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SOUTHERN COMPANY
Energy to Serve Your World℠

May 2, 2008

Docket Nos.: 50-424

NL-08-0667

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Vogtle Electric Generating Plant – Unit 1
Pressurizer Nozzle Full Structural Weld Overlay Evaluation and
Nondestructive Examination Results, Spring 2008 Outage (1R14)

Ladies and Gentlemen:

By letter (NL-08-0611) dated April 18, 2008, Southern Nuclear Operating Company (SNC) submitted, to the NRC, the Vogtle Electric Generating Plant Unit 1 pressurizer nozzle full structural weld overlay (FSWOL) evaluation for the Spring 2008 outage (1R14), as required by the NRC safety evaluation report (SER) dated March 10, 2008 (TAC Nos. MD6307 and MD6308), in addition to ultrasonic examination results and repair information for the weld overlay installations.

Enclosure 1 of SNC letter NL-08-0611 contained the Westinghouse Electric Company structural weld overlay evaluation report, which was labeled as Proprietary Class 2 but, in fact, contained no proprietary information. The Enclosure to this letter contains a version of the Westinghouse structural weld overlay evaluation report that is not labeled as proprietary.

Thank you very much for your assistance in this matter, and SNC apologizes for any inconvenience.

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

Sincerely,

D. H. Jones
Vice President – Engineering

DHJ/LPH/daj

Enclosure: Vogtle Unit 1 Full Structural Weld Overlay Evaluation

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

U. S. Nuclear Regulatory Commission
Mr. V. M. McCree, Acting Regional Administrator
Mr. R. A. Jervey, NRR Project Manager – Vogtle
Mr. G. J. McCoy, Senior Resident Inspector – Vogtle

Vogtle Electric Generating Plant, Unit 1
Pressurizer Nozzle Full Structural Weld Overlay Evaluation and
Nondestructive Examination Results, Spring 2008 Outage (1R14)

Enclosure 1

Vogtle Unit 1 Full Structural Weld Overlay Evaluation

Westinghouse

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Our ref: GP-18333, Rev. 1
Ref: 1) LTR-PAFM-08-66

April 22, 2008

Attention: Mr. J. Olson
Mr. J. Edwards

SOUTHERN NUCLEAR OPERATING COMPANY
VOGTLE ELECTRIC GENERATING PLANT UNIT 1
Transmittal of Structural Weld Overlay Evaluation Report

Dear Mr. Tynan:

Attached for your information and use, please find the Plant Vogtle Unit 1 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 1R14 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 questions or require additional information, please feel free to contact Chris Ng at (724) 722-6030, or me at (412) 374-3365.

Very truly yours,

WESTINGHOUSE ELECTRIC COMPANY

E C Arnold

E. C. Arnold, Manager
Southern Nuclear Projects

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VOGTLE UNIT 1 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 1 during the Spring 2008 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 alternatives [1, 2] 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 1 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 commitment stated in the NRC safety evaluation report [3] for the alternative submitted by SNC.

"*The licensee will provide to the NRC, prior to entering Mode 4, the stress analysis report which will include results showing that the requirements of Subarticles NB-3200 and NB-3600 of the ASME Code, Section III are satisfied. The stress analysis will also include results showing that the requirements of IWB-3000 of the ASME Code, Section XI, are satisfied. The results will show that the postulated crack including its growth in the nozzles do not adversely affect the integrity of the overlaid welds.*"

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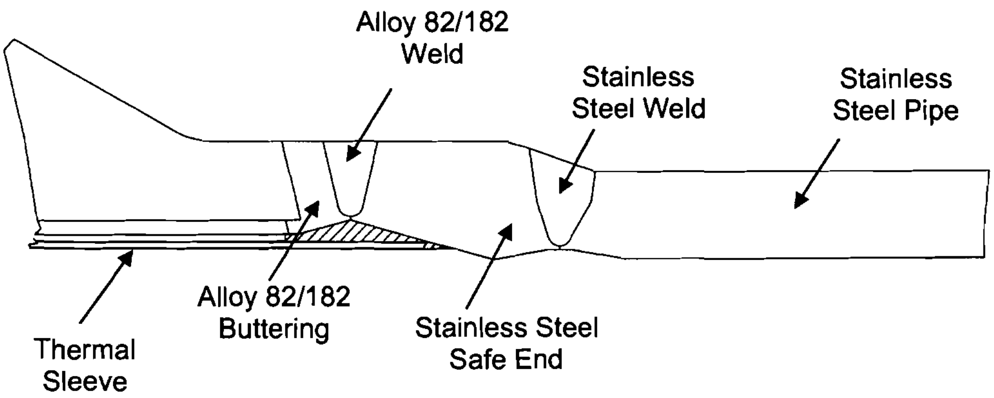

Figure 1 Schematic of Pressurizer Surge Nozzle Configuration

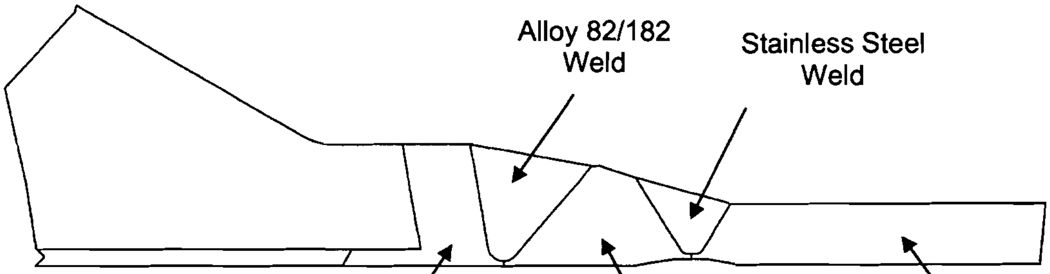

Figure 2 Schematic of Typical Pressurizer Safety and Relief Nozzle Configuration

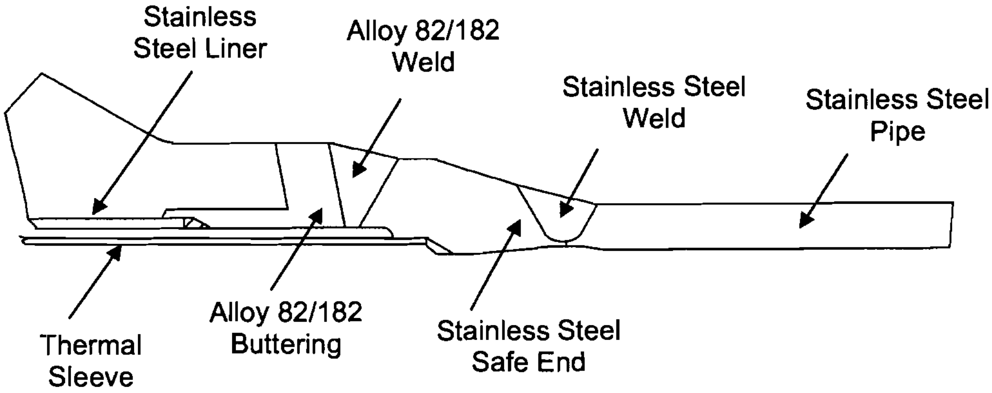

Figure 3 Schematic of Typical Pressurizer Spray Nozzle Configuration

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 the concern that the components subject to being overlaid contain levels of trace chemicals (e.g., sulfur) that could cause unacceptable indications in the weld overlay material, an initial layer of low carbon austenitic stainless steel and austenitic nickel alloy was applied as a buffer between the base metal and the weld overlay material. This buffer will be considered as a "non-credited" layer and will provide an acceptable chemical composition to apply the full structural weld overlay.

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

	Alloy 82/182 Weld Overlay		Stainless Steel Weld Overlay	
Nozzle	Thickness	Length	Thickness	Length
	(in)	(in)	(in)	(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

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	61.5	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 per-cent (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 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.

<u>Dissimilar Metal Weld (Alloy 82/182)</u>

The crack growth analysis performed in accordance with the IWB-3640 requirement [4] 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 [5] and ASME publications [4, 6] 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 1 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.

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 1. 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 1 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.

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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

Conclusion

The Vogtle Unit 1 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 1 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 2008 outage.

Since the requirements in the SNC alternatives are met, the structural integrity of the dissimilar-metal butt weld region for all the Vogtle Unit 1 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 1 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. SNC Letter NL-07-1320 dated July 24, 2007, "Joseph M. Farley Nuclear Plant, Vogtle Electric Generating Plant, Proposed Alternative for Application of Pressurizer Nozzle Full-Structural Weld Overlays"

2. SNC Letter NL-07-2206 dated December 26, 2007, "Joseph M. Farley Nuclear Plant – Unit 2, Vogtle Electric Generating Plant – Unit 1, Proposed Alternative for Application of Full-Structural Weld Overlays on Pressurizer Nozzles"

3. SNC Letter NL-08-0405 dated March 10, 2008, Subject: "Farley Unit 2 and Vogtle Unit 1 RE: Safety Evaluation of Proposed Alternative To Apply Weld Overlay to Dissimilar Metal Welds of Pressurizer Nozzles (TAC Nos. MD6307 and MD6308)."

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

5. 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.

6. 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.

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