Southern Nuclear
Operating Company, Inc.
Post Office Box 1295
Birmingham, Alabama 35201-1295

Tel 205.992.5000

SOUTHERN COMPANY
Energy to Serve Your World℠

May 3, 2007

Docket No.: 50-364

NL-07-0961

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

Joseph M. Farley Nuclear Plant Unit 2
Pressurizer Nozzle Full Structural Weld Overlay Evaluation

Ladies and Gentlemen:

Southern Nuclear Operating Company (SNC) completed the Performance Demonstration Initiative (PDI) qualified ultrasonic examination (UT) of Farley Nuclear Plant (FNP) Unit 2 pressurizer surge nozzle full structural weld overlay (FSWOL), on May 2, 2007. This activity was accomplished in accordance with SNC's alternative ISI-GEN-ALT-06-03, 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 states:

> "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 FNP Unit 2 pressurizer surge nozzle FSWOL evaluation, requested per 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/JLS/daj

Enclosure: FNP Unit 2 Pressurizer Surge Nozzle Full Structural Weld Overlay Evaluation

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
Mr. J. R. Johnson, Vice President – Farley
Mr. D. H. Jones, Vice President – Engineering
RTYPE: CFA04.054; LC# 14576

U. S. Nuclear Regulatory Commission
Dr. W. D. Travers, Regional Administrator
Ms. K. R. Cotton, NRR Project Manager – Farley
Mr. E. L. Crowe, Senior Resident Inspector – Farley

Enclosure

Farley Nuclear Plant Unit 2
Pressurizer Surge Nozzle Full Structural Weld Overlay Evaluation
Spring 2007 Outage (2R18)

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

May 2, 2007

ALA-07-55

Ref: (1) PO QP060344

Mr. J. R. Johnson
Vice President Farley Project
Southern Nuclear Operating Company
Farley Nuclear Plant
US Highway 95, 5 Miles South Of Columbia
Columbia, AL 36319

Attention: Mr. Keith Wooten
Mr. Randy Andrews

SOUTHERN NUCLEAR OPERATING COMPANY
JOSEPH M. FARLEY NUCLEAR PLANT UNIT 2
Transmittal of Surge Nozzle Structural Weld Overlay Evaluation Report

Dear Mr. Johnson:

Attached for your information and use please find the Plant Farley Unit 2 surge nozzle full structural weld overlay evaluation letter report. The purpose of this letter report is to address the SNC commitment to the NRC to submit this report prior to entry into Mode 4 from the 2R18 refueling outage. 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, Mark Urso at (412) 374-4349, or me at (412) 374-3365.

Very truly yours,

WESTINGHOUSE ELECTRIC COMPANY

E C Arnold

E. C. Arnold, Manager
Southern Nuclear Projects

cc: B. D. McKinney *
W. L. Bargeron *
J. E. Love
J. A. Wehrenberg
J. L. Tain
D. P. Hayes
W. F. Kitchens
B. J. George *
R. H. Parker *
R. E. Mullins *
M. W. Dove *
J. E. Fridrichsen *
S. H. Chesnut *
B. L. Moore
D. R. Andrews *
J. G. Horn *
K. D. Wooten *
R. V. Badham *
D. G. Beaty *
J. M. Walden *
C. Schroeder (W-FNP)

* w/att

bcc: E. C. Arnold
L. W. Stern
M. A. Urso
R. M. Orsulak
R. C. Bedard
C. J. Brown
C. K. Ng
W. A. Bamford
R. L. Brice-Nash
ALA File

FARLEY UNIT 2 SURGE NOZZLE 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) installed a full structural weld overlay on the pressurizer surge nozzle at Farley Unit 2 during the Spring 2007 refueling outage. A schematic of the surge nozzle is shown in Figure 1. The alternative [1-5] 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 the Farley Unit 2 pressurizer surge nozzle, 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 [6] 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.*"

Examination Results

PDI-qualified (App VIII, Supp 10) manual UT was performed and indications were detected in the surge nozzle dissimilar metal weld. To further characterize these indications, a phased array examination (App VIII, Supp 10), which is qualified for sizing, was performed on the surge nozzle. The phased array examination identified a suspected circumferential indication approximately 3.5 inches in length and ½ inch deep (33% through-wall) near the interface of the butter weld and the dissimilar metal weld. The phased array examination also identified two suspected axial indications, separate from the suspected circumferential indication, with a reported depth of less than 20% through-wall. When indications were identified, which were potentially connected to the inside surface, a contingency weld overlay was applied in accordance with the alternative [1–5].

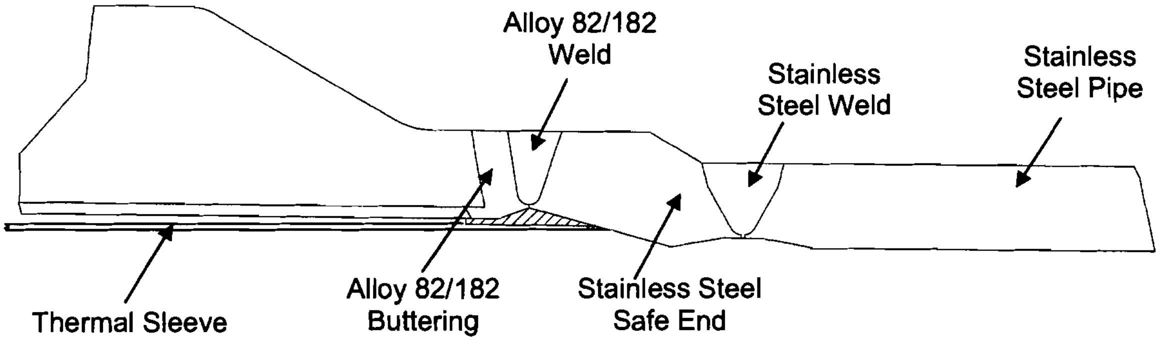

Figure 1 Schematic of Pressurizer Surge Nozzle Configuration

Weld Overlay Design

Based on the Farley plant specific loadings at the surge nozzle, the minimum required full structural weld overlay thickness was determined in accordance with the SNC alternative requirements. Per the alternative, a flaw was postulated 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. In addition the full structural weld overlay thickness over the Alloy 82/182 weld was increased to account for at least 10 years of crack growth into the weld overlay by the postulated flaw. 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.

The minimum full structural weld overlay design dimensions are shown in Table 1 for the repaired/mitigated pressurizer surge nozzle, and do not include any required sacrificial layers.

Table 1: Minimum Structural Weld Overlay Repair/Mitigation Design Dimensions

	Alloy 82/182 Weld Overlay		Stainless Steel Weld Overlay	
Nozzle	Thickness	Length	Thickness	Length
	(in.)	(in.)	(in.)	(in.)
Surge	0.68	2.57	0.47	2.35

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.

ASME Section III Stress Evaluation

The effects of the full structural weld overlay were evaluated to demonstrate that the repaired/mitigated pressurizer surge nozzle 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 repaired/mitigated pressurizer surge nozzle, were found to be at the tapered end of the weld overlay on the original stainless steel piping. The limiting results from the stress evaluation are summarized in Table 2. These results show that the repaired/mitigated pressurizer surge nozzle still meets the applicable ASME Code Section III requirements.

Table 2: ASME Section III Stress Results for Repaired/Mitigated Surge Nozzle

Primary Stress Plus Secondary Stress Intensity		Expansion Stress Intensity		Fatigue Usage	
Calculated (ksi)	Allowable $3S_m$ (ksi)	Calculated (ksi)	Allowable $3S_m$ (ksi)	Calculated	Allowable
51.5	54.3	42.3	48.6	0.08	1.0

Weld Overlay Residual Stress Evaluation

The pressurizer surge nozzle was conservatively analyzed to include an assumed 50% through-wall weld repair made from the inside surface around the full circumference 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 surge nozzle dissimilar metal butt weld region 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 model, the surge 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 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 repaired/mitigated pressurizer surge nozzle are compressive on the inside surface of the nozzle, over the entire length of the PWSCC-susceptible material and up to about 80% through the original wall; 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 repaired/mitigated surge nozzle based on as-found flaw size detected during the pre-overlay inspection. The following summarizes the crack growth results for the dissimilar metal and stainless steel welds for the repaired/mitigated surge nozzle.

Dissimilar Metal Weld (Alloy 82/182)

The crack growth analysis performed in accordance with the IWB-3640 requirement [7] was based on the as-found flaw sizes at the region of concern. The objective of the analysis was to determine the service life required for the as-found flaw to propagate to an allowable flaw depth without adversely impacting the integrity of the structural weld overlay. A 50% through-wall axial and circumferential flaw were conservatively postulated in the crack growth analysis since none of the indications detected in the original weld material during the pre-overlay inspection were more than 50% through the original wall.

The postulated flaws were 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 curve used in the crack growth evaluation for the austenitic nickel alloy was obtained from NUREG/CR 6721 [8].

Crack growth analyses have been performed to confirm that the full structural weld overlay designs for the repaired/mitigated pressurizer surge nozzle is adequate for at least 20 years for the as-found flaws in the Alloy 82/182 weld. The results of the crack growth evaluation are shown in Table 3 and demonstrated that the as-found flaws in the Alloy 82/182 weld would not reach 100% of the original wall in at least 20 years. No PWSCC crack growth needs to be considered based on the negligible crack growth shown in Table 3 because the residual stresses resulting from the full structural weld overlay are compressive up to about 80% through the original wall.

Stainless Steel Weld

Similar crack growth evaluations were performed for the stainless steel butt weld. Because a PDI-qualified UT examination in the stainless steel weld was not performed before the structural weld overlay, a 75% through-wall flaw, which is consistent with the PDI qualification, was conservatively postulated in the crack growth analysis. The results of the crack growth analysis confirm that the full structural weld overlay design at the stainless steel weld for the repaired/mitigated pressurizer surge nozzle is adequate for at least 20 years. The results of the crack growth evaluation are shown in Table 3 and demonstrated that conservatively postulated 75% through-wall flaws in the stainless steel weld would not reach 100% of the original wall in at least 20 years.

Table 3: Crack Growth Results for Repaired/Mitigated Pressurizer Surge Nozzle

Weld	Flaw Configuration	Initial Flaw Depth (in.)	Initial Flaw Depth / Original Wall Thickness Ratio	Final Flaw Depth (in.) in 20 years
A82/182	Axial	0.781	0.50	0.783
	Circumferential	0.781	0.50	0.785
Stainless Steel	Axial	1.06	0.75	1.06
	Circumferential	1.06	0.75	1.06

Conclusion

The Farley Unit 2 pressurizer surge nozzle full structural weld overlay design has been demonstrated to meet the requirements in the SNC alternative through finite element analysis and fracture mechanics evaluation. The results of the crack growth analysis have demonstrated that the as-found flaws detected in the Alloy 82/182 weld 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 the Farley Unit 2 repaired/mitigated pressurizer surge nozzle is maintained with the full structural weld overlay. The full structural weld overlay design was 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 Farley Unit 2 pressurizer surge nozzle 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."

5. SNC Letter NL-07-0626 dated March 15, 2007, "Joseph M. Farley Nuclear Plant, Vogtle Electric Generating Plant, Additional Information Regarding the Proposed Alternative for Application of Pressurizer Nozzle Full-Structural Weld Overlays – Revision 2.0."

6. NRC Letter dated April 3, 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)

7. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 2001 Edition through the 2003 Addenda.

8. 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, April 2001.