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MAR 0 2 2004

PSEG
Nuclear LLC

LR-N04-0040

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

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING RELIEF REQUEST S1-RR-I3-B21, NRC ORDER EA-03-009 ON REACTOR PRESSURE VESSEL HEAD INSPECTIONS SALEM GENERATING STATION UNIT NO. 1 FACILITY OPERATING LICENSE NO. DPR-70 DOCKET NO. 50-272

Reference: Letter LRN-03-0329, Relaxation Request to NRC Order (EA-03-009) Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (Relief Request S1-RR-I3-B21), dated September 24, 2003.

On February 11, 2003 the U. S. Nuclear Regulatory Commission (NRC) issued Order EA-03-009 for interim inspection requirements for reactor pressure vessel (RPV) Heads at pressurized water reactor facilities. The Order requires specific inspection of the RPV head and associated penetration nozzles. On September 24, 2003, pursuant to the procedure specified in Section IV.F of the Order, PSEG Nuclear LLC (PSEG), requested relaxation from the requirements of the Order regarding nondestructive examination of the penetration nozzles below the J-groove weld that attaches the nozzle to the head.

On January 8, 2004 the NRC sent a draft request for additional information followed up with a teleconference on January 9, 2004, to discuss the request with the PSEG. The NRC issued a formal request for this additional information on January 22, 2004. On February 20, 200 the NRC issued the First Revised NRC Order (EA-03-009). The revised Order modified the requirements regarding nondestructive examination of the penetration nozzles below the J-groove weld. The relief request also applies for the revised Order. Attachment 1 contains PSEG's response to the request for additional information.

A101

If you have any questions or require additional information, please contact Mr. Michael Mosier at (856) 339-5434.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 3/2/04

Sincerely,
John Carlin

Vice President – Nuclear Assessments

·)NS

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**SALEM GENERATING STATION
UNIT NO. 1
FACILITY OPERATING LICENSE NO. DPR-70
DOCKET NO. 50-272
REQUEST FOR ADDITIONAL INFORMATION
RELIEF REQUEST S1-RR-I3-B21
NRC ORDER EA-03-009**

In Section 5 of relief request S1-RR-I3-B21 PSEG requested relief from NRC Order EA-03-009, Section IV.C.(1)(b)(i), "Ultrasonic testing of each RPV head penetration (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone" and anticipated achieving ultrasonic testing (UT) coverage reaching from two (2) inches above the J-groove weld down to the lowest elevation that can be practically inspected on each nozzle with the probe being used. On February 20, 200 the NRC issued the First Revised NRC Order (EA-03-009). The revised Order modified the requirements regarding nondestructive examination of the penetration nozzles below the J-groove weld. The relief request applies to Section IV.C.(5)(b)(i) and IV.C.(5)(b)(iii) of the revised Order since the actual inspection coverage may be less than one inch. Inspection coverage discussed in the response to question 3 is based upon design drawings and is greater than one inch. However field experience has shown that the J-groove weld reinforcement is larger than shown on the design drawings.

<u>**NRC Question 1:**</u>

What penetration nozzles are to be covered by this relaxation request (RPV head vent, instrument, CEDM, etc.)? Provide the number and type of penetrations.

<u>**PSEG Response to Question 1:**</u>

This relaxation request is for 79 reactor vessel head penetrations. Table 1-1 provides the number and type of penetration. The original head vent, which is now used for the reactor vessel level instrumentation system (RVLIS), is the subject of relief request S1-RR-I3-B22.

Table 1-1
Number and Type of Penetration

Penetration Description	Number
Control Rod Drive Mechanism - full length	53
Control Rod Drive Mechanism - part length	7
Head Vent (modified Control Rod Drive Mechanism - part length)	1
Spare Control Rod Drive Mechanism	13
Instrument Column	5
Total Penetrations	79

NRC Question 2:

Provide drawing(s) of the nozzle design and head configurations.

PSEG Response to Question 2:

Combustion Engineering drawings 233-040 and 233-048 show the head configuration. Combustion Engineering drawing 233-051 shows the nozzle design including the tapered and threaded portion at the bottom of the nozzle.

NRC Question 3:

Provide cross section drawings showing limitations of the UT examinations (nozzle design and test equipment). What is the expected examination volume for the different nozzle angles and designs?

PSEG Response to Question 3:

The penetration nozzles installed in the Salem Unit 1 Reactor Vessel head have a 15 degree chamfer that is 0.233 inches deep on the inside diameter (ID) of the tube. There is also a threaded area with a thread relief on the outer diameter of the tube that extends up 0.75 inches from the bottom. These geometries limit the coverage for both of the UT inspection tools that will be used at Salem. When the lower transducer on the probes goes below the top of the ID chamfer, the probes lose contact with the ID surface and it is not possible to obtain data.

PSEG Response to Question 3 (cont'd):

Westinghouse will use two probes to perform UT inspection of the penetration nozzles at Salem. The trinity probe will be used to inspect nozzles that contain thermal sleeves (53) and part-length CRDM drive shafts (7 total). The open housing probe will be used to inspect nozzles without thermal sleeves (19 total). Both probes use circumferential time of flight tip diffraction (TOFD) as the primary crack detection method. The TOFD technique uses two transducers (one a transmitter, and one a receiver). For detection of circumferential cracks, the transducers are oriented along the vertical axis of the probe. The focus point of the TOFD beam is at the midpoint between the upper and lower transducers. Credit is only taken for inspecting areas that are covered by the focus point. The open housing probe has a PCS-24 transducer with a 55 degree angle of refraction. The Trinity Probe has a PCS-23.4 transducer with a 44 degree angle of refraction. The transducer spacing for the Trinity Probe is less than that of the open housing probe and the transducers are also a smaller size. This causes the focus point of the Trinity Probe transducers to be at a lower elevation than the open housing probe focus point when the probes reach the top of the ID chamfer. Therefore, the Trinity Probe would cover more area at the bottom of the tube. However, due to the difference in the refracted angles, the thread relief on the outside diameter (OD) of the tube interferes with the TOFD beam for the Trinity Probe. So there is an additional area above the thread relief where the Trinity Probe cannot inspect. Figure 3-1 shows the lower transducer at the top of the ID chamfer and the TOFD beam interference with the OD thread relief. Figure 3-2 shows the probe at the minimum elevation where the TOFD beam is not interrupted by the thread relief. The hashed areas from both figures make up the total portion of the tube that cannot be inspected. The dimensions listed in the Table 3-1 are based on the maximum coverage limitation of 0.851 inches shown in the Figure 3-2. With the PCS-24 transducer, the open housing probe circumferential TOFD beam is not interrupted by the OD thread relief. In addition to the circumferential TOFD transducer, the open housing probe has an axial TOFD transducer that the Trinity Probe does not have. The axial TOFD signal allows the open housing probe to inspect the tube down to the top of the ID chamfer. The dimensions listed in the Table 3-1 reflect the axial TOFD transducer coverage limitation of 0.233 inches. This is why the open housing probe coverage is consistently greater than the Trinity Probe coverage. Figure 3-3 shows both the axial and circumferential open housing probe TOFD coverage.

Table 3-1 shows the distance from the toe of the J-groove weld to the top of the zone which cannot be inspected. These dimensions are based on the reactor vessel design drawings for Salem Unit 1. Figure 3-4 illustrates the Trinity Probe TOFD coverage. Field experience has shown that the J-groove weld reinforcement is larger than shown on the design drawings. The penetrations are grouped according to elevation and radial distance from the center of the head. These dimensions are captured by the penetration head angle shown in Figure 3-5. The head angle is measured from the centerline of the

PSEG Response to Question 3 (cont'd):

reactor head to the intersection of the inner radius of the head with the center of each penetration tube.

Table 3-1
TOFD Coverage Below Weld

Pentration Number	Head Angle	Inspection Method	TOFD Coverage below J-weld	
			Uphill Side	Downhill Side
1	0°	Trinity Probe	1.159	1.159
2-5	8.0°	Open Housing Probe	2.327	1.797
6-9	11.4°	Trinity Probe	1.929	1.169
10-13	16.2°	Trinity Probe	2.269	1.169
14, 16, 18, 20	18.2°	Trinity Probe	2.399	1.159
15, 17, 19, 21	18.2°	Open Housing Probe	3.017	1.777
22-25	23.3°	Trinity Probe	2.789	1.169
26-29	24.8°	Open Housing Probe	3.527	1.797
30-33	26.2°	Trinity Probe	3.019	1.169
34	26.2°	Open Housing Probe	3.637	1.787
35-37	26.2°	Trinity Probe	3.019	1.169
38-45	30.2°	Trinity Probe	3.359	1.169
46-49	33.9°	Trinity Probe	3.709	1.189
50-57	35.1°	Trinity Probe	3.829	1.199
58-61	36.3°	Trinity Probe	3.959	1.199
62-69	38.6°	Trinity Probe	4.189	1.199
70-73	44.3°	Trinity Probe	4.839	1.209
74-79	48.7°	Open Housing Probe	6.097	1.837

Figure 3-1
Trinity Probe – Lower TOFD Transducer at Top of Chamfer

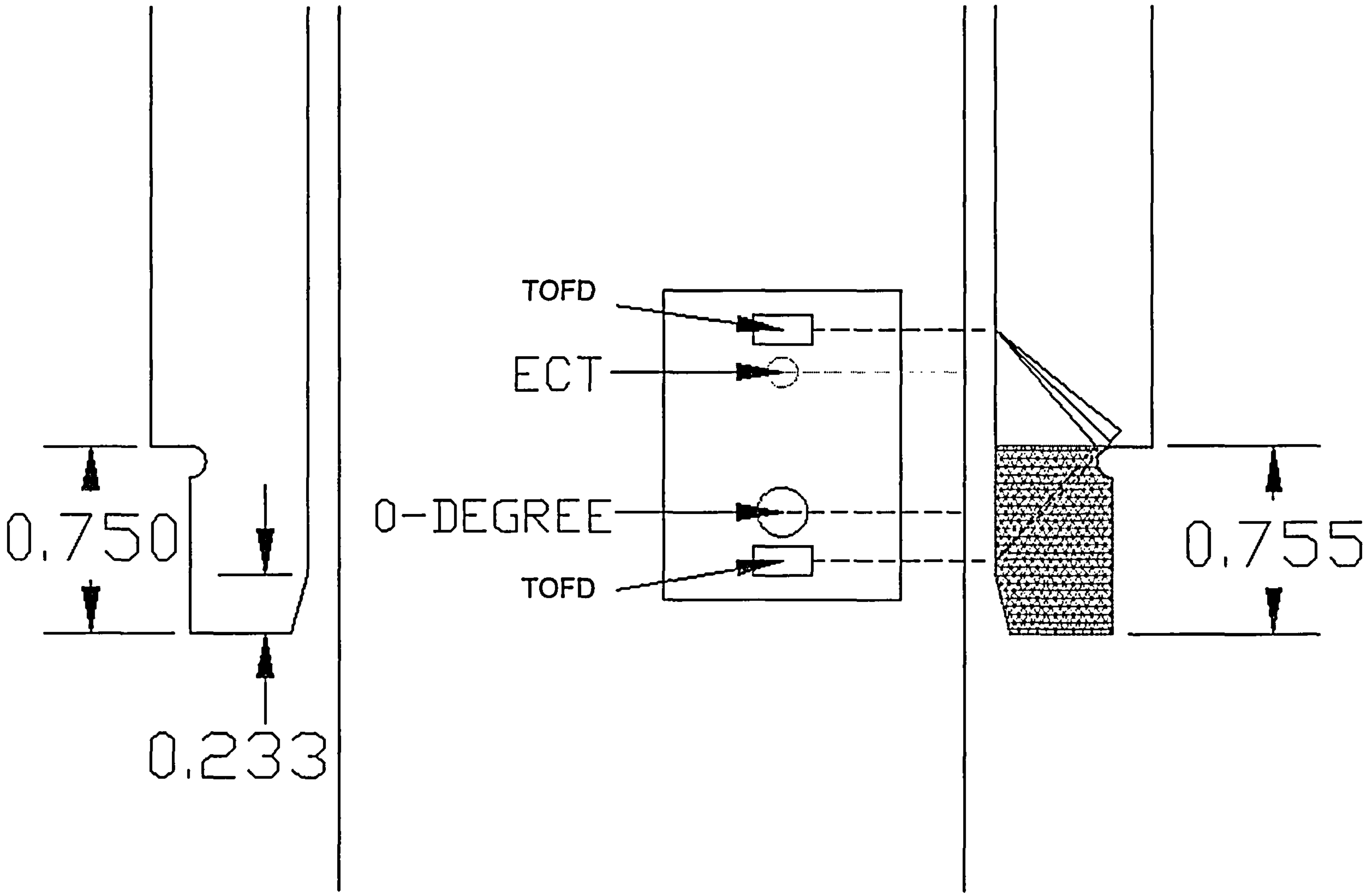


Figure 3-2
Trinity Probe - TOFD Beam Uninterrupted by Thread Relief

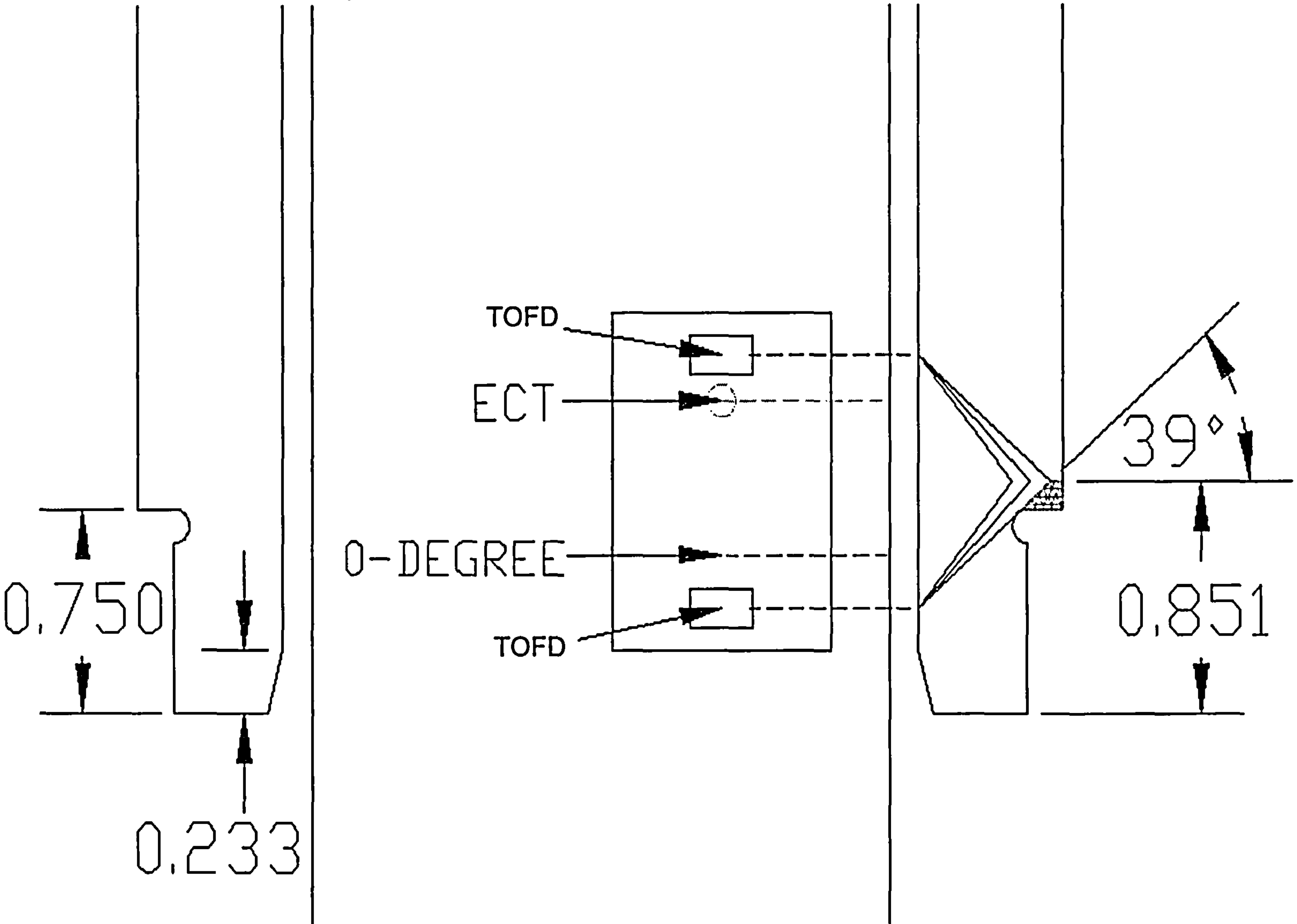
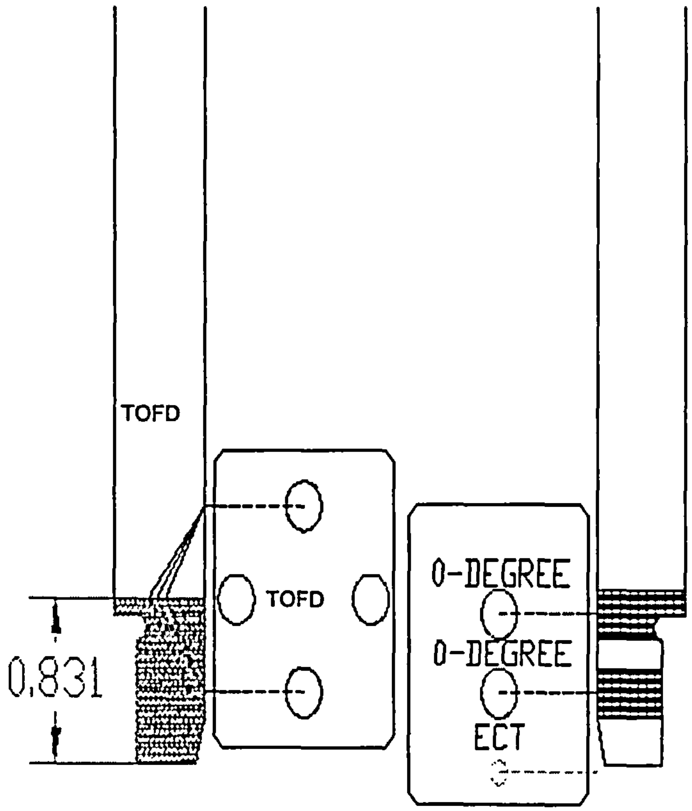
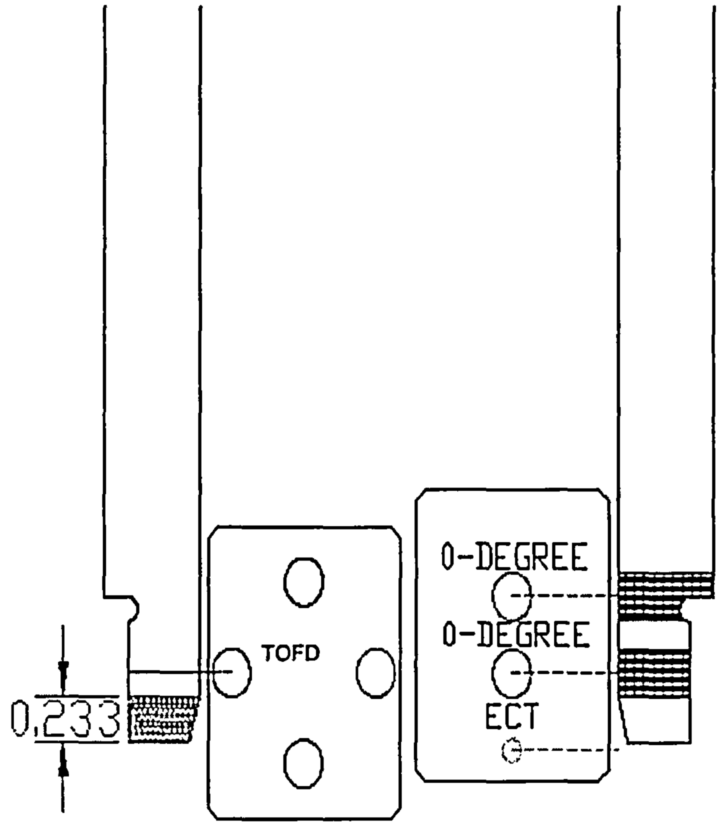


Figure 3-3
Open Housing Probe Coverage



Circumferential TOFD



Axial TOFD

Figure 3-4
Illustration of Trinity Probe TOFD Coverage

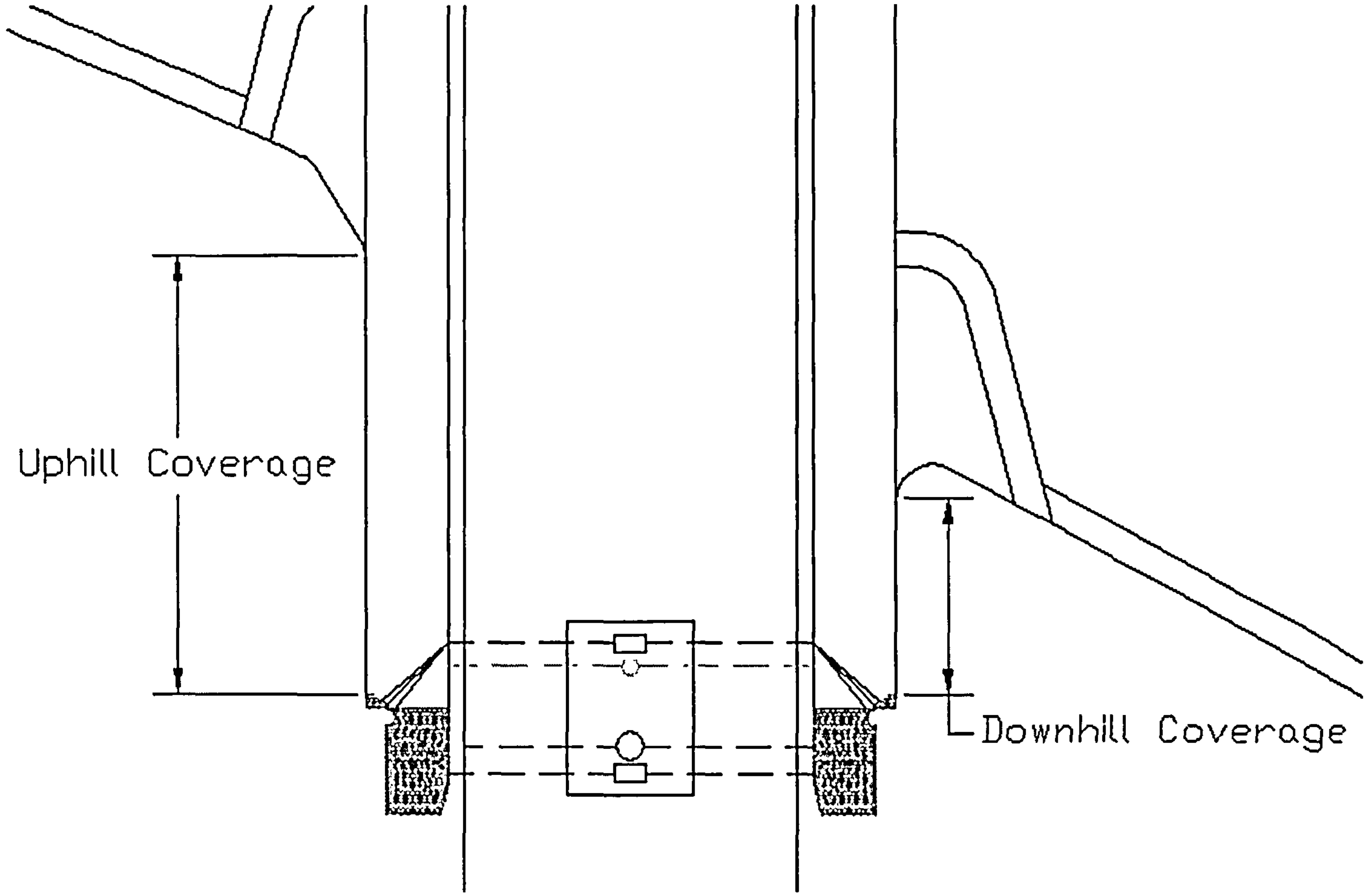
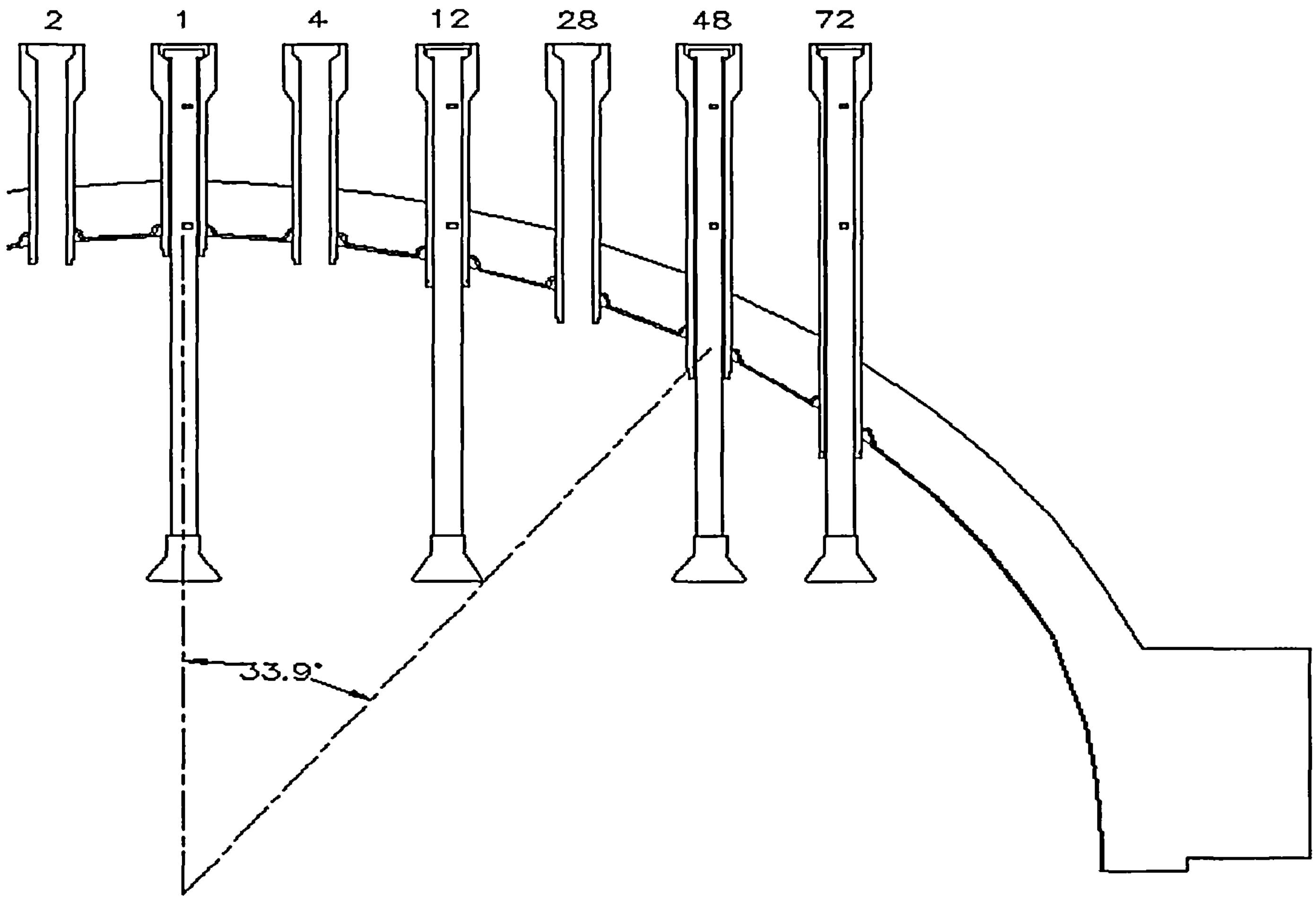


Figure 3-5
Example of Head Angle



NRC Question 4:

Provide a cross sectional figure of the head and penetrations showing how far each penetration protrudes below the bottom surface of the head using as-built dimensions and considering the UT results from the last inspection (if any). Are there any photos from the last or previous outages? If so, provide any photos that show how far the penetrations protrude below the head.

PSEG Response to Question 4:

The Salem 1R16 inspection in April 2004 will be the first under the head UT inspection. Therefore, there are no previous photographs showing how far the penetrations protrude below the head. Information showing the minimum distance that the penetrations protrude below the RPV head is provided in response to question 3.

NRC Question 5:

What is the minimum distance from the bottom of the weld to the point where examination data will not be acquired in the lower portion of the nozzle?

PSEG Response to Question 5:

See response to Question 3.

NRC Question 6:

Describe previous examinations performed on the vessel head and nozzles. Discuss what probes were used, and how any indications were dispositioned. Also, discuss how the UT was qualified.

PSEG Response to Question 6:

Salem 1 prior head examinations were bare metal visual examinations performed in April 2001 in 1R14 and again in October 2002 in 1R15. Both examinations did not find any evidence of boric acid deposits on the surface of the reactor head.

NRC Question 7:

Provide the heat numbers for the RPV head penetration nozzles, and any industry inspection history.

PSEG Response to Question 7:

NEI in January 2003 submitted to the NRC the heat numbers for Salem 1 and the balance of Westinghouse NSSS units. PSEG has reviewed that data to determine whether any heats at Salem 1 reported cracking at any other licensee. Heat Numbers identified at Salem 1 are shown with other licensee locations as follows:

	Heat Number	Other Licensee
Salem 1	NX5983	Diablo Canyon 1 and Robinson
Salem 1	NX5411	Salem 2 and McGuire 1
Salem 1	NX7280	Diablo Canyon 1 and DC Cook 1
Salem 1	NX4882	Indian Point 2 and 3
Salem 1	NX8069	DC Cook 1
Salem 1	NX5965	Diablo Canyon 1 and Indian Point 3
Salem 1	NX5981	Robinson

PSEG has reviewed the reported inspection results from November 2003 for the other licensees with Salem 1 heats and to the best of PSEG knowledge does not find any reported indication that the Salem 1 heats have shown evidence of PWSCC at this time.

NRC Question 8:

The request states that "UT of the most highly stressed portion of the nozzle (the weld heat affected zone) is unaffected by this limitation." Provide tabular listings or graphs of the maximum stresses in the cross-section from the top of the J-groove weld region to the nozzle end for a range of nozzle angles.

PSEG Response to Question 8:

Figures 8-1 through 8-7 are graphs of the inside and outside surface hoop stress distribution from the top of the J-weld to the bottom of the head penetration nozzles. Graphs are provided for the uphill side and the downhill side of the head penetrations for four nozzle angles. There are a total of 15 nozzle angles for the head penetrations at Salem Unit 1. Selected rows of penetrations and the center penetration were analyzed to provide additional results so that a trend can be established as a function of radial location. The penetration nozzle angles selected for this analysis consist of the center penetration (0-degrees), the outermost penetration (48.7°) and two angles in between the center and the outermost penetrations (26.2° and 44.3°).

Figure 8-1

Hoop Stress Distribution Downhill and Uphill Side (0° CRDM Penetration Nozzle)

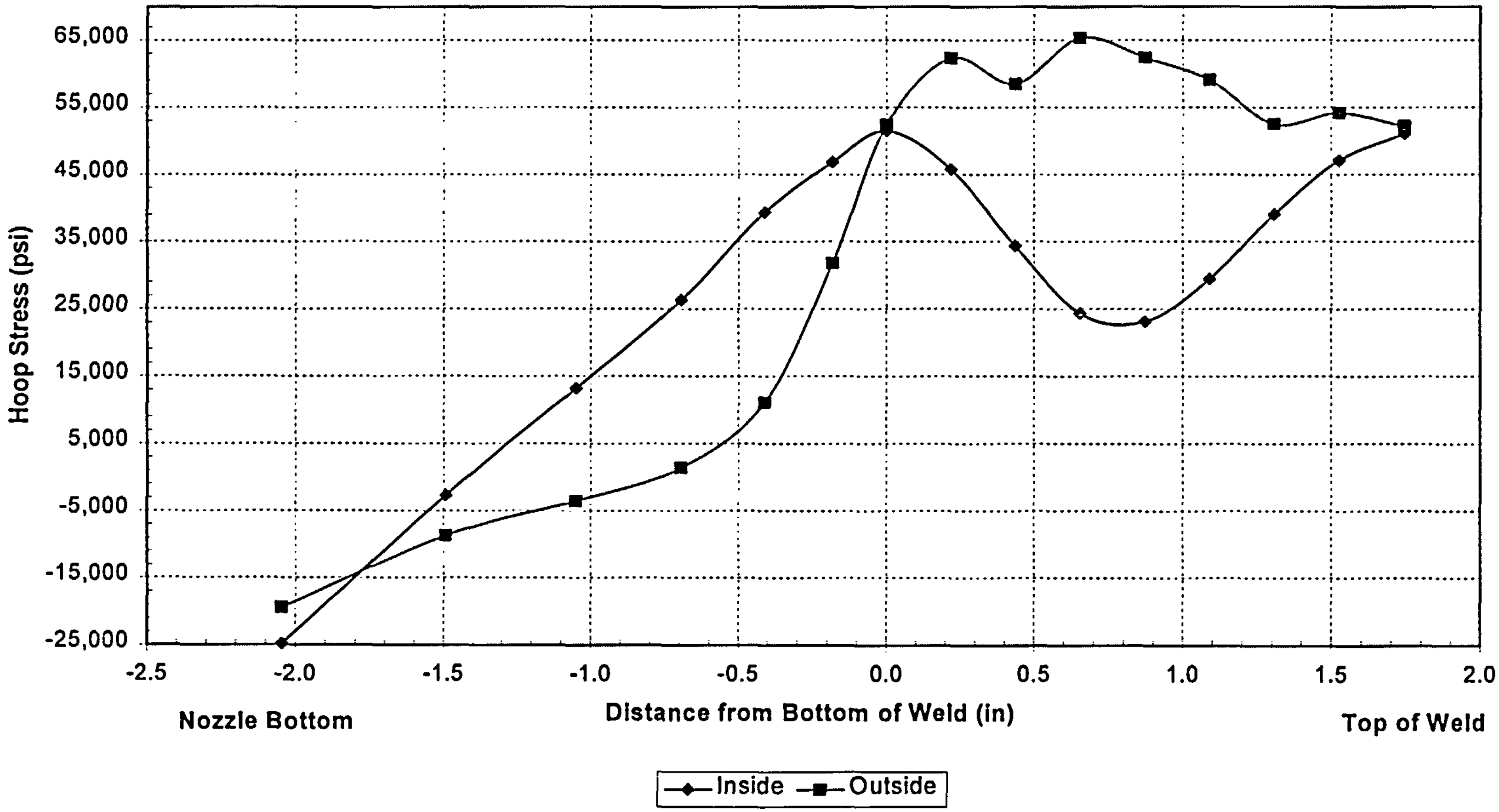


Figure 8-2

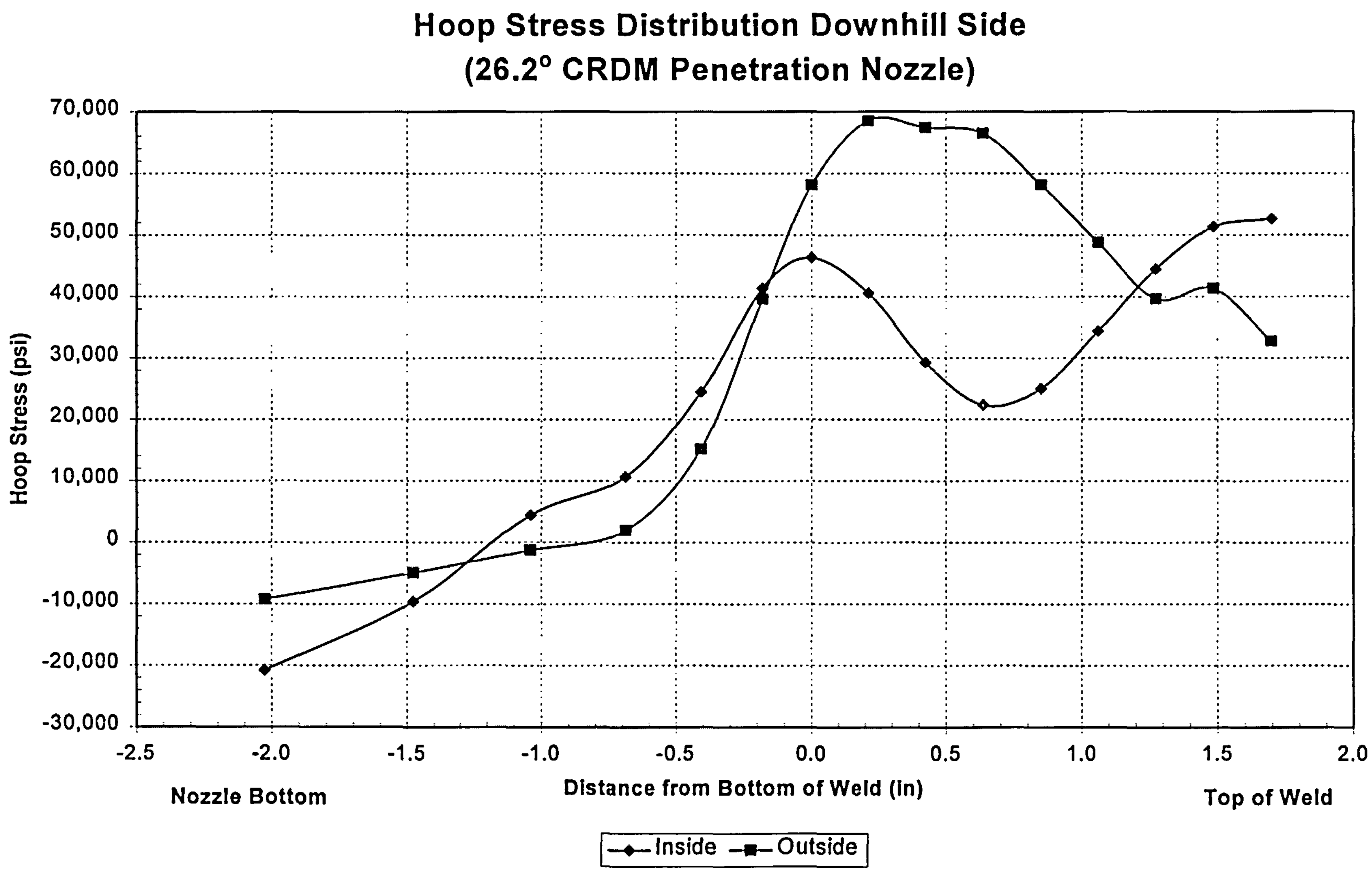
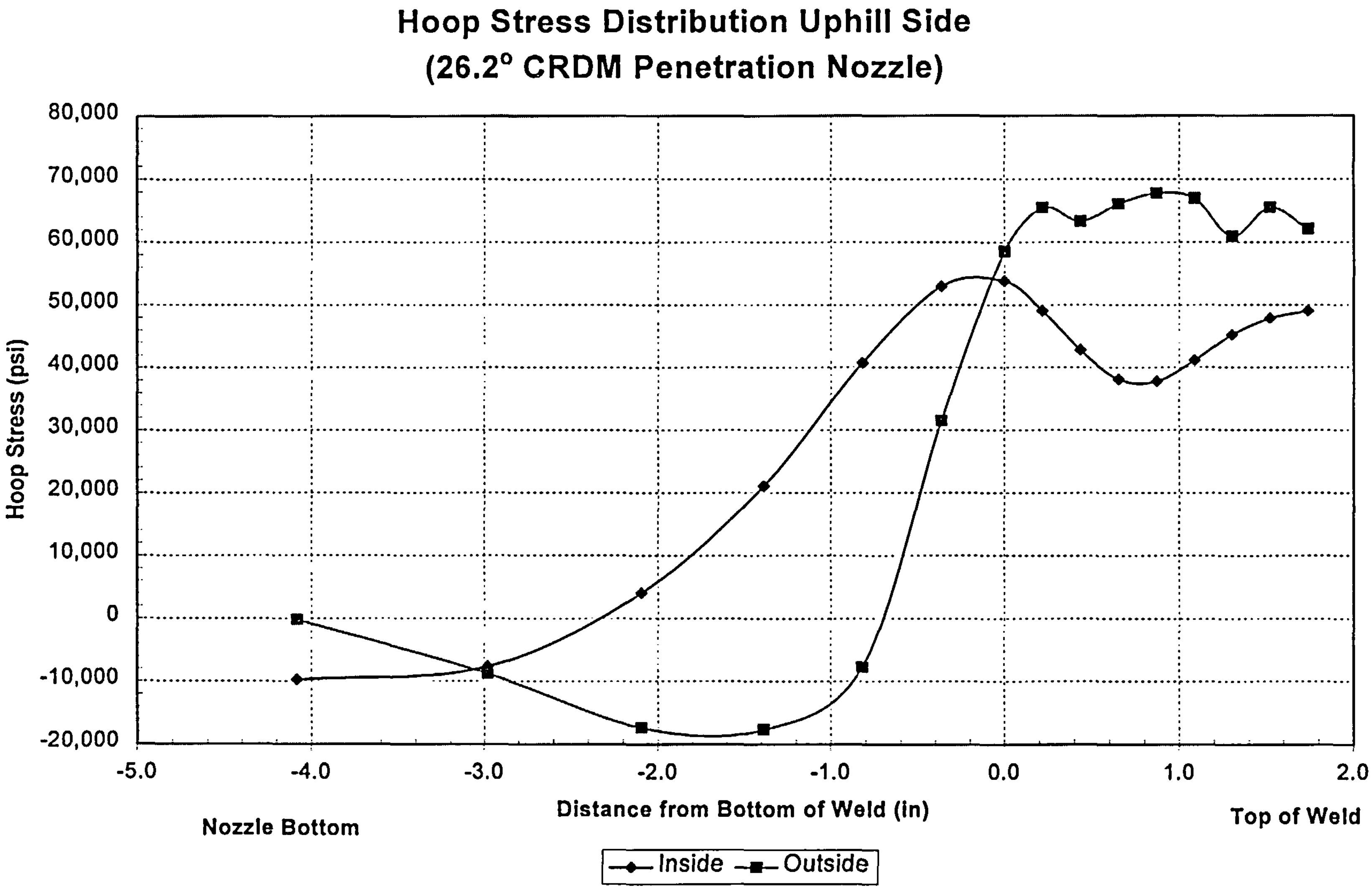

Hoop Stress Distribution Downhill Side
(26.2° CRDM Penetration Nozzle)
Hoop Stress (psi)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Nozzle Bottom
Distance from Bottom of Weld (in)
Top of Weld
Inside
Outside

Figure 8-3


Hoop Stress Distribution Uphill Side
(26.2° CRDM Penetration Nozzle)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
Hoop Stress (psi)
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
Distance from Bottom of Weld (in)
Nozzle Bottom
Top of Weld
Inside
Outside

F

Figure 8-4

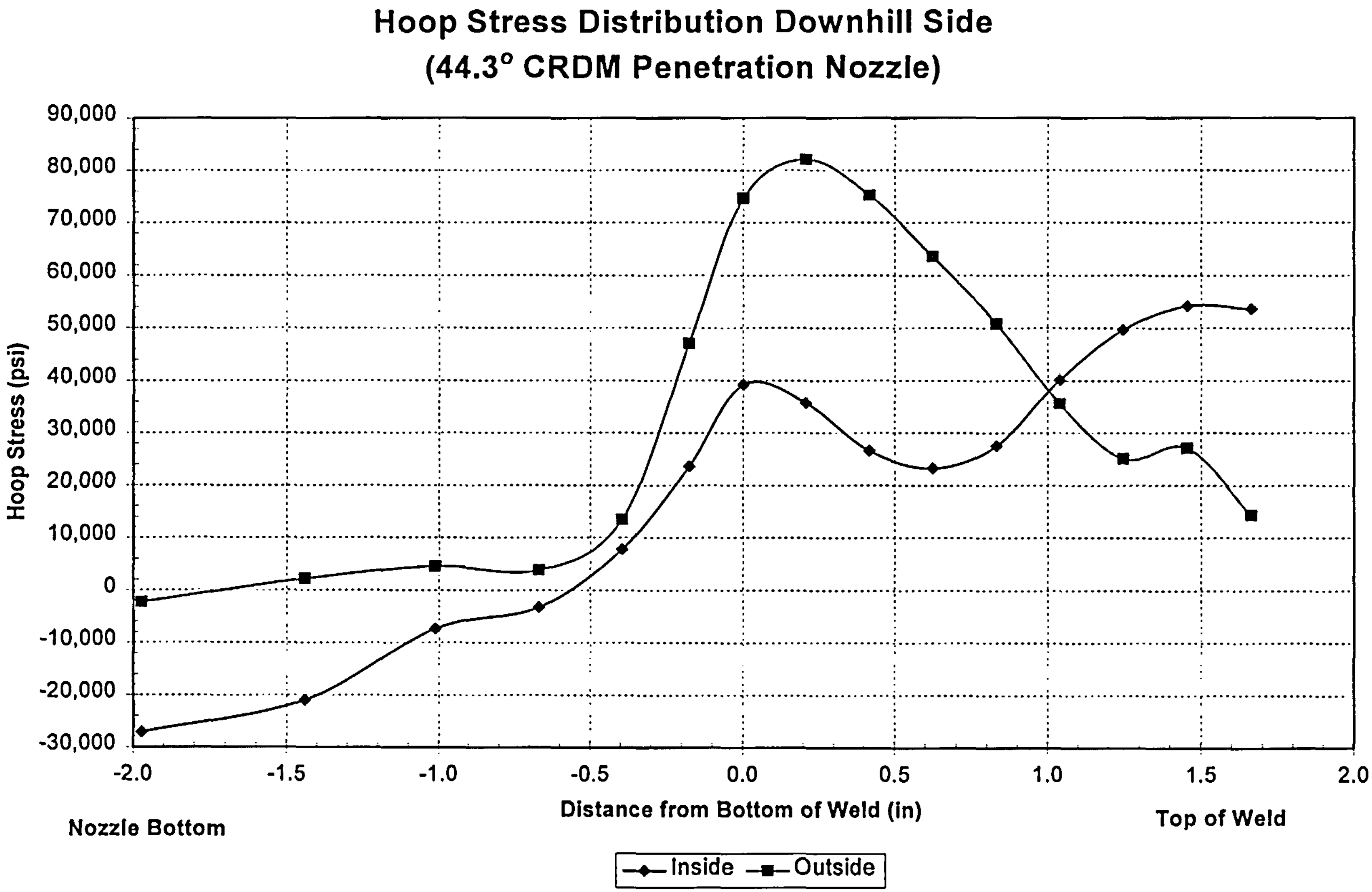

Hoop Stress Distribution Downhill Side
(44.3° CRDM Penetration Nozzle)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
Hoop Stress (psi)
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Nozzle Bottom
Distance from Bottom of Weld (in)
Top of Weld
Inside
Outside

Figure 8-5

Hoop Stress Distribution Uphill Side
(44.3° CRDM Penetration Nozzle)

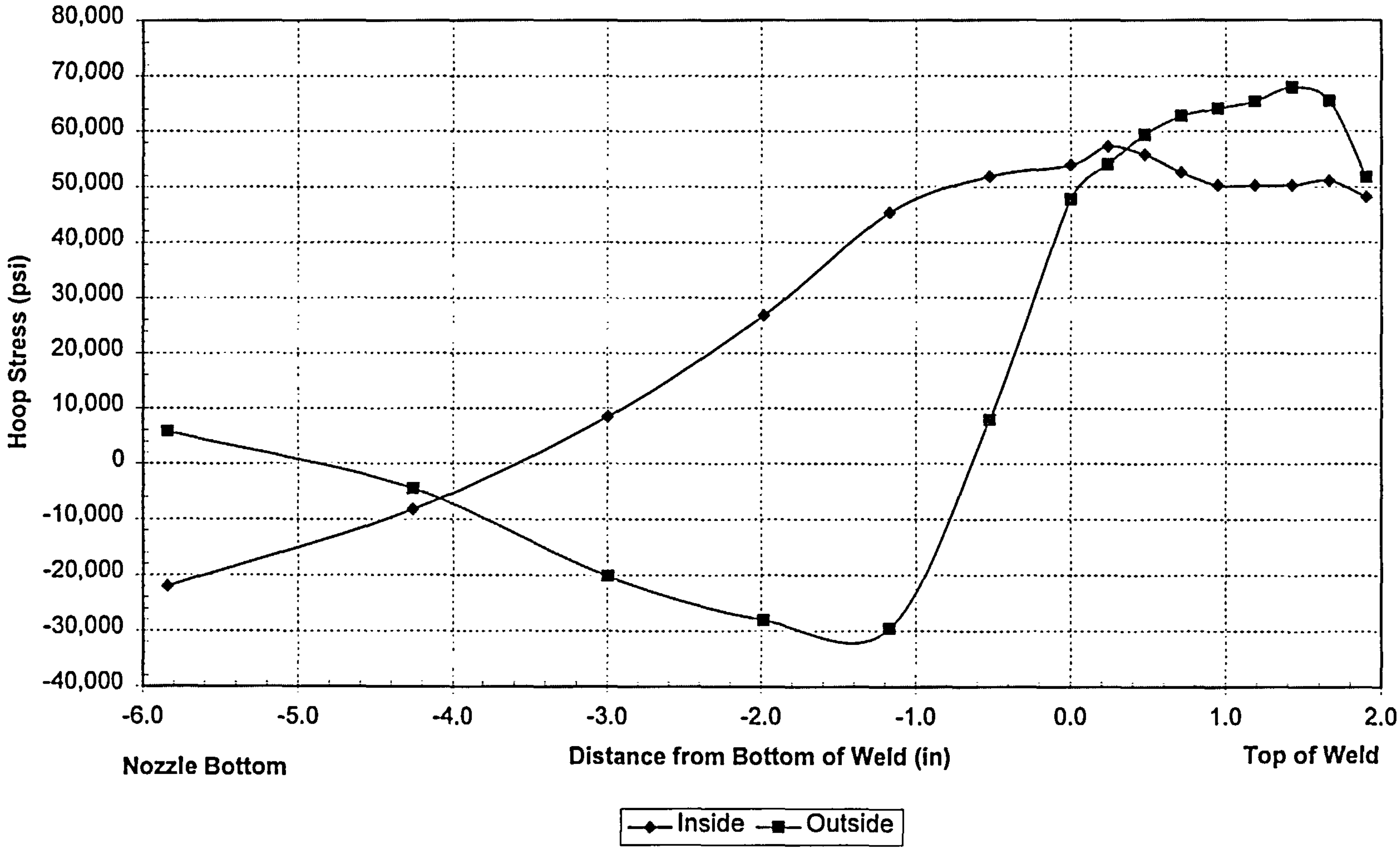


Figure 8-6

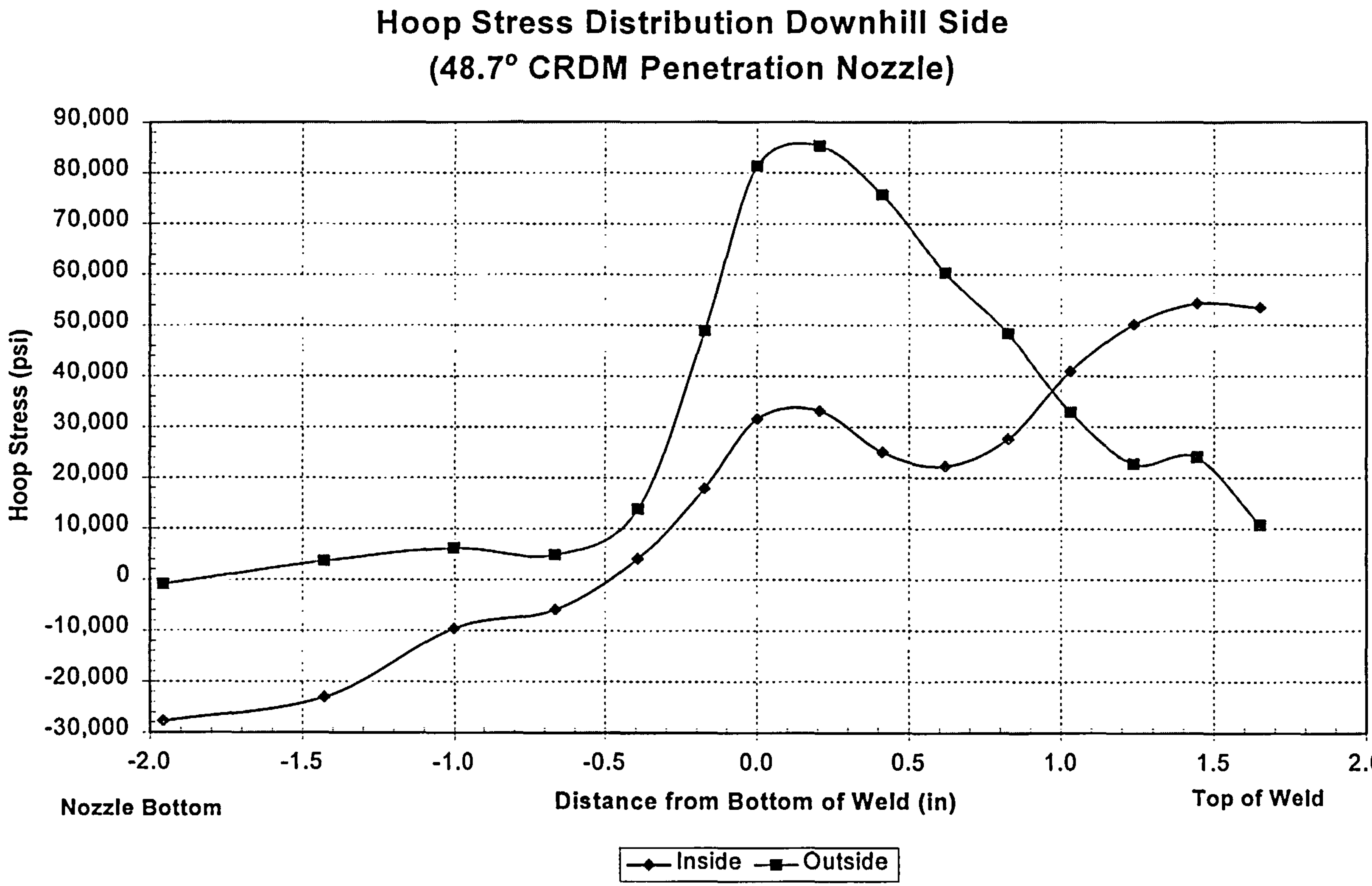
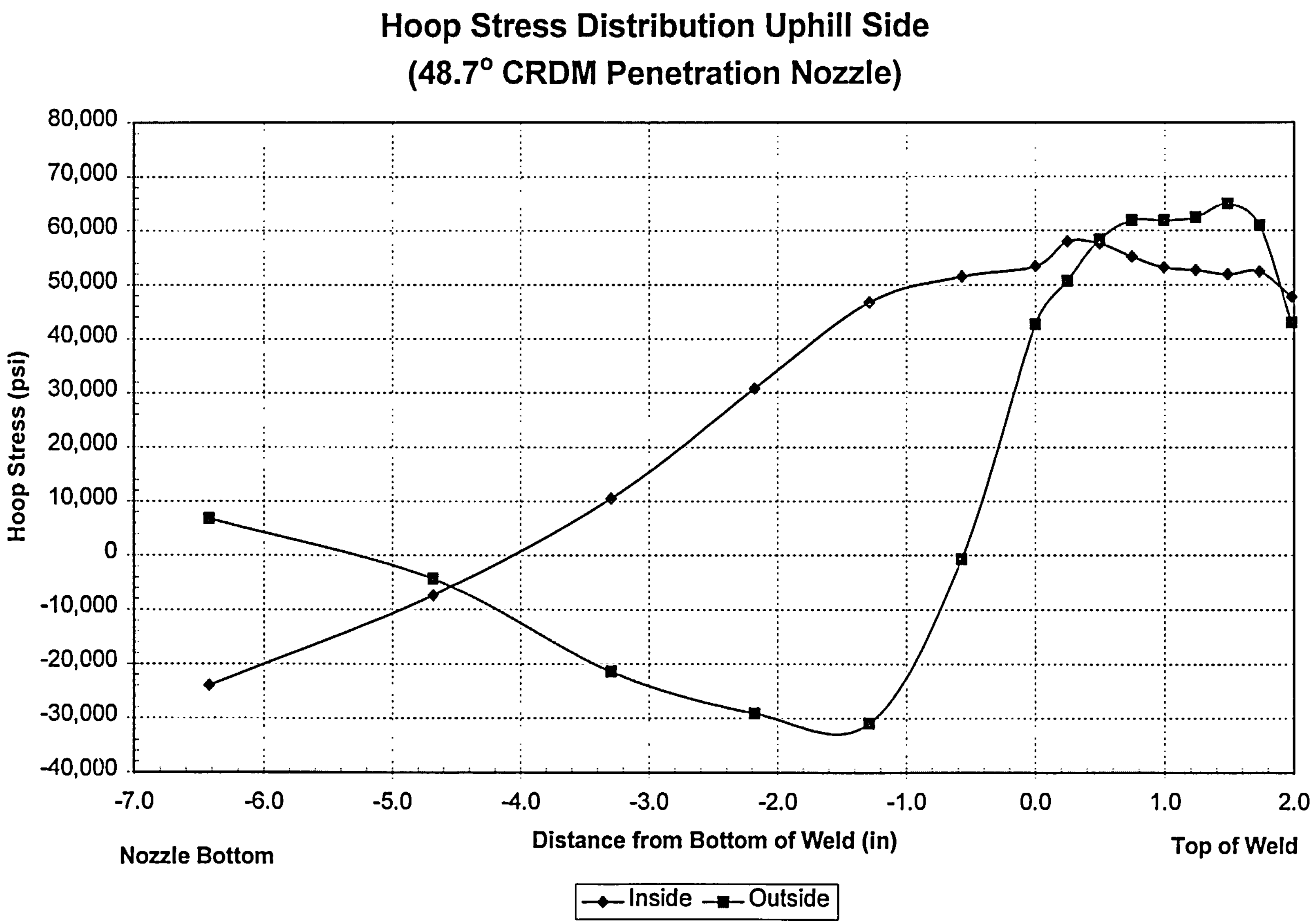

Hoop Stress Distribution Downhill Side
(48.7° CRDM Penetration Nozzle)
Hoop Stress (psi)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Nozzle Bottom
Distance from Bottom of Weld (in)
Top of Weld
Inside
Outside

Figure 8-7


Hoop Stress Distribution Uphill Side
(48.7° CRDM Penetration Nozzle)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
Hoop Stress (psi)
-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
Nozzle Bottom
Distance from Bottom of Weld (in)
Top of Weld
Inside
Outside

NRC Question 9:

Provide a technical justification, such as an analysis or an evaluation, to show that cracks initiated from the unexamined area will not propagate into the pressure boundary and exceed the ASME Code allowable crack sizes within a minimum of one operating cycle using a conservative crack-growth rate from industry experience. Describe uncertainties in this calculation (e.g., stress levels, crack-growth rate, etc.) and the uncertainty in the results.

PSEG Response to Question 9:

A crack growth calculation below the calculated distance below the tip of the weld was performed demonstrating that more than one operating cycle would elapse before a postulated flaw in the unexamined area of the penetration nozzle would propagate into the pressure boundary formed by the J-groove weld. An operating cycle for Salem Unit 1 is 1.5 calendar years, and is typically less than 1.5 Effective Full Power Year (EFPY). The methodology and the technical basis of the crack growth calculation, which was based on the hoop stress distribution provided in the response to Question 8 and the Primary Water Stress Corrosion Cracking (PWSCC) crack growth rate recommended in MRP-55 Rev.1, are provided in WCAP-16214-P, Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Salem Units 1 and 2.

The distance below the J-groove weld to the top of the zone that cannot be inspected has been calculated to be more than 1 inch based on design dimensions (see Table 3-1) with the downhill side of the penetration nozzle being more limiting. However, the upper extremity of an axial through-wall flaw was conservatively postulated to be located at 0.5 inches or less below the J-groove weld in the crack propagation calculation for the downhill side of the penetration nozzle. Figures 9-1 through 9-4 provide results of the calculation. The calculation demonstrates that the minimum time for a flaw to propagate from that location to the bottom of the J-groove weld would be at least 3 EFPY, which is more than 2 operating cycles.

The results of the flaw propagation calculation indicate that, even if a flaw were to occur in the region of the penetration nozzle not being inspected, there would be adequate opportunity for detection prior to the crack reaching the reactor coolant system pressure boundary. The result demonstrates that the extent of the proposed inspection coverage would provide reasonable assurance for the structural integrity of the Unit 1 RPV head penetration nozzles and the J-groove welds.

Figure 9-1
Through-Wall Axial Crack Growth with Initial Upper Crack Tip located at 0.5 inch Below the Weld (Center CRDM Penetration)

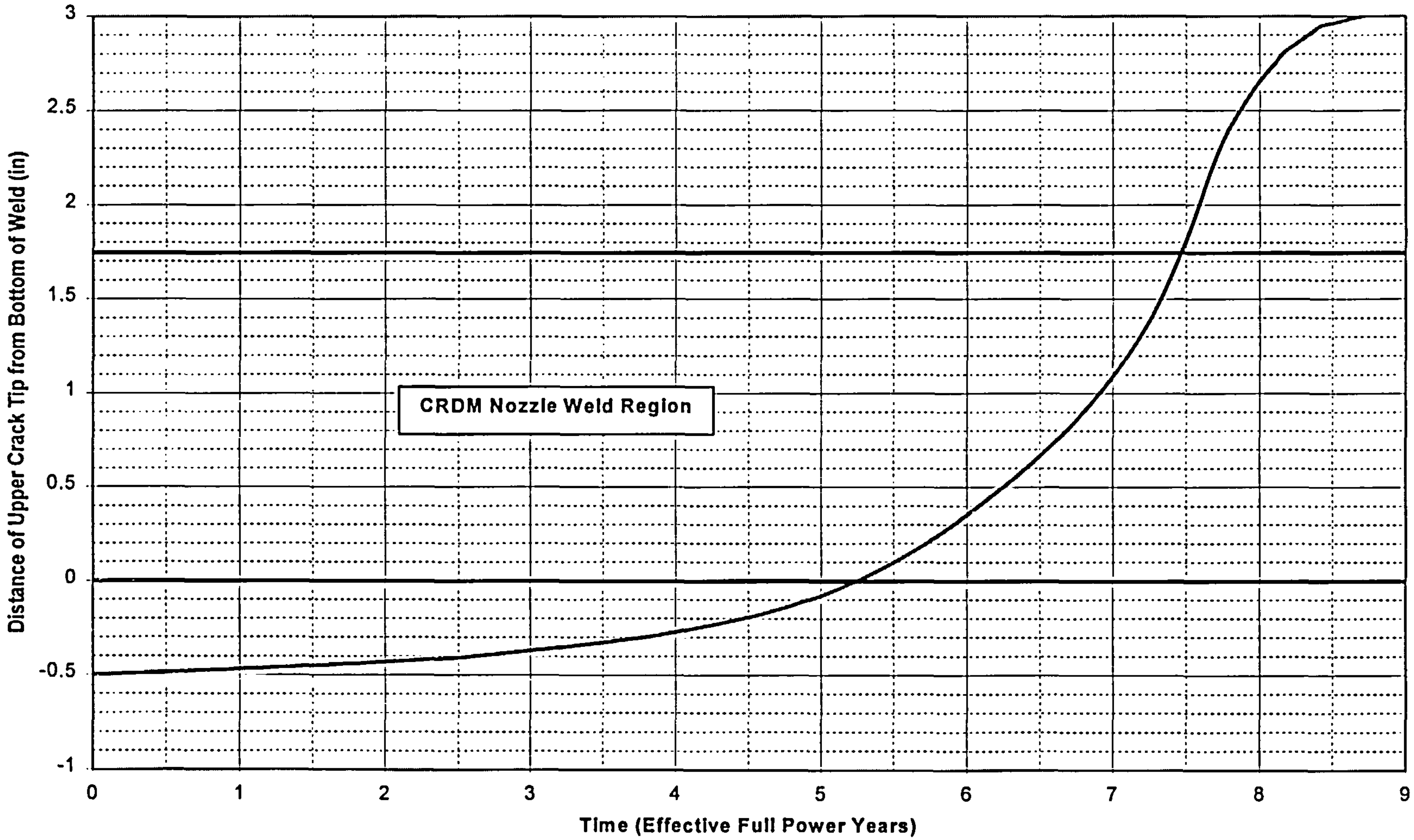


Figure 9-2

Through-Wall Axial Crack Growth with Initial Upper Crack Tip located at 0.5 inch Below the Weld (26.2 Degrees CRDM Penetrations, Downhill Side)

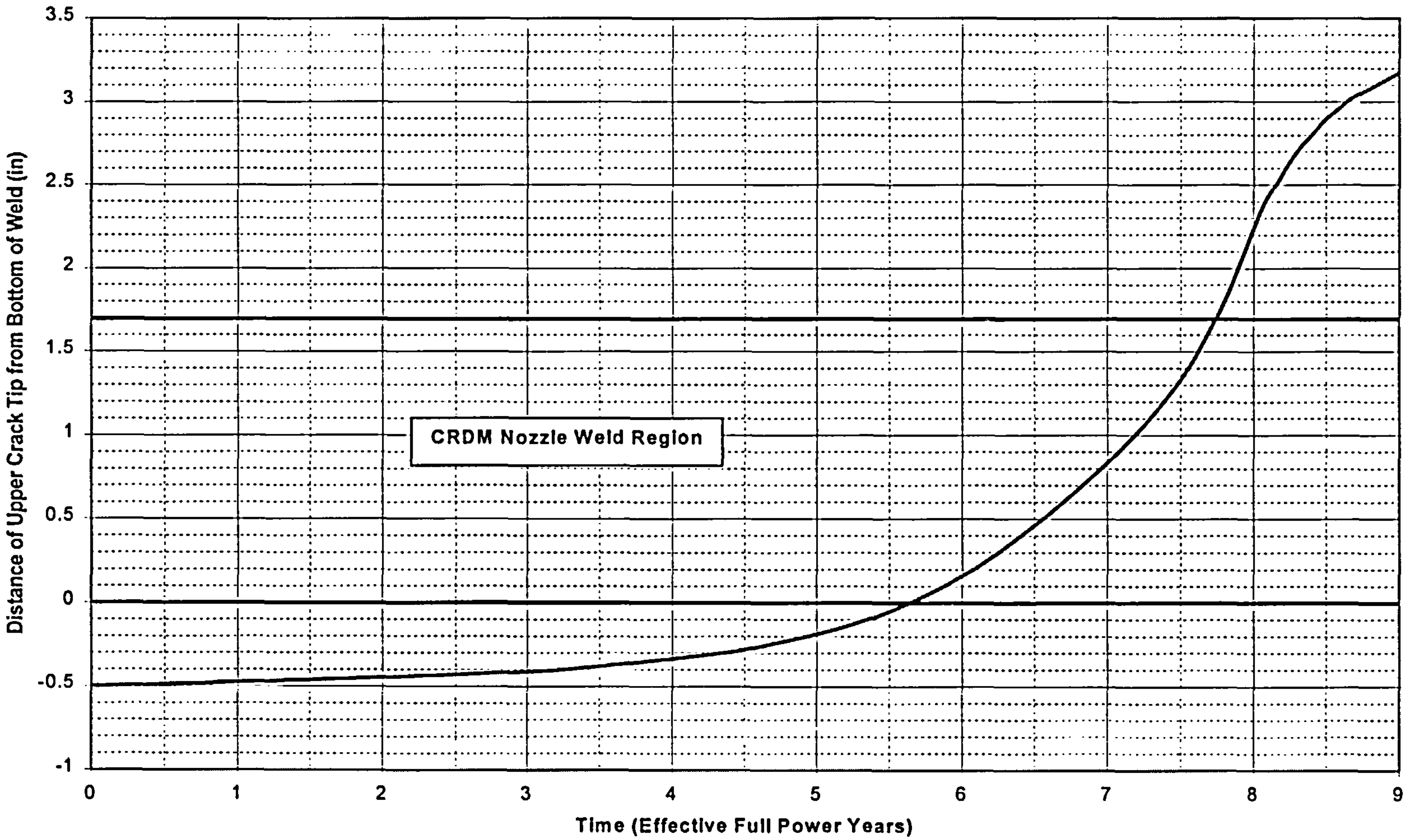


Figure 9-3
Through-Wall Axial Crack Growth with Initial Upper Crack Tip located at 0.3 inch Below the Weld (44.3 Degrees CRDM Penetrations, Downhill Side)

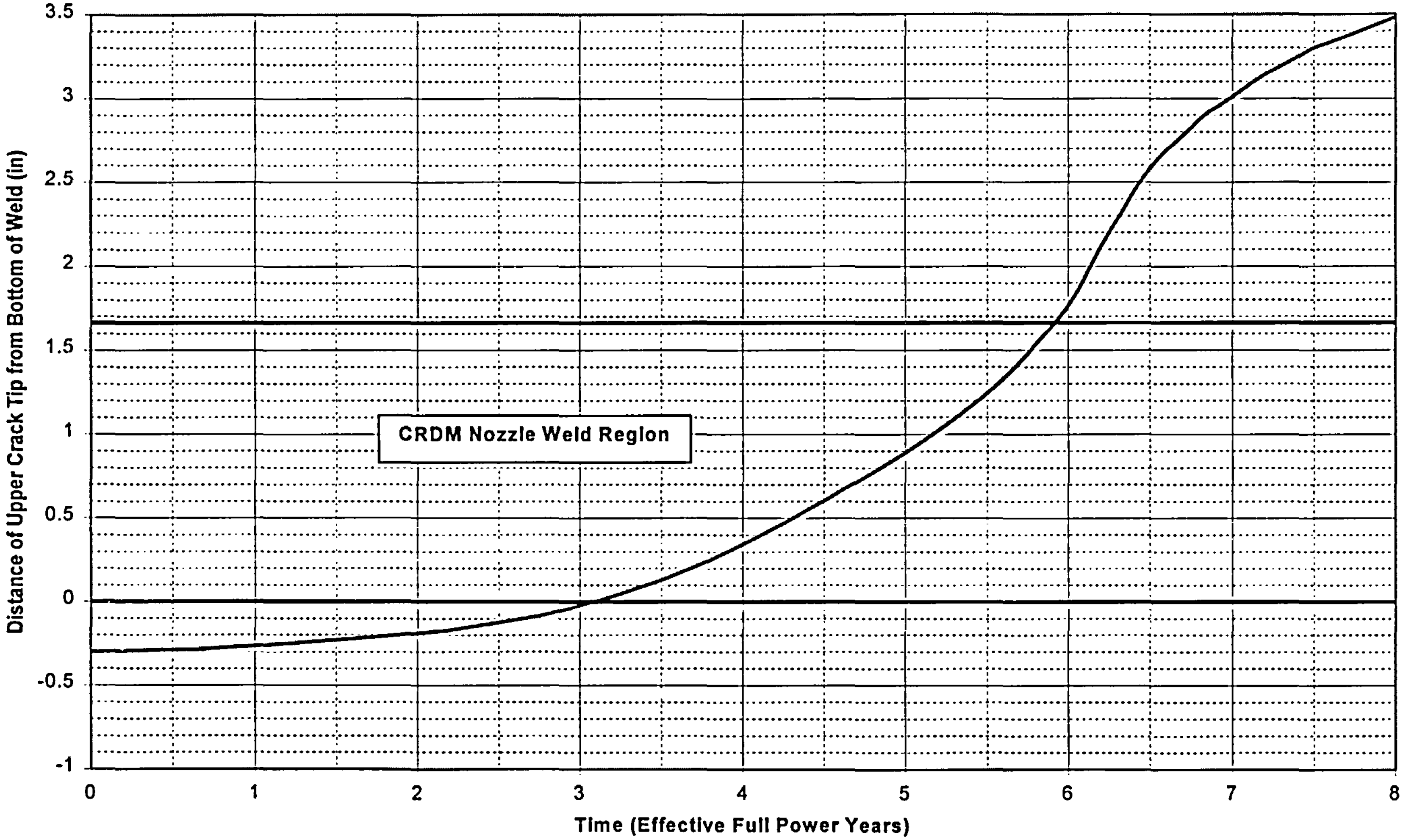
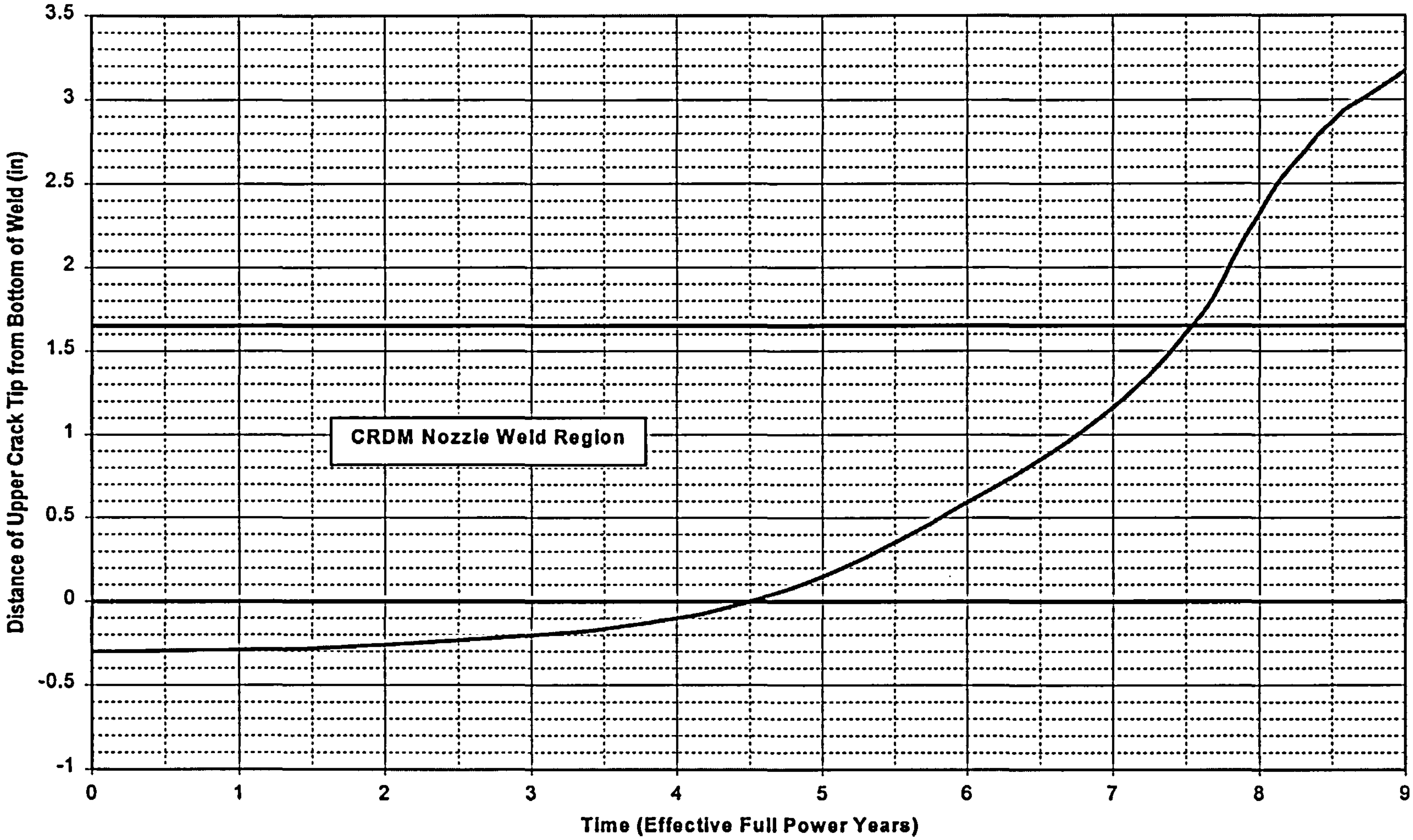


Figure 9-4
Through-Wall Axial Crack Growth with Initial Upper Crack Tip located at 0.3 inch Below the Weld (48.7 Degrees CRDM Penetrations, Downhill Side)



NRC Question 10:

Does the structural integrity evaluation described in your answer to question number 9 use the crack-growth formula in industry report MRP-55? The staff has not made a determination on the subject industry report. Therefore, if using MRP-55, PSEG must agree to and document the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs the licensee of an NRC-approved crack-growth formula. If the licensee's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

PSEG Response to Question 10:

The crack growth used in the structural integrity evaluation for Salem 1 is the same as reported in industry report MRP-55. PSEG agrees to comply with the condition language as stated in this question should this crack growth formula be unacceptable to the NRC.

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233-051-5

D-01

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