

NDT Procedure for Ultrasonic Inspection

A Nondestructive testing (NDT) Procedure suitable for General Ultrasonic Inspections. This is a sample UT procedure and may be required to be modified as per specific requirements.

NDT Procedure No: TNE-DOC-UT-01 Rev '0'



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PROCEDURE FOR ULTRASONIC EXAMINATION

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1. Scope:

- This procedure defines the criteria and general requirements to carry out ultrasonic examination on ferritic welded joints.
- This procedure applicable to most geometric configurations and materials encountered in fabrication under normal conditions. However, special configuration and materials may require modified methods and techniques .in this case special procedure shall be demonstrated prior to use to the satisfaction of the Authorized Inspector in accordance with the requirements of T-150, ASME Code Sec. V. The procedure qualification record shall be attached to this procedure.

2. Reference:

2.1 This Procedure refers to the following:

- ASME Code Section V-Non Destructive Examination, applicable edition/addenda.
- ASME Code Section I, for acceptance criteria.
- ASME Code Section VIII, Div I for acceptance criteria.
- ANSI/ASME B31.1, applicable edition/addenda, for acceptance criteria.
- ANSI/ASME B31.3, applicable edition/addenda, for acceptance criteria.
- National Board Inspection Code, NBIC-23, applicable edition.
- AWS D1.1- applicable edition.
- Clients' specification requirements for acceptance criteria.
- Written Practice No. TNE-Doc-UT-01 Rev '0.' "In case of conflict between Code requirements and Client's specifications, Code requirements shall prevail".

3. Definitions:

- ASNT: American Society for Non-Destructive Testing.
- ASME: American Society for Mechanical Engineers.
- DAC: Distance Amplitude Correction.
- NDE: Non-Destructive Examination.
- IIW : The International Institute of Welding.

4. Responsibilities:

- The NDE Examiner shall be responsible for conducting and reporting the results of examination in accordance with the applicable Code and Client's specifications, whichever is more restrictive.

5. Personnel Qualifications:

- All personnel involved in Ultrasonic Examinations shall be qualified to Level II in accordance with the requirements of Trinity NDT, Written Practice (Training, Qualification & Certification for NDE Personnel).
- When the written practice is revised, the certification of NDE personnel remains valid to the requirements of the previous revision until the expiry date of the personnel qualification certificate; then, recertification to the requirements of the new revision is required.
- Subcontractor's personnel involved in Ultrasonic Examinations shall be qualified to Level II in accordance with the requirements of subcontractor's written practice which shall be reviewed and accepted by Trinity NDT QA/QC Manager.
- The certification of personnel shall be checked by the QA/QC Manager or NDE Level III prior to work commencement.

6. Procedure:

6.1 Equipment:

6.1.1 Ultrasonic examination equipment shall be of the pulse echo type utilizing "A" scan presentation, capable of generating and receiving frequencies between 1 and 5 MHz as a minimum and shall be capable of recording UT data including the scanning positions.

6.1.2 The flaw detector shall be calibrated in accordance with the relevant calibration procedure. A certificate of conformance shall accompany each flaw detector.

6.1.3 The ultrasonic instrument shall provide linear vertical presentation within $\pm 5\%$ of the full screen height (FSH) for 20% to 80% FSH and to be recorded in Screen Height Linearity Record Form No. TNE-UT-Doc-02 Rev '0.' The procedure for evaluating screen height linearity is carried out as per ASME section V, article 4, appendix I (and or AWS D1.1-6.30).

6.1.4 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. The procedure for evaluating amplitude control linearity shall be performed as per ASME section V, Article 4, appendix II. And to be recorded in Amplitude Control Linearity Form No. TNE-UT-Doc-03 Rev '0.'

6.1.5 The requirements of 6.1.3 and 6.1.4 above; shall be met at intervals not to exceed three months for analogue type instruments and one year for digital type instrument, or prior to first use thereafter.

6.1.6 When any part of the examination system is changed, a calibration check shall be made on the basic calibration block to verify that distance range points and sensitivity setting (s) satisfy the requirements of ASME section V, T-466.3.

6.1.7 A calibration check on at least one of the reflectors in the basic calibration block shall be performed at the completion of each examination or series of similar examinations, and when examination personnel are changed. The distance range and sensitivity values recorded shall satisfy the requirements of ASME section V, T-466.3.

6.1.8 If during any check, it is determined that the examination equipment is not functioning properly, all of the product that has been examined since the last valid equipment calibration shall be re-examined.

6.2 Materials:

6.2.1 Search units shall be electrically matched to the flaw detector.

6.2.2 Search units shall be in the frequency range 1 MHz to 5 MHz and be free of noise and internal reflections. Twin or single transducer elements may be used dependent upon the configuration of weld under examination.

6.2.2.1 In case of AWS D1.1

- **Straight-beam** Search unit transducers shall have an active area of not less than 1/2in² nor shall more than 1 in². The transducer be round or square.

- **Angle-Beam** Search Units shall consist of a transducer and an angle wedge. The unit may be comprised of the two separate elements or may be an integral unit.

Search Units shall be square or rectangular in shape and may vary from 5/8in to 1in in width and from 5/8in to 13/16in in height. The search unit shall produce a sound beam in the material being tested within $\pm 2^\circ$ of one of the following proper angles: 70°, 60°, or 45°. The transducer frequency shall be between 2 and 2.5 MHz.

6.2.3 Search units with contoured contact wedges may be used to aid the ultrasonic coupling. Calibration shall be done with the contact wedges used during the examination.

6.2.4 Each flaw detector shall have a full set of search units with cables; the search units shall be of type, size and frequency, as required by the governing specification.

6.2.5 Calibration blocks shall include but not be limited to "IIW -V2" UT reference Block. The operator shall also have access to IIW-V1, and such others that may be required to ensure compliance with regard to calibration of flaw detector and probe characteristics, e.g. beam angle, beam profile, exit point (index), etc.

6.2.5.1 In case of AWS D1.1 the "IIW" UT reference block shall be the standard used for both distance and sensitivity calibration

6.2.6 Basic Calibration Block Material shall be of the same product form, and material specification or equivalent P-Number grouping as one of the materials being examined. For the purpose of this procedure P-Numbers 1, 3, 4, and 5 materials are considered equivalent. The calibration block shall have the same heat treatment specification for the type and grade and also have the same surface finish.

6.2.7 Measurements of beam spread for scan indexing limits shall be taken only when required by a referencing code section. Beam spread angles shall be measured once for a search unit wedge combination in the calculated far field at the beginning of each period of extended use, or every 3 months, whichever is less.

6.2.8 Search units with worn faces shall not be used.

6.2.9 Couplant shall be used to give the maximum acoustic transmission between the probe face and the material under examination. The couplant shall be cellulose paste, liquid soap, oil, or grease. In all cases the couplant including additive, shall not be detrimental to the material being examined.

6.3 Surface Condition:

6.3.1 Welds that are being examined using ultrasound shall be prepared to provide a sufficiently smooth and regular area for scanning to be undertaken. The area shall extend at least the full skip distance required, and shall be free of any irregularities such as spatter, grinding or chipping marks scale, etc., which may hinder the scanning pattern or cause confusion in the interpretation of the resultant display i.e. excessive surface noise.

6.4 Technical Information:

6.4.1 Prior to commencement of examination, the following information shall be obtained:

- Type of material.
- Joint configuration.
- Welding Process.
- Other information that may have a bearing on the inspection e.g. post weld heat treatment, etc.

6.5 Examination Procedure:

6.5.1 For examinations in materials where the examination surface diameter is greater than 20 in. (508 mm), a block of essentially the same curvature shall be used, or alternatively, a flat basic calibration block, may be used, provided that, gain correction shall be adjusted as described in code section V, Article 4, Appendix B.

6.5.2 For examination in materials where the examination surface diameter is 20 in. (508 mm), or less, the calibration block shall be curved. Except where otherwise stated in the reference code, a single curved basic calibration block may be used to calibrate the examination on surfaces in the range of curvature from 0.9 to 1.5 times the basic calibration block diameter.

6.5.3 The scanning shall be 100%. The entire volume shall be examined with a 10% overlap of the probe. The rate of search unit movement for examination shall not exceed 6 inches per second (152mm/sec) unless calibration is verified at scanning speed.

6.5.4 For reflectors oriented transverse to the weld the scanning shall be done parallel to the weld axis. If the weld is not ground flushed the probe shall be controlled such that it faces nearly parallel to the weld body. The search unit shall be manipulated so that the ultrasonic energy passes through the required volume of weld and adjacent base material. The search unit shall be rotated 180 deg and the examination repeated. If the weld cap is not ground flat, the examination shall be performed from the base metal on both sides of the weld cap in both weld axis directions.

6.5.5 Calibration:

6.5.5.1 Straight Beam Calibration (0° Probe):

(A) The equipment is calibrated using a straight beam probe for a suitable range for the thickness of material being examined. A minimum of two back wall echoes from the material under test be noted during the examination.

(B) A Distance Amplitude Correction curve (DAC curve) shall be produced using the appropriate calibration block. The gain control is adjusted to produce a response of 80% full screen height and the screen is marked. Then the probe is re-positioned to give the maximized response for each of the remaining holes. At each maximized position, mark the position of maximum response on the screen. Connect the screen marks to produce the DAC curve. This gain setting is primary reference level.

6.5.5.2 Angle Beam Calibration:

(A) The equipment is calibrated for a suitable range for the beam path length required to satisfactorily complete the examination, (i.e. Full Skip Distance).

(B) Produce a DAC curve in accordance with paragraph 6.5.5.1(B).

6.5.5.3 System calibration shall be carried out at the commencement of and at 4 hourly intervals during the inspection and on completion of an inspection.

If during the calibration confirmation the sweep range of the DAC curve has changed by the following tolerances:

Sweep Range:

If a point of the DAC curve has moved on the time base by more than 10% of its original time base position.

DAC Curve:

If a point on DAC curve has changed by $\pm 20\%$ or 2 dB from its original amplitude.

Then the following action shall be taken:

Sweep Range:

The calibration shall be corrected with a note of the correction being made on the report. If any signals have been recorded, all recorded indications shall be re-examined with the corrected calibration and their values corrected accordingly on the report.

DAC Curve:

If any point on the DAC curve has decreased by 20% or 2 dB all recorded data since the last valid calibration shall be marked void. A new DAC curve shall be produced with a note to this effect on the report and the voided are as shall be re-examined. If any point on the DAC Curve has increased following the production of the new DAC curve. A note of this shall be made on the report.

6.5.6 Inspection Technique:**6.5.6.1 Parent Metal Examination**

Prior to any examination of the weldments, the parent material shall be examined. A compression wave 0 examination will be carried out for a minimum of 3 in. (75 mm) either side of the weld to locate any flaws in the parent material and to determine its thickness.

6.5.6.2 Weld Examination. Plate and Pipe Welds

A critical root scan shall be carried out from both sides of the weld, with at least one angle probe directed essentially perpendicular to the weld axis so as to distinguish between root variations and the existence of root cracks or crack-like defects. This may be done where practicable with the aid of a magnetic strip placed so that the distance from the probe index to the root will be constant. The body and fusion faces of the weld shall then be examined using a continuous scanning raster from both sides of the weld between the weld center line or the cap edge whichever is appropriate and full skip plus the cap width using at least two probes of differing angles

6.5.7 Scanning:

6.5.7.1 A Datum reference point shall be clearly marked on the work-piece and shall be marked with the weld identification. The datum shall be used for a reference for locating defects, and the reporting of defects.

6.5.7.2 The weld and base metal shall be scanned, where required by the referencing code section to the extent possible with the straight beam search unit.

6.5.7.3 Angle beam scanning shall be performed at a gain setting at least two times the primary reference level. Evaluation shall be performed with respect to the primary reference level.

6.5.7.4 The angle beam shall be directed at approximate right angles to the weld axis from two directions where possible to detect discontinuities oriented parallel to the weld axis.

6.5.7.5 The angle beam shall be directed essentially parallel to the weld axis and shall be manipulated so that the angle beam passes through the required volumes of weld and adjacent base metal specified by the referencing code in order to detect discontinuities oriented transverse to the weld axis. The search unit shall be rotated 180° and the examination shall be repeated.

6.5.7.6 The rate of search unit movement for examination shall not exceed 6 in. /sec. unless calibration is verified at scanning speed.

6.5.8 In case of AWS D1.1

- The testing angle and scanning procedure shall be in conformance with those in AWS D1.1 Table 6.7.
- The Indication Rating “d” represents the algebraic difference in decibels between the indication level and the reference level with correction for attenuation as indicated in the following expression.

Instruments with gain in dB: $a - b - c = d$

6.6 Defect Evaluation And Sizing

6.6.1 Any imperfection which causes an indication in excess of 20% DAC shall be investigated to the extent that it can be evaluated in terms of the acceptance standards of the referencing code section. The indication shall be investigated to:

- Confirm its existence.
- Determine its location with reference to the established datum points.
- Determine its size.
- Determine its nature.

This investigation may require scanning from other positions and with different probes. It is highly subjective in its nature and should be carried out with extreme care. The recommended sizing techniques are as follows:

- Defect Length

Use the 6 dB drop technique, marking the probe centre at the defect end points.

- Through Thickness Dimension

Use the 20 dB technique in conjunction with an adjustable flaw location slide. The recording levels and rejection levels shall be in accordance with the referencing Code or standard. All defects shall be assessed in accordance with the requirements of the applicable referencing Code Section.

6.6.2 In case of AWS D1.1

- Each weld discontinuity shall be accepted or rejected on the basis of its indication rating and its length, in conformance with AWS D1.1 Table 6.2 for statically loaded structures or Table 6.3 for cyclically loaded structures.

The length of such indication shall be determined by measuring the distance between the transducer centerline locations where the indication rating amplitude drops 50%(6 dB) below the rating for the applicable discontinuity classification. This length shall be recorded under “discontinuity length”

6.7 Acceptance Standards

6.7.1 ASME Code, Sec. I Paragraph PW-52.

6.7.2 ASME Code, Sec. VIII Div I (Mandatory Appendix I2).

6.7.3 ASME B31.1 Paragraph (I36.4.6).

6.7.4 AWS D1.1 ,Clause 6 .Table 6.2 and 6.3

6.8 Reporting

6.8.1 Upon completion of the examination the examiner shall prepare an examination report, for each weld or area of weld examined, using Ultrasonic Examination Report - Form No. TNE-UTR-03 Rev '0.'. All restrictions which limit the effectiveness of the test must be recorded.

6.8.2 All reflectors greater than 50% of the reference level shall be reported and shall be described with regard to size, shape, location and probable identity/classification.

6.8.3 In addition, sketches and drawings shall be prepared to support written descriptions.

7. Attachments:

7.1 Ultrasonic Examination Report TNE-UTR-03 Rev '0.'

7.2 Screen Height Linearity Record TNE-UT-Doc-02 Rev '0.'

7.3 Amplitude Control Linearity Record.....TNE-UT-Doc-03 Rev '0.'