

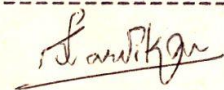
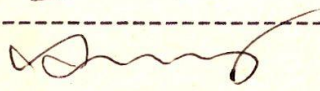


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PROCEDURE FOR ULTRASONIC EXAMINATION OF WELDS

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RECORD OF REVISION

Rev No	Rev. Date	Details of Revision
06	28-3-94	Revised in entirety.
07	01-08-96	Revised in entirety.
08	01-04-97	Revised to merge and replace BHE:NDT:PB:UT:01/01,01/02,01/03, 11,13,14,16,17 & 25 to represent as a single procedure.



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1.0 SCOPE

1.1 This procedure defines the requirements of equipment, calibration, examination procedure and acceptance standards for ultrasonic examination of ferritic welds that is required to be performed by contract or referencing code for the following products :

a) Butt,corner and Tee joints in components of boilers, Pressure vessels , heat-exchangers and HP/LP bypass sulzer Valves, with a dia greater than 120 mm and thickness equal to or greater than 10 mm.

b) Butt joints in pipes of dia greater than 120 mm and thickness equal to or greater than 10 mm .

c) Butt joints in boiler pipes/tubes í 31.8 to 120 mm and thickness 3.6 mm to 13 mm.

2.0 REFERENCE

2.1 ASME Section I/V/VIII Divn. 1&2,/1995 & 1996 Addenda.

3.0 EQUIPMENT

3.1 The equipment shall be of pulse - echo type that responds to frequencies 1 MHz to 6 MHz.

3.1.1 Krautkramer/Germany and equivalent models will be used.

3.2 Equipment Calibration

3.2.1 The Screen height linearity and amplitude control linearity shall be performed in accordance with BHE:NDT:UT:Calib:1 at the beginning of each period of extended use or every 3 months whichever is less.

3.3 Probes

3.3.1 Probes can be either single or dual transducer elements. Probes with curved contact wedges may be used to improve ultrasonic coupling in which case calibration shall be done with contact wedges used during the examination.

3.3.2 The nominal probe frequency shall be 2 MHz. High frequency (4 MHz) probes will be used to improve flaw resolution and flaw length dimensioning. Frequency < 2 MHz will be used to assure adequate penetration, when coarse grain structures are encountered.

3.4 Couplant

3.4.1 Grease - oil mix ,oil or glycerine will be used as couplant. The couplant used for the examination shall be the same that is used for calibration.

4.0 PERSONNEL QUALIFICATION

4.1 Personnel performing examinations shall be qualified in accordance with BHE:NDT:G :CRT: The testing and evaluation shall be conducted by minimum Level-I Personnel.

5.0 SURFACE PREPARATION

5.1 For longitudinal flaw scanning the base metal on both surfaces and each side of the weld shall be free of weld



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spatter, impurities, rust, scale, foreign matter and disturbing unevenness for appropriate skip distances to allow free movement of probes.

- 5.2 For transverse flaw scanning where the weld surface interferes with the examination, both inner & outer weld surfaces shall be flush ground to permit examination.

6.0 EXAMINATION

- 6.1 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 deg on either side with overlap between successive scanings. Each pass of the probe shall over-lap a minimum of 10% of the crystal element dimension perpendicular to the direction of the scan.

6.2 Rate of probe movement

- 6.2.1 The rate of probe movement for examination shall be less than 150 mm/sec.

6.3 Angle beam/Longitudinal flaw scanning

- 6.3.1 The angle beam shall be directed at 90 ° to the weld axis. The probe shall be manipulated so that ultrasonic energy passes through the required volumes of weld and adjacent base material.

6.4 Angle-beam/ transverse flaw scanning

- 6.4.1 The angle beam shall be directed essentially parallel to the weld axis and the probe shall be manipulated so that the angle beam passes through required volumes of weld and adjacent base metal. The probe shall be rotated 180 deg and examination repeated.

6.5 Scanning sensitivity

- 6.5.1 The scanning shall be performed at a gain setting + 6 dB of the primary reference level. Evaluation shall be performed with respect to primary reference level.

6.6 Repair

- 6.6.1 Repaired welds in all the above materials shall be re-examined by the same procedure used for original testing.

6.7 Report

- 6.7.1 A detailed report duly signed by a minimum Level II NDE personnel shall be issued in a standard format .
- 6.7.2 The records made in the inspection register shall be retained for a minimum period of one year, unless otherwise required.

7.0 POST EXAMINATION CLEANING

- 7.1 After the examination is over the couplant applied on the surface shall be removed, if the residue couplant could interfere the further use of the test piece.

8.0 WELDS IN BOILER DRUMS,PRESSURE VESSELS & VALVES

- 8.1 BASIC CALIBRATION BLOCK :Fig. (1) & (2)



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- 8.1.1** The material from which the block is fabricated shall be of the same product form and material specification or equivalent P-Number grouping of the materials being examined.
- 8.1.2** The finish on the surfaces of the block shall be representative of the surface finishes on the production material.
- 8.1.3** For contact examination the temperature difference between the examination and basic calibration block surfaces shall be within 14 degree C.
- 8.1.4** For examination in materials where the examination surface dia is greater than 508 mm, either a block of essentially the same curvature or a flat basic calibration block shall be used.
- 8.1.5** For materials with examination surface diameter 508 mm or less, the basic calibration block shall be curved. A single curved basic calibration block may be used to calibrate, examination of surfaces, in the range of 0.9 to 1.5 times the basic calibration block diameter.
- 8.1.6** Where the block thickness $\geq$ 25 mm spans two of weld thickness ranges the block's use shall be acceptable in those portions of each thickness range covered by 25 mm.
- 8.2** Basic calibration reflector:
- 8.2.1** The cylindrical holes shall be used as calibration reflector and shall have a minimum length of 38 mm.
- 8.2.2** Rectangular notches also may be used to compare flaws that may arise and orient normal to the surfaces. These notches shall have a minimum length of 50 mm and shall not interfere with establishing the primary reference response.
- 8.3** Calibration check
- 8.3.1** When any part of the examination system is changed a calibration check shall be made on the calibration block. A calibration check on at least one of the basic reflectors in the basic calibration block shall be made at the finish of each examination, every 4 hrs. during the examination and when examination personnel (except for automated units) are changed.
- 8.4** Sweep Range correction
- 8.4.1** 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, then the sweep range calibration shall be corrected.
- 8.4.2** If reflectors are recorded on data sheets, these data sheets shall be considered invalid and a new calibration shall be recorded. All recorded indications since the last valid calibration shall be re-examined with corrected calibration and their values changed on the data sheets.
- 8.5** DAC correction
- 8.5.1** If a point on the Distance - amplitude correction (DAC) curve has decreased 20% or 2 dB of its amplitude, all data sheets since the last calibration or calibration check shall be considered invalid.



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- 8.5.2** A new calibration shall be made and recorded. The invalid areas covered shall be re-examined.
- 8.5.3** If any point of the distance-amplitude correction (DAC) curve has increased more than 20% or 2dB of its amplitude, all recorded indication since the last valid calibration or calibration check shall be re-examined with corrected calibration and their values shall be changed on the data-sheets.
- 9.0** SCANNING ADJACENT BASE MATERIAL
- 9.1** The scanning of adjacent base material shall be performed with straight-beam probe to detect reflectors that might affect interpretation of angle beam results. Locations and areas of such reflectors shall be recorded. This adjacent base material examination is not to be used as acceptance - rejection examination.
- 10.0** TECHNIQUES FOR ANGLE BEAM CALIBRATION
- 10.1** Sweep Range: Fig.(5)
- 10.1.1** The maximum sweep range shall be adjusted such that the at 3/8 skip distance the left edge of 3/4T hole indication falls on approx.60% of time base CRT screen.
- 10.2** Distance Amplitude Calibration (DAC) : Fig.(6)
- 10.2.1** The center-line of the probe shall be at least 38 mm from the nearest side of the block. Rotation of the beam into the 'corner' formed by the hole and side of the block shall not be used for calibration.
- 10.2.2** The calibration shall be performed by positioning the probe from 1/8 to 5/8 skip distances for obtaining maximum response from 1/4T ,1/2T and 3/4 T cylindrical holes. The echo peaks of the indication are connected to provide distance amplitude correction curve (DAC) .
- 10.3** Calibration correction for rectangular notches
- 10.3.1** To evaluate reflectors that may arise and orient normal to the surfaces the amplitude response from rectangular notches may be utilised. In such cases, the response from these notches shall be brought within 5% of DAC as in 10.2 and appropriate dB correction shall be taken into account for evaluation of discontinuities.
- 10.4** Exemption to DAC
- 10.4.1** A DAC is not required where the examination is limited to Half-skip distance in a material of less than 25 mm thickness. In such cases the amplitude level from a single calibration reflector shall be used.
- 11.0** STRAIGHT BEAM CALIBRATION
- 11.1** Sweep Range Calibration:
- 11.1.1** The Sweep range is calibrated using IIW Block adjusting delay and range controls so that the sweep is 1.25 times that of production material thickness.
- 11.2** Distance - amplitude corrections : Fig.(7)



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11.2.1 The calibration shall be performed by positioning the probe for maximum response from the side-drilled holes. The echo peaks of the indication are connected to provide distance amplitude curve (DAC) for the side drilled holes.

12.0 STRAIGHT BEAM EXAMINATION:

12.1 For straight beam examination longitudinal wave probes (0 degree) shall be used.

12.1.1 For straight beam examination the crystal dimensions shall be in the range of 10 mm to 25 mm.

12.1.2 The weld and fusion-zone of adjacent base material shall be scanned to the extent possible from one surface of the production part.

13.0 ANGLE BEAM EXAMINATION:

13.1 Scanning angle : Fig.(3)

13.1.1 For angle beam examination shear wave probes between 45 degree and 70 degree shall be used.

13.1.2 One shear-wave angle beam probe shall be employed for examination of all butt joints , corner and Tee joints that require ultrasonic testing to be performed by contract or referencing code.

13.1.3 For angle beam examination the crystal dimensions shall be selected appropriate to the contact examination surface and generally be in the range of 8 mm to 25 mm.

13.2 Scanning Position and Directions : Fig.(8) to (11)

13.2.1 Scanning shall be performed from both surfaces and from each side of the weld between 1/8 to 5/8 skip distances from the weld-centre line.

13.2.2 All welds in valves other than type RSK 360/10 and NR 64/500 EK valves ,will undergo only longitudinal flaw scanning.

13.2.3 For welds in Sulzer valves scanning shall be either from the outside (OD) or inside surface (ID) of the nozzle depending upon the configuration of the weld.

13.2.4 When examination is practical from one surface only, the 1/4 T volume lying below the examination surface , shall be examined from each side of the weld ,by additionally positioning and moving the probe from 3/4-T to 1-T (full) skip distance.

13.2.5 When examination is practical from one surface and one side only two angle-beam probes shall be used . One of the angle-beam employed shall be 45 degree.

14.0 EVALUATION:

14.1 Any imperfection which causes an indication in excess of 20% DAC (-14 dB) shall be interpreted to determine the identity, shape and locations of all such imperfections to characterize them for their nature and type.

14.2 Indications that are determined to originate from metallurgical structure such as weld metal to austenitic clad interface shall be classified as spurious indications.

14.3 Recording:



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- 14.3.1 All indications having signal amplitudes equal to and above 50% of the reference level shall be recorded.
- 14.4 Flaw length measurements : Fig.(12)
- 14.4.1 Indications from discontinuities that remain from 100% DAC to 20% of DAC the length of the reflector shall be obtained by recording the position and location along the lengths of the weld as determined by 50% level of maximum amplitude for each end of reflector(6 db drop).
- 14.4.2 Indications that exceed the reference level the length of the reflector shall be determined by recording the position and location along the lengths of the weld until the maximum amplitude echo just falls below the 100% DAC reference response curve(0 db drop).
- 15.0 ACCEPTANCE STANDARD:
- 15.1 Indications characterized as cracks, lack of fusion of incomplete penetration are not acceptable regardless of length.
- 15.2 Indications from other imperfections are not acceptable if the indications exceed the reference level and have lengths which exceed
- a) 6 mm for 't' upto 19 mm,
 - b) $1/3t$ for t from 19 mm to 57 mm
 - c) 19 mm for t over 57 mm
- where 't' is thickness of weld excluding any allowable reinforcement.
- 15.3 For a butt weld joining two members having different thickness at the weld 't' is the thinner of the thickness. If a full penetration weld includes a fillet weld, the thickness of 'throat' of the fillet shall be included in 't'.
- 16.0 WELDS IN PIPES OF OUTER DIA (OD) GREATER THAN 120 mm
- 16.1 BASIC CALIBRATION BLOCK:
- 16.1.1 The basic calibration block for pipe welds shall be a section of the pipe of the same nominal size, schedule, heat-treatment and material specification or equivalent P-Number grouping.
- 16.1.2 The surface finish of the calibration block shall be representative of the surface finish of the piping.
- 16.2 Calibration reflector:
- 16.2.1 The calibration reflectors shall be longitudinal and circumferential notches on both the inner and outer
- 17.0 ANGLE BEAM CALIBRATION:
- 17.1 DAC shall be established with notches used as calibration reflectors. The echo peaks from these notches at $1/2, 1$ and 1.5 skip distances shall be joined to generate a 3 point DAC Curve. This is the primary reference response (PRR).
- 18.0 ANGLE BEAM EXAMINATION:



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18.1 Scanning angle:

18.1.1 For angle beam examination one shear wave angle-beam probe of 45 degree shall be generally used. Other beam angles 60 degree or 70 degree will be used when it is appropriate to the configuration of piping being examined, its thickness and groove angle employed for welding.

18.1.2 For angle beam examination the crystal dimensions shall be selected appropriate to the contact examination surface and generally be in the range of 8 mm to 25 mm.

18.2 Scanning Position and Directions:

18.2.1 Scanning shall be performed from outer surface only and from each side of the weld between 1/2 to one full skip distance .

18.2.2 When examination is practical from one surface and one side only two angle-beam probes shall be used . One of the angle-beam employed shall be 45 degree.

19.0 EVALUATION:

19.1 Any imperfection which causes an indication in excess of 20% DAC (-14 dB) shall be interpreted to determine the entity, shape and locations of all such imperfections to characterize them for their nature and type.

19.2 Indications that are determined to originate from surface conditions such as weld root geometry, counter-bore, weld reinforcement shall be classified as 'geometry indications' .

19.3 Recording:

19.3.1 All indications having signal amplitudes equal to and above 50% of the reference level shall be recorded.

19.4 Flaw length measurement:

19.4.1 The measurements shall be made as in 14.4

19.5 ACCEPTANCE STANDARD:

19.5.1 The acceptance shall be as in 15.0

20.0 WELDS IN PIPES/TUBES OUTER DIA (OD) $\geq$ 120 mm

20.1 This procedure is applicable to induction pressure welds (IPW) & fusion welds in boiler tubes for the purpose of detecting radial-type defects having their major dimension circumferentially relative to the tube axis.

21.0 BASIC CALIBRATION BLOCK:

21.1 The basic calibration block shall be a section of the pipe with a diameter and thickness within $\pm 30\%$ of the production material pipe ,heat-treatment and material specification or equivalent P-Number grouping.

21.2 Calibration Reflector:



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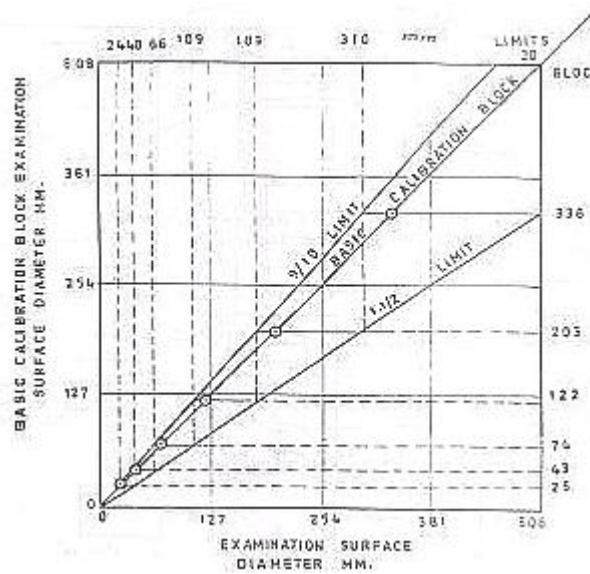
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- 21.2.1** The calibration reflectors shall be Circumferential notches on both the inner and outer surface . The calibration reflectors shall be minimum 6 mm long, 0.8mm deep for wall-thickness upto 6 mm and 1.0 mm deep for wall thickness greater than 6 mm.
- 21.2.2** The notches in the calibration piece shall be kept clean. If contaminated by couplant or accumulated dirt the notches shall be cleaned by washing with a stream of water directed into and along the notch and rinsed with acetone, or other rapid drying solvent.
- 22.0 ANGLE BEAM CALIBRATION:**
- 22.1** The angle beam probe shall be directed toward ID notch that yields the maximum response, adjusting the instrument settings to 80% of full screen height (FSH), in half node if practicable or in 1.5 skip or more so that this indication appears around 50 % of the time-base. The left end of the gate shall be adjusted to this position on the CRT.
- 22.2** The probe shall be then positioned at distance necessary to resolve the OD notch and the right end of the gate shall be adjusted to this sweep position on the CRT. The gate length just established will be the area for acceptance or rejection of indication when combined with the proper transducer position. The OD notch shall be used as reference to establish the gate length only.
- 23.0 ANGLE BEAM SCANNING:**
- 23.1** Only longitudinal flaw scanning shall be performed from outer surface and from each side of the weld upto to 2 skip distances using 70 deg. shear-wave probe.
- 24.0 EVALUATION:**
- 24.1** Indications that are determined ,by careful evaluation of the examination area, to originate from surface conditions such as weld root geometry, counter-bore, weld reinforcement, mismatched upset on ID and OD ,they shall be classified as geometry indications.
- 24.2** Indications contained within the OD upset may be removed and re-examined provided the OD reinforcement has not been reduced below the specified minimum wall thickness.
- 25.0 ACCEPTANCE STANDARD: Fig.(16)**
- 25.1** Any flaw-indication exceeding the primary reference shall be unacceptable .
- 25.2** Welds made by Induction Pressure welding the following 'surface imperfections' Viz off-center and mismatch greater than 1.5 mm ; peak and melt on OD as shown in Fig.16 are not acceptable.

BASIC CALIBRATION BLOCK

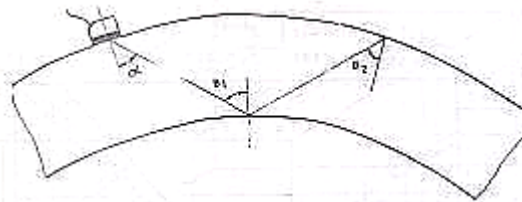
FIG (1)



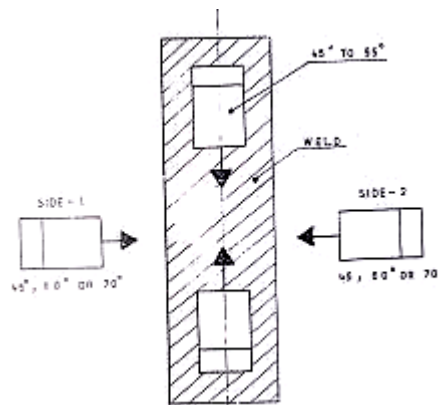
Fig(2)-RATIO LIMITS FOR CURVED SURFACES

General Notes

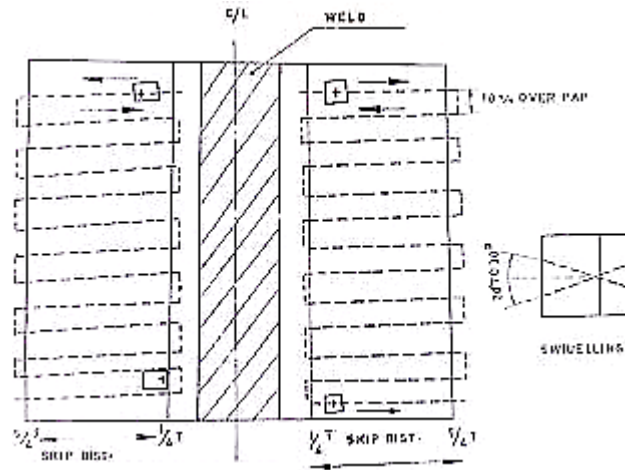
- Plot examination surface of basic calibration block on 45° diagonal line
- Draw horizontal line through that point from 0.9 to 1.5 limit line
- The ends of this line read on the horizontal scale give the range of examination surface diameters which may be examined with a system calibrated on this block
- Thickness range requirements shall also be satisfied.



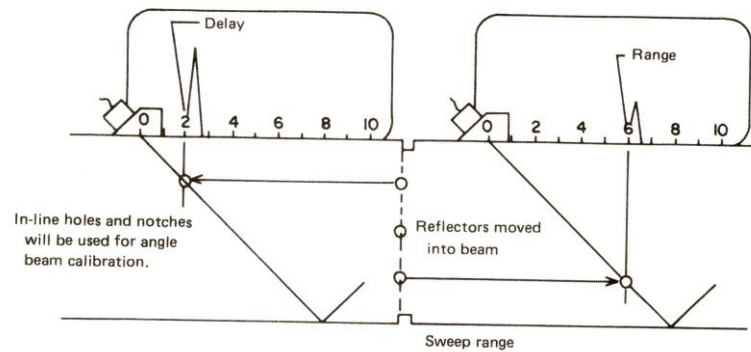
Fig(3)-INCIDENT BEAM PATH IN STEEL (α) AND IMPACT ANGLES B1 AND B2 ON SURFACES



Fig(3A) SCANNING DIRECTIONS FOR ANGLE BEAM

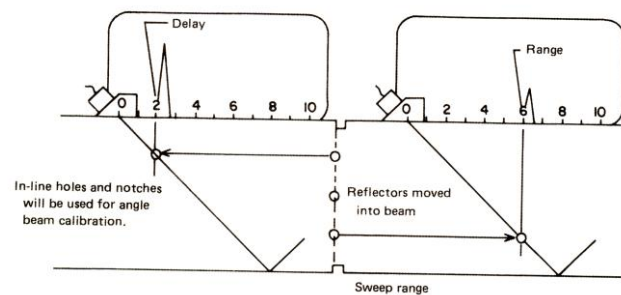


Fig(4) SCANNING

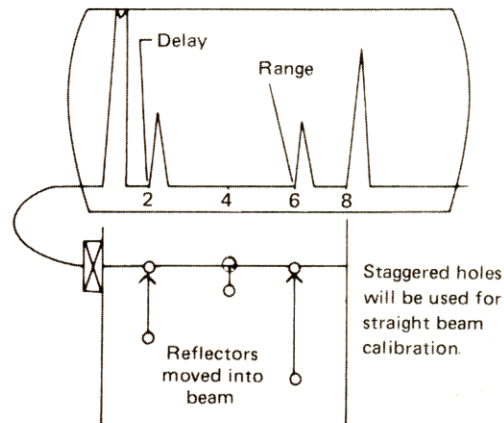


Fig(5) SWEEP RANGE(ANGLE BEAM)

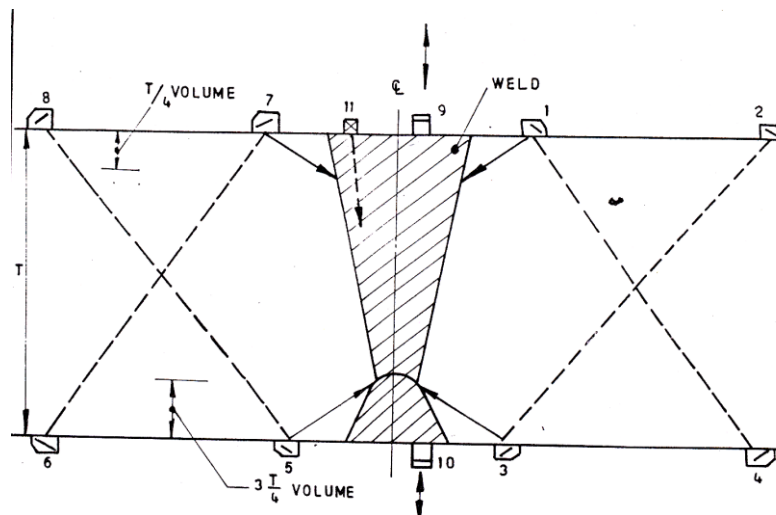
Note: For delay IIW Block 100 mm radius echo or as above will be used



Fig(6) SENSITIVITY AND DISTANCE AMPLITUDE CORRECTION(ANGLE BEAM)



Fig(7) SENSITIVITY AND DISTANCE AMPLITUDE CORRECTION (ST.BEAM)



FIG(8)-SCANNING DIRECTIONS AND EVALUATION AREAS FOR BUTT WELD

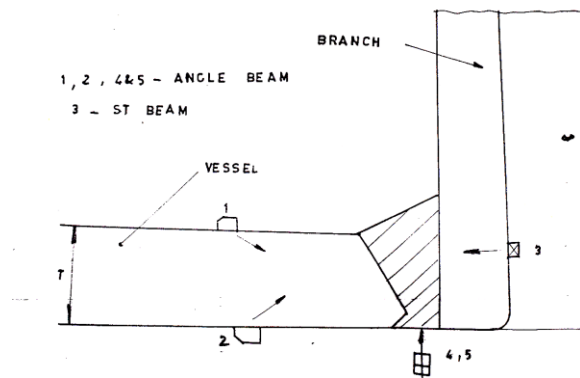
Probe Position:

1 to 8 :Scanning perpendicular to weld axis- Angle beam

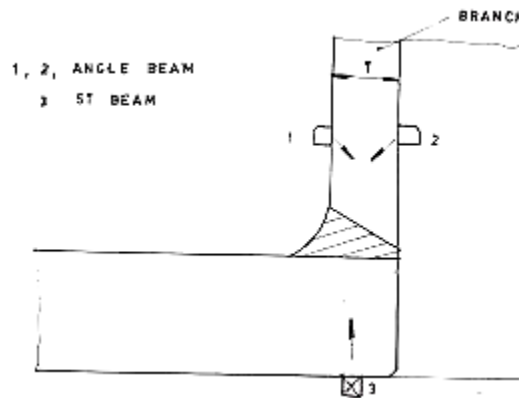
9 to 10 :Scanning along weld axis- Angle beam

11 :Straight beam scanning

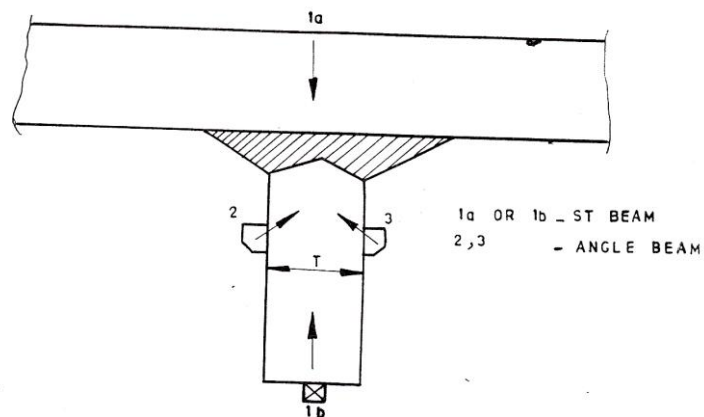
Evaluation area: 1/4 to 5/4 T on sweep line



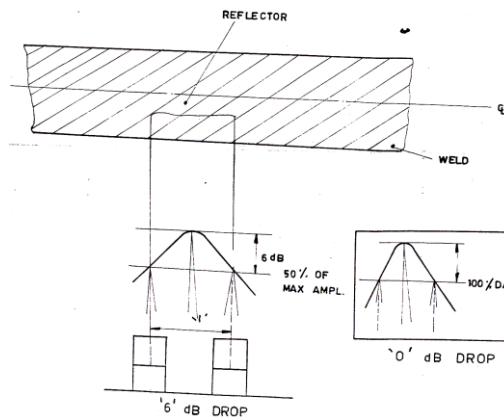
Fig(9): SCANNING DIRECTION- FULL PENETRATION CORNER WELD(SET-THROUGH)



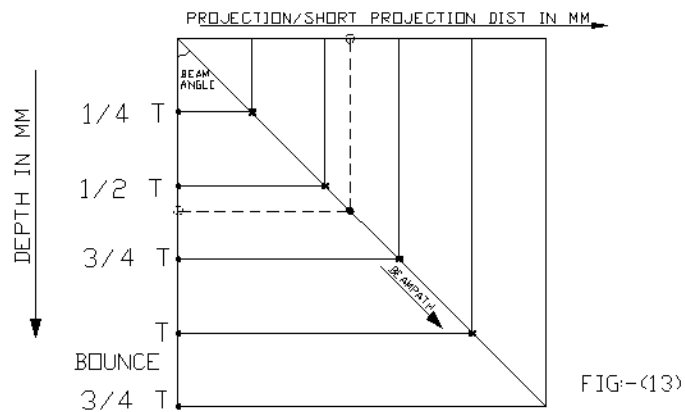
FIG(10) SCANNING DIRECTIONS FULL PENETRATION CORNER WELDS(SET-ON)



FIG(11) SCANNING DIRECTION FOR 'T' WELDS (ATTACHMENT)



FIG(12) MEASUREMENT OF LENGTH OF REFLECTOR

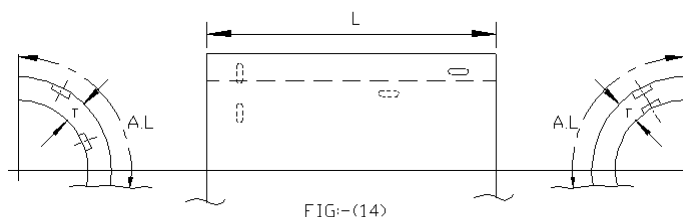


Fig(13) CONSTRUCTION OF BEAM PATH LINE(Eg45°)

- Project vertically $\frac{1}{4} T$ value and measured projected distance to intersect at X. Repeat for $\frac{1}{2}T$, $\frac{3}{4}T$, T and $\frac{3}{4}T$ after bounce
- Join X X X X points to prepare beam path line. Check X X X X values are close to CRT readings

TO LOCATE REFLECTS ON MATERIAL SURFACE AND IN THROUGH THICKNESS

- Note the reflectors beam path in mm on CRT sweep line
- Project vertically ----- lines to meet projection distance & depth and locate the reflector on the surface.



Fig(14) ANGLE BEAM CALIBRATION(PIPE WELD)
TYPICAL BLOCK DIMENSION

Length L = 203mm or 8 T whichever is greater

Minimum arc length(AL)

- 1) For OD 102 mm and less : 270°
- 2) For OD >102 mm the greater of 3T or 203 mm

SPECIFIC NOTCH DIMENSIONS

Length L = 25.4 mm
Depth D = 10 % t WITH TOLERANCE +10 % to -20% of depth
Width = 3.2mm to 6.4 mm
Location -Not closer than T from the block edge

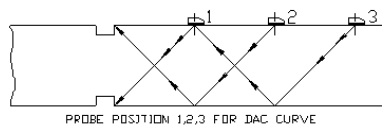
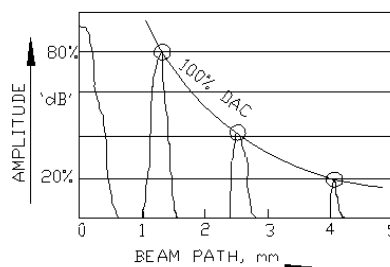


FIG-(15)



Fig(15) DISTANCE AMPLITUDE CORRECTION (ANGLE BEAM)

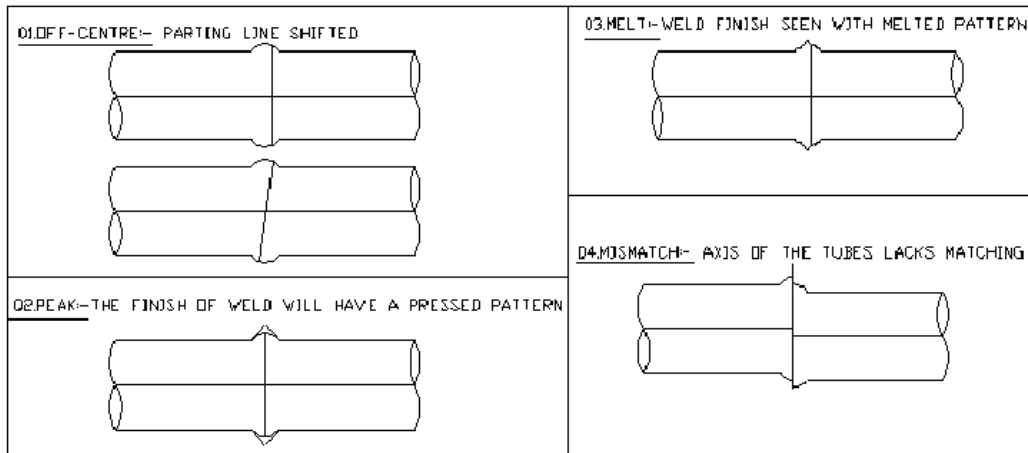


FIG:-(16)

Fig(16) ACCEPTANCE FOR VISUAL DEFECTS

NB- 01-Off-Centre, Mismatch >1.5 mm, Peak and Melt are not acceptable
02- UT need not be done
