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“पुराने को छोड़ नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 4260 (2004): Recommended practice for ultrasonic testing of butt welds in ferritic steel [MTD 21: Non-Destructive Testing]
Indian Standard

RECOMMENDED PRACTICE FOR ULTRASONIC TESTING OF BUTT WELDS IN FERRITIC STEEL

(Third Revision)

ICS 77.040.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

November 2004
FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Non-destructive Testing Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1967 and subsequently revised in 1975 and 1986. This has now been revised again in the light of experience gained and the latest developments in ultrasonic testing of welds. The requirements for distance amplitude correction examination procedure and periodic calibration have been modified.

This standard is intended to be a guide for method of ultrasonic testing of welds by direct contact pulse echo reflection method.

For general technique relating to ultrasonic testing, reference may be made to IS 3664:1981 'Code of practice for ultrasonic pulse echo testing by contact and immersion methods (first revision).

This standard gives detailed procedure of examination of butt welds in ferritic steel.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2:1960 'Rules for rounding off numerical value (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.
Indian Standard
RECOMMENDED PRACTICE FOR ULTRASONIC TESTING OF BUTT WELDS IN FERRITIC STEEL
(Third Revision)

1 SCOPE
1.1 This standard prescribes a method for ultrasonic testing and inspection of welds by direct contact pulse echo reflection method. This method is applicable to material thickness over 5 mm.

1.2 These requirements are established for detection, location and evaluation of reflection within the weld, heat affected zone and adjacent material. The examination classification are:
   a) Welds in ferritic product forms in wrought and cast materials, other than pipes; and
   b) Ferritic welds in ferritic pipes.

1.3 This standard covers technique to be employed at normal temperature. Care shall be taken to ensure that the temperature of test piece is not above the temperature for which the probe is designated.

2 REFERENCES
The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<table>
<thead>
<tr>
<th>IS No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2417:2003</td>
<td>Glossary of terms relating to ultrasonic testing (first revision)</td>
</tr>
<tr>
<td>3664:1981</td>
<td>Code of practice for ultrasonic pulse echo testing by contact and immersion method (first revision)</td>
</tr>
<tr>
<td>8791:1971</td>
<td>Code of practice for ultrasonic flaw detection of ferritic steel forging</td>
</tr>
<tr>
<td>12666:1988</td>
<td>Method for performance assessment of ultrasonic flaw detection equipment</td>
</tr>
<tr>
<td>13805:2004</td>
<td>General standard for qualification and certification of non-destructive testing personnel</td>
</tr>
</tbody>
</table>

3 TERMINOLOGY
For the purpose of this standard, the definitions given in IS 2417 shall apply.

4 EQUIPMENT
4.1 The ultrasonic apparatus shall be capable of producing, receiving and displaying high frequency acoustic pulses over the nominal range of 1 to 5 MHz, and shall be of pulse echo reflection type. Other frequencies may be used, if equal to better sensitivity can be demonstrated.

4.2 The ultrasonic instruments and probes shall be capable of being used without difficulty in the temperature range of -10 to +50°C.

4.3 The ultrasonic instrument shall provide linear vertical presentation within ± 5 percent of full screen height from 20 to 80 percent of the full screen height. The screen height linearity shall be measured and recorded in accordance with IS 12666.

4.4 The ultrasonic apparatus shall have an amplitude control, accurate over its useful range of ± 20 percent of the nominal amplitude ratio to allow measurement of indications beyond the linear range of the vertical display on the screen. The amplitude control linearity shall be measured as described in IS 12666.

4.5 The ultrasonic apparatus shall be adjusted for sweep range and calibrated prior to inspection as described in IS 12666.

5 TEST PROCEDURES

5.1 Basic Calibration Block

5.1.1 The basic calibration reflectors shall be used to establish a primary reference response of the equipment. The basic calibration reflectors may be located either in the finished component material provided the same shall not affect the serviceability or in a basic calibration block.

5.1.2 The material from which the block is fabricated shall be of the same product form, that is, plate, forging bar, tubes, etc, and material specification, having similar acoustic characteristics of the finished component. The thickness of basic calibration block shall be related to finished component thickness as shown in Table 1 corresponding to Fig. 1. When two or more base material thicknesses are involved, the
calibration block thicknesses shall be determined by average thickness of weld. The finish on the surface of the block shall be representative of the surface finishes on the finished components.

5.1.3 For contact examination the temperature difference between the examination and the calibration block surfaces shall be within 14°C. Calibration and sensitivity setting shall be performed under temperature conditions similar to those used in the test or appropriate compensations for angle and sensitivity changes shall be made.

6 PROBE

6.1 A shear wave probe which produces an angle of 45° to 70° in the examination medium is normally used. The selection of the beam angle is dependent on the thickness and geometry of the weld. The recommended beam angles for different thicknesses of material are shown below:

<table>
<thead>
<tr>
<th>Thickness mm</th>
<th>Beam Angle Inside the Medium degree</th>
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<tr>
<td>Up to 30</td>
<td>70</td>
</tr>
<tr>
<td>Over 30 to 50</td>
<td>60</td>
</tr>
<tr>
<td>Over 50</td>
<td>45</td>
</tr>
</tbody>
</table>

6.2 Probes with a beam angle less than 45° and more than 70° may be used, if the geometry of the weld is more adaptable to the chosen beam angle. Shoes may be found necessary to fit into the probes to suit the curvature of the surface. Whenever such probes are used for examination, calibration also has to be done with the same type.

6.3 The nominal frequency shall be in the range of 2 to 5 MHz. Unless variables such as production material and grain structure require the use of other frequencies to assure adequate penetration or better resolution.

7 COUPLANT

A satisfactory couplant, liquid or paste, having good wetting properties to permit the transmission of mechanical vibrations between the probe and material under test shall be used. Oil, glycerine, water greases; silicone and white lead paste are among the more commonly used couplants.

8 SURFACE PREPARATION

8.1 The base metal on each side of the weld shall be free of weld spatter, surface irregularities or foreign matter that might interface with the examination.

8.2 The weld ripples or weld surface irregularities shall be removed by any suitable mechanical means to such a degree that the resulting ultrasonic examination from any remaining irregularities cannot mask any objectionable defects. The finished surface of the reinforcement should merge smoothly into the surface of the adjacent base material.

8.3 The volume of the base material through which the sound will travel in angle beam examination shall

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Weld Thickness, t mm</th>
<th>Basic Calibration Block Thickness, T mm</th>
<th>Hole Diameter</th>
<th>(Clause 5.1.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>25.4 or less</td>
<td>19 or t</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>ii)</td>
<td>Over 25.4 up to 51</td>
<td>38 or t</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>Over 51 up to 102</td>
<td>76 or t</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>iv)</td>
<td>Over 102 up to 151</td>
<td>127 or t</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>Over 152 up to 203</td>
<td>176 or t</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>vi)</td>
<td>Over 203 up to 254</td>
<td>228 or t</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>vii)</td>
<td>Over 254 (see Notes)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES
1 For such increase in thickness of 51 mm or fraction thereof, the hole diameter shall increase 1.6 mm.
2 Hole shall be drilled and reamed to a minimum of 38 mm essentially parallel to the examination surface.
3 Curved surfaces: For curved surfaces, two curved blocks, one for each representative curvature or two sets of calibration reflectors oriented 90° from each other shall be used.
4 Notches may be provided as required.
5 Tolerances for hole diameter shall be ± 0.8 mm.
6 Tolerance on notch depth shall be ± 10 and – 20 percent.
7 Tolerance on hole location through thickness shall be ± 3.2 mm.
be completely scanned with a straight beam search unit usually of 2 MHz frequency to detect and record reflections which might affect interpretation of angle beam results. This is not intended as an acceptance/rejection examination.

8.4 Dual probes may be employed in plates of thickness 5 mm to 12 mm for detection of reflectors.

9 DISTANCE AMPLITUDE CORRECTION

9.1 Compensation for the distance traversed by the ultrasonic beam as it passes through the material is provided by the use of curves shown in Fig. 2.

9.2 The angle beam probe shall be directed towards the basic calibration reflectors in the calibration block. The centre-line of the probe shall not point towards the corners of the hole. The sound beam shall be oriented perpendicular to the axis of the side drilled holes. The probe is positioned for maximum response from the side-drilled hole that gives the highest amplitude. The sensitivity controls are adjusted to provide an 80 percent (+5 percent of full screen height) of full screen indication from the hole. The peak of the indication is marked on the CRT screen. The probes are positioned at other nodal positions covering the expected examination range.
corresponding peaks are marked on the CRT screen. The peaks are joined by a smooth line whose length cover the examination range to generate DAC curve.

9.3 For evaluation of discontinuities oriented perpendicular to examination surface at or near the surfaces, 45° probe is positioned at appropriate distance necessary for maximum signal amplitude from the square notch machined on the opposite surface of the calibration block. This amplitude reference level is alone chosen for evaluation of discontinuities at or near the surfaces.

9.4 If an electronic distance amplitude correction device is used the reference response shall be equalised at 50 percent of full screen height over the distance range employed in the examination.

9.5 For weld thickness 25 mm or less a single calibration reflector shall be located at 50 percent T thickness of calibration block. No DAC curve need be established. The signal amplitude obtained from the reflector is kept as the reference amplitude level for testing. The signal amplitude obtained shall be appropriate to the metal path (beam bath) distance employed for the examination of a welded component.

9.6 For straight beam examination, the straight beam probe is positioned for maximum response from the hole that gives the highest amplitude. The sensitivity control of the unit are to be adjusted to provide an 80 percent of full screen height. The probe shall be positioned for maximum response from the another holes and the peaks of the indication shall be marked on the screen. The peaks are smoothly connected and extended through the thickness to provide the distance amplitude curve from the side drilled holes.

10 EXAMINATION PROCEDURE

10.1 The volume of the weld shall be examined by moving the probe over the examination surface so as to scan the entire examination volume. Each pass of the probe shall overlap a minimum of 10 percent of the transducer (piezo electric element) dimensions perpendicular to the direction of the scan.

10.2 The rate of probe movement for examination shall not exceed 150 mm/s.

10.3 During movement, both towards and away from the welded joints of flat/near flat surface, the probe shall be oscillated over an angle 10° to 15° on each side of a line normal to the centre line of the weld.

11 SCANNING

11.1 For straight beam examination the probe is positioned directly on the weld surface of the examination material. The weld shall be scanned progressively along and across the width of weld inclusive of adjacent heat affected zone to its entire length. Penetration is always verified with back reflection amplitude.

11.2 When dual probes are employed for examination, the included angle between the beam paths shall be such that the focal length of the probe is not less than the thickness of the weld under examination. The examination shall be performed with the plane separating the elements of the dual probe parallel and perpendicular to the axis of the weld in two directions as described in 11.1.

11.3 The scanning shall be performed at a gain setting 6 dB above the reference level. Evaluation shall be performed at the primary reference level for straight beam examinations.

11.4 Angle beam examinations of weld thickness less than 10 mm shall be carried out from both sides of the weld on the same surface. The total width of the scanning zone shall be equal to twice the skip distance.

11.5 For weld thickness between 10 mm and 100 mm, angle beam examination shall be done from both sides of the weld on the same surface wherever practicable, the scanning zone being a full skip distance.

11.6 For welds over 100 mm in thickness the welds shall be scanned using angle beam probes from four sides, that is, from both sides of the weld from inner and outer surfaces. The probe shall be moved as near as possible to the centre line of the weld to ensure full coverage. The scanning width shall be 5/8th of a skip distance from weld centre line.

12 SCANNING FOR REFL ECTORS ORIENTED PARALLEL TO WELD

12.1 The angle beam shall be directed as approximate right angles to the weld axis from two directions where possible. The probe shall be manipulated so that the ultrasonic energy passes through the required volumes of weld and adjacent base metal. The scanning shall be performed at a gain setting of 6 dB above the reference level. Evaluation shall be performed with respect to the primary reference level.

12.2 Scanning for Reflectors Oriented Transverse to Weld

The angle beam shall be directed essentially parallel to the weld axis. The probe shall be adjusted so that the angle beam passes through the required volumes of weld metal and adjacent base metal. The scanning shall be performed at a gain setting 6 dB above the reference level and evaluation will be performed with respect to the primary reference level. The probe shall be rotated 180° and the examination repeated.

13 EVALUATION

13.1 Any imperfection which causes an indication in excess of 20 percent DAC shall be investigated to estimate the nature of flaw, then can be evaluated
in terms of a acceptances standard. The indications of height 50 to 100 percent DAC shall be recorded.

13.2 Recording of indication shall be made with respect to the reference level.

14 FERRITIC WELDS IN FERRITIC PIPE

14.1 Basic Calibration Block

14.2 The basic calibration block for weldments shall be a section of the same nominal size, schedule heat treatment and material specification as the material being examined. The surface finish of the calibration block shall be representative of the surface finish of the piping.

14.3 The basic calibration reflections shall be longitudinal and circumferential notches on both the inner and outer surfaces. The sizes and locations of the calibration reflectors are shown in Fig. 3.

15 ANGLE BEAM CALIBRATION

15.1 The nominal frequency shall be 2.0 MHz. Higher frequencies may be used, if there is a need for greater resolution.

15.2 The nominal beam angle of 45° shall be used. Other angles may be used as appropriate based on the configurations of weld joint being examined.

16 DISTANCE-AMPLITUDE CORRECTION (DAC)

16.1 A distance-amplitude correction (DAC) curve is established by beaming the angle beam probe towards the calibration reflector that yields the maximum response to 80 percent of full screen height. The probe is then manipulated without changing instrument settings, to obtain maximum response from the calibration reflectors at the distance increment necessary to generate a 3 point DAC curve.

Welds may be tested as described in 11, 12 and 13.

16.2 Selection of Calibration Reflectors

A side drilled hole may be used for initial acceptance of pipe weld, provided that it can be demonstrated that the hole calibration produces a sensitivity equal to or greater than the notch calibration.

17 EVALUATION

17.1 Any imperfection that causes an indication in excess of 20 percent DAC shall be investigated to estimate the nature of flaw that can be evaluated in terms of acceptance standard. The indications of height 50 to 100 percent DAC shall be recorded.

17.2 Recording of indications shall be made with respect to the reference level.

18 PROCEDURES FOR DETERMINING THE LOCATION AND SIZE OF FLAWS

18.1 Flaw Location

The position of flaw within the weld may be estimated from the position of the flaw echo on the CRT screen. The distance between the flaw echo and the initial pulse as read from the calibrated time base on the screen is the actual beam path distance $W'$ of flaw. From the known beam angle of the probe used, the precise location of the flaw from the entry surface can be calculated using the formula $t = W \cos \alpha$ where $t$ is the thickness of component on which the probe is placed within half skip distance from the centre of the weld. When the crystal is placed between half and full skip distance, the formula is to be corrected as $2t = W \cos \alpha$. Alternatively a flaw locating rule or accurate sketches may be drawn to locate the flaws in a weld.

![Fig. 3 Angle Beam Calibration (Pipe Welds)](image)

**Typical Block Dimensions:**

- Length ($L$) 200 mm or 8T whichever is greater
- Minimum ARC Length A.L.:
  - i) for O.D. 101.6 mm or less 270 deg.
  - ii) for O.D. greater than 101.6 mm the greater of 3T or 200 mm.

**Specific Notch Dimensions:**

- Length 25 mm, Min.
- Depth 10 percent, T (tolerance on depth + 10 percent – 20 percent).
- Width 3.2 mm or 6.4 mm
- Location Not closer than T from any block edge.
18.2 Size of the Flaw

18.2.1 In order to estimate the size of a flaw in any particular direction, the effective beam width at the flaw position has to be known. In the flaw size investigation it is to be determined first, whether the flaw is a large reflector or a small reflector. Large reflector is one that is larger than the sound beam at its position, and a small reflector is one that is smaller than the sound beam at its position.

18.2.2 The size of a large reflector is determined by scanning the borders of the flaw with the ultrasonic beam, by moving the probe from the centre of the discontinuity until the height (6 dB drop). This operation is repeated to establish the boundary. This is true for straight beam probes and in horizontal, vertical plane for angle beam probes.

18.2.3 In case of a small reflector using angle beam probes measurements of beam spread in the vertical plane shall be made on the side drilled holes as given in Fig. 1 and Table 1 for appropriate thickness at different distance from the shear wave probe. To estimate the flaw size the probe is scanned so that the beam moves parallel to vertical direction and the distance within which the flaw echo amplitude within 6 dB of the maximum, is determined. The flaw size is given by the difference between the probe distance moved to touch the edges of the calibration hole and flaw in the weld multiplied by the cosine of the beam angle inside the medium. The calibration hole chosen shall be appropriate to the scanning path of the flaw.

18.2.4 To obtain the boundary in the horizontal plane, the shear wave probe is moved parallel to the blind side drilled hole described in 18.2.3 until the amplitude drips to 6 dB from its maximum amplitude at different distances from the probe. The distance from the edge of the block to the position of crystal subtracted from the depth of the hole gives half-beam width. To estimate the flaw size in a horizontal plane the probe is moved laterally so that the beam axis moves parallel to the lateral direction and the distance is within which the flaw echo amplitude is within 6 dB of the maximum is determined. The flaw also is given by the difference between the dimensions and effective full beam width.

19 NATURE OF FLAWS

19.1 On determining the location and size of the flaw and from the knowledge of defects normally encountered in different welding processes, an estimate of the nature of flaw may be made. These different types may be classified, namely, isolated pores, types elongated (worm hole) and planar flaws are usually differentiated by various scanning techniques.

19.1.1 Isolated pores are indicated by a constant echo signal height using a swivel scan.

19.1.2 Elongated cylindrical flaws are indicated by a constant signal height over a significant length and a sharp peak for a shorter length in lateral and depth scanning depending upon the orientation of the flaw.

19.1.3 Planar flaws produce sharp peaks when scanned normal to their direction and drops suddenly when the probe is swivelled.

20 ACCEPTANCE

Ultrasonic acceptance or rejection criteria for individual butt weld shall be based on a realistic appraisal of service requirements that shall be established between the purchaser and the manufacturer on the basis of the quality that can normally be obtained in such welds.

21 CHECK FOR LINEARITY ON TIME BASE, SCREEN HEIGHT AND AMPLITUDE CONTROL

21.1 Time Base Linearity

When the time base is linear, the distance between repeat echoes shall be equal. The check shall be made at the time of calibration of test ranges. The position of the echoes are noted without parallax by adjusting the echo height to 50 percent of full screen height. The displayed readings shall not deviate ± 2 percent of the range calibrated or one minor division of the screen.

21.2 Linearity of Vertical Scale and Amplitude Control

A straight beam search unit frequency 2 MHz or 4 MHz shall be positioned over the depth resolution notch in the IIW block described in IS 12666 so that the signal from the notch is 20 percent of screen height and the signal from the 100 mm block surface is 40 percent of screen height. When the sensitivity of the apparatus is altered so that the signal from notch is raised in increment of one major vertical scale division until the 100 mm location signal reaches full scale and then lowered in increment the smaller indication reading shall be 50 percent of the larger amplitude within 5 percent of full screen height. The readings shall be established to the nearest of 1 percent of full screen height.

21.3 Amplitude Control Linearity

To verify the accuracy of amplitude control of the ultrasonic apparatus an angle beam search unit is positioned on the calibration block as shown in Fig. 1 so that the indication from the 1/2 T hole is peaked on the screen. With the increase and decrease in the attenuation shown in the following table the indication must fall within the specified limits:
The settings and readings must be estimated to the nearer one percent of full screen.

**22 CALIBRATION CONFIRMATION**

22.1 Calibration shall be performed prior to use of the system in the thickness range under examination, a calibration check shall verify the sweep range calibration and distance-amplitude correction.

22.2 Sweep Range Correction

If a point on the DAC curve has moved on the sweep line more than 10 percent of the sweep reading or 5 percent of full sweep, whichever is great, correct the sweep range calibration and note the correction in the examination record. If reflectors are recorded on the data sheets, those data sheets shall be avoided and a new calibration shall be recorded. All recorded indications since the last valid calibration or calibration check shall be re-examined with the corrected calibration and their values shall be changed on the data sheets.

22.3 DAC Correction

If a point on the distance-amplitude correction (DAC) curve has decreased 20 percent or 2 dB of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new calibration shall be made and recorded and the area covered by the voided data shall be re-examined. If any point of the distance-amplitude correction (DAC) curve has increased more than 20 percent of 2dB of its amplitude, all recorded indications since last valid calibration or calibration check shall be re-examined with the corrected calibration and their values shall be changed on the data sheets.

**23 PERSONNEL REQUIREMENTS**

Personnel performing ultrasonic examination to the requirements of this article shall be qualified as required by IS 13805.

**24 REPORT**

A report of the examination shall be made. The report shall include a record indicating the weld or volume examined, the location of each recorded reflector and the identification of the operator who carried out each examination or part thereof. The report shall be placed in file and maintained in accordance with IS 8791 and IS 3364.
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Amendments Issued Since Publication

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