WASHINGTON PUBLIC POWER SUPPLY SYSTEM	NO. QCI 6-4
NDE & I INSTRUCTION	REV. NO. 5
	EFFECTIVE DATE 3/28/89
	QUALITY AFFECTING ☒ YES ☐ NO
TITLE: ULTRASONIC EXAMINATION FEEDWATER NOZZLE INNER RADII	

1.0 PURPOSE AND SCOPE

1.1 This procedure defines the requirements for manual, pulse-echo ultrasonic examination of the feedwater nozzle inner radius, (Zones 1, 2, and 3), ASME Section XI, Category B-D. Scanning by this procedure is done from the reactor vessel O.D. wall and nozzle surfaces using refracted shear wave search units. Figure 1 illustrates the Zones which can be effectively scanned from the outside surfaces of the vessel plate and nozzle.

1.2 This procedure covers the angle beam shear wave technique that is unique to the nozzle design. Specific refraction angles have been determined by individual nozzle geometry as depicted in Figures 2, 3 and 4.

1.3 This instruction is intended to meet the requirements of Sections V and XI of the ASME Boiler and Pressure Vessel Code (1980 with Addenda through Winter 1980).

1.4 BWR Calibration Data listed in Table I have been predetermined from the Supply System's feedwater nozzle mockup so the qualified examiner need only use the vessel calibration block representing the shell course containing the nozzle.

2.0 DEFINITIONS

None.

3.0 REQUIREMENTS

3.1 Personnel Qualifications

3.1.1 Personnel performing examinations to the requirements of this instruction shall be a certified to at least Level II, in ultrasonics in accordance with the requirements of Reference 6.2 and (b) below. Supply System personnel shall be (a) certified to at least Level II in accordance with Reference 6.3 and (b) qualified using the Supply System BWR feedwater nozzle mockup and this ultrasonic examination procedure.

3.1.2 Personnel not specifically qualified on the BWR feedwater nozzle mock-up, but designated as Trainee, Level I, II or III UT may assist a qualified examiner in performance of examinations to this instruction.

3.1.3 At least one person responsible for reviewing the results of the ultrasonic examination shall be a Supply System person certified as an ultrasonic Level III in accordance with Reference 6.3 in addition to meeting the requirements of (b) above.

3.2 Radial Clearance

The thermal insulation should be clear of the nozzle and vessel to create a free space 12 inches out from the nozzle cylinder outer surface.

3.3 Equipment

3.3.1 The pulse-echo, ultrasonic, flaw detection instrument shall be equipped with a fine gain or attenuation control graduated in units no larger than 2 dB. Instruments considered acceptable for this examination are listed below; however, other instruments may be used if the model type has been qualified.

Krautkramer USIP-11, USL-48, USD-10
Nortec NDT 131 or 131D, 132D

3.3.2 Single element ceramic transducers, having an area of .44 to 1.0 square inch, with a nominal frequency of 2.25 MHz shall be used with specific wedges, Figure 5. The refracted angle within the material shall be within the limits shown in Table I. Additionally, data may be taken with other sizes, frequencies, and angles, after completing the examination to the above requirements.

3.3.3 Ultragel II or its equivalent shall be used as the liquid couplant.

3.3.4 The vessel calibration standard listed in Table I shall be used. This standard corresponds to the shell thickness containing the subject nozzle.

3.3.5 IIW-2 ROMPAS or modified Type DC (square ended semicircle) sweep calibration reference blocks.

3.3.6 Flashlight for reading instrument control knobs.

3.4 Surface Preparation

The contact surface shall be clean and free of dirt, dust, weld spatter, loose paint, or other material which would interfere with free movement of the transducer or impair transmission of ultrasonic energy into the material.

3.5 Scanning Speed Limit

The scanning speed shall not exceed 3 inches per second.

3.6 Nozzle Indentification

Prior to the examination, the nozzles shall be marked and identified in accordance with a nozzle marking plan as illustrated in Figure 6. Sanford's "Sharpie" black tip marker is the accepted pen device.

3.7 General Requirements for Calibration

Calibration shall include the complete ultrasonic examination system. Any change in couplants, cables, or ultrasonic instruments shall be cause for recalibration. Sweep calibrations may be made with a standard angle beam wedge using the IIW or similar curved block, and must be representative of the metal path expected for the zone to be examined, reference Table I.

3.7.1 Instrument Calibration - Prior to the initiation of scheduled examinations, the ultrasonic instrument shall be checked for screen height and amplitude control linearity per paragraphs 3.7.2 and 3.7.3.

3.7.2 Screen Height (per ASME) Linearity Check - An angle beam search unit shall be positioned on a calibration block and signals obtained from two reflectors. The search unit position shall be adjusted to give a 2:1 ratio of amplitudes between the two reflectors. The gain control (sensitivity) shall be adjusted and the larger signal brought to 80% of full screen height (FSH), adjusting position if necessary to maintain the 2:1 signal ratio. Without moving the search unit, adjust the gain control to successively set the larger signal from 100% to 20% FSH in 10% increments or 2 dB steps. The smaller amplitude must be 50% of the larger amplitude within 5% of FSH. Instruments that do not meet these requirements shall not be used.

3.7.3 Amplitude Control Linearity Check - The angle beam search unit shall be positioned on a calibration block and a peaked signal amplitude obtained from a hole or notch. The indication shall be brought as near as possible to 80% FSH with

the dB control. If necessary, the final adjustment to 80% FSH is made with the variable gain control or dB switch. Using only the dB control, the dB changes indicated below shall be made and the resulting amplitude compared with the allowable amplitude limits as specified below. Instruments that do not meet these limits shall not be used. The procedure shall be repeated for 40% and 20% FSH amplitudes.

Initial Amplitude Set of % FSH	dB Control Change	Amplitude Limits (% FSH)
80	- 6	32 to 48
80	-12	16 to 24
40	+ 6	64 to 96
20	+12	64 to 96

3.7.4 Recalibration (Sweep Only) - If the indication from the calibration reflector has moved on the sweep line more than one inch of metal path, correct the sweep range calibration and note the correction on the calibration data sheet. If recordable reflectors are noted on the examination data sheets, those data sheets shall be voided. A new calibration shall be made and recorded, and the voided examination areas shall be re-examined.

3.7.5 Recalibration (Amplitude Only) - If the amplitude of the calibration notch has changed by more than 10% FSH when a check is made on the reference block, all data sheets since the last positive calibration check shall be marked void. A new calibration shall be recorded and the voided examination areas re-examined. The voided sheets may be discarded.

Calibration shall be performed at the beginning of each series of examinations. A calibration verification shall be made at intervals not exceeding four hours during the examinations.

4.0 CALIBRATION AND EXAMINATION

4.1 Sweep Calibration

An initial instrument sweep calibration shall be made for shear wave velocity by using the examination search unit with a conventional angle beam shear wave wedge and the IIW, Rompas or modified DC type curved calibration block. Sweep calibration data is listed in

Table I for each nozzle. The oscilloscope's screen shall read directly in inches of metal path and the data entered on the calibration data sheet, Figure 7.

4.1.1 Zone 1 - Using a Rompas block, direct the ultrasonic beam toward the large radius, with the exit point of the transducer at the radius center mark on the block, maximize the CRT signals by moving the transducer forward and back. Adjust the "Range" and "Delay" controls until the first reflection signal is at "2" on the horizontal graticule line on the CRT and the following signals appear at "5" and "8". Lock the range control knob and delay the signal at "8" to zero position. Signals should now appear at zero, 3, 6 and 9. Next, delay the signal at 6 to zero. Signals should again appear at zero, 3, 6 and 9. If they do not, make minor adjustments so they do. The CRT is now calibrated for 14 to 24 inches of metal path.

4.1.2 Zone 2 - Using the transducer with the convex 25° shear wedge, obtain peaked signals from the 1/2 to 3/4 "T" holes in calibration block No. 120. Adjust the range and sweep to obtain reflection signals at positions 3.5 and 5.4. Delay the signal at 5.4 to the 0.4 position. The CRT is now calibrated for 5 to 15 inches of metal path.

4.1.3 Zone 3 - Using the transducer with the flat 25° shear wedge, calibrate as in 4.1.2.

4.2 Amplitude Calibration

Basic calibration gain sensitivity shall be determined by both the applicable vessel calibration block and the transfer sensitivity gain as shown in Table 1. Basic calibration shall be established with sufficient gain so that 2X scanning can be performed without changing the variable gain control.

To determine the basic sensitivity level, the search unit shall be held on the applicable vessel calibration block with the signal amplitude from the 3/4 T-hole maximized. The instrument gain controls shall then be adjusted so that the 3/4 T-hole signal amplitude is brought to 50% FSH. This basic sensitivity level shall then be adjusted for each zone according to Table 1's "Transfer Sensitivity dB Gain Increase." After adjusting to the transfer sensitivity gain increase, the gain setting shall now be the primary reference level of 1X. Examination scanning shall be at 2X (+6 dB) above the primary reference level.

NOTE: As shown in Table 1, Zone 1 requires no additional gain adjustment after the 3/4 T-hole is maximized at 50% FSH to achieve the

primary reference level (see Note 4). Transfer sensitivity gain is 0 for Zone 1. However, for Zones 2 and 3 the primary reference gain level is an additional 12 dB over the 3/4 T-hole maximized at 50% FSH.

CAUTION: Care must be exercised during calibration to assure the shear wave component is used for calibration since there is also a strong longitudinal wave component generated by the angle beam transducer, especially for Zone 2 and 3 calibration. A peaked shear wave signal from the 3/4 T hole should appear at approximately 5.7 inches metal path when the transducer is approximately 2-3/8 inches surface distance from a line normal to the hole centerline. The refracted longitudinal wave should produce a peaked signal at approximately 4-3/4 inch metal path at a surface distance of 6-1/2 inches.

4.3 Examination

A Level II or III UT examiner shall view the CRT display during the examination. A record of each nozzle inner radius examination shall be made on examination data sheets (Figure 8), which shall be numbered in sequence with calibration data sheets. Scanning shall be performed at 2X above the primary gain level (1X). Measurement and recording of ultrasonic indications shall be done at the 1X level.

Zone - 1

The inner radius Zone 1 shall be scanned in two directions (CW and CCW) from the vessel plate as shown in Figure 9. Scanning shall be done in a circumferential or radial motion with a minimum overlap of 0.5 inches. The moveable pointer on the transducer wedge shall be positioned in the groove marked "CCW" for scanning counter clockwise and "CW" for scanning clockwise. While scanning, the pointer shall be aimed at the nozzle bore to the extent practical with the transducer oscillated slightly. The examiner shall reference Figure 9 for transducer orientation.

The scan boundaries extend from the end of the blend radius to a distance of 9 inches out on the shell wall. The operator shall occasionally rotate the wedge toward the bore axis to obtain a direct reflection signal from the inner radius as a check to confirm penetration.

Zone - 2

The inner surface of the nozzle shall be scanned from the exterior surface of the nozzle using the appropriate search units in two directions: clockwise (CW) and counterclockwise (CCW) (Figure 11). A circumferential scanning pattern spaced at intervals not exceeding 0.25 in. (3/4 in. overlap) shall be followed around the nozzle body to obtain full coverage of the inner surface Zone 2.

Zone - 3

The nozzle forging and the inside bore shall be examined to the maximum extent possible using the cylindrical surface for scanning (Figure 12). The scan path of the search unit shall overlap the adjacent scan by a minimum of 0.50 inch. The search unit shall be scanned circumferentially around the nozzle forging so the angle beam shear wave covers all 360° of the circumference in both the clockwise and counterclockwise directions.

4.4 Data Recording

Indications in the region of the blend radius which have an amplitude greater than 50% FSH at the 2X scanning level and which travel in time position on the CRT shall be investigated to determine maximum amplitude.

Indications in the region of the blend radius which exceed 25% FSH at the primary reference level (1X) and which travel in time position on the CRT, shall be recorded on the examination data sheet. Report signal amplitude in % FSH, metal path in inches, search unit direction as clockwise (CW) or counterclockwise (CCW), and search unit position.

4.5 Reference Points for Physical Measurement

Reference points for physical measurement of azimuth shall be in accordance with the nozzle reference plan shown in Figures 10, 11, and 12.

4.6 CRT Display Photos

Photos of the CRT display shall be taken at the option of the Level III Examiner to further document the ultrasonic signal character. Pertinent data shown below shall be recorded on the back of each photo.

1. Report No.
2. ISI Drawing No.
3. Zone No.
4. Sweep Distance
5. Indication No.

5.0 DATA PROCESSING

5.1 The recorded data shall be reviewed by a level III Examiner to determine if additional examination and/or interpretation is required.

5.2 Recorded indications shall be plotted on a scale no less than quarter size and reviewed by the Level III Examiner.

6.0 REFERENCE

6.1 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, 1977 Edition through Summer 1978 Addenda.

6.1.1 Section XI - "Rules for Inservice Inspection of Nuclear Power Plant Components".

6.1.2 Section V - Nondestructive Examination".

6.2 American Society for Nondestructive Testing, June 1975 Edition. Recommended Practice SNT-TC-1A "Nondestructive Testing Personnel Qualification and Certification".

6.3 The Supply System "Program Manual for Qualification and Certification of Examination, Testing and Inspection Personnel WMC-034".

6.4 Nozzle forging drawings - General Electric/CBI Nuclear

TABLE I

ULTRASONIC CALIBRATION DATA FOR
EXAMINATION OR BWR NOZZLE INNER RADII

NOZZLE TYPE - N4 FEEDWATER

	ACOUSTIC ANGLES DEGREES[1]			CRT DISPLAYED SWEEP	CAL STANDARD #	TRANSFER SENSITIVITY dB GAIN INCREASE
	A	B	C			
Zone 1	22	70	70	14" to 24"	UT 120[2]	0
Zone 2	22	25[3]	63-70	5" to 15"	UT 120	12
Zone 3	0-10	25	63	5" to 15"	UT 120	12

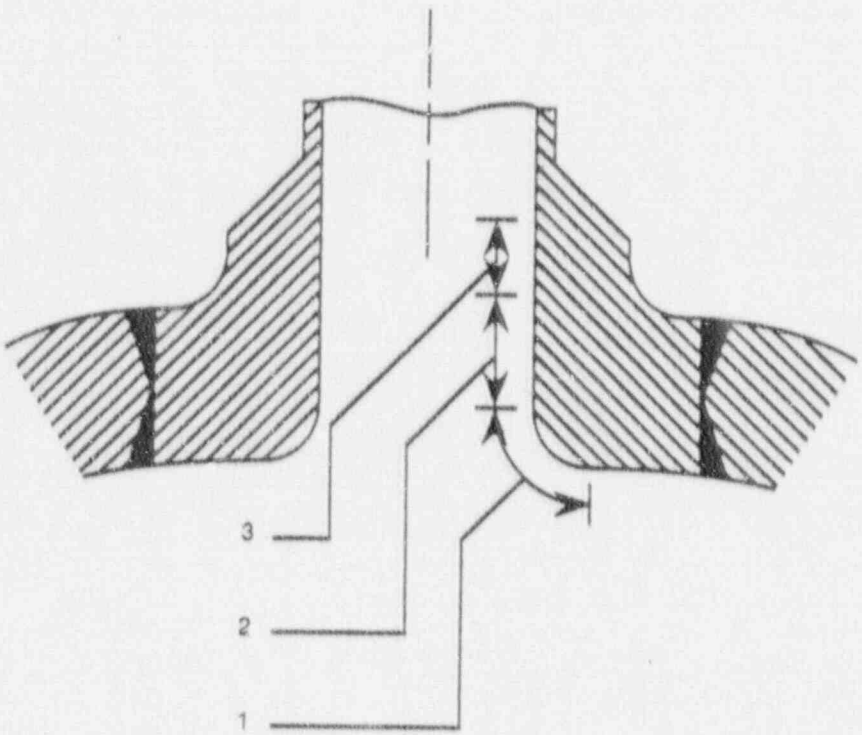
1. See Figures 2A, 2B, 3 and 4

2. The 5/16 in. dia., 3/4 T hole (5.06 in. below the contact surface) shall be used for calibration.

3. Convex shoe

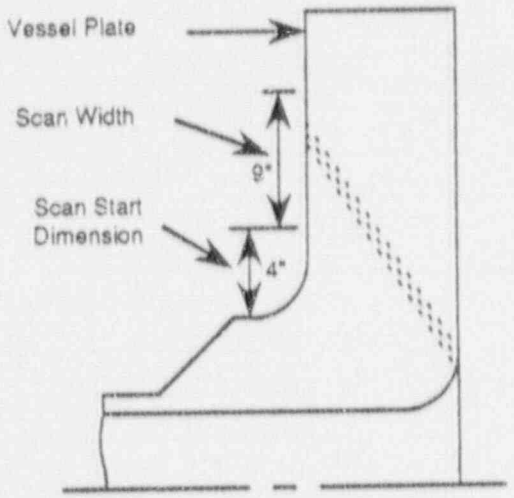
   NOTE: The following is in reference to Zone 1 transfer sensitivity.

4. Gain setting for 50% FSH indication is 6 dB less for RFW nozzle mock-up notch (Notch A) than for 3/4 T-hole of calibration standard UT-120. Therefore, as a conservative measure, the 3/4 T-hole gain setting has been accepted as the primary gain level.

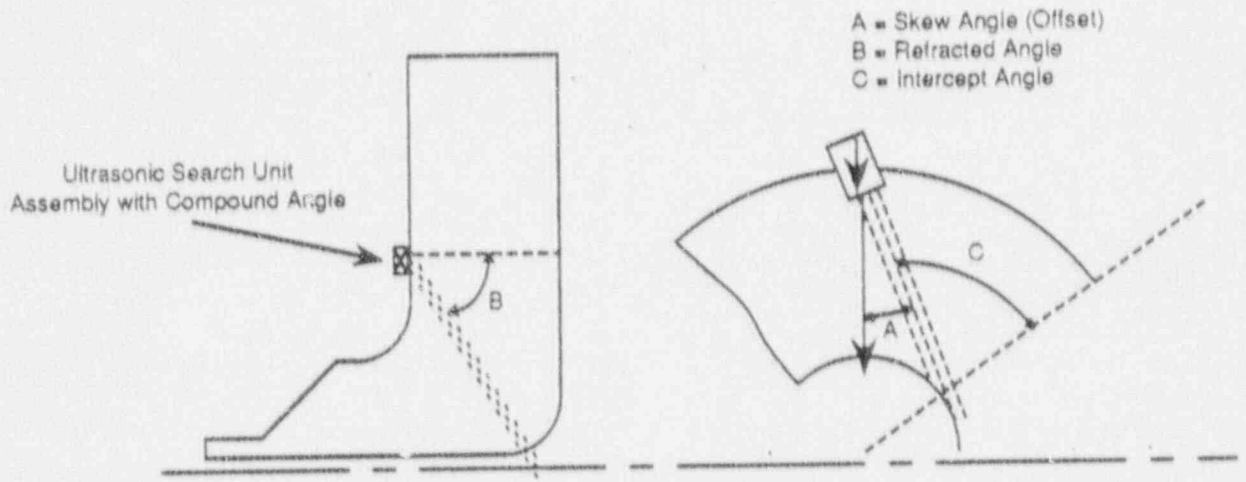


NOZZLE EXAMINATION ZONES

FIGURE 1



2A. Nominal Entry Point For Sound Beam
For Zone 1



2B. SOUND BEAM GEOMETRY IN NOZZLE
FOR ZONE 1

FIGURES 2A and 2B

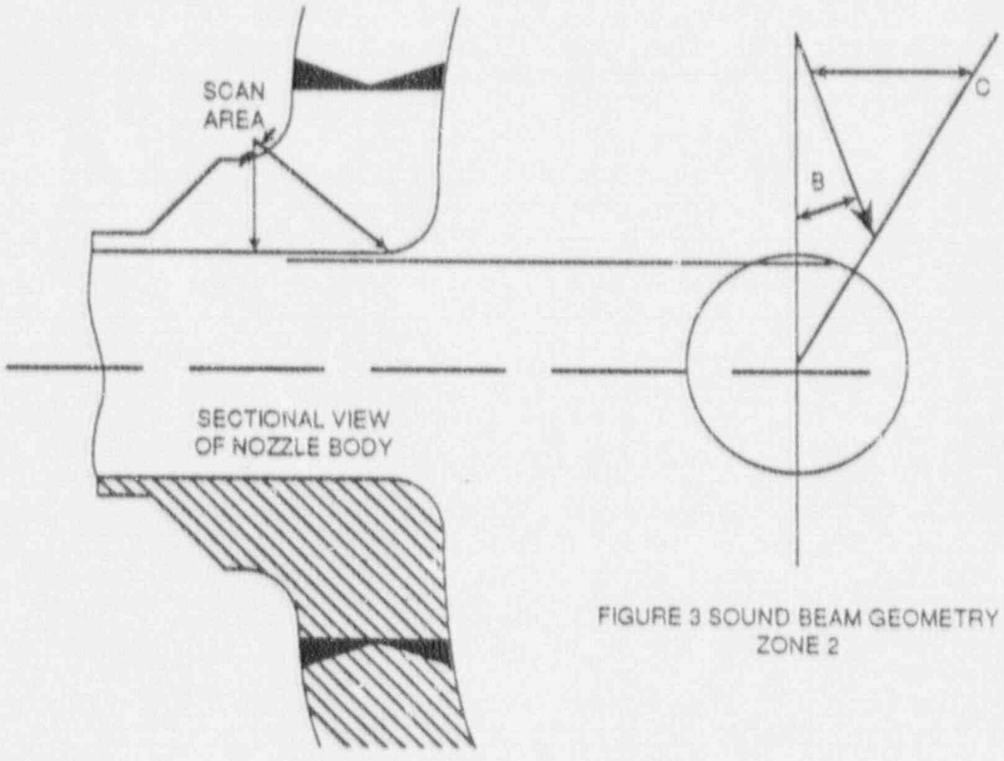


FIGURE 3 SOUND BEAM GEOMETRY
ZONE 2

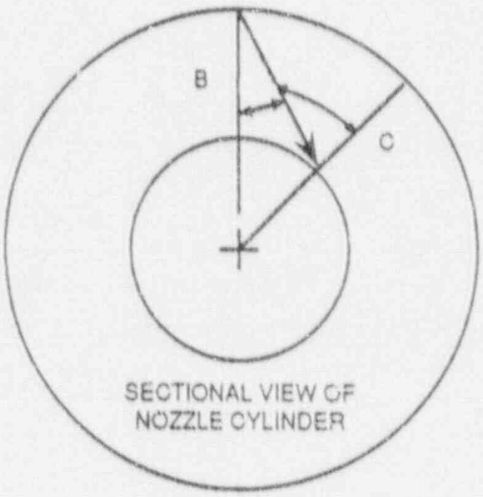


FIGURE 4 SOUND BEAM
GEOMETRY, ZONE 3

FIGURES 3 and 4

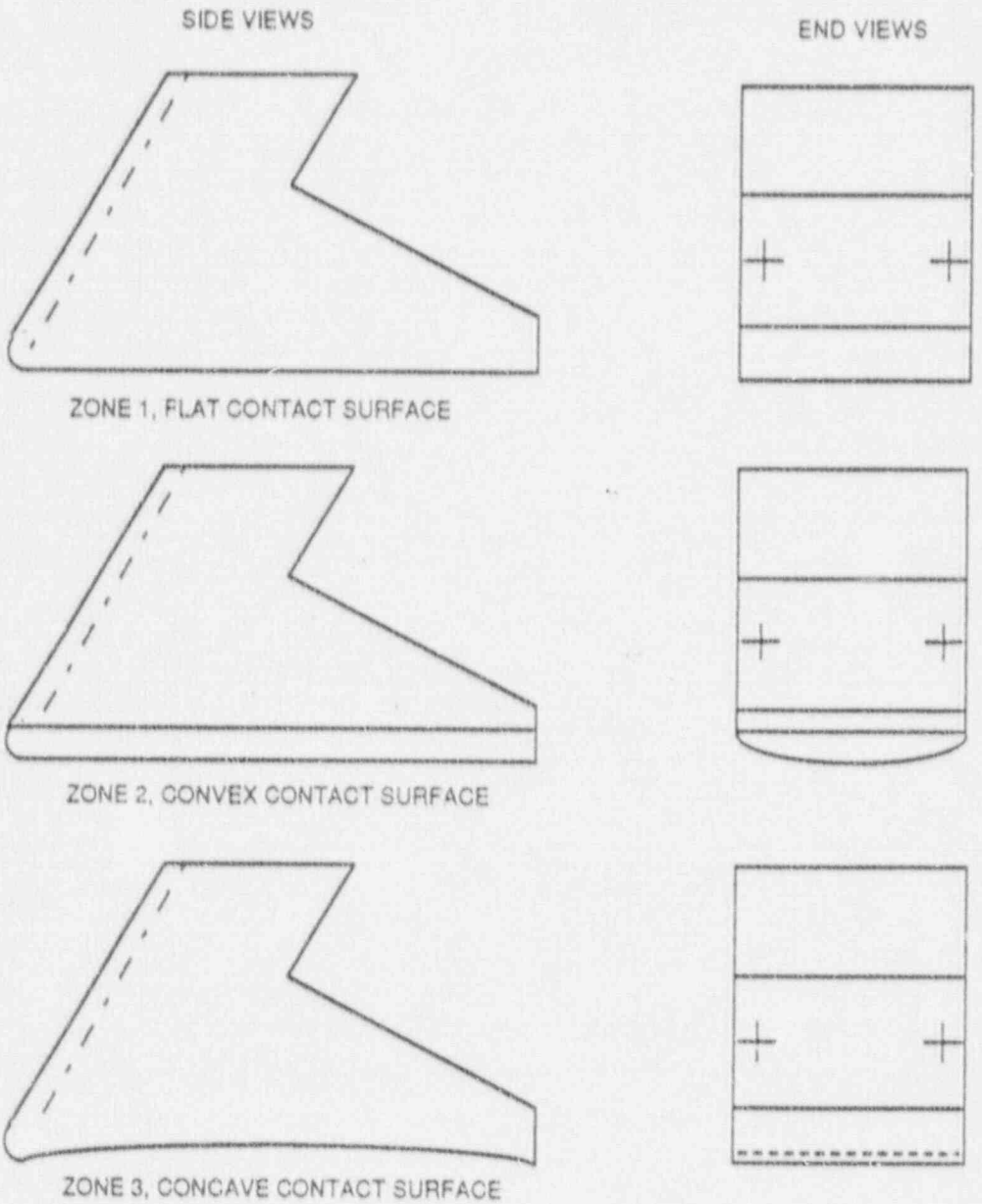


FIGURE 5 TRANSDUCER WEDGE CONFIGURATIONS

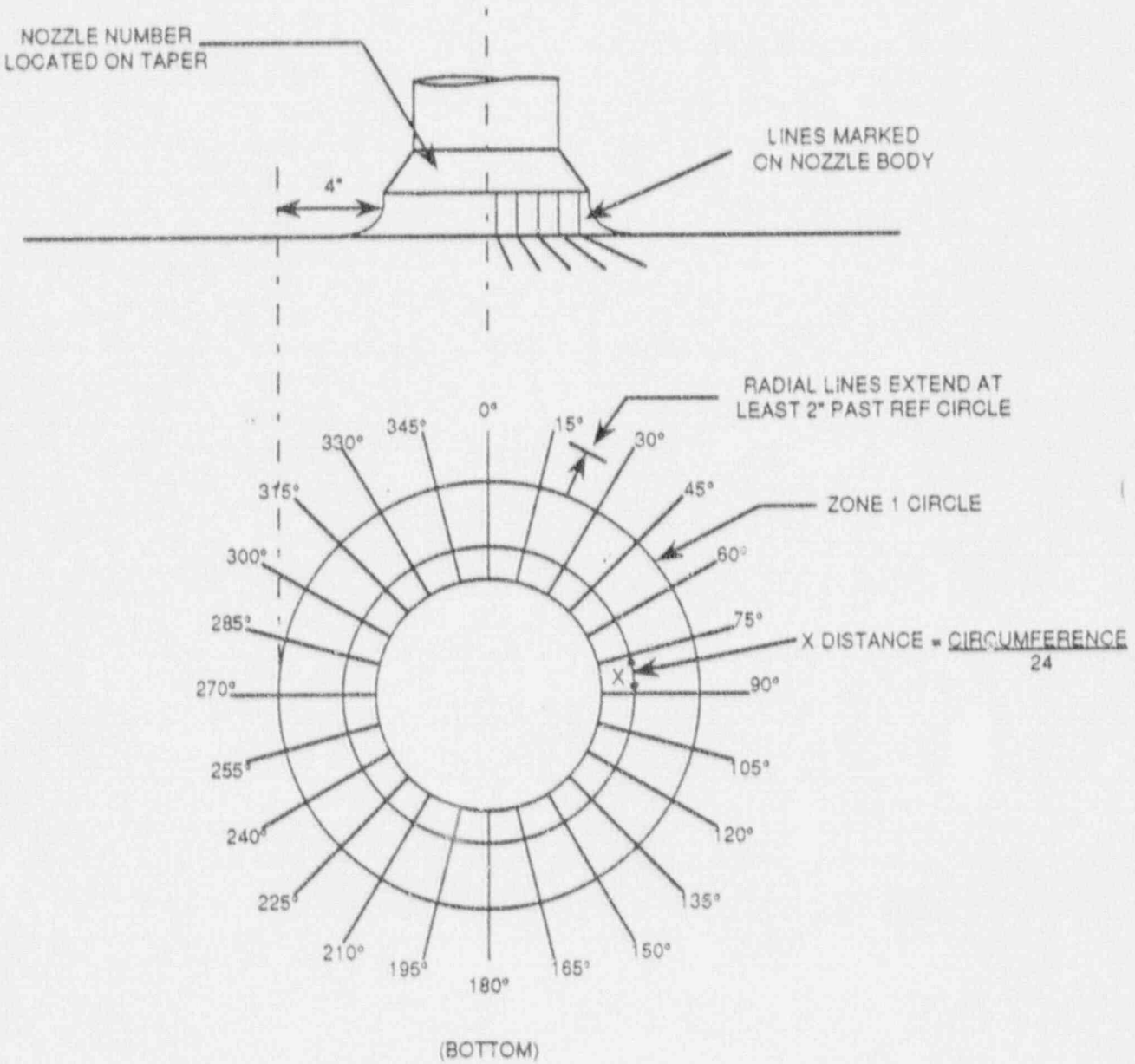


FIGURE 6 NOZZLE MARKING PLAN

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

ULTRASONIC CALIBRATION SHEET

PROJECT:	SYSTEM:		SHEET NO.:
EXAMINER:	LEVEL:	DATE:	THERMOMETER S/N:
EXAMINER:	LEVEL:	INSTRUCTION NO.:	REVISION:

CALIBRATION STANDARD	CALIBRATION STANDARD SIMULATOR	TRANSDUCER	
SERIAL NUMBER _____	S/N _____ TEMP _____ °F	S/N _____ WAVE MODE _____	CABLE TYPE _____
THICKNESS _____	AMP _____ SWEEP _____ IN.	SIZE _____ FREQ _____ MHz	LENGTH _____
TEMPERATURE _____ °F	GAIN IN db _____	ACTUAL ANGLE _____	COUPLANT _____
			BATCH NO. _____

CHART RECORDER TYPE:	S/N:	UT INSTRUMENT TYPE:	S/N:

INSTRUMENT CALIBRATION

PREVIOUSLY PERFORMED ON CALIBRATION SHEET NUMBER _____

SCREEN HEIGHT LINEARITY FOR CONTINUOUS GAIN CONTROL									
HIGH	100	90	80	70	60	50	40	30	20
LOW			40						

SCREEN HEIGHT LINEARITY FOR 2db STEP GAIN CONTROL									
db	+2	0	−2	−4	−6	−8	−10	−12	−14
HIGH		80							
LOW		40							

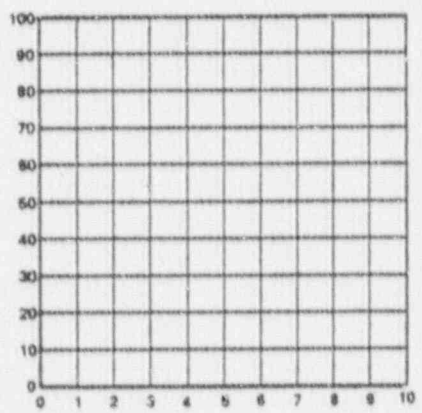
AMPLITUDE CONTROL LINEARITY				
AMPLITUDE %	80	80	40	20
db CHANGE	−6	−12	+6	+12
READING %				
LIMITS %	72 - 88	56 - 72	84 - 96	84 - 96

INITIAL CAL TIME: _____ SYSTEM CALIBRATION FINAL CAL TIME: _____

INSTRUMENT SETTINGS		REFLECTORS	AMPLITUDE %FSH	SWEEP READING IN INCHES
COARSE RANGE	=	/8 NODE		
COARSE DELAY	=	/8 NODE		
RANGE CALIB	=	/8 NODE		
DELAY CALIB	=	/8 NODE		
FREQUENCY	=	/8 NODE		
GAIN IN db	=	/8 NODE		
DAMPING	=	/8 NODE		
REJECT	=	BKR db		
FILTER	=	SEARCH UNIT ORIENTATION	AXIAL / CIRCUMFERENTIAL	
	=	WELDS OR PARTS EXAMINED		
	=			
	=			
	=			

SAMPLE

SCREEN DAC PRESENTATION



FULL SCREEN SWEEP _____ IN.

CAL CHECKS

REVIEWED BY LEVEL III:	DATE:	REVIEWED BY:	DATE:

949-16286

FIGURE 7

ULTRASONIC EXAMINATION DATA SHEET – NOZZLE INNER RADIUS

REPORT NO.: EW-003

PROJECT: WNP-2	SYSTEM: Feed Water		ISI DRAWING NO.: RPV - 101
NOZZLE DESCRIPTION: N 4 Feed Water			NOZZLE NO.: N 4 - 150 - IR
MATERIAL TYPE: Carbon Steel		ZONE NO.: 1	ZONE NO.: / ZONE NO.:
NO. OF SCAN DIRECTIONS: 2 each zone		DATE: 2/23/83	DATE: / DATE:
INSTRUCTION NO.: QCI 6-4	REVISION: 0	TIME START: 0940	TIME START: / TIME START:
EXAMINER: J Smith	LEVEL: II	TIME STOP: 1050	TIME STOP: / TIME STOP:
EXAMINER: A Brown	LEVEL: III	PART TEMP: 65 °F	PART TEMP: °F / PART TEMP: °F
CAL STANDARD NO.: Shell Ring #3	THICKNESS: 6.6"	CAL SHEET NO.: JS-003	CAL SHEET NO.: / CAL SHEET NO.:
ACCEPTANCE CRITERIA:		ANGLE: 70°	ANGLE: / ANGLE:

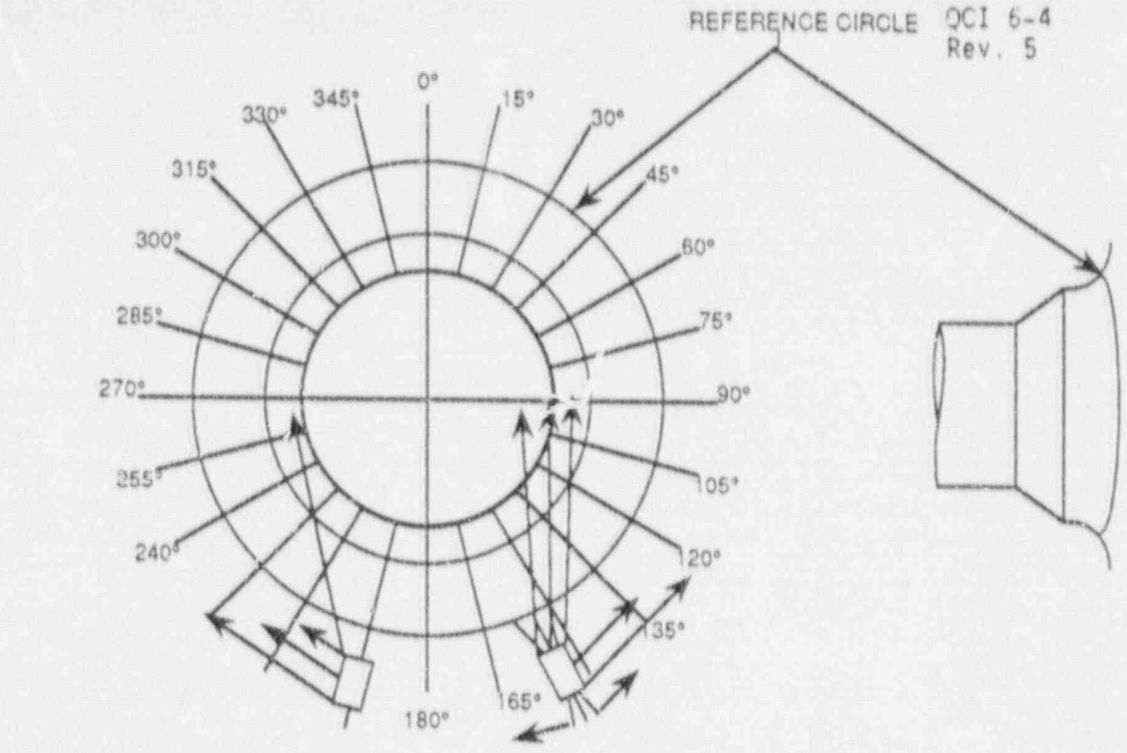
INDICATION NUMBER	POLAR REFERENCE	AZIMUTH (CCW)	D DISTANCE	AMPLITUDE % FSH	METAL PATH	SCAN (CW OR CCW)	ZONE NO.	COMMENTS
1	45	2.25	1.25	90	14.75	CW	1	
2	315	3.2	3.05	65	15.04	CCW	1	
3	300	2.6	2.2	70	17.8	CCW	1	
4	85	3.2	3.0	75	17.7	CW	1	

SAMPLE

REVIEWED BY LEVEL III: L. Green	DATE: 2/23/83	REVIEWED BY:	DATE:

748-1645A

FIGURE 8



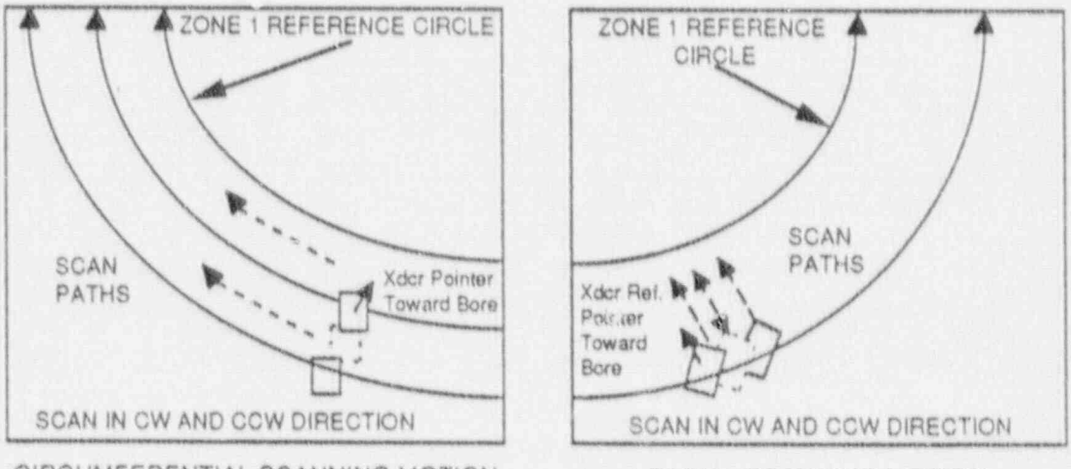
FIXED AZIMUTH CIRCUMFERENTIAL SCAN TECHNIQUE

SECONDARY

MOVING AZIMUTH SCAN TECHNIQUE

PRIMARY

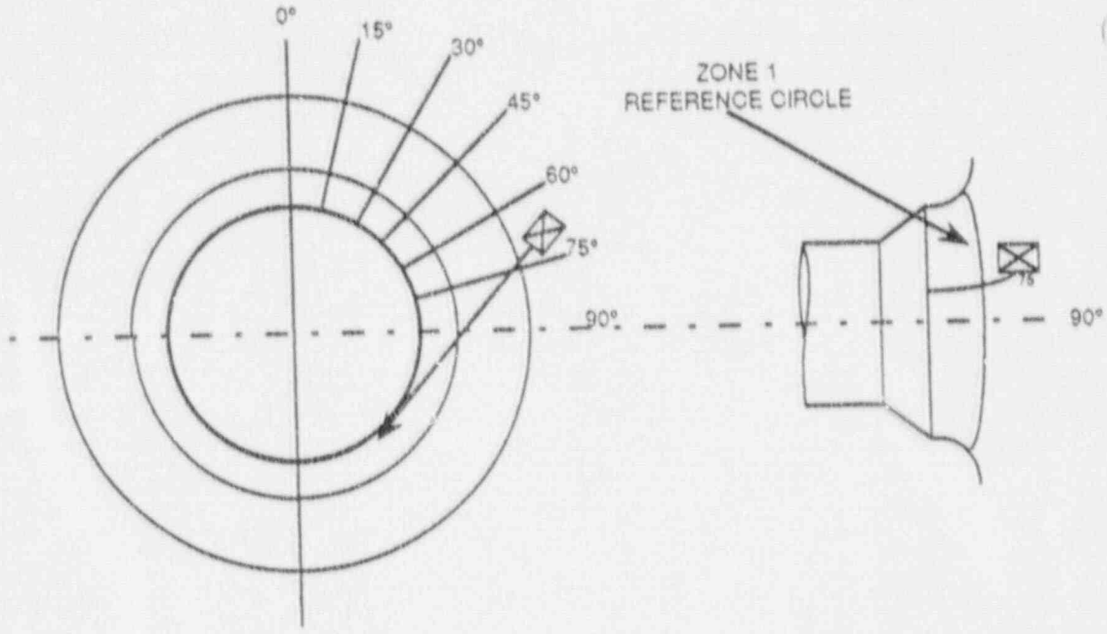
CIRCUMFERENTIAL AND RADIAL SCANNING

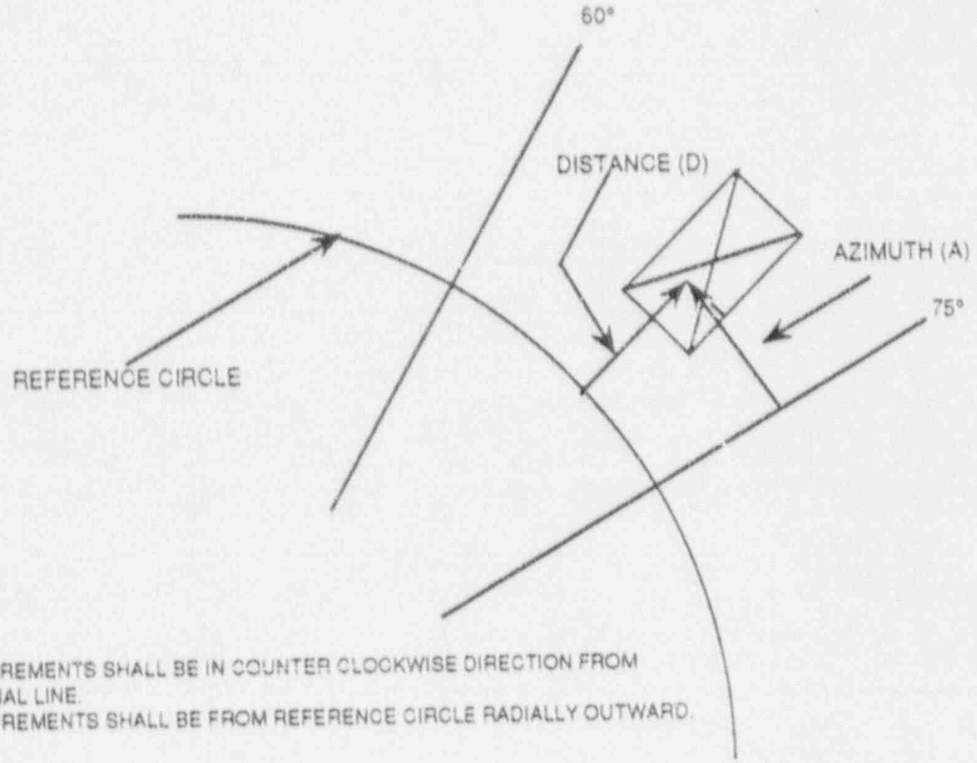


CIRCUMFERENTIAL SCANNING MOTION

RADIAL SCANNING MOTION

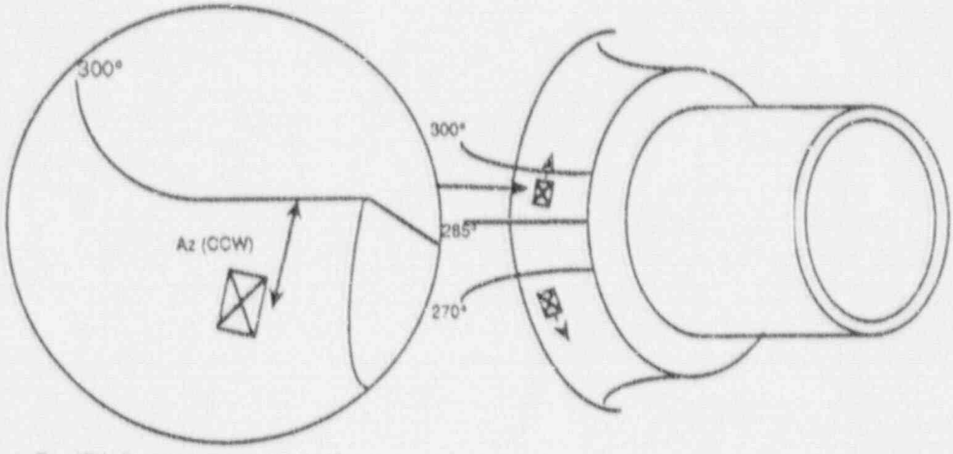
FIGURE 9 SCANNING MOTIONS FOR THE ZONE 1 EXAMINATION



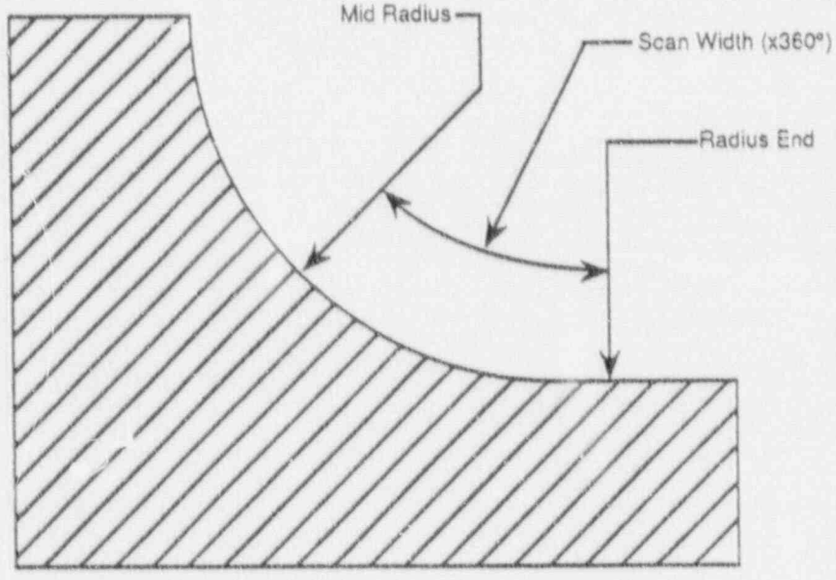


NOTE:
ALL (A) MEASUREMENTS SHALL BE IN COUNTER CLOCKWISE DIRECTION FROM NEAREST RADIAL LINE.
ALL (D) MEASUREMENTS SHALL BE FROM REFERENCE CIRCLE RADIALLY OUTWARD.

FIGURE 10 MEASUREMENT CRITERIA FOR RECORDING UT



For "D" distance measurement
See Figure 12



NOZZLE CROSS SECTION

FIGURE 11 REQUIRED SCAN PATHS AND MEASUREMENT CRITERIA
FOR ZONE 2 EXAMINTIONS

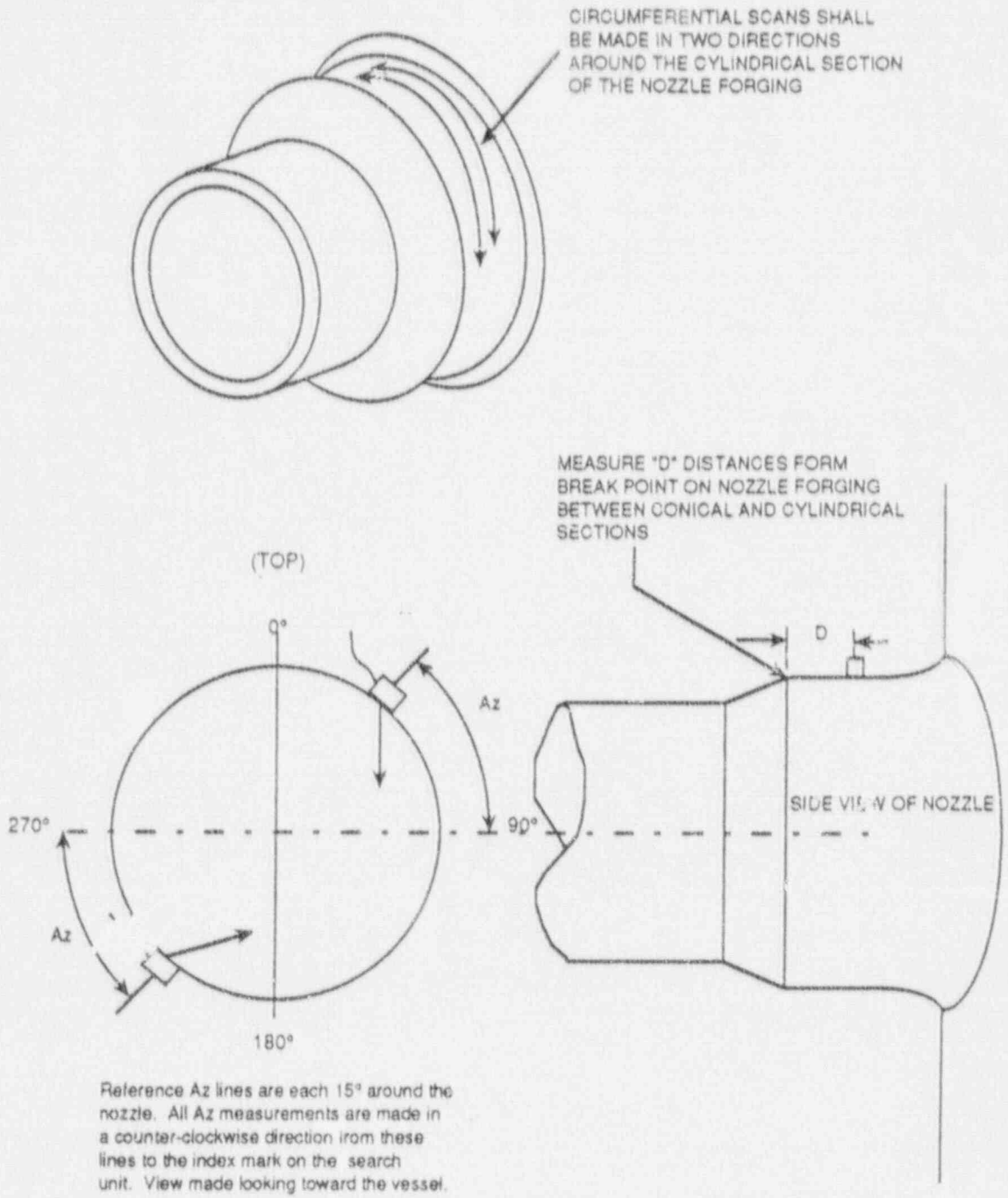


FIGURE 12. ZONE 3 SCANNING AND LOCATION REQUIREMENTS

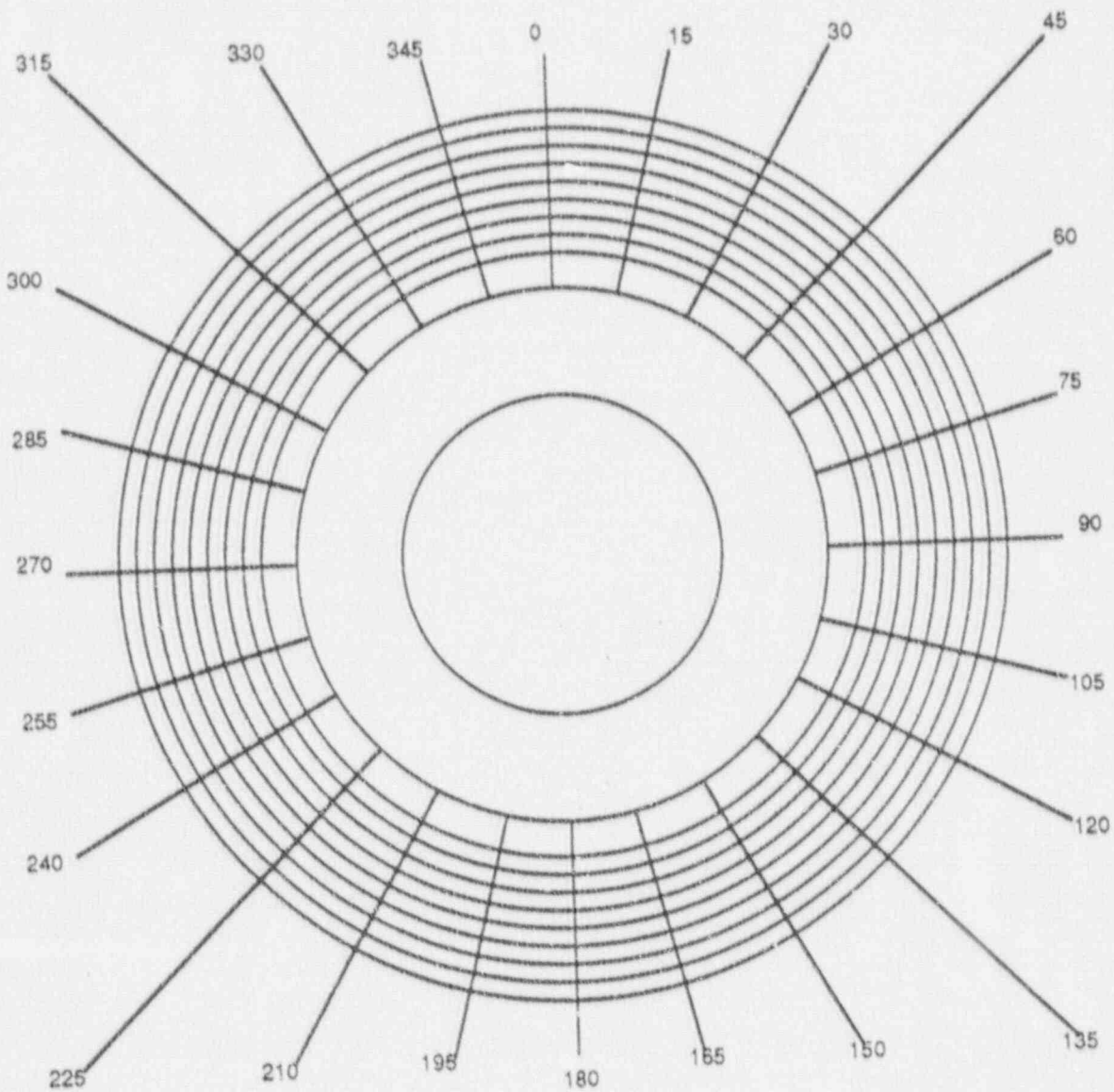

0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
Plot of indication(s)
for nozzle No. : _____
Report No. : _____
Scale 1 : 4

FIGURE 13