May 12, 2003

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: VIRGIL C. SUMMER NUCLEAR STATION — RELIEF REQUEST-11-07 ASSOCIATED WITH THE RISK-INFORMED INSERVICE INSPECTION (RI-ISI) PROGRAM (TAC NO. MB6523)

Dear Mr. Byrne:

By letter dated September 16, 2002, South Carolina Electric and Gas Company submitted Relief Request RR-II-07, "Risk-Informed Inservice Inspection Program Plan, V.C. Summer Nuclear Station, Revision 0," as a proposed alternative to the American Society of Mechanical Engineers (ASME) Code, Section XI, requirements for the selection and examination of Class 1 and 2 piping welds at Virgil C. Summer Nuclear Station (VCSNS) during the second 10-year inservice inspection interval. You also provided a response to a request for additional information concerning the proposed RI-ISI program by letter dated January 29, 2003. The VCSNS RI-ISI program was developed in accordance with the methodology contained in the U. S. Nuclear Regulatory Commission (NRC) approved Electric Power Research Institute (EPRI) Topical Report EPRI-TR-112657, Revision B-A. The proposed RI-ISI program is an acceptable alternative to the requirements of the ASME Code, Section XI, for inservice inspection of Code Class 1 piping, Categories B-F and B-J welds and Class 2 piping, Categories C-F-1 and C-F-2 welds.

The NRC staff authorizes the proposed alternatives in Relief Request-II-07, for the second 10-year inservice inspection interval of VCSNS, pursuant to 10 CFR 50.55a(a)(3)(i) on the basis that the alternatives provide an acceptable level of quality and safety.

Sincerely,

/***RA***/

John A. Nakoski, Chief, 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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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF FROM ASME CODE REQUIREMENTS

FOR SECOND 10-YEAR INSERVICE INSPECTION PROGRAM

BASED ON RISK-INFORMED ALTERNATIVE APPROACH

VIRGIL C. SUMMER NUCLEAR STATION

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

DOCKET NO. 50-395

1.0 INTRODUCTION

The current inservice inspection (ISI) requirements for the Virgil C. Summer Nuclear Station (VCSNS, the licensee), are based on the 1989 edition of Section XI, of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, “Rules for Inservice Inspection of Nuclear Power Plant Components” (ASME Code). By letter dated September 16, 2002 (Reference 1), South Carolina Electric and Gas Company (SCE&G) submitted Relief Request (RR)-II-07, "Risk-Informed Inservice Inspection Program Plan, V.C. Summer Nuclear Station, Revision 0," as a proposed alternative to the ASME Code, Section XI, requirements for the selection and examination of Class 1 and 2 piping welds at VCSNS during the second 10-year ISI interval. The licensee provided additional information in a letter dated January 29, 2003 (Reference 2). The licensee stated that its Risk Informed (RI)-ISI program was developed in accordance with the methodology contained in the Electric Power Research Institute (EPRI) Topical Report EPRI TR-112657 (Reference 3), which has been previously reviewed and approved by the U.S. Nuclear Regulatory Commission (NRC) staff.

2.0 BACKGROUND

2.1 Applicable Requirements

Title 10, *Code of the Federal Regulations* (10 CFR) Section 50.55a(g) requires that ISI of the ASME Code Class 1, 2, and 3 components be performed in accordance with Section XI of the ASME Code and applicable addenda, except where specific written relief has been granted by the NRC pursuant to 10 CFR 50.55a(g)(6)(i). The regulation 10 CFR 50.55a(a)(3) states, in part, that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the applicant demonstrates that the proposed alternatives would provide an acceptable level of quality and safety or if the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements set forth in the Code to the extent practical within the limitations of design, geometry, and materials of construction of the components. The

regulations require that ISI of components conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. For VCSNS, the applicable edition of Section XI of the ASME Code for the second 10-year ISI interval, is the 1989 edition. The licensee's RR-II-07 stated that the RI-ISI program will be implemented during the third period of the second 10-year ISI interval.

2.2 Summary of Proposed Approach

The licensee is required to perform ISI in accordance with the ASME Code, Section XI, which specifies that for each successive 10-year ISI interval, 100 percent of Category B-F welds and 25 percent of Examination Category B-J welds in Class 1 piping greater than 1 inch in nominal diameter be selected for volumetric and/or surface examination based on existing stress analyses and cumulative usage factors. For Examination Category C-F piping welds in Class 2 piping, 7.5 percent of non-exempt welds shall be selected for volumetric and/or surface examination.

The licensee has proposed to use an RI-ISI program for a subset of ASME Class 1 and Class 2 piping (Examination Categories B-F, B-J, and C-F) welds as an alternative to the ASME Code, Section XI, requirements. The proposed RI-ISI program follows a previously approved RI-ISI methodology delineated in EPRI TR-112657.

The licensee has indicated that the existing augmented inspection program implemented in response to NRC Generic Letter (GL) 89-08, "Flow Accelerated Corrosion (FAC)," is credited in the RI-ISI program development, but is not affected or changed by the RI-ISI program. The augmented inspection program for the service water intake and piping, the Service Water System Corrosion Monitoring and Control Program, is not affected by the proposed RI-ISI program.

3.0 EVALUATION

Pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff has reviewed and evaluated the licensee's proposed RI-ISI program on the basis of the guidance and acceptance criteria provided in the following documents: EPRI TR-112657, NRC's safety evaluation report on EPRI TR-112657, Regulatory Guides (RGs) 1.174 (Reference 4) and 1.178 (Reference 5), and Standard Review Plan (SRP), Chapter 3.9.8 (Reference 6).

3.1 Proposed Changes to the ISI Program

The scope of the licensee's proposed RI-ISI program is limited to ASME Class 1 and Class 2 piping welds for Examination Categories B-F for pressure-retaining dissimilar metal welds in vessel nozzles, B-J for pressure retaining welds in piping, C-F-1 for pressure-retaining welds in austenitic stainless steel or high-alloy piping, and C-F-2 for pressure retaining welds in carbon or low alloy steel piping. The RI-ISI program is proposed as an alternative to the existing ISI requirements of the ASME Code, Section XI. A general description of the proposed changes to the ISI program is provided in Sections 3 and 5 of the licensee's submittal.

The licensee stated that the proposed RI-ISI program is consistent with the guidelines in EPRI TR-112657, that states industry and plant-specific piping failure information, if any exists, is to be utilized to identify piping degradation mechanisms and failure modes and that consequence evaluations are to be performed using probabilistic risk assessments to establish safety ranking of piping segments for selecting new inspection locations.

3.2 Engineering Analysis

In accordance with the guidance provided in RGs 1.174 and 1.178, the licensee provided the results of an engineering analysis of the proposed changes, using a combination of traditional engineering analysis and supporting insights from the probabilistic risk analysis (PRA). The licensee stated that the results of the engineering analysis demonstrate that the proposed changes are consistent with the principles of defense-in-depth. The licensee performed an evaluation to determine susceptibility of components (i.e., a weld on a pipe) to a particular degradation mechanism that may be a precursor to leak or rupture, and then performed an independent assessment of the consequence of a failure at that location.

As previously noted, the licensee's RI-ISI program at VCSNS is applicable to ASME Class 1 Categories B-F and B-J and ASME Class 2 Categories C-F-1 and C-F-2 piping welds. Augmented programs for flow accelerated corrosion (FAC, GL 89-09), and service water integrity (GL 89-13) are not subsumed into the RI-ISI program and remain unaffected. The approach adopted for the augmented inspection programs is consistent with the EPRI TR-112657 guidelines and, therefore, is considered to be acceptable. Piping systems within the scope of the RI-ISI program were divided into piping segments. Pipe segments are defined as lengths of pipe whose failure (anywhere within the pipe segment) would have the same consequence and which are exposed to the same degradation mechanisms. That is, some lengths of pipe whose failure would have the same consequence are split into two or more segments when two or more regions are exposed to different degradation mechanisms. The licensee's submittal also stated that the failure potential assessment, presented in Table 3.3 of the submittal, was generated utilizing industry failure history, plant-specific failure history, and other relevant information using the guidance provided in EPRI TR-112657. The NRC staff concludes that the licensee has met the SRP 3.9.8 guidelines to confirm that a systematic process was used to identify the components' (i.e., pipe segments) susceptibility to common degradation mechanisms, and to categorize these degradation mechanisms into appropriate degradation categories with respect to their potential to result in a postulated leak or rupture.

Section 3 of Reference 1 describes a deviation from the EPRI RI-ISI methodology (Reference 3) for assessing the potential for Thermal Stratification Cycling and Striping (TASCS). The licensee stated that the methodology used in VCSNS's RI-ISI program for assessing the potential for TASCS is the same as the TASCS methodology provided by EPRI in a letter dated February 28, 2001 (Reference 7). The licensee has provided additional considerations for determining the potential for TASCS. These considerations include piping configuration and potential turbulence, low-flow conditions, valve leakage, and heat transfer due to convection. The NRC staff finds these considerations to be appropriate for determining the potential for TASCS.

Additionally, the licensee stated that the consequences of pressure boundary failures were evaluated and ranked based on their impact on core damage frequency (CDF) and large early release frequency (LERF), and that the impact due to both direct and indirect effects was

considered using guidance provided in the EPRI TR-112657. The licensee reported no deviations from the NRC staff approved consequence evaluation methodology, in the EPRI report. Therefore, the NRC staff considers the consequence evaluation performed by the licensee for this application to be acceptable.

3.3 Probabilistic Risk Assessment

To support this RI-ISI submittal, the licensee used model 3EUP.CAF of the VCSNS Level 1 and 2 PRA. Reference 1 states that the CDF and the LERF estimates from the 3EUP.CAF PRA model are 5.6E-5/yr and 7.0E-7/yr, respectively.

The licensee submitted its individual plant examination (IPE) on June 18, 1993. The NRC staff evaluation report on the IPE, issued in May 1997, did not report any major weaknesses found in the IPE and concluded that the IPE satisfies the intent of GL 88-20. The contractor's technical evaluation report (TER) was attached to the May 1997 NRC staff evaluation on the IPE. The TER stated that instrument miscalibration events were not explicitly modeled in the analysis of pre-initiators in the human reliability analysis. The licensee stated in Reference 1 that the potential for instrument calibration error has been evaluated and determined to be minimal. In response to the Request for Additional Information dated January 29, 2003, the licensee further stated that most instrument miscalibration events are not severe enough to cause an actual system failure. Since it is unlikely that a miscalibration event will cause a system failure, it is unlikely that any segments will be assigned to higher safety significance categories if miscalibration events are modeled in the PRA used for RI-ISI analysis. Therefore, it is not necessary to incorporate miscalibration events into the PRA to support this RI-ISI analysis.

Reference 1 states that personnel from Westinghouse completed a review of the VCSNS PRA Model 3AUP.CAF on March 22, 2002. The review identified four possible areas for improvement in the licensee's model: (1) use of more recent generic and plant specific initiating event frequencies, (2) better documentation of the fault tree development process, including the results of the model review process, (3) improvements to the modeling of several scenarios for the steam generator tube rupture and interfacing system loss-of-coolant accident events, and (4) incorporation of more-recent data and common-cause information into the updated model for special initiators, such as a total loss of service water. The licensee stated that these areas for improvement will not affect the RI-ISI evaluation and that the independent review concluded that the VCSNS PRA is generally suitable for risk-informed applications. In response to an NRC staff question (Reference 2), the licensee stated that the differences between the PRA model version used to support the RI-ISI submittal, 3EUP.CAF, and the version reviewed by Westinghouse, 3AUP.CAF, would not impact the results of the March 22, 2002, review.

The NRC staff did not review the PRA analysis to assess the accuracy of the quantitative estimates. Quantitative results of the PRA are used, in combination with a quantitative characterization of the pipe segment failure likelihood, to support the assignment of segments to broad safety significance categories reflecting the relative importance of pipe segment failures on CDF and LERF and to provide an illustrative estimate of the change in risk. Inaccuracies in the models or assumptions large enough to invalidate the analyses developed to support RI-ISI program should have been identified in the licensee's or the NRC staff's reviews. Minor errors or inappropriate assumptions will only affect the consequence

categorization of a few segments and will not invalidate the general results or conclusions. The NRC staff finds that the quality of the VCSNS PRA is adequate to support this submittal.

The degradation category and the consequence category are combined according to the approved methodology described in the EPRI TR-112657 (Reference 3) to categorize the risk significance of each segment. The risk significance of each segment is used to determine the number of weld inspections required in each segment.

As required by Section 3.7 of TR-112657, the licensee has evaluated the change in risk expected from replacing the current Section XI ISI program with the RI-ISI program. The analysis estimates the net change in risk due to the positive or negative influence of adding or removing locations from the inspection program. The expected change in risk is quantitatively evaluated using the Simplified Risk Quantification Method described in Section 3.7 of EPRI TR-112657. Some of the systems show an estimated increase in risk, while others show an estimated reduction in risk. VCSNS estimates that the aggregate change in CDF is about 7.87E-9/yr and the aggregate change in LERF is about 2.29E-9/yr, excluding any increased probability of detection (POD) due to the use of improved inspection techniques. Including the expected increased POD results, the aggregate estimated changes in CDF and LERF would be -8.58E-9/yr and -2.47E-9/yr, respectively.

The NRC staff finds that the licensee's process to evaluate and bound the potential change in risk is reasonable because it accounts for the change in the number and location of elements inspected, recognizes the difference in degradation mechanisms related to failure likelihood, and considers the effects of enhanced inspection. All system level and aggregate estimates of the changes in CDF and LERF are less than the corresponding guideline values in EPRI TR-112657. The NRC staff finds that redistributing the welds to be inspected on the basis of the safety-significance of the segments provides assurance that segments whose failure has a significant impact on plant risk will receive an acceptable, and often improved, level of inspection. Therefore, the NRC staff concludes that the implementation of the RI-ISI program as described in the licensee's application will have an impact on risk consistent with the guidelines of RG 1.174 and, thus, will not cause the NRC safety goals to be exceeded.

3.4 Integrated Decisionmaking

As described in the licensee's submittal (Reference 1), an integrated approach is utilized in defining the proposed RI-ISI program by considering the traditional engineering analysis, risk evaluation, and the implementation and performance monitoring of piping under the program. This is consistent with the guidelines of RG 1.178.

The selection of pipe segments to be inspected, described in Section 3.5 of the submittal, is based on the results of the risk category rankings and other operational considerations. The submittal stated that in accordance with EPRI TR-112657, 25 percent of high safety-significant and 10 percent of medium safety-significant elements are selected for inspection. Table 3.5 of the submittal provides the number of locations and inspections by risk category for the VCSNS systems within the scope of the program. Table 5.1 of the Risk-Informed Inservice Inspection Program Plan, V. C. Summer Nuclear Station, Revision 0, (RI-ISI Program Plan) provides a summary table comparing the number of inspections required under the existing ASME Code Section XI, ISI program with the number required by the alternative RI-ISI program. Table 3.6-1 of the RI-ISI Program Plan gives a summary of the proposed RI-ISI program versus the current

Section XI program on a per-system basis by each applicable risk category. The licensee stated that the failure estimates and the selection of piping segments with high and medium risk rankings were determined using the guidance provided in EPRI TR-112657.

The methodology described in EPRI TR-112657 requires that existing augmented programs be maintained, with the exception of the programs for thermal fatigue and intergranular stress corrosion cracking of Category A piping welds, which the RI-ISI program supersedes. Also, the EPRI report describes targeted examination volumes (typically associated with welds) and methods of examination based on the type(s) of degradation expected. The NRC staff has reviewed these guidelines and has determined that, if implemented as described, the RI-ISI examinations should result in better detection of service-related degradations than the currently required ASME Section XI examinations.

The objective of ISI required by ASME Section XI is to identify conditions (i.e., flaw indications) that are precursors to pressure boundary leaks and ruptures that may impact plant safety. The RI-ISI program is judged to meet this objective. Further, the risk-informed selection process is a technically sound "inspection for cause" program. The process not only identifies the risk-important areas of the piping systems, but also defines the appropriate examination methods, examination volumes, procedures, and evaluation standards necessary to address the degradation mechanism(s) of concern and the ones most likely to occur at each location to be inspected. Thus, the location selection process is acceptable since it is consistent with the process described in EPRI TR-112657, which takes into account defense-in-depth and includes coverage of systems subjected to degradation mechanisms in addition to those covered by augmented inspection programs.

Chapter 4 of EPRI TR-112657 provides guidelines for the areas and/or volumes to be inspected, as well as examination methods, acceptance standards, and evaluation standards for each degradation mechanism. Based on the review of the cited portion of the EPRI report, the NRC staff concludes that the examination methods for the proposed RI-ISI program are acceptable since they are selected based on specific degradation mechanisms, pipe sizes, and materials of concern.

3.5 Implementation and Monitoring

Implementation and performance monitoring strategies require careful consideration by the licensee and are addressed in Element 3 of RG 1.178 and the SRP 3.9.8. The objective of Element 3 is to assess the performance of the affected piping systems under the proposed RI-ISI program by implementing monitoring strategies that confirm the assumptions and analyses used in the development of the RI-ISI program. Pursuant to 10 CFR 50.55a(a)(3)(i), a proposed alternative, in this case the implementation of the RI-ISI program, including inspection scope, examination methods, and methods of evaluation of examination results, must provide an acceptable level of quality and safety.

The licensee stated in its submittal that upon approval of the RI-ISI program, procedures that comply with the EPRI TR-112657 guidelines will be prepared to implement and monitor the RI-ISI program. The licensee confirms that the applicable portions of the ASME Code not

affected by the change, such as inspection methods, acceptance standards, pressure testing, corrective measures, documentation requirements, and quality control requirements, would be retained.

The licensee stated in Section 4 of the submittal that the RI-ISI program is a living program and its implementation will require feedback of new relevant information to ensure the appropriate identification of high safety-significant piping locations. The submittal also stated that, as a minimum, risk ranking of piping segments will be reviewed and adjusted on an ASME period basis and that significant changes may require more frequent adjustment as directed by NRC bulletin or GL requirements or by industry and plant-specific feedback.

In response to a NRC staff question, the licensee has stated (Reference 2) that the ISI program would be updated and submitted to the NRC consistent with the Code requirements in effect at the time such update is required (currently every 10 years). The licensee further stated that this may, again, take the form of a relief request to implement an updated RI-ISI program, depending on future regulatory requirements. The licensee also stated that the RI-ISI program would be resubmitted to the NRC prior to the end of any 10-year interval for changes that impact the basis for the NRC's plant-specific approval of the RI-ISI program. The examples of changes include a change to the RI-ISI methodology, a change in the scope of the piping (e.g., Class 3 piping), and an industry operating experience event deemed applicable to the piping segments at VCSNS and where the degradation mechanism has the potential severity level to warrant repeated scheduled examinations.

The proposed periodic reporting requirements meet existing ASME Code requirements and applicable regulations and, therefore, are considered acceptable. The proposed process for RI-ISI program updates meets the guidance of RG 1.174 that risk-informed applications include performance monitoring and feedback provisions. Therefore, the process for program updates is considered acceptable.

4.0 CONCLUSION

Pursuant to 10 CFR 50.55a(a)(3)(i), the proposed alternatives to the ASME Code, Section XI, requirements may be used when authorized by the NRC if the applicant demonstrates that the alternative provides an acceptable level of quality and safety. In this case, the licensee's proposed alternative is to use the RI-ISI evaluation process described in the NRC approved EPRI TR-112657. The NRC staff concludes that the licensee's proposed RI-ISI program is consistent with the methodology described in EPRI TR-112657 and will provide an acceptable level of quality and safety pursuant to 10 CFR 50.55a(a)(3)(i).

The NRC staff finds that the results of the different elements of the engineering analyses are considered in an integrated decision-making process. The impact of the proposed change in the ISI program is founded on the adequacy of the engineering analyses and acceptable change in plant risk in accordance with RG 1.174 and RG 1.178 guidance. The VCSNS methodology also considers implementation and performance monitoring strategies. Inspection strategies ensure that failure mechanisms of concern have been addressed and there is adequate assurance of detecting degradation before structural integrity is affected. The risk significance of piping segments is taken into account in defining the inspection scope for the RI-ISI program.

System pressure tests and visual examination of piping structural elements will continue to be performed on all ASME Class 1 and 2 systems in accordance with the ASME Code program. The RI-ISI program applies the same performance measurement strategies as the existing ASME Code requirements and, in addition, increases the inspection volumes at some weld locations.

The VCSNS methodology provides for conducting an engineering analysis of the proposed changes using a combination of engineering analysis with supporting insights from a PRA. Defense-in-depth and quality are not degraded in that the methodology provides reasonable confidence that any reduction in existing inspections will not lead to degraded piping performance when compared to existing performance levels. Inspections are focused on locations with active degradation mechanisms as well as on selected locations that monitor the performance of piping systems.

The NRC staff's review of the licensee's proposed RI-ISI program concludes that the program is an acceptable alternative to the current ISI program based upon ASME Code, Section XI, requirements for Class 1 and Class 2 welds. Therefore, the licensee's proposed alternative is authorized pursuant to 10 CFR 50.55a(a)(3)(i) on the basis that the alternative provides an acceptable level of quality and safety. This safety evaluation authorizes application of the proposed RI-ISI program during the second 10-year ISI interval for VCSNS. All other ASME Code, Section XI, requirements for which relief was not specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

5.0 REFERENCES

1. Letter, Stephen A. Byrne (SCE&G), to NRC, *Virgil C. Summer Nuclear Station, Docket No: 50-395, Operating License No: NPF-12, Request for Revision to ASME Boiler and Pressure Vessel Code, Section XI Relief Request (NRR 00-0058) RR-II-07,* dated September 16, 2002.

2. Letter, Stephen A. Byrne (SCE&G), to NRC, *Virgil C. Summer Nuclear Station, Docket No: 50-395, Operating License No: NPF-12, Response to NRC questions regarding Request for Revision to ASME Boiler and Pressure Vessel Code, Section XI Relief Request (NRR 00-0058) RR-II-07,* dated January 29, 2003.

3. Electric Power Research Institute, *Revised Risk-Informed Inservice Inspection Evaluation Procedure*, EPRI TR-112657, Revision B-A, January 2000.

4. U.S. Nuclear Regulatory Commission, *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis*, Regulatory Guide 1.174, July 1998.

5. U.S. Nuclear Regulatory Commission, *An Approach for Plant-Specific Risk-Informed Decision Making: Inservice Inspection of Piping*, Regulatory Guide 1.178, September 1998.

6. U.S. Nuclear Regulatory Commission, *Standard Review Plan for Trial Use for the Review of Risk-Informed Inservice Inspection of Piping*, NUREG-0800, SRP Chapter 3.9.8, May 1998.

7. Letter, Pat O'Regan (EPRI), to Dr. Brian Sheron, *Extension of Risk-Informed Inservice Inspection (RI-ISI) Methodology,* February 28, 2001.

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