

**Southern Nuclear
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Post Office Box 1295
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April 13, 2007

Docket No.: 50-425

NL-07-0837

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

Vogtle Electric Generating Plant Unit 2
Pressurizer Nozzle Full Structural Weld Overlay Evaluation

Ladies and Gentlemen:

Southern Nuclear Operating Company (SNC) completed the last performance demonstration initiative (PDI) qualified ultrasonic examination (UT) of Vogtle Electric Generating Plant (VEGP) Unit 2 pressurizer nozzle full structural weld overlays (FSWOLs) on April 1, 2007. This activity was accomplished in accordance with SNC's alternative ISI-GEN-ALT-06-03, Rev. 2, which was approved per NRC safety evaluation report (SER) (TAC Nos. MD2794, MD2795, MD2796 AND MD2797). The last paragraph on page 8 and the first paragraph on page 9 of the SER state:

“The licensee is required to evaluate residual stresses and flaw growth of the repaired weldments to demonstrate that the pressurizer nozzles after the weld overlay installation will perform their intended design function. The licensee agreed to submit a stress analysis report similar to the one required to meet paragraphs g(2) and g(3) in Code Case N-504-2. Calculations shall be performed in accordance with IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required. The size of all flaws will be projected to the end of the design life of the overlay. The licensee noted that there are no existing flaws in the Farley or Vogtle units that required acceptance by analytical evaluation at this time.

The staff expects the results to show that the postulated crack, including its growth in the nozzles, will not adversely affect the integrity of the overlaid welds. The licensee agreed to submit the evaluations prior to entry into Mode 4 from the refueling outage. The staff finds that the licensee's response is acceptable because it will perform a stress analysis which will be available for staff review.”

The VEGP Unit 2 pressurizer nozzle FSWOL evaluation requested by the SER is enclosed.

This letter contains no NRC commitments. If you have any questions, please advise.

Sincerely,



B. J. George
Manager, Nuclear Licensing

BJG/DRG/daj

Enclosure: Vogtle Unit 2 Full Structural Weld Overlay Evaluation

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
T. E. Tynan, Vice President – Vogtle
Mr. D. H. Jones, Vice President – Engineering
RType: CVC7000

U. S. Nuclear Regulatory Commission
Dr. W. D. Travers, Regional Administrator
Mr. B. K. Singal, NRR Project Manager – Vogtle
Mr. G. J. McCoy, Senior Resident Inspector – Vogtle

Enclosure

**Vogtle Electric Generating Plant Unit 2
Pressurizer Nozzle Full Structural Weld Overlay Evaluation
Spring 2007 Outage (2R12)**



Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

GP-18161
April 12, 2007

Mr. T. E. Tynan
Vice President, Nuclear Vogtle Project
Southern Nuclear Operating Company, Inc.
Vogtle Electric Generating Plant
7821 River Road
Waynesboro, GA 30830

Ref: (1) PO 7071336
(2) LTR-PAFM-07-41

Attention: Mr. Jim Edwards
Mr. Jack Stringfellow

SOUTHERN NUCLEAR OPERATING COMPANY
VOGTLE ELECTRIC GENERATING PLANT UNIT 2
Transmittal of Structural Weld Overlay Evaluation Report

Dear Mr. Tynan:

Attached for your information and use please find the Plant Vogtle Unit 2, full structural weld overlay evaluation letter report. The purpose of this letter report is to fulfill the SNC commitment prior to entry into Mode 4 from the 2R12 refueling outage as stated in the NRC safety evaluation report for the proposed alternative submitted by SNC for application of the pressurizer nozzle full structural weld overlay. The report incorporates resolution of comments obtained during review by SNC of a draft version of the report.

Should you have any comments or questions, please contact Christopher Ng at (724) 722-6030, or me at (412) 374-3365.

Very truly yours,

WESTINGHOUSE ELECTRIC COMPANY

A handwritten signature in cursive script, appearing to read 'E. C. Arnold'.

E. C. Arnold, Manager
Southern Nuclear Projects

Mr. Tynan

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VOGTLE UNIT 2 FULL STRUCTURAL WELD OVERLAY EVALUATION

Introduction

Structural weld overlay is a repair and/or mitigation technique used to reinforce nozzle safe-end regions and piping susceptible to Primary Water Stress Corrosion Cracking (PWSCC). Southern Nuclear Operating Company (SNC) has installed a full structural weld overlay on each of the six pressurizer nozzles at Vogtle Unit 2 during the Spring 2007 refueling outage. Schematics of the surge nozzle, typical safety/relief nozzle and spray nozzle configurations are shown in Figures 1, 2 and 3 respectively. The alternative [1, 2, 3, 4] submitted by SNC to the NRC was used as the basis for the full structural weld overlay design and qualification.

The structural weld overlay involved applying a specified thickness and length of weld material over the dissimilar metal weld in a configuration that ensured structural integrity was maintained. The applied weld material (Alloy 52/52M) forms a structural barrier to primary water stress corrosion cracking (PWSCC) and produces a compressive residual stress condition at the inner portion of the nozzle/safe end region that mitigates future crack initiation and/or propagation. Due to the proximity of the stainless steel butt weld (safe end to pipe) to the dissimilar metal butt weld (nozzle to safe end) for all of the Vogtle Unit 2 pressurizer nozzles, the weld overlay not only covers the dissimilar metal butt weld, but also covers and extends past the stainless steel butt weld.

The purpose of this report is to fulfill the following requirement stated in the NRC safety evaluation report [5] for the alternative submitted by SNC.

"The licensee is required to evaluate residual stresses and flaw growth of the repaired weldments to demonstrate that the pressurizer nozzles after the weld overlay installation will perform their intended design function. The licensee agreed to submit a stress analysis report similar to the one required to meet paragraphs g(2) and g(3) in Code Case N-504-2. Calculations shall be performed in accordance with IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required. The size of all flaws will be projected to the end of the design life of the overlay. The staff expects the results to show that the postulated crack, including its growth in the nozzles, will not adversely affect the integrity of the overlaid welds. The licensee agreed to submit the evaluations prior to entry into Mode 4 from the refueling outage."

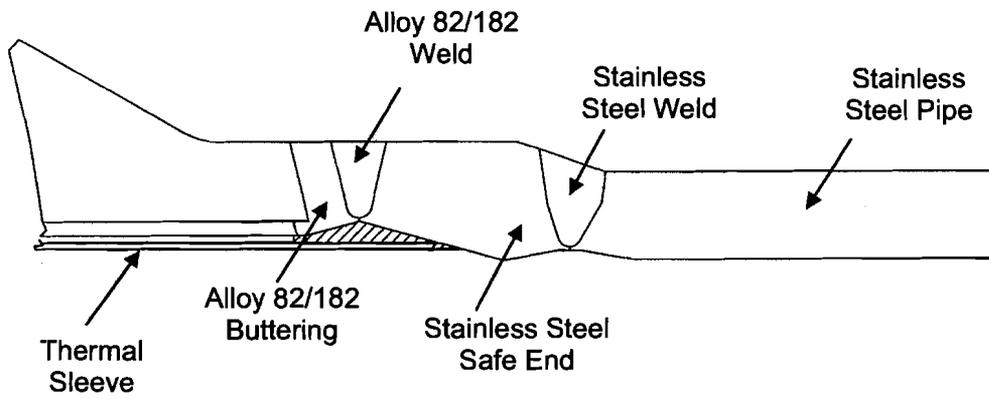


Figure 1 Schematic of Pressurizer Surge Nozzle Configuration

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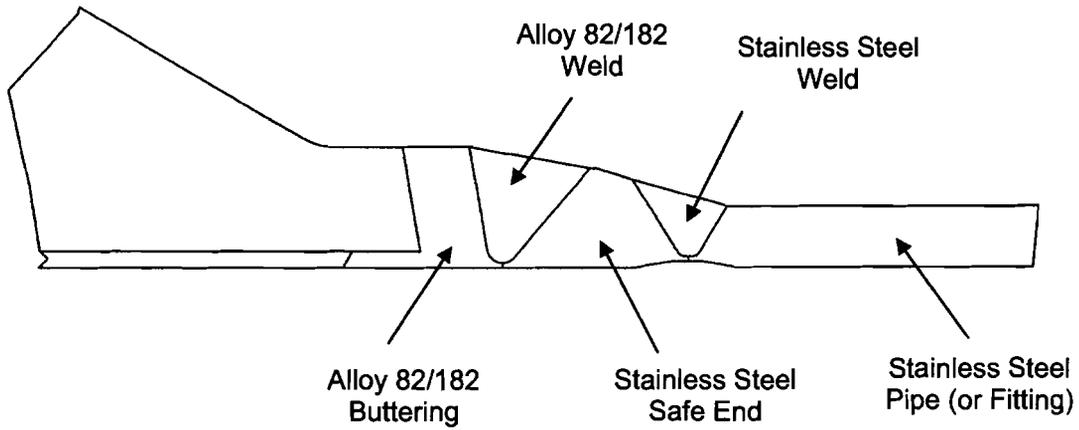


Figure 2 Schematic of Typical Pressurizer Safety and Relief Nozzle Configuration

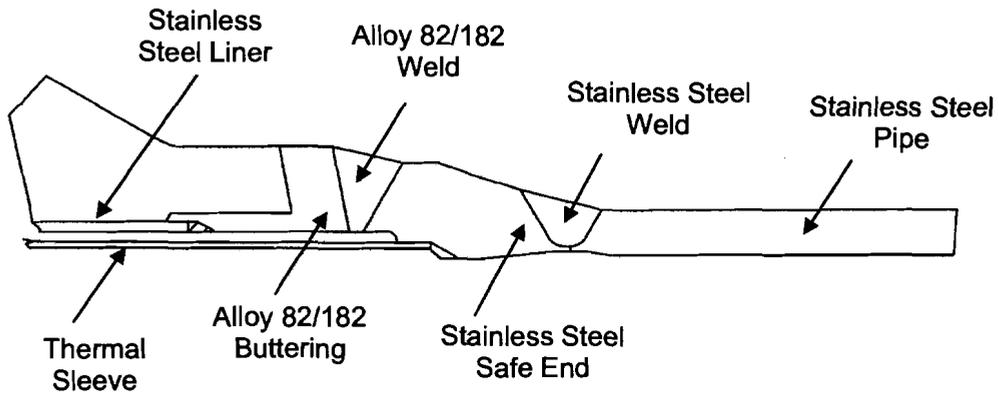


Figure 3 Schematic of Typical Pressurizer Spray Nozzle Configuration

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Weld Overlay Design

Based on the Vogtle plant specific loadings at the nozzles, the minimum required full structural weld overlay thickness was determined in accordance with the SNC alternative requirements. Per the alternative, a flaw was assumed to be 100% through the original wall thickness for the entire circumference. The thickness of the full structural weld overlay applied meets the criteria of IWB-3640. Due to a concern for potential weld dilution, a sacrificial layer was applied prior to the addition of the required full structural weld overlay thickness to ensure that the Chromium (Cr) content in the first layer exceeded 24% for PWSCC resistance. The minimum full-structural weld overlay thickness did not take credit for the sacrificial layer.

The full structural weld overlay length was based conservatively on the length of $0.75\sqrt{Rt}$ per the SNC alternative, where R and t are the outer radius and wall thickness of the pipe/nozzle respectively. In addition, the full structural weld overlay was extended to include the stainless steel butt weld region. The ability to examine the weld overlay was a controlling factor in the structural weld overlay design; therefore additional weld metal was added to improve the ability to examine the overlay, beyond that required for repair and/or mitigation. As a result, the final full structural weld overlay length and thickness exceeded the requirements for a full structural weld overlay designed in accordance with the SNC alternative.

Since the full structural weld overlay was applied before any Performance Demonstration Initiative (PDI) qualified UT examinations were performed, the possibility of discovering an almost through-wall flaw at the Alloy 82/182 weld during the final PDI qualified UT examination of the completed weld overlay was considered. To allow for this possibility, the approach used was to further increase the required full structural weld overlay thickness over the Alloy 82/182 weld to account for at least 10 years of crack growth into the weld overlay. This was conservative, since no PWSCC indications were detected in the upper 25% of the original weld material during the PDI qualified examinations after the structural weld overlay was applied. No increase in the full structural weld overlay thickness was necessary over the stainless steel weld, since PWSCC is not an active mechanism in stainless steel.

The minimum full structural weld overlay design dimensions are shown in Table 1 for all the mitigated pressurizer nozzles, and do not include any required dilution or sacrificial layers.

Table 1: Minimum Structural Weld Overlay Repair Design Dimensions

| Nozzle | Alloy 82/182 Weld Overlay | | Stainless Steel Weld Overlay | |
|---------------|---------------------------|----------------|------------------------------|----------------|
| | Thickness (in) | Length (in) | Thickness (in) | Length (in) |
| Spray | 0.36 | 1.30 | 0.26 | 1.06 |
| Safety/Relief | 0.47 | 1.78 | 0.39 | 1.56 |
| Surge | 0.66 | 2.58 | 0.60 | 2.72 |

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ASME Section III Stress Evaluation

The effects of the full structural weld overlay were evaluated to demonstrate that the mitigated pressurizer nozzles continue to meet the applicable ASME Code Section III NB-3200 and NB-3600 requirements and the conclusions documented in the existing piping and pressurizer nozzle stress reports remain valid. The limiting stress intensity and fatigue usage factor, reflecting the impact of the full structural weld overlay for the mitigated pressurizer nozzles, were found to be at the tapered end of the weld overlay on the original stainless steel piping. The limiting results from the stress evaluations are summarized in Table 2. These results show that the mitigated pressurizer nozzles still meet the applicable ASME Code Section III requirements.

Table 2: ASME Section III Stress Results for Mitigation Nozzles

| Nozzle | Primary Stress Plus Secondary Stress Intensity | | Expansion Stress Intensity | | Fatigue Usage | |
|---------------|--|---------------------|----------------------------|---------------------|---------------|-----------|
| | Calculated (ksi) | Allowable 3Sm (ksi) | Calculated (ksi) | Allowable 3Sm (ksi) | Calculated | Allowable |
| Spray | 43.0 | 47.5 | 20.0 | 47.5 | 0.97 | 1.0 |
| Safety/Relief | 46.1 | 61.4 | 60.9 | 61.4 | 0.016 | 1.0 |
| Surge | 49.0 | 50.1 | 52.6 | 52.9 | 0.24 | 1.0 |

Weld Overlay Residual Stress Evaluation

The pressurizer nozzles were conservatively analyzed to include an assumed 360°, fifty percent (50%) through-wall weld repair, made from the inside surface during the initial fabrication process, to simulate the initial residual stress state. Finite element analyses were performed to determine the residual stresses in the pressurizer nozzle dissimilar metal butt weld regions resulting from the structural weld overlay in order to support the subsequent crack growth evaluations. Weld passes were grouped into weld areas as has been done in most weld simulation analyses in the industry. Each weld area applied represents one or more weld beads.

The weld areas were added to the model using the ANSYS "birth and death" options. These options are useful in simulating the structural weld overlay process in which each weld overlay area is added to the original nozzle configuration sequentially. For the structural weld overlay finite element models, each nozzle is modeled to include the final nozzle configuration with the structural weld overlay. All the finite elements used to model the structural weld overlay are present in the model at the start of the weld overlay simulation analysis. Element "death" option is activated at the beginning of the weld overlay process when all the finite elements pertaining to the weld overlay are being artificially deactivated, but not physically removed from the finite element model. This means that the elements are still present in the model but they have no

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stiffness or conductivity. During the weld overlay process, each weld area is then reactivated sequentially using the "birth" option of ANSYS to simulate the application of weld passes. The "birth" option does not actually introduce any additional finite elements to the model, but only reactivates the elements that were being deactivated at the beginning of the weld overlay process. This process using the "birth" option continues until the full structural weld overlay has been applied to the original nozzle configuration.

The resulting residual weld stresses for the mitigated pressurizer nozzles are compressive on the inside surface of the nozzles, over the entire length of the PWSCC-susceptible material; thereby, minimizing the potential for any future PWSCC crack initiation and/or crack propagation.

Crack Growth Evaluation

Using the through-wall stress distribution consisting of residual stresses resulting from the full structural weld overlay, thermal transient stresses and applicable mechanical loadings, crack growth analyses were performed for the mitigated nozzles. The following summarizes the crack growth results for the dissimilar metal and stainless steel welds for the mitigated nozzles.

Dissimilar Metal Weld (Alloy 82/182)

The crack growth analysis performed in accordance with the IWB-3640 requirement [6] involved postulating a flaw at the region of concern. The objective of the analysis was to determine the service life required for the flaw to propagate to an allowable flaw depth without adversely impacting the integrity of the structural weld overlay. A 100% through wall flaw was postulated in the original weld (versus the 75% required in the alternative) and only fatigue crack growth was considered in the weld overlay material since it is PWSCC resistant.

The postulated flaw was subjected to cyclic loading due to the applicable plant specific thermal transients including the residual stresses resulting from the structural weld overlay mitigation process. The thermal transients considered in the analysis were distributed equally over the plant design life. The crack growth rate reference curves used in the crack growth evaluation for the austenitic nickel alloy and stainless steel materials were obtained from NUREG/CR 6721 [7] and ASME publications [6, 8] respectively.

Since the full structural weld overlay was applied before any PDI-qualified UT examinations were performed, the possibility of discovering an almost through the original wall flaw during the final PDI-qualified UT examination of the completed weld overlay was considered in the crack growth evaluation. Even though this is a highly unlikely scenario, the required full structural weld overlay thickness for the pressurizer nozzles has taken into account at least 10 years of fatigue crack growth into the weld overlay material resulting from a postulated 100% initial through-wall flaw. Crack growth analyses into the weld overlay material have been performed to confirm that the full structural weld overlay designs for all the mitigated pressurizer nozzles are adequate for at least 10 years even for postulated 100% initial through-wall flaws in the Alloy 82/182 weld. The results of the crack growth evaluation are shown in Table 3. Since final PDI-qualified UT examination for all the Vogtle Unit 2 mitigated pressurizer nozzles did not identify any unacceptable indications in the outer 25% of the original wall thickness, the assumptions and therefore the results of the crack growth calculations are conservative.

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Table 3 crack growth results indicate that small crack growth is expected in 10 years in the Alloy 82/182 welds for the spray and surge nozzle, while there is no expected crack growth for the safety/relief nozzles. In accordance with the SNC alternative, all nozzles will be inservice examined within two refueling outages after the implementation of the full structural weld overlay at Vogtle Unit 2. Assuming that there are no new indications detected, subsequent inservice examinations will be performed as described in the alternative. Since small flaw growth is expected in the spray and surge nozzles, these two nozzles will be included in the 25% sample to be examined approximately every 10 years.

Stainless Steel Weld

Similar crack growth evaluations were performed for the stainless steel butt welds. The full structural weld overlay designs for the spray and safety/relief nozzles are adequate for at least 10 years, even for postulated 100% initial through-wall flaws in the stainless steel welds.

The structural weld overlay design for the surge nozzle is adequate for a postulated 75% initial through-wall flaw. Since final PDI-qualified UT examination for all the Vogtle Unit 2 mitigated pressurizer nozzles did not identify any flaws in the outer 25% of the original wall thickness, it can be concluded that a postulated 75% through-wall flaw would not adversely impact the integrity of the structural weld overlay.

Table 3: Crack Growth Results for Mitigation Pressurizer Nozzles

| Nozzle | Weld | Flaw Configuration | Initial Flaw Depth (in.) | Initial Flaw Depth / Original Wall Thickness Ratio | Final Flaw Depth (in.) in 10 years |
|----------------------|------------------------|---------------------------|---------------------------------|---|---|
| Spray | A82/182 | Axial | 1.000 | 1.00 | 1.018 |
| | | Circumferential | 1.000 | 1.00 | 1.008 |
| | Stainless Steel | Axial | 0.600 | 1.00 | 0.600 |
| | | Circumferential | 0.600 | 1.00 | 0.600 |
| Safety/Relief | A82/182 | Axial | 1.405 | 1.00 | 1.405 |
| | | Circumferential | 1.405 | 1.00 | 1.405 |
| | Stainless Steel | Axial | 0.800 | 1.00 | 0.800 |
| | | Circumferential | 0.800 | 1.00 | 0.800 |
| Surge | A82/182 | Axial | 1.580 | 1.00 | 1.587 |
| | | Circumferential | 1.580 | 1.00 | 1.678 |
| | Stainless Steel | Axial | 1.031 | 0.75 | 1.031 |
| | | Circumferential | 1.031 | 0.75 | 1.031 |

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Conclusion

The Vogtle Unit 2 pressurizer nozzle full structural weld overlay designs have been demonstrated to meet the requirements in the SNC alternative through finite element analysis and fracture mechanics evaluation. Since the final PDI-qualified UT examinations did not detect any flaw in the upper 25% of the original Alloy 82/182 and stainless steel weld material in any of the pressurizer nozzles, the full structural weld overlay designs for all the Vogtle Unit 2 pressurizer nozzles are adequate before the next in-service inspection period. The postulation of an initial 75% through-wall flaw would not adversely affect the integrity of the full structural weld overlay implemented during the Spring 2007 outage.

Since the requirements in the SNC alternative are met, the structural integrity of the dissimilar-metal butt weld region for all the Vogtle Unit 2 mitigated pressurizer nozzles is maintained with the full structural weld overlay. The full structural weld overlay design is developed based on the assumption of a 360° through-wall flaw. The use of Alloy 52/52M PWSCC-resistant weld material for the structural weld overlay will prevent any future PWSCC crack growth into the structural weld overlay even if any indications were to grow through the existing pipe wall thickness. Consequently, the full structural weld overlay implemented for Vogtle Unit 2 pressurizer nozzles will mitigate future PWSCC crack initiation and/or propagation and thus maintain structural integrity of the dissimilar-metal butt weld regions.

References

1. Southern Nuclear Operating Company Letter NL-06-1713 dated August 10, 2006, "Joseph M. Farley Nuclear Plant, Vogtle Electric Generating Plant, Proposed Alternative for Application of Pressurizer Nozzle Full-Structural Weld Overlays."
2. Southern Nuclear Operating Company Letter NL-06-2434 dated October 20, 2006, "Joseph M. Farley Nuclear Plant, Vogtle Electric Generating Plant, Response to Request for Additional Information Regarding Proposed Alternative for Application of Full Structural Weld Overlays on Pressurizer Nozzles."
3. Southern Nuclear Operating Company Letter NL-06-2768 dated January 3, 2007, "Joseph M. Farley Nuclear Plant, Vogtle Electric Generating Plant, Proposed Alternative for Application of Pressurizer Nozzle Full-Structural Weld Overlays and Response to Request for Additional Information."
4. SNC Letter NL-07-0366 dated February 21, 2007, "Joseph M. Farley Nuclear Plant, Vogtle Electric Generating Plant, Proposed Alternative for Application of Pressurizer Nozzle Full-Structural Weld Overlays – Revision 2.0."

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5. NRC Letter dated March 8, 2007, NRC to Southern Nuclear Operating Company, Subject: "Joseph M. Farley Nuclear Plant, Units 1 and 2, and Vogtle Electric Generating Plant, Units 1 and 2 – Alternative for Application of Pressurizer Nozzle Full-Structural Weld Overlays (TAC Nos. MD2794, MD2795, MD2796 and MD2797)
6. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 2001 Edition through the 2003 Addenda.
7. Chopra, O. K., Soppet, W. K., and Shack, W. J., "Effects of Alloy Chemistry, Cold Work, and Water Chemistry on Corrosion Fatigue and Stress Corrosion Cracking of Nickel Alloys and Welds," NUREG/CR 6721, May 2001.
8. Bamford, W. H., "Fatigue Crack Growth of Stainless Steel Piping in a Pressurized Water Reactor Environment," Trans ASME, Journal of Pressure Vessel Technology, February 1979.