Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

November 15, 2004

10 CFR 50.55a(a)(3)(i)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop: OWFN P1-35
Washington, D.C. 20555-0001

Gentlemen:

In the Matter of	)	Docket Nos. 50-260
Tennessee Valley Authority		50-296

BROWNS FERRY NUCLEAR PLANT (BFN) - UNITS 2, AND 3 - AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) SECTION XI, INSERVICE INSPECTION (ISI) PROGRAM - REQUESTS FOR RELIEF 2-ISI-22, AND 3-ISI-18 FOR EXAMINATION OF REACTOR PRESSURE VESSEL (RPV) NOZZLE-TO-VESSEL SHELL WELDS AND NOZZLE INNER RADIUS SECTIONS - RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION (RAI) (TAC NOS. MC0167 AND MC0168)

This letter provides TVA's response to an NRC request for additional information regarding BFN Units 2 and 3 requests for relief 2-ISI-22 and 3-ISI-18. The requests for relief were submitted for NRC review by TVA letter dated July 25, 2003.

These requests for relief sought to reduce the examination frequency for the BFN Units 2 and 3 reactor pressure vessel nozzle-to-vessel welds and nozzle inner radius sections from 100 percent to 25 percent for each system and nominal pipe size. The relief requests cited the Boiling Water Reactor Vessel Internals Project (BWRVIP) technical report "BWRVIP-108: BWR Vessel and Internals Project, Technical Basis for the Reduction of Inspection Requirements for the Boiling Water Reactor Nozzle-To-Vessel Shell Welds and Nozzle Blend Radii," as the technical basis for the requests.

As part its review of TVA's requests for relief the NRC staff, by letter dated March 24, 2004, identified questions where additional information is needed to complete its review.

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The enclosure to this letter contains the specific NRC requests for additional information and the corresponding responses. It should be noted that responses to questions specific to the BWRVIP-108 Report were provided by the Electric Power Research Institute (EPRI).

There are no new regulatory commitments in this letter. If you have any questions, please contact me at (256) 729-2636.

Sincerely,

T. E. Abney
Manager of Licensing
and Industry Affairs

cc: See Page 3

Enclosure
cc (Enclosure):

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ENCLOSURE

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 2 AND 3
AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) SECTION XI,
INSERVICE INSPECTION (ISI) PROGRAM

REQUESTS FOR RELIEF 2-ISI-22 AND 3-ISI-18,
RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

(SEE ATTACHED)

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 2 AND 3
AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) SECTION XI,
INSERVICE INSPECTION (ISI) PROGRAM

REQUESTS FOR RELIEF 2-ISI-22 AND 3-ISI-18,
RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

By letter dated July 25, 2003, TVA submitted BFN Units 2 and 3 requests for relief 2-ISI-22 and 3-ISI-18. These requests for relief sought to reduce the examination frequency for the BFN Units 2 and 3 reactor pressure vessel nozzle-to-vessel welds and nozzle inner radius sections from 100 percent to 25 percent for each system and nominal pipe size. The relief requests cited the Boiling Water Reactor Vessel Internals Project (BWRVIP) technical report BWRVIP-108, "BWR Vessel and Internals Project, Technical Basis for the Reduction of Inspection Requirements for the Boiling Water Reactor Nozzle-To-Vessel Shell Welds and Nozzle Blend Radii," as the technical basis for the requests.

As part its review of TVA's requests for relief the NRC staff, by letter dated March 24, 2004, identified questions where additional information is needed to complete its review. Listed below are the specific NRC requests for additional information and the corresponding responses.

Responses to RAI 2-1 through 2-10 and RAI 2-14 through 2-20 were prepared by the BWRVIP and are generically applicable to the fleet of BWRs. The BWRVIP is requesting NRC to review these responses with the objective of approving Code Case N-702 which permits a reduction of the BWR nozzle-to-shell welds and nozzle blend radii inspections from 100 percent to 25 percent of the nozzles every 10 years. BWRVIP-108 and the responses to these RAIs provide the generic technical basis to support this Code Case.

NRC RAI 1-1

Estimate the dose saving for inspection of each type of nozzles associated with the relief requests

TVA Response to RAI 1-1

The dose savings for BFN Units 2 and 3 would be approximately 10 to 11 Man Rem for each unit during a ten-year inspection interval.

This estimate includes craft preparation, examination, and RADCON dose incurred. The estimated dose savings for each type of nozzle is provided below.

N1 - Recirc Outlet Nozzles =	1.5 Man Rem (1 nozzle reduction)
N2 - Recirc Inlet Nozzles =	6.0 Man Rem (7 nozzle reduction)
N3 - Main Steam Nozzles =	1.5 Man Rem (3 nozzle reduction)

N5 - Core Spray Nozzles =	0.5 Man Rem (1 nozzle reduction)
N6 & N7 - RPV Head Nozzles =	0.050 Man Rem (1 nozzle reduction)
N8 - Recirc Instrument Nozzles =	0.6 Man Rem (1 nozzle reduction)

NRC RAI 1-2

Elaborate on the plant-specific inspection history by (a) identifying the type of nozzles (e.g., main steam nozzles or core spray nozzles) being inspected and the extent of coverage for each type, (b) providing information regarding disposition of reportable indications, especially those requiring flaw evaluations, and (c) providing the operating hours accumulated to date for each nozzle.

TVA Response to RAI 1-2

The majority of the above requested information was provided in Attachment B of requests for relief 2-ISI-22 and 3-ISI-18. The information has been updated to reflect the Unit 3 (Spring 2004) refueling outage examinations and provided as Attachments A (Unit 2) and B (Unit 3) of this enclosure.

The nozzle identification numbers shown in Attachments A and B, the corresponding plant system, and nozzle size are provided below:

N1A and N1B - Reactor Recirculation Outlet Nozzles (28-inch diameter), (Total of 2 nozzles)

N2A, N2B, N2C, N2D, N2E, N2F, N2G, N2H, N2J, and N2K - Reactor Recirculation Inlet Nozzles (12-inch diameter), (Total of 10 nozzles)

N3A, N3B, N3C, and N3D - Main Steam Nozzles (26-inch diameter), (Total of 4 nozzles)

N4A, N4B, N4C, N4D, N4E, N4F - Feedwater Nozzles (12-inch diameter), (Total of 4 nozzles)

N5A and N5B - Core Spray Nozzles (10-inch diameter), (Total of 2 nozzles)

N6A, N6B, and N7 - Reactor Pressure Vessel (RPV) Head Nozzles, N-6 (6-inch diameter), N-7 (4-inch diameter), (Total of 3 nozzles)

N8A and N8B - Jet Pump Instrumentation Nozzles (4-inch diameter), (Total of 2 nozzles)

N9 (capped) - Control Rod Drive Return Line Nozzle (4-inch diameter), (Total of 1 nozzle)

N10 - Standby Liquid Control Nozzle (1.5-inch diameter), (Total of 1 nozzle)

The operating hours for the nozzles in each unit (as of the unit's most recent refueling outage) are as follows.

As of February 24, 2003: Unit 2 operating hours - 5,781.05 Full Power Days (15.96 FPY)

As of March 01, 2004: Unit 3 operating hours - 4,602.57 Full Power Days (12.86 FPY)

NRC RAI 2-1

It is stated in Section 3.2 that "On BWR/6 RPVs, all nozzles except recirculation nozzles are unclad to improve the capability for inspection of the nozzle-to-shell welds by ultrasonic testing (UT)." Is cladding modeled in your finite element method (FEM) model for the RPV recirculation nozzle? Provide an assessment of the impact on the final probabilistic fracture mechanics (PFM) results if cladding is not modeled in the FEM model for the recirculation nozzle (Page 3-2).

BWRVIP Response to RAI 2-1

All finite element models used in the analyses are without the stainless steel cladding, including the recirculation nozzles. The presence of stainless steel cladding has a small effect on the nozzle thermal stresses [1,2]. The nozzle thermal stresses depend on the heat transfer coefficient at the nozzle inside surface. The cladding has an effect only near the inner surface of the nozzles. Also, the effect is more severe when there is a steep through-wall temperature gradient. This situation usually happens only at the beginning of thermal transients, with a step or large gradient change of the temperature at the inside surface of the nozzle.

This localized surface thermal stress due to the stainless steel cladding has some effect on the crack initiation in the cladding. But this surface thermal stress effect is only very transient in nature, since it occurs mostly at the early stage of the transient. Its effect diminishes when a steady state condition is achieved. The crack growth, either stress corrosion (SCCG) or fatigue (FCG), is governed more by the overall through-wall stress distribution at steady state.

In the fracture mechanics evaluation, it is also assumed that, when a crack is initiated, the initial crack depth is the same as the clad thickness. This initial crack size will not fracture until the crack grows deep enough into the wall thickness. When the crack grows deeper, to depths where the effect of the cladding is not significant, it is the overall through wall stress distribution that is the predominant factor in determining the stress intensity factor, not the local stress at the inside surface due to the presence of the stainless steel cladding.

In the probabilistic fracture mechanics (PFM) evaluation, the effect of the cladding residual stress is accounted for in the nozzle-to-shell weld evaluation. The residual stress due to the cladding is shown in Figure 1, [3]. The cladding residual stress is a random variable in the PFM evaluation. Therefore, the impact of the cladding as a residual stress effect is included in the evaluation for the nozzle-to-shell weld.

NRC RAI 2-2

Provide a quantitative assessment of the impact on the final PFM results by your assumption that SA-302, Grade B, modified material is equivalent to SA-533 Grade B, Class 1, for the vessel and that the modified SA-366 is equivalent to SA-508, Class 2, for the nozzles (Page 4-2).

BWRVIP Response to RAI 2-2

The chemical composition for SA 302 Grade B, and SA 533 Grade B are:

SA 302 Grade B: Mn - ½ Mo,
SA 533 Grade B: Mn - ½ Mo - ½ Ni.

The chemical composition for SA 336, and SA 508 Class 2 are:

SA 336: Ni - ½ Mo - ½ Cr,
SA 508: Class 2: ¾ Ni - ½ Mo - 1/3 Cr – V

The mechanical and thermal properties for these four steels are obtained from Reference 4 for comparison to provide a quantitative assessment. The mechanical properties include Young's modulus (E) and thermal expansion (α). The thermal properties include thermal conductivity (K) and thermal diffusivity.

The comparison between SA 302 and SA 533 is presented in Table 1. For the mechanical material properties, these two materials are the same. For the thermal material properties, the largest difference is 5.62 percent, in diffusivity at 100 °F.

The comparison between SA 336 and SA 508 is presented in Table 2. For the mechanical material properties, these two materials are the same. For the thermal material properties, the largest difference is 1.51 percent, in diffusivity at 100 °F. These differences are considered small in the finite element analyses of the nozzles. These small differences will not have a significant effect on the analysis results.

NRC RAI 2-3

The summation sign Σ in Equation (4-3) suggests that force F is a discrete function. Provide the theta value for each discrete F value and demonstrate that the summation of all moments generated by discrete forces is M_{RES} (Page 4-3).

BWRVIP Response to RAI 2-3

A unit moment of 1 in-kip was applied to each nozzle in the finite element model. Table 3 provides the discrete values (forces and moment arm) at each angle for the four nozzles: core spray, main steam, recirculation inlet, and recirculation outlet. The summation of moments for each nozzle is presented in the last row in the Table 3. It is shown that the difference is no more than 0.2 percent from the unit moment of 1000 in-lbs.

NRC RAI 2-4

Provide the applied forces and bending moments for all four types of nozzles and justify the exclusion of the twisting moment (moment about the x-axis in Figure 4.10) from your analysis. Compare your applied forces and bending moments with design loads for boiling-water reactor (BWR) plants and demonstrate that your selection is bounding (Page 4-3).

BWRVIP Response to RAI 2-4

The nozzle loads are used in the finite element analysis. The stresses due to these nozzle loads were not included in the PFM evaluation since they do not cause significant stresses at the two locations of interest. The postulated cracking is at the nozzle blend radius region or nozzle-to-shell weld, not at the pipe to safe-end weld or safe-end to nozzle weld. The wall thickness at the nozzle blend radius region and nozzle-to-shell weld location is much thicker than the pipe or safe-end wall thickness. The significant stresses in these locations (i.e., nozzle blend radius and nozzle-to-shell weld) are due to internal pressure and the thermal transient loadings on the inside vessel surface.

In the crack growth evaluation, the axial or hoop stresses are the driving forces because the crack is usually in the longitudinal or the circumferential direction. Torsional moment is used only when a Mode III crack is evaluated. For vessels and piping, either a circumferential crack or a longitudinal crack (Mode I crack), is the dominant mode of failure. Therefore, the torsional moment is not used which is consistent with typical ASME Section XI flaw evaluations procedures.

NRC RAI 2-5

Justify your selection of the thermal loads for the four types of nozzles. Compare your idealized thermal loads shown in Figure 4-12 to Figure 4-20 with those from operating history of BWR plants and demonstrate that your selection is bounding (Page 4-4).

BWRVIP Response to RAI 2-5

Thermal transients on nozzles and the RPV are typically defined in the thermal cycle diagrams (TSDs). Several TSDs for various plants were reviewed and the transients used in the analysis were considered representative of the significant transients these nozzles are subjected to. Although not all plants were evaluated, which would be a tedious and significant effort, the transient definitions are not expected to vary significantly such that it would invalidate any of the results obtained.

T. Sakai et al., and D. Pando et al., [18,19] observed, based on comparison of actual measured temperature (using fatigue monitoring systems) that actual transients are much less severe than those assumed in the thermal stress analyses, Figures 2 through 4. Therefore, the selection of transients is considered appropriate and conservative for this analysis.

In addition, some of these transients analyzed in BWRVIP-108 are for emergency conditions (i.e., SRV Blow Down & Loss of Feedwater Pumps) that may not have happened in the operating plants that have installed a system to record the data. Therefore, there may not be any real operating data

available for comparison. For many of these emergency events, instantaneous or assumed near-instantaneous temperature/flow changes are assumed which provides higher bound results.

NRC RAI 2-6

The boundary conditions for your FEM model are shown graphically in Figure 4-21. Clarify them by using three translational degrees of freedom, for example, specify the boundary conditions at the bottom nodes as: r(free), θ(free), and z(fixed). Also, point out the degrees of freedom that you specified in the FEM model to prevent the rigid body motion (Page 4-5).

BWRVIP Response to RAI 2-6

The global coordinate system for the model is shown in Figure 4-21 of Reference 5. The global x-axis is into the nozzle towards the center of the vessel (parallel to nozzle centerline). The global y-axis is in the vertical direction, in the direction of the longitudinal axis of the vessel. The global z-axis is defined by the right hand rule.

A symmetry boundary condition is imposed at the circumferential end of the vessel portion of the model, Figure 4.4 of Reference 5. This represents a zero displacement normal to the vertical end surface at the vessel portion of the model. In terms of the global Cartesian coordinate system, at this surface, there is deformation in the global Cartesian x- and z- directions. But after a transformation from a global Cartesian coordinate system to a local cylindrical system for the vessel, there would be no displacement in the local cylindrical θ (hoop)-direction of the vessel, but there still would be displacement in the local cylindrical r (radial)-direction of the vessel. Deformation in the longitudinal direction (i.e., vertical direction) of the vessel can also occur.

A symmetrical boundary condition is imposed at the bottom end of the vessel portion of the model. This represents a zero displacement in the vertical (y-direction in the global coordinate system) direction at this location (vertical displacements are with respect to this reference location). Since this boundary condition is at the bottom plane of the model, it will prevent the rigid body motion of the model.

NRC RAI 2-7

Figures 4-30 through 4-37 show the stresses for the blend radius and the nozzle-to-vessel shell weld for the four types of nozzles. Explain (1) why the pressure-induced hoop stress varies so much azimuthally, considering that the nozzle hole in the vessel will have similar effect on all azimuthal positions, especially when the typical angular distance between the nozzle and the edge of the FEM model is about eight times the diameter of the nozzle and (2) why the hoop stresses at nozzle blend radius are significantly worse than those at the nozzle-to-shell weld. This serves as a check of your FEM modeling accuracy (Page 4-5).

BWRVIP Response to RAI 2-7

The pressure hoop stress varies azimuthally because the geometric configuration changes from a longitudinal plane (i.e., along vertical direction) to transverse plane (i.e., in the x-z plane). Along the

longitudinal plane, the vessel section is a straight section. At the transverse plane (cut horizontally), the vessel section is a circular section. This section shape has a significant effect on the stress in the nozzles blend radius region. In addition, the discontinuity of the nozzle to vessel intersection adds to the magnitude of the nozzle blend radii stresses.

Three-dimensional finite element analyses have been performed for nozzle stresses due to pressure and thermal loadings, [6,7]. They show significant stress variation at the azimuth locations. Figures 5 and 6 present the hoop stress at the longitudinal plane and the transverse plane, respectively, of a nozzle subjected to an internal pressure [6]. The maximum hoop stress at the nozzle blend radius in the longitudinal plane, Figure 5, is higher than the hoop stress at the nozzle blend radius in the transverse plane, Figure 6.

The hoop stresses for the four nozzles: core spray, recirculation inlet, recirculation outlet, and main steam are shown in Figures 7 through 10, respectively. The stresses in these figures are obtained using a local cylindrical coordinate system, such that the r (x)-axis is in the radial direction of the nozzle, θ (y)-axis is in the circumferential (or hoop) direction of the nozzle, and the z-axis is in the longitudinal centerline of the nozzle. These also show the hoop stress at the longitudinal plane (i.e., 90° and 270°) is higher than the transverse plane (i.e., 0° and 180°).

This is consistent with the ASME Code Section III, NB-3338. Stress indices are used to calculate the nozzle stress. It is also shown that the hoop stress in the longitudinal plane, at the inside surface of the nozzle is higher than the hoop in the transverse plane, at the inside surface.

Table 5 presents the comparison of the stresses at the longitudinal plane and transverse plane among the four nozzles, results from Reference 6, and stress indices from Reference 8. It is shown that they have a very similar ratio, except the recirculation outlet and main steam nozzles. The high stress ratios for the recirculation outlet and main steam are due to the taper inside surface at the nozzle bore region, shown in Figure 11.

NRC RAI 2-8

The assumed cracks are described in the statement, "The fracture mechanics evaluation presented in Sections 5 and 6 considers flaws either parallel or perpendicular to the nozzle-to-shell weld location. The evaluation considers an axial flaw at the nozzle blend radii." Provide schematics of these three types of flaw (location and orientation) in Figure 4-1 (Page 4-6). Also, provide test and service data supporting the assumed aspect ratio of 2 to 1 for all flaws before and during the crack growth (Page 5-6).

BWRVIP Response to RAI 2-8

The nozzle corner crack is at the nozzle blend radius region. This nozzle corner crack model is illustrated in Figure 12. This nozzle corner crack can be at any azimuth angle in the nozzle. Therefore, when it is initiated at the transverse plane of the reactor vessel, it is in the circumferential orientation with respect to the vessel transverse plane. When it is initiated at the longitudinal plane of the reactor vessel, it is in the longitudinal orientation with respect to the vessel longitudinal section. If using a local cylindrical coordinate with the longitudinal axis along the centerline of the nozzle, the normal to

the plane of the nozzle corner crack is always in the θ-direction of the local cylindrical coordinate system. In the nozzle corner crack model, the stress intensity factor depends only on the crack depth. A similar situation occurs in the nozzle-to-shell weld. This weld is a circular shape in the reactor vessel, around the nozzle. A crack can initiate at any azimuth angle in this weld, Figure 13. Therefore, when it is initiated at the top or bottom of the circular nozzle to vessel shell weld, the crack is circumferential with respect to the vessel orientation. If it is initiated at the side of the circular nozzle to vessel shell weld, the crack is in an axial orientation within the reactor vessel.

The use of a crack aspect ratio of 2 to 1 is based on the following assumptions:

1. The crack is assumed to initiate in the nozzle-to-shell weld or adjacent to the weld in the base metal.

2. The crack can initiate at any azimuthal angle in the nozzle-to-shell weld.

3. The crack propagates along the nozzle-to-shell weld

4. Crack aspect ratio remains constant during crack growth.

5. The crack at any azimuth angle can be resolved into a circumferential component and a longitudinal component with respect to the reactor vessel for fracture mechanics and crack growth evaluation consistent with ASME Code Section XI procedures, and Reference 9.

6. The crack length would not be longer than the nozzle diameter, based on (3) and (5).

7. The final crack aspect ratio due to crack growth can be estimated from the average ratio of the vessel wall thickness to the nozzle-to-shell weld diameter for the four nozzles. This final crack aspect ratio is also the initial crack aspect ratio, since constant crack aspect ratio is assumed in crack growth calculation. The average ratio is calculated to be about 3.8. This ratio assuming a constant aspect ratio growth with the crack depth is equal to the vessel wall thickness, and the projected length of the crack from the circumference of the circular nozzle-to-shell weld.

8. Larger crack aspect ratio is not used due to the weld configurations, the crack propagating along the welds, and the constant crack aspect ratio used in the crack growth analyses.

Therefore, the use of a crack aspect ratio of $l/a = 2$ is appropriate in the PFM evaluation.

<u>NRC RAI 2-9</u>

To be consistent with the staff position made on a variety of issues related to the BWRVIP-05 review, please provide the following:

The role that RPV copper and nickel contents play in the PFM analysis under the assumed negligible fluence condition.

BWRVIP Response to RAI 2-9a:

When the neutron fluence is negligible, the role of weld chemistry, copper and nickel contents, or chemistry factor (CF), has a negligible effect in the PFM. In Reference 10, the adjusted reference temperature (ART) is given by:

$ART = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin}$

Where $\Delta RT_{NDT} = CF*FF$
CF = chemistry factor, (defined in Table 1 of Reference 10)
FF = fluence factor = $f^{(0.28-0.10*\log(f))}$
$f = f_{surf}\,(e^{-0.24x})$
f_{surf} = neutron fluence at the inner surface of the vessel,
x = depth into the vessel wall

When fluence is negligible (<< 10^{17} n/cm2 (E> 1MeV)), the FF also becomes negligible (<< 1). Therefore ΔRT_{NDT} is also negligible. Thus, the effect of CF is not significant. This implies that the ART depends only on the Initial RT_{NDT}. The margin term is used only in the deterministic evaluation. In PFM, the margin term is represented by the distribution of the random parameters of Initial RT_{NDT} and ΔRT_{NDT}.

NRC RAI 2-9b:

A figure showing all test data (additional data plus the original five pertinent to BWRVIP-05) with the fitted curve representing the stress corrosion initiation equation of Table 5-1.

BWRVIP Response to RAI 2-9b:

The stress corrosion initiation equation is obtained from Reference 3. This equation is developed based on data shown in Figure 14 [3].

The following is an excerpt from BWRVIP-05 [3] on the data evaluation. Note that Figure 8-4 from BWRVIP-05 is reproduced as Figure 14 in this RAI response.

"Cladding stress corrosion crack initiation data were obtained from existing literature, and from estimates based on field experience with stainless steel weld metal and casting cracking. These data are illustrated by the open squares in Figure 8-4, in terms of time to failure (assumed to be crack initiation) versus applied stress. These data are relatively sparse, which is indicative of the strong resistance of this material to stress corrosion cracking. Nonetheless, some field cracking has been observed, which is collectively represented by the single point at 30 ksi and 1×10^5 hours to failure. Conversely, a great deal of data is available for wrought sensitized stainless steel in the BWR environment, as indicated by the solid diamonds in the figure. For purpose of this study, best-fit curves were developed for both sets of data, with the cast/weldment curve, as expected, falling well above the wrought curve in terms of time to failure. In order to characterize the statistical variability of the data, a log-normal fit was developed for the wrought data relative to its best-fit curve, which distribution was also assumed to be applicable to the cast/weldment curve. That is, it was assumed that, if sufficient cast/weldment data

were available, it would distribute about the cast/weldment curve in the same manner in which the wrought data distribute about the wrought curve.

.... It is further assumed that the cast/weldment curve of Figure 8-4 applies only to susceptible material, while initiation times of five times that of the curve apply to non-susceptible material."

NRC RAI 2-9c

Justification for assuming that the initial RT_{ndt} for the weld and forging is –20 F

BWRVIP Response to RAI 2-9c

The initial RT_{NDT} of –20 °F was obtained from the BWR vessel shell vertical weld data. It is the average value of the BWR fleet, calculated as shown in Table 5-1 of the original report [5]. This initial RT_{NDT} is applicable to the nozzle-to-shell weld.

For the forging or the nozzle corner crack analysis, additional properties were obtained for SA508 Cl 2. From the data provided for SA 508 Cl 2, the average initial RT_{NDT} is 24.13 °F with a standard deviation of 26.48 °F, a maximum of 75 °F, and a minimum of –40 °F. Additional Monte Carlo simulations were performed with these values. The evaluation was performed for all nozzles in the blend radius region for the 25 percent and 90 percent inspection coverage cases. The results are presented in Table 6.

The increase in failure probability between the 25 percent inspection and the "essentially 100 percent" is less than 1.18×10^{-7} for 40 years, (corresponding to $<2.95 \times 10^{-9}$ per year). This is well below the requirement of 1×10^{-6} per reactor year as stated in NUREG 1.174 [17].

NRC RAI 2-9d

Justification for using a fatigue crack growth rate based on limited data as shown in Figure 5-1.

BWRVIP Response to RAI 2-9d

In order to include the fatigue crack growth effect in the PFM evaluation, the distribution of the fatigue crack growth correlation is required. Since the ASME fatigue crack growth does not provide the distribution, it has to be derived from the raw data. Also, a digitized format of the raw data used to derive the ASME fatigue crack growth law is not readily available. Therefore, it has to be interpreted from the figures available in the published literature. The interpretation is difficult due to a large number of data clustered in the figures.

In the current evaluation, a fatigue crack growth law along with its distribution is derived using a subset of the original data that were used to formulate the Section XI fatigue growth laws. The derived fatigue crack growth correlation is compared to the ASME 74' linear and 86' bilinear crack growth laws, Figure 15. This shows a very reasonable comparison. In addition, from the PFM results,

it was shown that the crack growth due to fatigue is significantly small compared to the crack growth due to stress corrosion. Therefore, the fatigue crack growth, regardless of the correlations used, does not have a large impact in the probability of failure of the vessel.

NRC RAI 2-9e

The basis for the assumed flaw density, flaw distribution, flaw number due to stress corrosion initiation, and probability of detection curves for the nozzle/shell weld and nozzle blend radius.

BWRVIP Response to RAI 2-9e

The flaw size distribution is the same as those used in Reference 3 and NRC Safety Evaluation Report [11]. The flaw size distribution was based on the data developed in the NRC Pressure Vessel Research Users Facility (PVRUF), and represents a major improvement in the RPV probabilistic assessments.

The PVRUF flaw size distribution, in the cumulative distribution form, is [11]:

$$F(x) = 1 - 0.1616\exp(-6.94x) - 0.00139*\exp(-4.06x) \text{ for } x > 0.0787, \text{ and} \quad (2)$$

$$F(0.0787) = 0.9054$$

where x = flaw size

This flaw size distribution has a probability of 91 percent for flaws under 0.0787 inches.

The number of flaws in the weld is based on the Marshall distribution, [12]. Based on the interpretation used in Reference 13, a mean density of number of flaws is 45 flaws/m^3. The Marshall distribution includes the entire range of flaw sizes from 0 to infinite size. In Reference 14, only those flaws with through-wall dimension greater than 1.5 mm (0.0591 inches) are considered. This reduces the average number of flaws to 30 flaw/m^3 for flaws > 1.5 mm (0.0591 inches). The volume of the nozzle-to-vessel shell weld can be estimated using a conventional double V-groove. Using the largest nozzle, recirculation outlet, the volume of the weld is estimated to be $0.5*(3*7)*2*\pi*25 = 1649$ in^3 (0.027m^3). With a density of 30 flaw/m^3, it gives 0.81 flaws per nozzle-to-shell weld. Therefore, a mean number of 1 flaw per nozzle-to-vessel shell weld is assumed. This mean flaw number is used for cracks initiated from stress corrosion or welding.

NRC RAI 2-9f:

Justification for using any test data, methodology, or conclusions of BWRVIP-05 for reactor vessels shells and welds data in this application.

BWRVIP Response to RAI 2-9f:

The test data and methodology of BWRVIP-05 [3] are used for the evaluation of the shell welds in the beltline region of the reactor vessels. The data and methodology have been evaluated and reviewed by NRC and documented in the final SER [11]. The nozzle-to-shell welds are part of the reactor vessels. They are manufactured from similar materials, quality procedures and inspected by the same inspection

techniques. Therefore, it is justified to use the same test data and methodology from BWRVIP-05 to perform the PFM evaluation. Some of the parameters need to be adjusted accordingly, such as fluence and number of flaw in the weld, due to the locations and length of the welds. These have been identified and discussed in the previous sections.

NRC RAI 2-10

Perform a worst-case study using the following revisions:

a. A conservative stress corrosion crack (SCC) initiation curve for sensitized 304 stainless steels.
b. A more conservative number of flaws per nozzle for nozzle blend radius, say 0.1 instead of 0.001.
c. A standard deviation of 15 percent of the mean for fracture toughness.
d. A standard deviation of 15 percent of the mean for upper-shelf fracture toughness.
e. The Argonne National Laboratory SCC growth rate (approximately 10 times of your rate; also, the typo "σ" in your SCC equation in Table 5-1 should be corrected).
f. A threshold stress intensity factor of 10 ksi$\sqrt{in}$, considering recent progress in understanding other types of SCC.
g. The current ASME Section XI reference bilinear fatigue crack growth law (R>0.65) for carbon and low alloy steels in water environment for both nozzle-to-vessel welds and nozzle blend radii.
h. Flaw density, flaw distribution, and probability of detection much more conservative than those used in the BWRVIP-05 review. (Since it is difficult to get consensus on these parameters, a sensitivity study on their influence on PFM results in useful.)

BWRVIP Response to RAI 2-10

PFM evaluations in BWRVIP-108 were performed to provide a best-estimate of the failure probability for the nozzle blend radius and nozzle-to-shell welds. It is intended to eliminate the inherent conservatism used in the deterministic evaluation where the upper bound value of each parameter is unrealistically used simultaneously in the analyses. Therefore, the use of worst case or upper bound values of input in a PFM evaluation is not appropriate, and in fact unrealistic.

The failure due to the presence of a crack in the reactor vessel weld depends on a number of parameters. It is understood that the most conservative value in each of these parameters is unlikely to occur simultaneously at the same location in a reactor vessel. The use of probabilistic evaluation is to evaluate the likelihood of these parameters interacting with each other in a reactor vessel leading to failure. This does not rule out the potential for a case where all upper limit values occur at the same location. Therefore, the use of upper bound input values in a PFM analysis produces overly-conservative results that are not supported by field data and industrial experience. It also defeats the purpose of a probabilistic evaluation. An overly-conservative PFM analysis is analogous to a deterministic analysis with every input at its most conservative values. Furthermore, no criteria or methodology has been provided regarding how the input/output and these results would be used or assessed by the staff.

The inputs used in the BWRVIP-108 evaluation are consistent with the methodology employed in BWRVIP-05 and associated responses to staff RAIs, which has been approved by the NRC. The inputs used in BWRVIP-05 are based on the most current data at the time with an appropriate distribution to describe the scatter behavior of the available data. The available data are mostly from the industrial field data. They are considered the most representative for the study. Therefore, the BWRVIP does not advocate performing a "worst case" PFM analyses.

BWRVIP-108 recommends a reduction of inspection to 25 percent from the current ASME Code requirement of 100 percent every 10 years. The recommendation is based on similar methodologies in BWRVIP-05 [3] used for the elimination of inspection of the circumferential shell welds in the reactor vessels. The methodologies used in Reference 3 have been reviewed and evaluated by the NRC staff. In addition, the recommendation in BWRVIP-108 is consistent with the current inspection requirement of ASME Section XI for Class 1 piping system.

NRC RAI 2-11

Is it unclear how the licensee plans to implement BWRVIP-108 at BFN-2 and -3. Several issues exist concerning nozzle selection and distribution, scheduling, prioritization and historical examinations. For each plant, BFN-2 and -3, develop a matrix, or table, that lists all nozzles on the reactor pressure vessel, and for each nozzle, include the following information:

a. Date of last inspection, for both volumetric and/or enhanced VT-1.
b. Highlight specific nozzles chosen to be among the proposed 25 percent sample.
c. Explain how nozzles in each type (as listed in the licensee's request) were selected for the proposed 25 percent sample (e.g., stress, operating conditions, fabrication or historical factors, randomly, etc.).
d. Identify nozzles remaining to be examined during the current interval, with and without approval of the proposed alternative.
e. Planned examination date(s) for nozzles in the proposed alternative.
f. Include above information for nozzles outside the scope of the proposed alternative (e.g., feedwater).

TVA Response to RAI 2-11

See Attachment A (Unit 2) and Attachment B (Unit 3) of this enclosure for previous examination dates and results.

The following table is the selection of RPV Nozzles for the 25 percent sample for the current ten-year inspection interval for each unit:

UNIT 2	UNIT 3
N1A, N1A-IR	N1B, N1B-IR
N2B, N2B-IR	N2B, N2B-IR,
N2F, N2F-IR	N2D, N2D-IR
N2J, N2J-IR	N2F, N2F-IR
N3B, N3B-IR	N3A, N3A-IR
N5A, N5A-IR	N5B, N5B-IR
N6B, N6B-IR	N6A, N6A-IR
N7, N7-IR	N7, N7-IR
N8A, N8A-IR	N8A, N8A-IR
N9, N9-IR	N9, N9-IR
N10, N10-IR	N10, N10-IR

The above RPV nozzles were selected on a random basis due to the fact that all of the RPV nozzle-to-vessel welds and nozzle inner radius sections have been previously ultrasonically (UT) and/or visually (enhanced visual EVT-1) examined. The results of the examinations met ASME Section XI Code, Division 1, Subsection, IWB-3512 acceptance requirements.

Listed below are the RPV nozzles remaining to be examined during the current ten-year inspection interval, for BFN Units 2 and 3, with and without approval of the proposed requests for relief.

UNIT 2 THIRD INTERVAL REMAINING NOZZLE EXAMS	UNIT 2 W/APPROVAL EXAM SCHEDULED 2ND PERIOD CYCLE 13 OR 14	UNIT 3 SECOND INTERVAL REMAINING NOZZLE EXAMS	UNIT 3 W/APPROVAL EXAM SCHEDULED*
N1B, N1B-IR	N3B, N3B-IR	N2G, N2G-IR	COMPLETE
N2A, N2A-IR	N5A, N5A-IR	N2H, N2H-IR	
N2C, N2C-IR	N6B, N6B-IR	N2J, N2J-IR	
N2D, N2D-IR	N7, N7-IR	N2K, N2K-IR	
N2E, N2E-IR	N9, N9-IR	N3C, N3C-IR	
N2G, N2G-IR	N10, N10-IR	N3D, N3D-IR	
N2H, N2H-IR		N8B, N8B-IR	
N2K, N2K-IR			
N3A, N3A-IR			
N3B, N3B-IR			
N3C, N3C-IR			
N5A, N5A-IR			
N5B, N5B-IR			
N6B, N6B-IR			
N7, N7-IR			
N8B, N8B-IR			
N9, N9-IR			
N10, N10-IR			

The Unit 2 RPV Feedwater nozzles and inner radius sections (N4A, N4A-IR, N4B, N4B-IR N4C, N4C-IR, N4D, N4D-IR, N4E, N4E-IR, N4F, and N4F-IR) were UT examined during Cycle 12 in March 2003. These nozzles will be rescheduled for UT examination in the first period of the fourth ten-year inspection interval. The fourth ten-year inspection interval begins May 25, 2011.

The Unit 3 RPV Feedwater nozzles (N4A, N4A-IR, N4B, N4B-IR N4C, N4C-IR, N4D, N4D-IR, N4E, N4E- IR, N4F, and N4F-IR) were UT examined in Cycle 11 in March 2004. These nozzles will be rescheduled in the second period of the third ten-year inspection interval. The third ten-year inspection interval for Unit 3 is scheduled to begin on November 19, 2005.

NRC RAI 2-12

In the licensee's proposed alternative, it is unclear whether the nozzles initially selected for examination during the current period/interval will be re-inspected during successive periods/intervals. In addition, the distribution and completion percentages required during each period require clarification. Please confirm that, except for the total number of examinations, all other applicable requirements of ASME Section XI will be met.

TVA Response to RAI 2-12

Periodic examination percentages for nozzles addressed by this proposed alternative will be in accordance with Note (2) of Table IWB-2500-1, Examination Category B-D. The relief submitted is for the respective unit's current interval only. Subsequent interval requirements will be addressed in that interval's program submittal but will request relief similar to this until Code Case N-702 is approved in RG 1.147 and subsequently incorporated into the Code. All applicable requirements of ASME Section XI will be met except for the total number of examinations.

NRC RAI 2-13:

In addition to the reduced volumetric examinations described in the proposed alternative, previous requests for relief concerning enhanced VT-1 visual examinations of nozzle inner radius sections have either been approved by the NRC staff, or are pending approval. The licensee states:

"TVA is requesting that the reduction from 100 percent to 25 percent of the nozzles each 10-year inspection interval in this [2-ISI-22 and 3-ISI-18] request for relief apply to the aforementioned requests for relief, for the enhanced remote or direct visual (VT-1) examination, capable of a 1-mil wire resolution, in accordance with ASME Section XI, VT-1 requirements."

Clarify whether enhanced VT-1 visual examinations will continue to be performed on all RPV nozzles (excluding feedwater), or only on a reduced population of nozzles selected by the BWRVIP-108 proposed alternative. If the latter, confirm that enhanced VT-1 visual examinations will be performed on the same nozzles selected under this proposed alternative.

TVA Response to RAI 2-13:

Enhanced VT-1 visual examinations will continue on the reduced population of nozzles selected by this proposed alternative. The VT-1 will be performed on the same nozzles selected under this proposed alternative.

NRC RAI 2-14 and RAI 2-16

NRC RAI 2.14:

On page 2-2 of BWRVIP-108, it is stated that results from failed candidates with more than two missed detections or false calls are excluded from the data being analyzed. Further discuss the failed candidate data in terms of what is being included versus excluded from the analysis, and state the percentage of total candidate data that is represented by failed candidate data that is being excluded.

NRC RAI 2.16

On page 2-3 of the BWRVIP-108, statements regarding the relative merits of using "passed" versus "passed plus failed" candidates to estimate probability of detection (POD). It is stated:

"The inclusion of candidates that failed in their first attempt is provided for information. Inclusion of passed candidates only may be overly optimistic, as the large majority of candidates were required to detect 100 percent of the flaws in order to pass."

It is important to emphasize that POD curves calculated from passed candidates will always produce an overly-optimistic estimate of these candidates' true POD. This type of testing bias is so well known in statistics that it has a special term of regression to the mean.

The term *regression to the mean* refers to the propensity of a random variable that is extreme on its first measurement to tend to be closer to the center of the distribution on a later measurement. This means that if one selects candidates with "high" POD scores (i.e., the passed candidates), they would tend to exhibit lower scores if tested again. A second test on the passed candidates would produce an unbiased estimate of their true POD, and exhibit a bias with respect to the first set of scores. It would be difficult to calculate the magnitude of this bias; not only would one need to know the statistical variability in the test (which is available), but one would also need to know the variability in the candidates capability. However, this variability would generally affect the bias in POD in the following manner.

- Test variability low and candidate variability high implies the bias in POD will be low.
- Test variability high and candidate variability low implies the bias in POD will be high.

An important conclusion is that the true POD curve (for passed candidates) is somewhere between the "passed" and "passed plus failed" curves. Both curves are important in evaluating inspection performance. Of course, a reviewer would feel most comfortable with "passed" and "passed plus failed" curves that were close together. In selecting one of these two curves to represent inspection performance, the "passed plus failed" curve should be used because it is more conservative.

From the comments on page 2-5, it appears that the sizing model developed in 2.1.2 has been developed from "passed" data. The discussion above concerning biases that are associated with "passed" data when estimating POD curves are also relevant to sizing. Please estimate the flaw sizing model using "passed plus failed" data, and discuss the magnitude of the potential bias and how this affects the overall analyses for detection and sizing performance.

<u>BWRVIP Response to RAI 2-14 and 2-16:</u>

1. Additional information is requested relative to the data that is excluded from the POD and sizing accuracy evaluations.

   Both RAIs concern the segmentation of the database into "Passed", "Failed" or "Unqualified" candidates. "Passed" candidates have met all of the requirements of Appendix VIII, Supplement 4. "Failed" candidates had no more than two misses or two false calls. "Unqualified" candidates had more than two false calls and/or two missed detections. "Unqualified" refers to those candidates who do not have the prerequisite skills and knowledge to pass the test. The "Unqualified" candidates should not have taken the examination in the first place and must receive additional training before being allowed to retake the examination. The ASME and the Performance

Demonstration Initiative (PDI) do not have prerequisite or screening criteria to eliminate unqualified candidates. The criteria for the divisions are based on professional judgments and the criteria described below.

2. The BWRVIP believes the NRC is asking for the technical basis for the three separate categories ("Passed", "Failed" or "Unqualified") and their use or exclusion. "Unqualified" candidates have been excluded based on the following logic:

    a. They would have a near zero probability of passing a retest by chance unless they receive additional training.
    b. False calls can invalidate the accuracy of POD estimates. False calls in this examination result from a failure to correctly locate the source of the reflection and interpreting mode-converted signals as flaws. The procedure describes how these mode conversion signals should be analyzed.
    c. The qualified procedures require the use of high-angle longitudinal waves; many examiners have never been exposed to this more complex method of examination. The use of longitudinal waves requires additional training, particularly in the interpretation of the mode-converted signals and at the clad-to-base metal interface.
    d. Detections by "Unqualified" candidates were more random, that is they were just as likely to miss large flaws as small flaws. On the other hand "Passed" and "Failed" candidates missed only those flaws in the smallest category (less than 0.25 inch).
    e. Only "Passed" candidates are currently in the population of RPV examiners.

The BWRVIP agrees that use of failed candidates in the POD estimation would be conservative. However, the use of unqualified candidates is overly conservative, as these individuals have virtually no possibility of passing the examination and entering the work force of qualified examiners, without further training. Heasler [20] in his analysis of the two-stage qualification process, which is used by PDI, estimates the probability of an unqualified examiner passing the examination to be less than 1 percent. The basis for establishing the Appendix VIII acceptance criteria was that no more than 5 percent of unqualified candidates would be capable of passing the examination.

3. In response to the staff's question regarding how many measurements were excluded from consideration, there were a total of 568 Supplement 4 detection measurements. Candidates who met the Pass plus Fail criterion performed 88.7 percent of these measurements. The unqualified group represented 11.3 percent of the total and was excluded from the evaluation.

4. Regarding the effects of sizing accuracy, the BWRVIP believes that the use of only passed candidates is the correct approach for the following reasons:
    a. The RMSE measurement is an accurate estimate of candidate variability. The measurement is continuous rather than binary.
    b. Only those candidates with a sizing accuracy of 0.15 inch ASME or less would be performing examinations.
    c. Based on the large number of measurements that have been performed we believe that the bias and variability is well understood.
    d. The sizing model considers the total variability of sizing errors, i.e., within candidate, between candidates and test variability.

NRC RAI 2-15

On page 2-2 of the BWRVIP-108, it is stated:

'The term ε_i, is assumed to be normally distributed with a variance of σ^2_ε."

The standard estimates used for logistic regression are maximum likelihood estimates that assume the data is binomially distributed. Confirm that the Electric Power Research Institute is using the standard estimation method for logistic regression, and if so, the description should he altered to reflect this method.

BWRVIP Response to RAI 2-15

Pat Heasler of PNNL developed the regression method (PNLPODFIT) that is used by EPRI. The work of Heasler and others is referenced in this regard in BWRVIP-108 and Reference 22. This is the same method/program used by PNNL.

NRC RAI 2-17

On page 2-7 of BWRVIP-108, it is stated that only passed candidates are included in the analysis of sizing error. Later on page 2-11, the report states, "For the purpose of calculating structural reliability the "ALL" curve of Figure 2-9 is most appropriate for examinations performed since 1995 as well as future examinations." In the earlier work of Section 2, the passed plus failed data is used for detection but in this section dealing with PCR, only the passed candidates are being used. Explain the basis for only using the "passed" candidates.

Section 2 provides a quantitative description of inspection capability (i.e., in the form of probability of reporting or rejecting the flow as unacceptable (PCR)). However, it cannot be determined whether or not the capability is "poor" or "excellent" unless a benchmark has been established for comparison of the results. For example, if the proposed 25 percent reduction in examinations would be acceptable whenever the PCR curve was above 90 percent for flaws larger than 0.3-inches, one might conclude that the current inspection capability is "acceptable." Provide definitions for acceptable and unacceptable PCR curve results.

BWRVIP Response to RAI 2-17

1. Refer to the response to RAI 2-14 and 2-16, Item 4 for the basis for using only passed candidates.

2. The NRC asked why passed plus failed candidates was not used for calculating PCR and why POD was used rather than PCR for probabilistic calculations of Section 5.6.

   The concepts of Probability of Correct Sizing (PCS) and the Probability of Correct Rejection (PCR) were introduced as part of ongoing investigation to better understand the impact of

inservice inspections on component reliability. They are included here for information. Probabilistic evaluations normally use only POD. As an example, please refer to the work of Simonen [22].

The POD "ALL" curve of Figure 2-1 is conservative relative to the PCR curve of Figure 2-9.

3. The NRC requested a definition of acceptable and unacceptable Probability of Correct Rejection (PCR).

   The ASME Code, Section XI, Appendix VIII, Supplement 4, defines acceptable detection and sizing performance. The BWRVIP does not propose any alternative standards of performance.

<u>NRC RAI 2-18</u>

The results presented in Fig 2-10 are quite dramatic. One would like to conclude that the reduction in sizing error sigma could be completely ascribed to Improvements in inspection capability. However, the reduction may be due to a number of factors such as differences in the flaws (or materials) between Program for the Inspection of Steel Components (PISC) and Performance Demonstration Initiative (PDI). The report contains no discussion as to the reasons for this significant reduction in sizing error. Please discuss this dramatic change, and provide the technical details of the similarities and differences in these data.

<u>BWRVIP Response to RAI 2-18</u>

Many factors could explain the differences and similarities of the test and resultant POD and sizing accuracy. These would include the test blocks, flaws, personnel, testing protocol, procedures, and technology. The results of the PISC Program are described in References 23 and 24. A more recent publication [21] describes in more detail the improved performance based on performance demonstration testing by the PDI Program.

Discussions of these individual factors are discussed below.

<u>Test Blocks and Flaws</u>

The PSIC flat test blocks were slightly larger in thickness and were examined from both the inner and outer surface. Both used similar fabrication techniques. All of the PISC flaws, regardless of access, were detectable at a sensitivity of 20 percent DAC. The PDI samples require an additional 6 to 10 dB of gain for the detection of clad to base metal flaws from the outside surface. The PDI sample blocks are considered more conservative.

<u>Personnel</u>

Personnel performing the PISC demonstrations were select national teams, including high-level scientists from research laboratories. The US teams that participated in the PISC exercise were more representative. The PDI personnel demonstrations are performed on an individual basis

by examiners who will be performing the examination in the field. The PDI individuals are considered more representative of the population that will be performing BWR OD examinations.

Protocol

The PISC trials were a collaborative effort among several individuals; The PDI demonstrations are strictly an individual effort. There were no penalties for false calls in the PISC program; the PDI program imposes penalties for excessive false calls. The time allowed and the number of flaws was about the same. Both exercises include manual as well as automated examinations.

Procedures

The majority of the PISC conventional procedures used amplitude threshold methods for detection and amplitude drop for sizing, according to the various national standards. For examination from the OD surface the procedures predominantly relied on shear wave technology. Procedures that have been successful in the PDI demonstrations have used signal to noise ratio without an amplitude threshold. The PDI sizing results were based on crack tip diffraction rather than the currently discredited amplitude drop technique. Sizing accuracy was the most dramatic improvement shown by the demonstrations.

Technology

Automated examination technology has improved dramatically since the time of the PISC-II exercises. However, manual instruments in both cases relied on the interpretation of A-Scan signals. Even though modern instruments are more sophisticated, they still rely on the same basic information. The crack tip sizing techniques have now advanced to the point where they can provide very accurate information. This advance is based more on knowledge of the interaction between flaws and the sound wave as opposed to instruments and search units that are more sophisticated.

In conclusion, the PDI demonstration is at least, if not more, challenging than the PISC exercise.

NRC RAI 2-19

In BWRVIP-108, Section 5.6, it is stated that "POD pass plus fail" curves were used in the probabilistic fracture mechanics (PFM) calculation. From the analysis in Section 2.0, it would seem that the proper curve to use would be the PCR curve, which also includes the effects of sizing error. Explain why the PCR curve results were not used for the PFM calculations.

BWRVIP Response to RAI 2-19

Refer to the response to RAI 2-17, Item 2.

NRC RAI 2-20

Tables 5-3 to 5-5 show little information concerning the efficacy of inspections. Provide a ratio of failure probabilities which would be much more informative.

BWRVIP Response to RAI 2-20

Refer to the response to RAI 2-17, Item 2.

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Table 1 Comparison of Material Properties Between SA 302 and SA 533
(a) Mechanical Properties

Young's Modulus ($x10^6$ psi)				Thermal Expansion ($x10^{-6}$/°F)			
Temp(°F)	SA 302	SA 533	% Diff	Temp	SA 302	SA 533	% Diff
70	29.2	29.2	0	100	7.06	7.06	0
200	28.5	28.5	0	200	7.25	7.25	0
300	28	28	0	300	7.43	7.43	0
400	27.4	27.4	0	400	7.58	7.58	0
500	27	27	0	500	7.7	7.7	0
600	26.4	26.4	0	600	7.83	7.83	0
700	25.3	25.3	0	700	7.94	7.94	0
800	23.9	23.9	0	800	8.05	8.05	0

(b) Thermal Properties

Temperature (°F)	Conductivity (Btu/hr-ft-°F)			Diffusivity (ft^2/hr)		
	SA 302	SA 533	% Diff	SA 302	SA 533	% Diff
100	23.6	22.6	4.42	0.451	0.427	5.62
200	24.4	23.4	4.27	0.437	0.42	4.05
300	24.7	23.8	3.78	0.42	0.408	2.94
400	24.6	23.8	3.36	0.398	0.389	2.31
500	24.2	23.5	2.98	0.377	0.366	3.01
600	23.5	23	2.17	0.353	0.342	3.22
700	22.5	22.3	0.90	0.328	0.319	2.82
800	22	21.7	1.38	0.3	0.295	1.69

Table 2 Comparison of Material Properties Between SA 336 and SA 508

(a)Mechanical Properties

Young's Modulus ($x10^6$ psi)				Thermal Expansion ($x10^{-6}/°F$)			
Temp(°F)	SA 336	SA 508	% Diff	Temp(°F)	SA 336	SA 508	% Diff
70	27.8	27.8	0	100	6.5	6.5	0
200	27.1	27.1	0	200	6.67	6.67	0
300	26.7	26.7	0	300	6.87	6.87	0
400	26.1	26.1	0	400	7.07	7.07	0
500	25.7	25.7	0	500	7.25	7.25	0
600	25.2	25.2	0	600	7.42	7.42	0
700	24.6	24.6	0	700	7.59	7.59	0
800	23	23	0	800	7.76	7.76	0

(b)Thermal Properties

Temperature (°F)	Conductivity (Btu/hr-ft-°F)			Diffusivity (ft^2/hr)		
	SA 336	SA 508	% Diff	SA 336	SA 508	% Diff
100	23.9	23.7	0.84	0.454	0.447	1.57
200	24.2	24	0.83	0.432	0.427	1.17
300	24.1	23.9	0.84	0.411	0.406	1.23
400	23.8	23.6	0.85	0.39	0.385	1.30
500	23.2	23.1	0.43	0.366	0.362	1.10
600	22.6	22.4	0.89	0.343	0.339	1.18
700	21.9	21.7	0.92	0.319	0.316	0.95
800	21.2	21	0.95	0.297	0.293	1.37

Table 3 Applied Unit Moment (1 in-kip)

Deg	Core Spray			Main Steam			Recirculation Inlet			Recirculation Outlet		
	F (lb)	r (in)	F*r (in-lb)	F (lb)	r (in)	F*r (in-lb)	F (lb)	r (in)	F*r (in-lb)	F (lb)	r (in)	F*r (in-lb)
0	14.66	3.41	50.00	4.39	11.39	49.99	6.84	7.33	50.10	3.64	13.73	50.00
9	14.48	3.37	48.78	4.34	11.25	48.77	6.75	7.24	48.87	3.60	13.56	48.77
18	13.95	3.24	45.23	4.18	10.83	45.23	6.50	6.97	45.32	3.47	13.05	45.23
27	13.07	3.04	39.70	3.91	10.15	39.69	6.09	6.53	39.77	3.25	12.23	39.70
36	11.86	2.76	32.73	3.55	9.22	32.72	5.53	5.93	32.79	2.95	11.10	32.72
45	10.37	2.41	25.00	3.10	8.05	25.00	4.84	5.18	25.05	2.58	9.71	25.00
54	8.62	2.00	17.28	2.58	6.70	17.27	4.02	4.31	17.31	2.14	8.07	17.27
63	6.57	1.55	10.17	1.99	5.17	10.31	3.10	3.33	10.33	1.65	6.23	10.31
72	4.53	1.05	4.77	1.36	3.52	4.77	2.11	2.26	4.78	1.13	4.24	4.78
81	2.29	0.53	1.22	0.69	1.78	1.22	1.07	1.15	1.23	0.57	2.15	1.22
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
99	-2.29	-0.53	1.22	-0.69	-1.78	1.22	-1.07	-1.15	1.23	-0.57	-2.15	1.22
108	-4.53	-1.05	4.77	-1.36	-3.52	4.77	-2.11	-2.26	4.78	-1.13	-4.24	4.78
117	-6.66	-1.55	10.31	-1.99	-5.17	10.31	-3.10	-3.33	10.33	-1.65	-6.23	10.31
126	-8.62	-2.00	17.28	-2.58	-6.70	17.27	-4.02	-4.31	17.31	-2.14	-8.07	17.27
135	-10.37	-2.41	25.00	-3.10	-8.05	25.00	-4.84	-5.18	25.05	-2.58	-9.71	25.00
144	-11.86	-2.76	32.73	-3.55	-9.22	32.72	-5.53	-5.93	32.79	-2.95	-11.10	32.72
153	-13.07	-3.04	39.70	-3.91	-10.15	39.69	-6.09	-6.53	39.77	-3.25	-12.23	39.70
162	-13.95	-3.24	45.23	-4.18	-10.83	45.23	-6.50	-6.97	45.32	-3.47	-13.05	45.23
171	-14.48	-3.37	48.78	-4.34	-11.25	48.77	-6.75	-7.24	48.87	-3.60	-13.56	48.77
180	-14.66	-3.41	50.00	-4.39	-11.39	49.99	-6.84	-7.33	50.10	-3.64	-13.73	50.00
189	-14.48	-3.37	48.78	-4.34	-11.25	48.77	-6.75	-7.24	48.87	-3.60	-13.56	48.77
198	-13.95	-3.24	45.23	-4.18	-10.83	45.23	-6.50	-6.97	45.32	-3.47	-13.05	45.23
207	-13.07	-3.04	39.70	-3.91	-10.15	39.69	-6.09	-6.53	39.77	-3.25	-12.23	39.70
216	-11.86	-2.76	32.73	-3.55	-9.22	32.72	-5.53	-5.93	32.79	-2.95	-11.10	32.72
225	-10.37	-2.41	25.00	-3.10	-8.05	25.00	-4.84	-5.18	25.05	-2.58	-9.71	25.00
234	-8.62	-2.00	17.28	-2.58	-6.70	17.27	-4.02	-4.31	17.31	-2.14	-8.07	17.27
243	-6.66	-1.55	10.31	-1.99	-5.17	10.31	-3.10	-3.33	10.33	-1.65	-6.23	10.31
252	-4.53	-1.05	4.77	-1.36	-3.52	4.77	-2.11	-2.26	4.78	-1.13	-4.24	4.78
261	-2.29	-0.53	1.22	-0.69	-1.78	1.22	-1.07	-1.15	1.23	-0.57	-2.15	1.22
270	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
279	2.29	0.53	1.22	0.69	1.78	1.22	1.07	1.15	1.23	0.57	2.15	1.22
288	4.53	1.05	4.77	1.36	3.52	4.77	2.11	2.26	4.78	1.13	4.24	4.78
297	6.66	1.55	10.31	1.99	5.17	10.31	3.10	3.33	10.33	1.65	6.23	10.31
306	8.62	2.00	17.28	2.58	6.70	17.27	4.02	4.31	17.31	2.14	8.07	17.27
315	10.37	2.41	25.00	3.10	8.05	25.00	4.84	5.18	25.05	2.58	9.71	25.00
324	11.86	2.76	32.73	3.55	9.22	32.72	5.53	5.93	32.79	2.95	11.10	32.72
333	13.07	3.04	39.70	3.91	10.15	39.69	6.09	6.53	39.77	3.25	12.23	39.70
342	13.95	3.24	45.23	4.18	10.83	45.23	6.50	6.97	45.32	3.47	13.05	45.23
351	14.48	3.37	48.78	4.34	11.25	48.77	6.75	7.24	48.87	3.60	13.56	48.77
ΣFr			999.94			999.96			1002.01			1000.00

Table 4 Stress Indices for Nozzles in Cylindrical Shells [8]

Stress	Longitudinal Plane		Transverse Plane	
	Inside	Outside	Inside	Outside
σ_n (nozzle hoop direction)	3.1	1.2	1	2.1
σ_t (nozzle axial direction)	-0.2	1	-0.2	2.6
σ_r (nozzle radial direction	-t/R	0	-t/R	0
S (stress intensity)	3.3	1.2	1.2	2.6

Note: t = nominal wall thickness of vessel
R = inside radius of cylindrical shell

Table 5 Comparison of Nozzle Stresses

	Core Spray	Recirculation Inlet	Recirculation Outlet	Main Steam	Reference 6	ASME NB-3338
Longitudinal	41664 psi	45972 psi	40341 psi	39437 psi	44997 psi	3.2
Transverse	11902 psi	14112 psi	6309.8 psi	5493.5 psi	13960 psi	1
Ratio	3.5	3.26	6.4	7.18	3.22	3.2

Table 6 Probability of Failure for Nozzle Blend Radius Corner Cracks

Nozzle	Inspection Coverage	Conditional Failure Probability due to Event	Event Probability	Failure Probability	Increase in Probability
Core Spray	25%	$3x10^{-6}$	$1x10^{-3}$	$3x10^{-9}$	$3x10^{-9}$
	90%	$<1x10^{-6}$	$1x10^{-3}$	$<1x10^{-9}$	
Main Steam	25%	$<1x10^{-6}$	$1x10^{-3}$	$<1x10^{-9}$	$<1x10^{-9}$
	90%	$<1x10^{-6}$	$1x10^{-3}$	$<1x10^{-9}$	
Recirc. Inlet	25%	$1.18x10^{-4}$	$1x10^{-3}$	$1.18x10^{-7}$	$1.18x10^{-7}$
	90%	$1x10^{-6}$	$1x10^{-3}$	$1x10^{-9}$	
Recirc. Outlet	25%	$4.7x10^{-5}$	$1x10^{-3}$	$4.7x10^{-8}$	$4.6x10^{-8}$
	90%	$1x10^{-6}$	$1x10^{-3}$	$1x10^{-9}$	

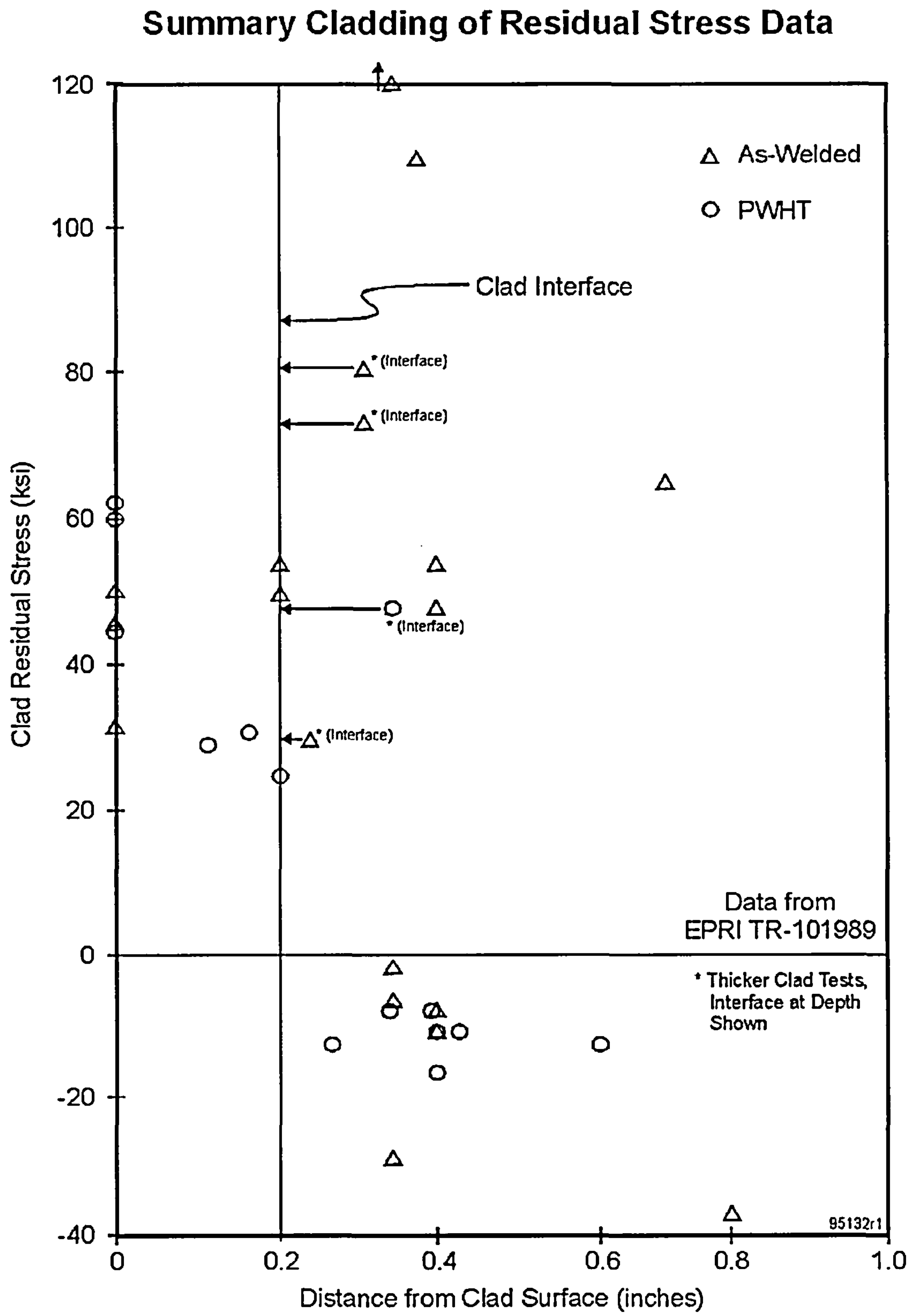


Figure 1 Cladding Residual Stress Data

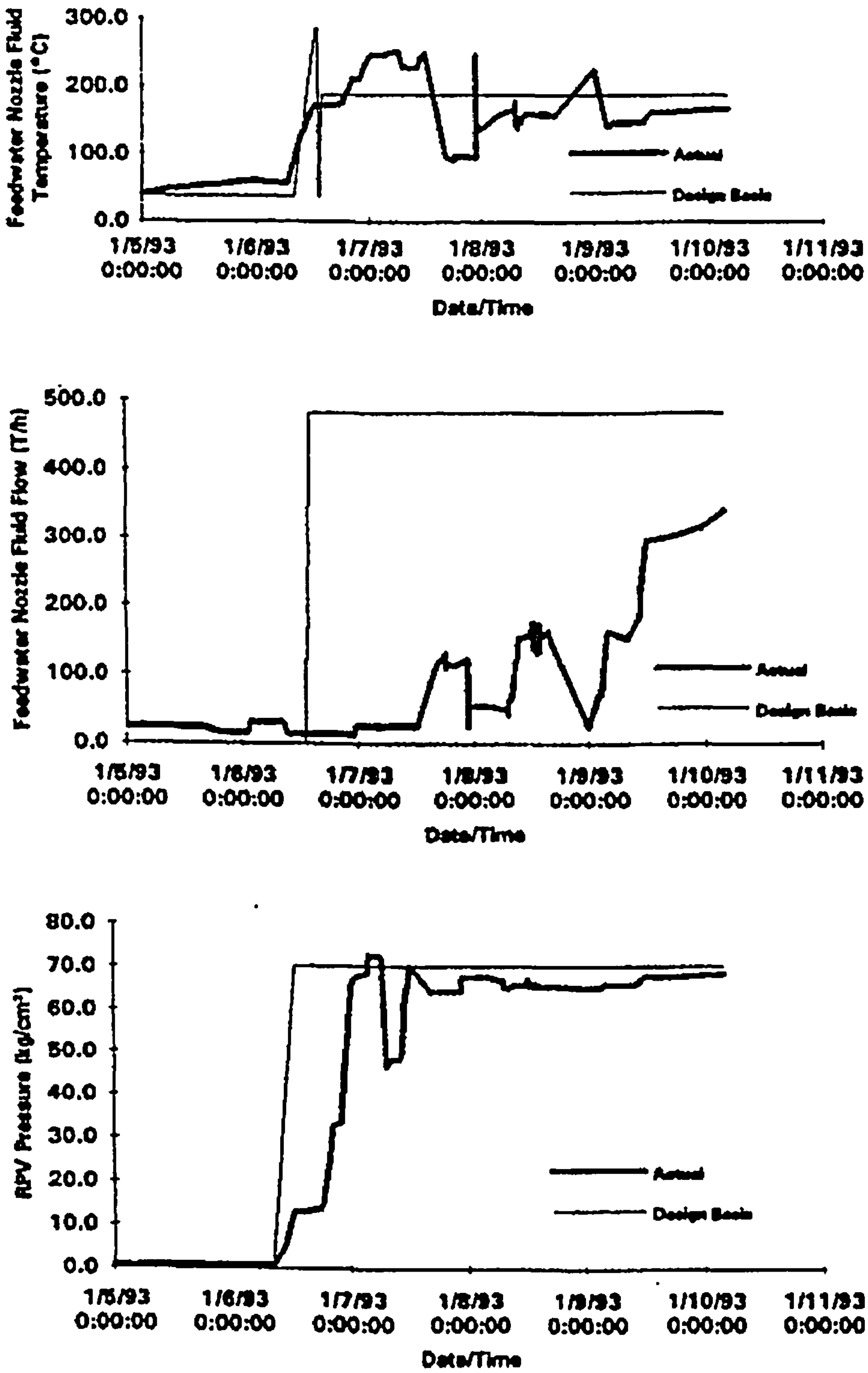


Figure 2 Comparison of Actual vs Design Startup Event

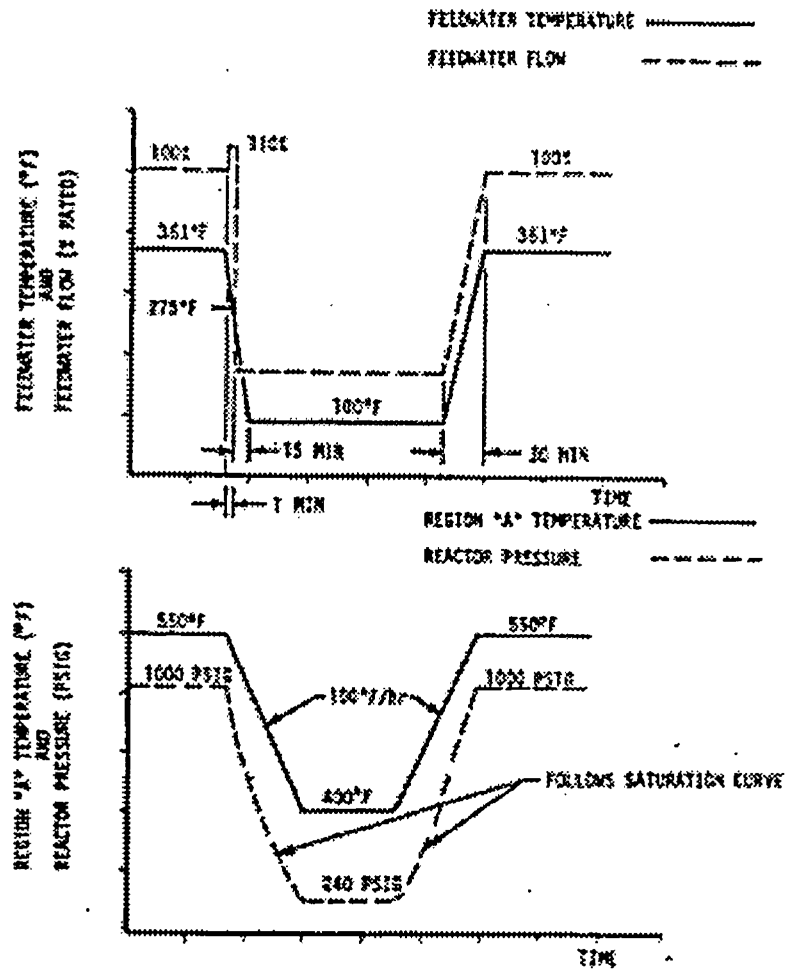


Figure 3 Definition of Scram Design Transient

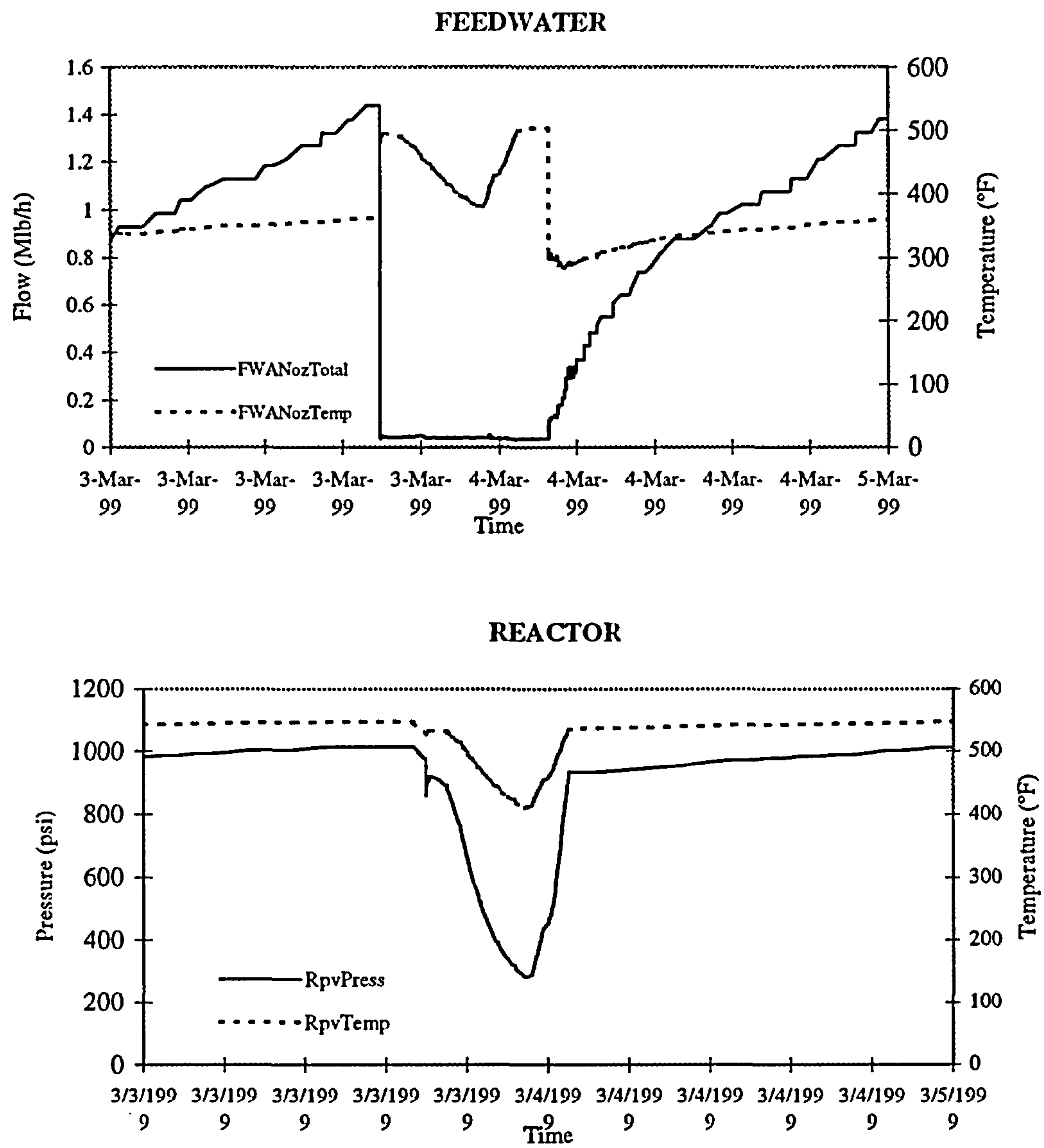


Figure 4 Actual Scram Transient

Figure F-2. Pressure Case, θ = 0°.

Figure 5 Nozzle Hoop Stress, Longitudinal Section, Internal Pressure [6]

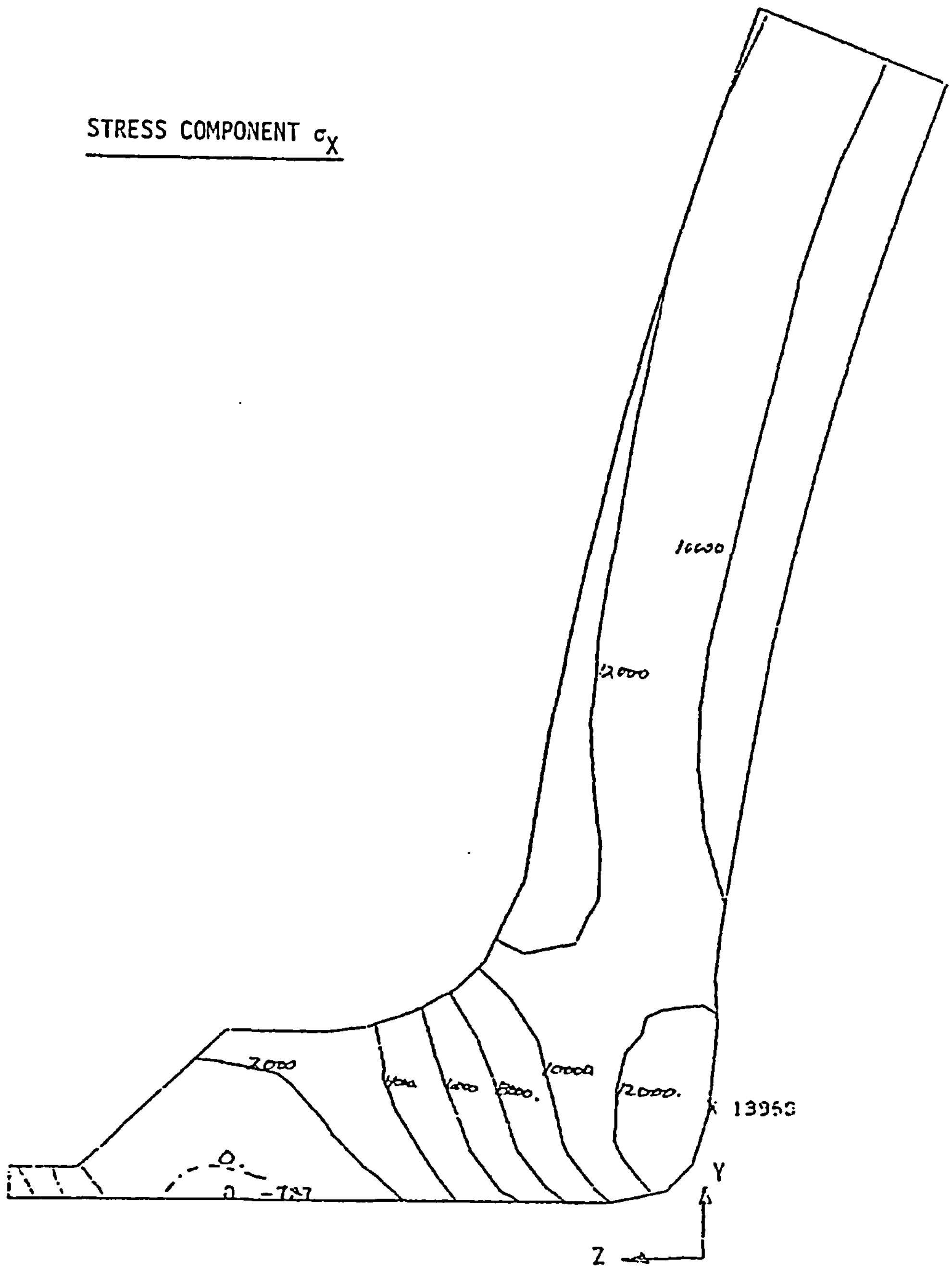


Figure F-4. Pressure Case, θ = 90°.

Figure 6 Nozzle Hoop Stress, Transverse Section, Internal Pressure [6]

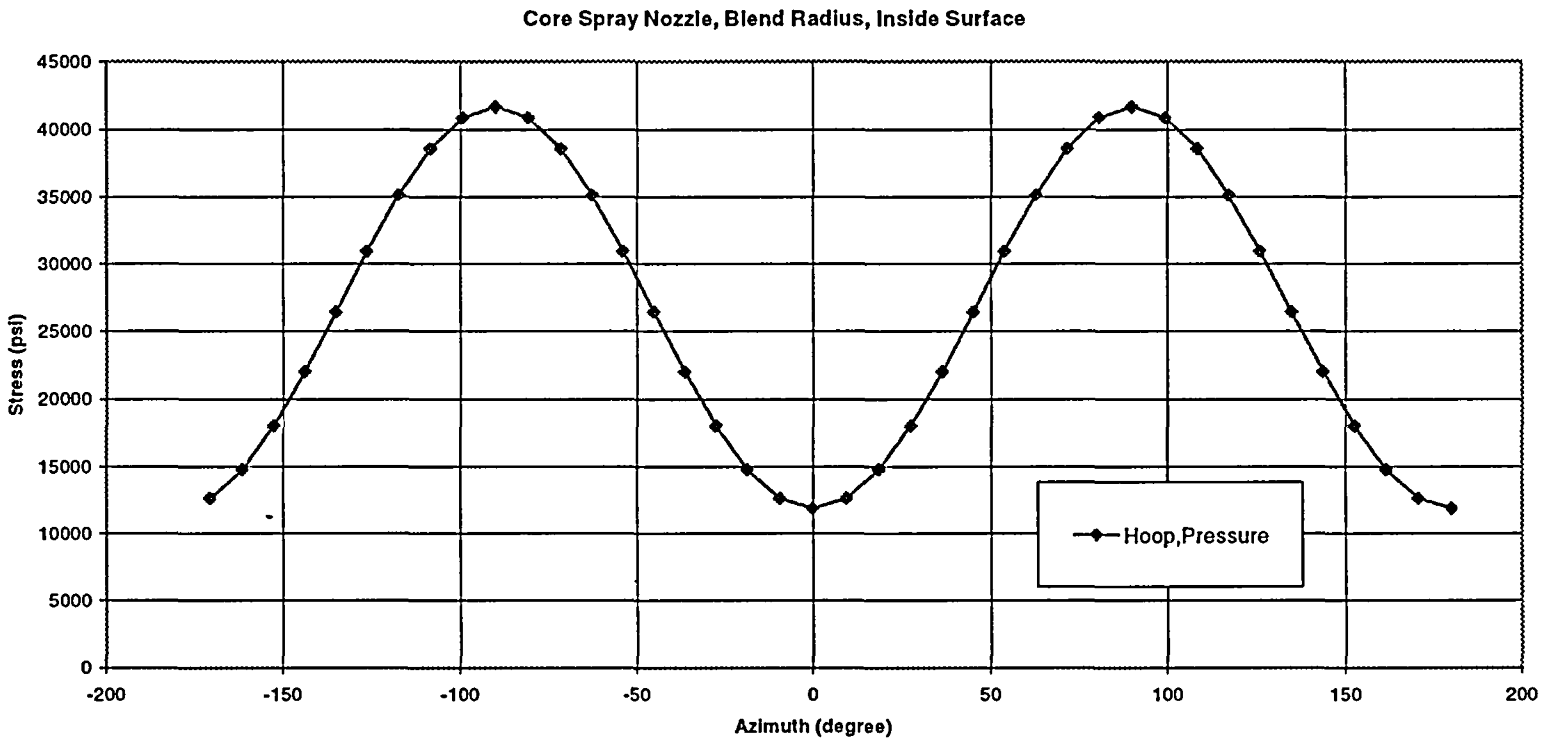


Figure 7 Core Spray Nozzle, Blend Radius Location, Inside Surface Hoop Stress in Local Cylindrical Coordinate System

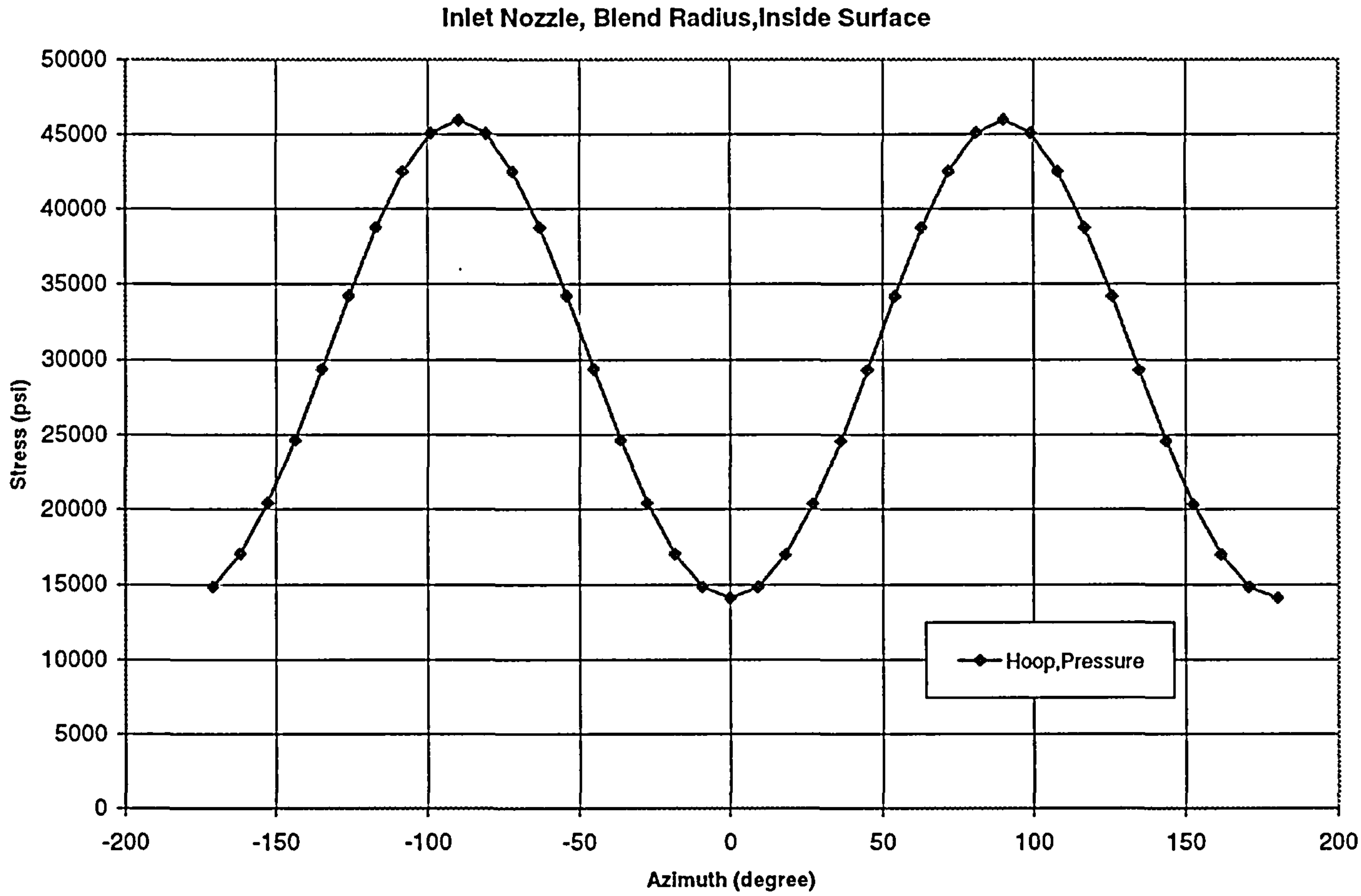


Figure 8 Recirculation Inlet Nozzle, Blend Radius Location, Inside Surface Hoop Stress in Local Cylindrical Coordinate System

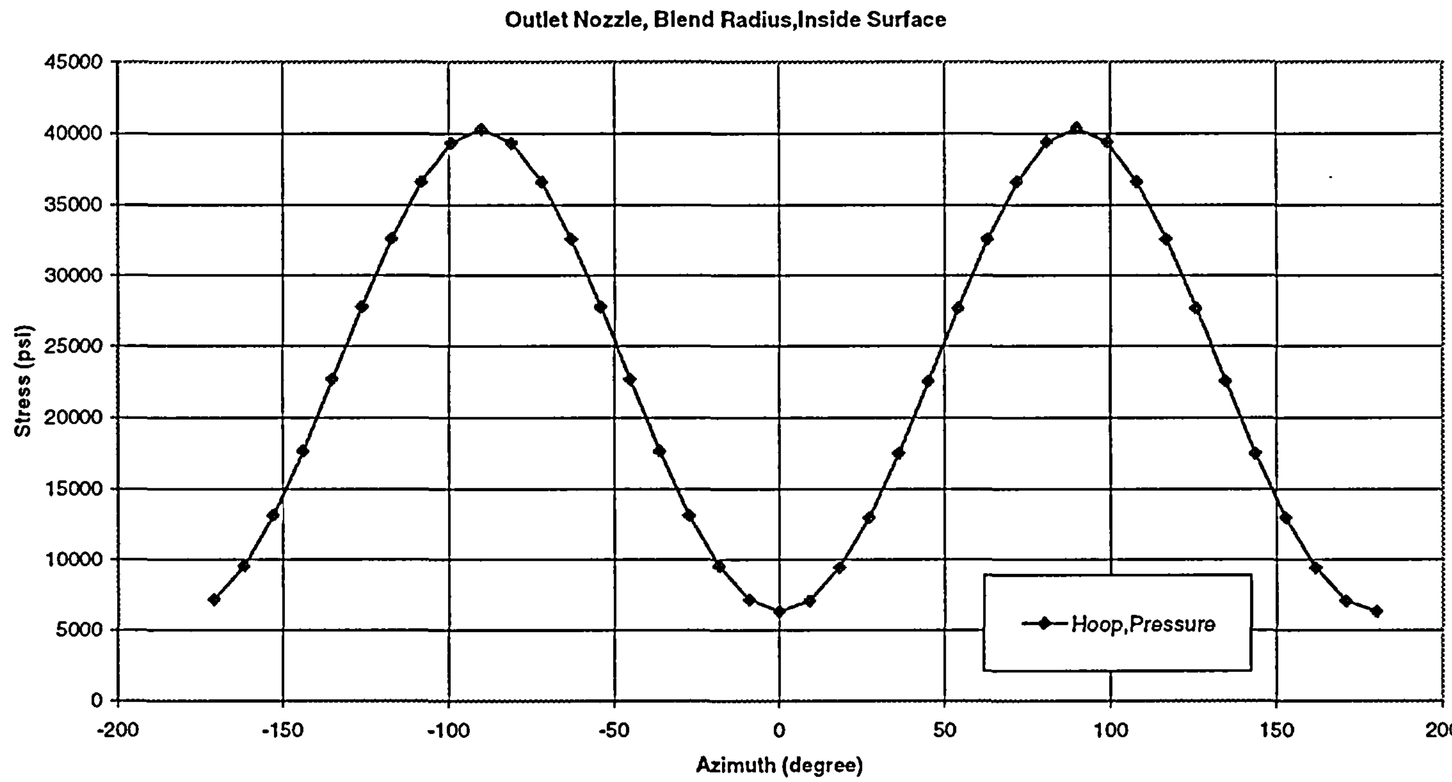


Figure 9 Recirculation Outlet Nozzle, Blend Radius Location, Inside Surface Hoop Stress in Local Cylindrical Coordinate System

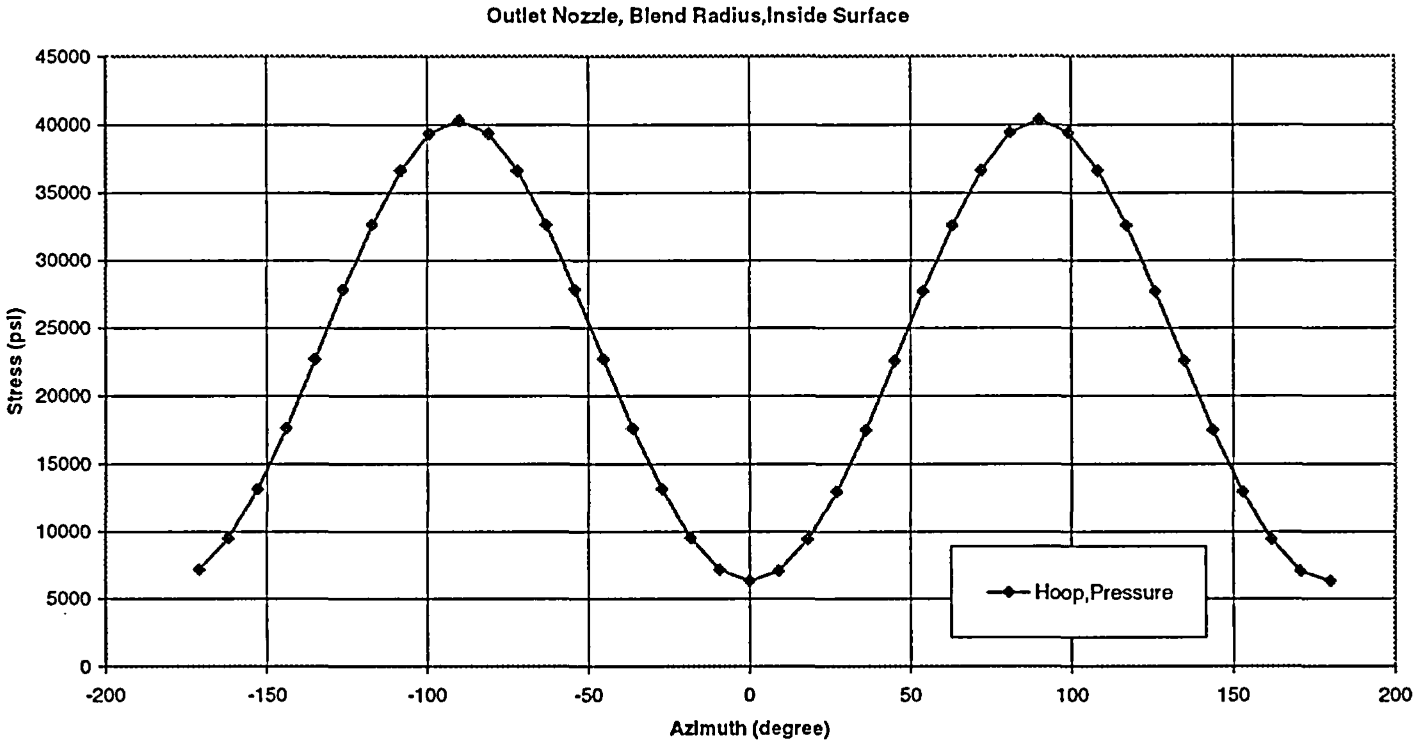
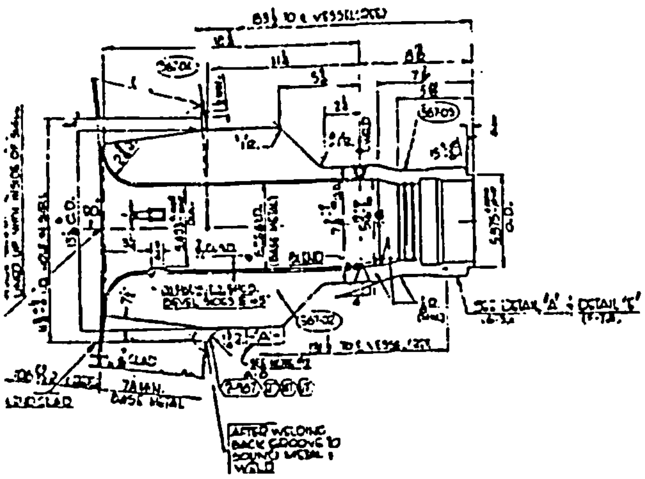
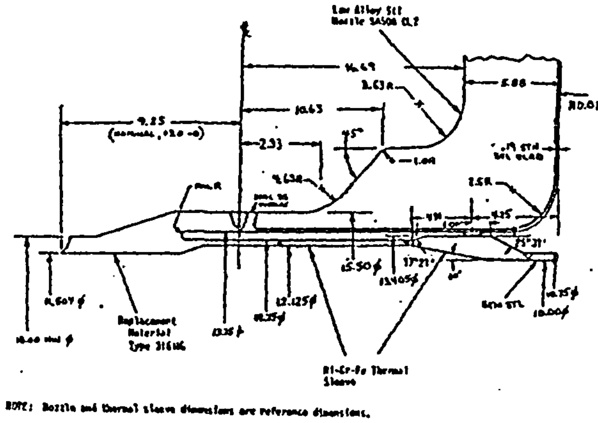


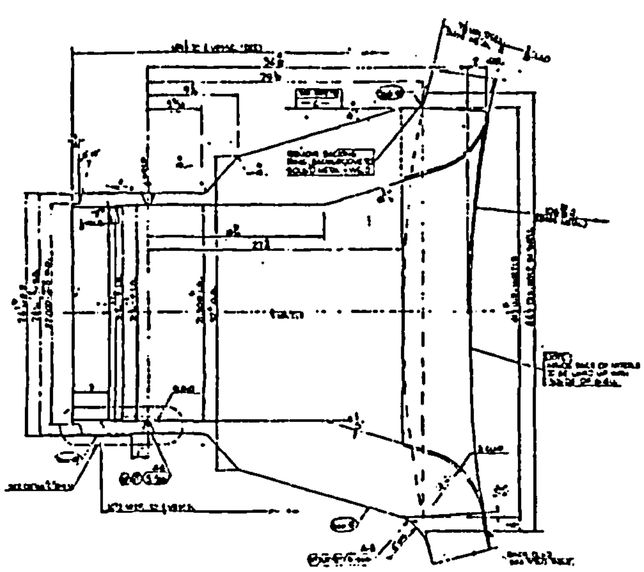
Figure 10 Main Steam Nozzle, Blend Radius Location, Inside Surface Hoop Stress in Local Cylindrical Coordinate System



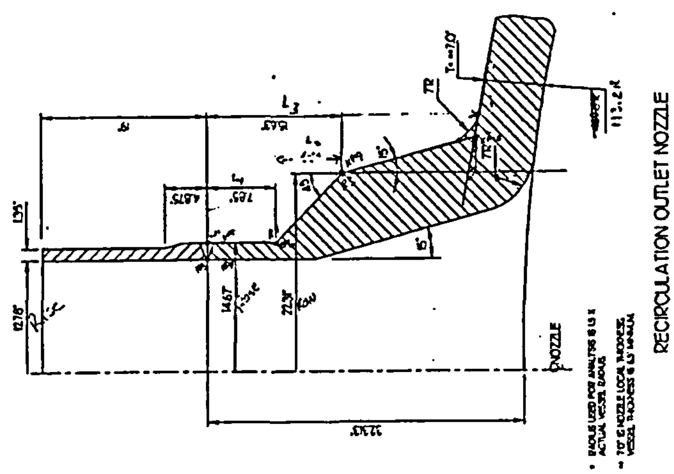
(a) Core Spray



(b) Inlet



(c) Main Steam



(d) Outlet

Figure 11 Nozzle Configurations

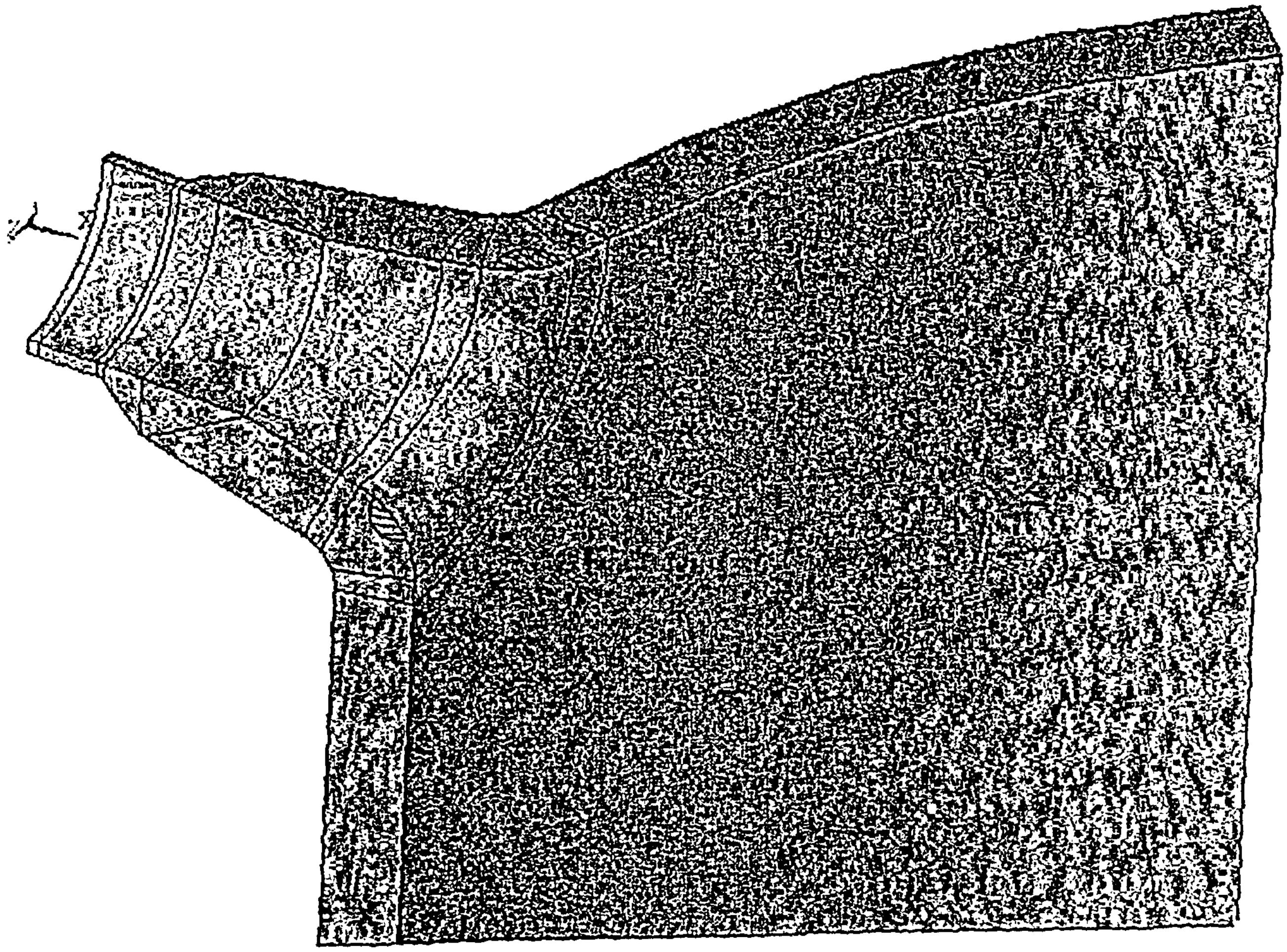


Figure 12 Nozzle Corner Crack

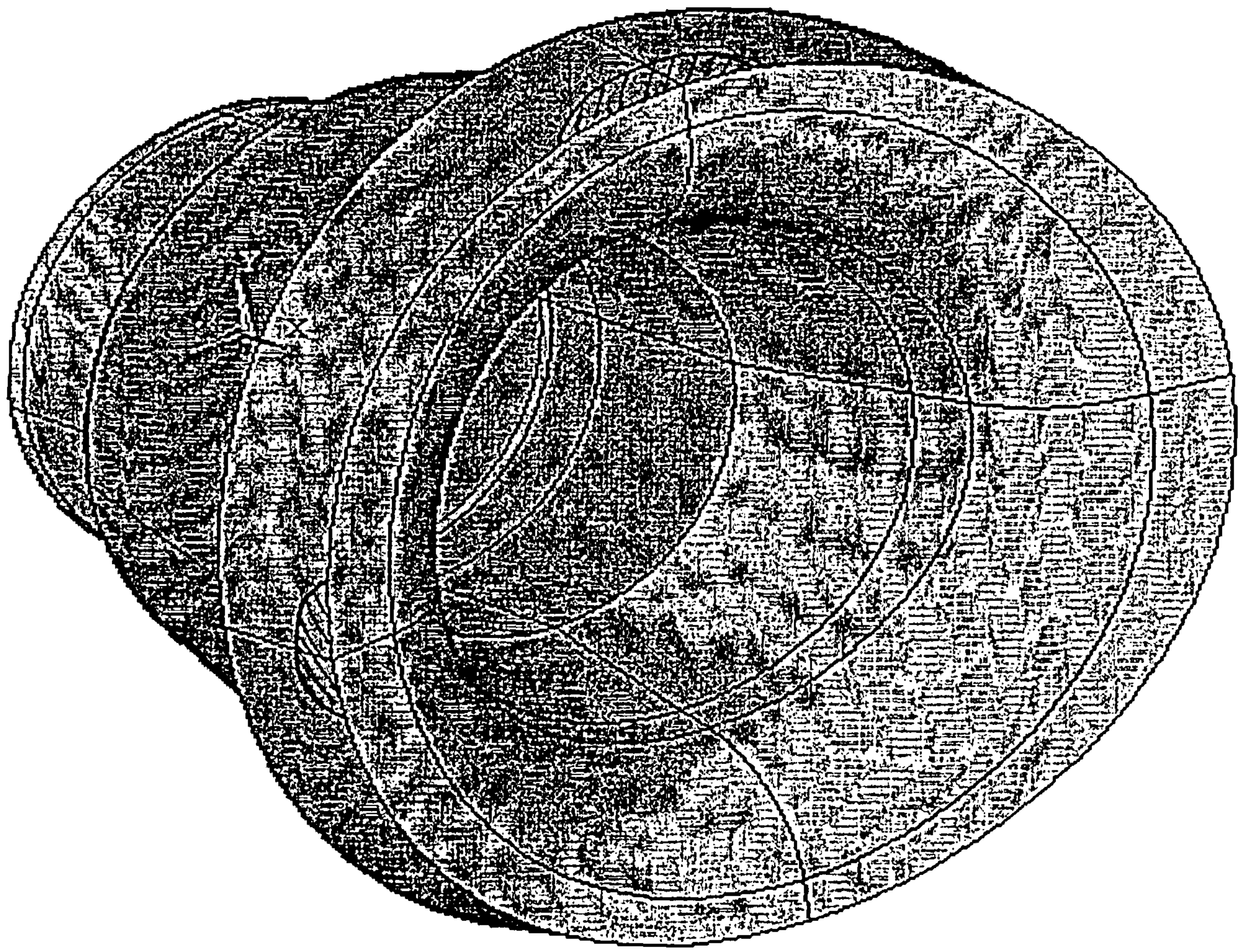


Figure 13 Crack Model in Shell to Nozzle Weld

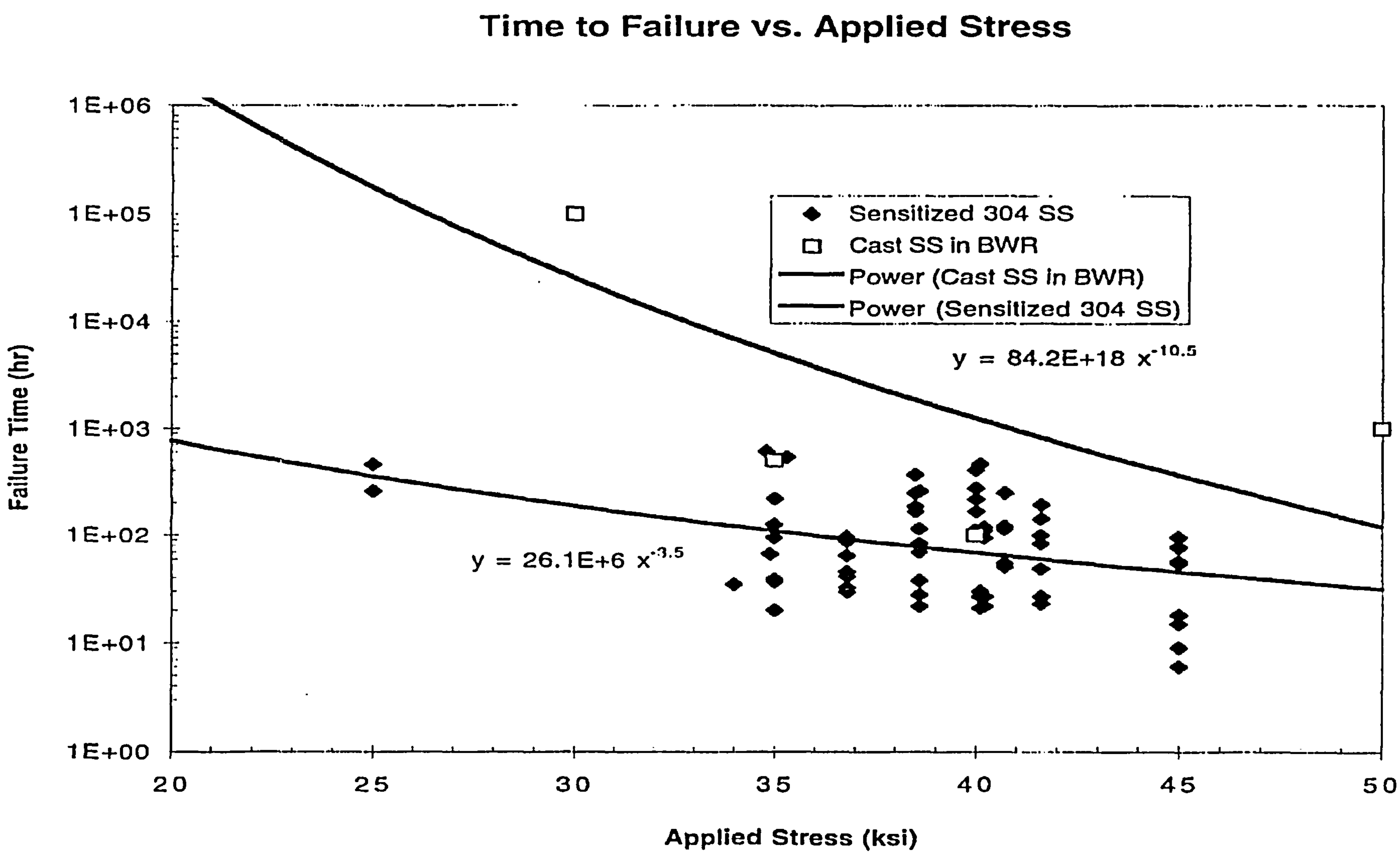


Figure 14 Cladding Stress Corrosion Crack Initiation Data

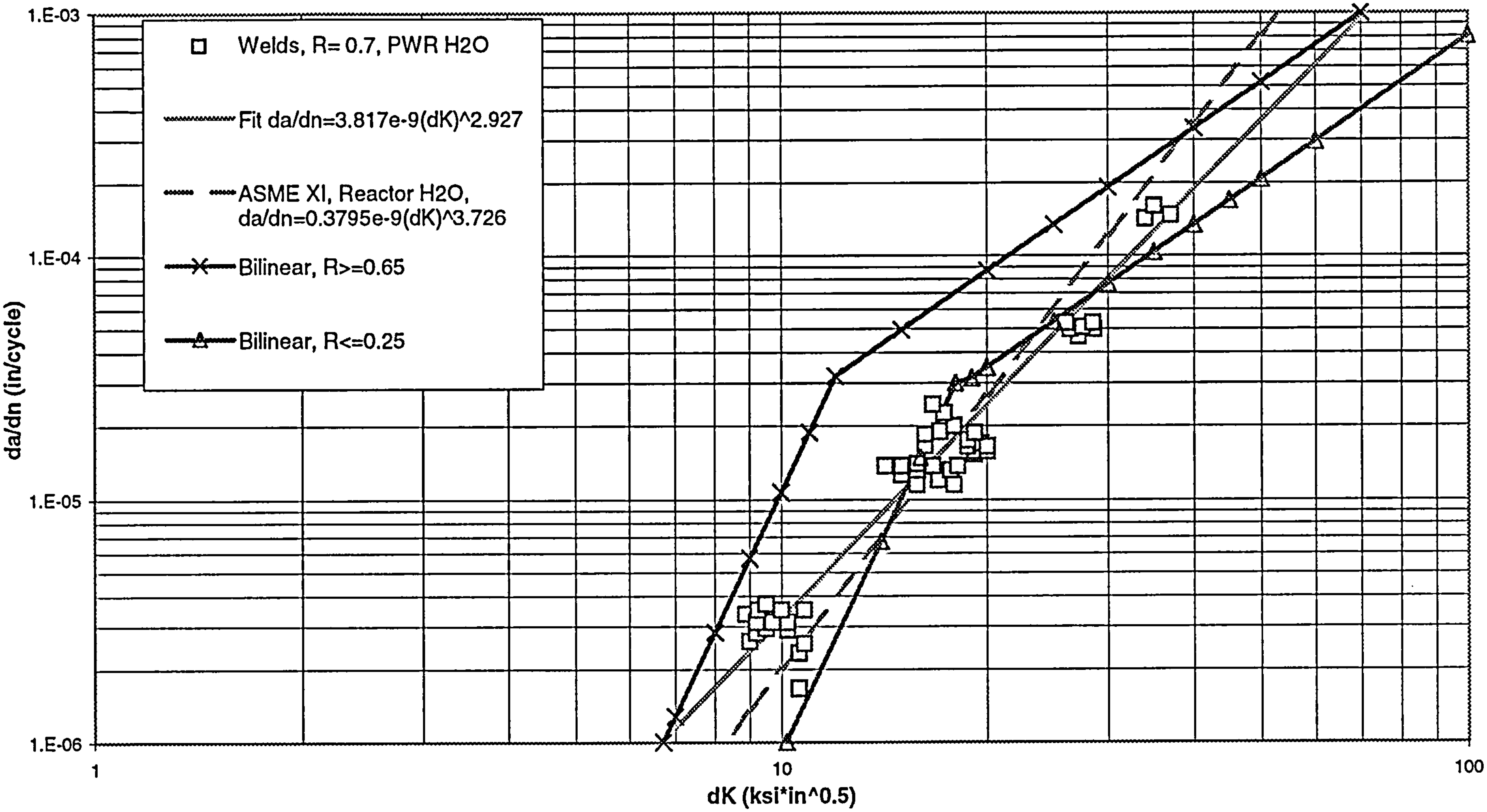


Figure 15 Comparison of Fatigue Crack Growth Laws

Attachment A

2-ISI-22

UNIT 2 RPV NOZZLE EXAMINATIONS SUMMARY

REQUEST FOR RELIEF 2-ISI-22
UNIT 2 RPV NOZZLE EXAMINATIONS SUMMARY

COMPONENT	CYCLE		DATE		REPORT #		EXAM. RESULTS		COVERAGE	
N1A	3	7	9/24/80	10/11/94	R-065, R-067, R-070	R-1001	A	A	*Note 1	60%
N1A-IR	5B	7	7/20/90	10/6/94	R-1400	R-1002	A	A	*Note 1	100%
N1B	4	9	9/28/82	10/15/97	R-181, R-178, R-195	R-207	A	A	*Note 1	72%
N1B-IR	5B	9	7/20/90	11/3/97	R-1399	R-207A	A	A	*Note 1	100%
N2A	4	9	9/28/82	10/15/97	R-171, R-183, R-199	R-208	A	A	*Note 1	77%
N2A-IR	4	9	9/28/82	11/21/97	R-202	R-208A	A	A	*Note 1	100%
N2B	1/3	7	5/17/78 9/23/80	10/23/94	R-048, R-063	R-1021	A	A	*Note 1	52%
N2B-IR	1	7	5/20/78	10/6/94	R-046	R-1022	A	A	*Note 1	100%
N2C	4	9	9/28/82	10/15/97	R-172, R-182, R-196	R-209	A	A	*Note 1	77%
N2C-IR	4	9	9/28/82	11/21/97	R-200	R-209A	A	A	*Note 1	100%
N2D	5B	11	9/20/86 10/22/87	4/6/01	R-137, R-829, R-832	R-126	A	A	*Note 1	67%
N2D-IR	5B	11	9/25/86	4/6/01	R-193	R-126A	A	A	*Note 1	100%
N2E	5B	11	9/20/86 10/22/87	4/7/01	R-136, R-828, R-833	R-127	A	A	*Note 1	67%
N2E-IR	5B	11	9/25/86	4/7/01	R-192	R-127A	A	A	*Note 1	100%
N2F	4A	7	6/6/81	10/22/94	R-006, R-011, R-013	R-1023	A	A	*Note 1	55%
N2F-IR	4A	7	6/7/81	10/6/94	R-020	R-1024	A	A	*Note 1	100%
N2G	4	9	9/28/82	10/15/97	R-179, R-180, R-198	R-210	A	A	*Note 1	77%
N2G-IR	4	9	9/28/82	11/21/97	R-206	R-210A	A	A	*Note 1	100%
N2H	4	9	9/28/82	10/15/97	R-173, R-184, R-197	R-211	A	A	*Note 1	77%
N2H-IR	4	9	9/29/82	11/21/97	R-207	R-11A	A	A	*Note 1	100%
N2J	4A	7	6/6/81	10/22/94	R-007, R-014, R-015	R-1025	A	A	*Note 1	55%
N2J-IR	4A	7	6/7/81	10/6/94	R-019	R-1026	A	A	*Note 1	100%
N2K	5B	11	9/16/86 10/22/87	10/7/01	R-138, R-830, R-834	R-128	A	A	*Note 1	67%

COMPONENT	CYCLE		DATE		REPORT #		EXAM. RESULTS		COVERAGE	
N2K-IR	5B	11	9/25/86	10/7/01	R-194	R-128A	A	A	*Note 1	100%
N3A	5B	11	9/27/86 10/21/87	3/31/01	R-198, R-201, R-893	R-129	A	A	*Note 1	61%
N3A-IR	5B	11	9/28/86	3/31/01	R-255	R-129A	A	A	*Note 1	100%
N3B	4	9	9/26/82	10/15/97	R-067, R-074, R-075	R-212	A	A	*Note 1	75%
N3B-IR	4	9	9/21/82	11/21/97	R-142	R-212A	A	A	*Note 1	100%
N3C	5B	11	9/27/86 12/21/86	3/31/01	R-196, R-199, R-892	R-130	A	A	*Note 1	61%
N3C-IR	5B	11	9/28/86	3/31/01	R-254	R-130A	A	A	*Note 1	100%
N3D	1	7	5/17/78	10/13/94	R-047	R-1003	A	A	*Note 1	57%
N3D-IR	1	7	5/20/78	10/6/94	R-045	R-1004	A	A	*Note 1	100%
N4A	3	7	10/9/80	10/7/94	R-107, R-109, R-122	R-1009	A	A	*Note 1	59%
N4A-IR	3	7	10/7/80	10/17/94	R-105	R-1009	A	A	*Note 1	100%
N4B	4	9	9/12/82	10/15/97	R-089, R-091, R-094	R0213	A	A	*Note 1	67%
N4B-IR	4	9	9/21/82	11/21/97	R-140	R-213A	A	A	*Note 1	100%
N4C	4	9	9/12/82	10/15/97	R-088, R-090, R-095, R-103	R-214	A	A	*Note 1	67%
N4C-IR	4	9	9/21/82	11/21/97	R-141	R-214A	A	A	*Note 1	100%
N4D	5B	11	9/20/86 12/22/87	4/5/01	R-128, R-134, R-897	R-131	A	A	*Note 1	69%
N4D-IR	5B	11	9/25/86	4/5/01	R-190	R-131A	A	A	*Note 1	100%
N4E	5B	11	9/20/86 10/22/87	4/5/01	R-126, R-133, R-895	R-132	A	A	*Note 1	69%
N4E-IR	5B	11	9/25/86	4/3/01	R-189	R-132A	A	A	*Note 1	100%
N4F	3	7	10/9/80	10/17/94	R-108, R-110, R-121	R-1005	A	A	*Note 1	54%
N4F-IR	3	7	10/7/80	10/17/94	R-104, R-008, R-010, R-012	R-1007	A	A	*Note 1	100%

COMPONENT	CYCLE		DATE		REPORT #		EXAM. RESULTS		COVERAGE	
N5A-IR	3	7	10/8/80	10/20/94	R-114	R-1028	A	A	*Note 1	100%
N5B	4	9	9/24/82	10/15/97	R-089, R-105, R-106	R-215	A	A	*Note 1	65%
N5B-IR	4	9	9/21/82	11/21/97	R-138	R-215A	A	A	*Note 1	100%
N6A	3	6	9/18/80	2/13/93	R-050, R-051, R-052	R-064	A	A	*Note 1	100%
N6A-IR	3/5B	6	10/3/80 11/4/88	2/13/93	R-087, R-1111	R-063	A	A	*Note 1	100%
N6B	5B	10	11/16/87	4/25/90	R-859, R-862, R-865	R-353	A	A	*Note 1	100%
N6B-IR	5B	10	11/4/88	4/25/90	R-1110	R-331	A	A	*Note 1	100%
N7	5B	10	11/16/87	4/23/90	R-854, R-857, R-860	R-352	A	A	*Note 1	100%
N7-IR	5B	10	11/4/88	4/25/90	R-1112	R-335	A	A	*Note 1	100%
N8A	3	7	9/24/80	10/17/94	R-061, R-062, R-069	R-1008	A	A	*Note 1	68%
N8A-IR	3	7	10/6/80	10/18/94	R-101	R-1011	A	A	*Note 1	73%
N8B	5B	11	9/20/86 11/16/87	4/3/01	R-139, R-831, R-835	R-133	A	A	*Note 1	72%
N8B-IR	5B	11	9/25/86	4/4/01	R-191	R-133A	A	A	*Note 1	100%
N9	4	9	9/24/82	10/15/97	R-098, R-104, R-161	R-216	A	A	*Note 1	75%
N9-IR	4	9	9/21/82	11/21/97	R-139	R-216A	A	A	*Note 1	100%
N10	-	11	-	4/3/01	-	R-134	-	A		56%

Note 1: The examination method (UT) and techniques utilized in the First Ten-Year ISI Interval were basically the same as used in the Second Ten-Year ISI Interval, therefore the percentage of examination coverage is essentially the same for the RPV Nozzle-To-Vessel Shell Welds and Inner Radius Sections.

Note 2: In results column "A" refers to acceptable per ASME Section XI, Subarticle IWB-3512 acceptance criteria

UNIT 2 RPV NOZZLE EXAMINATIONS
THIRD (CURRENT) INTERVAL, FIRST PERIOD ONLY

COMPONENT	CYCLE	DATE	REPORT #	EXAM. RESULTS	COVERAGE
N1A	12	3/4/03	R-160	A	48.8%
N1A-IR	12	3/7/03	R-169	A	100%
N2B	12	3/3/03	R-161	A	51.5%
N2B-IR	12	3/7/03	R-167	A	60%
N2F	12	3/3/03	R-162	A	51.5%
N2F-IR	12	3/7/03	R-169	A	60%
N2J-IR	12	3/7/03	R-169	A	60%
N3D	12	3/1/03	R-164	A	47.3%
N3D-IR	12	3/3/03	R-169	A	100%
N4A	12	3/2/03	R-141	A	45.4%
N4A-IR	12	3/2/03	R-141	A	100%
N4B	12	3/4/03	R-142	A	45.4%
N4B-IR	12	3/4/03	R-142	A	100%
N4C	12	3/1/03	R-143	A	45.4%
N4C-IR	12	3/1/03	R-143	A	100%
N4D	12	3/4/03	R-144	A	45.4%
N4D-IR	12	3/4/03	R-144	A	100%
N4E	12	3/2/03	R-145	A	45.45
N4E-IR	12	3/2/03	R-145	A	100%
N4F	12	3/4/03	R-146	A	45.4%
N4F-IR	12	3/4/03	R-146	A	100%
N6A	12	2/28/03	R-110	A	90.5%
N6A-IR	12	3/1/03	R-106	A	100%
N8A	12	3/5/03	R-165	A	89.5%
N8A-IR	12	3/7/03	R-169	A	60%

Note: In results column, "A" refers to acceptable per ASME Section XI, Subarticle IWB-3512 acceptance criteria.

Attachment B

3-ISI-18

UNIT 3 RPV NOZZLE EXAMINATIONS SUMMARY

REQUEST FOR RELIEF 3-ISI-18
UNIT 3 RPV NOZZLE EXAMINATIONS SUMMARY

COMPONENT	CYCLE		DATE		REPORT #		EXAM. RESULTS		COVERAGE	
N1A	2	8	10/18/79	10/8/98	R-256/R-272	R-205	A	A	25%	72%
N1A-IR	5B	8	11/16/93	10/8/98	R-1172	R-205A	A	A	100%	100%
N1B	4	10	12/8/81	3/29/02	R-112, R-149, R-157	R-156	A	A	20%	77%
N1B-IR	5B	10	11/16/93	3/29/02	R-1173	R-157	A	A	100%	100%
N2A	4	10	12/7/81	4/1/02	R-109, R-127, R-152	R-158	A	A	20%	77%
N2A-IR	4	10	12/9/81	4/1/02	R-161	R-159	A	A	100%	100%
N2B	2	8	10/19/79	10/8/98	R-238, R-258, R-265	R-206	A	A	25%	77%
N2B-IR	2	8	1016/79	10/8/98	R-233	R-206A	A	A	100%	100%
N2C	4	10	12/7/81	4/1/02	R-111, R-119, R-153	R-160	A	A	20%	77%
N2C-IR	4	10	12/9/81	4/1/02	R-162	R-161	A	A	100%	100%
N2D	2	8	10/16/79	10/8/98	R-235, R-260, R-266	R-207	A	A	25%	77%
N2D-IR	2	8	10/16/79	10/8/98	R-229	R-207A	A	A	100%	100%
N2E	4	10	12/7/81	4/1/02	R-110, R-150, R-154	R-162	A	A	20%	77%
N2E-IR	4	10	12/9/81	4/1/02	R-163	R-163	A	A	100%	100%
N2F	2	8	10/19/79	10/8/98	R-237, R-261, R-269	R-208	A	A	25%	77%
N2F-IR	2	8	10/16/79	10/8/98	R-231	R-208A	A	A	100%	100%
N2G	4	*11	12/8/81		R-113, R-148, R-158		A		20%	
N2G-IR	4	*11	12/8/81		R-165		A		100%	
N2H	5B	*11	11/13/93		R-1174		A		42%	
N2H-IR	5B	*11	11/12/93		R-1204		A		100%	

COMPONENT	CYCLE		DATE		REPORT #		EXAM. RESULTS		COVERAGE	
N2J	5B	*11	11/15/93		R-1175		A		42%	
N2J-IR	5B	*11	11/14/93		R-1205		A		100%	
N2K	5B	*11	11/15/93		R-1176		A		42%	
N2K-IR	5B	*11	11/15/93		R-1206		A		100%	
N3A	4	10	11/20/93	3/31/02	R-045, R-047, R-049, R-051, R-052	R-164	A	A	20%	77%
N3A-IR	4	10	11/22/93	3/10/02	R-061	R-165	A	A	100%	100%
N3B	2	8	10/23/79	10/8/98	R-273, R-293, R-253	R-209	A	A	25%	75%
N3B-IR	2	8	10/16/79	10/8/98	R-226	R-209A	A	A	100%	100%
N3C	5B	*11	11/10/93		R-1177		A		28%	
N3C-IR	5B	*11	11/17/93		R-1207		A		100%	
N3D	5B	*11	11/10/93		R-1178		A		28%	
N3D-IR	5B	*11	11/11/93		R-1178		A		100%	
N4A	4	10	11/30/81	3/20/02	R-083, R-084, R-085	R-166	A	A	20%	77%
N4A-IR	4	10	11/23/81	3/20/02	R-067	R-167	A	A	100%	100%
N4B	2	8	10/22/79	10/14/98	R-251, R-270, R-281	R-211	A	A	25%	68%
N4B-IR	2	8	10/15/79	10/9/98	R-221	R-211A	A	A	100%	100%
N4C	2	8	10/22/79	10/14/98	R-250, R-268, R-282	R-212	A	A	25%	68%
N4C-IR	2	8	10/16/79	10/9/98	R-232	R-212A	A	A	100%	100%
N4D	5B	11	11/16/93	3/08/04	R-1182	R-182	A	A	44%	94.37%
N4D-IR	5B	11	11/9/93	3/12/04	R-1208	R-184	A	A	100%	100%
N4E	5B	11	11/16/93	3/08/04	R-1183	R-183	A	A	43%	94.37%
N4E-IR	5B	11	11/12/93	3/12/04	R-1209	R-185	A	A	100%	100%

COMPONENT	CYCLE		DATE		REPORT #		EXAM. RESULTS		COVERAGE	
N4F	4	10	11/20/81	3/20/02	R-054, R-057, R-068	R-168	A	A	20%	77%
N4F-IR	4	10	11/23/81	3/20/02	R-068	R-169	A	A	100%	100%
N5A	2	8	10/22/79	10/8/98	R-249, R-267, R-284	R-216	A	A	20%	64%
N5A-IR	2	8	10/16/79	10/8/98	R-228	R-216A	A	A	75%	100%
N5B	4	10	12/3/81	4/2/02	R-093, R-101, R-105	R-170	A	A	20%	71%
N5B-IR	4	10	11/24/81	3/31/02	R-081	R-171	A	A	83%	100%
N6A	5B	7	8/1795 9/27/91	3/1/97	R-591, R-591A	R-247	A	A	100%	100%
N6A-IR	5B	7	9/28/91	3/1/97	R-598	R-243	A	A	100%	100%
N6B	5B	11	8/1795 9/27/91	3/06/04	R-592, R-592A	R-186	A	A	100%	93.12%
N6B-IR	5B	11	9/28/91	3/07/04	R-597	R-093	A	A	100%	100%
N7	5B	10	8/1795 9/27/91	3/29/02	R-590, R-590A	R-125	A	A	100%	70%
N7-IR	5B	10	9/28/91	3/30/02	R-599	R-115	A	A	100%	100%
N8A	2	8	10/19/79	10/9/98	R-247, R-259, R-271	R-217	A	A	68%	71%
N8A-IR	2	8	10/16/79	10/9/98	R-230	R-217A	A	A	100%	100%
N8B	5B	*11	11/6/93		R-1185		A		68%	
N8B-IR	5B	*11	11/7/93		R-1185		A		100%	
N9	4	10	12/3/81	4/1/02	R-092, R-103, R-099	R-172	A	A	25%	74%
N9-IR	4	10	1124/81	4/1/02	R-079	R-173	A	A	100%	100%
N10		11		3/04/04		R-187		A		97.31%
N10-IR		11		3/04/04		R-188		A		90%

***Note 1: Scheduled for examination in Unit 3 Cycle 11 (Spring 2004) Refueling Outage, but deferred to Unit 3 Cycle 12 (Spring 2006) Refueling Outage.**

Note 2: In results column, "A" refers to acceptable per ASME Section XI, Subarticle IWB-3512 acceptance criteria.