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FOR SPEC. P-505

BECHTEL CONSTRUCTION, INC.
MANUAL ULTRASONIC EXAMINATION PROCEDURE FOR
RHR HEAT EXCHANGER WELDS
UT-HT-EX-1
REVISION 4

Date January 9, 1987

MATERIALS AND QUALITY SERVICES

Prepared and Approved Michael J. Mayo — 1-9-87
NDE Level III Examiner — Date

Reviewed William E. Olmstead Jr. — 1/9/87
Date

Approved per R. A. Manley — 1/12/87
Manager, M&QS — Date

Authorized for use by
M. J. Mitchell — 1/12/87
Manager of Construction — Date

(FOR LIMERICK ONLY)

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Approved for use at Limerick
D. L. Schmidt PECo Level III 1/22/87

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1.0 SCOPE

1.1 This procedure specifies the minimum requirements for ultrasonic examination of Residual Heat Removal (RHR) heat exchanger shell and nozzle welds.

1.2 Weld configurations and nominal weld thicknesses covered by this procedure are shown in Figures 3 through 8. The RHR heat exchanger shell is constructed of carbon steel (SA516-70). The RHR heat exchanger flange and nozzles are constructed of carbon steel (SA105, Class II).

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 those of 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 The maximum nominal transducer dimension for circular, square, or rectangular active elements shall not exceed 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 may be used for evaluation of an indication or where wall thickness or geometric configuration impedes effective use of a 45-degree angle beam for examination.

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

3.3 General Examination Requirements

3.3.1 Couplants

3.3.1.1 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.

3.3.1.2 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.

3.3.2 Examination Frequency

3.3.2.1 The ultrasonic examination frequency for examinations performed in accordance with this procedure shall be:

1) Nominal 2.25 MHz for all 0-degree straight beam examinations.

2) Nominal 2.25 MHz for all angle beam examinations of carbon steel.

NOTE: Other frequencies may be utilized if deemed necessary, as dispositioned by a Level III.

3.3.3 Examination Angles and Coverage

3.3.3.1 Each heat exchanger shell weld and adjacent base metal volume (examination volume) for 1/2 inch on each side of the weld shall be ultrasonically examined using 45-degree angle beam techniques applied in two directions parallel with the weld and two directions perpendicular to the weld axis and on both sides of the weld where part geometry and access allow.

3.3.3.2 Each heat exchanger nozzle weld and adjacent base metal volume (examination volume) for a distance of 1/4 inch beyond the edge of the weld crown within the inner one-third thickness shall be ultrasonically examined using 45-degree shear wave angle beam techniques applied perpendicular to the weld from the shell side, except where restricted by part geometry or access. An increased ultrasonic beam path (full vee) may be used during a one-sided perpendicular scan to achieve the full coverage required by the Code. In addition, each heat exchanger nozzle weld examination volume for 1/4 inch on each side of the weld shall be ultrasonically examined using 45-degree shear wave angle beam techniques applied in two directions parallel with the weld, except where restricted by part geometry or access.

3.3.3.3 Straight beam techniques shall be applied, where part geometry allows, to all parent material through which the angle beams will pass during angle beam examinations to detect indications that may interfere with the interpretation of angle beam results. Indications detected are to be recorded in accordance with this procedure; however, the results of this examination are not to be used for acceptance/rejection purposes.

3.3.3.4 In addition, straight beam techniques shall be applied to the weld and required volume where part geometry allows. Indications shall be recorded in accordance with this procedure. This shall include straight beam examination of parent material when no back echo is obtainable.

3.3.3.5 Other beam angles may be used as determined necessary, i.e., for evaluation of reflectors, to compensate for geometric constraints, etc. All information shall be recorded on the Ultrasonic Examination Data Report, MQS-014.

3.3.3.6 Where the examination surface, geometry, or other conditions (weld, contour, access, etc.) do not allow a meaningful ultrasonic examination to be performed, the examiner shall record the area of nonexamination and the particular interfering condition in the space provided on the Ultrasonic Examination Data Report, MQS-014. In addition, a sketch of the weld and adjacent conditions shall be attached. Photos may be taken and incorporated as part of the report.

3.3.3.7 All welds examined shall be entered in the space provided on the Ultrasonic Examination Data Report, MQS-014. If there are no recordable indications, it shall be so noted on the Data Report.

3.3.4 Basic Calibration Block(s)

3.3.4.1 The basic calibration reflectors shall be used to establish a primary reference response of the equipment. The basic calibration reflectors may be located either in the component material or in a basic calibration block. Where the block thickness ± 1 inch (± 25 mm) spans two of the weld thickness ranges shown in Figure 2, the block's use shall be acceptable in those portions of each thickness range covered by 1 inch (25 mm).

3.3.4.2 The material from which the basic calibration block is fabricated shall be one of the following:

1) nozzle dropout from the component;

2) a component prolongation; or

3) material of the same material specification, product form, and heat treatment as one of the materials being examined.

▲ 3.3.4.3 The basic calibration block shall be as specified in 3.3.4.1 and shall use side drilled holes as calibration reflectors. See Figure 2 for the required dimensions.

▲ 3.3.4.4 The following basic calibration blocks shall be used:

1) Calibration block No. LIM-F-.812-CS - 1 SDH at 1/2t

2) Calibration block No. LIM-1.00-P - 1 SDH at 1/2t

3) Calibration block No. LIM-F-1.18-CS - 1 SDH at 1/4t

▲ 3.3.4.4.1 The basic calibration standards designated above shall be used for basic instrument calibration and for establishing reference sensitivity levels for examination of the welds specified in this procedure. Use of these calibration blocks shall be qualified by demonstration in accordance with ASME Section XI, IWA-2240.

3.3.5 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.

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 1 so that echoes can be observed from any two reflectors in a calibration block.

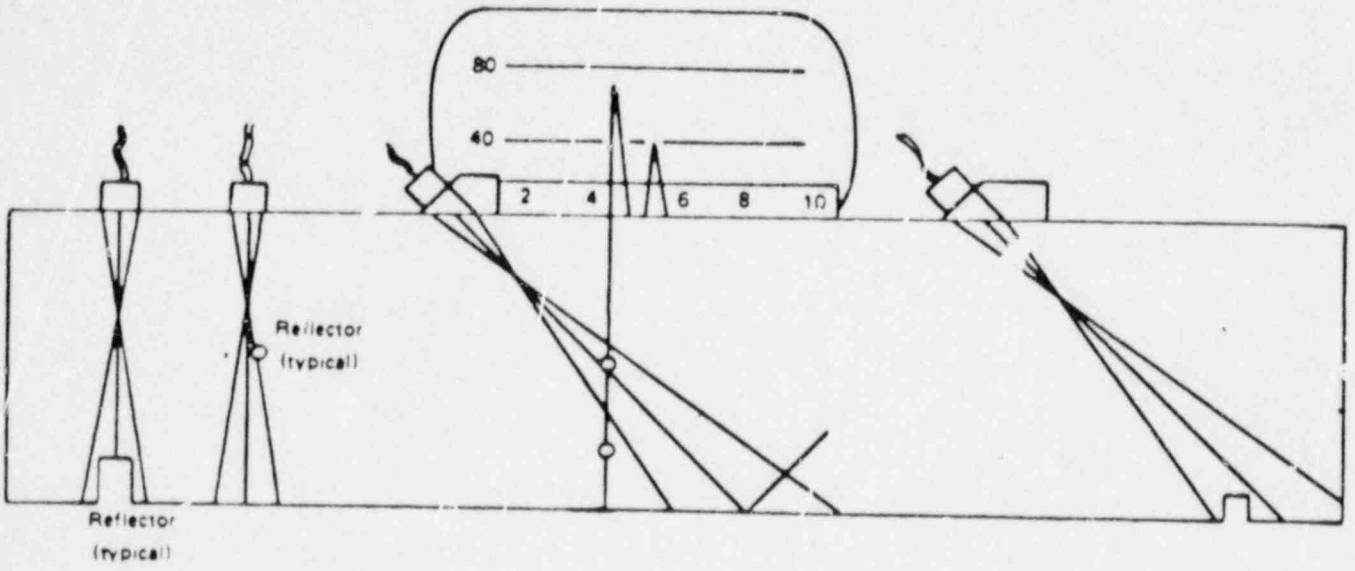


FIGURE 1. Linearity

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 1, the echo amplitude shall fall within the specified limits.

TABLE 1
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: 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 verification 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 3.3.5.

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 initial calibration or as an alternate as described in paragraph 4.6, except when system components are changed.

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.

NOTE: When using calibration block LIM-F-1.18-CS, calibration shall be accomplished from both major surfaces.

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 four 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, or 5 percent of full sweep, whichever is greater, 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

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 hole which gives the highest amplitude. 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) Without changing the gain, position the search unit to display the maximum response from the remaining hole. Mark this response on the screen.

3) Connect the screen marks and extrapolate the line through the part thickness to form the DAC curve.

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.

4.5 Angle Beam Calibration

4.5.1 Angle beam calibration of the ultrasonic system sweep shall be performed using the basic calibration block. The sweep shall, as a minimum, incorporate the entire examination volume, and may be established as follows:

4.5.1.1 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 3.3.5) or calculate and use the metal path distance for each reflector in the basic calibration block.

4.5.1.2 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.

4.5.1.3 A one-half V-path calibration shall be performed in the following manner. The shape of the DAC curve shall be generated using the 1/4- 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. The DAC and notch response shall also be recorded on the Calibration Report form. The DAC curve is the primary reference level (1X).

4.5.1.4 For metal paths greater than one-half V-path, calibration shall be performed using either the 1/4t- and 3/4t- or 1/2t-side drilled holes. 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 hole which gives the highest amplitude. 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 to obtain a response from the other holes contained within the selected beam path distance. Manipulate the transducer to maximize these signals and mark sweep and amplitude positions on the CRT screen. Draw a smooth line through these points and extrapolate to cover the full examination range. This is the primary reference level (1X).

4.5.1.5 Should any point on the DAC fall below 20% FSH, the Lead PSI Technician shall be contacted for direction.

4.5.1.6 Angle beam sensitivity correction for planar reflectors at or near the opposite surface shall be established as follows:

1) Position the search unit to obtain maximum amplitude from the far surface notch, and with instrument at reference sensitivity, mark the screen to show peak amplitude (near the horizontal division representing "t").

2) When evaluating indications that occur at or near the surface, the indications shall be compared directly with the amplitude obtained from the notch.

4.5.2 A DAC is not required where the examination is limited to one-half vee path in a material less than 1 inch (25 mm) thick, in which case the amplitude level from a single calibration reflector (1/2t) shall be used.

4.6 Intermediate calibration checks may be performed using one of the reference blocks described in paragraph 3.3.5, provided the following is documented in the appropriate blocks on the Ultrasonic Calibration Report, MQS-013:

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

2) Reference reflector used, i.e., 1 inch radius.

3) Gain setting establishing the signal peak amplitude at 50% FSH.

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

4.7 As a minimum, the following data shall be recorded on a 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 heat exchanger (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.

14) Instrument settings.

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/Angle Beam - Scanning sensitivity shall be at least 6 dB above the primary reference level.

5.3 Scanning Speed

5.3.1 Scanning speed shall not exceed 6 inches per second.

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 volume described in paragraphs 3.3.3.1 and 3.3.3.2 shall be examined.

5.5 Scanning for Interfering Reflectors - Straight Beam

5.5.1 Scanning of the weld and adjacent base metal through which angle beams will pass shall be performed to detect reflectors that might affect interpretation of angle beam results. Scanning sensitivity shall be as referenced in 5.6.1. This scan is not to be used as an acceptance-rejection examination. For each indication that exceeds 50 percent of reference, 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 - Straight Beam

5.6.1 The examination volume shall be scanned to the extent possible with the straight beam search unit. The scanning shall be performed at a gain setting of at least two times the primary reference level. Evaluation shall be performed with respect to the primary reference level.

5.7 Scanning for Reflectors - Angle Beam

5.7.1 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. The scanning shall be performed at a gain setting at least two times the primary reference level. Evaluation shall be performed with respect to the primary reference level.

5 7.2 The angle beam examination for reflectors transverse to the weld (angle beam parallel to weld) shall be performed on the weld crown and adjacent base metal by one-half V path in two directions along the weld. The scanning shall be performed at a gain setting at least two times the primary reference level. Evaluation shall be performed with respect to the primary reference level.

5.7.3 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.

5.8 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 greater than 50 percent of DAC shall be recorded.

6.1.2 All indications greater than 100 percent of DAC shall be investigated to the extent necessary to determine the shape, identity, and location of the reflector in terms of the acceptance criteria of paragraph 7.2.

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 50 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 and locations parallel to the reflector at the points where the reflector amplitude equals:

1) 50 percent of DAC for reflectors that equal or exceed 50 percent of DAC.

2) 50 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.

6.2.4 Indications that are recorded to the requirements of 6.2.3 and additional information generated during evaluation (paragraph 7.0) shall be recorded or referenced on Form MQS-014.

6.3 Reference System

6.3.1 The search unit location shall be measured along the weld in the direction that the established 0 datum "V" mark is pointing. The recording shall be the distance from the point of the mark to the center of the search unit. Longitudinal welds shall be measured from the intersection of the corresponding circumferential weld. When no 0 datum has been established, the responsible Lead Level II ultrasonic examiner shall be consulted and a datum shall be established.

6.3.2 The search unit position shall be measured from the weld centerline.

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 for all indications recorded per the requirements of paragraphs 5.5.1 and/or 6.1.1. 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 and/or 6.1.1 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 5.5.1 or 6.1.1:

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 not determined to be geometrical 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 Tables 2, 3, or 4, or paragraph 7.2.1, as applicable.

7.2.1 Allowable Laminar Indications

1) Laminar indications in vessel shell or head material within the boundary of the nozzle weld examination volumes shall be governed by the standards of Table 3.

2) Laminar flaws in the nozzle wall shall be considered as planar indications, and the standards of Table 4 shall apply.

8.0 DOCUMENTATION AND RECORDS

8.1 Ultrasonic calibration data shall be documented on Form MQS-013 (Figure 9).

8.2 Indication recording shall be documented on Form MQS-014 (Figure 10).

8.3 Material thickness and contour profiling shall be documented on Form MQS-015 (Figure 11).

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

HEAT EXCHANGER SHELL WELDS

TABLE 2

ALLOWABLE PLANAR INDICATIONS

Aspect Ratio (1) a/l	Surface Indications (2) a/t, (percent)	Subsurface Indications (2)(4) a/t, (percent)
0.00	2.0	2.6Y
0.05	2.1	2.8Y
0.10	2.3	2.9Y
0.15	2.6	3.2Y
0.20	2.9	3.6Y
0.25	3.2	4.1Y
0.30	3.7	4.6Y
0.35	3.7	5.2Y
0.40	3.7	5.8Y
0.45	3.7	6.5Y
0.50	3.7	7.2Y

NOTES:

(1) Dimensions of a and l are defined in IWA-3300. For intermediate flaw aspect ratios a/l, linear interpolation is permissible. Refer to IWA-3200(b).

(2) Component thickness t is measured normal to the pressure retaining surface of the component. Where the section thickness varies, the average thickness over the length of the planar indication is the component thickness.

(3) The total depth of a subsurface indication is 2a.

(4) $Y = (S/t)/(a/t) = S/a$. If Y is less than 0.4, the flaw indication is classified as a surface indication. If Y is greater than 1.0, use Y = 1.0.

HEAT EXCHANGER SHELL WELDS
(continued)

TABLE 3

ALLOWABLE LAMINAR INDICATIONS

Component Thickness (1) (2) t, in.	Laminar Area (3) A, sq in.
2.5 and less	6
4	12
6	18
8	24
10	30
12	36
14	42
16	48

NOTES:

(1) Component thickness t is measured normal to the pressure retaining surface of the component. Where the section thickness varies, the average thickness over the area of the laminar indication is the component thickness.

(2) For intermediate thicknesses, linear interpolation of area is permissible. Refer to IWA-3200(c).

(3) The area of laminar flaw is defined in IWA-3360.

HEAT EXCHANGER NOZZLE WELDS

TABLE 4

ALLOWABLE PLANAR INDICATIONS

Aspect Ratio (1) a/l	Surface Indications (2) a/t, (percent)	Subsurface Indications (2)(4) a/t, (percent)
0.00	1.8	2.3Y
0.05	2.0	2.4Y
0.10	2.2	2.6Y
0.15	2.4	2.9Y
0.20	2.7	3.3Y
0.25	3.1	3.7Y
0.30	3.5	4.1Y
0.35	3.5	4.6Y
0.40	3.5	5.2Y
0.45	3.5	5.9Y
0.50	3.5	6.5Y
Inside corner region	2.5	Not applicable

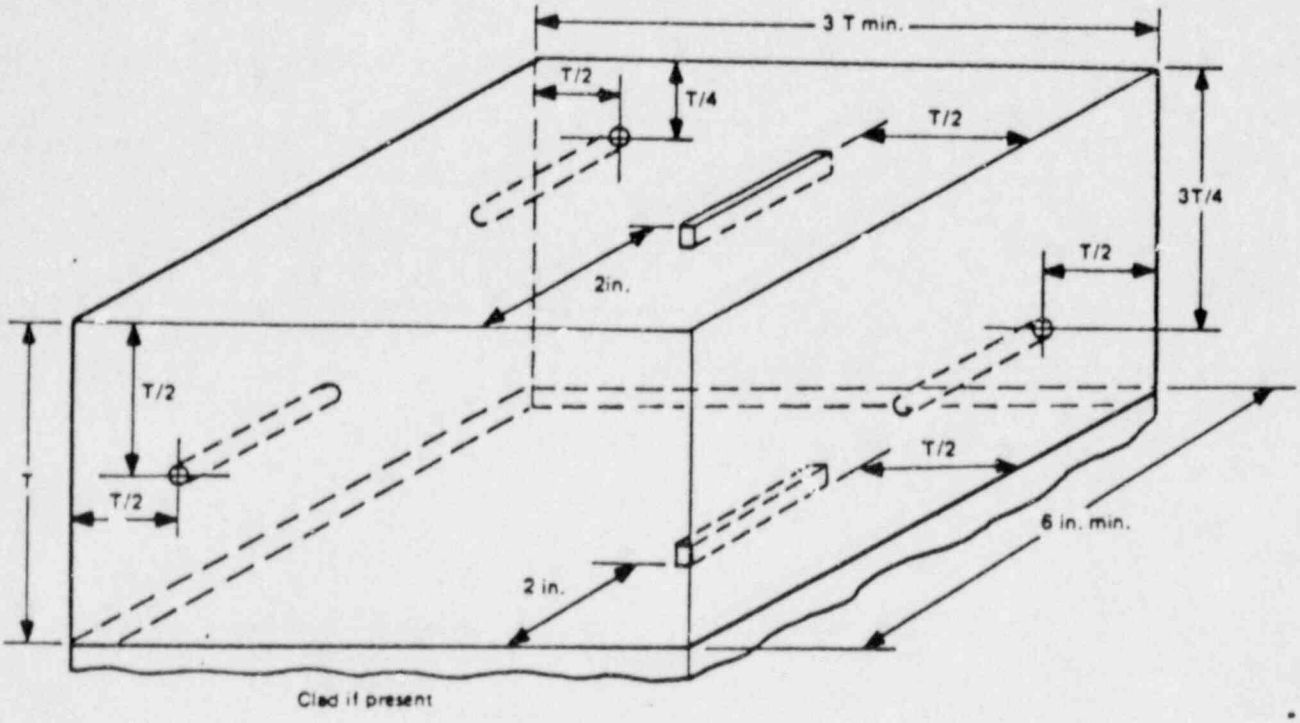
NOTES:

(1) Dimensions of a and l are defined in IWA-3300. For intermediate flaw aspect ratios a/l, linear interpolation is permissible. Refer to IWA-3200(b).

(2) See Table IWB-3512-1 for the appropriate component thickness t as a function of flaw location.

(3) The total depth of a subsurface indication is 2a.

(4) $Y = (S/t)/(a/t) = S/a$. If Y is less than 0.4, the flaw indication is classified as a surface indication. If Y is greater than 1.0, use Y = 1.0.



Weld Thickness (t)	Basic Calibration Block Thickness (T)	Hole Diameter	Notch Size:
1 in. or Less	3/4 in. or t	3/32 in.	Width = 1/8 in. to 1/4 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.	Depth = 2% T
Over 4 in. through 6 in.	5 in. or t	1/4 in.	
Over 6 in. through 8 in.	7 in. or t	5/16 in.	Length = 2 in. min.
Over 8 in. through 10 in.	9 in. or t	3/8 in.	
Over 10 in. See Note (5).			

NOTES:

(1) Holes shall be drilled and reamed a minimum of 1-1/2 in. deep, essentially parallel to the examination surface.

(2) Alternately, the block may be constructed as shown in Fig. T-434.1.

(3) Curved surfaces: for curved surfaces, two curved blocks, one for each representative curvature; or two sets of calibration reflectors oriented 90 deg. from each other shall be used.

(4) Notches may be provided as required.

(5) For each increase in thickness of 2 in. or fraction thereof, the hole diameter shall increase 1/16 in.

(6) The tolerance for hole diameter shall be ± 1/32 in. The tolerance on notch depth shall be + 10 and − 20%. The tolerance on hole location through the thickness shall be ± 1/8 in.

FIGURE 2

BASIC CALIBRATION BLOCK

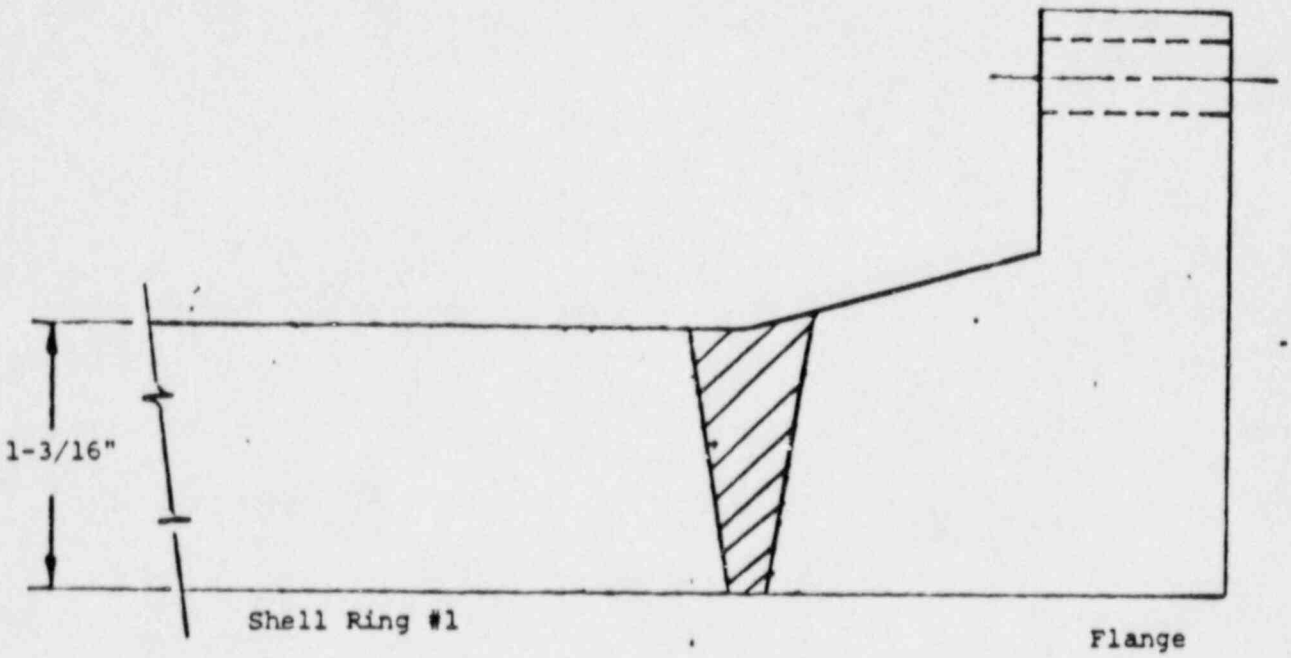


FIGURE 3

RHR HEAT EXCHANGER SHELL-TO-FLANGE WELD

Calibration Standard LIM-F-1.18-CS

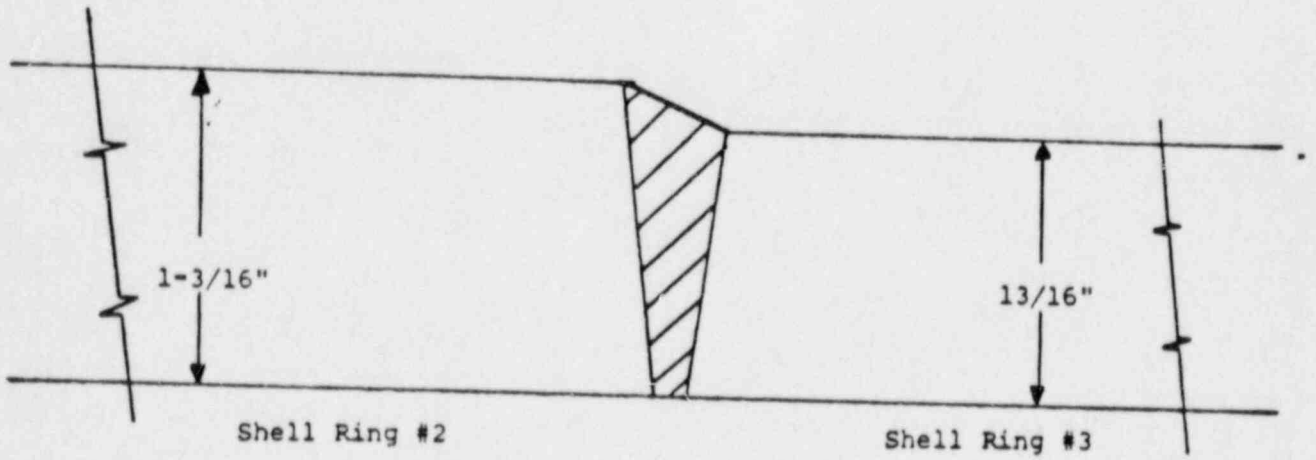


FIGURE 4

RHR HEAT EXCHANGER SHELL-TO-SHELL WELD

Calibration Standards LIM-F-.812-CS and LIM-F-1.18-CS

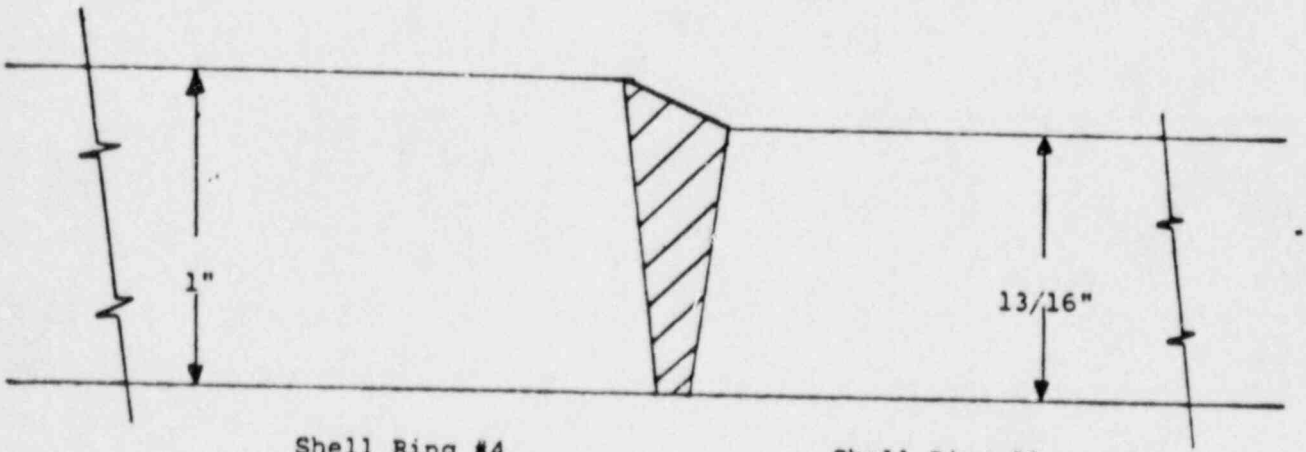


FIGURE 5

RHR HEAT EXCHANGER SHELL-TO-SHELL WELD

Calibration Standards LIM-F-.812-CS and LIM-1.00-P

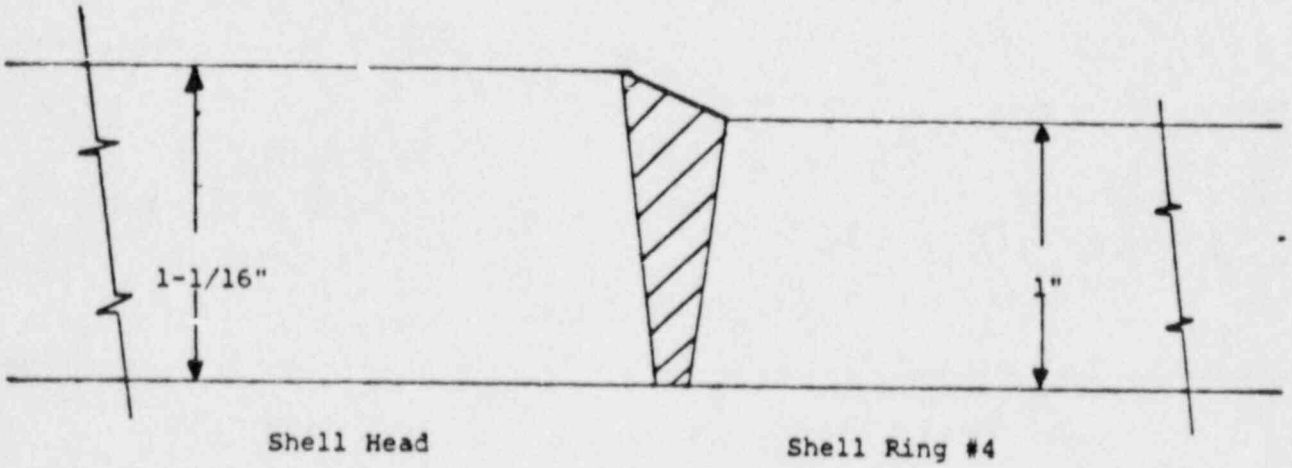


FIGURE 6

RHR HEAT EXCHANGER HEAD-TO-SHELL WELD

Calibration Standard LIM-1.00-P

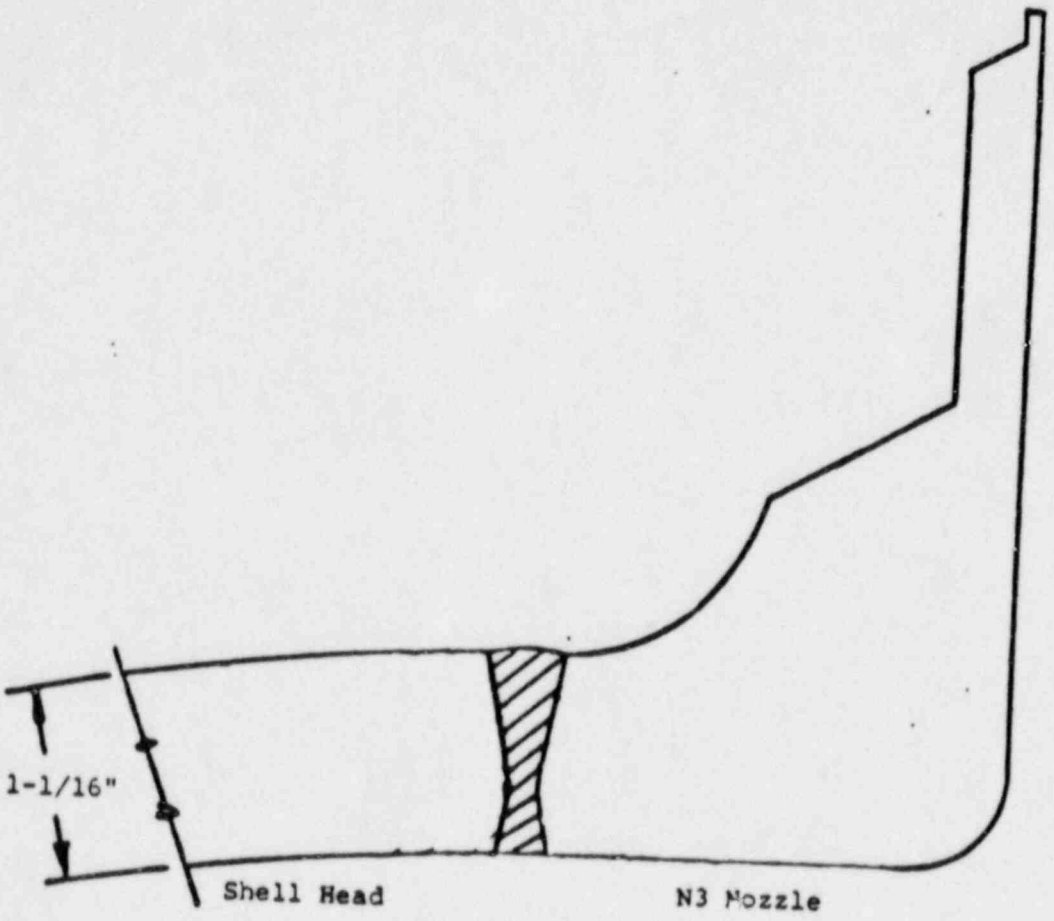


FIGURE 7

RHR HEAT EXCHANGER INLET NOZZLE WELD

Calibration Standard LIM-1.00-P

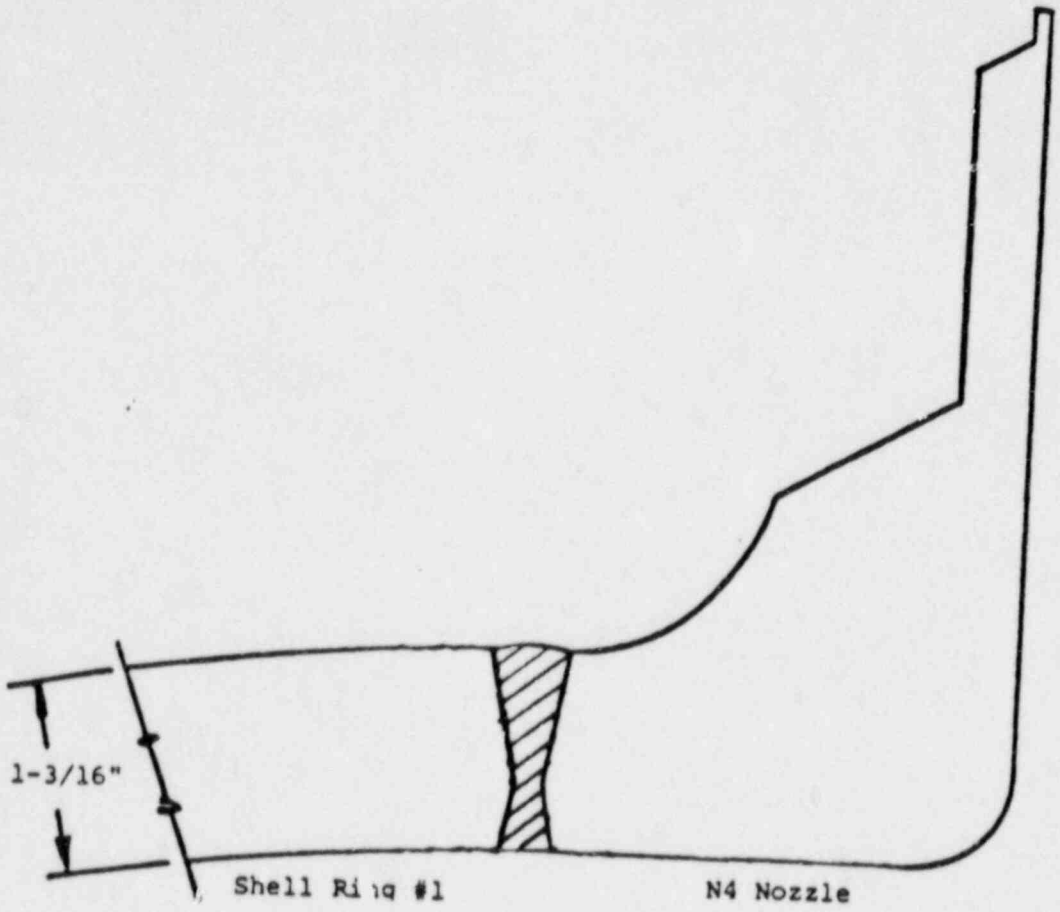


FIGURE 8

RHR HEAT EXCHANGER OUTLET NOZZLE WELD

Calibration Standard LIM-F-1.18-CS

BECHTEL

ULTRASONIC CALIBRATION REPORT

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

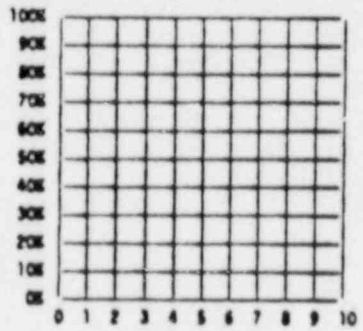
INSTRUMENTATION DATA	SEARCH UNIT DATA
Manufacturer	Measured Angle
Model No.	Mode
Serial No.	Transducer Mfgr
Next Calibration Due Date	Type
SETTINGS AT REFERENCE LEVEL	Serial No.
Coarse Sweep/Range	Frequency
Fine Sweep/Range	Size/Shape
Coarse Delay	Wedge Material
Fine Delay	Cable Type
Frequency	Cable Length
Repetition Rate	Connections
Filter	Coupling Brand/Batch No.
Reject	
Damping	
Other	
Other	
Reference Gain / Scanning Gain	

LINEARITY			
SCREEN HEIGHT			
High	Low	50% ± 5%	Limits ± 5%
100		55	45
90		50	40
80	40	45	35
70		40	30
60		35	25
50		30	20
40		25	15
30		20	10
20		15	5
10		10	0

AMPLITUDE CONTROL				
Amplitude % FSH	80%	80%	40%	20%
dB Change	-6dB	-12dB	+6dB	+12dB
Reading % FSH				
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



SCREEN WIDTH = _____

MAJOR DIVISION = _____

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

MQS-013
R1 02/86

FIGURE 9

ULTRASONIC CALIBRATION REPORT

Form MQS-013

Form MQS-003 Rev 3/80

BECHTEL

ULTRASONIC EXAMINATION DATA REPORT

Client	Plant/Unit	Exam Report No.	Supplemental Exam Report No.		Exam Date
Iso/Spool No.	Weld No.	Code Category	Procedure	Rev	Exam Surface

Exam Description:

[ ] Straight Beam - Cal. Report No. _____

[ ] Angle Beam Parallel to Weld - Cal. Report No. _____

[ ] Angle Beam Perpendicular to Weld - Cal. Report No. _____

Time: Start _____ Finish _____

Pipe Diameter	Thickness: Nominal / Minimum	Examiner	Level	Examiner	Level
Joint Configuration	Material	Signature	Date	Signature	Date

PEAK INDICATION DATA									END POINT DATA						
					Minimum Position		Maximum Position		Minimum		Maximum				
Ind No.	Ind. dB at DAC	CRT Div (Peak)	S.U. Loc (Peak)	S.U. Pos (Peak)	CRT Div	S.U. Pos	CRT Div	S.U. Pos	S.U. Loc	S.U. Pos	S.U. Loc	S.U. Pos	End Point Amplitude	ACC	REJ	COMMENTS

EXAMINATION LIMITATIONS

SKETCH

Lead PSI Technician	Level	Date
PECo Reviewer	Level	Date
ANII		Date

MQS-014
R1 02/86

FIGURE 10

ULTRASONIC EXAMINATION DATA REPORT

Form MQS-014

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

FIGURE 11

ULTRASONIC THICKNESS/PROFILE REPORT

Form MQS-015