October 1, 2002

Mr. Stephen A. Byrne
Senior Vice President, Nuclear Operations
South Carolina Electric & Gas Company
Virgil C. Summer Nuclear Station
Post Office Box 88
Jenkinsville, South Carolina 29065

SUBJECT: SAFETY EVALUATION OF FLAWS DETECTED IN V. C. SUMMER NOZZLE-TO-PIPE WELDS IN THE HOT LEGS OF LOOPS B AND C (TAC NO. MB4870)

Dear Mr. Byrne:

The South Carolina Electric & Gas Company (the licensee) submitted letters dated May 4, May 7, and June 21, 2002, for the U.S. Nuclear Regulatory Commission (NRC) to review its Refueling Outage (RFO) 13 inspection findings concerning reactor pressure vessel nozzle-to-pipe welds in the hot legs of loops B and C at the Virgil C. Summer Nuclear Station (VCNS). In its submission, the licensee noted that eddy current testing during RFO 12 detected flaws as long as 0.234 inch in the same hot leg welds. In its safety evaluation (SE) dated February 20, 2001, the NRC staff approved operation of the VCNS for one fuel cycle, based on primary water stress corrosion cracking (PWSCC) crack growth rate (CGR) that bounds the test data provided by the licensee. The intent of the licensee's recent submittal was to justify continued operation of the unit beyond the approved fuel cycle, based on a lower plant-specific PWSCC CGR and a much reduced driving force for crack growth attributable to the application of the mechanical stress improvement processing (MSIP) to the subject piping welds.

The NRC staff has completed its review of the inspection findings from RFO 13 and concludes that the VCNS plant-specific PWSCC CGR is much lower than that assumed in the February 20, 2001, SE. In addition, based on the review of an analytical evaluation of applying the MSIP to VCNS' RPV hot leg nozzle welds, the staff agrees with the licensee's assertion that the driving force for the cracks has been either eliminated or greatly reduced. On the bases of these considerations, the staff has determined that the licensee's original flaw evaluation (with no or negligible projected flaw growth in the current fuel cycle) satisfies the rules in Section XI of the Boiler and Pressure Vessel Code promulgated by the American Society of Mechanical Engineers (ASME), and operation of VCNS without repair of the subject weld for one additional fuel cycle (until RFO 14) is acceptable. The licensee will perform an inservice inspection of the nozzles, in accordance with Section XI of the ASME Code, during RFO 14.

Sincerely,

/RA/

Karen R. Cotton, Project Manager, Section 1
Project Directorate ll
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-395

Enclosure: Safety Evaluation

cc w/encl: See next page

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CONCERNING FLAWS DETECTED IN NOZZLE-TO-PIPE WELDS IN

THE HOT LEGS OF LOOPS B AND C

SOUTH CAROLINA ELECTRIC & GAS COMPANY

DOCKET NO. 50-395

1.0 INTRODUCTION

The South Carolina Electric & Gas Company (the licensee) submitted letters dated May 4, May 7, and June 21, 2002, for the U.S. Nuclear Regulatory Commission (NRC) to review its Refueling Outage (RFO) 13 inspection findings concerning reactor pressure vessel (RPV) nozzle-to-pipe welds in the hot legs of loops B and C at the Virgil C. Summer Nuclear Station (VCNS). In its submission, the licensee noted that eddy current testing (ET) during RFO 12 detected flaws as long as 0.234 inch in the same hot leg welds. In its safety evaluation (SE) dated February 20, 2001, the NRC staff approved operation of the VCNS for one fuel cycle, based on primary water stress corrosion cracking (PWSCC) crack growth rate (CGR) that bounds the test data provided by the licensee. The intent of the licensee's recent submittal was to justify continued operation of the unit beyond the approved fuel cycle, based on a much lower plant-specific PWSCC CGR and a much reduced driving force for crack growth attributable to the application of the mechanical stress improvement processing (MSIP) to the subject piping welds.

2.0 EVALUATION

The licensee provided the comparison of the inspection results of the RPV nozzle-to-pipe welds in the hot legs of loops B and C for RFO 12 and RFO 13 in a letter dated May 4, 2002. The inspections were preformed using ultrasonic testing (UT) and ET during RFO 12 and RFO 13. The purpose of the comparison was to examine crack growth rate.

2.1 Comparison of 2000 and 2002 UT and ET Inspection Results

The licensee's ET results from RFO 13 in 2002 showed that all four indications (three circumferential and one axial) had locations and amplitudes similar to those observed during RFO 12 in 2000. Based on the lengths of the indications, all three circumferential indications showed no crack growth, but the axial indication (the limiting flaw) showed growth in length from 0.25 inch (based on 2000 ET data) to 0.5 inch (based on 2002 ET data). Although none of the four indications could be identified by UT in 2000, two were confirmed by UT during the 2002, inspection. Since direct measurement of crack depth was not available in 2000, the staff indirectly estimated the initial crack depth using the ET-measured length of 0.25 inch and an aspect ratio (length-to-depth) of 2 for the crack, which is consistent with the staff's flaw

characterization based on destructive measurements stated in the February 20, 2001, SE. By contrast, the staff used the 2002 UT data to directly estimate the current crack depth. Consequently, the staff determined that the crack growth in depth during the past fuel cycle was 0.192 inch (from 0.125 inch to 0.317 inch). This plant-specific PWSCC CGR is much lower than that assumed in the staff's February 20, 2001, SE.

2.2 Crack Growth Rate After Applying the MSIP

Without considering the MSIP, the staff predicts that the limiting crack will grow to 0.509 inch deep by the end of the current cycle, based on the plant-specific PWSCC CGR of 0.192 inch per fuel cycle specified in Section XI of the Boiler and Pressure Vessel Code (code) promulgated by the America Society of Mechanical Engineers (ASME). This crack depth is far less than the limit of 1.76 inches (based on 75 percent of the pipe-wall thickness) specified in the ASME Code promulgated by the. Moreover, the licensee took an additional step toward mitigating the degradation mechanism by applying MSIP to the subject piping during RFO 13. The licensee then documented the pre-MSIP and post-MSIP piping stresses in a plant-specific report entitled, "Analytical Verification of the MSIP for PWR [Pressurized Water Reactor] RPV Hot Leg Nozzle Weld for VC Summer (Loop B/C)," dated January 2002. This report reveals that the as-welded residual tensile stress in the region from the inside diameter to approximately a quarter of the pipe-wall thickness has been converted into compressive stresses since the MSIP was applied. They also remain compressive after adding operating stresses, which means that the driving force for the crack growth has been either eliminated or greatly reduced by applying the MSIP. By comparing the post-MSIP stresses (presumed to include U-shaped pre-MSIP axial residual stresses) with those of a thinner pipe (presumed to include linear, pre-MSIP axial residual stresses), the licensee concluded that the post-MSIP residual stress distribution across the thickness is not sensitive to the presumed pre-MSIP residual stress distribution. In addition, in its letter of May 7, the licensee provided information from two proprietary reports entitled, "An Application of the Mechanical Stress Improvement Process to Large Bore Piping," October 1987 and "Evaluation of Repair, Replacement, Mitigation, and Examination Approaches for Boiling Water Reactor Nozzle/Safe-end Configurations," September, 1993, prepared by the Electric Power Research Institute (EPRI), on the generic application of the MSIP for staff consideration.

Based on the licensee's plant-specific stress report and the two EPRI generic reports, the staff accepts this qualitative analysis. The MSIP results in stress redistribution under plasticity, rather than stress superposition under elasticity. Consequently, with the MSIP, the general behavior of the pipe is more important than the pre-MSIP residual stress distribution. Further support of the positive effect from applying MSIP can be found in the EPRI report, entitled "Evaluation of Repair, Replacement, Mitigation, and Examination Approaches for Boiling Water Reactor Nozzle/Safe-end Configurations," dated September 27, 1993. The licensee also provided additional information regarding this EPRI report and concluded that although the pre-MSIP inside diameter measured stresses for a 12-inch diameter pipe did not directly correlate to the finite element method results because of excessive local repair, the results correlated reasonably well with the measured and predicted values of post-MSIP residual stresses.

In summation, the licensee has demonstrated that the stress field at the vicinity of the detected cracks in the nozzle to-pipe welds in the hot legs of loops B and C is compressive while the unit is in normal operating condition, therefore, the staff agrees with the licensee's assertion that the driving force for the cracks has been either removed or greatly reduced.

3.0 CONCLUSIONS

The NRC staff has completed its review of the VCNS findings from RFO 13, inspection. The VCNS plant-specific PWSCC CGR is much lower than that assumed in the February 20, 2001, SE. In addition, based on the review of an analytical evaluation of applying the MSIP to VCNS' RPV hot leg nozzle welds, the staff agrees with the licensee's assertion that the driving force for the cracks has been either removed or greatly reduced. On the basis of these considerations, the staff has determined that the original flaw evaluation (with no or negligible projected flaw growth in the current fuel cycle) meets the rules in Section XI of the ASME Code, and the licensee can operate for one additional fuel cycle (until RFO 14) without repairing the subject welds. The licensee stated in the June 21, 2002, submittal that it will perform an inservice inspection of the nozzles, in accordance with Section XI of the ASME Code, during RFO 14. The licensee will submit its inspection results to the staff for review to enable the staff to assess the adequacy of the licensee's future inspection plans for the detected flaws.

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Date: October 1, 2002

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The NRC staff has completed its review of the inspection findings from RFO 13 and concludes that the V.C. Summer plant-specific PWSCC CGR is much lower than that assumed in the 2001, SE. In addition, based on the review of an analytical evaluation of applying the MSIP to V.C. Summer's RPV hot leg nozzle welds, the staff agrees with the licensee's assertion that the driving force for the cracks has been either eliminated or greatly reduced. On the bases of these considerations, the staff has determined that the licensee's original flaw evaluation (with no or negligible projected flaw growth in the current fuel cycle) satisfies the rules in Section XI of the Boiler and Pressure Vessel Code promulgated by the American Society of Mechanical Engineers (ASME), and operation of V.C. Summer without repair of the subject weld for one additional fuel cycle (until RFO 14) is acceptable. The licensee will perform an inservice inspection of the nozzles, in accordance with Section XI of the ASME Code, during RFO 14.

Sincerely,
/RA/
Karen R. Cotton, Project Manager, Section 1
Project Directorate ll
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-395
Enclosure: Safety Evaluation
cc w/encl: See next page

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