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BECHTEL CONSTRUCTION, INC.  
ULTRASONIC EXAMINATION PROCEDURE FOR  
RECIRCULATION PUMP STUDS  
UT-RCP-STUDS  
REV. 4

Date April 10, 1987

MATERIALS AND QUALITY SERVICES

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FOR LIMERICK PROJECT ONLY

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*Approved for use at Limerick  
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## 1.0 SCOPE

1.1 This procedure specifies the minimum requirements for ultrasonic examination of recirculation pump (RCP) studs.

1.2 Configuration and nominal dimensions of the carbon steel pump studs are shown in Figure 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 Code Case N307.

2.4 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 10.00 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 of 2.25 MHz for all 0-degree straight beam examinations.

3.2.2.2 Angle beam examination from the RCP stud bore shall be between 6 MHz and 7.5 MHz.

### 3.2.3 Liquid Couplants

3.2.3.1 The ultrasonic liquid couplant to be used for 0° examinations using this procedure shall be any commercially available couplant. The same couplant shall be used for calibration and examination.

3.2.3.2 The ultrasonic liquid couplant to be used for examinations from the bore of the stud shall be demineralized water enhanced with rust inhibitor. The same couplant shall be used for calibration and examination.

3.2.4 The following test equipment shall be used as a minimum.

- a. Pulse echo ultrasonic instrument.
- b. Search units, 1/2 inch diameter, 2.25 MHz 0-degree.
- c. Special search units for OD examination from the bore 0.5 inch x 0.25 inch, 6.0 to 7.5 MHz, nominal 75°, de-focused.
- d. Forward shooting recirculation stud bore search unit fixture.
- e. AFT shooting recirculation stud bore search unit fixture.
- f. Couplant
- g. Thermometer

## 4.0 CALIBRATION REQUIREMENTS

### 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.

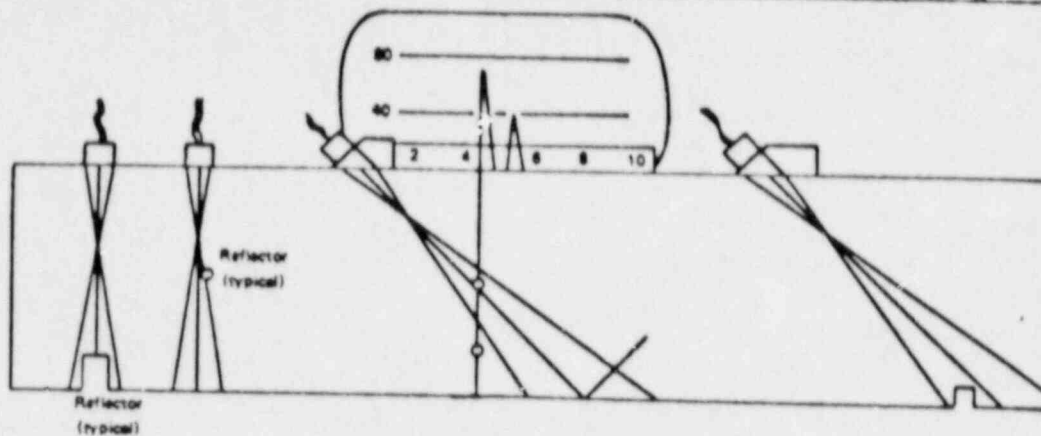


FIGURE I. Linearity

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  $\pm 20$  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 I, the echo amplitude shall fall within the specified limits.

TABLE I  
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 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 Calibration Data Sheets

4.2.1 Calibration Data Sheets may be numbered sequentially, and shall be signed by the examiner(s) upon completion, noting applicable SNT-TC-1A levels.

4.2.2 Calibration Blocks

4.2.2.1 Calibration block No. LIM-3.00"-STUD-CS shall be used for basic instrument calibration and for establishing reference sensitivity levels for examination of the recirculation pump studs.

4.3 Search Unit Calibration

4.3.1 Prior to performing system calibration (4.4), the search unit beam exit point shall be determined. 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 the calibration block specified in paragraph 4.2.2.1.

4.4 System Calibration

4.4.1 General Requirements

4.4.1.1 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.

4.4.1.2 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 of a calibration check. Intermediate calibration checks may be performed in the same manner as the initial calibration.

4.4.1.3 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.

4.4.2 System Calibration Check

4.4.2.1 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.

4.4.2.2 If any point on the DAC curve has decreased more than 20 percent of 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.

4.4.2.3 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.

4.4.2.4 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.

4.4.2.5 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.

#### 4.4.3 Stud Calibration

4.4.3.1 Basic Straight Beam Calibration for Studs. Reference Figures 1 and 2.

- 1) Adjust the instrument sweep controls to provide a screen width representing 25 inches of sound path. Peak the reflection from the flat bottom hole (FBH) from the plugged surface side. This will occur at approximately 1.2 horizontal screen positions. Peak the reflection from the FBH from the opposite side of the stud. This will occur at approximately the eighth horizontal screen position.
- 2) Adjust the amplitude from the reflection of the FBH from the plugged side to 80 percent full screen height (FSH).
- 3) Maximize the amplitude from the FBH through the length of the stud and mark its amplitude and horizontal screen position.
- 4) Plot a distance amplitude correction (DAC) line by connecting the peak amplitude locations from the flat bottomed holes (marked on the CRT) with a continuous line extended to cover the full examination range.
- 5) This is the reference sensitivity. REcord all data and instrument settings on the Calibration Report, MQS-013.

NOTE: If the reflection from the FBH through the length of the stud cannot be resolved, consult with the Lead PSI Technician for disposition and document any changes made to the technique.

4.4.3.2 Angle Beam Calibration from the Stud Bore (using the aft shooting recirculation stud bore search unit fixture). Reference Figures 3, 4a and 4b.

- 1) Using the aft shooting recirculation stud bore search unit assembly, maximize the reflection presentation from the N-1 notch, and adjust its sweep position to CRT position 5.
- 2) Set the amplitude from the reflection of the N-1 notch to 80 percent FSH.
- 3) Position the search unit assembly to maximize the reflection amplitudes from the N-2 and N-3 notches and record their amplitudes and index locations.
- 4) This is the reference sensitivity. Record all data and instrument settings on the Calibration Report, MQS-013.

NOTE: No DAC required due to constant metal path.

4.4.3.3 Angle Beam Calibration from the Stud Bore (using the forward shooting recirculation stud bore search unit fixture). Reference Figures 3, 4a and 4b.

- 1) Maximize the reflection presentation from the N-5 notch and adjust its sweep position to CRT position 5.
- 2) Set the amplitude from the reflection of the N-5 notch to 80 percent FSH.
- 3) Position the search unit assembly to maximize the reflection from the N-4 notch and record its amplitude and index locations.
- 4) This is the primary reference level. Record all data and instrument settings on the Calibration Report, MQS-013.

NOTE: No DAC required due to constant metal path.

4.4.4 Straight and Angle Beam Calibration Check

- 1) Straight beam calibration checks shall verify the calibration of paragraph 4.4.3.1.
- 2) Angle beam calibration checks shall be conducted as follows:
  - a) A system calibration check shall verify the notch amplitude responses and the sweep range calibration at the start and finish of examinations, and at least every four hours during each examination. It shall include any change in Level II examination personnel, transducers, cables, batteries, or couplants.

- b) If any notch amplitude response has changed by more than 20 percent of 2 dB of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new calibration shall be made and recorded and the voided examination areas shall be reexamined.
- c) If the sweep position of a calibration reflector has moved on the sweep line more than 5 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 conducted, and the voided examinations repeated.

## 5.0      EXAMINATION

### 5.1      Requirements

#### 5.1.1      Examination Angles and Coverage

5.1.1.1 Volumetric examination shall be performed using 0° straight beam techniques applied to one end surface of the studs (Figure 1). Note: If indications are seen at recording levels when scanning from one surface only, the stud shall be scanned from both ends.

5.1.1.2 Ultrasonic examination of the OD surface of the stud shall be performed from the stud bore with a shear wave technique (Figure 3).

5.1.1.3 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 data sheets.

5.1.1.4 Where surface conditions do not permit a meaningful ultrasonic examination, the examiner shall record the location and the particular interfering condition on the UT Examination Data Report - Bolting (Figure 6) and an Incomplete Examination Report (IER). In addition, he shall make a sketch of the part's condition and attach it to the report. Photos may be taken and incorporated as part of the report. All parts examined shall be entered on the examination report. If there are no recordable indications, it shall be so noted on the report.

5.1.1.5 Examination volumes for recirculation pump studs are shown in Figures 1 and 1a.

### 5.2      Procedure

5.2.1 Straight beam examination of the recirculation pump studs shall be performed at a scanning sensitivity level of 2X (6 dB) greater than the calibrated primary reference level.

5.2.2 For straight and angle beam examinations, a suitable scan pattern shall be used, allowing a minimum of 10 percent overlap of the transducer width (diameter) for each scan pass.



5.2.3 Angle beam examinations of the recirculation pump studs' nonthreaded areas shall be performed at the primary reference level. Angle beam examinations of the threaded areas shall be performed at primary reference level unless "thread roll" exceeds 30 percent FSH. If "thread roll" exceeds 30 percent FSH, the examination will be discontinued, and the Lead PSI Technician shall be notified for disposition.

5.2.4 Angle beam examinations from the stud bore shall be indexed 50 percent of the search unit's long axis (0.25 inch per index). After each index, the search unit fixture shall be rotated 360°. Continue indexing until the entire ID length of the stud is covered.

5.2.5 Scanning speed shall not exceed 6 inches per second.

## 6.0 EXAMINATION RECORDING REQUIREMENTS

6.1 Ultrasonic calibration data shall be documented on Form MQS-013, Figure 5.

6.2 Indication recording shall be documented on the UT Examination Data Report - Bolting (Figure 6).

6.2.1 All angle beam indications showing a signal amplitude response 50 percent of the reference response shall be recorded on the appropriate data sheet at the time of stud examination.

6.2.2 All straight beam indications showing an amplitude response  $\geq 20$  percent of DAC shall be investigated to determine origin and extent. All nongeometric indications that exceed 20 percent of DAC shall be recorded and a surface examination to the standards of IWB-3515.1 shall be performed.

6.2.3 Each recorded indication shall be identified as to depth, length, signal, amplitude, and location relative to the stud datum point. Length and location end points shall be recorded at 50 percent of maximum amplitude.

6.2.4 Indications from all studs shall be reported in inches below the stud datum point and in inches/degrees clockwise (CW) or counterclockwise (CCW) from the datum point, and in inches radially inward toward the center of the stud when looking down upon the top of the stud. Note: Datum zero shall be established on the top end of the stud and denoted with an arrow symbol.

6.2.5 All indication recordings shall be to the nearest 0.050 inch.

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

6.3.1 The following data shall be recorded on the Ultrasonic Examination Data Report (Figure 6):

- 1) Data sheet identification, date, and time period of examination.
- 2) Names and certified levels of examination personnel.
- 3) Examination procedures(s) and revisions(s).

- 4) Applicable calibration report number.
- 5) Identification of stud examined.
- 6) Surface from which examination was conducted.
- 7) Record of indications (or of volume free of indications).
- 8) Reference to supplemental surface examination if required by paragraph 6.2.2.

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

#### 7.0 EVALUATION OF INDICATIONS

- 1) All straight beam indications showing signal amplitude responses  $\geq 20$  percent of the reference response shall be evaluated to Table 1. The evaluation of all such indications shall be performed by the Lead PSI Technician.
- 2) All angle beam indications showing signal amplitude responses  $\geq 50$  percent of the reference response shall be evaluated to Table S1. The evaluation of all such indications shall be performed by the Lead PSI Technician. In addition, all angle beam indications shall be compared to the various notch reflection amplitudes to establish approximate depth of the reflector.
- 3) For straight and angle beam, planar nonaxial indications, refer to Table 1 for allowable planar indications.
- 4) Any two or more subsurface indications, at any diameter of the stud, which combine to reduce the net diameter are acceptable provided the combined flaw depths do not exceed the sum of the allowable limits specified in Table 1 for the corresponding flaw aspect ratios, divided by the number of indications.
- 5) Any axial indication detected by the volumetric examination shall be confirmed by a surface examination, and the standards of IWB-3513.1 shall apply.

TABLE 1

## ALLOWABLE PLANAR INDICATIONS

Materials: SA-193 Grade B7, SA-320 Grade L43, SA-540  
Class 3 Grade B23, B24 that meet the requirements  
of NB-2333

Diameter Range: Nominal Sizes Greater Than 4 in.

Aspect Ratio, $a/l$	Subsurface <sup>1</sup> Indications, $a$ , in.
0.0	0.10
0.10	0.10
0.20	0.15
0.30	0.15
0.40	0.20
0.50	0.25

Diameter Range: Nominal Sizes 2 in. and Greater, But  
Not Over 4 in.

Aspect Ratio, $a/l$	Subsurface Indications, <sup>2</sup> $a$ , in.
0.0	0.075
0.10	0.075
0.20	0.10
0.30	0.10
0.40	0.15
0.50	0.18

## NOTES:

- (1) Dimensions  $a$  and  $l$  are defined in IWA-3300. For intermediate flaw aspect ratios  $a/l$ , linear interpolation is permissible. Refer to IWA-3200(b).
- (2) The total depth of an allowable subsurface indication is twice the listed value.

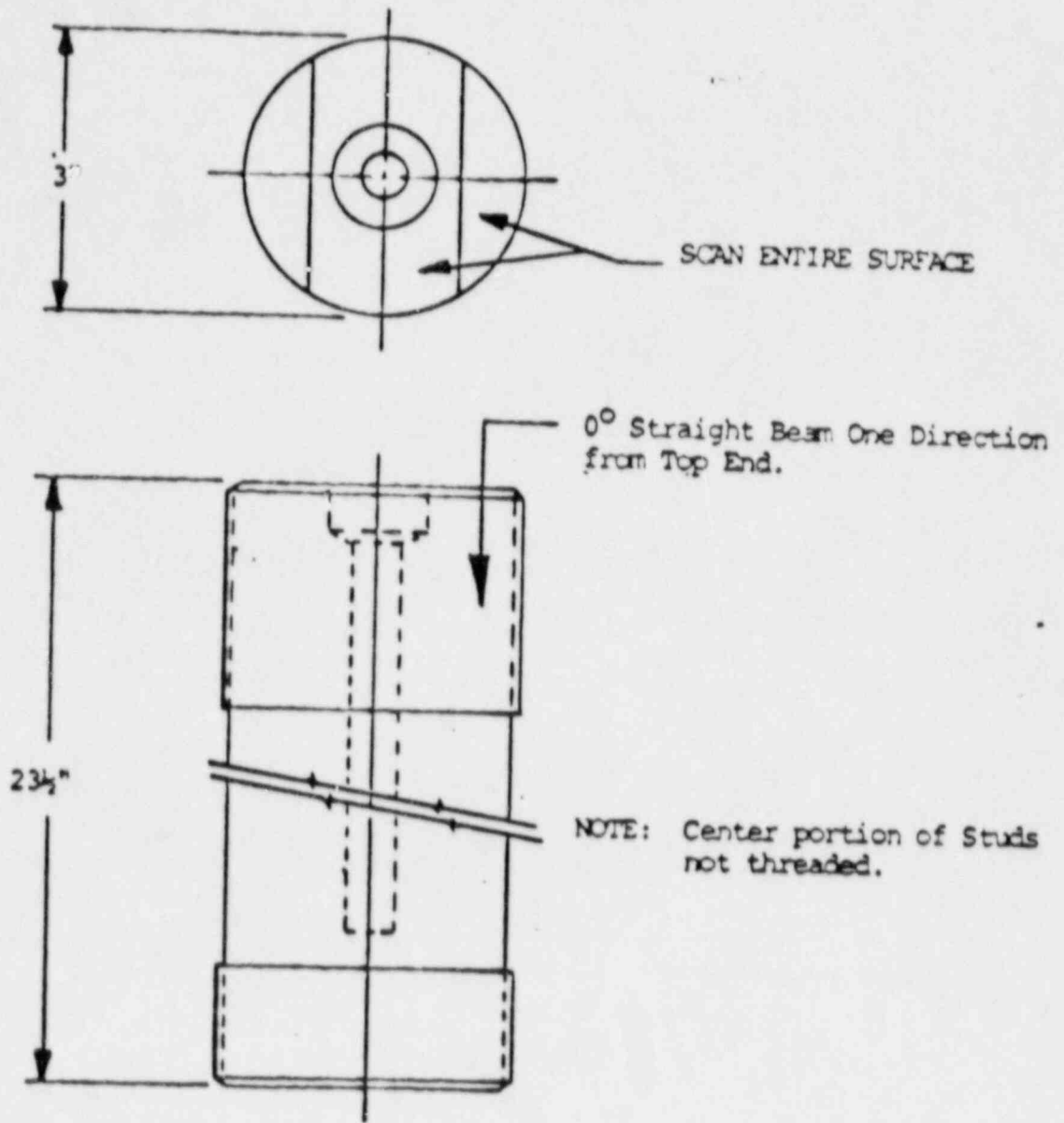


FIGURE 1.

ULTRASONIC EXAMINATION OF RECIRCULATION STUDS

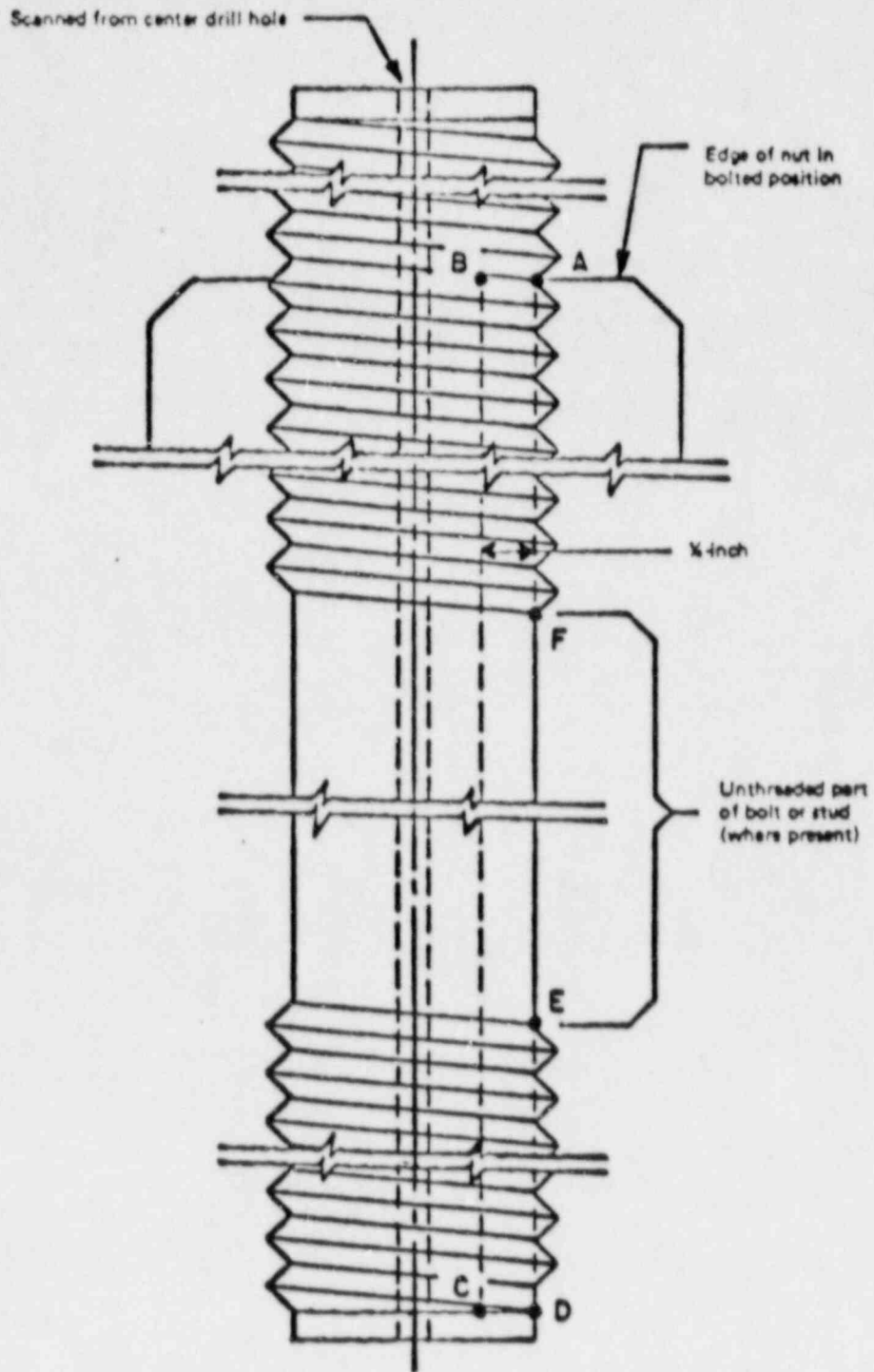


FIGURE 1a.

EXAMINATION VOLUME (A-B-C-D-E-F-A) FOR  
RCP STUDS WHEN SCANNED FROM THE  
CENTER-DRILLED HOLE

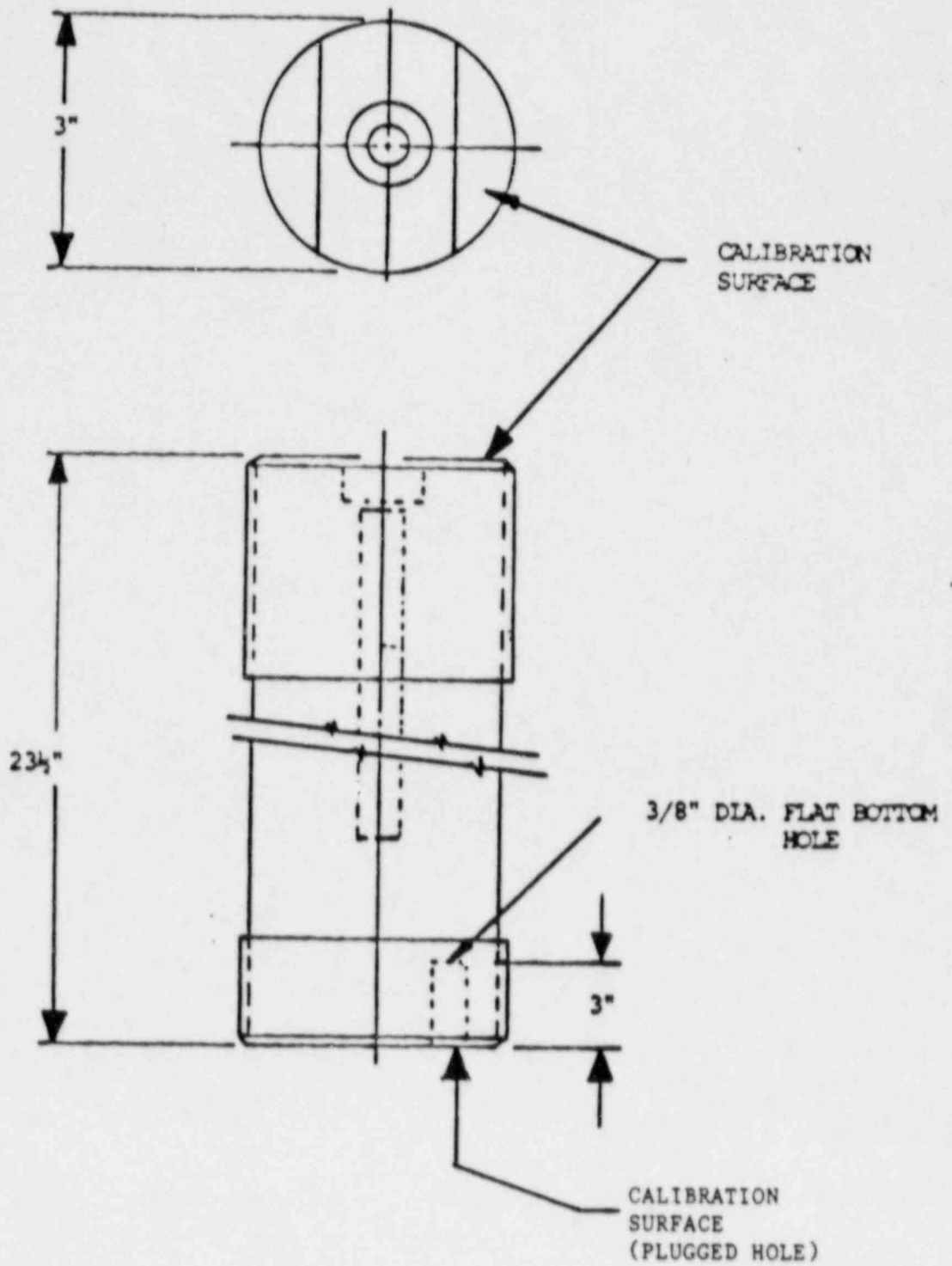


FIGURE 2.

ULTRASONIC REFERENCE STANDARD

Form MJS-003  
Rev. 3/80

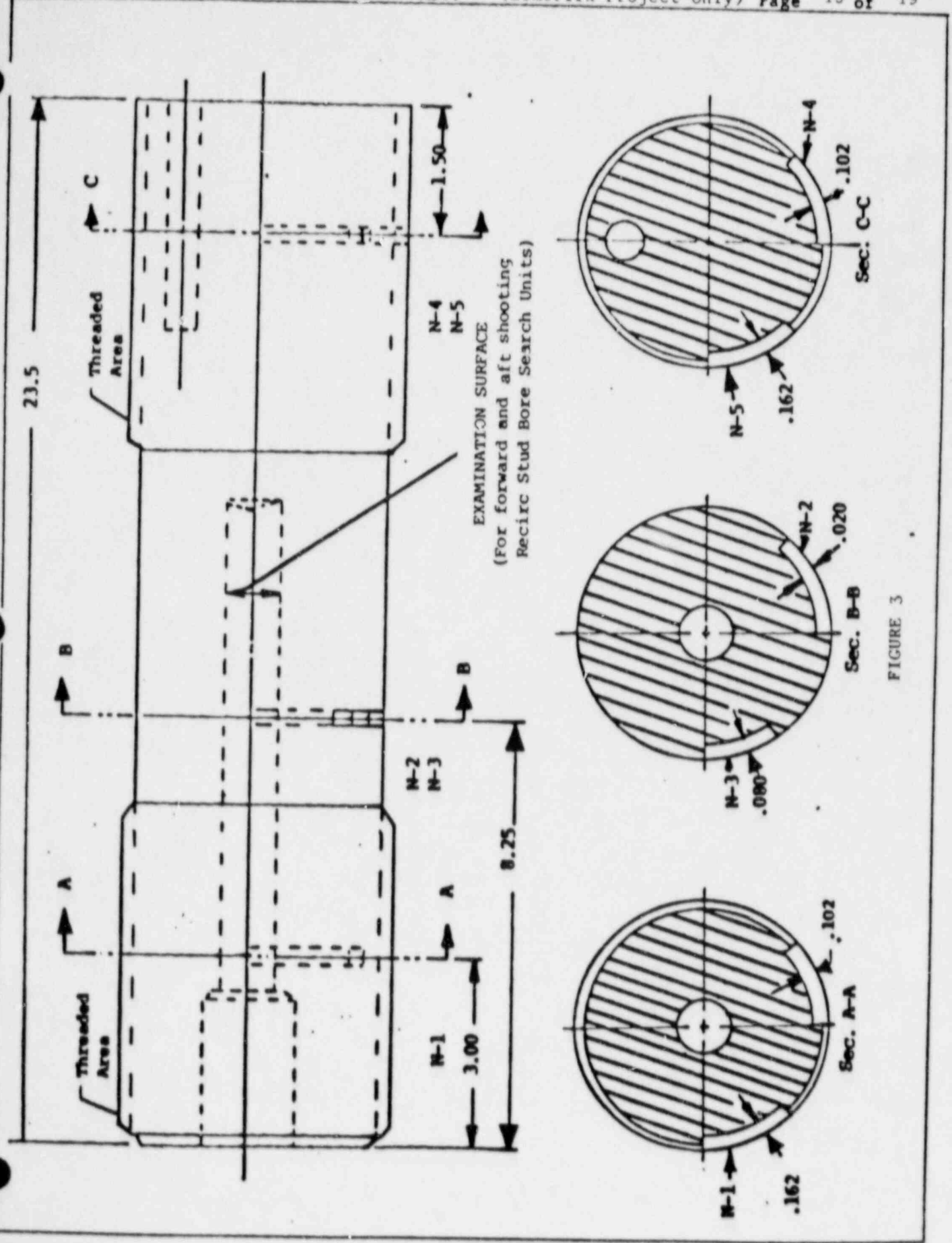


FIGURE 3

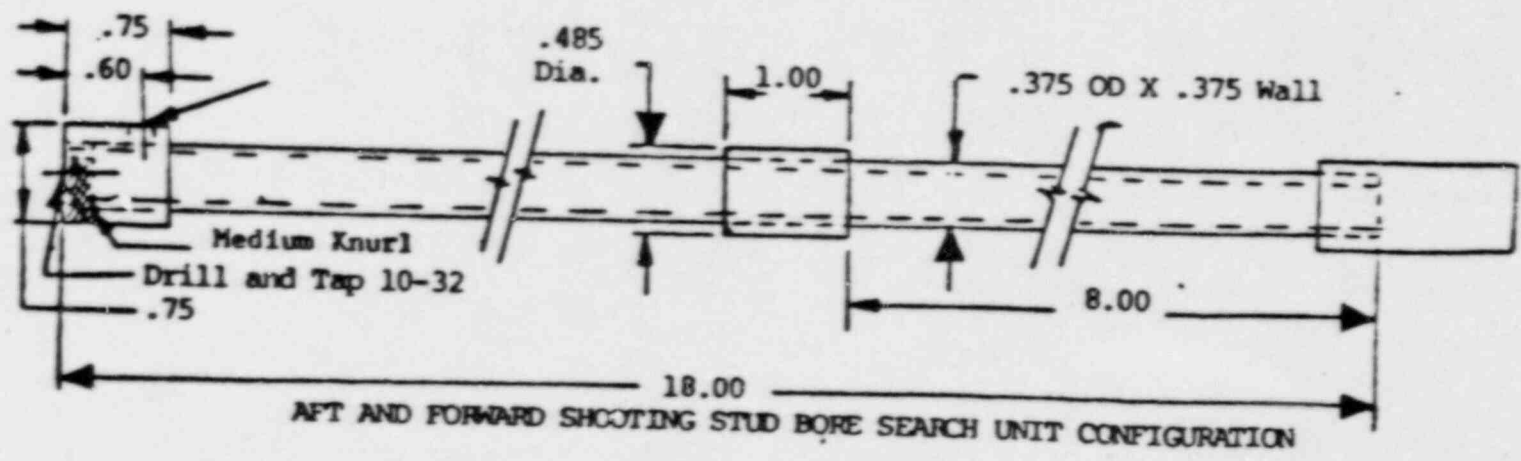


FIGURE 4a.



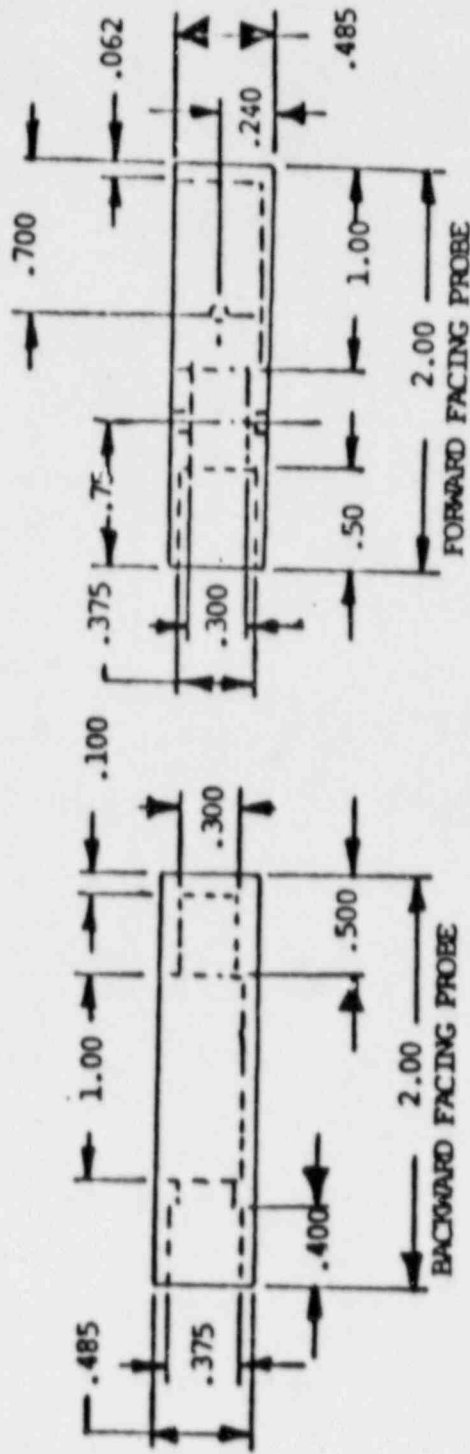
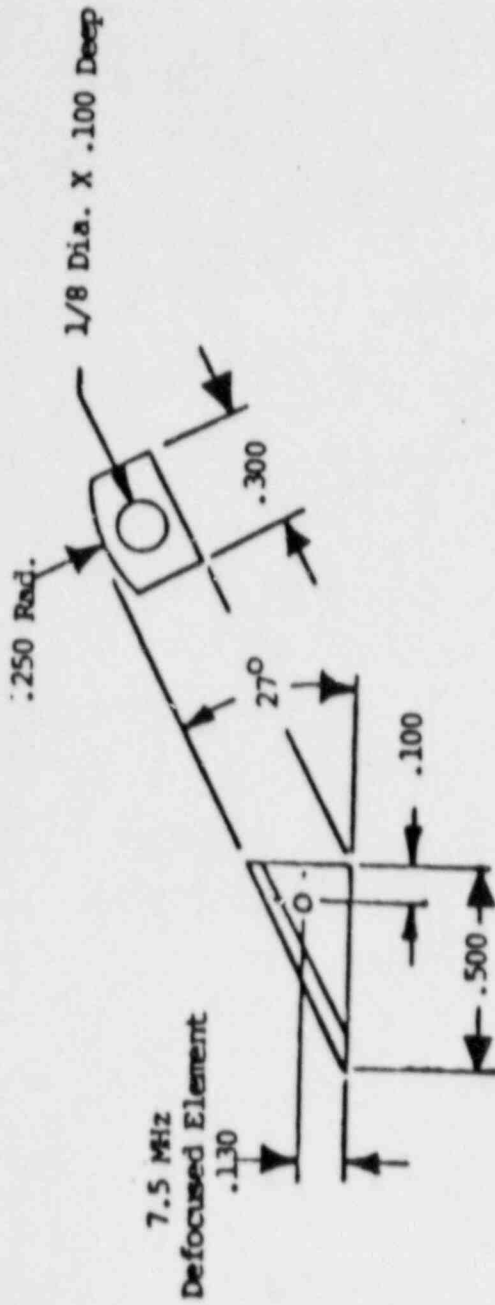


FIGURE 4b.



ULTRASONIC CALIBRATION REPORT

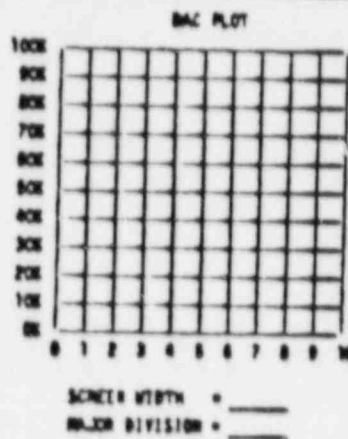
Client		Plant/Date		Report No.	
Team Description:		<input type="checkbox"/> Angle Beam Parallel to Weld <input type="checkbox"/> Straight Beam <input type="checkbox"/> Angle Beam Perpendicular to Weld		Procedure	
Basic Block Serial No.		Basic Block Thickness/Material		Reference Block I.D.	
Examiner		Level		Thermometer No.	
Signature		Date		Examiner	
				Level	
				Date	

INSTRUMENTATION DATA		SEARCH UNIT DATA		LINEARITY			
Manufacturer		Measured Angle		SCREEN HEIGHT			
Model No.		Mode		High	Low	50% ± 95	Limits ± 95
Serial No.		T-Ducer Mfg		100		95	45
Next Calibration Due Date		Type		90		90	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 SFSH		80%	80%	60%	20%
dBcr		dB Change		-6dB	-12dB	+6dB	+12dB
dBcr		Reading SFSH					
Reference Gain		Scanning Gain		Limits SFSH	22 - 48	16 - 24	64 - 96
						64 - 96	64 - 96

CAL. TIME	DATE	REFLECTOR	SHEEP	GAIN	TEMP	REACTIVITY	BLDCK	PART
Initial								
Check								
Check								
Check								
Check								
Check								
Check								
Final								

Lead PSI Technician	Level	Date
PSI Examiner	Level	Date
AWI	Level	Date

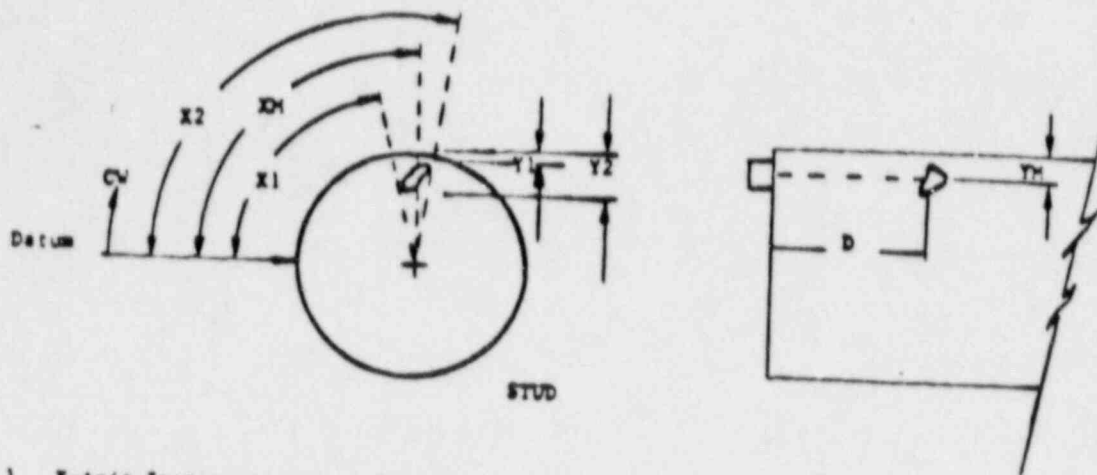


MQS-013  
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FIGURE 5

ULTRASONIC CALIBRATION REPORT, FORM MQS-013

Rev. 1, 3/80



1. X-Axis Increments not to Exceed Allowable Scan Increments.
2. End Points Shall Be 50% of MAX.

Indication No.	Stud No.	MAX. Amplitude	D in inches	X at Max Amplitude	X1 at -6dB	X2 at -6dB	Y at Max Amplitude	Y1 (2) at -6dB	Y2 (2) at -6dB

Comments:

Examiner \_\_\_\_\_ Date \_\_\_\_\_ Level \_\_\_\_\_  
 Examiner \_\_\_\_\_ Date \_\_\_\_\_ Level \_\_\_\_\_  
 Reviewer \_\_\_\_\_ Date \_\_\_\_\_ Level \_\_\_\_\_

FIGURE 6

UT EXAMINATION DATA REPORT - BOLTING

Form MJS-003  
 Rev. 1 3/80