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# ULTRASONIC EXAMINATION PROCEDURE

**DOCUMENT NO: PNEC/UT/01.Rev 0**

|                                   |                     |                    |
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|                                   |                     |                    |
| <b>PREPARED &amp; APPROVED BY</b> | <b>CERTIFIED BY</b> | <b>REVIEWED BY</b> |

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## **1 SCOPE:**

This procedure explains the requirements for manual A-scan , pulse echo , contact technique of ultrasonic examination of weldments and materials of carbon and low alloy steel in pressure vessels.

## **2 REFERENCE:**

**2.1** ASME Boiler and Pressure Vessel Code Section V, Edition 2010.

**2.2** ASME Boiler and Pressure Vessel Code Section VIII Division-1, Edition 2010.

**2.3** ASME Boiler and Pressure Vessel Code Section VIII Division-2, Edition 2010.

**2.4** ASME Boiler and Pressure Vessel Code Section IX Edition 2010.

**2.5** PNEC/WP/01. PNEC Written Practice for Training, Qualification and Certification of NDE Personnel.

## **3 PERSONNEL QUALIFICATION:**

**3.1** All personnel involved in Ultrasonic Testing , interpretation and evaluation shall be qualified as per PNEC Written Practice.

**3.2** Personnel performing Ultrasonic Testing shall be certified to a minimum of Level I.

**3.3** Personnel performing interpretation and evaluation of test results shall be certified to a minimum of Level II.

## **4 EQUIPMENT:**

**4.1** The examination shall be conducted with A scan type pulse echo ultrasonic equipment that generates frequencies over the range of 1MHz to 5MHz and shall be equipped with a stepped gain control in units of 2 dB or less.

**4.2** The reject control shall be in the 'off' position for all examination.

**4.3** The equipment shall have valid calibration and stickered mentioning the date of expiry.

## **5 SEARCH UNITS:**

**5.1** Search units may contain single crystal/dual crystal transducers.

**5.2** For straight beam examination longitudinal wave probes (0°) shall be used. For angle beam examination shear wave probes of 45° shall generally be used and PNECeast one probe of other angles up to 70° shall be used appropriate to the configuration being

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examined. Groove angle and thickness shall be considered in selecting the probe angle other than 45°

**5.3** For straight beam examination, the crystal dimensions shall be selected in the range of 5 mm to 25 mm. For angle beam examination, the crystal dimensions shall be selected appropriate to the contact available with examination surface and will generally be 8x9 mm 14x14 or 20x22 mm.

**5.4** Probes of frequencies between 2.5 MHz and 4 MHz shall be used for both straight beam and angle beam examination.

## **6 SURFACE CONDITION:**

**6.1** The finished contact surface shall be free from weld spatter and surface irregularities which will impair the free movement of the search unit.

**6.2** The weld reinforcement shall be ground flush smooth with adjacent base material, if required.

## **7 COUPLANT:**

**7.1** Grease/oil may be used as couplant. The couplant used for the examination shall be the same as that used for calibration.

**7.2** Couplant used on nickel base alloys shall not contain more than 250 ppm of sulfur.

**7.3** Couplants used on austenitic stainless steel or titanium shall not contain more than 250 ppm of halides (Chlorides plus fluorides).

## **8 CALIBRATION OF EQUIPMENT:**

### **8.1 Basic Reference Block:**

The basic reference reflectors shall be used to establish a primary reference response of the equipment. The material from which the block is fabricated shall be of the same product form and material specifications or equivalent P - Number grouping (P. Nos. 1, 3, 4 and 5 , 5A through 5C and 15A through 15F are considered equivalent) as one of the material being examined.

**8.2** Reference blocks for dissimilar metal welds, the material selection shall be based on the material on the side of the weld from which the examination will be conducted. If the examination will be conducted from both sides, calibration reflectors shall be provided in both materials.

**8.3** Reference blocks shall receive PNECeast the minimum tempering treatment required by the material specification for the type and grade.

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- 8.4** When two or more base material thicknesses are involved, the reference block thickness shall be determined by the average thickness of the weld.
- 8.5** The thickness and the location and size of holes in the basic reference block to be used shall be as indicated in the **Figure - 1**.
- 8.6** The finish on the surface of the reference block shall be representative of the surface finish on the component. Variation in component configuration and surface finish, require transfer correction to be calculated.
- 8.7** The reference block material shall be completely examined with a straight beam search unit. Areas that contain an indication exceeding the remaining back reflection shall not be used as block material.
- 8.8** When the component has flat surfaces or curved surface with a diameter greater than 20 inches, a flat basic reference block shall be used (**Figure - 1**).
- 8.9** When the component is curved and has a diameter less than 20 inches, a curved basic reference block shall be used. The components to be tested can have a curvature between 0.9 to 1.5 times of basic reference block diameter. Curved basic reference block shall be used (**Figure - 2**).
- 8.10** For testing a weld thickness 't', the calibration block of the same thickness will be ideal. However, the thickness of the calibration blocks acceptable for use shall be
- |                                       |   |        |
|---------------------------------------|---|--------|
| For weld thickness 25mm or less       | - | 19mm   |
| For weld thickness 25mm through 50mm  | - | 38mm   |
| For weld thickness 50mm through 100mm | - | 75mm   |
| For weld thickness over 100mm         | - | t±25mm |
- 8.11** The reference blocks manufactured in house, shall be inspected and certified by NDT Level III.

## **9 CALIBRATION TECHNIQUES:**

### **9.1 Technique for Straight Beam Calibration:**

**9.1.1** The sweep range for straight beam is set on the equipment using the IIW V1 block.

**9.1.2 Distance - Amplitude Correction:** The probe is positioned for maximum response from the hole that gives the highest amplitude and set to 80% (±5%) full screen height. The peak of the indication is marked on the screen with a glass marking pencil. Without disturbing the sensitivity controls of the unit, the probe is positioned for maximum response from the other two hole indications and their peaks marked on the screen.

The screen marks are connected and extended through the thickness to provide the distance amplitude correction (DAC) curve using flat bottom holes.

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## 9.2 Technique for Angle Beam Calibration:

**9.2.1** The basic calibration block shall be used for distance amplitude correction and position calibration.

**9.2.2** The sweep range is selected and the equipment is calibrated to the selected range using IIW - V1 or V2 blocks.

**9.2.3 Distance - Amplitude Correction (DAC):** To construct a DAC a basic calibration block having drilled holes at  $\frac{1}{4}T$ ,  $\frac{1}{2}T$  and  $\frac{3}{4}T$  shall be used. The gain is adjusted to provide an  $80\% \pm 5\%$  of full screen indication from the  $\frac{1}{4}T$  hole.

The peak of the indication is marked on the screen with a glass marking pencil. Without disturbing the settings, the probe is positioned for maximum response from the  $\frac{1}{2}T$ ,  $\frac{3}{4}T$  holes and  $T + \frac{1}{4}T$  hole after the beam has bounced from the opposite surface. The peak marks of the indications from the side drilled holes are connected to provide DAC curve.

When calibrated using notched specimen, indication from the root notch is brought to 80% of screen height and the sensitivity level is noted.

**9.3** A calibration check on PNECeast one of the basic reflections in the basic calibration block shall be made to ensure proper functioning of the equipment, at the beginning and finish of each examination or series of similar examinations, every 4 hours during the examination and when examination personnel are changed.

**9.4** The sensitivity (in dB) used for DAC shall be evaluation sensitivity or reference level.

**9.5** Transfer correction if any obtained, shall be added to test / evaluation sensitivity.

## 10 EXAMINATION SURFACE:

**10.1** For straight beam examination the weld and base material shall be scanned progressively along and across the weld surface to the extent possible from at least one surface of the part. Each pass of the search unit shall overlap a minimum of 15% of the transducer dimension parallel to the direction of scan indexing.

## 10.2 Angle Beam Scanning:

### 10.2.1 Defects parallel to the Weld (*Figure - 3*) :

The angle beam shall be directed at  $90^\circ$  to the weld axis, from two directions where possible. The probes shall be manipulated so that the ultrasonic energy passes through the required volumes of the weld and adjacent base material.

### 10.2.2 Defects Transverse to Weld (*Figure -4*) :

For detection of transverse defects the weld shall be examined using 45 deg. angle beam probe.

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For butt joints the angle beam shall be directed essentially perpendicular to the weld axis. The probe shall be manipulated so that the angle beam passes through required volumes of the weld and adjacent base metal. The probe shall be rotated at 180° and examination shall be repeated.

#### **11 SCANNING SENSITIVITY:**

Scanning sensitivity shall be a minimum of +6dB above the reference level. However evaluation of indications shall be performed at the primary reference level.

#### **12 EXAMINATION COVERAGE :**

For the angle beam examination the entire volume of the weld inclusive of adjacent base metal shall be examined by moving the probe over the examination surface.

During scanning, the probes shall be moved to and fro with swiveling action of 10° to 15° on either side with overlap between successive scanning.

Each pass of the probes shall overlap a minimum of 15% of the crystal element dimension perpendicular to the direction of the scan.

In any case the rate of probe movement for examination shall not exceed 125mm per second.

#### **13 CALIBRATION CONFIRMATION:**

A calibration check as discussed in 8.3, shall verify the sweep range calibration and distance amplitude correction.

##### **13.1 Sweep Range Correction:**

If a point on the DAC curve has moved on the sweep line more than 10% of the sweep reading or 5% of full sweep whichever is greater, the sweep range calibration shall be corrected. All recorded indications since the last valid calibration or calibration check shall be re-examined with the corrected calibration and the value changed.

##### **13.2 DAC Correction:**

If a point on the DAC curve has changed 20% or 2dB of its amplitude, all recorded indications since the last valid calibration check shall be re-examined with the corrected calibration.

#### **14 EVALUATION:**

Imperfections that cause an indication greater than 20% of the reference level shall be investigated to the extent that the ultrasonic examination personnel can

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determine their shape, identity, and location, and evaluate them in terms of clause number 15.0.

Discrimination of flaw indication from geometric indications shall be carried out by manual finger damping.

Sizing of the defect shall be carried out by 6 dB drop method.

## **15 ACCEPTANCE STANDARD**

**ASME SEC. VIII DIV.1 APPENDIX - 12**  
**ASME SEC. VIII DIV.2**  
**ASME SEC. IX**

## **16 POST EXAMINATION CLEANING:**

After the examination is completed the couplant applied on the surface shall be removed to the pre-inspection condition.

## **17 REPAIR & RETEST:**

Repaired weld regions shall be ultrasonically re-examined by the same procedure used for original testing.

## **18 REPORT:**

**18.1** Details of inspection of original weld and repaired area shall be recorded as per Exhibit No: PNEC/UT/01/f 01.REV 0 Date: 10.08.2012

**18.2** Recording all reflections from uncorrected areas having responses that exceed 50% of reference level shall be made.

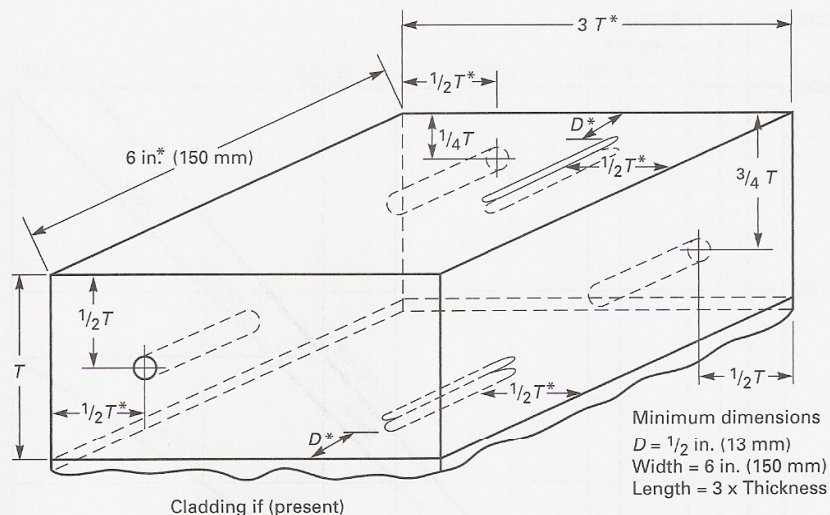
## **19 PROCEDURE QUALIFICATION:**

This procedure shall be qualified by performance demonstration and the variables with actual values and qualified range shall be recorded on Procedure Qualification Record Exhibit No: PNEC/UT/01/F02.REV 0 Date: 10.08.2012

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| Weld Thickness ( $t$ ),<br>in. (mm) | Calibration Block<br>Thickness ( $T$ ),<br>in. (mm) | Hole<br>Diameter,<br>in. (mm) | Notch Dimensions,<br>in. (mm)        |
|-------------------------------------|-----------------------------------------------------|-------------------------------|--------------------------------------|
| Up to 1 (25)                        | $\frac{3}{4}$ (19) or $t$                           | $\frac{3}{32}$ (2.5)          | Notch depth = 2% $T$                 |
| Over 1 (25) through 2 (50)          | $1\frac{1}{2}$ (38) or $t$                          | $\frac{1}{8}$ (3)             | Notch width = $\frac{1}{4}$ (6) max. |
| Over 2 (50) through 4 (100)         | 3 (75) or $t$                                       | $\frac{3}{16}$ (5)            | Notch length = 1 (25) min.           |
| Over 4 (100)                        | $t \pm 1$ (25)                                      | [Note (1)]                    |                                      |

\* Minimum dimension.

#### GENERAL NOTES:

- Holes shall be drilled and reamed 1.5 in. (38 mm) deep minimum, essentially parallel to the examination surface.
- For components equal to or less than 20 in. (500 mm) in diameter, calibration block diameter shall meet the requirements of T-434.1.7.2. Two sets of calibration reflectors (holes, notches) oriented 90 deg from each other shall be used. Alternatively, two curved calibration blocks may be used.
- The tolerance for hole diameter shall be  $\pm \frac{1}{32}$  in. (0.8 mm). The tolerance for hole location through the calibration block thickness (i.e., distance from the examination surface) shall be  $\pm \frac{1}{8}$  in. (3 mm).
- For blocks less than  $\frac{3}{4}$  in. (19 mm) in thickness, only the  $\frac{1}{2} T$  side-drilled hole and surface notches are required.
- All holes may be located on the same face (side) of the calibration block, provided care is exercised to locate all the reflectors (holes, notches) to prevent one reflector from affecting the indication from another reflector during calibration. Notches may also be in the same plane as the inline holes (See Appendix J, Fig. J-431). As in Fig. J-431, a sufficient number of holes shall be provided for both angle and straight beam calibrations at the  $\frac{1}{4} T$ ,  $\frac{1}{2} T$ , and  $\frac{3}{4} T$  depths.
- Minimum notch depth shall be 1.6%  $T$  and maximum notch depth shall be 2.2%  $T$  plus the thickness of cladding, if present.
- Maximum notch width is not critical. Notches may be made by EDM or with end mills up to  $\frac{1}{4}$  in. (6.4 mm) in diameter.
- Weld thickness,  $t$ , is the nominal material thickness for welds without reinforcement or, for welds with reinforcement, the nominal material thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing Code Section. When two or more base material thicknesses are involved, the calibration block thickness,  $T$ , shall be determined by the average thickness of the weld; alternatively, a calibration block based on the greater base material thickness may be used provided the reference reflector size is based upon the average weld thickness.

#### NOTE:

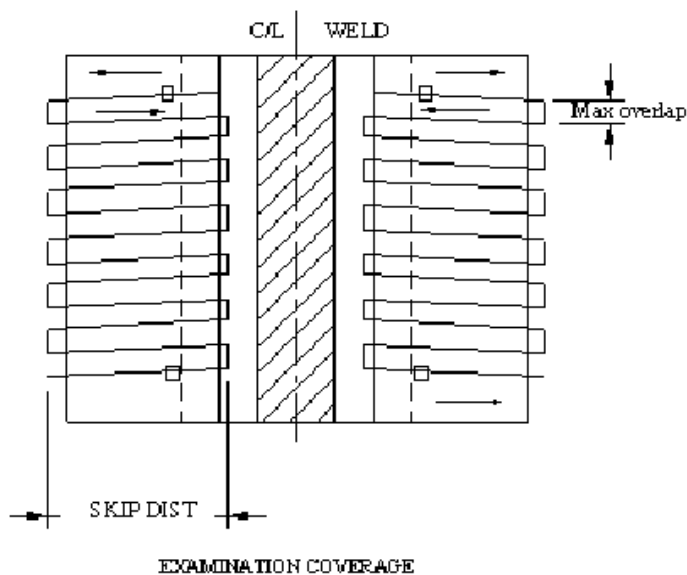
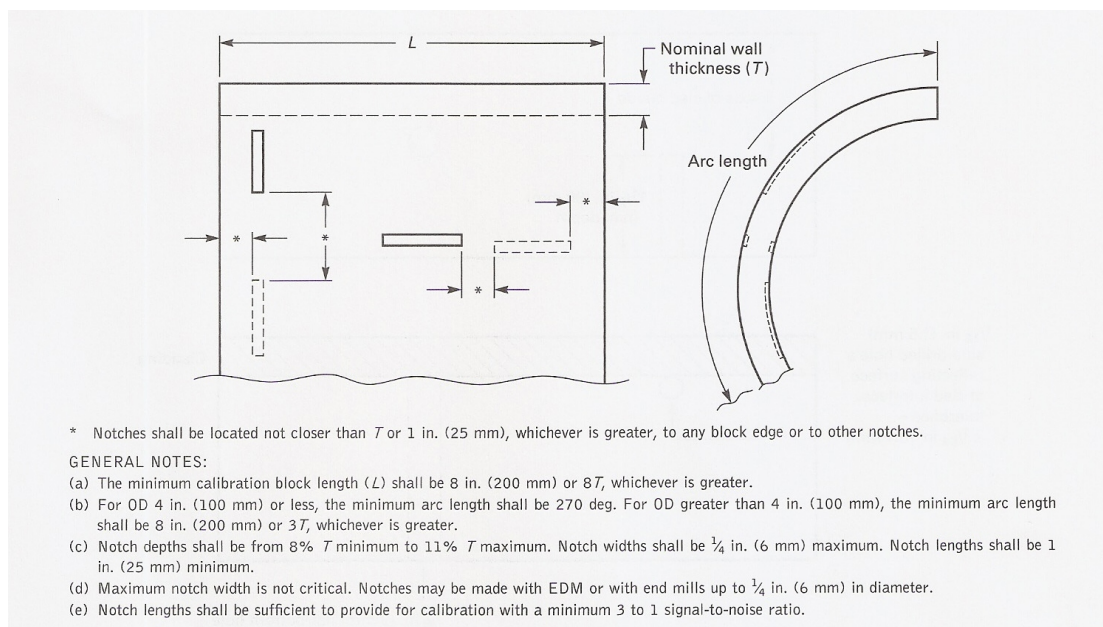
- For each increase in weld thickness of 2 in. (50 mm) or fraction thereof over 4 in. (100 mm), the hole diameter shall increase  $\frac{1}{16}$  in. (1.5 mm).

**FIGURE - 1 NON - PIPING CALIBRATION BLOCKS**

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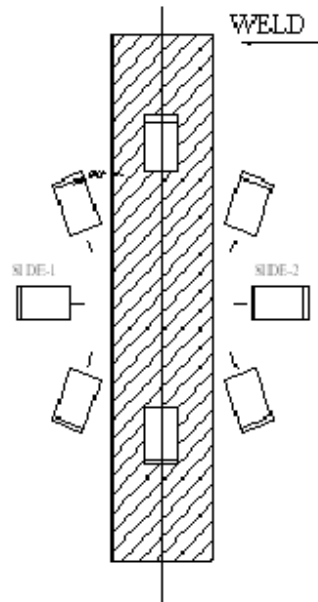
**FIG-2 PIPING CALIBRATION BLOCKS****FIGURE - 3 SCANNING TECHNIQUE**

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**FIGURE - 4 SCANNING DIRECTIONS FOR ANGLE BEAM**

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### **ULTRASONIC EXAMINATION REPORT**

|                                                         |                           |                          |                             |                |           |
|---------------------------------------------------------|---------------------------|--------------------------|-----------------------------|----------------|-----------|
| Client                                                  |                           |                          |                             |                |           |
| Job Description                                         |                           | Report No.               |                             |                |           |
| Drawing No.                                             |                           | Date of Test             |                             |                |           |
| Material                                                |                           | Calibration Block        |                             |                |           |
| Thickness                                               |                           | Reference Block          |                             |                |           |
| Procedure No.                                           |                           | Calibration Range        | Normal:                     |                |           |
| Weld Configuration                                      |                           |                          | Angle:                      |                |           |
| Surface condition                                       |                           | Search Unit              | Normal                      | Angle          | Angle     |
| Equipment                                               |                           | Serial No.               |                             |                |           |
| Model                                                   |                           | Size                     |                             |                |           |
| Serial No.                                              |                           | Frequency                |                             |                |           |
| Search unit cable type & length :                       |                           |                          | Couplant                    |                |           |
| Calibration Data:                                       |                           |                          |                             |                |           |
| Area of restricted access Or In accessible weld if any: |                           |                          |                             |                |           |
| Gain Normal                                             |                           | Reference                | Scanning                    | Gain Angle     | Reference |
|                                                         |                           |                          |                             |                |           |
| <b>Sl. No.</b>                                          | <b>Job Identification</b> | <b>Indication Length</b> | <b>Type of Indication</b>   | <b>Results</b> |           |
|                                                         |                           |                          |                             |                |           |
|                                                         |                           |                          |                             |                |           |
| METHOD OF SCANNING DIRECTION SKETCH:                    |                           |                          |                             |                |           |
| <b>REMARKS:-</b>                                        |                           |                          |                             |                |           |
|                                                         |                           |                          | <b>AUTHORIZED INSPECTOR</b> |                |           |
| Name :                                                  |                           | Name:                    | Name:                       |                |           |
| Signature& Date:                                        |                           | Signature& Date:         | Signature& Date:            |                |           |
| Level :                                                 |                           | Designation:             | Designation:                |                |           |

**Exhibit No: PNEC/UT/01/F02.REV 0/Date: 10.08.2012**

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