
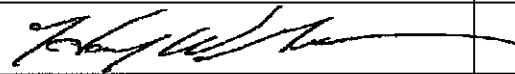





TITLE: GENERAL PROCEDURE FOR ULTRASONIC EXAMINATION OF WELDMENTS PER AWS D1.1

PAGE NO.: 1 OF 30

Approval	Diamond  Inspection Inc.	
Name	Harry W. Gibson NDE Level III	
Signature		
Date	February 1, 2007	February 1, 2007

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TABLE OF CONTENTS

	PAGE
1.0 Scope	3
2.0 References	3
3.0 Personnel	3
4.0 Material Type and Thickness Range	3
5.0 Ultrasonic Equipment	4
6.0 Calibration of Equipment	9
7.0 Testing Procedures	11
8.0 Preparation and Disposition of Reports	17
9.0 Calibration of Ultrasonic Test Instrument with IIW or Other Approved Reference Blocks	20
10.0 Equipment Qualification Procedures	24
11.0 Discontinuity Size Evaluation Procedures	28
12.0 Scanning Patterns	29
13.0 Examples of dB Accuracy Certification	30

14. please include report of UT and a sample

1.0 SCOPE

- 1.1 This procedure covers the general procedure and requirements for ultrasonic examination of groove welds and heat-affected zones as required by AWS D1.1. This specific procedure prohibits the ultrasonic examination of tube-to-tube T-, Y- or K-connections.
- 1.2 Diamond G Inspection, Inc. certifies that this document meets the minimum requirements of AWS D1.1, and any other code or specification referencing methods for ultrasonic examination as defined by AWS D1.1. acceptance standards.

2.0 REFERENCES

- 2.1 American Welding Society (AWS)

D1.1 – Structural Welding Code – Steel, Section 6, Part F – Ultrasonic Testing (UT) of Groove Welds, latest edition and revision
- 2.2 American Society for Nondestructive Testing (ASNT)

Recommend Practice No. SNT-TC-1A – Personnel Qualification and Certification in Nondestructive Testing, latest edition and revision

ASNT Central Certification Program (ACCP) – Central Certification of Nondestructive Testing Personnel, latest edition and revision

3.0 PERSONNEL

- 3.1 Personnel performing and evaluating this examination shall be qualified and certified in conformance with the requirements of Diamond G Inspection's Written Practice, which shall meet the requirements of SNT-TC-1A.
- 3.2 NDT Level I, II or III personnel may perform the examination, however, only NDT Level II or III personnel shall evaluate the results.

4.0 MATERIAL TYPE and THICKNESS RANGE

The procedure is applicable the following type of materials and thicknesses:

- 4.1 Steel (carbon & stainless) – 5/16 in. (8.0 mm) and 8 in. (203 mm) thicknesses inclusive.

4.2 Steel (carbon & stainless) – <5/16 in. (8.0 mm) or >8 in. (203 mm) thicknesses testing shall be performed in conformance with Annex K of AWS D1.1.

5.0 ULTRASONIC EQUIPMENT

Which make, s/n will be used by the company? specify

5.1 UT Test Instrument Requirements

The ultrasonic test instrument shall be the pulse echo type suitable for use with search units oscillating at frequencies between 1 MHz and 6 MHz. The display shall an "A" scan rectified video trace.

5.2 Horizontal Linearity

The horizontal linearity of the ultrasonic test instrument shall be qualified over the full sound path distance to be used in testing in conformance with 10.1.

5.3 Requirements for UT Test Instruments

The ultrasonic test instruments shall include internal stabilization so that after warm-up, no variation in response greater than ± 1 dB occurs with a supply voltage change of 15% nominal or, in the case of a battery, throughout the charge operating life. There shall be an alarm or meter to signal a drop in battery voltage prior to test instrument shutoff due to battery exhaustion.

5.4 Calibration of UT Test Instruments

The ultrasonic test instrument shall have a calibrated gain control (attenuator) adjustable in discrete 1 or 2 dB steps over a range of at least 60 dB. The accuracy of the attenuator settings shall be within ± 1 dB. The procedure for qualification shall be as described in 5.8.2 and 10.2.

5.5 Display Range

The dynamic range of the test instrument's display shall be such that a difference of 1 dB of amplitude can be easily detected on the display.

5.6 Search Units

5.6.1 Straight Beam (Longitudinal Wave) Search Units

Straight beam (longitudinal wave) search units shall have an active area of not less than $\frac{1}{2}$ square inches (323 square mm) nor more than 1 square inch (645 square mm). The search unit shall be round or square.

- (1) Round search units shall be a minimum of $\frac{13}{16}$ inch diameter (21 mm) to a maximum of 1- $\frac{1}{8}$ inch diameter (28 mm).
- (2) Square search units shall be either $\frac{3}{4}$ inch x $\frac{3}{4}$ inch (19 mm x 19 mm) or 1 inch x 1 inch (25.4 mm x 25.4 mm).

Search unit shall be capable of resolving the three reflections as described in 9.2.5.

5.6.2 Angle Beam Search Units

Angle beam search units shall consist of a search unit and an angle wedge. The unit may be comprised of the two separate elements or may be an integral unit. The search unit shall be square or rectangular in shape.

5.6.3 Frequency

The search unit frequency shall be between 2 and 2.25 MHz, inclusive.

5.6.4 Search Unit Dimensions

The search unit crystal shall be square or rectangular in shape and may vary from $\frac{5}{8}$ in. to 1 in. (15 to 25 mm) in width and from $\frac{5}{8}$ to $\frac{13}{16}$ in. (15 to 20 mm) in height. The maximum width to height ratio shall be 1.2 to 1.0, and the minimum width to height ratio shall be 1.0 to 1.0.

5.6.5 Angles

The search unit shall produce a sound beam in the material being examined within plus or minus 2 degrees of one of the following angles: 70°, 60° or 45°, as described in 9.2.2.

5.6.6 Markings

Each search unit shall be marked to clearly indicate the frequency of the search unit, nominal angle of refraction, and index point. The index point location procedure is described in 9.2.1.

5.6.7 Internal Reflections

Maximum allowable internal reflections from the search unit shall be as described in 5.8.3.

5.6.8 Edge Distance

The dimensions of the search unit shall be such that the distance from the leading edge of the search unit to the index point shall not exceed 1 in. (25 mm).

5.6.9 IIW Block

The qualification procedure using the IIW reference block shall be in conformance with 9.2.6 and as shown in Figure 5.

5.6.10 Couplant

The couplant, including additives, shall not be detrimental to the material being examined.

5.7 Reference Standards

5.7.1 IIW Standard

The International Institute of Welding (IIW) ultrasonic reference block, as shown in Figure 1, shall be the standard used for both distance and sensitivity calibration. Other portable blocks may be used provided the reference level sensitivity for test instrument/search unit combination is adjusted to be the equivalent of that achieved with the IIW Block. (See Annex X of AWS D1.1, for examples).

5.7.2 Prohibited Reflectors

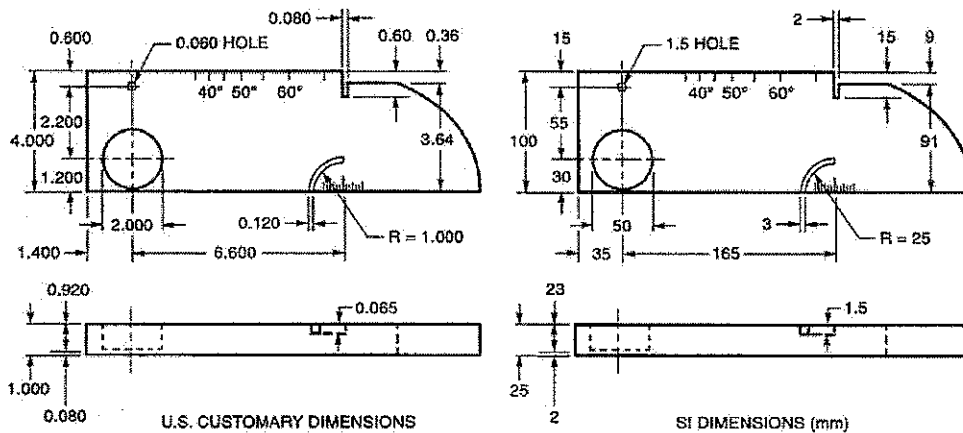
The use of a "corner" reflector for calibration purposes is prohibited.

5.7.3 Resolution Requirements

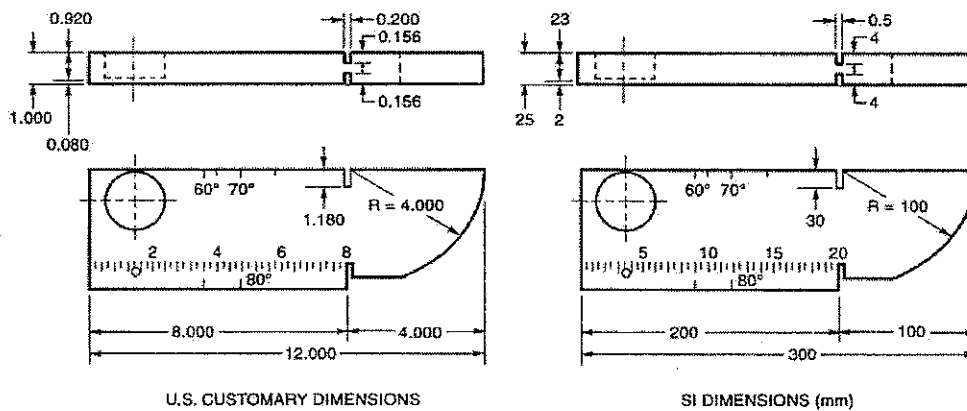
The combination of search unit and test instrument shall resolve three holes in the RC resolution reference test block shown in Figure 2. The search unit position is described in 9.2.5. The resolution shall be evaluated with the test instrument controls set at normal test settings and with indications from the holes brought to mid-screen height. Resolution shall be sufficient to distinguish at least the peaks of indications from the three holes. Use of the RC resolution reference block for calibration is prohibited. Each combination of test instrument search unit (shoe and search unit) shall be checked prior to its initial use. This equipments verification shall be done initially with each search unit and ultrasonic test

instrument combination. The verification need not be done again provided documentation is maintained that records the following items:

- (1) Ultrasonic test instrument make, model, and serial number.
- (2) Search unit's manufacturer, type, size, angle, and serial number.
- (3) Date of verification and technician's name.



(A) TYPE 1 (TYPICAL)

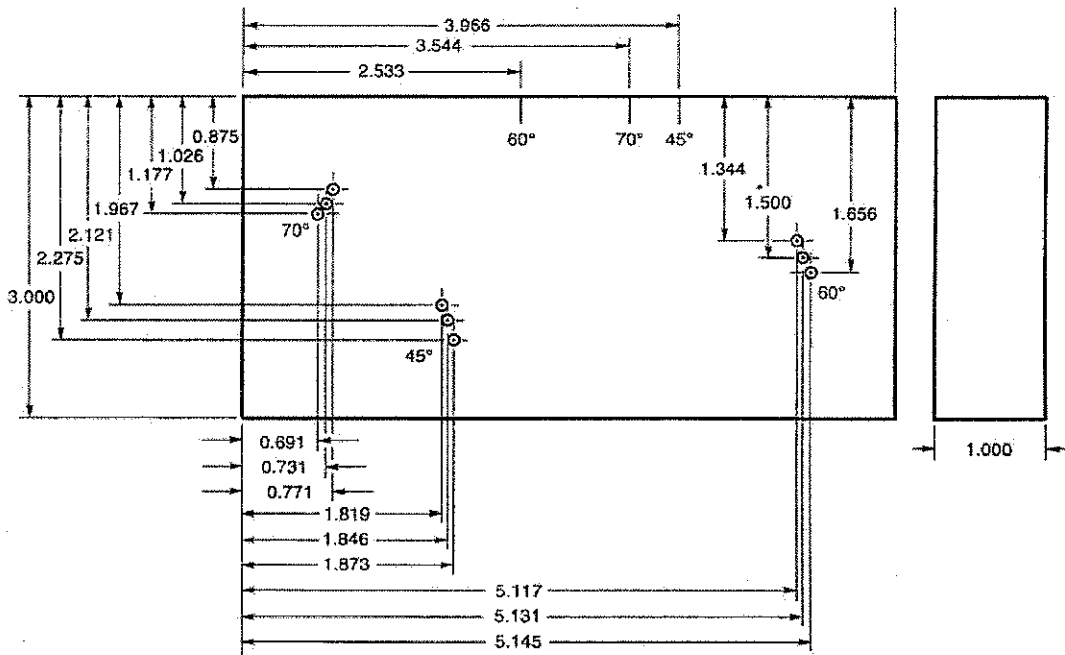


(B) TYPE 2 (TYPICAL)

General Notes:

- The dimensional tolerance between all surfaces involved in referencing or calibrating shall be within $\pm .005$ in. [0.13 mm] of detailed dimension.
- The surface finish of all surfaces to which sound is applied or reflected from shall have a maximum of 125 μ in. [3 μ m] r.m.s.
- All material shall be ASTM A 36 or acoustically equivalent.
- All holes shall have a smooth internal finish and shall be drilled 90° to the material surface.
- Degree lines and identification markings shall be indented into the material surface so that permanent orientation can be maintained.
- Other approved reference blocks with slightly different dimensions or distance calibration slots are permissible (see Annex X).
- These notes shall apply to all sketches in Figures 6.22 and 6.23.

Figure 1 – International Institute of Welding (IIW) UT Reference Block



General Note: All holes are 1/16 in. in diameter.

DIMENSIONS IN INCHES

Figure 2 – RC – Reference Block

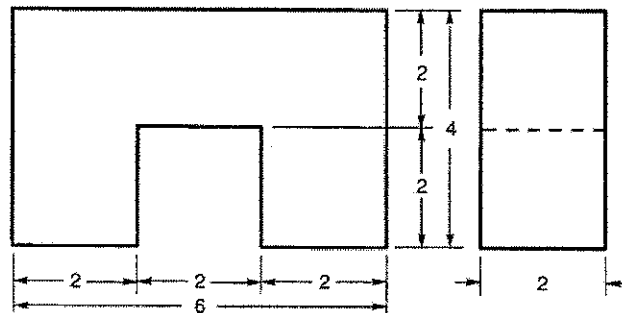


Figure 3 – Type – Distance and Sensitivity Reference Block

5.8 Qualification of Equipment

5.8.1 Horizontal Linearity

The horizontal linearity of the ultrasonic test instrument shall be requalified after each 40 hours of test instrument use in each of the distance ranges that the test instrument will be used. The qualification procedure shall be in conformance with 10.1. (See Annex X of AWS D1.1 for alternative method).

5.8.2 Gain Control

The test instrument's gain control (attenuator) shall meet the requirements of 5.8.4 and shall be checked for correct calibration at two month intervals in conformance with 10.2. Alternative methods may be used for calibrated gain control (attenuator) qualification if proven at least equivalent with 10.2.

5.8.3 Internal Reflections

Maximum internal reflection from each search unit shall be verified at a maximum time interval of 40 hours of test instrument use in conformance with 10.3.

5.8.4 Calibration of Angle Beam Search Units

With the use of an approved calibration block, each angle beam search unit shall be checked after each 8 hours of use to determine that the contact face is flat, that the sound entry point is correct, and that the beam angle is within the allowed plus or minus 2° tolerance in conformance with 9.2.1 and 9.2.2. Search units which do not meet these requirements shall be corrected or replaced.

6.0 CALIBRATION FOR EXAMINATION

6.1 Position of Reject Control

All calibrations and tests shall be made with the reject (clipping or suppression) control turned off. Use of the reject (clipping or suppression) control may alter the amplitude linearity of the test instrument and invalidate test results.

6.2 Technique

Calibration for sensitivity and horizontal sweep (distance) shall be made by the ultrasonic operator just prior to and at the location of testing of each weld.

6.3 Recalibration

Recalibration shall be made after a change of operators, each 30 minute maximum time interval, or when the electrical circuitry is disturbed in any way which includes the following:

- 6.3.1 Search unit change
- 6.3.2 Battery change
- 6.3.3 Electrical outlet change
- 6.3.4 Coaxial cable change
- 6.3.5 Power outage (failure)

6.4 Straight Beam Testing of Base Metal

Calibration for straight beam testing of base metal shall be made with the search unit applied to Face A of the base metal and performed as follows:

6.4.1 Sweep

The horizontal sweep shall be adjusted for distance calibration to present the equivalent of at least two plate thicknesses on the display.

6.4.2 Sensitivity

The sensitivity shall be adjusted at a location free of indications so that the first back reflection from the far side of the plate will be 50 to 75% of full screen height.

6.5 Calibration for Angle Beam Testing

Calibration for angle beam testing shall be performed as follows (see Annex X, X2.4 of AWS D1.1 for alternative method).

6.5.1 Horizontal Sweep

The horizontal sweep shall be adjusted to represent the actual sound path distance by using the IIW block or alternative blocks as specified in 5.7.1. The distance calibration shall be made using either the 5 in. (130 mm) scale or 10 in. (255 mm) scale on the display screen, whichever is appropriate. If, however, the joint configuration or thickness prevents full examination of the weld at either of these settings, the distance calibration shall be made using 15 or 20 in. (380 or 510 mm) scale as required. The search unit position is described in 9.2.3.

Note: The horizontal location of all screen indications is based on the location at which the left side of the trace deflection breaks the horizontal base line.

6.5.2 Zero Reference Level

The zero reference level sensitivity used for flaw evaluation ("b" on the ultrasonic test report, Annex D, Form D-11 of AWS D1.1 shall be attained by adjusting the calibrated gain control (attenuator) of the discontinuity detector, meeting the requirements of 5.0, so that a maximized horizontal reference level trace deflection results on the display screen, in conformance with 9.2.4.

7.0 TESTING PROCEDURES

7.1 "X" Line

An "X" line for flaw location shall be marked on the test face of the weldment in a direction parallel to the weld axis. The location distance perpendicular to the weld axis is based on the dimensional figures on the detail drawing and usually falls on the centerline of the butt joint welds, and always falls on the near face of the connecting member of T and corner joint welds (the face opposite Face C).

7.2 "Y" Line

A "Y" accompanied with a weld identification number shall be clearly marked on the base metal adjacent to the weld that is ultrasonically tested. This marking is used for the following purposes:

7.2.1 Weld identification

7.2.2 Identification of Face A

- 7.2.3 Distance measurements and direction (+ or -) from the "X" line
- 7.2.4 Location measurement from weld ends or edges

7.3 Cleanliness

All surfaces to which a search unit is applied shall be free of weld spatter, dirt, grease, oil (other than that used as a couplant), paint, and loose scale and shall have a contour permitting intimate coupling.

7.4 Couplants

A couplant material shall be used between the search unit and the test material. The couplant shall be either glycerin or cellulose gum and water mixture of a suitable consistency. A wetting agent may be added if needed. Light machine oil may be used for couplant on calibration blocks.

7.5 Extent of Testing

The entire base metal through which ultrasound must travel to test the weld shall be tested for laminar reflectors using a straight beam search unit conforming to the requirements of 5.6.1 and calibrated in conformance with 6.4. If any area of the base metal exhibits total loss of back reflection or an indication equal to or greater than the original back reflection height is located in a position that will interfere with the normal weld scanning procedure, its size, location, and depth from the A face shall be determined and reported on the ultrasonic test report and an alternate weld scanning procedure shall be used.

7.5.1 Reflector Size

The reflector size evaluation procedure shall be in conformance with 11.1.

7.5.2 Inaccessibility

If part of a weld is inaccessible to testing in conformance with the requirements of Table 1, due to laminar content recorded in conformance with 7.5, the testing shall be conducted using one or more of the following alternative procedures as necessary to attain full weld coverage:

- (1) Weld surface(s) shall be ground flush.
- (2) Testing from Faces A and B shall be performed.
- (3) Other search unit angles shall be used.

7.6 Testing of Welds

Welds shall be tested using an angle beam search unit conforming to the requirements of 5.6.2 with the test instrument calibrated in conformance with 6.5 using the angle as shown in Table 1. Following calibration and during testing, the only test instrument adjustment allowed is the sensitivity level adjustment with the calibrated gain control (attenuator). The reject (clipping or suppression) control shall be turned off. Sensitivity shall be increased from the reference level for weld scanning in conformance with Table 2 or 3, as applicable.

7.6.1 Scanning

The testing angle and scanning procedure shall be in conformance with those shown in Table 1.

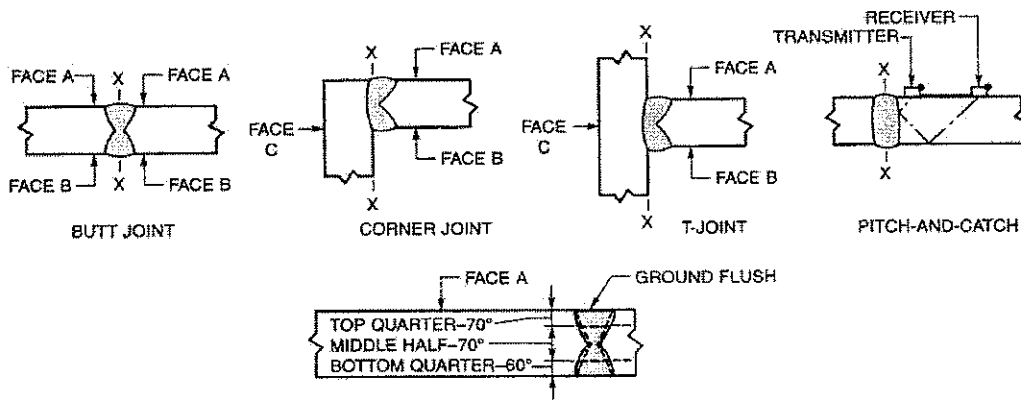
7.6.2 Butt Joints

All butt joint welds shall be tested from each side of the weld axis. Corner and T-joint welds shall be primarily tested from one side of the weld axis only. All welds shall be tested using the applicable scanning pattern or patterns shown in Figure 6 as necessary to detect both longitudinal and transverse discontinuities. It is intended that, as a minimum, all welds be tested by passing sound through the entire volume of the weld and the heat-affected zone in two crossing directions, wherever practical.

Table 1 – Testing Angle

Procedure Chart

Weld Type	Material Thickness, in. [mm]													
	5/16 [8] to 1-1/2 [38]	> 1-1/2 [38] to 1-3/4 [45]	> 1-3/4 [45] to 2-1/2 [60]	> 2-1/2 [60] to 3-1/2 [90]	> 3-1/2 [90] to 4-1/2 [110]	> 4-1/2 [110] to 5 [130]	> 5 [130] to 6-1/2 [160]	> 6-1/2 [160] to 7 [180]	> 7 [180] to 8 [200]					
Butt	1	0	1	F or 4	IG or F 5	IG or F 7	6 or F 10	8 or F 11	9 or F 12	12 or F 13	12	F		
T-	1	0	1	F or XF	F or XF	F or XF	F or XF	F or XF	F or XF	F or XF	13	F or XF	—	
Corner	1	0	1	F or XF	IG or F 4	IG or F 5	F or XF	6 or F 10	8 or F 11	9 or F 13	F or XF	14	F or XF	
Electroslag & Electroslag	1	0	1	0	IG or 4	IG or 3	P1 or P3	6 or 7	11 or 15	11 or 15	11 or 15	P3 or 15	11 or 15**	P3



General Notes:

- Where possible, all examinations shall be made from Face A and in Leg I, unless otherwise specified in this table.
- Root areas of single groove weld joints which have backing not requiring removal by contract, shall be tested in Leg I, where possible, with Face A being that opposite the backing. (Grinding of the weld face or testing from additional weld faces may be necessary to permit complete scanning of the weld root.)
- Examination in Leg II or III shall be made only to satisfy provisions of this table or when necessary to test weld areas made inaccessible by an unground weld surface, or interference with other portions of the weldment, or to meet the requirements of 6.26.6.2.
- A maximum of Leg III shall be used only where thickness or geometry prevents scanning of complete weld areas and HAZs in Leg I or Leg II.
- On tension welds in cyclically loaded structures, the top quarter of thickness shall be tested with the final leg of sound progressing from Face B toward Face A, the bottom quarter of thickness shall be tested with the final leg of sound progressing from Face A toward Face B; i.e., the top quarter of thickness shall be tested either from Face A in Leg II or from Face B in Leg I at the contractor's option, unless otherwise specified in the contract documents.
- The weld face indicated shall be ground flush before using procedure 1G, 6, 8, 9, 12, 14, or 15. Face A for both connected members shall be in the same plane.

(See Legend on next page)

Table 1 – Testing Angle (Continued)

- Legend:
- X — Check from Face "C."
 - G — Grind weld face flush.
 - O — Not required.
 - A Face — the face of the material from which the initial scanning is done (on T- and corner joints, follow above sketches).
 - B Face — opposite the "A" face (same plate).
 - C Face — the face opposite the weld on the connecting member or a T- or corner joint.
 - * — Required only where display reference height indication of discontinuity is noted at the weld metal-base metal interface while searching at scanning level with primary procedures selected from first column.
 - ** — Use 15 in. [400 mm] or 20 in. [500 mm] screen distance calibration.
 - P — Pitch and catch shall be conducted for further discontinuity evaluation in only the middle half of the material thickness with only 45° or 70° transducers of equal specification, both facing the weld. (Transducers must be held in a fixture to control positioning—see sketch.) Amplitude calibration for pitch and catch is normally made by calibrating a single search unit. When switching to dual search units for pitch and catch inspection, there should be assurance that this calibration does not change as a result of instrument variables.
 - F — Weld metal-base metal interface indications shall be further evaluated with either 70°, 60°, or 45° transducer—whichever sound path is nearest to being perpendicular to the suspected fusion surface.

Procedure Legend

Area of Weld Thickness

No.	Top Quarter	Middle Half	Bottom Quarter
1	70°	70°	70°
2	60°	60°	60°
3	45°	45°	45°
4	60°	70°	70°
5	45°	70°	70°
6	70°G A	70°	60°
7	60° B	70°	60°
8	70°G A	60°	60°
9	70°G A	60°	45°
10	60° B	60°	60°
11	45° B	70°**	45°
12	70°G A	45°	70°G B
13	45° B	45°	45°
14	70°G A	45°	45°
15	70°G A	70°A B	70°G B

7.6.3 Maximum Indication

When a discontinuity indication appears on the screen, the maximum attainable indication from the discontinuity shall be adjusted to produce a horizontal reference level trace deflection on the display screen. This adjustment shall be made with the calibrated gain control (attenuator), and the test instrument reading in decibels shall be used as the "Indication Level," "a," for calculating the "Indication Rating," "d" as shown on test report (Annex D, Form D-11 of AWS D1.1).

7.6.4 Attenuation Factor

The "Attenuation Factor, c," on the test report is attained by subtracting 1 in. (25 mm) from the sound path distance and multiplying the remainder by 2. This factor shall be rounded out to the nearest dB value. Fractional values less than ½ dB shall be reduced to the lower dB level and those of ½ dB or greater increased to the higher level.

7.6.5 Indication Rating

The "Indication Rating, "d," in the UT Report, Annex D, Form D-11 of AWS D1.1, represents the algebraic difference in decibels between the indication level and the reference level with correction for attenuation as indicated in the following expressions:

Instruments with gain in dB:

$$a - b - c = d$$

Instruments with attenuation in dB:

$$b - a - c = d$$

7.7 Length of Discontinuities

The length of discontinuities shall be determined in conformance with procedure described in 11.2.

7.8 Basis for Acceptance or Rejection

Each weld discontinuity shall be accepted or rejected on the basis of its indication rating and its length, in conformance with Table 2 for statically loaded structures or Table 3 for cyclically loaded structures, whichever is applicable. Only those discontinuities which are unacceptable need be recorded on the test report, except that for welds designated in the contract documents as being "Fracture Critical," acceptance ratings that are within 6 dB, inclusive, of the minimum unacceptable rating shall be recorded on the test report.

7.9 Identification of Rejected Area

Each unacceptable discontinuity shall be indicated on the weld by a mark directly over the discontinuity for its entire length. The depth from the surface and indication rating shall be noted on nearby base metal.

7.10 Repair

Welds found unacceptable by ultrasonic testing shall be repaired by methods allowed by 5.26 of AWS D1.1 or customer requirements. Repaired areas shall be retested ultrasonically with results tabulated on the original form (if available) or additional report forms.

7.11 Retest Reports

Evaluation of retested repaired weld areas shall be tabulated on a new line on the report form. If the original report form is used, an R1, R2, Rn shall prefix the indication number. If additional report forms are used, the R number shall prefix the report number.

8.0 PREPARATION AND DISPOSITION OF REPORTS

8.1 Content of Reports

A report form which clearly identifies the work and the area of inspection shall be completed by the ultrasonic Inspector at the time of inspection. The report form for welds that are acceptable need only contain sufficient information to identify the weld, the Inspector (signature), and the acceptability of the weld. An example of such a form is shown in Annex D, Form D-11 in AWS D1.1.

Table 2 – UT Acceptance - Rejection Criteria (Statically Loaded Nontubular Connections)

Discontinuity Severity Class	Weld Thickness ¹ in in. [mm] and Search Unit Angle												
	5/16 through 3/4 [8–20]		> 3/4 through 1-1/2 [20–38]		> 1-1/2 through 2-1/2 [38–65]			> 2-1/2 through 4 [65–100]			> 4 through 8 [100–200]		
	70°	70°	70°	60°	45°	70°	60°	45°	70°	60°	45°		
Class A	+5 & lower	+2 & lower	-2 & lower	+1 & lower	+3 & lower	-5 & lower	-2 & lower	0 & lower	-7 & lower	-4 & lower	-1 & lower		
Class B	+6	+3	-1 0	+2 +3	+4 +5	-4 -3	-1 0	+1 +2	-6 -5	-3 -2	0 +1		
Class C	+7	+4	+1 +2	+4 +5	+6 +7	-2 to +2	+1 +2	+3 +4	-4 to +2	-1 to +2	+2 +3		
Class D	+8 & up	+5 & up	+3 & up	+6 & up	+8 & up	+3 & up	+3 & up	+5 & up	+3 & up	+3 & up	+4 & up		

General Notes:

- Class B and C discontinuities shall be separated by at least 2L, L being the length of the longer discontinuity, except that when two or more such discontinuities are not separated by at least 2L, but the combined length of discontinuities and their separation distance is equal to or less than the maximum allowable length under the provisions of Class B or C, the discontinuity shall be considered a single acceptable discontinuity.
- Class B and C discontinuities shall not begin at a distance less than 2L from weld ends carrying primary tensile stress, L being the discontinuity length.
- Discontinuities detected at "scanning level" in the root face area of CJP double groove weld joints shall be evaluated using an indicating rating 4 dB more sensitive than described in 6.26.6.5 when such welds are designated as "tension welds" on the drawing (subtract 4 dB from the indication rating "d"). This shall not apply if the weld joint is backgrounded to sound metal to remove the root face and MT used to verify that the root face has been removed.
- ESW or EGWs: discontinuities detected at "scanning level" which exceed 2 in. [50 mm] in length shall be suspected as being piping porosity and shall be further evaluated with radiography.
- For indications that remain on the display as the search unit is moved, refer to 6.13.1.

Note:

1. Weld thickness shall be defined as the nominal thickness of the thinner of the two parts being joined.

Class A (large discontinuities)
 Any indication in this category shall be rejected (regardless of length).

Class B (medium discontinuities)
 Any indication in this category having a length greater than 3/4 in. [20 mm] shall be rejected.

Class C (small discontinuities)
 Any indication in this category having a length greater than 2 in. [50 mm] shall be rejected.

Class D (minor discontinuities)
 Any indication in this category shall be accepted regardless of length or location in the weld.

Scanning Levels	
Sound path ² in in. [mm]	Above Zero Reference, dB
through 2-1/2 [65 mm]	14
> 2-1/2 through 5 [65–125 mm]	19
> 5 through 10 [125–250 mm]	29
> 10 through 15 [250–380 mm]	39

Note:

2. This column refers to sound path distance; NOT material thickness.

Table 3 – UT Acceptance - Rejection Criteria (Cyclically Loaded Nontubular Connections)

Discontinuity Severity Class	Weld Thickness ¹ in in. [mm] and Search Unit Angle										
	5/16 through 3/4 [8–20]	> 3/4 through 1-1/2 [20–38]	> 1-1/2 through 2-1/2 [38–65]			> 2-1/2 through 4 [65–100]			> 4 through 8 [100–200]		
	70°	70°	70°	60°	45°	70°	60°	45°	70°	60°	45°
Class A	+10 & lower	+8 & lower	+4 & lower	+7 & lower	+9 & lower	+1 & lower	+4 & lower	+6 & lower	-2 & lower	+1 & lower	+3 & lower
Class B	+11	+9	+5 +6	+8 +9	+10 +11	+2 +3	+5 +6	+7 +8	-1 0	+2 +3	+4 +5
Class C	+12	+10	+7 +8	+10 +11	+12 +13	+4 +5	+7 +8	+9 +10	+1 +2	+4 +5	+6 +7
Class D	+13 & up	+11 & up	+9 & up	+12 & up	+14 & up	+6 & up	+9 & up	+11 & up	+3 & up	+6 & up	+8 & up

General Notes:

- Class B and C discontinuities shall be separated by at least 2L, L being the length of the longer discontinuity, except that when two or more such discontinuities are not separated by at least 2L, but the combined length of discontinuities and their separation distance is equal to or less than the maximum allowable length under the provisions of Class B or C, the discontinuity shall be considered a single acceptable discontinuity.
- Class B and C discontinuities shall not begin at a distance less than 2L from weld ends carrying primary tensile stress, L being the discontinuity length.
- Discontinuities detected at "scanning level" in the root face area of CJP double groove weld joints shall be evaluated using an indicating rating 4 dB more sensitive than described in 6.26.6.5 when such welds are designated as "tension welds" on the drawing (subtract 4 dB from the indication rating "d"). This shall not apply if the weld joint is backgouged to sound metal to remove the root face and MT used to verify that the root face has been removed.
- For indications that remain on the display as the search unit is moved, refer to 6.13.2.1.

Note:

1. Weld thickness shall be defined as the nominal thickness of the thinner of the two parts being joined.

Class A (large discontinuities)
 Any indication in this category shall be rejected (regardless of length).

Class B (medium discontinuities)
 Any indication in this category having a length greater than 3/4 in. [20 mm] shall be rejected.

Class C (small discontinuities)
 Any indication in this category having a length greater than 2 in. [50 mm] in the middle half or 3/4 in. [20 mm] length in the top or bottom quarter of weld thickness shall be rejected.

Class D (minor discontinuities)
 Any indication in this category shall be accepted regardless of length or location in the weld.

Scanning Levels	
Sound path ² in in. [mm]	Above Zero Reference, dB
through 2-1/2 [65 mm]	20
> 2-1/2 through 5 [65–125 mm]	25
> 5 through 10 [125–250 mm]	35
> 10 through 15 [250–380 mm]	45

Note:

2. This column refers to sound path distance; NOT material thickness.

8.2 Prior Inspection Reports

Before a weld subject to ultrasonic testing by the Contractor for the Owner is accepted, all report forms pertaining to the weld, including any that show unacceptable quality prior to repair, shall be submitted to the Inspector.

8.3 Completed Reports

A full set of completed report forms of welds subject to ultrasonic testing by the Contractor for the Owner, including any that show unacceptable quality prior to repair, shall be delivered to the Owner upon completion of the work. The Contractor's obligation to retain ultrasonic test reports shall cease (1) upon delivery of this full set to the Owner, or (2) one full year after completion of the Contractor's work provided that the Owner is given prior written notice.

9.0 CALIBRATION OF ULTRASONIC TEST INSTRUMENT WITH IIW OR OTHER APPROVED REFERENCE BLOCKS

See Figure 1, 2, 3 and 4.

9.1 Longitudinal Mode

9.1.1 Distance Calibration - See Annex X, X1 of AWS D1.1 for alternative method.

- (1) The search unit shall be set in position G on the IIW block.
- (2) The test instrument shall be adjusted to produce indications at 1 in. (25 mm on a metric block), 2 in. (50 mm on a metric block), 3 in (75 mm on a metric block), 4 in (100 mm on a metric block), etc., on the display.

9.1.2 Amplitude - See Annex X, X1.2 of AWS D1.1 for alternative method.

- (1) The search unit shall be set in position G on the IIW block.
- (2) The gain shall be adjusted until the maximized indication from first back reflection attains 50 to 75% screen height.

9.1.3 Resolution

- (1) The search unit shall be set in position F on the IIW block.
- (2) Search unit and test instrument shall resolve all three distances.

9.1.4 Horizontal Linearity Qualification

Qualification procedure shall be per 5.8.1.

9.1.5 Gain Control (Attenuation) Qualification

The qualification procedure shall be in conformance with 5.8.2 or an alternative method, in conformance with 5.8.2, shall be used.

9.2 Shear Wave Mode (Transverse)

9.2.1 Index point

The search unit sound entry point (index point) shall be located or checked by the following procedure:

- (1) The search unit shall be set in position D on the IIW block.
- (2) The search unit shall be moved until the signal from the radius is maximized. The point on the search unit which aligns with the radius line on the calibration block is the point of sound entry. (See Annex X, X2.1 of AWS D1.1 for alternative method.)

9.2.2 Angle

The search unit sound path angle shall be checked or determined by one of the following procedures:

- (1) The search unit shall be set in position B on IIW block for angles 40° through 60°, or in position C on IIW block for angles 60° through 70°. (See Figure 4.)
- (2) For the selected angle, the search unit shall be moved back and forth over the line indicative of the search unit angle until the signal from the radius is maximized. The sound entry point on the search unit shall be compared with the angle mark on the calibration block (tolerance $\pm 2^\circ$). (See Annex X, X2.2 of AWS D1.1 for alternative method.)

9.2.3 Distance Calibration Procedure

The search unit shall be set in position D on the IIW block (any angle). The test instrument shall then be adjusted to attain indications at 4 in. (100 mm on a metric block) and 8 in. (200 mm on a metric block) or 9 in. (225 mm on a metric block) on the display; 4 in. (102 mm) and 9 in. (230 mm) on a

Type 1 block; or 4 in. (102 mm) and 8 in. (203 mm) on a Type 2 block.
 (See Annex X, X2.3 of AWS D1.1 for alternative method.)

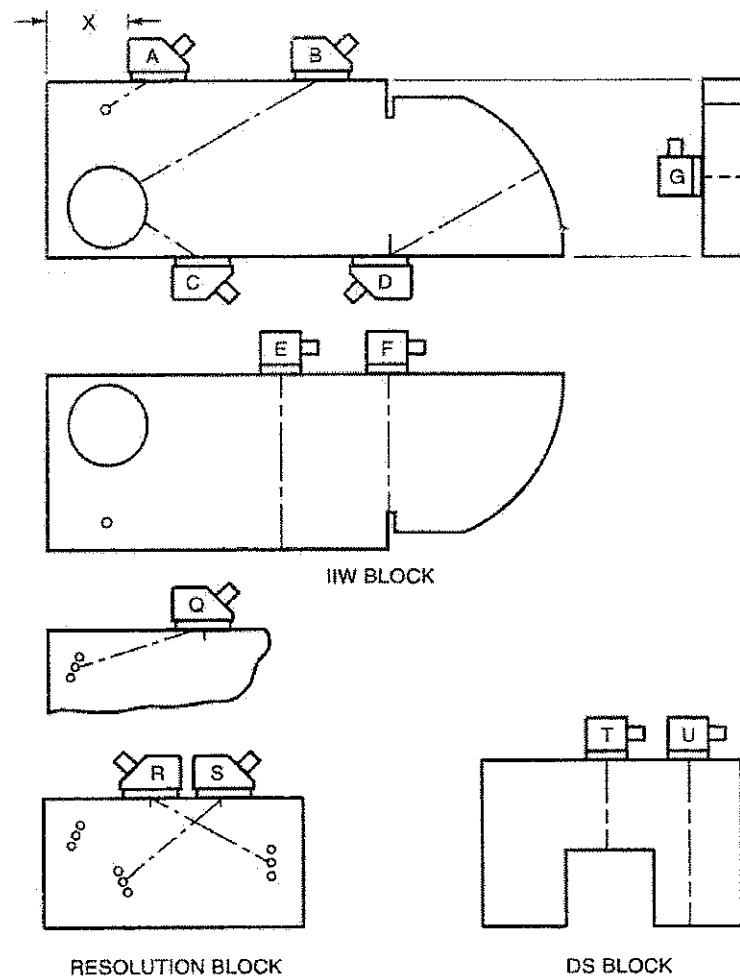


Figure 4 – Transducer Positions (Typical)

9.2.4 Amplitude or Sensitivity Calibration Procedure

The search unit shall be set in position A on the IIW block (any angle).
 The maximized signal shall then be adjusted from the 0.060 in. (1.59 mm) hole to attain a horizontal reference line height indication. (See Annex X,

X2.4 for alternative method.) The maximum decibel reading obtained shall be used as the "Reference Level, "b" reading on the Test Report sheet (See Annex D, Form D11 of AWS D1.1) in conformance with 5.7.1.

9.2.5 Resolution

- (1) The search unit shall be set on resolution block RC position Q for 70° angle, position R for 60° angle, or position S for 45° angle.
- (2) Search unit and test instrument shall resolve the three test holes, at least to the extent of distinguishing the peaks of the indications from the three holes.

9.2.6 Approach Distance of Search Unit

The minimum allowable distance between the toe of the search unit and the edge of the IIW reference block shall be as follows (See Figure 5):

for 70° search unit,
X = 2 in. (50 mm)

for 60° search unit,
X = 1-7/16 in. (37 mm)

for 45° search unit,
X = 1 in. (25 mm)

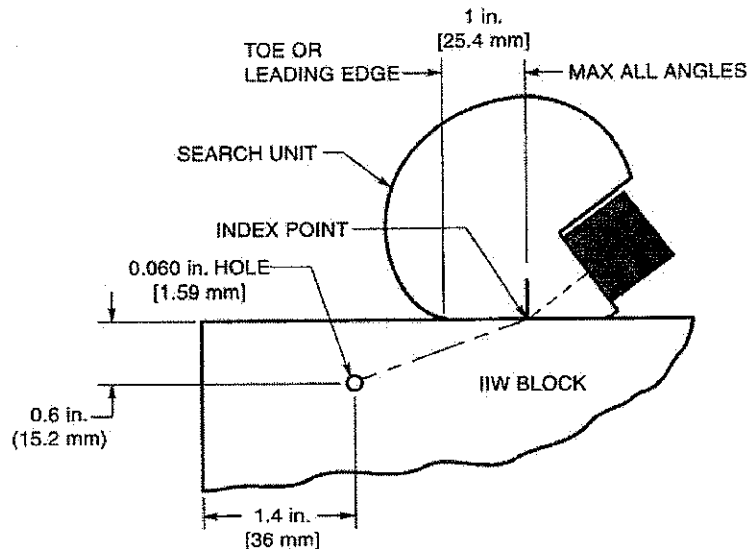


Figure 5 – Qualification Procedure of Search Unit Using IIW Reference Block

10.0 EQUIPMENT QUALIFICATION PROCEDURES

10.1 Horizontal Linearity: Procedure

Note: Since this qualification procedure is performed with a straight beam search unit which produces longitudinal waves with a sound velocity of almost double that of shear waves, it is necessary to double the shear wave distance ranges to be used in applying this procedure.

Example: The use of a 10 in. (250 mm) screen calibration in shear wave would require a 20 in. (500 mm) screen calibration for this qualification procedure.

The following procedure shall be used for test instrument qualification: (See Annex X, X.3 of AWS D1.1 for alternative method.):

- (1) A straight beam search unit shall be coupled meeting the requirements of 5.1.1 to the IIW or DS block in Position G, T, or U (see Figure 4) as necessary to attain five back reflections in the qualification range being certified. (See Figure 4)
- (2) The first and fifth back reflections shall be adjusted to their proper locations with use of the distance calibration and zero delay adjustments.

- (3) Each indication shall be adjusted to reference level with the gain or attenuation control for horizontal location examination.
- (4) Each intermediate trace deflection location shall be correct within 2% of the screen width.

10.2 dB Accuracy

10.2.1 Procedure

Note: In order to attain the required accuracy ($\pm 1\%$) in reading the indication height, the display shall be graduated vertically at 2% intervals, or 2.5% for instruments with digital amplitude readout, at horizontal mid-screen height. These graduations shall be placed on the display between 60% and 100% of screen height. This may be accomplished with use of a graduated transparent screen overlay. If this overlay is applied as a permanent part of the ultrasonic test instrument, care should be taken that the overlay does not obscure normal testing displays.

- (1) A straight beam search unit shall be coupled, meeting the requirements of 5.6.1 to the DS block shown in Figure 2 and position "T", Figure 4.
- (2) The distance calibration shall be adjusted so that the first 2 in. (50 mm) back reflection indication (hereafter called "the indication") is at horizontal mid-screen.
- (3) The calibrated gain or attenuation control shall be adjusted so that the indication is exactly at or slightly above 40% screen height.
- (4) The search unit shall be moved toward position U, see Figure 4, until the indication is exactly 40% screen height.
- (5) The sound amplitude shall be increased 6 dB with the calibrated gain or attenuation control. The indication level theoretically should be exactly at 80% screen height.
- (6) The dB reading shall be recorded under "a" and actual % screen height under "b" from step 5 on the certification report (see example in Annex D, Form D-8, Line 1 of AWS D1.1).
- (7) The search unit shall be moved further toward position U, Figure 4, until the indication is exactly 40% screen height.
- (8) Step 5 shall be repeated.
- (9) Step 6 shall be repeated; except, information should be applied to the next consecutive line on the certification report (see example in Annex D, Form D-8 of AWS D1,1).
- (10) Steps 7, 8, and 9 shall be repeated consecutively until the full range of the gain control (attenuator) is reached (60 dB minimum).

- (11) The information from Rows "a" and "b" shall be applied to equation 10.2.2 or the nomograph described in 10.2.3 to calculate the corrected dB.
- (12) Corrected dB from step 11 to Row "c" shall be applied.
- (13) Row "c" value shall be subtracted from Row "a" value and the difference in Row "d," dB error shall be applied.

Note: These values may be either positive or negative and so noted. Examples of Application of Forms D-8, D-9, and D-10 are to be found in Annex D of AWS D1.1.

- (14) Information shall be tabulated on a form, including minimum equivalent information as displayed on Form D-8 (see Annex D of AWS D1.1), and the unit evaluated in conformance with instructions shown on that form.
- (15) Form D-9 (see Annex D of AWS D1.1) provides a relatively simple means of evaluating data from item (14). Instructions for this evaluation are given in (16) through (18).
- (16) The dB information from Row "e" (Form D-8, see Annex D of AWS D1.1) shall be applied vertically and dB reading from Row "a" (see Annex of AWS D1.1) horizontally as X and Y coordinates for plotting a dB curve on Form D-9 (see Annex of AWS D1.1).
- (17) The longest horizontal length, as represented by the dB reading difference, which can be inscribed in a rectangle representing 2 dB in height, denotes the dB range in which the equipment meets the code requirements. The minimum allowable range is 60 dB.
- (18) Equipment that does not meet this minimum requirement may be used, provided correction factors are developed and used for discontinuity evaluation outside the test instrument acceptable linearity range, or the weld testing and discontinuity evaluation is kept within the acceptable vertical linearity range of the equipment.

Note: The dB error figures (Row "d", see Annex D of AWS D1.1) may be used as correction factor figures.

10.2.2 Decibel Equation

The following equation shall used to calculate decibels:

$$dB_2 - dB_1 = 20 \times \text{Log} \frac{\%_2}{\%_1}$$

$$dB_2 = 20 \times \text{Log} \frac{\%_2}{\%_1} + dB_1$$

As related to Annex D, Form D-8 in AWS D1.1

dB_1 = Row "a"

dB_2 = Row "c"

$\%_1$ = Row "b"

$\%_2$ = Defined on Form D-8 (see Annex D, AWS D1.1)

10.2.3 Annex D

The following notes apply to the use of the nomograph in Annex D, Form 10 in AWS D1.1:

- (1) Rows a, b, c, d, and e are on certification sheet, Annex D, Form D-8.
- (2) The A, B, and C scales are on the nomograph, Annex D, Form D-10.
- (3) The zero points on the C scale shall be prefixed by adding the necessary value to correspond with the test instrument settings; i.e., 0, 10, 20, 30, etc.

10.2.4 Procedure

The following procedures shall apply to the use of the nomograph in Annex D, Form D in AWS D1.1:

- (1) A straight line between the decibel reading from Row "a" applied to the C scale and the corresponding percentage from Row "b" applied to the A scale shall be extended.
- (2) The point where the straight line from step 1 crosses the pivot line B as a pivot point for a second straight line shall be used.
- (3) A second straight line from the average % point on the A scale through the pivot point developed in step 2 and on the dB scale C shall be extended.
- (4) This point on the C scale is indicative of the corrected dB for use in Row "c".

10.2.5 Nomograph

For an example of the use of the nomograph, see Annex D, Form D-10 in AWS D1.1.

10.3 Internal Reflections Procedure

- 10.3.1 Calibrate the equipment in conformance with 6.5.
- 10.3.2 Remove the search unit from the calibration block without changing any other equipment adjustments.
- 10.3.3 Increase the calibrated gain or attenuation 20 dB more sensitive than reference level.
- 10.3.4 The screen area beyond ½ in. (13 mm) sound path and above reference level height shall be free of any indication.

11.0 DISCONTINUITY SIZE EVALUATION PROCEDURES

11.1 Straight (longitudinal) Beam Testing

The size of lamellar discontinuities is not always easily determined, especially those that are smaller than the search unit size. When the discontinuity is larger than the search unit, a full loss of back reflection will occur and a 6 dB loss of amplitude and measurement to the centerline of the search unit is usually reliable for determining discontinuity edges. However, the approximate size evaluation of those reflectors, which are smaller than the search unit, shall be made by beginning outside the discontinuity with equipment calibrated in conformance with 6.4 and moving the search unit toward the area of discontinuity until an indication on the display begins to form. The leading edge of the search unit at this point is indicative of the edge of the discontinuity.

11.2 Angle Beam (Shear) Testing

The following procedure shall be used to determine lengths of indications which have dB ratings more serious than for a Class D indication. The length of such indication shall be determined by measuring the distance between the search unit 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" on the test report. Where warranted by discontinuity amplitude, this procedure shall be repeated to determine the length of Class A, B, and C discontinuities.

12.0 SCANNING PATTERNS

See Figure 6

12.1 Longitudinal Discontinuities

12.1.1 Scanning Movement A

Rotation angle $a = 10^\circ$.

12.1.2 Scanning Movement B

Scanning distance b shall be such that the section of weld being tested is covered.

12.1.3 Scanning Movement C

Progression distance c shall be approximately one-half the search unit width.

Note: movements A, B, and C are combined into one scanning pattern.

12.2 Transverse Discontinuities

12.2.1 Scanning pattern D is to be used when welds are ground flush.

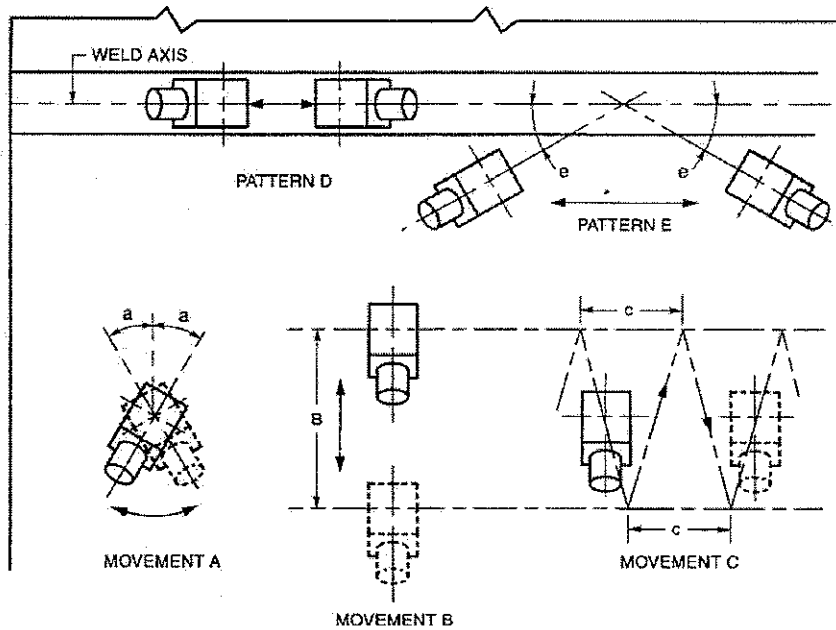
12.2.2 Scanning pattern E is to be used when the weld reinforcement is not ground flush. Scanning angle $e = 15^\circ$ max.

Note: The scanning pattern is to be such that the full weld section is covered.

12.3 Electroslag (ESW) or Electrogas (EGW) Welds (Additional Scanning Pattern)

Scanning Pattern E Search unit rotation angle "e" between 45° and 60°.

Note: The scanning pattern shall cover the full weld section.



General Notes:

- Testing patterns are all symmetrical around the weld axis with the exception of pattern D, which shall be conducted directly over the weld axis.
- Testing from both sides of the weld axis shall be made wherever mechanically possible.

Figure 6 – Plan View of UT Scanning Patterns

13.0 EXAMPLES OF dB ACCURACY CERTIFICATION

Annex D on AWS D1,1 shows examples of the use of Forms D-8, D-9, and D-10 for solution to a typical application of 10.2.