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PSEG
Nuclear LLC

NOV 01 2012

10 CFR 50.55a

LR-N12-0326

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Salem Generating Station Unit 1
Renewed Facility Operating License No. DPR-70
NRC Docket No. 50-272

Subject: Submittal of Relief Request Associated with the Third Ten-Year Inservice Inspection (ISI) Interval

References: 1) Letter from Paul Duke (PSEG Nuclear LLC) to USNRC, "Submittal of Relief Request Associated with the Third Ten-Year Inservice Inspection (ISI) Interval," dated April 24, 2012
2) Email from John Hughey (USNRC) to Paul Duke (PSEG Nuclear LLC), "RAIs For Salem U1 Relief Request S1-I3R-114 TAC No. ME8565," dated September 18, 2012

In Reference 1, PSEG Nuclear LLC (PSEG) submitted relief request S1-I3R-114 for Salem Generating Station Unit 1, requesting relief from specific requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components. Relief request S1-I3R-114 applies to the third 10-year inservice inspection (ISI) interval which ended on May 20, 2011.

In Reference 2, the NRC requested additional information. Attachment 1 to this letter provides PSEG's response.

There are no regulatory commitments contained within this letter.

NOV 01 2012

Should you have any questions concerning this matter, please contact Mr. Brian Thomas at 856-339-2022.

Sincerely,

Paul R. Duke, Jr.
Manager - Licensing
PSEG Nuclear LLC

Attachments (2)

cc: W. Dean, Administrator, Region I, NRC
NRC Senior Resident Inspector, Salem
J. Hughey, Project Manager, Salem, USNRC
P. Mulligan, Manager IV, NJBNE (w/o attachment)
L. Marabella, Corporate Commitment Tracking Coordinator (w/o attachment)
T. Cachaza, Salem Commitment Tracking Coordinator (w/o attachment)

REQUEST FOR ADDITIONAL INFORMATION REGARDING
SALEM GENERATING STATION, UNIT 1

REQUEST FOR RELIEF S1-I3R-114
DOCKET NUMBERS: 50-272 (TAC NO. ME8565)

By letter dated April 24, 2012 (Agencywide Document Access and Management System No. ML12125A152), the licensee, PSEG Nuclear LLC (PSEG), submitted Request for Relief (RR) S1-I3R-114 from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, *Rules for Inservice Inspection of Nuclear Power Plant Components* for Salem Generating Station, Unit 1 (Salem 1). The request for relief applies to the third 10-year inservice inspection interval (ISI), in which the licensee adopted the 1998 Edition through the 2000 Addenda of ASME Code Section XI as the code of record.

The NRC staff has reviewed the information submitted by the licensee, and based on this review, determined the following information is required to complete the evaluation.

General Information Required on Request for Relief S1-I3R-114

RAI 1: Based on the licensee's submittal, it appears that the 1995 Edition through the 1996 Addenda of the ASME Code was used for inspections performed during refueling outage (RFO) 15, and the only item in the subject request inspected during RFO-15 was Examination Category C-B, Item C2.21, Boric Acid Injection Tank Inlet nozzle-to-head Weld 1-BIT-1. Further, all other welds in RR S1-I3R-114 appear to have been inspected in RFO-16 through RFO-20, which were governed by the 1998 Edition through the 2000 Addenda of the ASME Code.

Please confirm these observations, and verify that the code of record for the third 10-year inservice inspection interval was the 1998 Edition through the 2000 Addenda of ASME Code Section XI.

Response:

The first outage (RFO-15) of the Salem Unit 1 third ISI Ten-Year Interval was implemented in accordance with 1995 Edition through the 1996 Addenda of the ASME Code. The remainder of the Unit 1 outages (RFO-16 through RFO-20) of the third ISI Ten-Year Interval were implemented in accordance with 1998 Edition through the 2000 Addenda of ASME Code Section XI. Following the start of the Salem Unit 1 third ISI Ten-Year Interval, PSEG submitted a letter to change the code year from the 1995 Edition through the 1996 Addenda to the 1998 Edition through the 2000 Addenda of ASME Code Section XI which was subsequently acknowledged by the NRC in a letter dated April 14, 2005 (ML050670439)

Request for Relief S1-I3R-114, Examination Category B-D, Item B3.120, Full Penetration Welded Nozzles in Vessels

RAI 2: In Attachments A-2 through A-5, the licensee has included multiple photographs and data sheets showing volumetric coverage percentages at different angle beam orientations for inside radius sections on pressurizer (PZR) nozzle welds. However, it is unclear as to what portions, and to what extent, coverage was obtained for the ASME Code-required volumes that have been completed. Please submit cross-sectional drawing showing volumetric coverage for each of the ultrasonic angles applied. Include dimensions, scanning directions, surface conditions, and ultrasonic techniques (longitudinal or shear wave) being used.

Response:

The limitations described in Attachments A-2 thought A-4 have been characterized as "surface condition difficulties (Cast Head) were encountered throughout the examination due to surface grinding, surface pitting and surface waviness along the required scanning areas." The area of limited examination was made evident by the loss of observed 10% to 20% ID clad roll typical of these exams. When the ID clad roll would drop below 10%, the examination areas were considered to have not been inspected. These areas of poor sound transmission were intermittent throughout the examinations. Due to the high dose levels in the area and the large amount of time it would take to make a detailed map of the limitations, an estimate of coverage was performed by the PDI qualified examiner. For the Attachments A-2 through A-4 these surface conditions affected only the 60 and 70 degree transducer scans. Because the scan surface is different for the 45 degree transducer scan, its coverage was 100%. Section 5 of EPRI report, Salem Unit 1 Pressurizer Nozzle Inner Radius Examinations IR-2004-41, has been added for information regarding applicable angles and coverage requirements (see Attachment 2).

The limitations described for attachment A-5 refer to a raised lettering in the casting that prevents any examination in that area, using a 70 degree shear wave scan. Section 4 of EPRI report Salem Unit 1 Pressurizer Nozzle Inner Radius Examinations IR-2004-41 has been added for information regarding applicable angles and coverage requirements.

Request for Relief S1-I3R-114, Examination Category C-A, Items C1.10 and C1.20, Pressure Retaining Welds in Pressure Vessels

RAI 3: In Table 1 of the licensee's submittal, the Seal Water Injection Filter shell-to-lower head Weld 1CVE18-SWIJ-2 is shown to have approximately 64.0 percent volumetric coverage. However, in Attachment A-10, page 2 of 3 of the licensee's submittal, the listed volumetric coverage is 84.0 percent. Please verify the correct volumetric coverage for Weld 1CVE18-SWIJ-2.

Response:

The correct volumetric coverage is 64.0 percent.

RAI 4: In Table 1 of the licensee's submittal, the No.1 Volume Control Tank (VCT) shell-to-lower head Weld 1-CVCT-2 noted that "indications identified and evaluated in previous exams were identified in this examination with no evidence of growth." In the licensee's Enclosure under section C on page 7, the licensee states that examinations were performed to the maximum extent practical with no recordable indications.

To clarify the contradicting statements, please state whether any indications were discovered as a result of ASME Code-required examinations, and how these indications have been dispositioned.

Response:

The information in Table 1 is correct; during the ISI volumetric examination of No.1 Volume Control Tank (VCT) shell-to-lower head Weld 1-CVCT-2 in RFO-13 two recordable sub-surface weld indications were identified with one indication of the two exceeding the acceptance criteria in ASME Section XI IWB-3500, a flaw evaluation was performed resulting in a use-as-is determination. A successive examination was completed during RFO-15, this examination revealed that the indications remained essentially unchanged and the weld examination schedule reverted back to the original schedule of inspections. The examination performed during RFO-19 was the next scheduled examination and again the indications remained essentially unchanged and the weld results were determined to be acceptable for continued service.

Request for Relief S1-I3R-114, Examination Category C-B, Item C2.21, Pressure Retaining Nozzle Welds in Vessels

RAI 5: The licensee has provided only general information regarding impracticality of obtaining ASME Code-required volumetric examinations for Boric Acid Injection Tank inlet and outlet nozzle-to-head Welds 1-BIT-1 and 1-BIT-2. Statements such as "nozzle configuration and surface conditions" are inadequate to describe the bases for not obtaining the ASME Code-required examination volumes.

Please submit detailed and specific information on any outside diameter surface feature, such as weld crown, diametrical weld shrinkage, or surface roughness conditions that caused limited volumetric coverage during the subject piping weld examinations. Discuss the efforts that were used to correct these conditions.

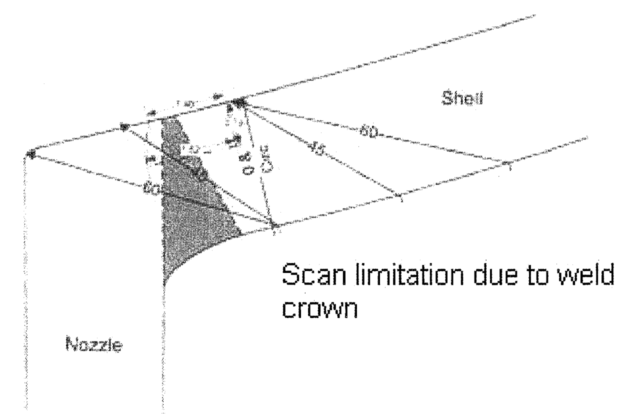
Response:

Scanning can not be performed from the nozzle side of Weld 1- BIT-1 and 1-BIT-2 due to the nozzle weld configuration. Weld crown reduction on the vessel side of the weld could not be performed to improve contact as it would compromise the original outer radius or the tapered fillet portion of the weld. Examination coverage is limited by the joint configuration only. No limitations have been attributed to scanning surface condition. The illustration below depicts weld 1-BIT-1 and is also applicable to1-BIT-2.

AREVA	UT Coverage Data Sheet	Summary No : 20444C Coverage Data Sheet No.: CDS-04

Customer Information			Component Information	
Utility: PSE&G	Plant: Salem	Unit: 1	Weld ID: 1-8d-1	Configuration: Inlet Nozzle to Shell

Limitation Areas



RAI 6: For Steam Generator #11 nozzle-to-shell Weld 16-BFN-2111-1, the licensee stated that the limitation was due to the steam generator insulation package support ring. However, no discussion of why this insulation support ring cannot be removed is provided. Please discuss whether the limited volumetric and surface examinations caused by interference from the insulation package support ring cannot be remedied by removal.

Response:

Examination of Steam Generator #11 nozzle-to-shell Weld 16-BFN-2111-1 was limited by a bolted insulation support ring. Removal of this support ring would require the erection of a large 360 degree scaffold around the generator to facilitate removal of the transition cone insulation.

It is estimated that the additional scaffold construction and insulation removal and replacement would require approximately 1R in additional outage dose.

Scaffold construction and removal:	man hours120 x 5mr per hr = 600mr
Insulation removal and replacement:	man hours 80 x 5mr per hr = 400mr

The accumulated dose estimates are based on the insulation ring coming off and going on without breaking the fasteners or damaging the insulation. Should this happen that would also increase the accumulated dose.

RAI 7: In Attachment 13, page 2 of 7, the licensee states that "a UT and PT examination was performed on inlet nozzle-to-shell [weld], 1-BIT-1." In all other documentation provided for the subject weld, the surface examination performed was stated to be a magnetic particle (MT) examination. Please verify which surface examination method was used on Weld 1-BIT-1.

Response:

The reference to PT examination was a typographical error on the examination documentation. Magnetic Particle (MT) Surface examination was performed on inlet nozzle-to-shell weld 1-BIT-1 in conjunction with UT examination during RFO-15.

Request for Relief S1-I3R-114, Examination Category R-A, Items R1.11, R1.16, and R1.20, Risk Informed Piping Examinations

RAI 8: The licensee's submittal states that the pipe-to-tee Weld 2-CV-1175-36, flange-to-pipe Weld 10-SW-2141-5, and elbow-to-flange Weld 10-SW-2183-3 were interrogated with 45- and/or 70-degree shear waves, as applicable. The licensee's submittal further states that examinations were performed in accordance with ASME Code Section XI Appendix VIII (performance demonstration), and consisted of single-sided examinations from the pipe side of the welds.

Confirm the insonification angles and wave modalities used to examine each of the subject welds listed above. Discussions with the industry's Performance Demonstration Initiative (PDI) administrator, the Electric Power Research Institute (EPRI), indicate that Supplement 2 qualifications require refracted longitudinal wave methods to be applied, if possible. If only shear wave techniques were used to examine the subject stainless steel welds, please explain why refracted longitudinal wave techniques were not used as part of a "best effort" examination. The L-wave method has been shown capable of detecting planar inside diameter (ID) surface-breaking flaws on the far-side of wrought stainless steel welds. Recent studies[1,2,3] recommend the use of both shear and L-waves to obtain the best detection results, with minimum false calls, in austenitic welds.

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1 Ammirato, F.V., X. Edelmann, and S.M. Walker, *Examination of Dissimilar Metal Welds in BWR Nozzle-to-Safe End Joints*, 8th International Conference on NDE in the Nuclear Industry, ASM International, 1987.

2 Lemaitre, P., T.D. Koble, and S.R. Doctor, *PISC III Capability Study on Wrought-to-Wrought Austenitic Steel Welds: Evaluation at the Level of Procedures and Techniques*, Effectiveness of Nondestructive Examination Systems and Performance Demonstration, PVP-Volume 317, NDE-Volume 14, ASME, 1995.

3 Anderson, M.T., A.A. Diaz, A.D. Cinson, S.L. Crawford, S.E. Cumblidge, S.R Doctor, K.M. Denslow, and S. Ahmed, 2011. *An Assessment of Ultrasonic Techniques for Far-Side Examinations of Austenitic Stainless Steel Piping Welds*, NUREG/CR-7113, PNNL-19353, U. S. Nuclear Regulatory Commission, Washington, DC.

Response:

PSEG performed examinations on pipe-to-tee Weld 2-CV-1175-36, flange-to-pipe Weld 10-SW-2141-5, and elbow-to-flange Weld 10-SW-2183-3 with 45- and/or 70-degree shear waves. The use of shear waves for detection of these examinations follows the current guidance in the Generic Procedure for the Ultrasonic Examination of Austenitic Pipe Welds PDI-UT-2.

Paragraph 6.8.1.c states:
When any portion of the examination accessibility is limited to a single side in materials equal to or less than 0.50" thick, a 2.25 MHz, 70° shear wave search unit shall be used for the detection and length sizing of flaws on the far side of the weld.

The nominal thickness for the three welds are, 2-CV-1175-36 = 0.330", 10-SW-2141-5 = 0.360", 10-SW-2183-3 = 0.360".

RAI 9: The licensee has requested relief from examining 100% of the ASME Code-required volumes for ten (10) Class 1 and 2 piping welds covered under a risk-informed ISI program.

Please state the total number of Class 1 and 2 piping welds included in the overall risk-informed program so that the 10 limited examinations can be assessed within the scope of all examinations being implemented. Confirm that no other welds in the R-A population are expected to have limited volumetric coverage.

Response:

Class 1 and 2 piping welds included in the overall risk-informed program
R-A Class 1 elements (welds) = 1395
R-A Class 2 elements (welds) = 1714
Total R-A Class 1 and 2 elements (welds) = 3109

Required R-A Class 1 examinations = 110
Required R-A Class 2 examinations = 36
Total required R-A examinations = 146

Although only 110 Class 1 R-A examinations are required, 9 additional welds were selected for examination to ensure that Class 1 examinations were not significantly less than 10%.

R-A Examinations Complete
Class 1 examinations = 119
Class 2 examinations = 36
Total R-A examinations = 155

During the development of the Salem Unit 1 fourth interval risk informed program, all third interval ISI limited R-A weld examinations were substituted with the exception of welds 14-PS-1131-2 and 2-CV-1175-36, which are discussed in RAI 10. No other currently selected welds are expected to have limited coverage. However the living program periodic update may cause new piping weld selections not previously evaluated for examination coverage in the future. In these new situations, Salem intends to prioritize examination coverage in the selection of examination locations for the RI-ISI program.

RAI 10: In the submittal, the licensee states that during the fourth interval RI-ISI program update, all except two (Welds 14-PS-1131-2 and 2-CV-1175-36) of the ten welds with limited examinations from the third 10-year inspection interval have been substituted. The two subject welds that remain in the RI-ISI schedule in the fourth ISI interval were maintained due to no suitable substitutions being available.

It is unclear why these substitutions on the other remaining eight welds could not have been performed during the third 10-year inservice inspection interval, or whether additional welds could have been examined to augment the reduced volumetric coverage resulting from the limited examinations of the subject welds. Please discuss why this approach could not have been accomplished, thus potentially eliminating the subject welds from requiring relief for limited examination coverage.

Response:

During the initial Risk informed implementation and living updates of the third ISI Interval it was Salem's understanding that substitutions were limited to elements within the same risk segment and damage mechanism. The risk informed update for the fourth ISI interval no longer restricts the substitutions to the same segment; Salem's understanding is that substitutions can be in the same system, risk category, and degradation mechanism, which allows easier substitutions for increased examination coverage.

RAI 11: In Attachment 15, pages 8 and 9 of 10, the licensee states under limitations that "the longitudinal wave probes are limited to a W distance of 0.80" from weld centerline due to the proximity of the nozzle." Please define the meaning of "W distance."

Response:

The "W distance" is the distance from the exit point of the transducer to the centerline of the weld.

EPRI Report
IR-2004-41

Salem Unit 1 Pressurizer Nozzle Inner Radius Examinations

Sections 4 and 5

4

SALEM UNIT 1 PRESSURIZER SPRAY NOZZLE INNER RADIUS EXAMINATION

Detection

Table 4-1 gives the necessary geometric inputs to the NDE Center spreadsheet model for the Salem Unit 1 pressurizer spray nozzle [2]. Figure 2-1 shows the geometric parameters, which define the nozzle. The ASME Section XI Class I examination volume is indicated in Figure 2-1.

Table 4-1. Salem Unit 1 Pressurizer Spray Nozzle Geometry Inputs to Spreadsheet Model

Inside Surface Dimensions	(inches)	Outside Surface Dimensions	(inches)
Rbore	2.25	Rnozzle	5
Rbi	0.5	Rbo	2
Rvi	42	Rvo	45.12

Figure 4-1 is a plot of the probe beam angle versus the probe skew angle for all values of surface distance, S at the fixed azimuth, θ = 0° (the spray nozzle is axi-symmetric). The curve in Figure 4-1 gives the information regarding the probe angles and probe skews needed to obtain a 50° corner trap response everywhere in the inner radius examination zone of the Salem Unit 1 pressurizer spray nozzle, i.e. the technique design curve.

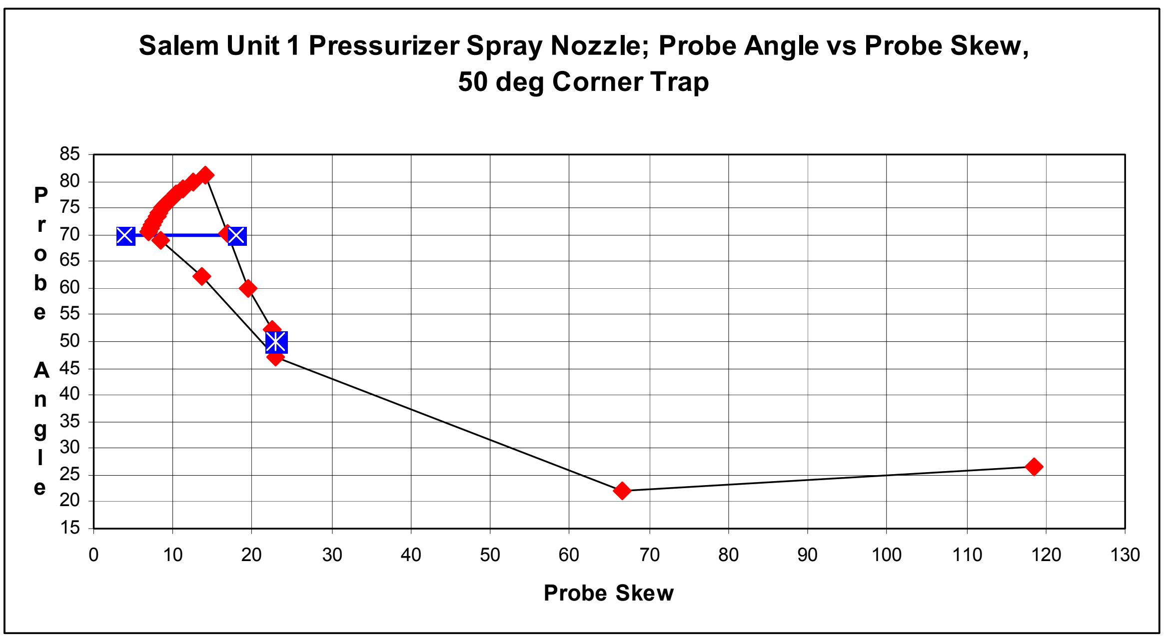


Figure 4-1.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Angle vs. Probe Skew for 50° Corner Trap; Technique Design Curve.

The EPRI spreadsheet model detection techniques to examine the Salem Unit 1 pressurizer spray nozzle involve scanning from the outer blend radius and the outer vessel shell. Table 4-2 gives the probe beam and skew angles, scan surface, and the mode of propagation.

Table 4-2.
Spreadsheet Model Detection Techniques for Salem Pressurizer Spray Nozzle.

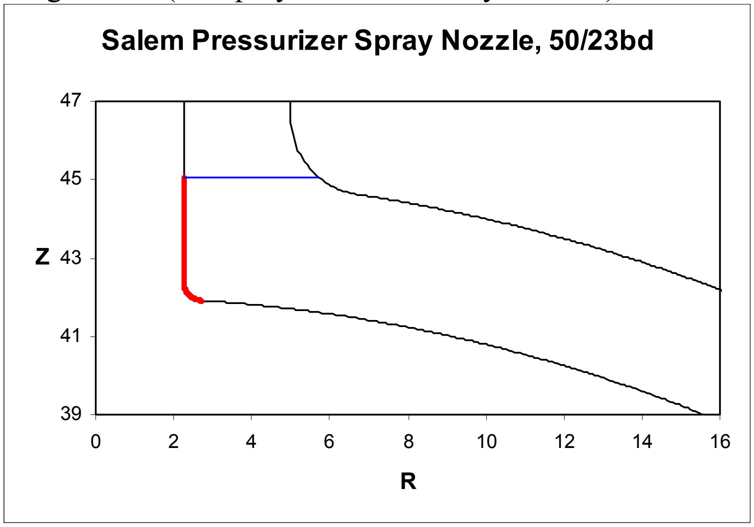
Probe Angle	Probe Skew	Scan Surface	Mode of Propagation
50	±23	Blend	Shear Wave
70	±(4 to 18)	Vessel	Shear Wave

Figure 4-1 shows these detection techniques in relation to the probe angle versus probe skew curve. These EPRI spreadsheet examination detection techniques are summarized again in Table 4-3 together with the corresponding scan surfaces, minimum and maximum probe radial positions, minimum and maximum metal paths, and maximum misorientation angle.

Table 4-3.
Spreadsheet Model Detection Techniques for Salem Unit 1 Pressurizer Spray Nozzle.

Probe Angle	Probe Skew	Scan Surface	Min R	Max R	Min MP	Max MP	Max Misorientation
50	±23	Blend	5.72	6.11	3.88	4.97	12
70	±(4 to 18)	Vessel	7.38	15.12	5.85	13.33	10

Figure 4-2 shows the minimum and maximum probe radial positions and the portion of the examination volume covered by the blend radius detection technique, 50/23b, for probes scanned at the azimuth angle of 0° (the spray nozzle is axi-symmetric).



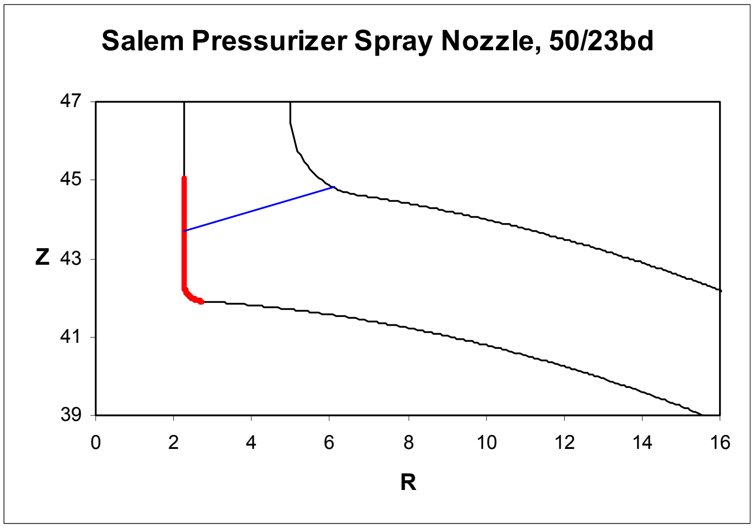


Figure 4-2.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Scan Limits and Examination Coverage for Blend Radius Detection Technique, 50/23b, at Theta = 0°.

Figure 4-3 shows the minimum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell detection technique, 70/(4 to 18)v, for probes scanned at the azimuth angle of 0°.

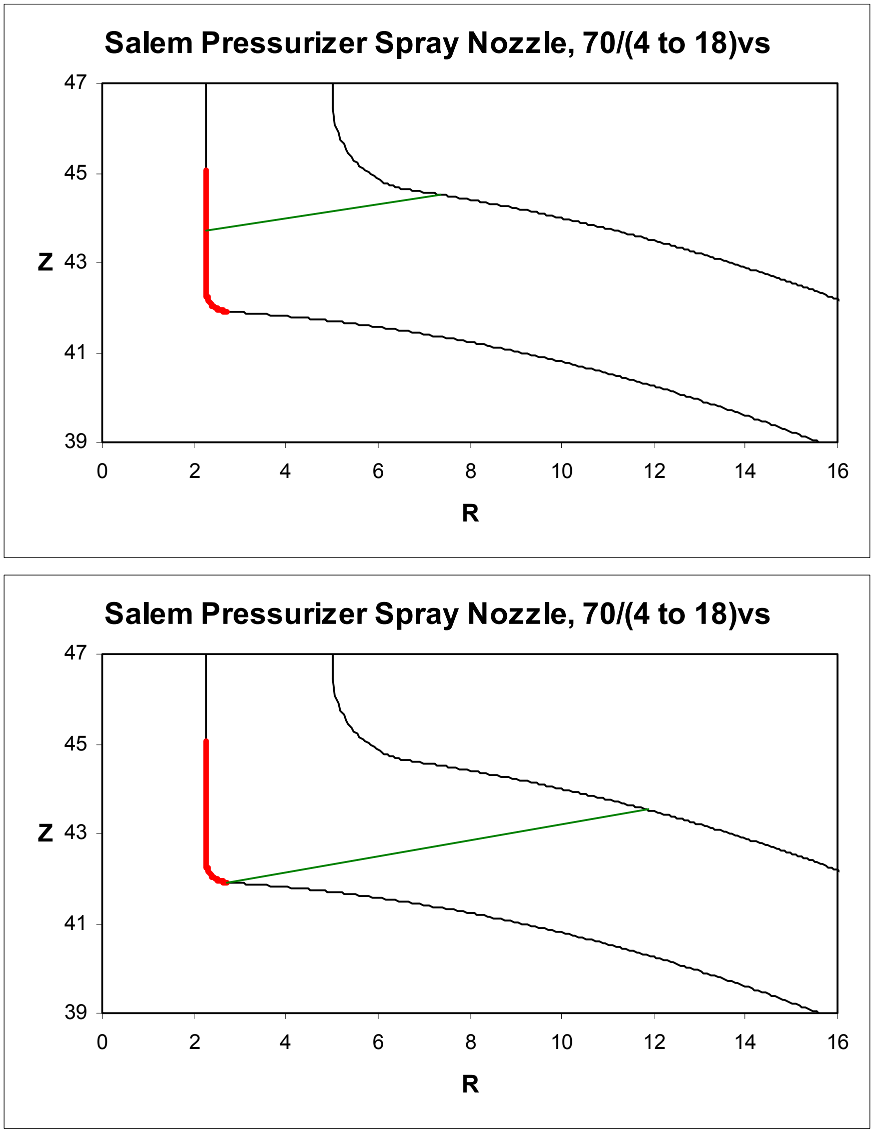


Figure 4-3.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Scans and Examination Coverage for Vessel Shell Detection Technique, 70/(4 to 18)v.

In viewing Figures 4-2 and 4-3, each of these probe/skew angle combinations is effective within some subset of the examination volume and ineffective in other areas. The blend radius detection technique 50/23b is effective for flaws on the upper half of the bore, the vessel shell detection technique, 70/(4 to 18)v is effective for flaws on the lower half of the bore and the inner blend radius. Figure 4-4 shows the combined coverage (misorientation angle) for nozzle inner radius examination volume for the blend radius detection technique; 50/23b and the vessel shell detection technique, 70/(4 to 18)v.

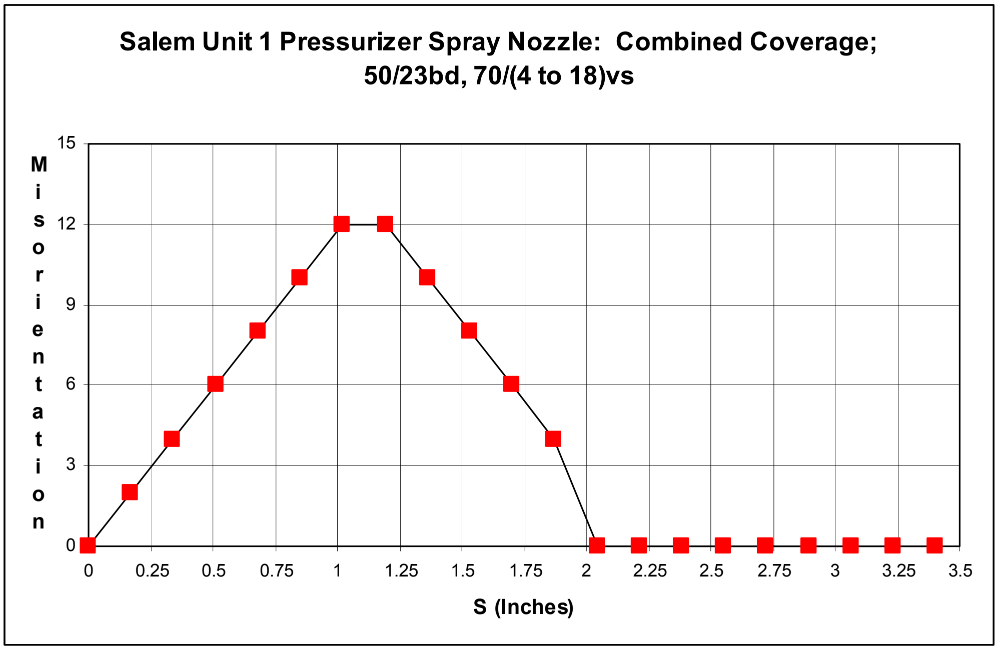


Figure 4-4.
Salem Pressurizer Spray Nozzle: Coverage Plot for Blend Radius Detection Technique; 50/23b and Vessel Shell Detection Technique, 70/(4 to 18)v.

Figure 4-5 shows the plot of the metal path to the points on the examination volume for the coverage shown in Figure 4-4.

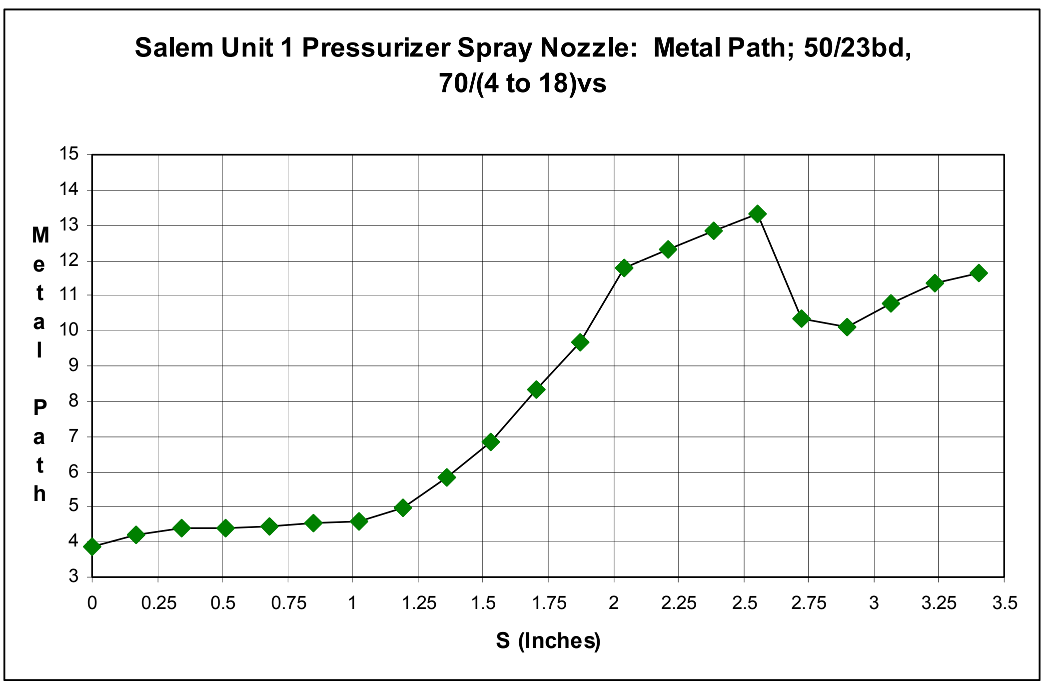


Figure 4-5.
Salem Pressurizer Spray Nozzle: Metal Path Plot; Blend Radius Detection Technique; 50/23b and Vessel Shell Detection Technique, 70/(4 to 18)v.

Figure 4-6 shows the plot of the beam angle at the flaw (nominal inspection angle) for the points on the examination volume for the coverage shown in Figure 4-4.

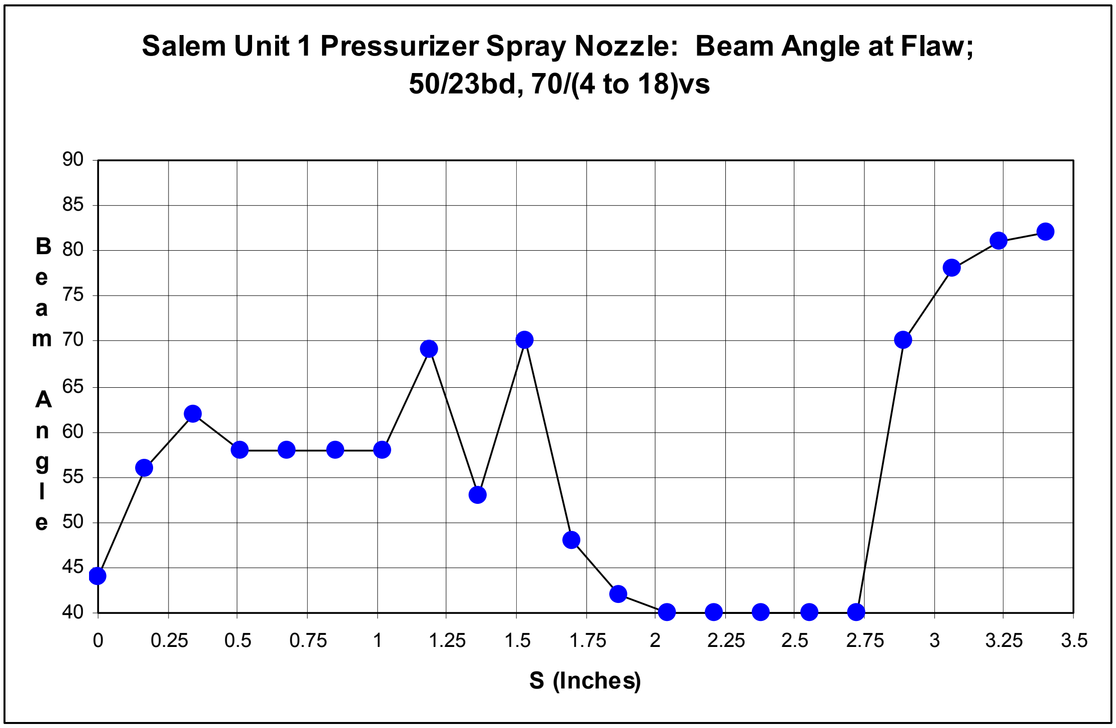


Figure 4-6.
Salem Pressurizer Spray Nozzle: Beam Angle at Flaw Plot; Blend Radius Technique; 50/23b and Vessel Shell Detection Technique, 70/(4 to 18)v.

Sizing

The EPRI spreadsheet model sizing techniques to examine the Salem Unit 1 pressurizer spray nozzle involve scanning from the outer blend radius and the outer vessel shell. Table 4-4 gives the probe beam and skew angles, scan surface, and the mode of propagation.

Table 4-4.
Spreadsheet Model Sizing Techniques for Salem Pressurizer Spray Nozzle.

Probe Angle	Probe Skew	Scan Surface	Mode of Propagation
50	±23	Blend	Shear Wave
70	±(4 to 16)	Vessel	Shear Wave
25	±90	Blend	Shear Wave

Figure 4-7 shows these sizing techniques in relation to the probe angle versus probe skew curve. These EPRI spreadsheet examination sizing techniques are summarized again in Table 4-5 together with the corresponding scan surfaces, minimum and maximum probe radial positions, minimum and maximum metal paths, and maximum misorientation angle.

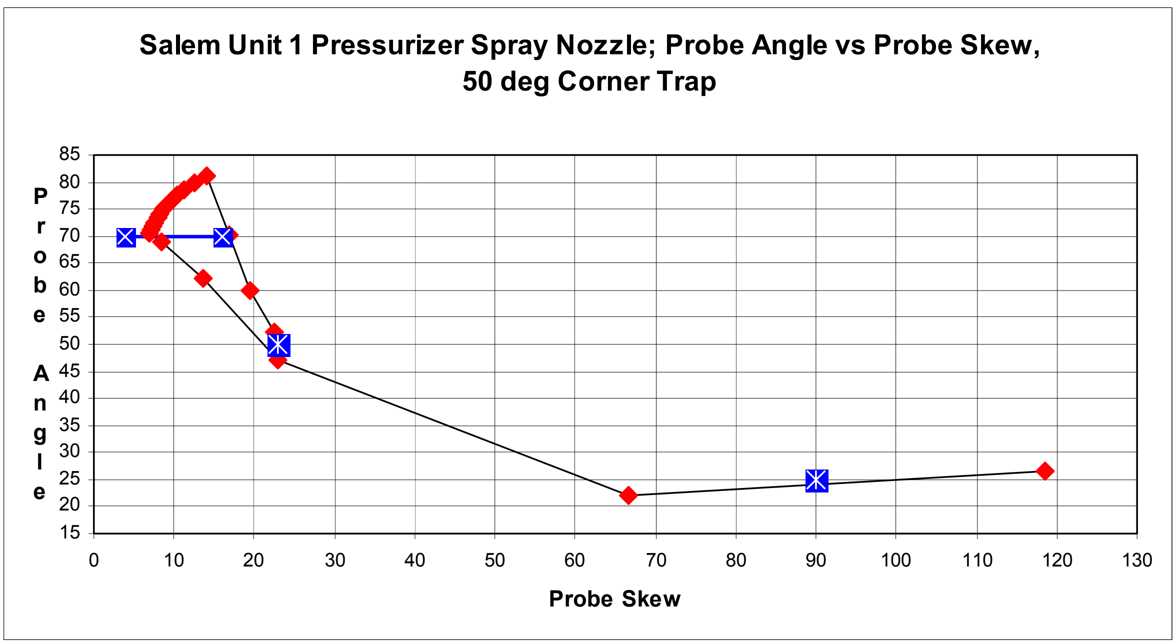


Figure 4-7.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Angle vs. Probe Skew for 50° Corner Trap; Technique Design Curve.

Table 4-5.
Spreadsheet Model Sizing Techniques for Salem Unit 1 Pressurizer Spray Nozzle.

Probe Angle	Probe Skew	Scan Surface	Min R	Max R	Min MP	Max MP	Max Misorientation
50	±23	Blend	5.72	6.53	3.88	6.04	14
70	±(4 to 16)	Vessel	7.38	15.12	5.85	13.33	10
25	±90	Blend	5.44	5.45	5.70	5.80	2

Figure 4-8 shows the minimum and maximum probe radial positions and the portion of the examination volume covered by the blend radius sizing technique, 50/23b, for probes scanned at the azimuth angle of 0°.

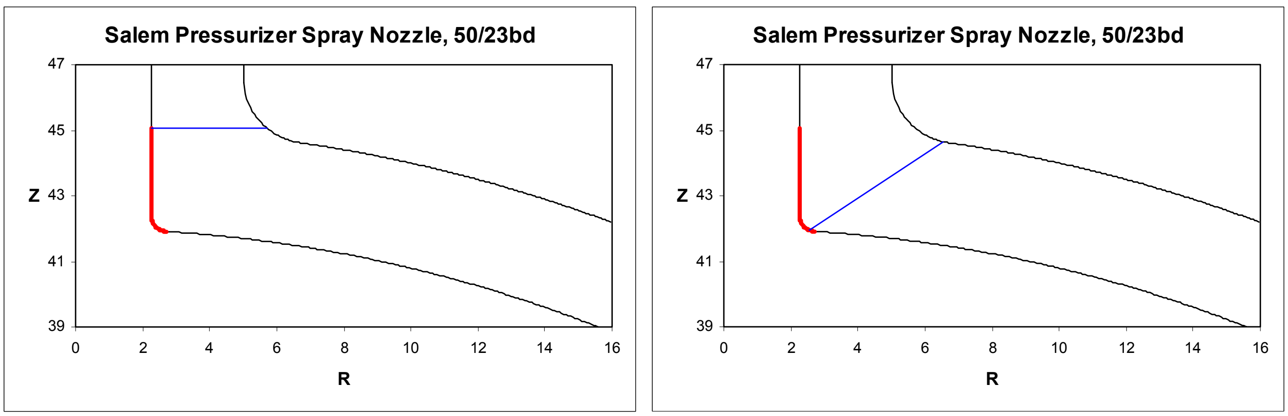


Figure 4-8.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Scan Limits and Examination Coverage for Blend Radius Sizing Technique, 50/23b, at Theta = 0°.

Figure 4-9 shows the minimum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell sizing technique, 70/(4 to 16)v, for probes scanned at the azimuth angle of 0°.

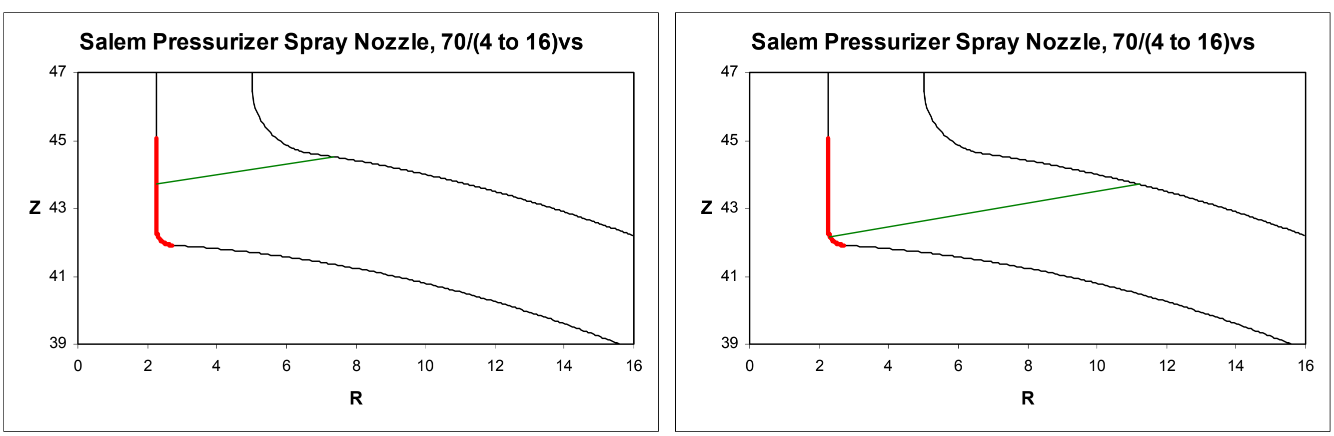
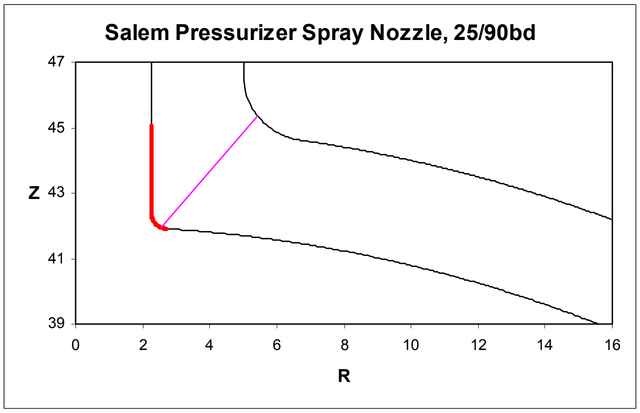


Figure 4-9.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Scans and Examination Coverage for Vessel Shell Sizing Technique, 70/(4 to 16)v.

Figure 4-10 shows the minimum and maximum probe radial positions and the portion of the examination volume covered by the blend radius sizing technique, 25/90b, for probes scanned at the azimuth angle of 0°.



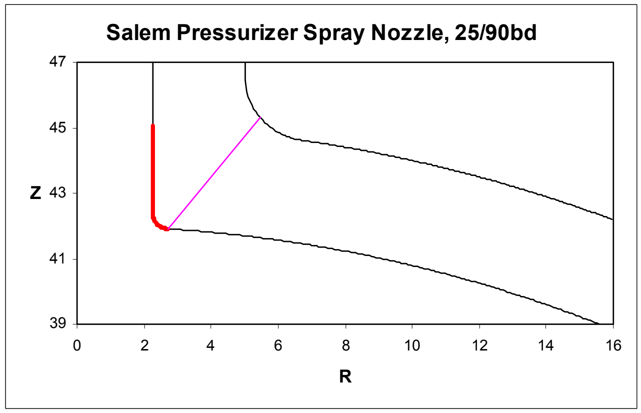


Figure 4-10.
Salem Unit 1 Pressurizer Spray Nozzle: Probe Scan Limits and Examination Coverage for Blend Radius Sizing Technique, 25/90b, at Theta = 0°.

In viewing Figures 4-8 through 4-10, each of these probe/skew angle combinations is effective within some subset of the examination volume and ineffective in other areas. The blend radius sizing technique 50/23b is effective for flaws on the upper part of the bore and the inner blend radius, the vessel shell sizing technique, 70/(4 to 16)v is effective for flaws on the lower part of the bore, the blend radius sizing technique 25/90b is effective for flaws the lower part of the inner blend radius. Figure 4-11 shows the combined coverage (misorientation angle) for nozzle inner radius examination volume for the blend radius sizing techniques; 50/23b, 25/90b and the vessel shell sizing technique, 70/(4 to 16)v.

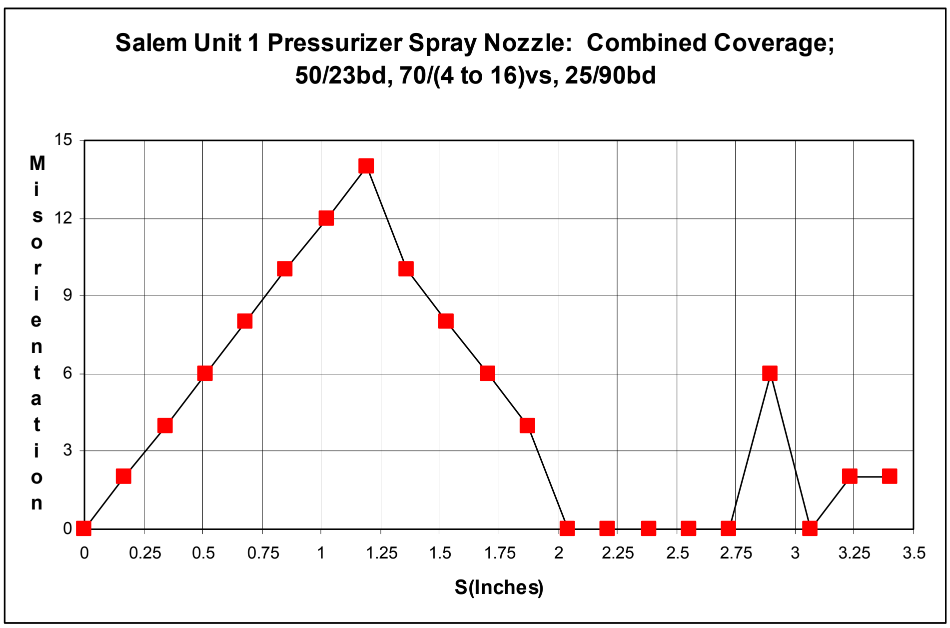


Figure 4-11.
Salem Pressurizer Spray Nozzle: Coverage Plot for Blend Radius Sizing Techniques; 50/23b, 25/90b and Vessel Shell Sizing Technique, 70/(4 to 16)v.

Figure 4-12 shows the plot of the metal path to the points on the examination volume for the coverage shown in Figure 4-10.

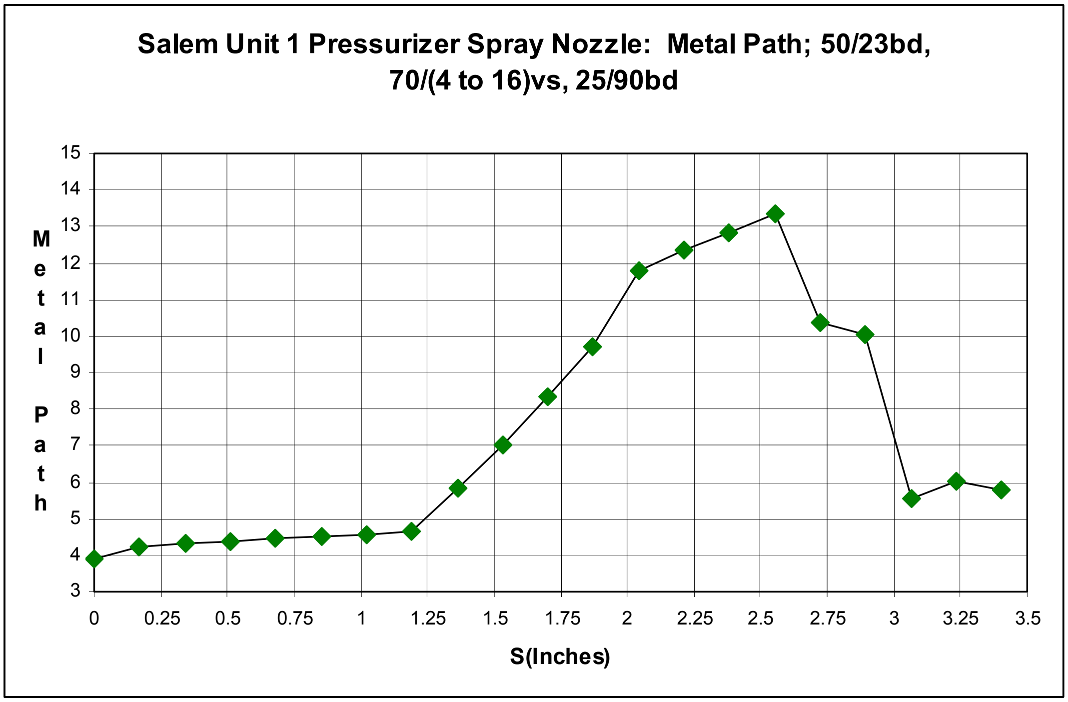


Figure 4-12.
Salem Pressurizer Spray Nozzle: Metal Path Plot; Blend Radius Sizing Techniques; 50/23b, 25/90b and Vessel Shell Sizing Technique, 70/(4 to 16)v.

Figure 4-13 shows the plot of the beam angle at the flaw (nominal inspection angle) for the points on the examination volume for the coverage shown in Figure 4-10.

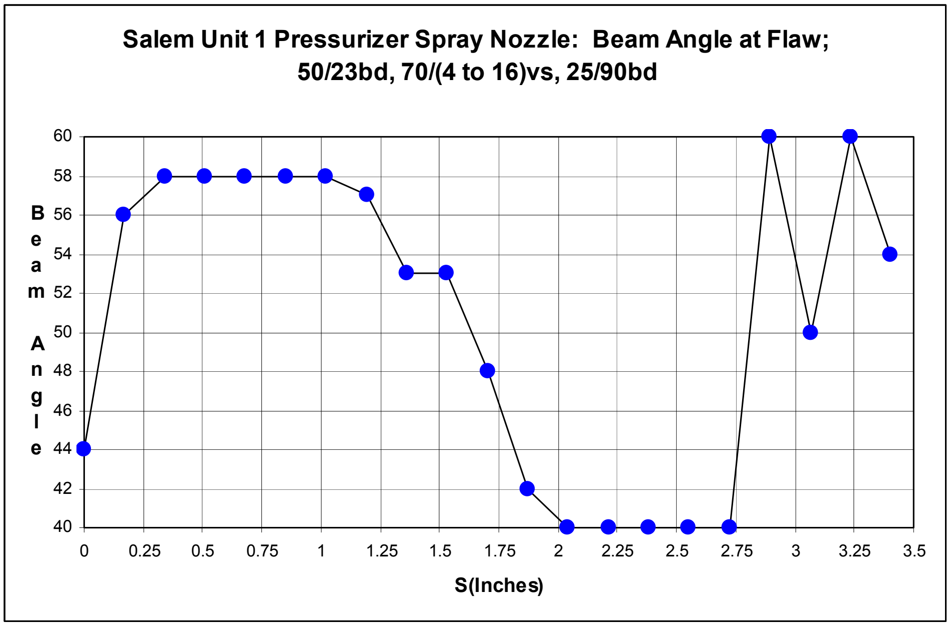


Figure 4-13.
Salem Pressurizer Spray Nozzle: Beam Angle at Flaw Plot; Blend Radius Techniques; 50/23b, 25/90b and Vessel Shell Sizing Technique, 70/(4 to 16)v.

5

SALEM UNIT 1 PRESSURIZER RELIEF NOZZLE INNER RADIUS EXAMINATION

Detection

Table 5-1 gives the necessary geometric inputs to the NDE Center spreadsheet model [2] for the Salem Unit 1 pressurizer relief nozzle. Figure 3-1 shows the geometric parameters, which define this tapered nozzle. The ASME Section XI Class I examination volume is also indicated in Figure 3-1.

Table 5-1.
Salem Unit 1 Pressurizer Relief Nozzle Geometry Inputs to Spreadsheet Model

Inside Surface Dimensions	(Degrees)/ (Inches)	Outside Surface Dimensions	(Degrees)/ (Inches)
		Outside Taper Angle	30
		Znozzle	49.75
Rbore	1.5625	Rnozzle	2.5
Rbi	1.5	Rbo	2.5
Rvi	42	Rvo	46.25

Figure 5-1 is a plot of the probe beam angle versus the probe skew angle for all values of surface distance, S at the fixed azimuth, θ = 0° (the relief nozzle is axi-symmetric). The curve in Figure 5-1 gives the information regarding the probe angles and probe skews needed to obtain a 50° corner trap response everywhere in the inner radius examination zone of the Salem Unit 1 pressurizer relief nozzle, i.e. the technique design curve.

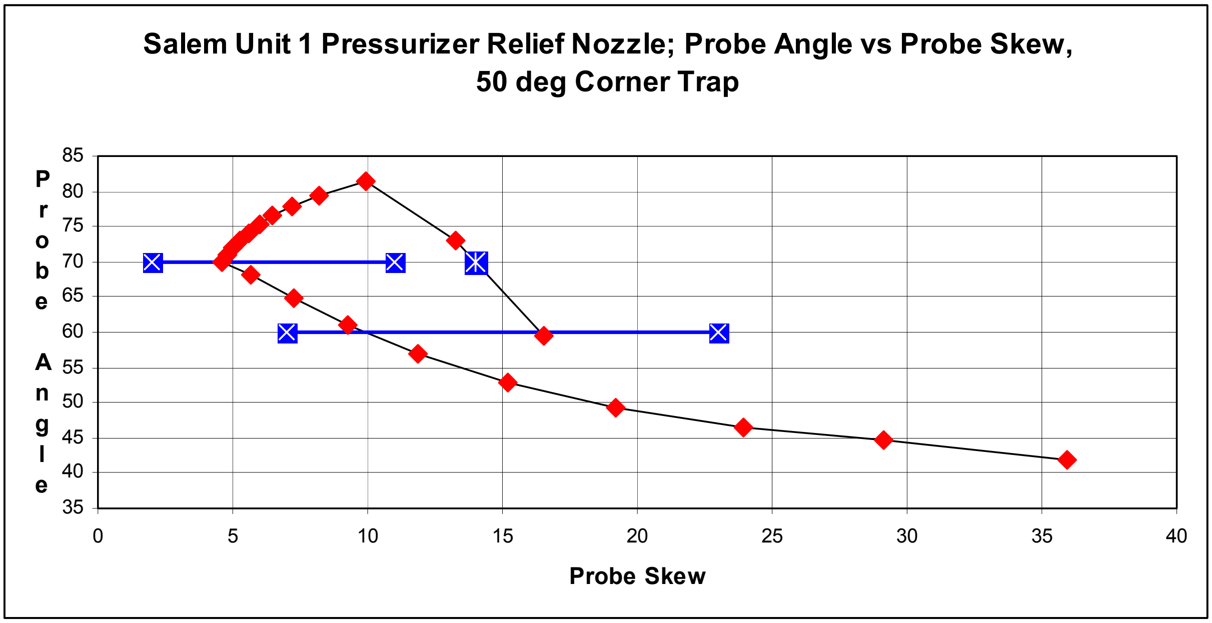


Figure 5-1.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Angle vs. Probe Skew for 50° Corner Trap; Technique Design Curve.

The EPRI spreadsheet model detection techniques to examine the Salem Unit 1 pressurizer relief nozzle involve scanning from the outer blend radius and the outer vessel shell. Table 5-2 gives the probe beam and skew angles, scan surface, and the mode of propagation.

Table 5-2.
Spreadsheet Model Detection Techniques for Salem Pressurizer Relief Nozzle.

Probe Angle	Probe Skew	Scan Surface	Mode of Propagation
70	±14	Blend	Shear Wave
70	±(2 to 11)	Vessel	Shear Wave
60	±(7 to 23)	Vessel	Shear Wave

Figure 5-1 shows these detection techniques in relation to the probe angle versus probe skew curve. These EPRI spreadsheet examination detection techniques are summarized again in Table 5-3 together with the corresponding scan surfaces, minimum and maximum probe radial positions, minimum and maximum metal paths, and maximum misorientation angle.

Table 5-3.
Spreadsheet Model Detection Techniques for Salem Unit 1 Pressurizer Relief Nozzle.

Probe Angle	Probe Skew	Scan Surface	Min R	Max R	Min MP	Max MP	Max Misorientation
70	±14	Blend	5.12	5.87	4.16	5.67	10
70	±(2 to 11)	Vessel	7.93	15.91	6.82	14.68	10
60	±(7 to 23)	Vessel	8.41	9.13	7.73	9.22	0

Figure 5-2 shows the minimum and maximum probe radial positions and the portion of the examination volume covered by the blend radius detection technique, 70/14b, for probes scanned at the azimuth angle of 0°.

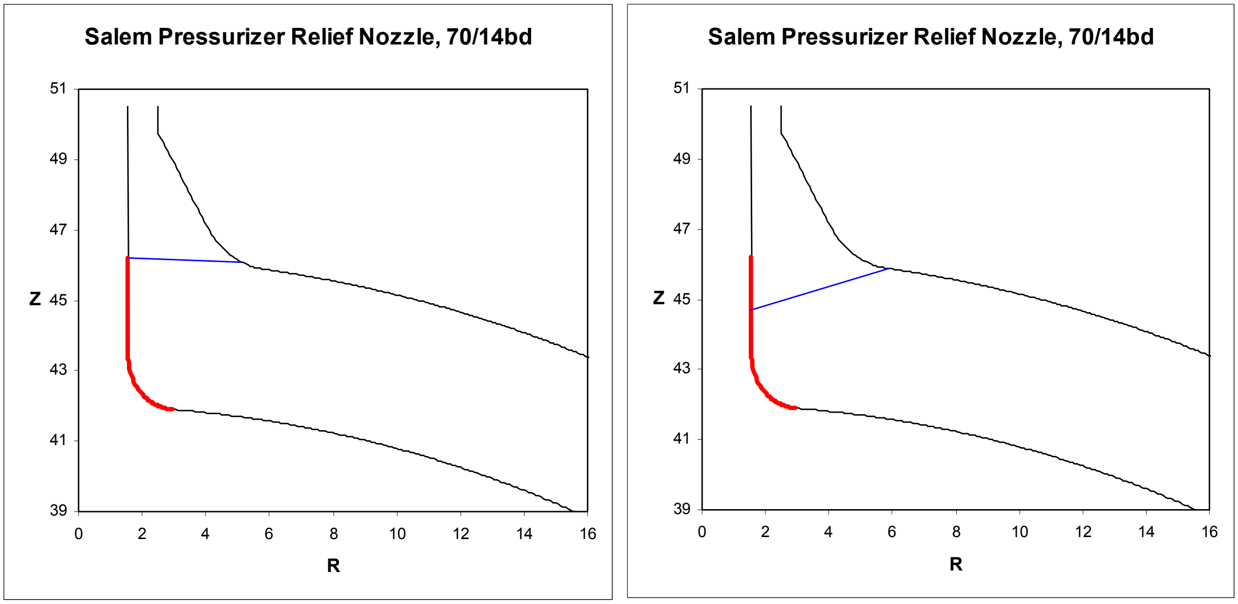


Figure 5-2.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scan Limits and Examination Coverage for Blend Radius Detection Technique, 70/14b, at Theta = 0°.

Figure 5-3 shows the minimum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell detection technique, 70/(2 to 11)v, for probes scanned at the azimuth angle of 0°.

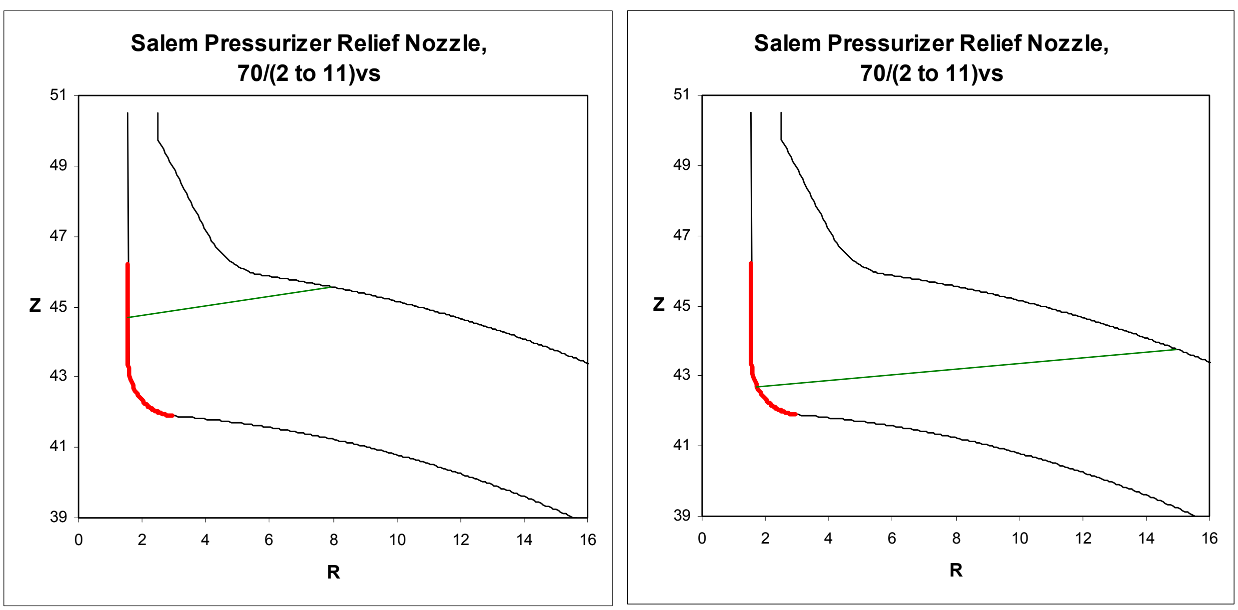


Figure 5-3.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scans and Examination Coverage for Vessel Shell Detection Technique, 70/(2 to 11)v.

Figure 5-4 shows the minimum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell detection technique, 60/(7 to 23)v, for probes scanned at the azimuth angle of 0°.

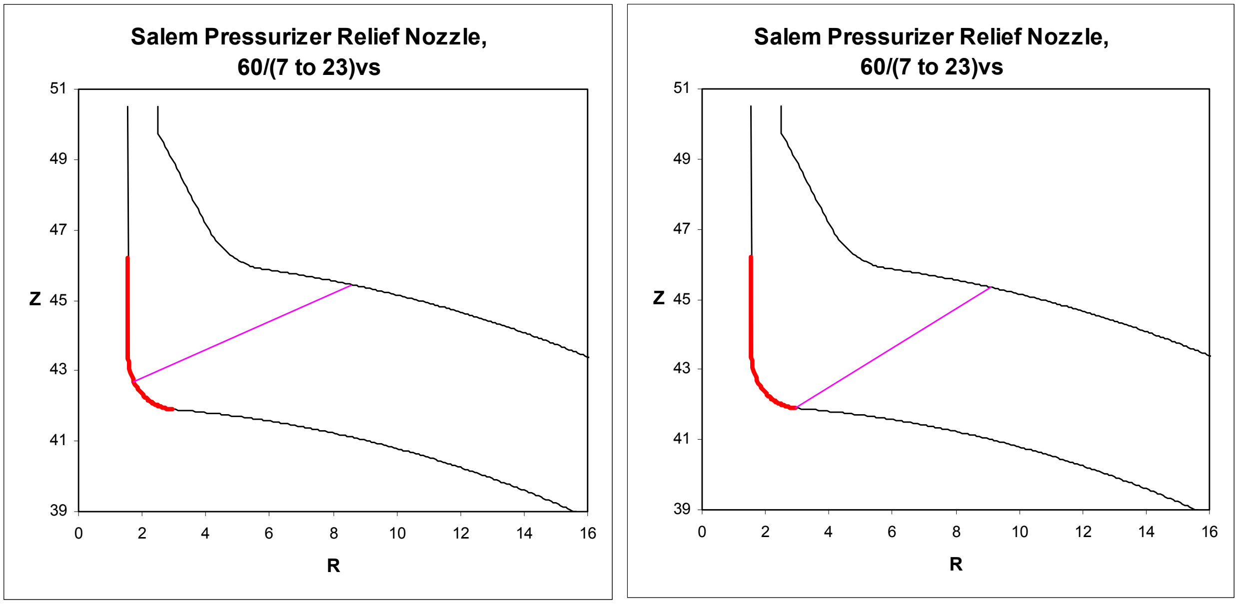


Figure 5-4.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scans and Examination Coverage for Vessel Shell Detection Technique, 60/(7 to 23)v.

In viewing Figures 5-2 through 5-4, each of these probe/skew angle combinations is effective within some subset of the examination volume and ineffective in other areas. The blend radius detection technique 70/14b is effective for flaws on the upper half of the bore, the vessel shell detection technique, 70/(2 to 11)v is effective for flaws on the lower half of the bore, the vessel shell detection technique, 60/(7 to 23)v is effective for flaws on the inner blend radius. Figure 5-5 shows the combined coverage (misorientation angle) for nozzle inner radius examination volume for the blend radius detection techniques; 70/14b, and the vessel shell detection techniques, 70/(2 to 11)v and 60/(7 to 23)vs.

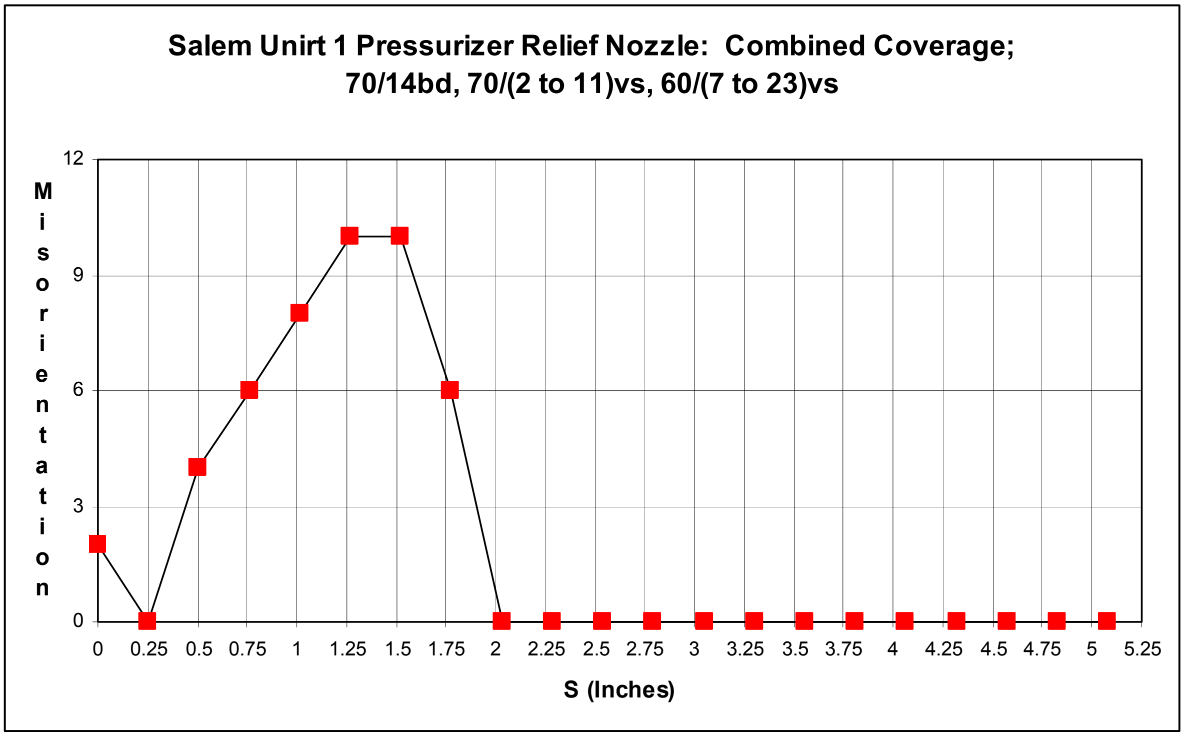


Figure 5-5.
Salem Pressurizer Relief Nozzle: Coverage Plot for Blend Radius Detection Technique; 70/14b and Vessel Shell Techniques, 70/(2 to 11)v and 60/(7 to 23)v.

Figure 5-6 shows the plot of the metal path to the points on the examination volume for the coverage shown in Figure 5-5.

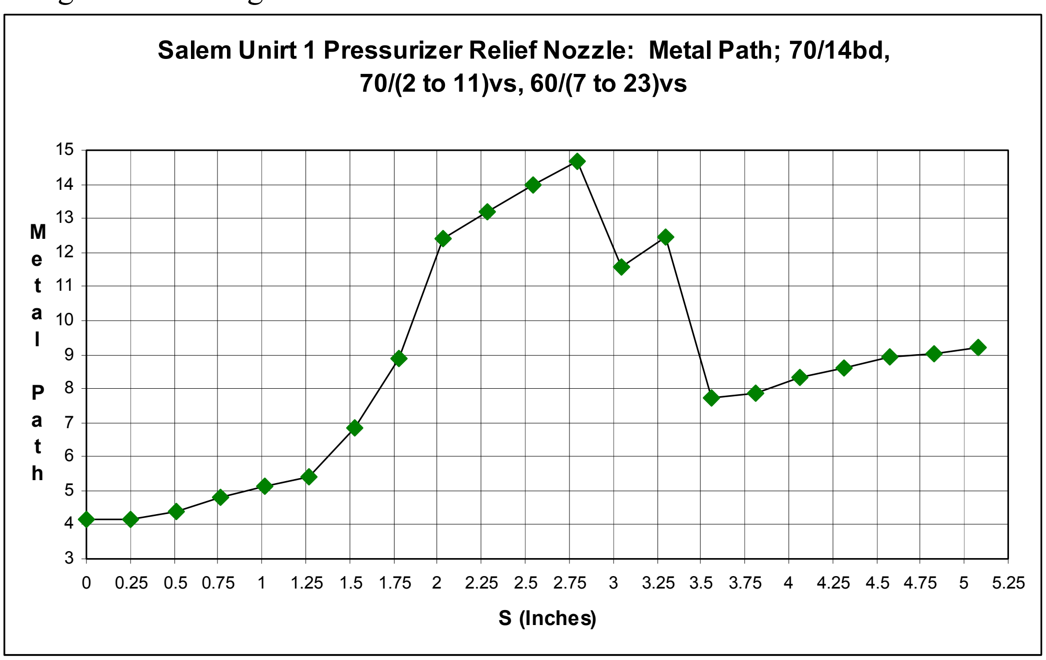


Figure 5-6.
Salem Pressurizer Relief Nozzle: Metal Path Plot; Blend Radius Detection Technique; 70/14b and Vessel Shell Techniques, 70/(2 to 11)v and 60/(7 to 23)v.

Figure 5-7 shows the plot of the beam angle at the flaw (nominal inspection angle) for the points on the examination volume for the coverage shown in Figure 5-4.

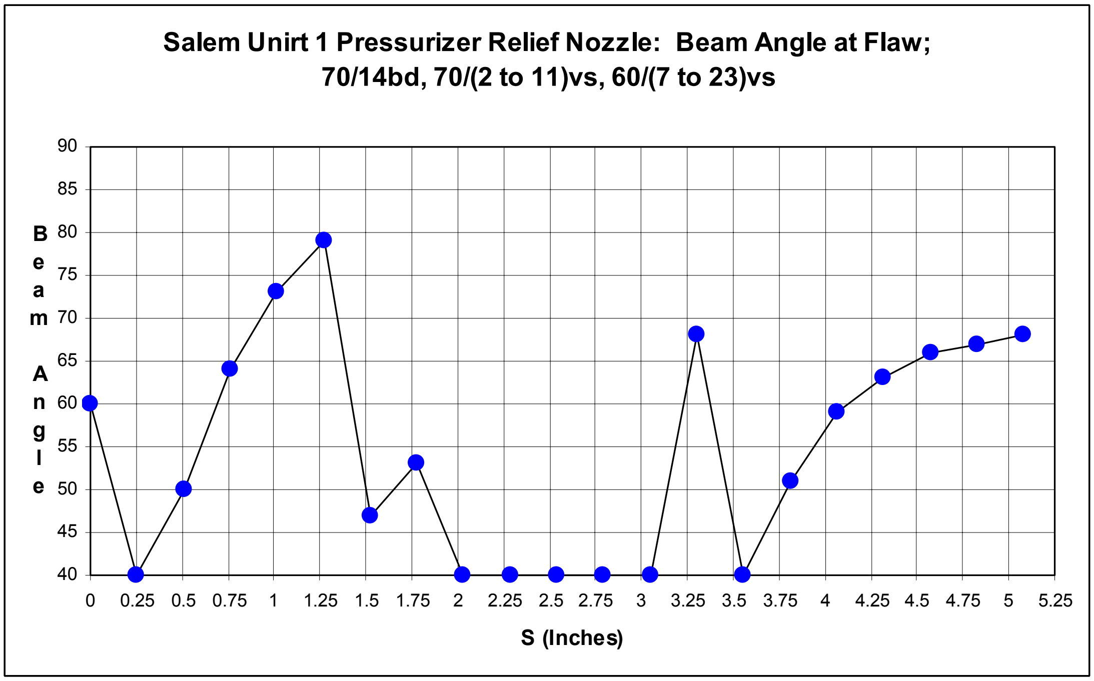


Figure 5-7.
Salem Pressurizer Relief Nozzle: Beam Angle at Flaw; Blend Radius Technique; 70/14b and Vessel Shell Techniques, 70/(2 to 11)v and 60/(7 to 23)v.

Sizing

The EPRI spreadsheet model sizing techniques to examine the Salem Unit 1 pressurizer relief nozzle involve scanning from the outer blend radius and the outer vessel shell. Table 5-4 gives the probe beam and skew angles, scan surface, and the mode of propagation. The techniques exclusive to sizing indications are shown in **bold.**

Table 5-4.
Spreadsheet Model Sizing Techniques for Salem Pressurizer Relief Nozzle.

Probe Angle	Probe Skew	Scan Surface	Mode of Propagation
70	±14	Blend	Shear Wave
70	±(2 to 11)	Vessel	Shear Wave
60	±(5 to 16)	Vessel	Shear Wave
45	**±(14 to 33)**	**Vessel**	**Shear Wave**

Figure 5-8 shows these sizing techniques in relation to the probe angle versus probe skew curve. These EPRI spreadsheet examination sizing techniques are summarized again in Table 5-5 together with the corresponding scan surfaces, minimum and maximum probe radial positions, minimum and maximum metal paths, and maximum misorientation angle.

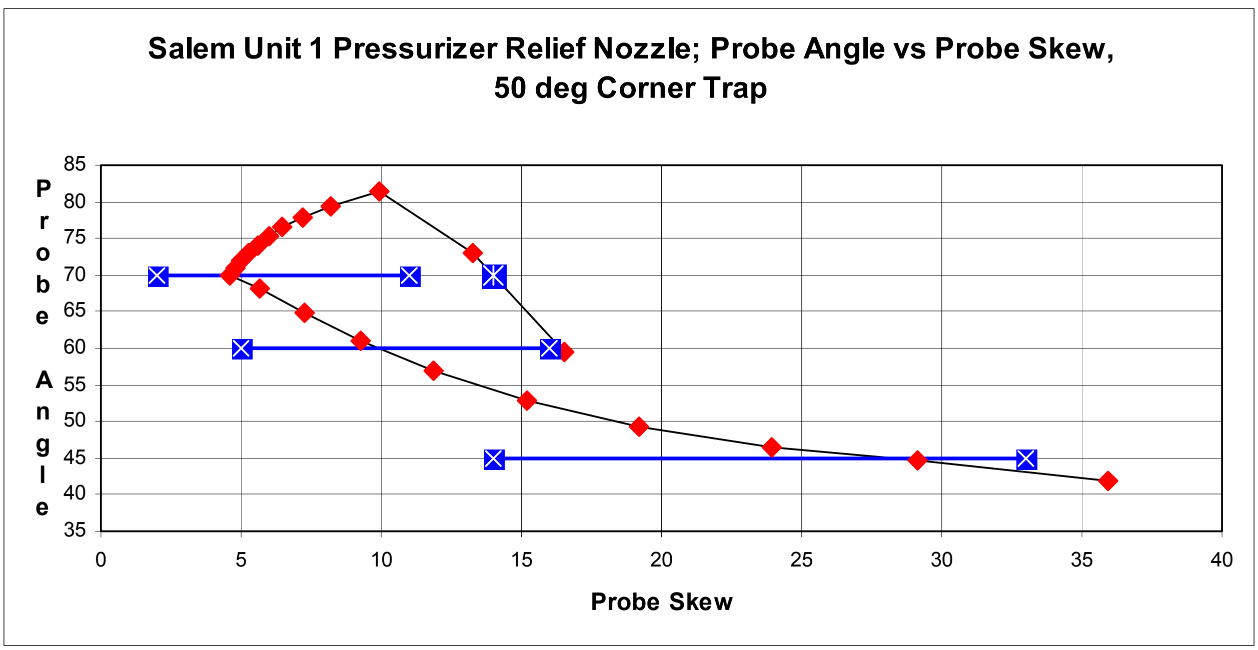


Figure 5-8.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Angle vs. Probe Skew for 50° Corner Trap; Technique Design Curve.

Table 5-5.
Spreadsheet Model Sizing Techniques for Salem Unit 1 Pressurizer Relief Nozzle.

Probe Angle	Probe Skew	Scan Surface	Min R	Max R	Min MP	Max MP	Max Misorientation
70	±14	Blend	5.12	5.86	4.16	4.84	14
70	±(2 to 11)	Vessel	6.49	15.91	5.29	14.68	10
60	±(5 to 16)	Vessel	8.41	9.79	7.73	8.81	2
45	±(14 to 33)	Vessel	6.39	6.61	6.20	6.69	2

Figure 5-9 shows the minimum and maximum probe radial positions and the portion of the examination volume covered by the blend radius sizing technique, 70/14b, for probes scanned at the azimuth angle of 0°.

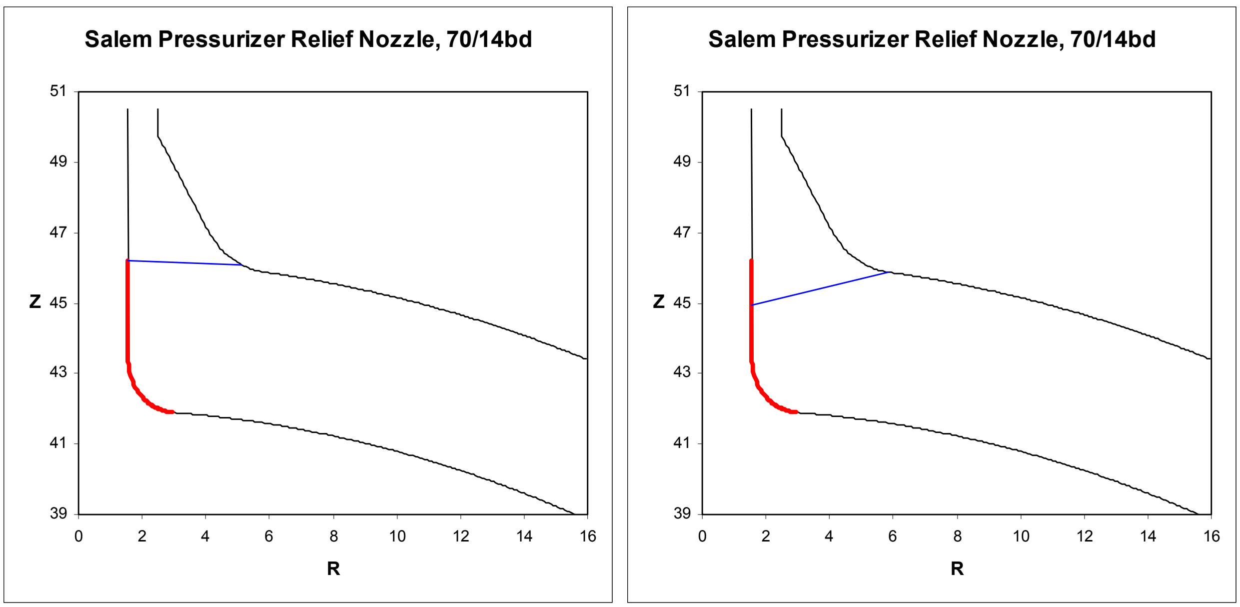


Figure 5-9.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scan Limits and Examination Coverage for Blend Radius Sizing Technique, 70/14b, at Theta = 0°.

Figure 5-10 shows the minimum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell sizing technique, 70/(2 to 11)v, for probes scanned at the azimuth angle of 0°.

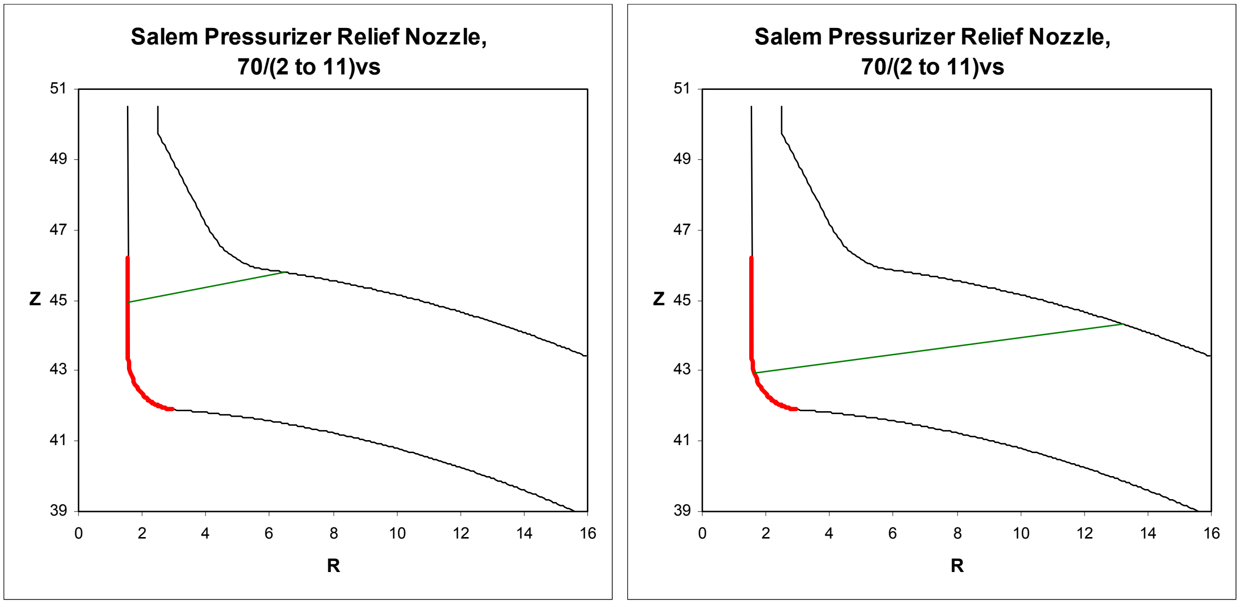


Figure 5-10.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scans and Examination Coverage for Vessel Shell Sizing Technique, 70/(2 to 11)v.

Figure 5-11 shows the maximum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell sizing technique, 60/(5 to 16)v, for probes scanned at the azimuth angle of 0°.

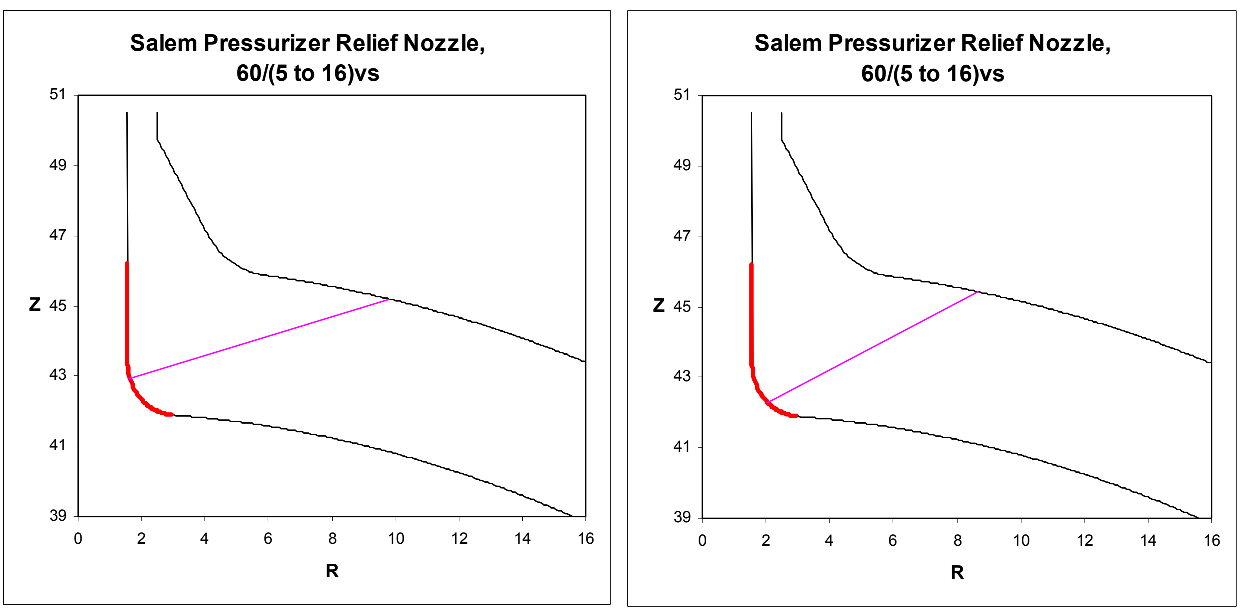


Figure 5-11.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scans and Examination Coverage for Vessel Shell Sizing Technique, 60/(5 to 16)v.

Figure 5-12 shows the maximum and intermediate probe radial positions and the portion of the examination volume covered by the vessel shell sizing technique, 45/(14 to 33)v, for probes scanned at the azimuth angle of 0°.

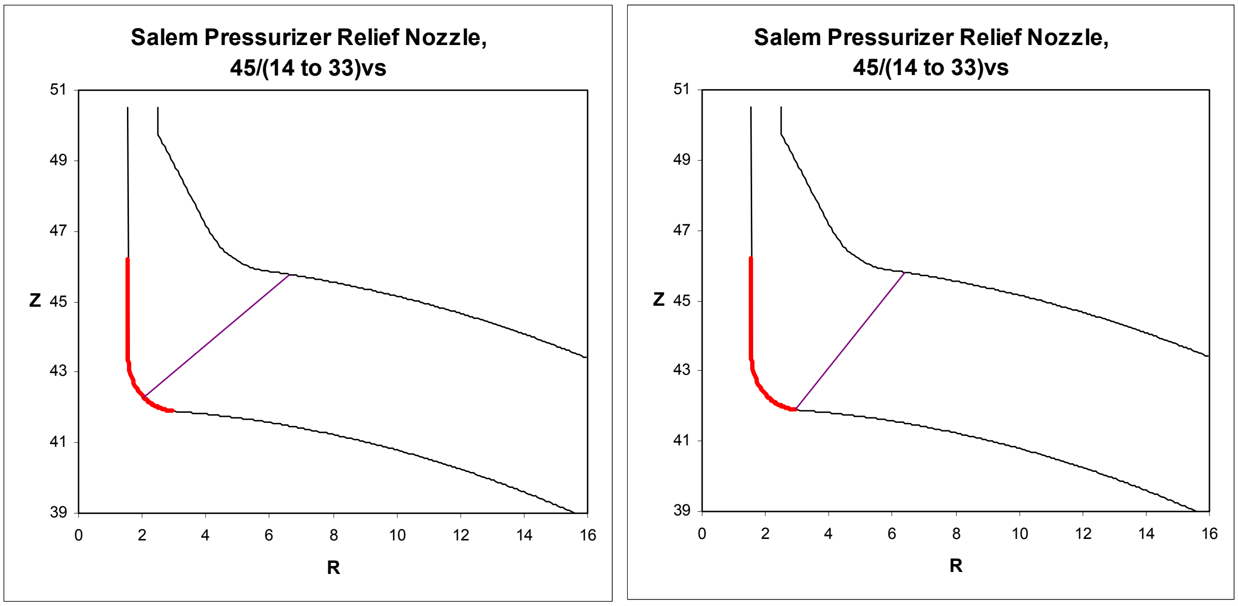


Figure 5-12.
Salem Unit 1 Pressurizer Relief Nozzle: Probe Scans and Examination Coverage for Vessel Shell Sizing Technique, 45/(14 to 33)v.

In viewing Figures 5-9 through 5-12, each of these probe/skew angle combinations is effective within some subset of the examination volume and ineffective in other areas. The blend radius sizing technique 70/14b is effective for flaws on the upper half of the bore, the vessel shell sizing technique, 70/(2 to 11)v is effective for flaws on the lower half of the bore, the vessel shell sizing technique, 60/(5 to 16)v is effective for flaws on the upper half of the inner blend radius, 45/(14 to 33)v is effective for flaws on the lower half of the inner blend radius. Figure 5-13 shows the combined coverage (misorientation angle) for nozzle inner radius examination volume for the blend radius sizing technique; 70/14b, and the vessel shell sizing techniques, 70/(2 to 11)v and 60/(5 to 16)vs, 45/(14 to 33)v.

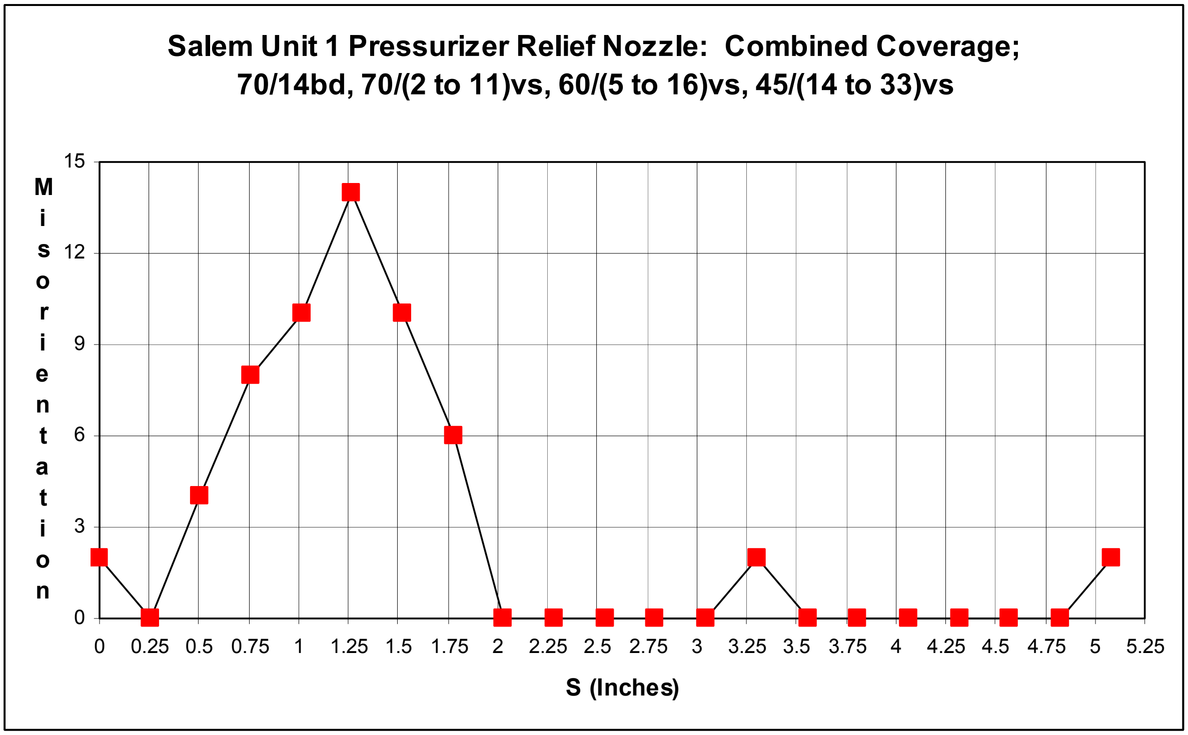


Figure 5-13.
Salem Pressurizer Relief Nozzle: Coverage Plot for Blend Radius Sizing Technique; 70/14b,Vessel Shell Techniques, 70/(2 to 11)v, 60/(5 to 16)v, 45/(14 to 33)v.

Figure 5-14 shows the plot of the metal path to the points on the examination volume for the coverage shown in Figure 5-13.

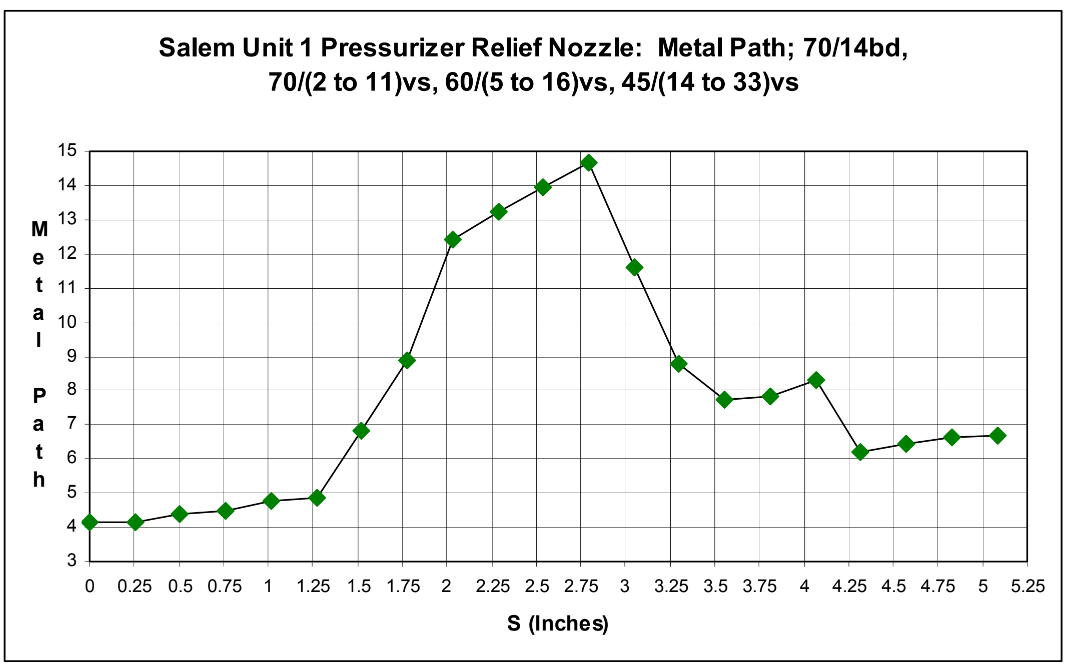


Figure 5-14.
Salem Pressurizer Relief Nozzle: Metal Path Plot; Blend Radius Sizing Technique; 70/14b,Vessel Shell Techniques, 70/(2 to 11)v, 60/(5 to 16)v, 45/(14 to 33)v.

Figure 5-15 shows the plot of the beam angle at the flaw (nominal inspection angle) for the points on the examination volume for the coverage shown in Figure 5-13.

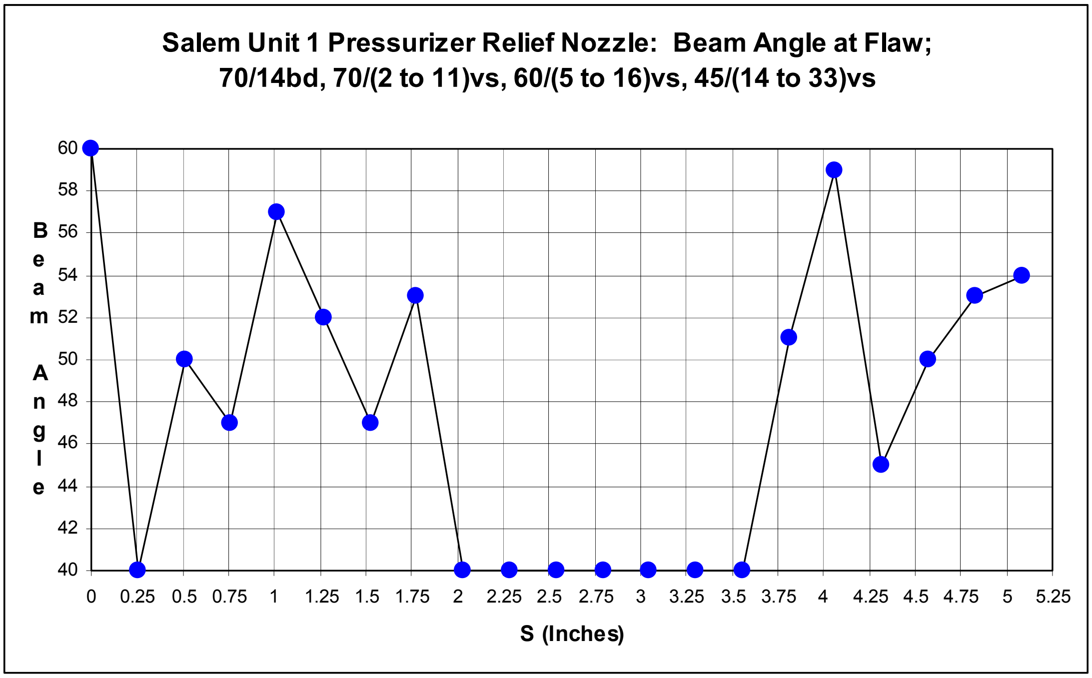


Figure 5-15.
Salem Pressurizer Relief Nozzle: Beam Angle at Flaw; Blend Radius Technique; 70/14b,Vessel Shell Techniques, 70/(2 to 11)v, 60/(5 to 16)v, 45/(14 to 33)v.