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BECHTEL CONSTRUCTION, INC.
MANUAL ULTRASONIC EXAMINATION PROCEDURE FOR
AUSTENITIC AND DISSIMILAR METAL PIPING WELDS
UT-AUSTENITIC
REVISION 9

Date March 18, 1987

MATERIALS AND QUALITY SERVICES

Prepared and Approved [signature] NDE Level III Examiner 3-18-87 Date

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(For Limerick Project Only)

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MQS G R1 8/83

## 1.0 SCOPE

1.1 This procedure specifies the minimum requirements for OD surface, manual contact ultrasonic examination of full penetration butt welds and adjacent base metal in austenitic and dissimilar metal piping systems, 0.2 to 6.0 inches in nominal wall thickness.

1.2 Configuration types include pipe-to-pipe, pipe-to-fitting, fitting-to-fitting, pipe-to-safe end and longitudinal welds.

1.3 Alternate examination techniques may be used as provided by IWA-2240 of Reference 2.1.

## 2.0 REFERENCES

2.1 ASME Boiler and Pressure Vessel Code, Section XI, 1980 Edition through Winter 1981 Addenda.

2.2 American Society for Nondestructive Testing, Recommended Practice SNT-TC-1A, 1980 Edition.

2.3 Bechtel Construction Procedure CP-W-4, Preservice Inspection of Nuclear Piping Systems.

## 3.0 GENERAL REQUIREMENTS

### 3.1 Personnel

3.1.1 Bechtel NDE Personnel shall be certified and certification records maintained in accordance with Bechtel's NDE Certification Standards, NEPQ 1 and NEPQ 2.

3.1.2 Subcontractor NDE Personnel shall be certified in accordance with their NDE Personnel Certification Procedure, which shall meet the requirements of the American Society of Nondestructive Testing's Recommended Practice No. SNT-TC-1A, 1980 Edition as well as ASME Boiler and Pressure Vessel Code, Section XI, 1980 Edition through Winter 1981 Addenda.

3.1.3 Complete certification records for the NDE Subcontractor's NDE personnel plus the Level III that certified the individual, shall be submitted to the designated Bechtel individual prior to performing final acceptance examination. Complete certification records for each individual shall be maintained on file at the jobsite.

### 3.2 Equipment

3.2.1 A pulse-echo ultrasonic instrument with an A-scan presentation shall be used. The instrument shall be equipped with a stepped gain control calibrated in units of 2 dB or less. The instrument shall be capable of generating and receiving frequencies of 1.00 to 5.00 MHz. Manufacturer's recommended maintenance checks of ultrasonic instruments shall be performed annually.

3.2.2 Search units may contain either single or dual transducer elements,

3.2.2.1 Transducers shall have a nominal frequency range of 1.0 to 5.00 MHz.

3.2.2.2 Generally, the maximum nominal transducer dimensions for circular, square, or rectangular active elements shall conform to the following:

| Nominal Material Thickness | Transducer Size* |
|---|---|
| 1/4" or less | 1/4" x 1/4" or 1/4" Round |
| 1/4" to 1/2" | 1/4" x 1/4" or 1/4" Round to 1/2" x 1/2" or 1/2" Round |
| 1/2" and above | 1/2" x 1/2" or 1/2" Round to 1" Round |

*For dual element transducers, the dimension applies to one of the two elements.

NOTE: Other transducers may be used provided a code calibration is documented.

3.2.3 Search unit cables shall be of the coaxial type.

3.2.4 Wedges shall be used to produce shear waves at a nominal 45-degree angle. Other angles and modes of propagation may be used for evaluation of an indication, or where wall thickness, geometric configuration or material characteristics impede effective use of a 45 degree angle beam for examination.

3.2.4.1 Transducers/Wedges of other sizes, angles, mode of propagation, or frequencies may be used where required by material characteristics, geometric configuration or for the evaluation of indications, with the approval of the cognizant Level III. Level III approval is not required if high attenuation and/or ultrasonic beam redirection appears to prevent full coverage by the shear angle beam technique. In this case, the Lead PSI Technician may elect to supplement shear wave examinations with longitudinal angle beam examination.

3.2.4.2 Variables such as weld preparation, weld crown width, or physical interference may preclude obtaining two directional coverage of the examination volume with 1/2 V-path examination from both sides of weld. If this interference occurs, the beam path shall be increased to obtain two direction coverage of the examination volume. Alternatively, the interference may be eliminated by one or more of the following:

1) reducing the dimension of the wedge edge-to-beam entry point

2) reducing search unit size

3) increasing the beam angle

4) conditioning the weld surface.

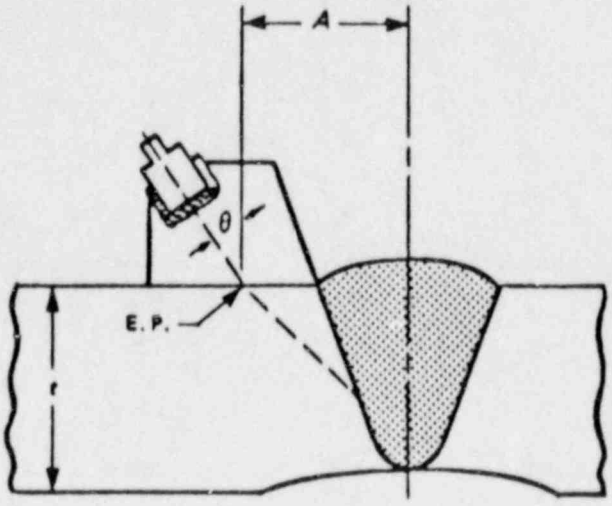



FIGURE 1

3.2.4.3 When examination is limited to 1/2 V-path, dimension A in Figure 1 shall meet the following criteria:

1) 0.93t for $\theta = 45°$
2) 1.6t for $\theta = 60°$
3) 2.5t for $\theta = 70°$

3.2.4.4 Calibration shall be done with the contact wedges used during the examination.

3.2.5 Couplants

3.2.5.1 Any commercially available couplant may be used to couple the transducer to the part during calibration and examination. The same couplant shall be used during both processes.

3.2.5.2 Couplants shall be certified for total sulfur and halogen content in accordance with ASTM D-129-64 and D-808-63, respectively. The total residual halogens and sulfur shall not exceed 1 percent by weight, respectively.

3.2.6 Basic Calibration Block

3.2.6.1 Calibration blocks shall be made from material of the same nominal diameter and nominal wall thickness or pipe schedule as the component to be examined.

3.2.6.2 Material Specification

1) The calibration blocks shall be fabricated from one of the materials specified for the components being joined by the weld.

2) Where the examination is to be performed from only one side of the joint, the calibration block material shall be the same specification as the material on that side of the joint.

3) If material of the same specification is not available, material of similar chemical analysis, tensile properties, and metallurgical structure may be used as approved by PECo.

3.2.6.3 The finish on the block surfaces shall be representative of the surface finish of the component to be examined.

3.2.6.4 The calibration blocks shall contain circumferentially and longitudinally oriented notches no greater than 1/4-inch wide and 1- to 2-inches long on the ID and OD surfaces. The sides of the notches shall be perpendicular to the entry surface (Figure 2).

3.2.6.5 Surface notch depths shall conform to Table 1 below:

TABLE 1

| Nominal Pipe Wall Thickness (t) | Notch Depth (D)* | Tolerance |
|---|---|---|
| Carbon Steel - less than 0.312 inch<br>Stainless Steel - less than 0.312 inch | 0.10 t | + 0.005 inch<br>- 0.010 inch |
| Carbon Steel - 0.312 to 6.0 inches | $0.104\ t - 0.009\ t^2$ | + 10 percent<br>- 20 percent |
| Stainless Steel - 0.312 to 6.0 inches | 0.10 t | + 10 percent<br>- 20 percent |

*Notch depth in base material (excluding cladding)

3.2.6.6 The calibration blocks shall contain holes to be used during straight beam and one-half V-path angle beam calibrations. The holes shall be drilled parallel to the length axis in the end surface of the pipe calibration block. For nominal thickness greater than 0.5 inch, a minimum of two holes, each of the same diameter (Table 2), located at 1/4t and 3/4t, shall be used. For nominal thickness equal to or less than 0.5 inch, a minimum of one hole, located at 1/2t shall be used.

3.2.6.7 Hole diameters shall conform to Table 2 below:

TABLE 2

| Weld Thickness (t) | Basic Calibration Block Thickness (T) | Hole Diameter |
|---|---|---|
| 1 in. or less | 3/4 in. or t | 3/32 in. |
| Over 1 in. through 2 in. | 1-1/2 in. or t | 1/8 in. |
| Over 2 in. through 4 in. | 3 in. or t | 3/16 in. |
| Over 4 in. through 6 in. | 5 in. or t | 1/4 in. |

NOTES:

(1) Holes shall be drilled and reamed a minimum of 1-1/2 inches deep, essentially parallel to the examination surface and perpendicular to the examination beam direction while meeting the requirements of paragraph 3.2.6.6.

(2) The tolerance for hole diameter shall be ± 1/32 inch. The tolerance on hole location through the thickness shall be ± 1/8 inch.

3.2.6.8 Calibration reflectors shall be positioned in the block in such a manner that, when the search unit is maximized on the reflector, the centerline of the search unit is greater than 3/4 inch from the adjacent side of the block.

3.2.6.9 Additional reflectors may be installed provided they do not interfere with establishing the primary reference level.

3.2.7 Reference blocks such as an IIW or a Rompas may be used for:

1) search unit beam exit point location
2) angle verification
3) sweep range calibration
4) system calibration checks

provided the block is fabricated from acoustically similar material.

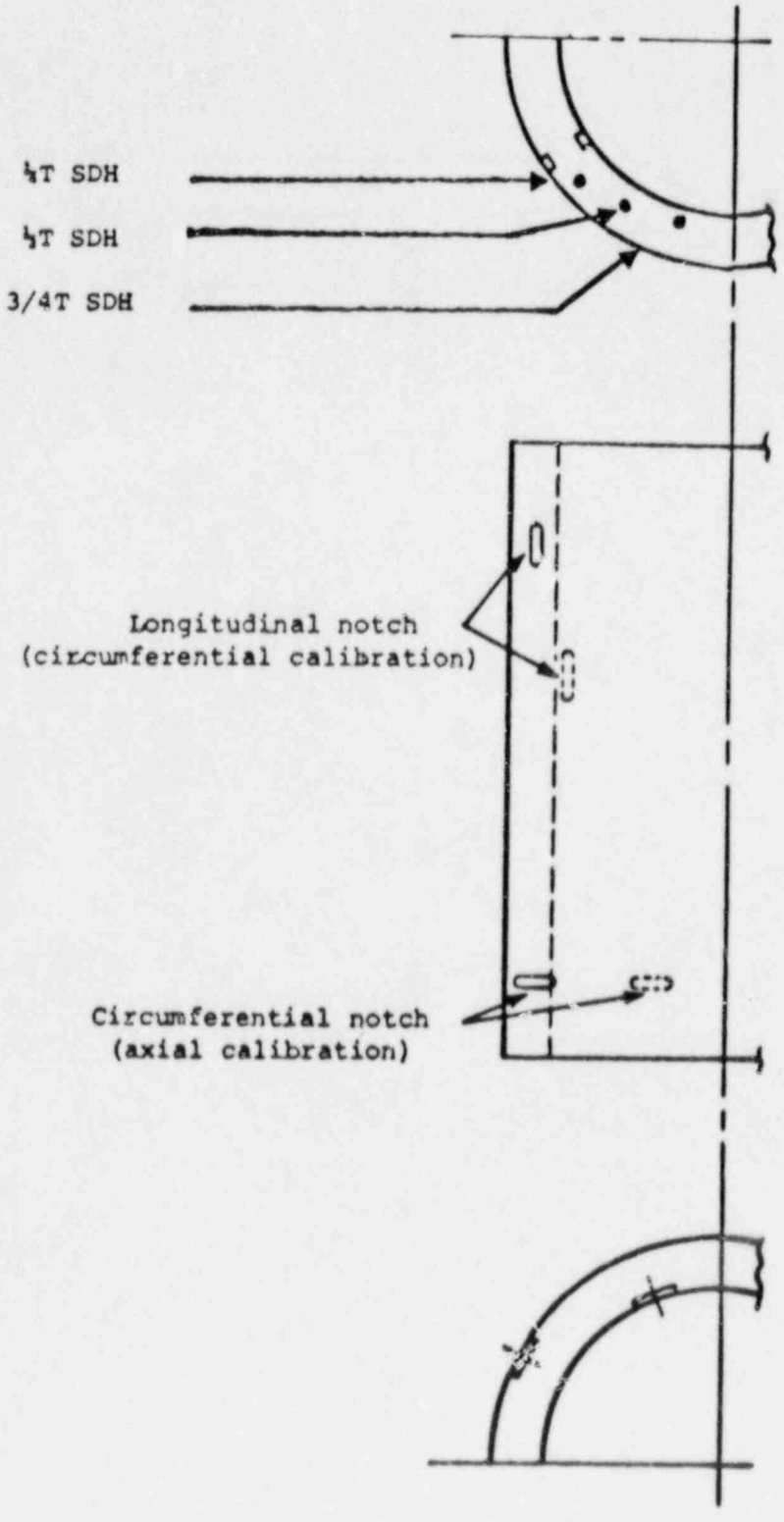



FIGURE 2. Recommended Pipe Basic Calibration Block

NOTE: Alternate block design and layout may be used, provided similar beam paths are utilized.

## 4.0 CALIBRATION

### 4.1 Instrument Calibration

4.1.1 Instrument calibration for screen height and amplitude control linearities shall be verified prior to the start of each day's examinations.

4.1.2 Screen Height Linearity

4.1.2.1 The ultrasonic instrument shall provide screen height linearity within 5 percent of full range for at least 80 percent of the full screen height (FSH) (baseline to maximum calibrated screen points).

4.1.2.2 To verify the capability of the ultrasonic instrument to meet the linearity requirements, position a search unit as shown in Figure 3 so that echoes can be observed from any two reflectors in a calibration block.

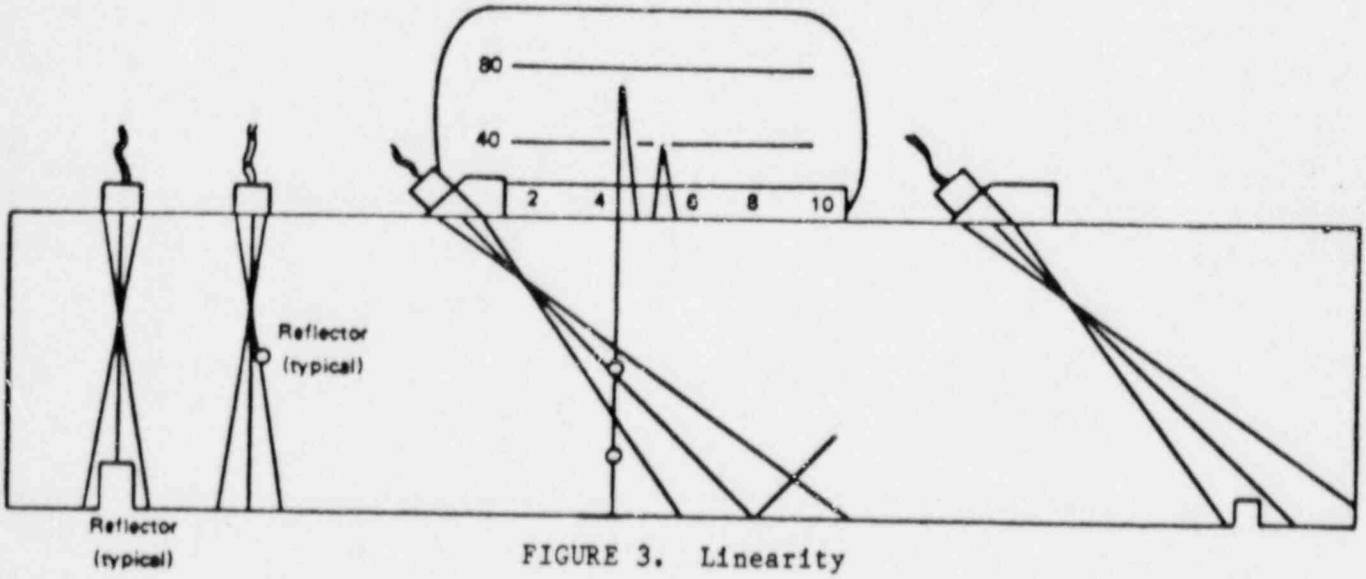



FIGURE 3. Linearity

4.1.2.3 Adjust the search unit position to give a 2:1 ratio of amplitudes between the two echoes, with the larger set at 80 percent of full screen height. Without moving the search unit, adjust only the calibrated gain control to successively set the larger echo from 100 percent to 20 percent of FSH, in 10-percent increments (or 2 dB steps if a fine control is not available), and read the amplitude of the smaller echo at each setting. The reading shall be 50 percent of the larger amplitude, within 5 percent of FSH. The settings and readings shall be estimated to the nearest 1 percent of full screen.

4.1.3 Amplitude Control Linearity

4.1.3.1 The ultrasonic instrument shall utilize an amplitude control, accurate over its useful range to ± 20 percent of the nominal amplitude ratio, to allow measurement of indications beyond the linear range of the vertical display on the screen.

4.1.3.2 To verify the accuracy of the amplitude control in the ultrasonic instrument, as required in paragraph 4.1.3.1, position a search unit so that an echo from one reflector in a calibration block is peaked on the screen. With the

increases and decreases in gain (dB) shown in Table 3, the echo amplitude shall fall within the specified limits.

TABLE 3
SPECIFIED LIMITS FOR ECHO AMPLITUDE

| Indication Set at Percent of Full Screen | dB Control Change (1) | Indication Limits, Percent of Full Screen |
|---|---|---|
| 80 percent | - 6 dB | 32 to 48 percent |
| 80 percent | - 12 dB | 16 to 24 percent |
| 40 percent | + 6 dB | 64 to 96 percent |
| 20 percent | + 12 dB | 64 to 96 percent |

NOTE:

(1) Minus denotes decrease in amplitude; plus denotes increase.

Convenient reflectors from any calibration block may be used with angle or straight beam search units. The settings and readings shall be estimated to the nearest 1-percent of full screen.

4.1.4 Screen height and amplitude control linearity verifications shall be documented in the appropriate blocks on the Ultrasonic Calibration Report, MQS-013.

4.1.5 Instruments that do not meet the requirements of paragraphs 4.1.2 or 4.1.3 shall not be used.

4.2 Search Unit Calibration

4.2.1 Prior to performing system calibration (4.3), the search unit beam exit point shall be determined and marked on the wedge. In addition, the beam angle shall be determined and documented in the "measured angle" block on the Ultrasonic Calibration Report, MQS-013. This shall be verified using one of the reference blocks described in paragraph 3.2.7.

4.3 System Calibration

4.3.1 General Requirements

4.3.1.1 A complete ultrasonic examination system calibration establishing the DAC curve shall be performed and the data documented appropriately on the Ultrasonic Calibration Report, MQS-013 each day prior to the examination.

4.3.1.2 Calibration shall include the complete ultrasonic examination system. Any change in search units, shoes, couplants, cables, ultrasonic instruments, recording devices, or any other parts of the examination system shall be cause for a calibration check. The initial and final calibration shall be performed on the basic calibration block. Intermediate calibration checks may be

performed in the same manner as the initia' calibration or as an alternate as described in paragraph 4.7.

4.3.1.3 The maximum calibration indications shall be obtained with the sound beam oriented essentially perpendicular to the axis of the calibration reflector. The centerline of the search unit shall be at least 3/4 inch from the nearest side of the block. (Rotation of the beam into a corner formed by the reflector and the side of the block may produce a higher amplitude signal at a longer beam path; this beam path shall not be used for calibration.)

4.3.1.4 Calibration shall be performed from the surface (clad or unclad) of the calibration block that corresponds to the component surface to be examined.

4.3.1.5 The temperature of the calibration block surface shall be within 25°F of the temperature of the examination surfaces. These temperatures and the serial number of the temperature measuring device shall be documented in the appropriate blocks on the Ultrasonic Calibration Report, MQS-013.

4.3.2 System Calibration Check

4.3.2.1 A system calibration check, which is the verification of the instrument sensitivity and sweep range calibration, shall be performed and documented on the Ultrasonic Calibration Report, MQS-013.

1) at the start and finish of each examination,
2) with any change in the examination equipment (instruments, recording instruments, search units, shoes, couplants, or cables),
3) with any change in examination personnel,
4) at least every twelve hours during system use.
5) At any time when, in the opinion of the operator, there is doubt as to the validity of the calibration.

4.3.2.2 If any point on the DAC curve has decreased 20 percent or 2 dB of its amplitude, all data sheets since the last calibration check shall be marked void. A new calibration shall be made and recorded, and the voided examination areas shall be reexamined.

4.3.2.3 If any point on the DAC curve has increased more than 20 percent or 2 dB of its amplitude, recorded indications taken since the last valid calibration or calibration check may be reexamined with the correct calibration and their values changed on the data sheets.

4.3.2.4 If any point on the DAC curve has moved on the sweep line more than 10 percent of the sweep division reading, correct the sweep range calibration and note the correction in the examination record. If recordable reflectors are noted on the data sheets, those data sheets shall be voided, a new calibration shall be recorded, and the examination areas shall be reexamined.

4.3.2.5 Pulse shape (dampening), noise suppression (reject), and filter controls shall be at the same position during examination, calibration (verification), and system linearity checks. Adjusting or changing these controls while the instrument is calibrated for an examination is prohibited. The minimum or "off" position is the recommended position for these controls.

4.4 Straight Beam Calibration

4.4.1 The sweep shall be calibrated to obtain a linear display throughout the entire examination range utilizing a reference block.

4.4.2 Sensitivity Calibration for Weld and Code-Required Volume

4.4.2.1 For calibration blocks which contain 1/4t and 3/4t side-drilled holes:

1) Position the search unit to display the response from the 3/4t hole. Adjust the gain to provide an 80 percent of full screen height signal. This is the primary reference level. Mark this response on the screen.

2) Draw a straight horizontal line on the screen through the thickness of the part. This is the DAC line.

3) Without changing the gain, note the sweep position and amplitude of the 1/4t hole response if possible.

4.4.2.2 For calibration blocks which contain only a 1/2t hole:

1) Position the search unit to obtain the maximum response from the 1/2t hole. Adjust the gain to provide an 80 percent of full screen height signal. This is the primary reference level. Mark the response on the screen.

2) Draw a straight horizontal line on the screen through the thickness of the part. This is the DAC line.

4.4.3 0-Degree Calibration for Base Metal Examination Through Which Angle Beams Shall Pass

4.4.3.1 Position the search unit on the component being examined in the area of base metal through which the angle beam will pass. Adjust the gain until the back reflection is at 80 percent FSH; this is the reference sensitivity for base metal examination. Record this gain on the calibration data sheet.

4.5 Angle Beam Calibration

4.5.1 When the weld crown is not ground flush, angle beam search units, as practical, shall meet the requirements of paragraph 3.2.4.3 to ensure full coverage of the weld root area.

4.5.2 Angle beam calibration of the ultrasonic system sweep shall be performed using the basic calibration block or reference block (paragraph 3.2.7). The sweep shall, as a minimum, incorporate the entire examination volume, and may be established as follows:

4.5.2.1 Place the angle beam transducer on the block so that the ultrasonic beam is aimed at the applicable reflector(s). Use the specified metal path distances in the applicable reference block (paragraph 3.2.7) or calculate and use the metal path distance for each reflector in the basic calibration block.

4.5.2.2 Maximize the return signals and adjust the sweep and range controls to position them on the sweep at convenient increments to include the required examination volume.

4.5.2.3 For welds accessible from both sides, a one-half V-path shear angle calibration shall be performed in the following manner. The shape of the DAC curve shall be generated using the axial 1/4-t and 3/4-t side drilled holes in a basic calibration block. When the calibration block only contains a 1/2t hole, the shape of the DAC curve shall be generated using the reflections from the hole at the 1/4 V-path and 3/4 V-path positions. In either case, the maximum hole response is set to 80 percent of the calibrated screen height. This response shall be obtained with the transducer aligned so that the beam is perpendicular to the SDH's (to prevent possible erroneous corner responses) and at least 3/4 inch from the adjacent side of the block. The DAC shall be clearly marked on the CRT screen and smoothly extrapolated to cover the full examination range. The 5/4 t hole response may be used as an aid for extrapolation. Sensitivity is obtained by using the gain control to adjust the peaked one-half V-notch response to the DAC curve. The DAC and notch response shall also be recorded on the Calibration Report form. The DAC curve corrected for the notch sensitivity is the primary reference level (1X) for all welds except the fitting side.

4.5.2.4 For welds accessible from one side only, a full V-path shear angle calibration shall be performed using either the circumferential or axial ID and OD notches. The shape of the DAC curve shall be generated by placing the angle beam transducer on the OD surface of the basic calibration block and obtaining a response from the ID notch at the one-half V-path position. Manipulate the transducer until the response is maximized on the CRT screen. Adjust the gain control to bring this signal to 80 percent FSH. Mark its amplitude and sweep position on the CRT screen. Without changing the gain, move the transducer away from the notch until a signal is obtained from the same notch at the one-and-one-half V-path position. Manipulate the transducer to maximize this signal and mark its sweep and amplitude position on the CRT screen. Obtain the reflected signal from the OD notch at the full V-path position. Manipulate the transducer to maximize this signal and mark its sweep and amplitude position on the CRT screen. Draw a smooth line through the three points. After the DAC curve has been established, 6 dB shall be added by adjusting the gain control. The resulting gain (DAC plus 6 dB) shall be the primary reference level for all one side shear angle beam exams.

4.5.2.5 If longitudinal angle beam examination is performed per paragraph 3.2.4.1 or 5.2.2, one-half vee calibration shall be accomplished as follows:

Using the axial 1/4 and 3/4t side-drilled holes in a basic calibration block, adjust and mark the CRT for the hole which produces the highest amplitude response to 80 percent FSH. This is the primary reference level. Without changing sensitivity, maximize the amplitude response from the remaining hole and mark its peak amplitude on the CRT. Draw a smooth DAC curve through these points and extrapolate through the full thickness range. Record the amplitude and sweep position from the appropriate ID notch and mark these positions on the CRT.

For basic calibration blocks which contain only a 1/2t hole:

Set the 1/2t hole to 80 percent and mark its position on the CRT. Draw a straight horizontal line through this point to cover the full thickness range. This is the primary reference level. In addition, record the amplitude and sweep position from the appropriate ID notch and mark these positions on the CRT.

4.6 During calibration, should any point on the DAC fall below 20% FSH, that response shall be increased to 20% FSH and the previous signal response shall be measured and recorded. This is the reference sensitivity for a secondary DAC. The shape and slope of both DACs shall be recorded on the Ultrasonic Calibration Report, MQS-013.

4.7 For fitting side welds, the primary reference level shall be the distance amplitude curve (DAC) initially obtained directly from the calibration block as described in paragraph 4.5.2.3 or 4.5.2.4, plus any sensitivity correction which may be required as a result of the acoustic compatibility correction techniques described in paragraphs 4.7.1 through 4.7.3.3 below.

4.7.1 Acoustic compatibility correction for angle beam shear wave examinations shall be accomplished using the thru-transmission technique and shall be performed in the axial direction (where applicable). This technique shall be performed on both sides of the circumferential piping weld.

4.7.2 Corrections for angle beams is accomplished by measuring and recording the surface distance between the exit points of the two transducers and dividing this value by two times the thickness measured at the equidistance between the search units. This measurement is the tangent of the angle.

4.7.2.1 This compatibility correction should be accomplished on the basic calibration block and the component to be examined to determine actual beam angle.

4.7.3 If the two sides of the circumferential weld require different amounts of gain for acoustic compatibility correction, the amount of gain required for each side of the weld shall be added to that side during examinations.

4.7.4 The method for determining the acoustical compatibility correction is dependent on the type of examination and calibration performed. The following methods shall be employed as appropriate.

4.7.4.1 Acoustic compatibility for 1/2 V-path calibration and examination:

1) Adjust the screen for a minimum of one full V-path presentation.

2) Position the search units on the OD surface of the calibration block and maximize the received signal after one full V-path through the material.

3) Adjust the sensitivity controls to produce a signal amplitude of 80 percent FSH.

4) Record this sensitivity on the data sheet.

5) Using the same equipment, position the search units on the OD surface of the examination component.

6) Using the sensitivity recorded in step 4 above, maximize the received signal after one full V-path through the material thickness.

7) If the amplitude of the received signal is different from 80 percent FSH, change the sensitivity to bring the signal amplitude to 80 percent FSH.

8) Record this change in dB on the data sheet.

9) If the sensitivity change recorded in step (8) is more than 4dB, the Lead PSI Technician shall be notified prior to completion of the examination. Final disposition for completion of the examination will be by a Bechtel Level III.

4.7.4.2 Acoustic compatibility for one V-path calibration and examination:

1) Adjust the screen for a minimum of two full V-paths presentation.

2) Position the search units on the OD surface of the calibration block and maximize the received signal after two full V-paths through the material.

3) Adjust the sensitivity controls to produce a signal amplitude of 80 percent FSH.

4) Record this sensitivity on the data sheet.

5) Using the same equipment, position the search units on the OD surface of the examination component.

6) Using the sensitivity recorded in step (4) above, maximize the received signal after two full V-paths through the material thickness.

7) If the amplitude of the received signal is different than 80 percent FSH, change the sensitivity to bring the signal amplitude to 80 percent FSH.

8) Record this change in dB on the data sheet.

9) If the sensitivity change recorded in step (8) is more than 4dB, the Lead PSI Technician shall be notified prior to completion of the examination. Final disposition for completion of the examination will be by a Bechtel Level III.

4.7.4.3 Acoustic compatibility for 1-1/2 V-path calibration and examination:

1) Adjust the screen for a minimum of two full V-paths presentation.

2) Position the search unit on the OD surface of the calibration block and maximize the received signal after one full V-path through the material thickness.

3) Adjust the sensitivity controls to produce a signal amplitude of 80 percent FSH.

4) Record this sensitivity on the data sheet.

5) Maximize the signal after two full V-paths through the calibration block thickness.

6) Record the amplitude of the received signal on the data sheet.

7) Using the same equipment used above, position the search units on the OD surface of the examination component.

8) Using the sensitivity from step (4) above, maximize the received signal after one full V-path through the material thickness.

9) If the amplitude of the received signal is different from 80 percent FSH, change the sensitivity to bring the signal amplitude to 80 percent FSH.

10) Record this change in dB on the data sheet.

11) Without changing the sensitivity and where accessibility on the component allows, maximize the received signal after two full V-paths through the component thickness.

12) If this signal is different than that recorded in step (6) above, change the sensitivity to bring the component amplitude response level to the amplitude response level of the calibration block.

13) Record this change in dB on the data sheet.

14) If the sensitivity changes in steps (10) and (13) above total more than 6dB, the Lead PSI Technician shall be notified prior to completion of the examination. Final disposition for completion of the examination will be by a Bechtel Level III.

4.8 Initial and intermediate calibration checks may be performed using one of the reference blocks described in paragraph 3.2.7, provided the following is documented in the appropriate blocks on the Ultrasonic Calibration Report, MQS-013.

1) Reference block type/serial number, e.g. Rompas S/N #953608.

2) Reference reflector used.

3) Gain setting establishing the signal peak amplitude if different from primary response.

4) Horizontal sweep position of left side of signal base.

4.9 As a minimum, the following data shall be recorded on the calibration data sheet (Form MQS-013):

1) calibration sheet identification and date of calibration;

2) names of examination personnel;

3) examination procedure number and revision;

4) basic calibration and reference block identification;

5) ultrasonic instrument identification and serial number;

6) beam angle, couplant, and mode of wave propagation in the material;

7) orientation of search unit with respect to the pipe (longitudinal or circumferential);

8) search unit identification -- frequency, size, and manufacturer's serial number;

9) special search units, wedges, shoe type, or saddle's identification, if used;

10) search unit cable type and length;

11) times of initial calibration and subsequent calibration checks;

12) amplitudes and sweep readings obtained from the calibration reflectors.

13) temperature measuring device serial number and temperatures of the calibration block(s) and part examined.

NOTE: If an electronic DAC curve is being used, a second record shall be made of the resultant amplitudes and sweep readings obtained from the calibration reflectors.

5.0 EXAMINATION

5.1 Surface Conditions

5.1.1 The examination surface shall be free of irregularities, loose material, or coatings that interfere with ultrasonic wave transmission.

5.2 Scanning Sensitivity

5.2.1 Straight Beam/Shear and Longitudinal Angle Beam - The scanning sensitivity should be at least 14 dB above the primary reference sensitivity. Scans may be performed at levels lower than 14dB above reference sensitivity when noise level requires a reduction in gain; however, scanning sensitivity shall, in no case, be less than 6dB above reference sensitivity. It is intended that the baseline noise level during scanning be an average of 5% FSH. Scanning sensitivity used shall be documented.

NOTE: The above scanning sensitivity may not be adequate in some highly attenuative materials. In these situations the gain shall be adjusted so the average baseline noise is an average 5% FSH.

▲ 5.2.2 "Front end noise" may extend to one-half the component thickness; however, a supplemental longitudinal wave examination will be required if this practice is employed for welds in the "No Break" boundaries.

5.3 Scanning Speed

▲ 5.3.1 Scanning speed shall not exceed 6 inches per second for straight beam examination.

▲ 5.3.2 Scanning speed shall not exceed 3 inches per second for angle beam examinations.

5.4 Coverage

5.4.1 Scan the examination volume with the sound beam overlapping each scan by at least 10% of the transducer dimension measured perpendicular to the scan path.

5.4.2 Examination volume: The inner 1/3 t of the weld and adjacent base metal volume for 1/4 inch on each side of the weld crown, as shown in Figure 4.

5.4.2.1 For Class 1 welds, the examination volumes shown in Figure 4 shall, to the extent practicable, be extended to include the full through-wall thickness.

5.5 Scanning for Reflectors - in the Weld and Code-Required Volume/Base Metal - Straight Beam

5.5.1 To the extent possible, scanning of the weld and adjacent base metal shall be performed to detect reflectors that might affect interpretation of angle beam results. This scan is not to be used as an acceptance-rejection examination when performed per paragraph 4.4.3. For the weld and Code-required volume each indication that exceeds 20 percent of reference, and for base metal examination, each indication that exceeds the remaining back reflection, the peak location and extremities to the 50 percent maximum amplitude level shall be documented as "possible interfering conditions" on the Ultrasonic Examination Data Report, MQS-014.

5.5.2 In addition to the requirements in paragraph 5.5.1, the material thickness shall be monitored. The thickness and location of the lowest wall thickness shall be documented on the Ultrasonic Examination Data Report, MQS-014.

▲ 5.6 Scanning for Reflectors - Angle Beam (Shear Wave)

5.6.1 The angle beam examination for reflectors parallel to the weld (angle beam perpendicular to weld) shall be performed by a one-half V-path from two sides of the weld, where practicable. The examination volume shall be scanned in two beam path directions. A sufficiently long examination beam path may be used to provide this coverage, i.e., one-half V-path and full V-path from only one side of the weld, when one-half V-path scans from two sides is deemed impractical.

5.6.2 The angle beam examination for reflectors transverse to the weld (angle beam parallel to weld) shall be performed in two directions covering the minimum area from 1/2 inch from one side of the weld crown to 1/2 inch from the other side of the crown, including the weld crown.

5.6.3 The search unit shall be continuously oscillated approximately 20 degrees to the left and right to aid in detecting reflectors oriented in a direction not normally expected. If oscillation is not possible, the sound beam shall be overlapped (paragraph 5.4.1) at least 50 percent.

5.6.4 For examination of branch connections, the most sensitive reference level (either the response from the circumferential or axial notch) may be used to scan the entire weld. However, if any recordable indications are observed, then the appropriate reference level must be used for recording purposes, as shown in Figure 5.

▲ 5.7 Scanning for Reflectors - Longitudinal Angle Beam

▲ 5.7.1 Scanning for reflectors using supplemental angle beam longitudinal wave transducers shall be performed perpendicular to the weld by a one-half V-path from both sides where practicable. Where two-sided access is impractical, the weld shall be scanned in three beam path directions from one side. The directions shall be in accordance with Figure 5a.

Scan #1 is performed perpendicular to the weld

Scan #2 is performed skewed a nominal 45 degrees to the weld in the CW direction

Scan #3 is performed skewed a nominal 45 degrees to the weld in the CCW direction.

All scans shall be performed with the search unit continuously oscillated approximately 20 degrees to the left and right to aid in the detection of reflectors oriented in a direction not normally expected.

▲ 5.8 Any obstruction or other condition preventing full coverage of the examination volume shall be documented on the Ultrasonic Examination Data Report, MQS-014 and an Incomplete Examination Report (IER).

## 6.0 EXAMINATION RECORDING REQUIREMENTS

### 6.1 Indication Recording

▲ 6.1.1 All indications 20 percent of DAC or greater shall be recorded. Sizing of indications will be at primary reference level.

6.1.2 Any indication suspected to be a crack, lack of fusion or incomplete penetration shall be recorded regardless of amplitude. Position and location information will be recorded where the reflector amplitude is 50 percent of maximum amplitude.

6.1.3 All indications recorded per the requirements of 6.1.1 and 6.1.2 shall be investigated to the extent necessary to determine the shape, identity, and location of the reflector.

6.2 Examination Documentation

6.2.1 The following data shall be recorded on the Ultrasonic Examination Data Report (Form MQS-014).

1) Data sheet identification, date and time period of examination.

2) Names and certified levels of examination personnel.

3) Examination procedure(s) and revision(s).

4) Applicable calibration report number.

5) Identification of weld examined.

6) Surface from which examination was conducted.

7) Record of indications (or of volume free of indications).

6.2.2 For each weld which is free of any recordable indications, the data report shall state "No Recordable Indications."

6.2.3 For each indication that equals or exceeds 20 percent of DAC, the following shall be recorded:

6.2.3.1 Peak amplitude dB setting when adjusted to the DAC (Ind. dB at DAC), sweep reading (MP - metal path), search unit position (S.U. POS), search unit location (S.U. LOC), and sound beam direction, i.e., axial upstream or downstream (US or DS). (Abbreviations correspond with Form MQS-014 block headings.)

6.2.3.2 Search unit positions and locations perpendicular to the reflector at the location of the peak amplitude positions and locations parallel to the reflector at the points where the reflector amplitude is:

1) 20 percent of DAC for reflectors that equal or exceed 20 percent of DAC.

2) 20 percent of DAC and 100 percent of DAC for reflectors that equal or exceed 100 percent of DAC.

6.2.3.3 For indications that are recorded to the requirements of 6.2.3 that can be determined to be related and intermittent, the requirements of 6.2.3.1 need only be recorded for the peak amplitude of the related family of indications.

6.2.3.4 For indications that are recorded to the requirements of 6.2.3.1 and additional information is generated during evaluation (paragraph 7.0) that information shall be recorded or referenced on Form MQS-014.

6.3 Reference System

6.3.1 The search unit location and position will be measured and recorded in accordance with Figure 5.

6.3.2 The recording shall be the distance to the beam exit point of the search unit from (whichever is appropriate):

1) The point of the datum Vee in the direction it is pointing

2) The weld centerline

3) The intersection of the corresponding circumferential weld

6.3.3 All position and location recordings shall be to the nearest 0.050 of an inch.

6.4 Weld Volume Profile

6.4.1 A weld volume profile shall be established in at least four places around the weld for circumferential welds and for all indications recorded per the requirements of paragraphs 5.5.1, 6.1.1 and/or 6.1.2 for circumferential and longitudinal welds. Intermittent related indications determined to be of the same origin (i.e. geometrical) need only have a single weld volume profile at the location of the peak amplitude of the composite indication.

6.4.1.1 At the position of maximum amplitude along each indication, the general OD contour of the weld and component surface shall be profiled by applying a pin gage to the weld and/or component surface. The pin gage contour measurement shall be continuous along the area to be profiled. An OD profile shall cover the weld and a sufficient distance of base metal to cover 1 inch beyond the search unit position, where possible. Outside diameter profiles shall be conducted by placing the pin gage on the OD surface of the weld and adjacent component material and applying pressure to obtain a contour. One tooth of the pin gage may be raised when profiling. This raised tooth (over the weld centerline) may be used as a reference to assure overlapping and continuity in the OD profile. After forming the contour and establishing the elevated gage tooth reference, this section of the OD contour shall be traced off the pin gage contour and the process repeated until the area of interest is completely profiled.

6.4.1.2 An ultrasonic A-scan instrument shall be used to conduct thickness measurements in the same location and direction as the OD profiles. These thickness measurements shall be recorded in approximately 0.2-inch increments with respect to the OD surface. Locations of thickness changes shall be identified in relation to a specific datum point. Alternate reference points may be used as required. Inside diameter profiles are established by connecting the recorded thickness measurement points and drawing a continuous line equal to the length of the ultrasonic scan and OD profile.

6.4.1.3 All thickness/profile data shall be drawn on the Form MQS-015 and attached to the applicable Ultrasonic Examination Data Report, Form MQS-014. In addition, all reflectors recorded per paragraph 5.5.1, 6.1.1 and/or 6.1.2 shall be plotted onto the profile at their appropriate locations.

## 7.0 EVALUATION AND ACCEPTANCE CRITERIA

7.1 All recorded indication data shall be evaluated by the Lead PSI Technician, or M&QS designated Acting Lead PSI Technician.

7.1.1 Any additional examinations that are performed to further evaluate a recorded indication shall be properly documented on Forms MQS-013, MQS-014 and MQS-015, as applicable.

7.1.1.1 A description of the examination technique used shall be included on the Ultrasonic Examination Data Report, Form MQS-014.

7.1.1.2 The additional Ultrasonic Examination Data Report shall be cross referenced with the Ultrasonic Examination Data Report originally documenting the indication using the Exam Report Numbers.

7.1.2 The following steps shall be applied when evaluating any indication recorded per the requirements of 6.1.1 and 6.1.2:

7.1.2.1 Verify that all examination documentation is complete in accordance with Section 6.2 and that each indication is plotted in accordance with paragraph 6.4.1.3.

7.1.2.2 Review the fabrication and weld specifications and/or end preparation drawings.

7.1.2.3 Interpret the indication from the area containing the reflector in accordance with the applicable procedure or by visual inspection.

7.1.2.4 As an option, other NDE methods or techniques such as alternate UT beam angles, UT profiling or radiography may be used.

7.1.2.5 The basis for classifying the origin of an indication as geometrical or metallurgical shall be recorded on the Ultrasonic Examination Data Report (Form MQS-014).

7.2 All recorded indications that equal or exceed 100 percent of DAC and are not determined to be geometric or metallurgical shall be evaluated in accordance with Article IWA-3000 of Reference 2.1. The examination results are then compared to the acceptance standards of Table 4 or Table 5, as applicable.

7.2.1 Any recorded indication that exceeds the allowable limits or can be determined to be a crack, lack of fusion or incomplete penetration shall be designated as rejectable on the Ultrasonic Examination Data Report, Form MQS-014, and shall be further documented on a Nonconformance Report (NCR) and submitted to the client for final evaluation and disposition.

## 8.0 DOCUMENTATION AND RECORDS

8.1 Ultrasonic calibration data shall be documented on Form MQS-013.

8.2 Indication recording shall be documented on Form MQS-014.

8.3 Material thickness and contour profiling shall be documented on Form MQS-015.

8.4 Examination reports shall be reviewed by the Lead PSI Technician for completeness and conformity to the requirements of this procedure.

TABLE 4

ALLOWABLE PLANAR INDICATIONS

Material: Austenitic steels that meet the requirements for the specified minimum yield strength of 35 ksi or less at 100°F

| | Volumetric Examination Method, Nominal Wall Thickness,[1,2] t, in. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.312 | | 1.0 | | 2.0 | | 3.0 | |
| Aspect Ratio,[1] a/ℓ | Surface Indication, a/t, % | Subsurface Indication[3,4] a/t, % | Surface Indication, a/t, % | Subsurface Indication[3,4] a/t, % | Surface Indication, a/t, % | Subsurface Indication[3,4] a/t, % | Surface Indication, a/t, % | Subsurface Indication[3,4] a/t, % |
| Preservice Examination | | | | | | | | |
| 0.00 | 9.4 | 9.4Y | 8.5 | 8.5Y | 8.0 | 8.0Y | 7.6 | 7.6Y |
| 0.05 | 9.6 | 9.6Y | 8.6 | 8.6Y | 8.2 | 8.2Y | 7.7 | 7.7Y |
| 0.10 | 9.8 | 9.8Y | 8.8 | 8.8Y | 8.3 | 8.3Y | 7.8 | 7.8Y |
| 0.15 | 9.9 | 9.9Y | 8.9 | 8.9Y | 8.4 | 8.4Y | 7.9 | 7.9Y |
| 0.20 | 10.0 | 10.0Y | 9.1 | 9.1Y | 8.6 | 8.6Y | 8.1 | 8.1Y |
| 0.25 | 10.0 | 10.0Y | 9.2 | 9.2Y | 8.7 | 8.7Y | 8.2 | 8.2Y |
| 0.30 | 10.0 | 10.0Y | 9.4 | 9.4Y | 8.9 | 8.9Y | 8.3 | 8.3Y |
| 0.35 | 10.0 | 10.0Y | 9.5 | 9.5Y | 9.0 | 9.0Y | 8.5 | 8.5Y |
| 0.40 | 10.0 | 10.0Y | 9.7 | 9.7Y | 9.1 | 9.1Y | 8.6 | 8.6Y |
| 0.45 | 10.0 | 10.0Y | 9.8 | 9.8Y | 9.3 | 9.3Y | 8.7 | 8.7Y |
| 0.50 | 10.0 | 10.0Y | 10.0 | 10.0Y | 9.4 | 9.4Y | 8.9 | 8.9Y |
| Inservice Examination | | | | | | | | |
| 0.00 | 11.7 | 11.7Y | 10.6 | 10.6Y | 10.0 | 10.0Y | 9.5 | 9.5Y |
| 0.05 | 12.0 | 12.0Y | 10.7 | 10.7Y | 10.2 | 10.2Y | 9.6 | 9.6Y |
| 0.10 | 12.2 | 12.2Y | 11.0 | 11.0Y | 10.4 | 10.4Y | 9.7 | 9.7Y |
| 0.15 | 12.4 | 12.4Y | 11.1 | 11.1Y | 10.5 | 10.5Y | 9.9 | 9.9Y |
| 0.20 | 12.5 | 12.5Y | 11.4 | 11.4Y | 10.7 | 10.7Y | 10.1 | 10.1Y |
| 0.25 | 12.5 | 12.5Y | 11.5 | 11.5Y | 10.9 | 10.9Y | 10.2 | 10.2Y |
| 0.30 | 12.5 | 12.5Y | 11.7 | 11.7Y | 11.1 | 11.1Y | 10.4 | 10.4Y |
| 0.35 | 12.5 | 12.5Y | 11.9 | 11.9Y | 11.2 | 11.2Y | 10.6 | 10.6Y |
| 0.40 | 12.5 | 12.5Y | 12.1 | 12.1Y | 11.4 | 11.4Y | 10.7 | 10.7Y |
| 0.45 | 12.5 | 12.5Y | 12.2 | 12.2Y | 11.6 | 11.6Y | 10.9 | 10.9Y |
| 0.50 | 12.5 | 12.5Y | 12.5 | 12.5Y | 11.7 | 11.7Y | 11.1 | 11.1Y |

NOTES:
(1) For intermediate flaw aspect ratios a/ℓ and thickness t, linear interpolation is permissible.
(2) t is nominal wall thickness of actual wall thickness as determined by UT examination.
(3) The total depth of a subsurface indication is 2a.
(4) Y = (S/t)/(a/t) = S/a. If Y < 0.4, the flaw indication is classified as a surface indication. If Y > 1.0, use Y = 1.0.

TABLE 5

ALLOWABLE LAMINAR INDICATIONS

| Nominal Pipe Wall Thickness, t, in. | Laminar Area sq in. |
|---|---|
| 0.625 and less | 1.25 |
| 2.0 | 4.0 |
| 6.0 | 12.0 |

NOTES:

(1) Area of a laminar indication is defined in subarticle IWA-3360 of reference 2.1.

(2) Linear interpolation with respect to nominal pipe wall thickness is permissible to determine intermediate value of allowable laminar area. Refer to subarticle IWA-3200(c) of reference 2.1.

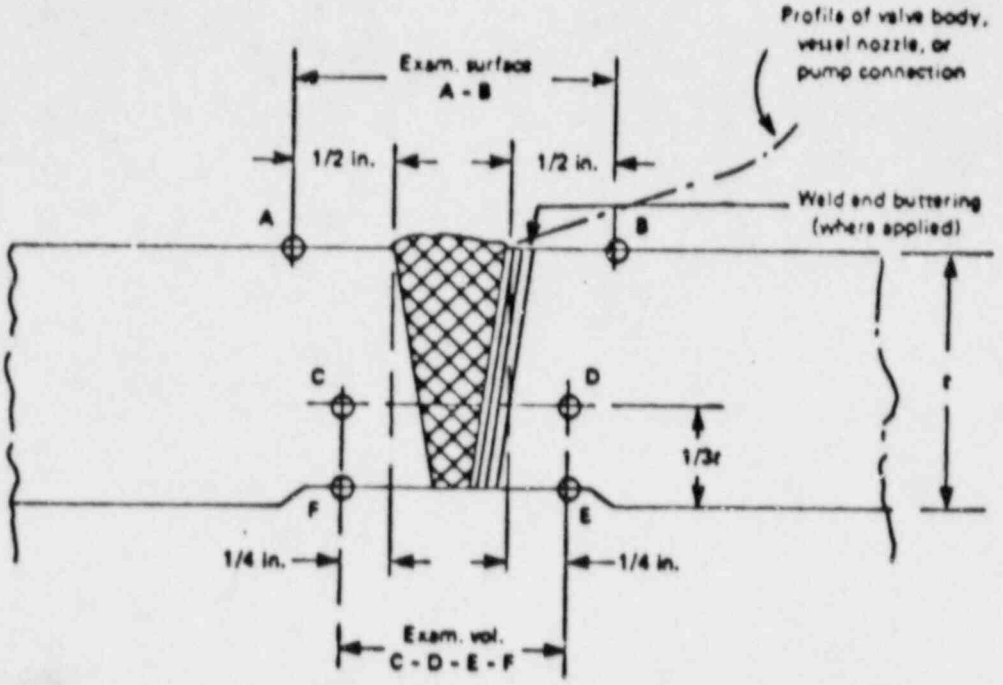
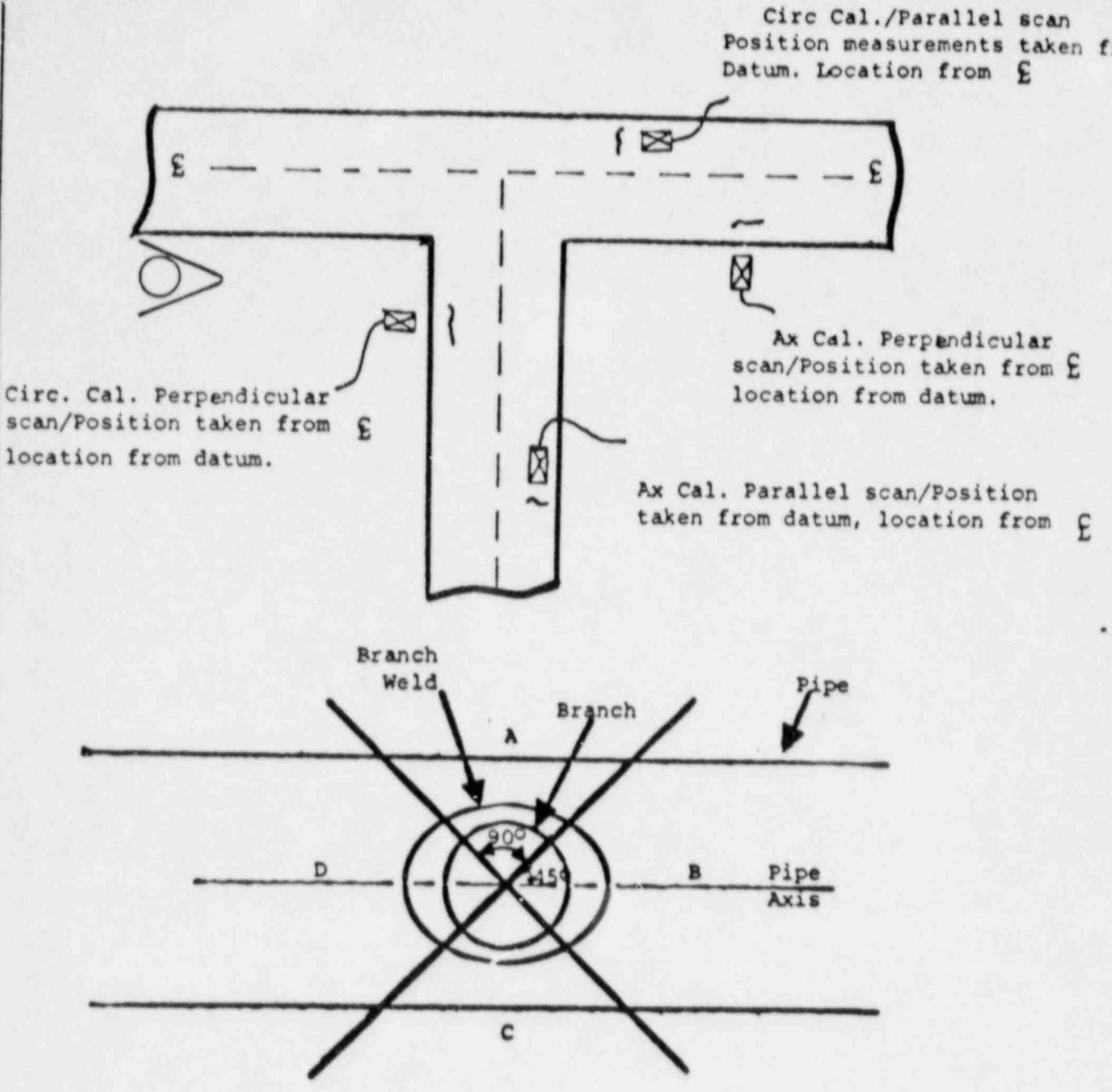


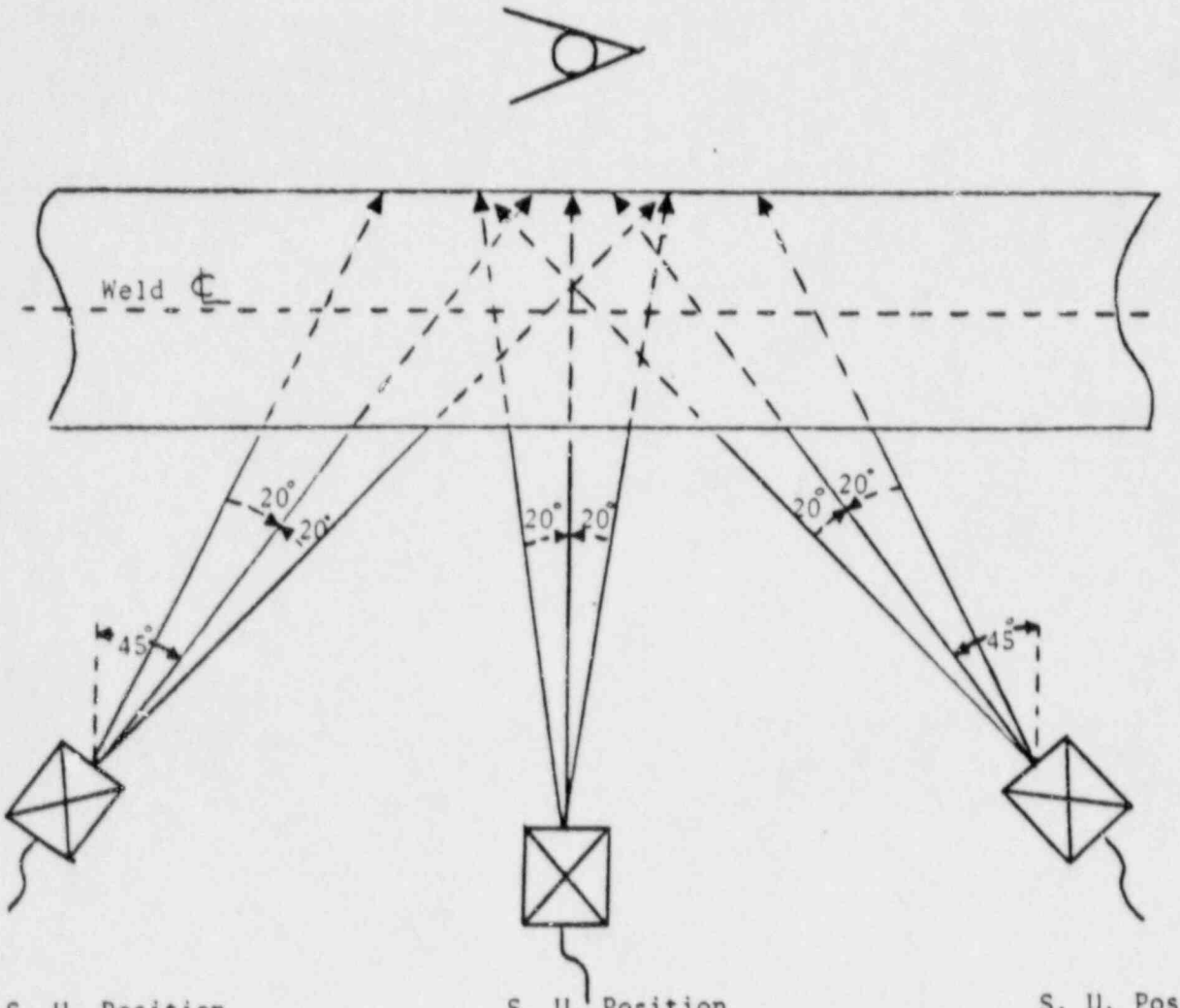

FIGURE 4. Similar and Dissimilar Metal Welds in Piping




Appropriate reference level for recording branch weld indications:

| Quadrant | Parallel Reflectors | Transverse Reflectors |
|---|---|---|
| A | Axial notch calibration | Circ. notch cal. |
| B | Circumferential notch calibration | Axial notch cal. |
| C | Axial notch calibration | Circ. notch cal. |
| D | Circumferential notch calibration | Axial notch cal. |

FIGURE 5. Branch Connection Weld Scanning Requirements




S. U. Position
for Scan #2
CW Skew

S. U. Position
for Scan #1
Perpendicular

S. U. Position
for Scan #3
CCW Skew

FIGURE 5a. Longitudinal Angle Beam Scan

Directions - One Side Access

ULTRASONIC CALIBRATION REPORT

| Client | Plant/Unit | | Report No. |
|---|---|---|---|
| Exam Description: ☐ Straight Beam ☐ Angle Beam Parallel to Weld ☐ Angle Beam Perpendicular to Weld | Procedure Rev. | | Weld No.: System: |
| Basic Block Serial No. | Basic Block Thickness/Material | Reference Block I.D. | Thermometer No. |
| Examiner | Level | Examiner | Level |
| Signature | Date | Signature | Date |

| INSTRUMENTATION DATA | | SEARCH UNIT DATA | LINEARITY | | | |
|---|---|---|---|---|---|---|
| Manufacturer | | Measured Angle | SCREEN HEIGHT | | | |
| Model No. | | Mode | High | Low | 50% ± 5% | Limits ± 5% |
| Serial No. | | T-ducer Mfgr | 100 | | 55 | 45 |
| Next Calibration Due Date | | Type | 90 | | 50 | 40 |
| SETTINGS AT REFERENCE LEVEL | | Serial No. | 80 | 40 | 45 | 35 |
| Coarse Sweep/Range | | Frequency | 70 | | 40 | 30 |
| Fine Sweep/Range | | Size/Shape | 60 | | 35 | 25 |
| Coarse Delay | | Wedge Material | 50 | | 30 | 20 |
| Fine Delay | | Cable Type | 40 | | 25 | 15 |
| Frequency | | Cable Length | 30 | | 20 | 10 |
| Repetition Rate | | Connections | 20 | | 15 | 5 |
| Filter | | Couplant Brand/Batch No. | 10 | | 10 | 0 |
| Reject | | AMPLITUDE CONTROL | | | | |
| Damping | | Amplitude % FSH | 80% | 80% | 40% | 20% |
| Other | | dB Change | -6dB | -12dB | +6dB | +12dB |
| Other | | Reading % FSH | | | | |
| Reference Gain | Scanning Gain | Limits % FSH | 32 - 48 | 16 - 24 | 64 - 96 | 64 - 96 |

| CAL. TIME | DATE | REFLECTOR | SWEEP | GAIN | TEMPERATURE BLOCK | TEMPERATURE PART |
|---|---|---|---|---|---|---|
| Initial | | | | | | |
| Check | | | | | | |
| Check | | | | | | |
| Check | | | | | | |
| Check | | | | | | |
| Check | | | | | | |
| Final | | | | | | |

DAC PLOT

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 1 2 3 4 5 6 7 8 9 10

SCREEN WIDTH = _____
MAJOR DIVISION = _____

| | | |
|---|---|---|
| Lead PSI Technician | Level | Date |
| PECo Reviewer | Level | Date |
| ANII | Level | Date |

MQS-013
R1 02/86

Form -003
Rev. 3/80

FIGURE 6. Ultrasonic Calibration Report, Form MQS-013

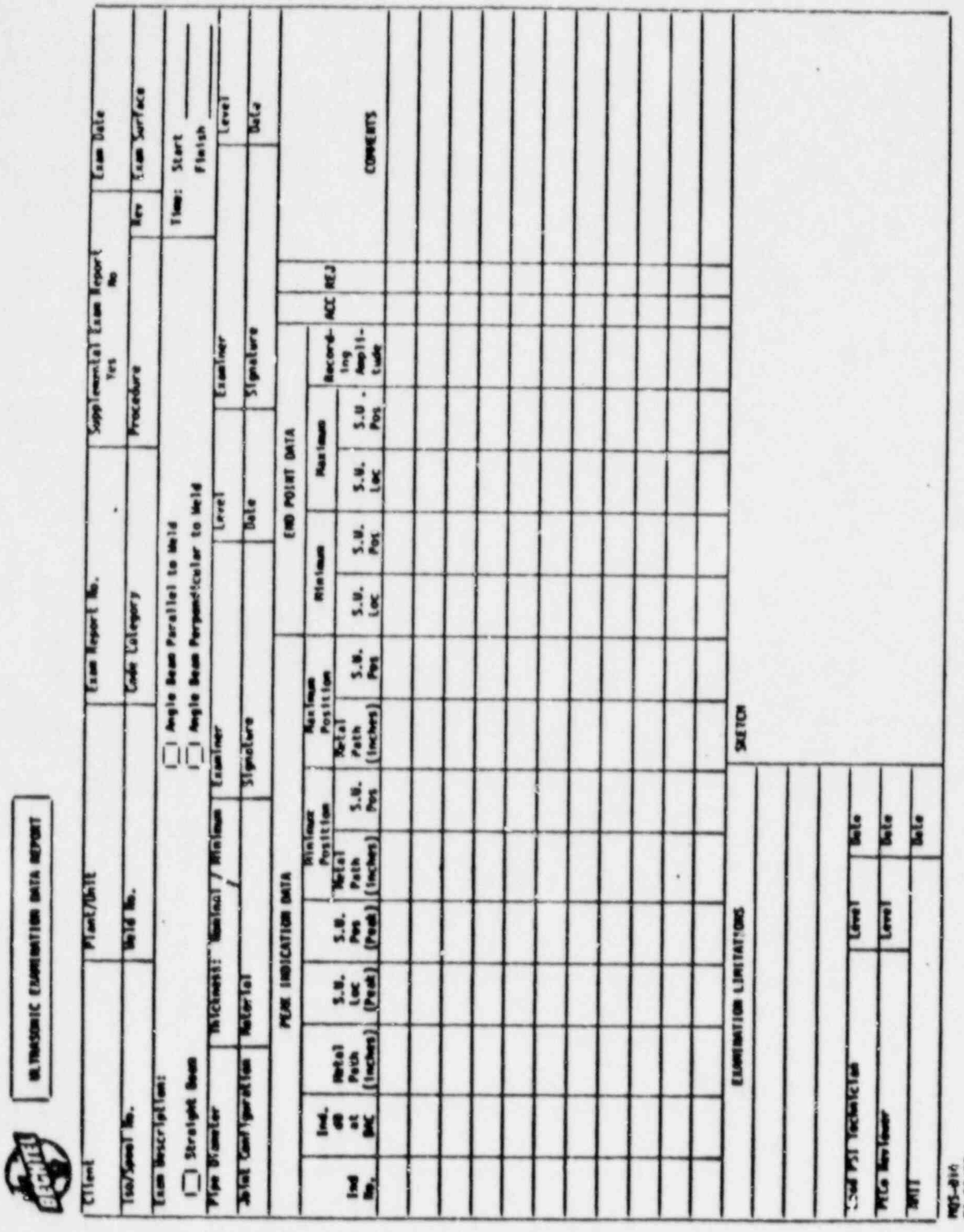



FIGURE 7. Ultrasonic Examination Data Report, Form MQS-014

Form QS-003
Rev. 3/80

BECHTEL

**WELD PROFILE REPORT**

OD CONTOUR WITH PIN GAGE

Exam Report No.:

Indication No.:

ID CONTOUR FROM THICKNESS MEASUREMENTS EVERY 0.2 INCH

| Weld Centerline Thickness: | | | |
|---|---|---|---|
| A | | B | |
| 0.2 | | 0.2 | |
| 0.4 | | 0.4 | |
| 0.6 | | 0.6 | |
| 0.8 | | 0.8 | |
| 1.0 | | 1.0 | |
| 1.2 | | 1.2 | |
| 1.4 | | 1.4 | |
| 1.6 | | 1.6 | |
| 1.8 | | 1.8 | |
| 2.0 | | 2.0 | |

COMMENTS:

| | | |
|---|---|---|
| Examiner: | Level: | Date: |
| Lead PSI Technician: | Level: | Date: |
| PECo Reviewer: | Level: | Date: |
| ANII: | | Date: |

MQS-015
R1 2/86

FIGURE 8. Ultrasonic Thickness/Profile Report, Form MQS-015