Quality Assurance
Procedure QAP 5951

Method of Test For

Ultrasonic Inspection Procedure for Butt Welds Using Structural Carbon Steel or High-Strength Low-Alloy Structural Steel for Welding

1. SCOPE

1.1 This written procedure conforms to ASNT SNT-TC-1A 4.3, QAP 5905, and AASHTO/AWS D1.5M/D1.5current edition Sections 3 and 6. Additional specific requirements are detailed, which, while maintaining conformance to the above referenced specifications, further control variables of the procedure to assure an accurate, meaningful evaluation.

1.2 This procedure shall be used to detect, locate and evaluate subsurface indications within the heat affected and weld zone of complete penetration butt joint welds in the thickness range of 5/16 inch through 8 inches inclusive. Injurious defects (amplitude, location and length which is unacceptable in the weld or heat affected zone for welds) discovered in the base metal shall be reported to Staff Bridge (see ASTMA6-9.1).

1.3 This procedure is applicable to new fabrication and in-service evaluations in which the test surface has been properly prepared. It is not applicable on painted surfaces or surfaces that do not provide intimate coupling with the search unit. Evaluations over painted surfaces may be made if a transfer correction is developed in accordance with Establishing an Ultrasonic Transfer Correction.

2. PERSONNEL

2.1 Personnel performing this examination shall be qualified in accordance with ASNT SNT-TC-1A.

3. REFERENCE

3.1 AASHTO/AWS D1.5MD1.5:2015,Sections 3 and 6.

3.2 ASTM A435

3.3 ASTM A6

3.4 Written Practice of Personnel Qualification and Certification per ASNT-SNT-TC-1A.

3.5 Procedure for Straight Beam Ultrasonic Examination of Steel Plates for Inclusions and Laminations.

3.6 Visual Test Procedure of Bridge Weldments, QAP 5910.

3.7 Magnetic Particle Inspection Procedure; Continuous Yolk, Dry, Visible Particles, QAP 5930.

3.8 Procedure for Determining the Characteristics of an Ultrasonic Search Unit, QAP 5950.

4. APPARATUS

4.1 INSTRUMENT

4.1.1 Pulse echo ultrasonic equipment shall meet the following requirements:

4.1.1.1 The instrument shall generate frequencies between 1MHz and 6MHz.

4.1.1.2 The CRT presentation shall be "A" scan.

4.1.1.3 The equipment shall include internal stabilization so that after warm up, no variation in response greater than 1 dB occurs with a voltage change of 15% nominal or, in the case of battery operation, within the charge operating life. There shall be a device indicating the end of charge life.

4.1.1.4 The size of the CRT screen shall allow detection of 1dB change.

4.1.1.5 The instrument shall have an attenuator,
i.e. gain control adjustable in discrete 1 or 2 dB steps over a range of at least 60 dB. The accuracy of the attenuator shall be within 1dB.

4.2 REFERENCE STANDARDS

4.2.1 IIW Type I (Reference Block)

4.2.2 DSC (Distance & Sensitivity Calibration Block)

4.2.3 RC (Resolution Block)

4.2.4 DS (Distance & Sensitivity Reference Block)

All reference standards shall be certified as compliant to the International Institute of Welding Standard.

4.3 Equipment

4.3.1 Straight Beam Transducers

4.3.1.1 Straight beam (longitudinal wave) transducers shall have an active area of not less than 1/2 square inch nor more than 1 square inch. The transducer shall be round with a minimum diameter 13/16 inch and a maximum diameter of 1-1/8 inch. The transducer central frequency shall be 2 to 2.5 MHz.

4.3.1.2 Other straight beam transducers may be used for evaluation, but not for determination of acceptance in accordance with ASTM A 435 (D 1.5-3.2.3.7(1)) or enforcing D 1.5-6.19.5.

4.3.2 Angle Beam Transducers

4.3.2.1 The transducer crystal shall be rectangular in shape, which may vary 5/8 to 1 inch in width and from 5/8 to 13/16 inch in height. The maximum ratio of width to height, (Fig 1), shall be 1.2 to 1.0, and the minimum ratio 1.0 : 1.0. The transducer central frequency shall be between 2 and 2.5 MHz, inclusive.

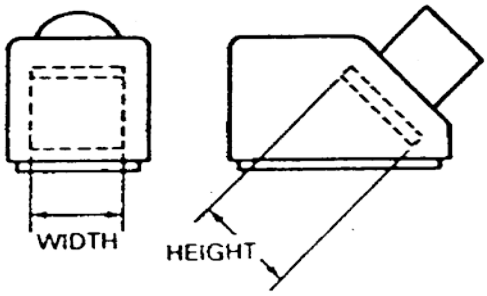

Figure 1

4.3.2.2 Other angle beam transducer sizes and frequencies may be used for Quality Assurance (Verification) scanning.

*NOTE: Higher frequencies are not as sensitive in locating planar flaws that deviate normally to the incident sound beam. However, resolution of near surface flaws often increases (shortened dead zone) for informational purposes. Frequency signature shall be assessed with multiple frequency tests requiring, at times, use of higher frequencies in evaluation. However, all acceptance evaluations based on flaw amplitude, location and length shall be made using the equipment specified herein.

4.3.3 Search Unit

4.3.3.1 Angle beam (transverse waves) transducers may be comprised of two separate elements or may be one integral unit. The search unit shall produce a refracted sound beam within
 2 degrees of the nominal angle required (70, 60 or 45 degrees). An adjustable multiple refracted angle search unit may be used to aid in the evaluation of planar indications.

4.3.3.2 Each search unit shall be marked to indicate the frequency of the transducer, nominal angle of refraction, and index point.

4.3.3.3 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 inch (see Fig 2).

4.3.4 Couplant

4.3.4.1 Couplant used between the search unit and test specimen shall be glycerin, glycerol 95%. It shall only be mixed with water when necessary to facilitate reasonable scanning efficiency at lower temperatures. It shall be used on vertical and overhead positions, if possible. Motor oil may be used only for calibrating reference level "b" on the 0.060 inch hole on the IIW block or the slot on DSC block.

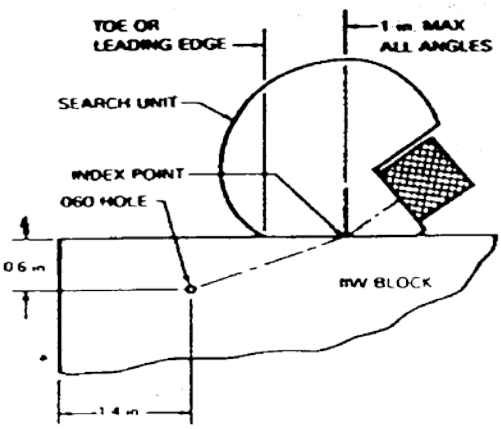

Figure 2

*NOTE: changes in couplant materials and therefore their transmissivity will affect the amplitude of sound recorded.

4.3.4.2 Couplant used between the transducer and Lucite wedge shall be Dow-Corning high vacuum grease or petroleum jelly.

4.3.5 Coaxial Cables

4.3.5.1 Co-axial cables shall be no longer than six feet and in good working order.

4.3.6 Grinder

4.3.6.1 Grinders shall be used to clean any tightly adhering spatter, mill scale (tight and loose), oxide layers and contour the test surface to allow full contact with the search unit. Any surface not meeting this criteria cannot be properly evaluated.

4.3.7 Brushes

4.3.7.1 Wire or fiber brushes shall be used, when necessary to remove all loose shop soils.

4.3.8 Squeegee

4.3.8.1 Squeegees shall be used to remove loose shop soils, locate couplant on the test specimen, and remove all couplant (All glycerin shall be removed from all test areas, including washing with water).

4.3.9 Ruler

4.3.9.1 A stainless steel ruler for locating reflectors, measuring depth and horizontal distance shall be scaled to a minimum of 1/16 inch or 1/10 inch (the tenths scale is preferred).

4.3.10 Calculator or Distance Chart

4.3.10.1 Either shall be used for establishing half or full skip distance, sound path, horizontal and vertical distances.

4.3.11 Marking Pencil

4.3.11.1 A marker, to mark on the test specimen, shall be used which does not dissolve in glycerin.

4.3.12 Nital

4.3.12.1 A 2% Nital etch may be required for information regarding location of the heat affected zone.

4.3.13 Clean Rags

4.3.14 Scraper

5. **INSTRUMENT QUALIFICATION**

5.1 HORIZONTAL LINEARITY

*NOTE: This procedure is used with a longitudinal wave which has a velocity 1.83 times that of the transverse wave, therefore it is necessary to correct (double) the shear (angle beam) wave distances to be used. For example: The use of a 10 inch screen calibration for a transverse wave would require a 20 inch screen calibration for this qualification procedure.

5.1.1 The horizontal linearity of the instrument shall be prequalified after each 40 hours of instrument use. Each distance range used in actual testing shall be qualified.

5.1.2 Procedure - The following procedure shall be used:

5.1.2.1 (See Figure 3) Couple the straight beam transducer specified in 4.3 to the (1) IIW block in position G or (2) to the DS block in position T or U or (3) to the DSC block in position M as necessary to attain 5 back reflections for the range being qualified (Figure 4).

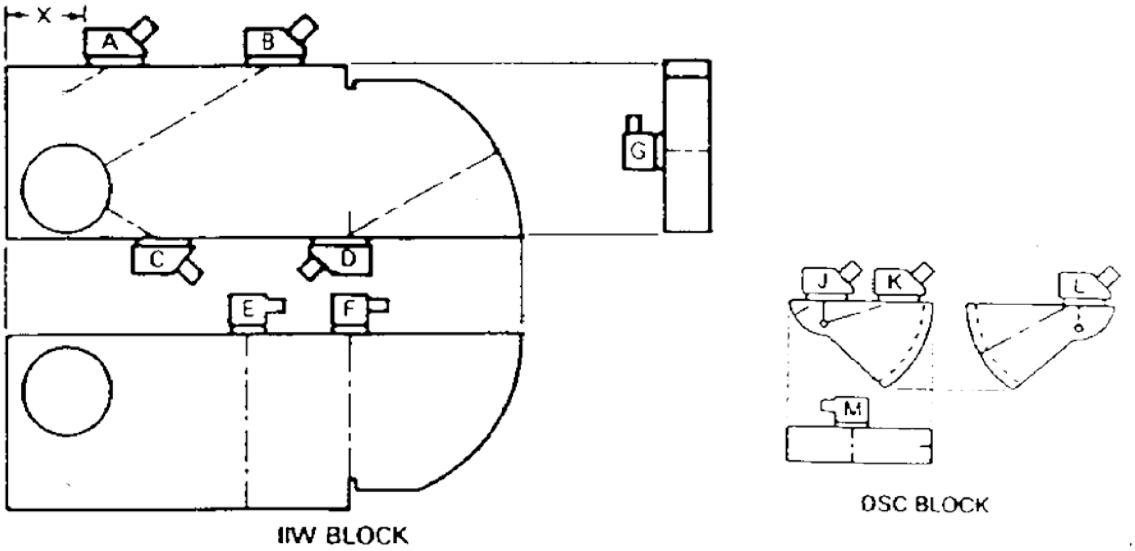

Figure 3

5.1.2.2 Adjust the first and fifth back reflections to their proper locations with the use of the distance calibration and zero delay adjustments. (It should be realized that the distance between the initial pulse indication and the first echo is always somewhat greater than the distance between successive multiple echoes, although theoretically, these distances should be equal when applying the single probe system.)

5.1.2.3 Each indication shall be adjusted to reference level with the gain control for horizontal location examination. Distance shall be read at the left hand side break in the baseline.

5.1.2.4 Each intermediate trace deflection location (1" or 25mm) shall be correct within □ 2% of the screen width.

5.2 VERTICAL LINEARITY

5.2.1 The instrument's gain control shall meet the requirements of 4.1.1.5 and shall be calibrated every two months.

5.2.2 Procedure NOTE: In order to attain the required accuracy, □ 1% in reading the indication height, the CRT screen shall be graduated vertically at 2% intervals at horizontal mid-screen. These graduations shall be placed on the CRT between 60% - 100% screen height. This may be accomplished with use of a transparent screen overlay. - The following procedure shall be used:

5.2.2.1 Couple a straight beam search unit, meeting the requirements of 4.3, to the DS block position T shown in Fig. 4. Adjust the distance calibration so that the first 2 inch back reflection indication is at horizontal mid-screen.

5.2.2.2 Adjust the calibrated gain so that the indication is at or slightly above 40% screen height.

5.2.2.3 Move the search unit toward position U (see Fig. 4) until the indication is exactly at 40% screen height.

5.2.2.4 Increase the amplitude 6 dB (2X screen height) with the calibrated gain. The indication level theoretically should be at 80% screen height.

5.2.2.5 Record the dB reading under "a" and actual %screen height under "b" from step 5 of the Certification report.

5.2.2.6 Move the search unit further toward position U until the indication is at 40% screen height.

5.2.2.7 Repeat step in 5.2.2.4

5.2.2.8 Repeat step in 5.2.2.5, except information is applied to the next consecutive line.

5.2.2.9 Repeat steps 5.2.2.6, 5.2.2.7, 5.2.2.8 consecutively until the full range of the gain control is reached (60 dB minimum).

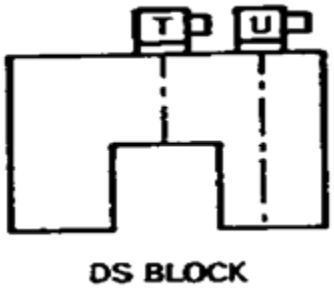

Figure 4

5.2.2.10 Apply the information from columns "a" and "b" to the following equation to calculate the corrected dB:

dB 2 - dB 1 = 20 x Log (%2 / %1) or

dB 2 = 20 x Log (%2 / %1) + dB 1

where:

B 1 = Column "a" dB 2 = Column "c"
%1 = Column "b"
%2 = 20 x Log (%2 divided by %1) + dB 1

5.2.2.11 Apply corrected dB from step 11 to Column "c"

5.2.2.12 Subtract Column "c" value from Column "a" value and apply the difference from in Column "d", dB error.

5.2.2.13 Information shall be tabulated including minimum equivalent information as displayed on that form, and the unit evaluated with instructions shown on that form. These values may be either positive or negative and so noted.

5.2.2.14 Information shall be graphed to show the acceptance window and range. Apply the information from column "e" vertically and dB reading from column "a" horizontally as X-Y coordinates for plotting a dB curve.

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 D 1.5 requirements. The minimum allowable range is 60 dB.

Equipment that does not meet this minimum requirement may be used, provided a table of correction factors are developed and used for flaw evaluation outside the acceptable vertical range for the instrument. The dB error figures, Column "d" are used as the correction factor.

5.2.2.15The date of prequalification shall be listed on the Equipment Qualification Log.

5.3 INTERNAL REFLECTIONS (SEARCH UNIT)

5.3.1 Maximum internal reflections from each search unit shall be verified every 40 hours of instrument use as follows:

5.3.1.1 Calibrate horizontal sweep and the reference level sensitivity.

5.3.1.2 Remove the search unit from the calibration block without changing any other adjustments.

5.3.1.3 Increase the calibrated gain 20 dB more sensitive than reference level.

5.3.1.4 The CRT screen beyond 1/2 inch sound path shall be free of any indication above the reference level (see Fig. 5)

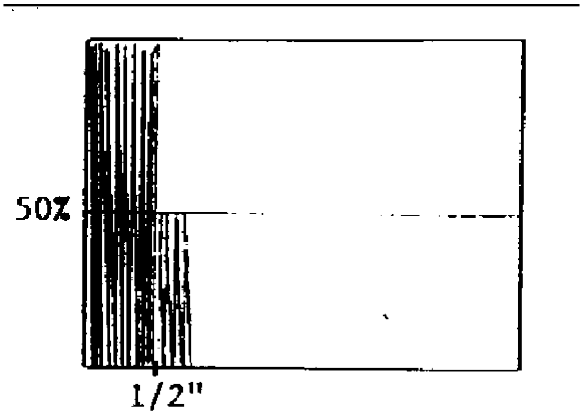

Figure 5

5.4 **SEARCH UNIT REFRACTED ANGLE**

5.4.1 After each 8 hours of search unit use, verify and record on the Equipment Qualification Log:

5.4.1.1 Contact face is flat - shall be within 0.005 inch.

5.4.1.2 Sound entry point is correct. Verify by setting the search unit in position D on the IIW block, position J on the DSC block and moving the unit until the radius signal is maximized. The point of the transducer which aligns with the index point on the block (see Fig. 6).

5.4.1.3 Using the 2 inch diameter hole in the IIW block (position B, Fig. 6) or the 1/8 inch diameter hole in the DSC block (position K, Fig. 6) couple the search unit to determine that the beam angle is within □ 2 degrees tolerance. Any units not meeting this tolerance shall be machined to produce the required refracted angle. This is permissible provided the distance between the toe or leading edge and entry point of the unit does not exceed 1 inch and that the internal reflections meet the requirements of 5.3.
Position transducer in position B on the IIW block for angles 40 through 60 degrees, or in position C on the IIW block for angles 60 through 70 degrees.
Position the transducer in position K for the DSC block (45 through 70 degrees) See Fig. 6.
For the selected angle, move the transducer back and forth over the line indicative of the transducer angle until the signal is maximized.Compare the sound entry point on the transducer with the angle mark on the block.

*NOTE: Locating flaws accurately requires using the actual refracted angle of the wedge.

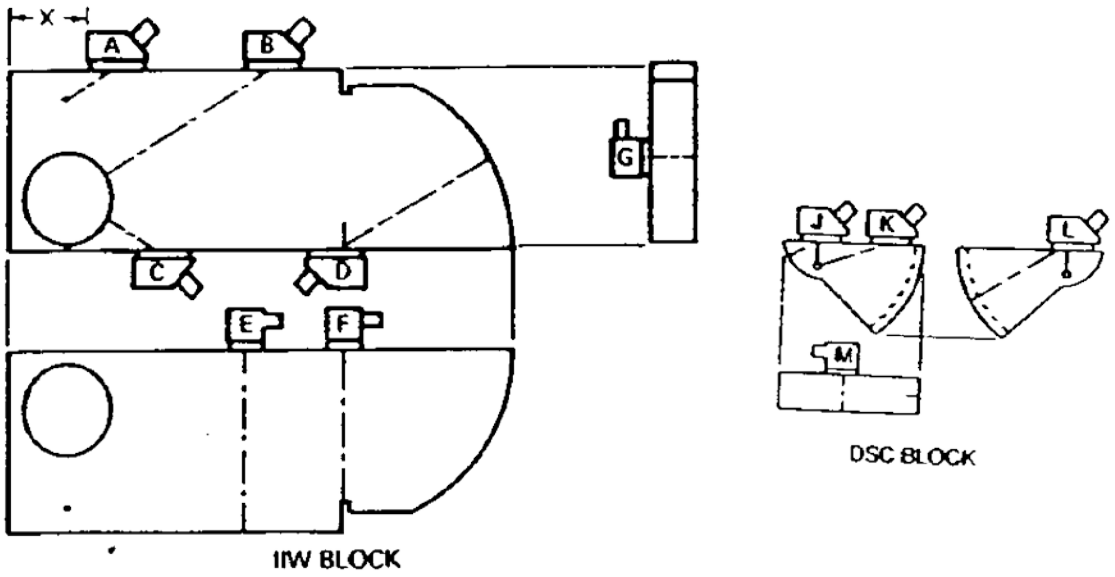

Figure 6

5.6 RESOLUTION

5.6.1 General

5.6.1.1 The resolution of each transducer - search unit combination shall be verified once every 6 months, or sooner, when: 1)the angle of the wedge has been corrected 2) the transducer has been dropped 3) the unit's performance is questionable.

5.6.2 Straight Beam Transducer Resolution - shall be performed as follows:

5.6.2.1 Set the transducer in position F on the IIW block (see Fig. 7).

5.6.2.2 The transducer shall clearly resolve all three distances.

5.6.3 Angle Beam Resolution

5.6.3.1 The combination of the search unit and instrument, using the settings previously qualified for vertical linearity, shall resolve each of the three appropriate set of holes for the angle used (see Fig. 7).

6. CALIBRATION FOR TESTING

6.1 GENERAL

6.1.1 All calibrations shall be performed with the transducer/search units, couplant, and test material at testing ambient temperature□ 5 degrees Fahrenheit.

6.1.1 All calibrations and tests to evaluate the acceptance of indications shall be made with reject off. This will be waived if optimization of the damp and reject controls are made such that:

6.1.1.1 Vertical linearity is acceptable in accordance with 5.2.

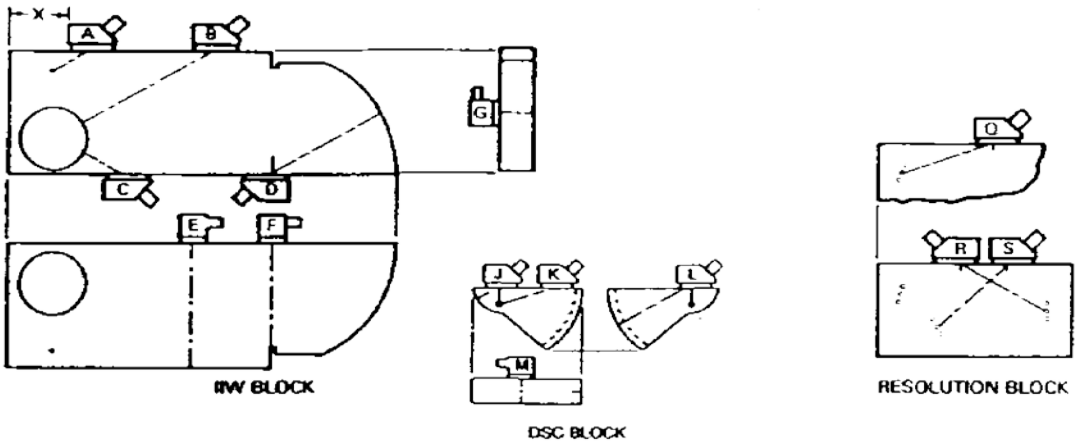

Figure 7

6.1.1.1 Resolution on the RC block is acceptable.

***NOTE:** Calibrations for verification scanning can, and often should be made with optimum balancing of damping and reject to decrease the signal to noise ratio, especially where long sound paths occur or when scanning within the initial pulse.

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

6.1.3 Recalibration shall be made for each operator, every 30 minutes, or when the electrical circuitry is disturbed as follows:

6.1.3.1 Transducer change

6.1.3.2 Battery change

6.1.3.3 Electrical outlet change

6.1.3.4 Coaxial cable change

6.1.3.5 Power outage (failure)

6.2 STRAIGHT BEAM CALIBRATIONS

***NOTE:** Straight beam calibrations and tests for examining steel plates, edge discontinuities for acceptance to D 1.5 Section 3 and ASTM A6, consult the Written Procedure "Straight Beam Ultrasonic Examination of Steel Plates for Inclusions and Laminations".

Sizing of flaws smaller than the diameter of the transducer or sizing as a ratio of amplitude of a flaw to the backwall amplitude is totally erroneous.

6.2.1 CALIBRATION FOR TESTING BASE METAL ADJACENT TO WELDS PRIOR TO ANGLE BEAM TESTING

6.2.1.1 Couple the search unit to Face A of the base metal and adjust the following:

6.2.1.1.1 Horizontal sweep shall be adjusted for distance calibration to present two back reflections.

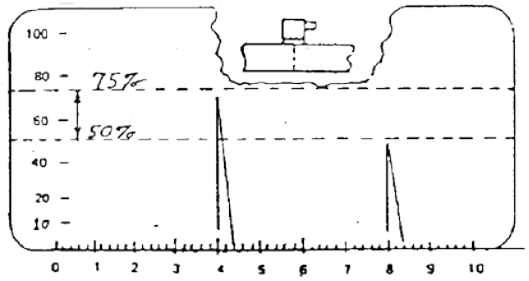

Figure 9

6.2.1.1.2 The sensitivity shall be established by locating the transducer on the base metal to be tested free of indications (other then the backwall indication) and bring the first back reflection to 50-75% screen height (see Fig 9). This indication shall remain on the CRT while sweeping the transducer along a 6 inch path (the surface condition of the plate viz., surfacial rust, scale etc. , as well as localized structure within the base metal will affect the amplitude of this signal). The transducer shall not be rotated while scanning.

6.2.2 PRECALIBRATION FOR ESTABLISHING DISTANCE PRIOR TO ANGLE BEAM CALIBRATION OR THICKNESS MEASUREMENTS

6.2.2.1 Any of the following methods may be used:

6.2.2.1.1 Using IIW block - Couple the search unit in position G on the IIW block (see Fig. 9). Adjust the instrument to produce indications at 1,2,3,4,etc. on the CRT.

6.2.2.1.2 Using DSC block - Couple the search unit in position M. Adjust the instrument to produce indications at 1,2,3 etc. on the CRT.

6.3 ANGLE BEAM (PULSE-ECHO, TRANSMIT-RECEIVE, SINGLE TRANSDUCER)

6.3.1 The horizontal sweep shall be adjusted to represent the actual sound path distance by using the IIW block, DC - distance reference block, or the DSC - distance and sensitivity reference block. The distance calibration shall be made using either the 5 inch or 10 inch scale on the CRT, whichever is appropriate, unless the required sound path is greater than 10 inches, in which case, a scale that incorporates the longest sound path shall be used
e.g. 15 or 20 inch.

The distance calibration procedure is as follows:

6.3.1.1 Set the transducer in position D on the IIW block (any angle). Set the transducer in position J or L on the DSC block (see Fig. 9)

6.3.1.2 Adjust the search unit to attain indications at:
4",9",14" on the IIW block (Type 1)

1",5",9",13" in position K on the DSC block

3",7",11" in position L on the DSC block

***NOTE:** Measurement shall be taken as the left hand side break in the baseline.

6.3.2 Amplitude (sensitivity) calibration shall be as follows:

6.3.2.1 Set the transducer in position A on the IIW block (see Fig. 9).

6.3.2.2 Adjust the maximized signal from the
0.060 inch hole to attain a horizontal reference line height indication.

6.3.2.3 The maximum decibel reading obtained shall be used as the "Reference Level", b reading on the Ultrasonic Test Report.

This is used in the following formula:

$$d = a - b - c$$

where:
a = Indication Level,
b = Reference Level,
c = Attenuation Factor (Sound path - 1" x 2dB)

d = Indication Rating.

6.3.2.3 The DSC block may be used to establish Reference Level b, only for a given transducer that
(1) has a central frequency of 2.25 MHz and (2) is correlated to the IIW block.

x - y = z

where:
x = IIW,
y = DSC.

For all future calibrations for this transducer, the value, z, shall be added to the y value at the time of calibration (b = y + z)

The value, z, shall be recorded on the wedge or logged for that transducer and be kept with it.

6.4 ANGLE BEAM (TRANSMIT - RECEIVE SEPARATE UNITS)

6.4.1 See Fig. 10. The reference plate used to calibrate horizontal sweep and reference level shall be of the same type and grade of steel being tested

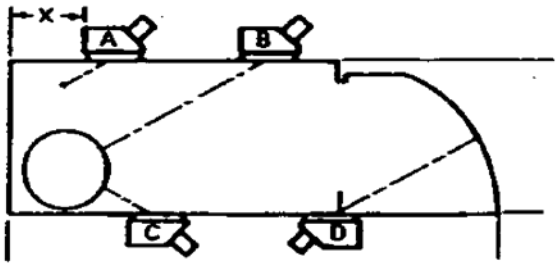

Figure 10

6.4.2 The reference side drilled holes shall be 0.060" □ 0.001" in diameter. It shall be produced by subdrilling and reaming to the final diameter. The hole shall be located at the mid depth of the planar indication for the evaluation of suspected planar flaws □ 1/2 inch.

6.4.3 The sweep shall be adjusted for the theoretical sound path for the reflected (from the side drilled

hole and Face B) centerline of the beam from the 0.625 inch, 3/4T and 5/4T hole, where T = thickness of the reference plate. This is accomplished by adjusting the transmitter (with correct standoff with respect to the hole) to receiver distance producing a maximum amplitude signal.

6.4.4 The amplitude from the 0.60 inch signal in the previous step shall be brought to reference height. This amplitude shall be recorded on the ultrasonic test report as reference level "B".

6.4.5 Scanning sensitivity shall be increased 20 dB above reference level.

6.4.6 The transmitting and receiving search units shall be calibrated specifically as such and shall not be interchanged.

6.4.7 The limits of the decay time and amplitude level shall be noted and determine the necessity for excavation.

7. TESTING PROCEDURE

7.1 GENERAL

7.1.1 Prior to ultrasonic evaluation, the entire surface, including the edges shall carefully be examined in accordance with Visual Test Procedure of Bridge Weldments, QAP 5910. Any surface conditions not meeting the contract requirements (e.g. undercut) or would obscure test results or otherwise negate meaningful testing shall be reported to Quality Control for correction and Q.C retest. Reduction in thickness from excessive grinding shall be verified by ultrasonic thickness measurements (edges may be checked with the micrometer).

7.1.2 A line on the Ultrasonic Test Report and on the test piece shall be established and designated as x-y. This is the center of the joint and is parallel to the weld axis. The x and the y mark shall distinguish the ends by which the location of an indication can be identified (See Fig. 11).

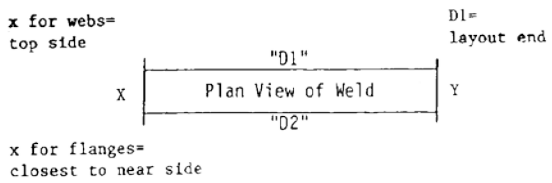

Figure 11

7.1.3 Distances perpendicular to the weld shall be designated as (each side) D1, D2. D1 shall nominally be designated as the layout end of the piece, when possible. The centerline of the joint shall be established to distinguish the evaluation procedure (Weld metal-base metal interface indications shall be evaluated with an incident sound angle closest to 90 degrees, with respect to the suspected flaw, with either 70, 60 or 45 degree transducer angles, as required per Table 1. Indications in this area on material to 1 1/2 inches in thickness shall be carefully evaluated for planar characteristics (lack of fusion).

7.1.4 Face A shall be assigned to the flush side on a transition joint and shall be marked on the piece when the butt joint joins equal thickness pieces.

7.1.5 Surface preparation shall be that prepared by the NDT Quality Control Operator, provided this preparation meets the following criteria:

7.1.5.1 The test surface is free of weld spatter, dirt grease, oil (other than couplant), paint, loose scale and has a contour permitting intimate coupling (125 microinch finish and no gaps under the search unit).

7.1.5.2 If the surface has been tested and contains loose scale or a point of tangency such that a meaningful test cannot be performed (e.g. superposition from propagated surface waves), the NDT operator must clarify his test.

7.1.5.3 If these conditions (7.1.4.2) are met, and yet the other conditions (7.1.4.1) are not met, prepare the surface accordingly.

7.1.5.4 Furthermore, if significant (particularly slag or planar) indications are found (judgment based upon the above, as well as length, amplitude and the type of flaw), prepare the surface by removing the existing mill scale to bright metal and re-evaluate.

7.1.5.5 Glycerin shall be applied to the test surface such that no voids are visible under the search unit while scanning. Cutting with water shall only be used as necessary to provide reasonable efficiency in scanning.

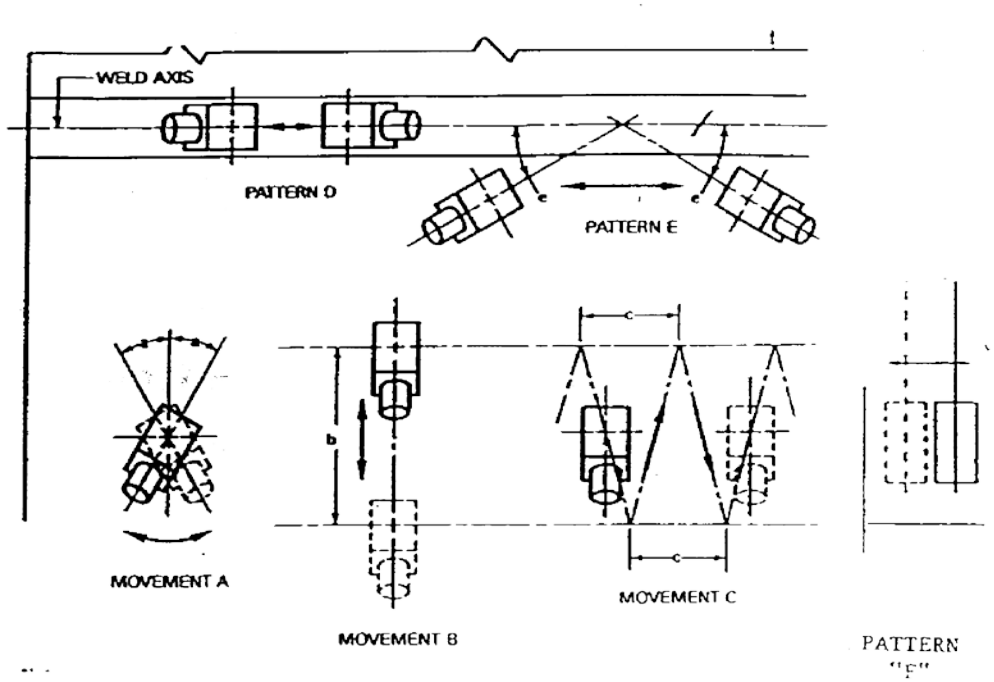

Figure 12

Notes:

1 Testing patterns are all symmetrical around the weld axis with the exception of pattern D which is conducted directly over the weld axis.
2 Testing from both sides of the weld axis is to be made whenever mechanically possible

7.1.5.6 The following procedure shall be used to determine the length of an indication(s) which have amplitude ratings more serious than class D:

7.1.5.6.1 The length shall be determined from the distance between the centerline of the transducer moved using pattern "F" (see Fig. 12) from the point the signal reaches maximum amplitude, is brought to reference height, the gain is increased 6dB (indication doubles in screen height) , and the signal again drops to reference screen height.

7.1.5.6.2 Record this length on the ultrasonic test report. This length is applicable for class A, B, and C flaws for redundant structures. This length is applicable for any amplitude (indication rating) within +6dB of a class C for

Fracture Critical Members.

7.2 STRAIGHT BEAM TESTING PRIOR TO ANGLE BEAM TESTS

7.2.1 The entire base metal through which the sound from the angle beam test must travel to test the weld shall be tested for laminar reflectors using a straight beam search unit conforming to the requirements of 4.3.1 and calibrated in accordance with 6.2.1. If any area of base metal exhibits a total loss of back reflection or an indication equal to or greater than the original back reflection height and is in an area of travel that will interfere with the transverse wave, its size, location and depth from face A shall be determined and reported on the ultrasonic test report. The length of lamellar discontinuities shall be determined as follows:

7.2.1.1 When a discontinuity indicates a diameter as large or larger than the diameter of the transducer, a total loss of back reflection and the center of the transducer shall be marked on the test plate where a 6 dB drop occurs (see Fig.13, move the transducer from the maximum signal from the flaw away until a 6dB drop occurs).

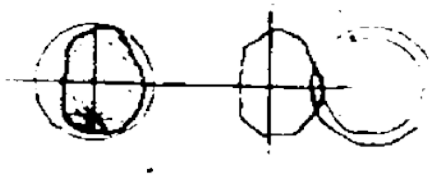

Figure 13

7.2.1.2 When the reflector is smaller than the diameter of the transducer, the perimeter boundary shall be measured at the center of the transducer where an indication just begins to appear (see Fig. 14, move the transducer from a boundary outside of the flaw toward the flaw).

In both of the cases above, it is important that the transducer not be rotated while moving (beam characteristics and attenuation may affect the amplitude).

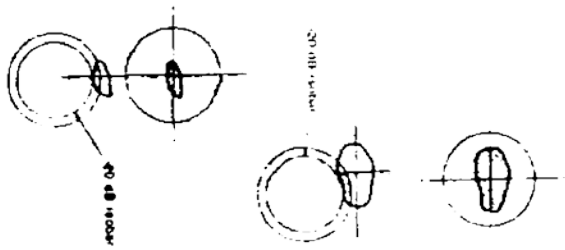

Figure 14

7.2.2 This shall be reported to the CDOT Bridge Construction Engineer as well as previous laminations found by Quality Control. The fabricator shall submit an alternate testing procedure prior to testing the weld. This procedure shall be forwarded to the CDOT Bridge Construction Engineer. The alternative procedure shall use one or more of the following alternative procedures.

7.2.2.1 Grind the weld surface(s) flush

7.2.2.2 Test from Faces A and B

7.2.2.3 Use other search unit angles

7.2.3 If an area within 1 inch from the face of the Figure 13weld exhibits a total loss of back reflection (D1.5, Fig. 3.1, type "Z" discontinuity), the internal lamination regardless of its area, shall be repaired in accordance with D1.5 3.2.3.7(2). The procedure to determine the loss of back reflection and area of the discontinuity shall be established in accordance with the Written Practice "Straight Beam Ultrasonic Examination of Steel Plates for Inclusions and Laminations".

Calibration for verifying this defect in this section will require calibration in accordance with 6.2.1.1. Aggregate area of this Type "Z" internal discontinuity is required to be evaluated in accordance with the above referenced Written Practice. Sizing shall be made for discontinuities smaller than the diameter of the transducer by scanning toward the reflector and marking the center of the transducer where a 6dB drop occurs.

7.3 ANGLE BEAM, ONE TRANSDUCER, ONE UNIT, BUTT JOINTS

7.3.1 Welds shall be tested using an angle beam search unit conforming to the requirements of this written practice. Sensitivity shall be increased from the reference level for weld scanning in accordance

with the provisions of Table 2 and 3, as applicable.

7.3.1 Welds shall be tested using an angle beam search unit conforming to the requirements of this written practice. Sensitivity shall be increased from the reference level for weld scanning in accordance with the provisions of Table 2 and 3, as applicable.

7.3.2 The testing angle and scanning procedure shall be in accordance with Table 1, except testing in Leg I Face A and B shall be performed on all tension welds and thickness transition welds from both sides of the weld axis.

7.3.3 All butt welds shall be tested from each side of the weld axis.

7.3.4 All welds shall be examined both longitudinal to their axis using scanning pattern D (see Fig 12) and transverse to the axis using scanning patterns A, B, C combined into a continuous movement. Sound shall be passed through the entire volume of weld metal and heat affected zones and meeting the requirements of Table 1 (D1.5 Table 6.3) or Table 2 (D1.5 Table 6.4).

7.3.5 When a discontinuity indication appears on the screen, the maximum amplitude attained from the reflector shall be adjusted to produce a horizontal reference level trace deflection on the CRT screen. This adjustment shall be made with the calibrated gain control. The instrument reading in decibels shall be used as the "Indication Level", "a", for calculating the "Indication Reading, "d", as shown on the Ultrasonic Test Report.

7.3.6 The "Attenuation Factor", "c", is attained by subtracting 1 inch from the sound path distance and multiplying the remainder by two. This factor shall be rounded to the nearest dB value. Fractional values less than 0.5 dB shall be rounded to the lower integral dB level and those equal to or greater than 0.5 dB shall be increased to the higher integral dB level.

7.3.7 The "Indication Rating", "d", on the Ultrasonic Test Report, is the difference in dB between the indication level and the reference level with correction for attenuation as indicated in the following formula:

a - b - c = d

where:
b = Indication Level
c = Attenuation Correction Factor (Sound path - 1") x 2dB
d = Indication Rating

7.3.8 The following procedure shall be used to determine the lengths of indications which have dB ratings more serious than for a class D indication. The length shall be determined by measuring the distance between the transducer centerline locations (using scanning pattern "F" without angulating the search unit - Fig 12) where the indication rating amplitude drops 50%, i. e. 6 dB below the highest amplitude (maximized) of the flaw. This length shall be recorded on the ultrasonic test report. This shall apply to class A, B, and C flaws.

7.3.9 Any indication at scanning sensitivity that produces a slow (relative) decay time as the search unit is moved away and towards the reflector shall be further evaluated as a planar (specular) indication. Further evaluation shall be required as follows:

7.3.9.1 The limit of the depth of the reflector shall be established based upon the beam profile of the

search unit previously established (Procedure for determining the beam characteristics of an ultrasonic search unit). The sensitivity shall be set so that a 20 dB drop in amplitude is measured. A datum reference mark shall be made on the test plate and the peripheral limit of the reflector measured based on the beam spread at the sound path indicated.

7.4 ANGLE BEAM, TWO TRANSDUCERS, TWO UNITS, BUTT JOINTS (SEE FIG 15)

7.4.1 A sketch of the joint with an overlay indicating the reflected sound paths (function of the transmitter - receiver standoff distance and test specimen thickness) shall be made to assess reflector location.

7.4.2 The procedure shall conform to this document elsewhere, with the following exceptions:

7.4.2.1 Any planar indications to be evaluated shall be brought to maximum amplitude first by moving the units (separated by the theoretical standoff) to maximize the indication.

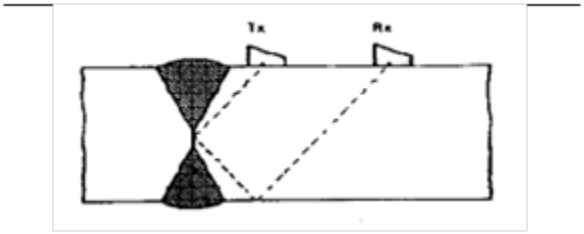

Figure 15

7.4.2.2 The receiver shall then be moved forwards or backwards without angulating, to further maximize the indication.

7.4.2.3 The indication rating shall then be determined from the signal height at the reference height from the DAC curve previously established.

7.4.2.3 The indication shall be evaluated from the indication rating in accordance with Table 2 (D1.5 Table 6.3) or Table 3 (D1.5 Table 6.4) as applicable and the decay time (distance) of the signal. Planar indications shall require excavation.

7.5 EVALUATION

7.5.1 Acceptance criteria for welds subject to tensile stresses, as indicated on the plans, shall be evaluated in accordance with Table 2 (D1.5 Table 6.3).

7.5.2 Acceptance criteria for welds indicated as subject to compression stresses on the plans shall be evaluated in accordance with Table 2 (D1.5 Table 6.4).

7.5.3 Portions of the weld that are unacceptable are as follows:

7.4.3.1 Any planar indication not excluded by investigation as a crack or lack of fusion.

7.5.3.2 Indications as noted in Table 3 (D1.5 Table 6.3) for tension welds.

7.5.3.3 Indications as noted in Table 3 (D1.5 Table 6.4) for compression welds.

7.5.3.4 Welds found unacceptable by this procedure (the length of a crack plus 2 inches each side of the crack - D1.5 3.7.2.4) shall be repaired as permitted by D 1.5 - 3.7. Repaired areas shall be ultrasonically tested Edges of plate repaired shall also include MT or PT) and reported on the original Ultrasonic Test Report.