WASHINGTON PUBLIC POWER SUPPLY SYSTEM

NDE & I INSTRUCTION

No.	QCI 6-4
Rev. No.	9
Effective Date	3|20|95
Quality Affecting	[X] 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 3a, 3b, 4 and 5.

1.3 This instruction is intended to meet the requirements of Sections V and XI of the ASME Boiler and Pressure Vessel Code (1989, no Addenda).

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 Contractor and Supply System personnel performing examinations to the requirements of this instruction shall be certified to at least Level II in ultrasonics in accordance with the requirements of Reference 7.2. Additionally, the examination team shall consist of at least one Level II or Level III in ultrasonics qualified using the Supply System BWR feedwater nozzle mockup and this ultrasonic examination procedure per paragraph 4.3.

3.1.2 Personnel not specifically qualified on the BWR feedwater nozzle mockup, 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 7.2.

3.2 Ultrasonic Instruments

3.2.1 The pulse-echo, ultrasonic flaw detection instruments shall be equipped with a stepped gain control, graduated in units no larger than 2 dB. Examples of instruments considered acceptable for examination are listed below.

Krautkramer USIP-11 Stavely Sonic 136
Krautkramer USL-48

3.2.2 The pulse repetition rate of the instrument shall be set between 250 Hz and 2000 Hz.

NOTE: Pulse repetition rates are automatically set by the Krautkramer USL-48 depending on the selected sweep range. The Sonic 136 automatically sets pulse repetition rates in the selected sweep range unless changed by the operator in the "special" menu.

3.3 Transducers

3.3.1 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 as shown in Figure 2. The refracted angle within the material shall be within the limits shown in Table I. Additionally, data may be taken with other transducer sizes, frequencies, wave modes, and angles, after completing the examination to the above requirements.

3.4 Cable - The maximum length of cable shall be 25' for type RG-174/U with no more than one intermediate connector. The maximum length of cable for type RG-58 shall be 100' with no more than 2 intermediate connectors.

3.5 Couplant - Soundsafe by Sonotech, Ultragel II, glycerin, or a glycerin deionized water mixture may be used as the liquid couplant. Other couplants may be used provided they have been approved by the plant.

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

3.6.1 IIW-2, ROMPAS, or modified Type DC (square ended semicircle) reference blocks may be used for sweep calibration.

3.7 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.

3.8 Specific Requirements

3.8.1 Radial Clearance

The thermal insulation should be clear of the nozzle and vessel to create a free space sufficient to access the inspection area; perform necessary nozzle marking, and scan the volume of material necessary to insonify the nozzle inner radius. See Figures 3A and 6 for specific access details.

3.8.2 Nozzle Identification

The N4 Feedwater Nozzles were marked and identified in accordance with the nozzle marking plan illustrated in Figure 6 prior to the pre-service ultrasonic examination. Due to the uncertain condition of these markings at the time of the inservice examination, and in keeping with ALARA, it is unnecessary to remark the nozzle unless indications are detected. In which case, localized remarking may be necessary to properly document the location of indications.

4.0 CALIBRATION

4.1 Instrument Calibration - The ultrasonic instrument linearity shall be checked before and after an examination and documented on the Calibration Data Sheet shown in Figure 7. Linearity shall be determined in accordance with the requirements of Paragraphs 4.1.1 and 4.1.2. Angle beam or straight beam search units may be used to perform these checks. The settings and readings shall be estimated to the nearest 1% of full screen height.

4.1.1 Screen Height Linearity Check - To verify the ability of the ultrasonic instrument to meet screen height linearity requirements, position a search unit so that responses can be observed from any two reflectors in a calibration block. Adjust the search unit position to give a 2 to 1 ratio of amplitudes between the responses, with the larger set at 80% of full screen height (FSH). Without moving the search unit, adjust the gain control to successively set the larger signal from 100% to 20% FSH in 10% increments or in 2 dB increments if the instrument is equipped with a stepped gain control. The smaller signal amplitude must be 50% of the larger amplitude signal within 5% FSH. Instruments that do not meet this requirement shall not be used.

4.1.2 Amplitude Control Linearity Check - To verify the accuracy of the amplitude control in the ultrasonic instrument, position a search unit so that a response from a reflector in the calibration block is peaked on the screen. The signal amplitude shall be brought as near as possible to 80% FSH with the dB control. If necessary, the final adjustment to 80% FSH can be made with the variable gain control. Using only the dB control, the dB changes indicated in the following table shall be made and the resulting amplitude compared with the allowable amplitude limits. The procedure shall be repeated for 40% and 20% FSH amplitudes. The initial settings and readings shall be estimated to the nearest 1% of full screen height. Instruments that do not meet this requirement shall not be used.

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

4.2 General Requirements for Examination Calibration

4.2.1 Calibration shall be performed from the surface of the calibration block which corresponds to the component surface to be examined.

4.2.2 The calibration block temperature shall be within 25°F for the component being examined.

4.2.3 Calibration shall include the complete ultrasonic examination system. Any change in couplants, cables, transducers, wedges, ultrasonic instruments, or any other parts of the examination system shall be cause for a calibration check.

a. Sweep calibrations may be made using standard angle beam wedges instead of the specific curvature wedges used for examination (Figure 2). This is due to the difficulty that may be experienced trying to calibrate a curved wedge on a flat surface.

4.2.4 An instrument sensitivity and sweep range calibration check shall be performed at the beginning of each day prior to use with each calibration block and shall be checked at the following intervals:

a. At least every 4 hours during an examination;

b. At the start and finish of each completed examination;

c. At each change of examiners;

d. In the event of loss of power; and

e. If any part of the examination system has been changed, such as, search units, cables or ultrasonic instruments;

f. If the operator suspects a malfunction.

4.2.5 After the primary distance amplitude correction (DAC) curve reference level has been established on the vessel calibration standard, a calibration reference response may be established on a Rompas or other standard reference block. The response shall include both sweep and amplitude calibration points and the gain setting used to establish them. This information shall be recorded on the appropriate area of the Calibration Data Sheet. This reference response may then be used to perform calibration checks. The tolerances of 4.2.7 and 4.2.8 shall apply for this operation.

4.2.6 Final calibration shall be performed on the calibration block used for initial calibration.

4.2.7 Recalibration (Sweep Only) - If the indication from any of the calibration reflectors has moved on the sweep line more than 10%, of the sweep division reading, correct the sweep range calibration and note the correction on the Calibration Data Sheet. If recordable indications were noted on the Examination Data Sheets, those data sheets shall be voided. A new calibration shall be made and recorded and the areas containing recordable indications shall be reexamined.

4.2.8 Recalibration (Amplitude)

a. If any point on the distance-amplitude correction (DAC) curve has decreased 20% or 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 areas examined since the last valid calibration or calibration check shall be reexamined.

b. If any point on the distance-amplitude correction (DAC) curve has increased more than 20% or 2 dB of its amplitude, all recorded indications since the last valid calibration or calibration check may be reexamined with the corrected calibration and their values changed on the data sheets.

4.2.9 All required calibration data shall be recorded on the Ultrasonic Calibration Data Sheet, Figure 7.

4.3 Qualification - Qualification using the Supply System BWR feedwater nozzle mockup involves performing a calibration and successfully detecting the notches machined in the mockup utilizing this procedure in the presence of the authorized nuclear inspector. Qualification records will include a completed calibration and examination data sheet reviewed by the ANI and maintained by Materials and Inspection.

5.0 PROCEDURE

5.1 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. Enter the data on the calibration data sheet, Figure 7.

5.1.1 Zone 1 - Using a Rompas block, direct the ultrasonic beam of this 70° transducer toward the large radius. With the exit point of the transducer at the radius center mark on the block, maximize the CRT signals. Adjust the "Range" and "Delay" controls until the first reflection signal is at "2" horizontal divisions 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.

5.1.2 Zone 2 - Using the transducer with the convex 25° shear wedge, obtain peaked signals from the 1/2 and 3/4 "T" holes in calibration block UT-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.

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

5.2 Amplitude Calibration

Amplitude calibration shall be performed with vessel calibration block UT-120 and the transfer sensitivity data shown in Table 1.

To determine the basic sensitivity level, maximize the signal from the 3/4T hole and adjust the gain controls to bring this signal to 50% FSH. The centerline of the search unit shall be at least 1-1/2 inch from the nearest side of the block. Depending upon which nozzle zone is being examined, adjust the gain controls again by the transfer sensitivity gain increase listed in Table 1. This gain setting is now the primary reference level (1X). Examination scanning shall be performed at a minimum of 2X above the primary reference level.

NOTE: Zone 1 transfer sensitivity is conservatively set at "0" since a 50% FSH response from the 3/4T hole of UT-120 provides a 2X response from the Zone 1 nozzle mockup notch (Notch A).

CAUTION: Care must be exercised during calibration to assure the shear wave component is used. There is a strong longitudinal wave component generated, especially for Zone 2 and 3. A peaked shear wave signal from the 3/4 T hole should appear at approximately 5.7 inches metal path and 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.

5.3 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). Scanning shall be performed at 2X above the primary reference 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 9A. Scanning shall be done in a circumferential or radial motion with a minimum overlap of 50% of the transducer element (see Figures 9B and 9C). The movable 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 oscillating slightly. The examiner shall reference Figures 9A, 9B and 9C for transducer orientations.

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 unit 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 using the cylindrical surface for scanning (Figure 12). The scan path of the search unit shall overlap the adjacent scan by a minimum of 50% of the transducer element. The search unit shall be scanned circumferentially around the nozzle forging so the shear wave insonifies the 360° circumference in both the clockwise and counterclockwise directions.

5.4 The scanning speed shall not exceed 4 inches per second.

5.5 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.

5.6 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.

5.7 CRT Display Photos

Photos of the CRT display may 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.

6.0 DATA PROCESSING

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

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

7.0 REFERENCE

7.1 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, 1989 no Addenda

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

7.1.2 Section V - Nondestructive Examination"

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

7.3 Nozzle forging drawings - General Electric/CBI Nuclear

TABLE I

ULTRASONIC CALIBRATION DATA FOR
EXAMINATION OR BWR NOZZLE INNER RADII

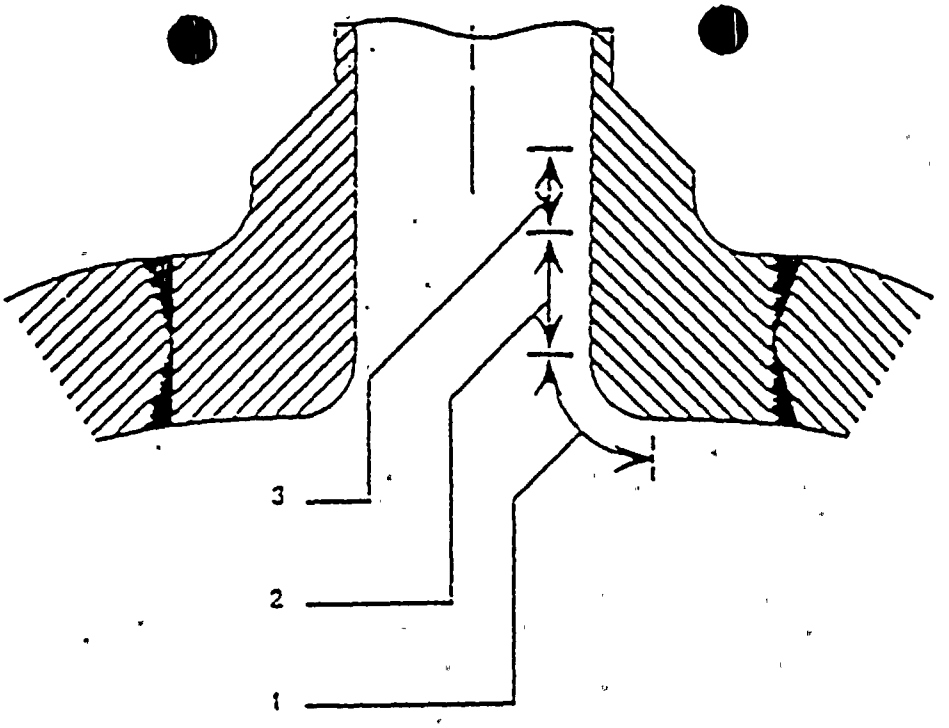
NOZZLE TYPE - N4 FEEDWATER

	ACOUSTIC ANGLES DEGREES[1]			CRT DISPLAYED SWEEP	CAL STANDARD #	TRANSFER SENSITIVITY dB GAIN INCREASE
	A	B	C			
Zone 1	33	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 3A, 3B, 4 and 5

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

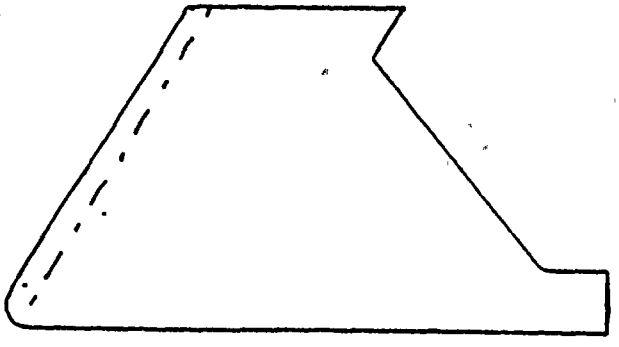
3. Convex shoe



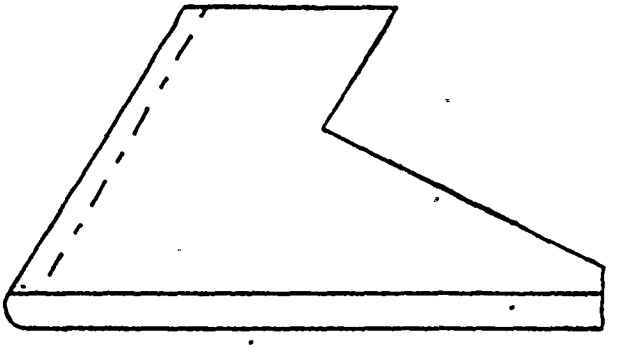
NOZZLE EXAMINATION ZONES

FIGURE 1

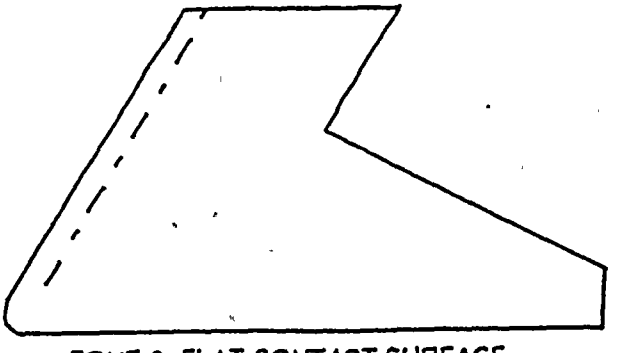
SIDE VIEWS



ZONE 1, FLAT CONTACT SURFACE

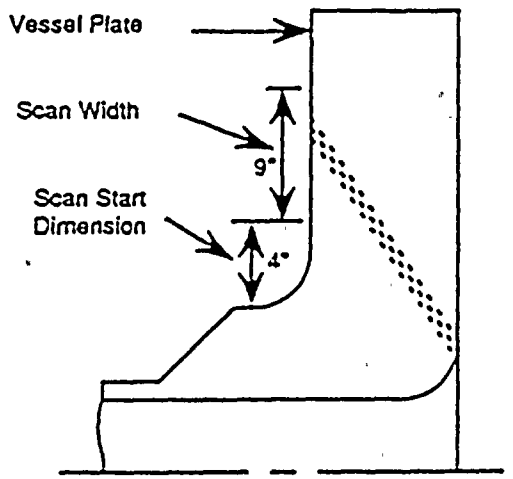


ZONE 2, CONVEX CONTACT SURFACE

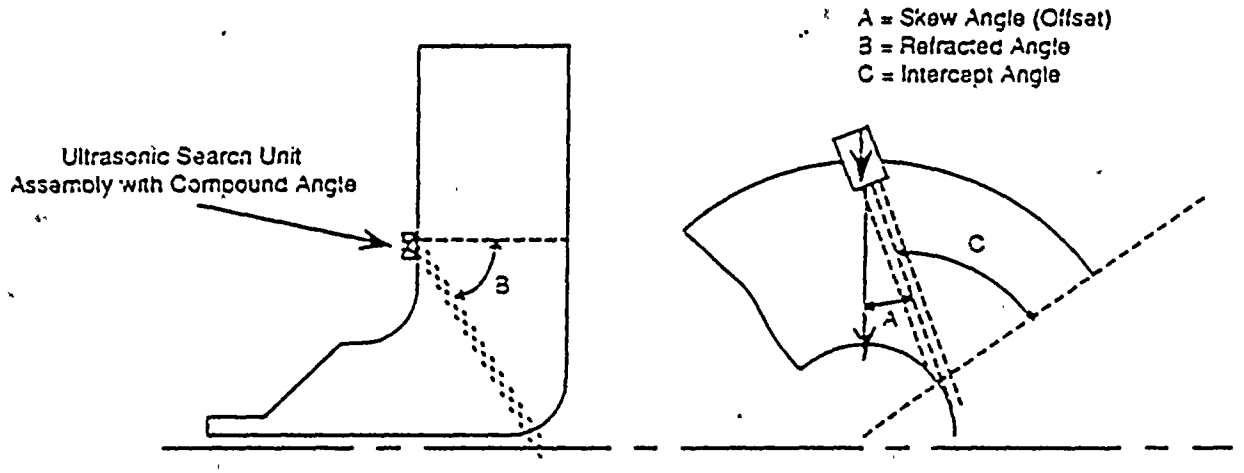


ZONE 3, FLAT CONTACT SURFACE

FIGURE 2 TRANSDUCER WEDGE CONFIGURATIONS



3A. Nominal Entry Point For Sound Beam For Zone 1



3B. SOUND BEAM GEOMETRY IN NOZZLE FOR ZONE 1

FIGURES 3A and 3B

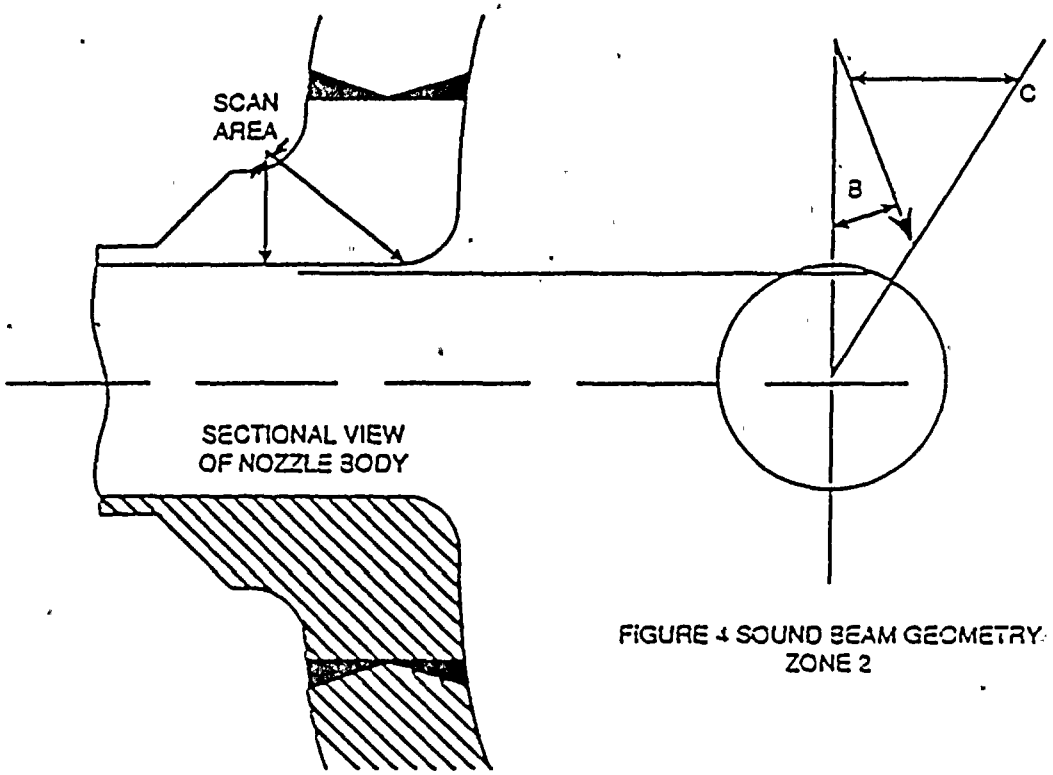


FIGURE 4 SOUND BEAM GEOMETRY
ZONE 2

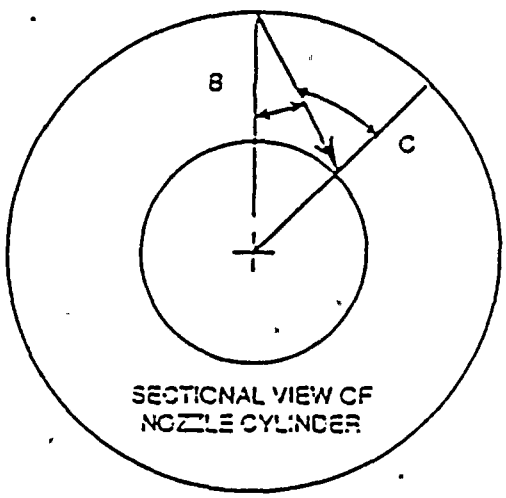


FIGURE 5 SOUND BEAM
GEOMETRY, ZONE 3

FIGURES 4 and 5

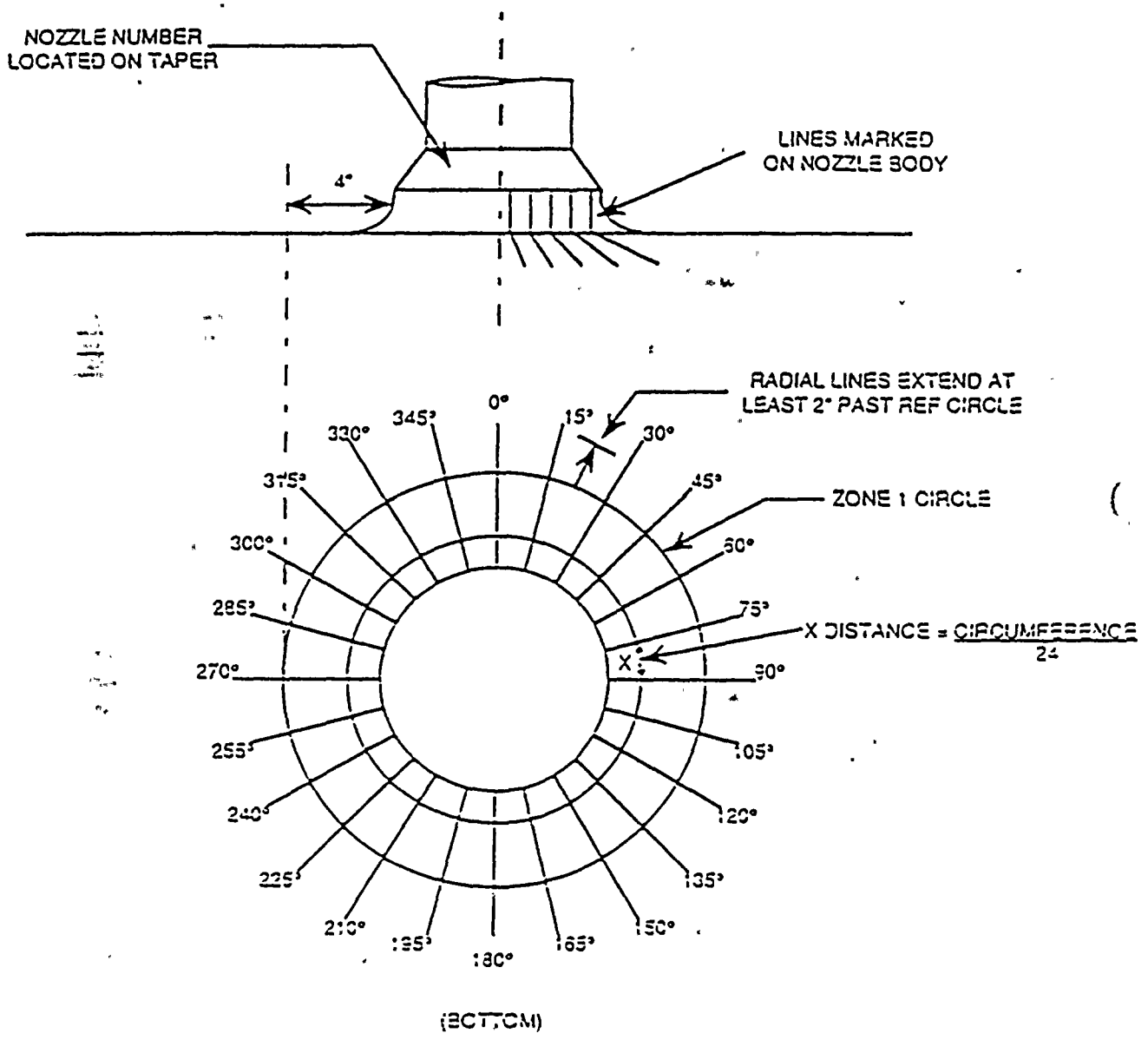


FIGURE 6 NOZZLE MARKING PLAN

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

ULTRASONIC CALIBRATION SHEET Zone 1 Calibration

PROJECT: WNP-2		SYSTEM: RPV			SHEET NO.: 503
EXAMINER: J. Smith		LEVEL: II	DATE: 2|15|95		THERMOMETER S/N: 4812
EXAMINER: A. Brown		LEVEL: III	INSTRUCTION NO.: QCI 6-4		REVISION: 9
CALIBRATION STANDARD	**CALIBRATION STANDARD SIMULATOR**		Harisonic **TRANSDUCER**		CABLE TYPE: RG-1746
SERIAL NUMBER: UT-120	S/N: N|A	TEMP: °F	S/N: R894	WAVE MODE:	LENGTH: 16'
THICKNESS: 6.6"	AMP:	SWEEP: IN.	SIZE: 1" x 1"	FREQ: 2.25 MHz	COUPLANT: Soundsafe
TEMPERATURE: 80 °F	GAIN IN db:		ACTUAL ANGLE: 70		BATCH NO.: 20922
CHART RECORDER TYPE: N|A	S/N:		UT INSTRUMENT TYPE: Sonic 136		S/N: 34643

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	50	45	40	34	29	25	20	15	10

SCREEN HEIGHT LINEARITY FOR 2db STEP GAIN CONTROL

db	+2	0	-2	-4	-6	-8	-10	-12	-14
HIGH	100	80	63	50	40	32	25	20	16
LOW	50	40	31	25	20	15	13	10	8

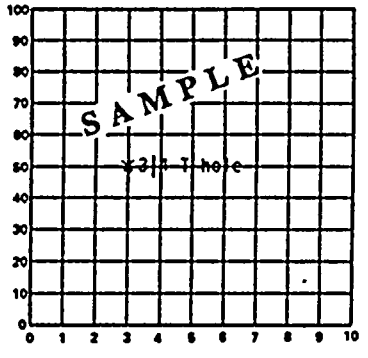
AMPLITUDE CONTROL LINEARITY

AMPLITUDE %	80	60	40	20
db CHANGE	-6	-12	+6	+12
READING %	40	20	80	81
LIMITS %	32-48	16-24	64-96	64-96

INITIAL CAL TIME: 08:30 — **SYSTEM CALIBRATION** — FINAL CAL TIME: 12:30

INSTRUMENT SETTINGS		REFLECTORS	AMPLITUDE %FSH	SWEEP READING IN INCHES
COARSE RANGE	N|A	3/8 NODE	50%	17.0"
COARSE DELAY	N|A	/8 NODE		
RANGE CALIB	10	/8 NODE		
DELAY CALIB	15.7	/8 NODE		
FREQUENCY	2.25	/8 NODE		
GAIN IN db	72	/8 NODE		
DAMPING	500.	/8 NODE		
REJECT	off	BKR db		
FILTER	1	SEARCH UNIT ORIENTATION ☐ AXIAL ☐ CIRCUMFERENTIAL		
		WELDS OR PARTS EXAMINED		
		N4-150-1R		
		Zone 1 Exam		

SCREEN DAC PRESENTATION



FULL SCREEN SWEEP 10" (14 to 24) IN.

CAL CHECKS	
09:39	J.S.

REVIEWED BY LEVEL III: L. Breen — DATE: 2\|15\|95

REVIEWED BY: J. Jones — DATE: 2\|15\|95

988-16286

FIGURE 7

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

ULTRASONIC EXAMINATION DATA SHEET -- NOZZLE INNER RADIUS

REPORT NO.: 1RPU-124

PROJECT: WNP-2	SYSTEM: RPV			SI DRAWING NO.: RPV-101	
NOZZLE DESCRIPTION: Reactor Feedwater Nozzle Inner Radius and Nozzle Bore				NOZZLE NO.: N4-150-IR, N4-150-NB	
MATERIAL TYPE: Carbon Steel		ZONE NO.: 1		ZONE NO.: 2	ZONE NO.: 3
NO. OF SCAN DIRECTIONS: 2 each zone (CW and CCW)		DATE: 2|15|95		DATE: 2|15|95	DATE: 2|15|95
INSTRUCTION NO.: QCI 6-4	REVISION: 9	TIME START: 0940		TIME START: 1053	TIME START: 1116
EXAMINER: J. Smith	LEVEL: II	TIME STOP: 1050		TIME STOP: 1113	TIME STOP: 1129
EXAMINER: A. Brown	LEVEL: III	PART TEMP: 80	°F	PART TEMP: 80	°F PART TEMP: 80 °F
CAL STANDARD NO.: UT-120	THICKNESS: 6.6"	CAL SHEET NO.: 503		CAL SHEET NO.: 504	CAL SHEET NO.: 505
ACCEPTANCE CRITERIA:		ANGLE: 70°		ANGLE: 25	ANGLE: 25

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	
N4-30-IR	0 - 360°	- No other recordable indications -					1	
N4-30-NB	0 - 360°	- No recordable indications -					2, 3	

SAMPLE

REVIEWED BY LEVEL III: L. Green	DATE: 2|15|95	REVIEWED BY:	DATE:

960-10434

FIGURE 8

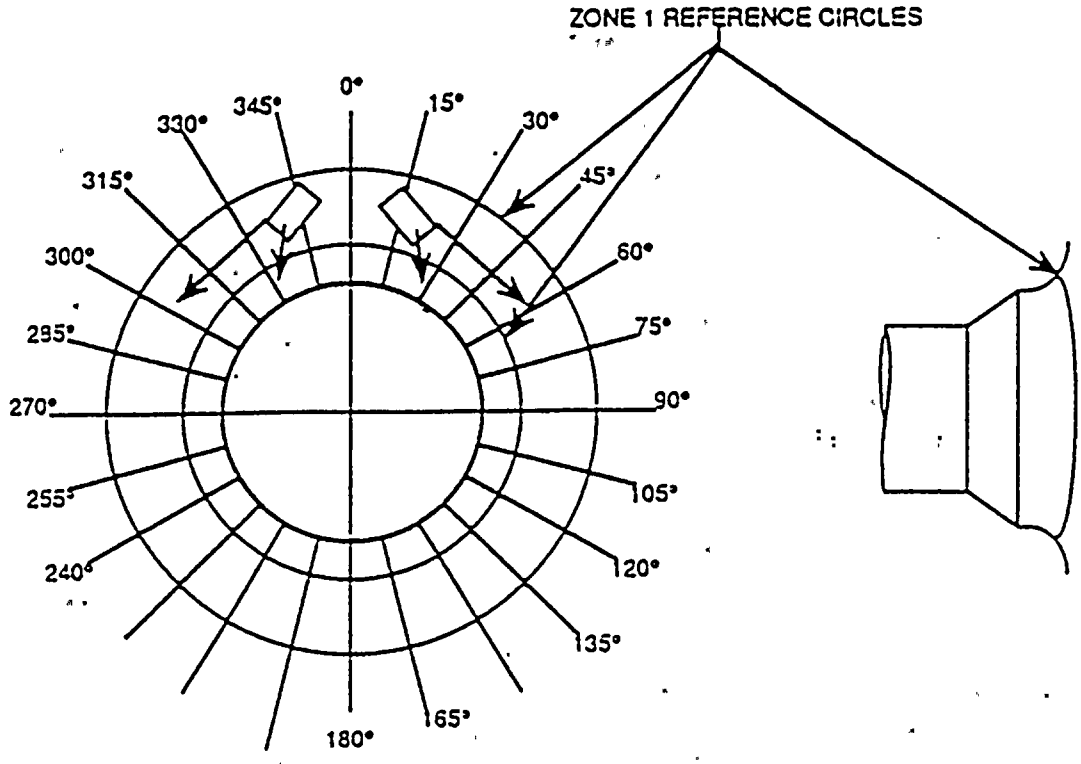
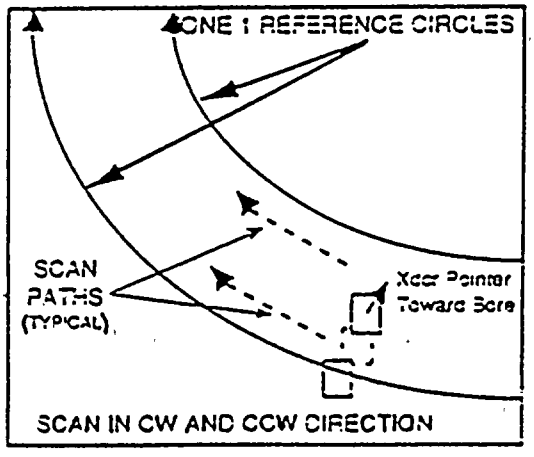
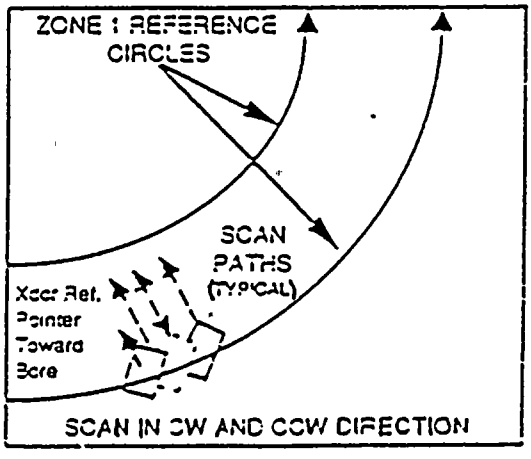


Figure 9A

CIRCUMFERENTIAL AND RADIAL SCANNING

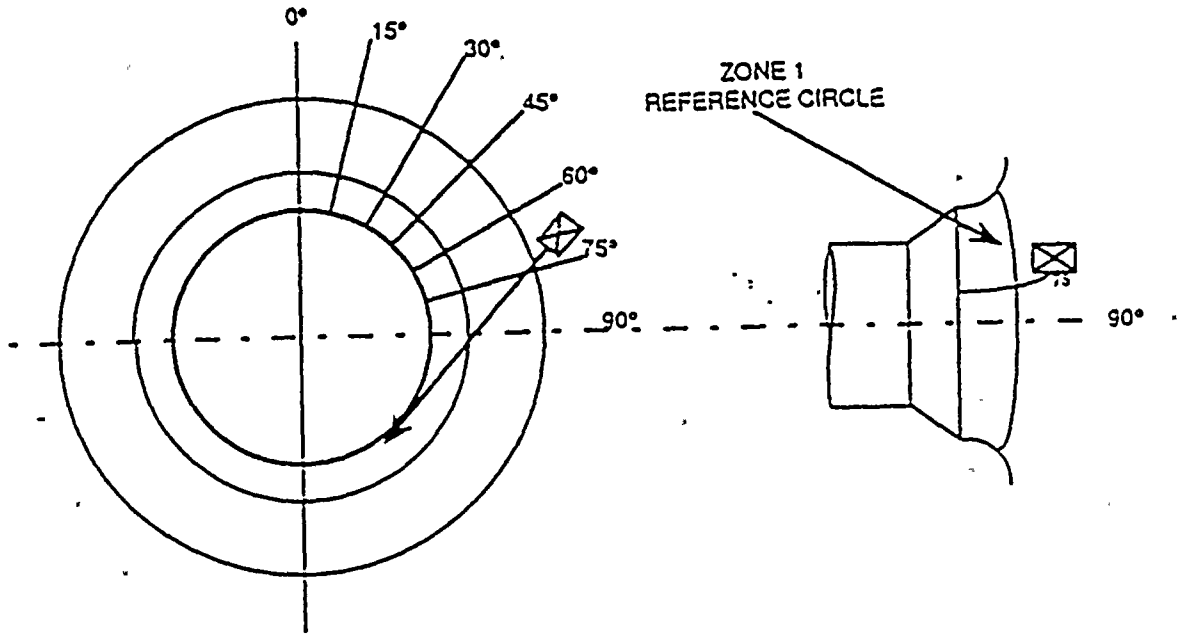


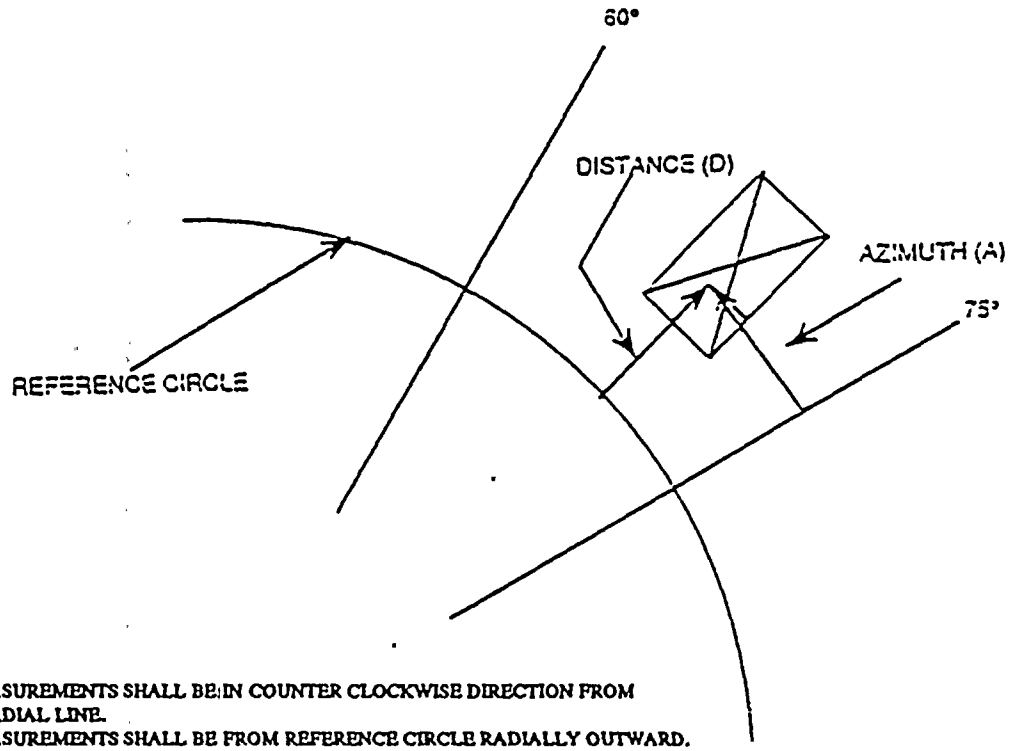
CIRCUMFERENTIAL SCANNING MOTION
(MOVING AZIMUTH SCAN PATHS)
Figure 9B



RADIAL SCANNING MOTION
(FIXED AZIMUTH SCAN PATHS)
Figure 9C

FIGURE 9 SCANNING MOTIONS FOR THE ZONE 1 EXAMINATION

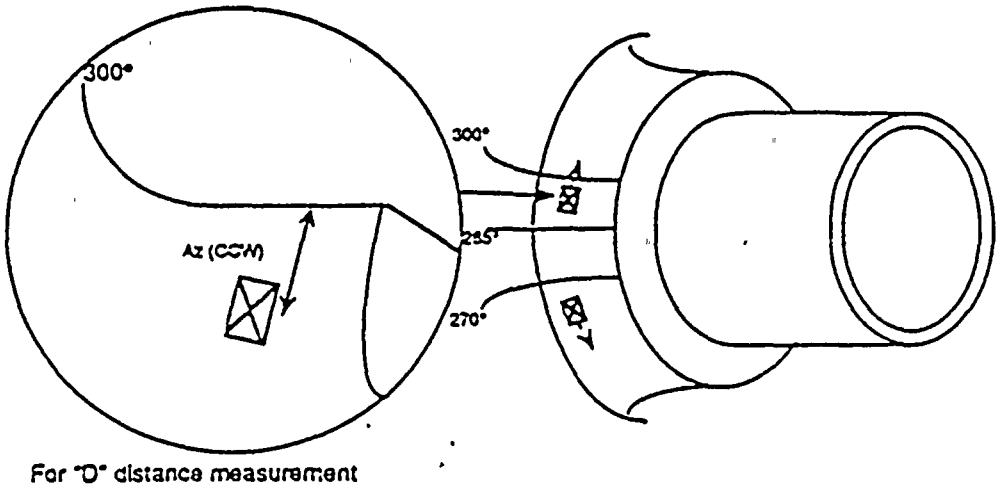




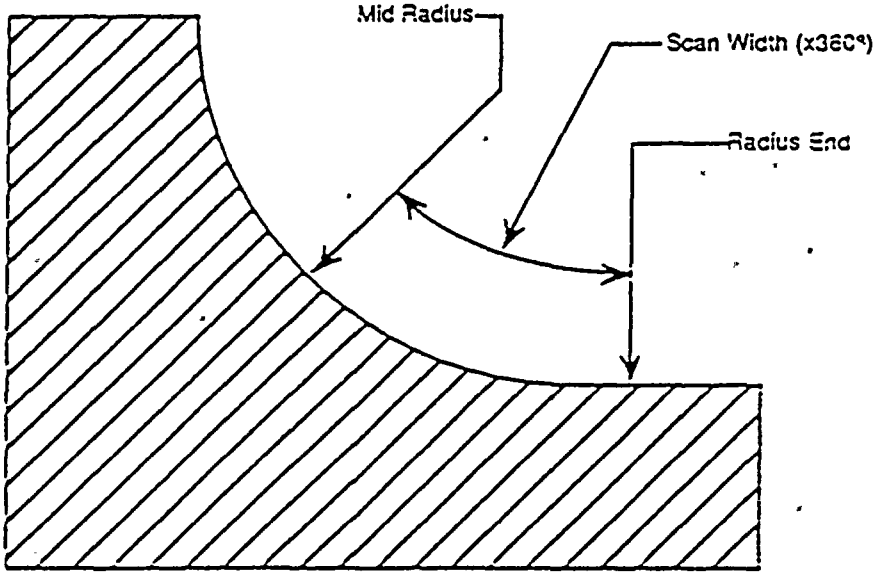
NOTE:

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

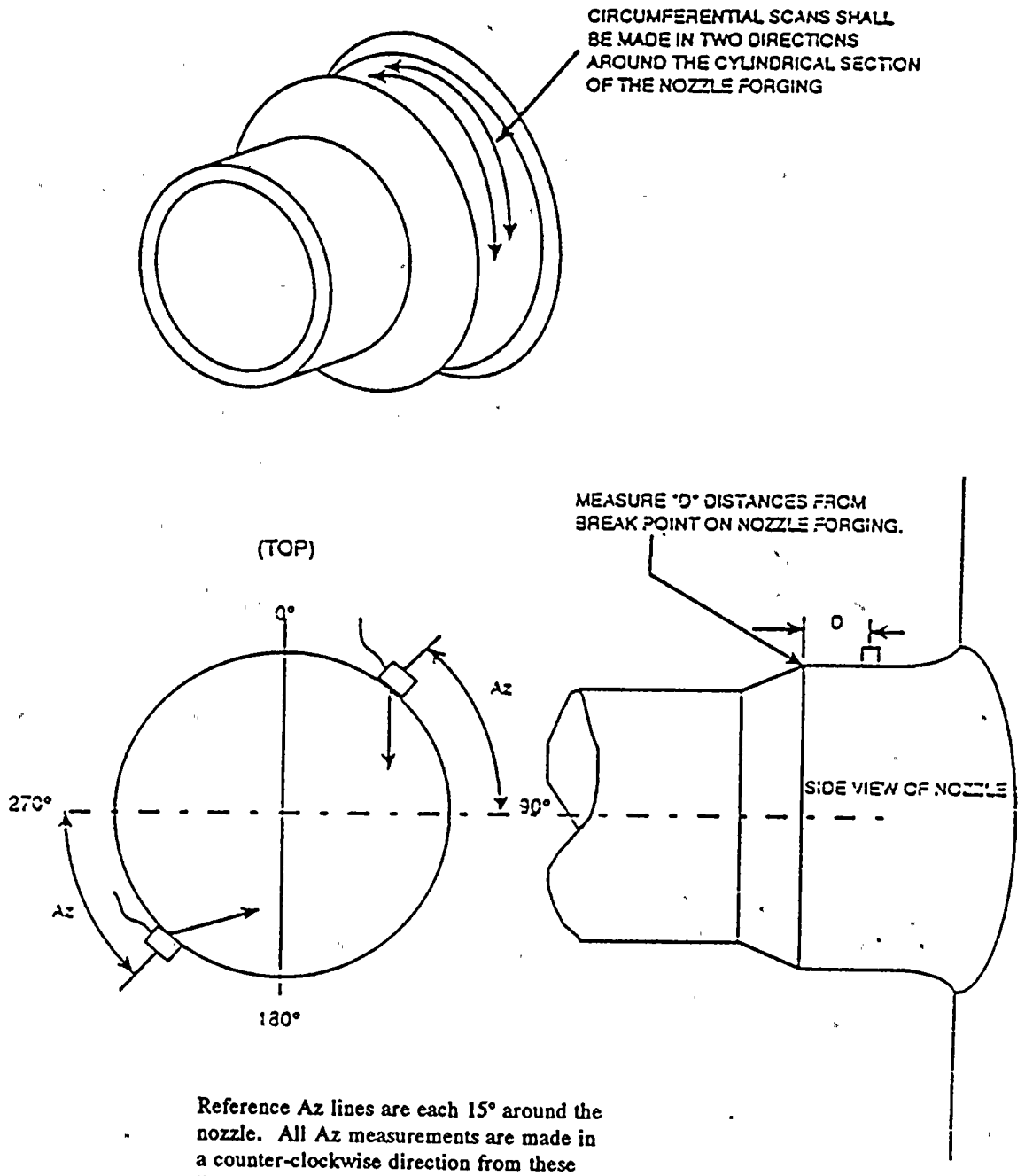


For "D" distance measurement
See Figure 12



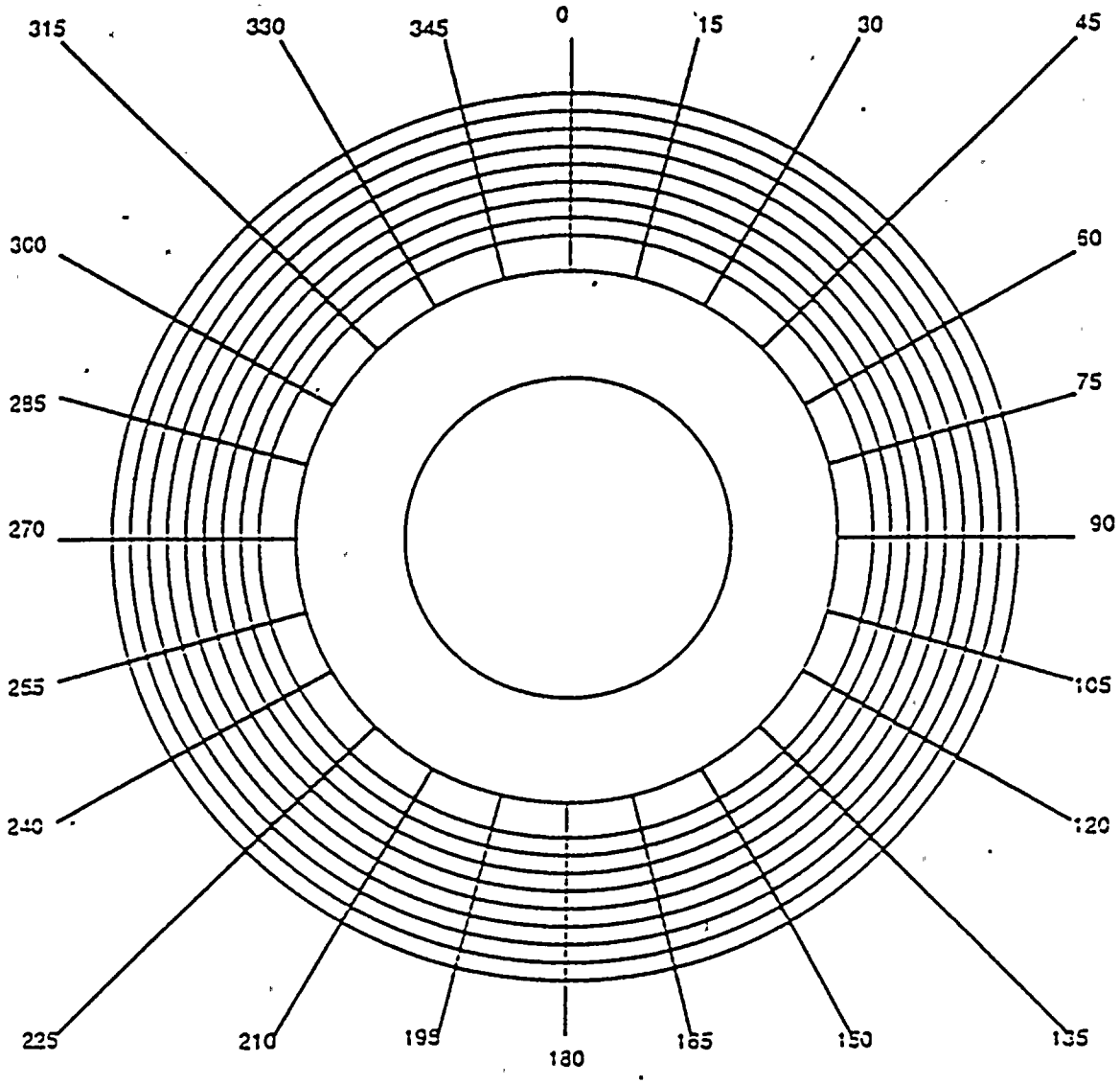
NOZZLE CROSS SECTION

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



Reference Az lines are each 15° around the nozzle. All Az measurements are made in a counter-clockwise direction from these lines to the index mark on the search unit. View made looking toward the vessel.

FIGURE 12 ZONE 3 SCANNING AND LOCATION REQUIREMENTS



Plot of indication(s)
for nozzle No.:_____

Report No.:_____

Scale 1/4

FIGURE 13