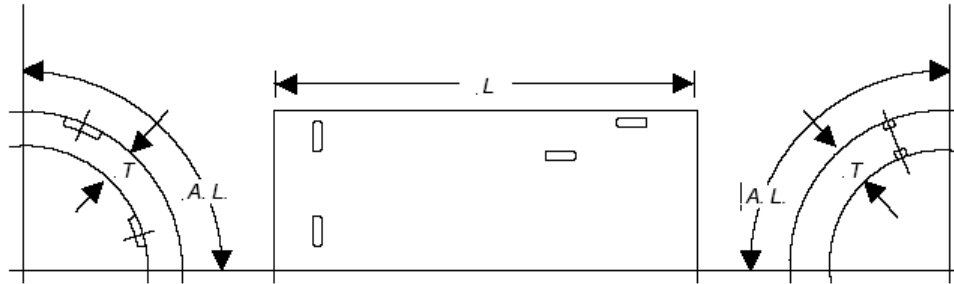


Fig. T-434.3 Calibration Block for Pipe

Note: Notches shall be located not closer than T or 1 in. (25mm), whichever is greater, to any block edge or to other notches.

GENERAL NOTES:

- (a) The minimum calibration block length (L) shall be 8 in. (203mm) or 8T, whichever is greater.
- (b) For OD 4 in. (102mm) or less the minimum arc length AL shall be 270 degrees. For OD greater than 4 in. (102mm), the minimum arc length shall be 8 in. (203mm) or 3T, whichever is greater.
- (c) Notch depths shall be from 8% I minimum to 11% T maximum. Notch widths shall be 1/4 in. (6.4mm) maximum. Notch lengths shall be 1 in. (25mm) minimum.

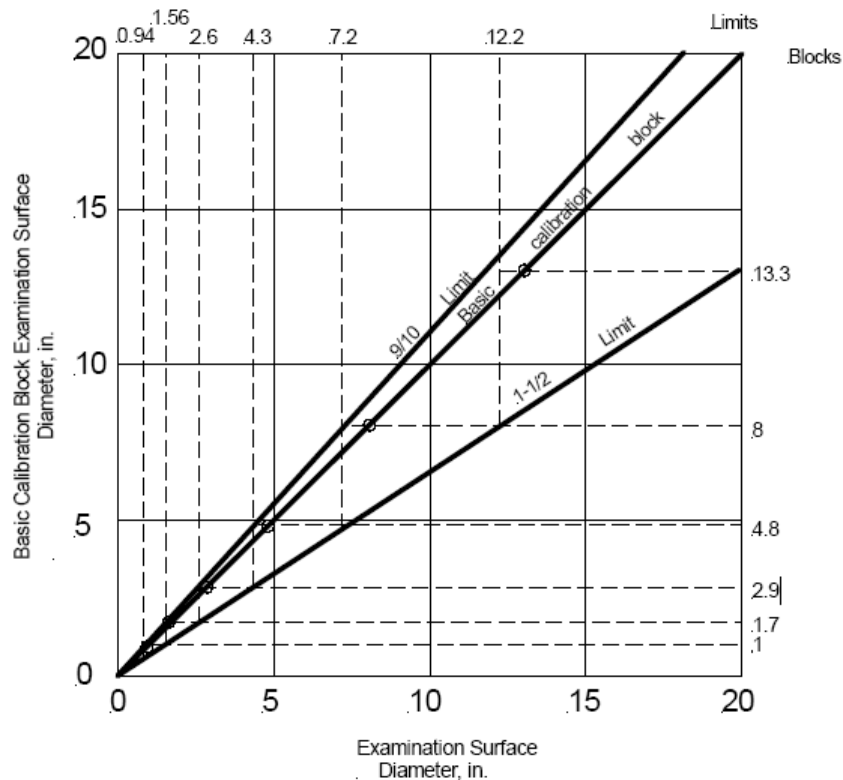


Figure T-434.1.7.2 Ratio Limits for Curved Surface

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

APPENDIX II Sweep Range and DAC Curve Verification

NOTE: This procedure is to be used provided no other specifications have been given at the start of examination. This procedure shall be performed on each search unit angle used for the examination, or if any conditions listed in Section 9.1 of this of this procedure occur.

1.0 Scope

- 1.1. This Appendix is to be used to provide general techniques for angle beam Calibration. Other techniques may be used

2.0 The Examiner shall select the shortest screen distance size that includes a minimum of 1 1/8 'V path' beyond the nominal production material thickness for angle beam examination.

- 2.1. Position the search unit for maximum response from the side drilled hole (SDH), which gives the highest amplitude.
- 2.2. Adjust the gain control to provide an indication of 80% (+5%) of full screen height (FSH). Mark the peak of the indication on the screen (for instruments with out electronic DAC).
 - 2.2.1. Document the db level (gain) on Ultrasonic Examination Report Form TNC 020. This will be your primary sensitivity (reference) level.
- 2.3. Position the search unit for maximum amplitude from another SDH and mark the peak on the screen.
- 2.4. Position the search unit for maximum amplitude from the third SDH and mark the peak on the screen.
- 2.5. Position the search unit for maximum amplitude from the 3/4 T SDH after the sound beam is in its nd leg (after sound reflects from the opposite surface). Mark the peak on the screen.
- 2.6. Repeat the process for the 1/2 T SDH.
- 2.7. Connect the screen marks with a smooth curve to provide the distance-amplitude curve (DAC).

APPENDIX III Accept \ Reject of Examined Items

NOTE: This procedure will be used to determine the acceptability of examined items if no other specification is provided at time of examination.

1.0 Examination of Marine Structural Welds

- 1.1. The Instrument shall be calibrated using an IIW block or DSC block.
- 1.2. Using the appropriate basic calibration block for the thickness of the area to be examined as per Appendix III, the operator shall build a Distance Amplitude Curve. This serves as the Amplitude Reject Level (ARL).
- 1.3. The transducer angle used on for the examination will be determined by the thickness item to be inspected.

Plate Thickness	Shear Wave Angle
5/16" to 1.5"	70°
1.5" to 2.5"	60° and 70°
Over 2.5"	45° and 60°

Other shear wave angles may be used provided it is demonstrated that they are suitable for the application involved.

- 1.4. A second DAC shall be plotted at 50% of the ARL. This serves as the "Record Level" and should be 6 db less sensitive than the ARL.
- 1.5. The base metal adjacent to the weld of the Item to be examined shall be scanned prior to the angle beam examination to detect the presences of any laminations or any other discontinuity in the base metal that may inhibit the examination of the weld.
- 1.6. Scanning patterns for longitudinally or transversely oriented discontinuities shall insure 'z' direction coverage through 100% of the weld and adjacent base material on each side of the weld.

NOTE: When discontinuities are found the sound beam is to be directed so as to maximize the signal amplitude. The transducer is then moved parallel to the discontinuity and away from the position of the maximum signal amplitude. The centerline of the wedge is to be used as the index point to mark the extremities of the indication.

- 1.7. For indications greater than ARL the extremity points of the discontinuity are to be marked when the signal amplitude drops to 50% of the ARL (this is a 6 db change)
- 1.8. For indications less than or equal to the ARL, the extremities points of the discontinuity are to be marked where the signal amplitude either remains below the DRL for a distance equal to 1/2 the major dimension of the transducer or drops to 1/2 of the peak amplitude whichever occurs first.

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

2.0 Examination of Pressure Retaining Welds

- 2.1. The Instrument shall be calibrated using an IIW block or DSC block.
- 2.2. The base metal adjacent to the weld of the Item to be examined shall be scanned prior to the angle beam examination to detect the presences of any laminations or any other discontinuity in the base metal that may inhibit the examination of the weld.
- 2.3. Using the appropriate basic calibration block for the thickness of the area to be examined as per Appendix III, the operator shall build a Distance Amplitude Curve. This serves as the DAC.
- 2.4. A 45° angle shall be used for the evaluation of all indications. Other shear wave angles may be used provided it is demonstrated that they are suitable for the application involved and meet the requirements of Section 5.2.
- 2.5. Scanning patterns for longitudinally or transversely oriented shall be the same as Section 10.

NOTE: When discontinuities are found the sound beam is to be directed so as to maximize the signal amplitude. The transducer is then moved parallel to the discontinuity and away from the position of the maximum signal amplitude. The centerline of the wedge is to be used as the index point to mark the extremities.

SPECIFICATION	NDT 0400	VER 2.0
QA APPROVAL BY:	IMELDA HERNANDEZ	11/10/2014
LEVEL III APPROVAL BY:	PAUL T. MARKS	11/10/2014

APPENDIX IV

Ultrasonic Test Report



ULTRASONIC TEST REPORT

DATE _____		REPORT NUMBER _____				
CUSTOMER/PROJECT Job No: _____		WELD OR PART IDENTIFICATION _____				
PROCEDURE NO: _____		ACCEPTANCE STANDARD _____	METHOD CONTACT _____ STRAIGHT _____ ANGLE _____ IMMERSION _____			
MATERIAL: _____	SURFACE CONDITION _____	THICKNESS/DIMENSIONS: _____				
DEGREES: 45° _____ 60° _____ 70° _____ THRU-TRANS _____ PULSE-ECHO _____		SCANNING SPEED: _____	INSTRUMENT: _____			
		MANUAL _____ AUTO _____	MODEL _____ SER# _____			
TRANSDUCER: SINGLE _____ DUAL _____	MANUFACTURER _____	MATERIAL _____	SIZE _____ FREQUENCY _____			
CALIBRATION AMPLITUDE _____	CALIBRATION DISTANCE _____	CALIBRATION BLOCK USED _____	COUPLANT _____			
SKETCH						
NOTES						
RESULTS						
IND. NO.	INDICATION TYPE/LOCATION SIZE/EXTENT	DEPTH	AMPLITUDE	REMARKS	ACCEPT	REJECT

EXAMINED BY:

PRINT NAME _____

SIGNATURE _____

WITNESSED BY:

PRINT NAME _____

SIGNATURE _____

FNDT-0400 Rev. A