March 13, 2008

Mr. Jeffrey B. Archie
Vice President, Nuclear Plant Operations
South Carolina Electric & Gas Company
Virgil C. Summer Nuclear Station
Post Office Box 88
Jenkinsville, SC 29065

SUBJECT: VIRGIL C. SUMMER NUCLEAR STATION, UNIT NO. 1 - EXEMPTIONS FROM THE REQUIREMENTS OF 10 CFR PART 50, SECTIONS 50.44, 50.46, AND APPENDIX K (TAC NO. MD5699)

Dear Mr. Archie:

The Nuclear Regulatory Commission (NRC) has approved the enclosed exemptions from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," and Appendix K, "ECCS Evaluation Models," for the Virgil C. Summer Nuclear Station, Unit No. 1. This action is in response to your letter dated May 31, 2007, as supplemented on October 11, 2007. The exemptions would allow one lead test fuel assembly (LTA) containing fuel rods that are all clad with Optimized ZIRLO^{TM} cladding or one LTA containing both Optimized ZIRLO^{TM} and AXIOM^{TM} fuel rod cladding to continue to be irradiated up to a burnup of 75 GigaWatt days per Metric Ton Uranium (GWd/MTU).

Your requests for exemptions also included a request for exemption from 10 CFR 50.44, "Combustible gas control for nuclear power reactors." The regulations in 10 CFR 50.44 were revised in 2003 so that they do not refer to specific types of zirconium cladding (68 FR 54123; September 16, 2003). Accordingly, the NRC staff is not issuing an exemption from 10 CFR 50.44 because the revisions to 10 CFR 50.44 noted above remove the need for such an exemption. This was discussed with your staff on January 17, 2008.

A copy of the enclosed exemption has been forwarded to the Office of the Federal Register for publication.

Sincerely,

/RA/

Robert E. Martin, Senior Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-395

Enclosure:
Exemption

cc w/encl: See next page

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Virgil C. Summer Nuclear Station

cc:

Mr. R. J. White
Nuclear Coordinator S.C. Public Service Authority
c/o Virgil C. Summer Nuclear Station Post Office Box 88, Mail Code 802
Jenkinsville, SC 29065

Resident Inspector/Summer NPS
c/o U.S. Nuclear Regulatory Commission
576 Stairway Road
Jenkinsville, SC 29065

Chairman, Fairfield County Council
Drawer 60
Winnsboro, SC 29180

Mr. Henry Porter, Assistant Director
Division of Waste Management
Bureau of Land & Waste Management
Dept. of Health & Environmental Control
2600 Bull Street
Columbia, SC 29201

Mr. Thomas D. Gatlin, General Manager
Nuclear Plant Operations
South Carolina Electric & Gas Company
Virgil C. Summer Nuclear Station
Post Office Box 88, Mail Code 300
Jenkinsville, SC 29065

Mr. Bruce L. Thompson, Manager
Nuclear Licensing
South Carolina Electric & Gas Company
Virgil C. Summer Nuclear Station
Post Office Box 88, Mail Code 830
Jenkinsville, SC 29065

Ms. Kathryn M. Sutton
Morgan, Lewis & Bockius LLP
111 Pennsylvania Avenue, NW.
Washington, DC 20004

7590-01-P

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

SOUTH CAROLINA ELECTRIC & GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION, UNIT NO. 1

DOCKET NO. 50-395

EXEMPTION

1.0 BACKGROUND

The South Carolina Electric & Gas Company (SCE&G, the licensee) is the holder of the Renewed Facility Operating License No. NPF-12 which authorizes operation of the Virgil C. Summer Nuclear Station, Unit No. 1 (VCSNS). The license provides, among other things, that the facility is subject to all rules, regulations, and orders of the Nuclear Regulatory Commission (NRC or the Commission) now or hereafter in effect.

The facility consists of a pressurized-water reactor located in Fairfield County in South Carolina.

2.0 REQUEST/ACTION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.12, "Specific Exemptions", SCE&G has, by letters dated May 31 and October 11, 2007, requested an exemption from 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors", and Appendix K to 10 CFR 50, "ECCS Evaluation Models," (Appendix K). The regulation in 10 CFR 50.46 contains acceptance criteria for emergency core cooling system (ECCS) for reactors fueled with zircaloy or ZIRLO^{TM} cladding. In addition, Appendix K requires that the Baker-Just equation be used to predict the rates of energy release, hydrogen concentration, and cladding oxidation from the metal-water reaction. The exemption

request relates solely to the specific types of cladding material specified in these regulations. As written, the regulations presume the use of zircaloy or ZIRLO™ fuel rod cladding. Thus, an exemption from the requirements of 10 CFR 50.46, and Appendix K is needed to irradiate a lead test assembly (LTA) comprised of different cladding alloys at VCSNS.

The exemptions requested by the licensee would allow the use of one LTA containing either all Optimized ZIRLO™ fuel rod cladding or a combination of Optimized ZIRLO™ and AXIOM™ fuel rod cladding to continue to be irradiated up to a burnup of 75 gigawatt days per metric ton uranium (GWd/MTU).

Previously, by letter dated January 14, 2005, the NRC staff approved the irradiation of four LTAs containing fuel rods with Optimized ZIRLO™ and several different developmental clad (AXIOM™) alloys. That exemption was contingent on the fuel rod burnup remaining within the applicable licensed limits, which for burnup, was a value of 62 GWd/MTU. The licensee inserted those LTAs into VCSNS for irradiation in fuel cycles 16 and 17. In the licensee's letters of May 31 and October 11, 2007, the licensee requested an exemption to continue the irradiation of one of the four LTAs for a third operating cycle. This LTA would be irradiated in fuel cycle 18 in order to gain high burnup experience. The licensee requested to irradiate the LTA to a peak rod average of up to 75 GWd/MTU.

The licensee also requested an exemption from 10 CFR 50.44, "Combustible gas control for nuclear power reactors." The requested exemption from 10 CFR 50.44 is not being considered further by the NRC staff because revisions were made to 10 CFR 50.44 (68 FR 54123; September 16, 2003), such that it does not refer to specific types of zirconium cladding, thus removing the need for such an exemption.

3.0 DISCUSSION

Pursuant to 10 CFR 50.12, the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of 10 CFR Part 50, when (1) the exemptions are authorized by law, will not present an undue risk to public health or safety, and are consistent with the common defense and security; and (2) when special circumstances are present. Under Section 50.12(a)(2) of 10 CFR, special circumstances include, among other things, when application of the specific regulation in the particular circumstance would not serve, or is not necessary to achieve, the underlying purpose of the rule.

Authorized by Law

This exemption would allow the licensee to re-insert one LTA containing either all Optimized ZIRLO™ fuel rod cladding or a combination of Optimized ZIRLO™ and AXIOM™ fuel rod cladding that does not meet the definition of Zircaloy or ZIRLO™ as specified by 10 CFR 50.46, and Appendix K, into the core of VCSNS during fuel cycle 18. As stated above, 10 CFR 50.12 allows the NRC to grant exemptions from the requirements of 10 CFR Part 50. The NRC staff has determined that granting of the licensee's proposed exemption will not result in a violation of the Atomic Energy Act of 1954, as amended, or the Commission's regulations. Therefore, the exemption is authorized by law.

No Undue Risk to Public Health and Safety

In regard to the fuel mechanical design, the SCE&G exemption request relates solely to the specific types of cladding material specified in the regulations. No new or altered design limits for purposes of 10 CFR 50, Appendix A, General Design Criterion 10, "Reactor Design", need to be applied or are required for this program. Following VCSNS Cycle 17, post-irradiation examinations (PIE) will be completed on the LTAs to

verify acceptable performance and to validate fuel performance model predictions. These models, tuned to the latest PIE data, will be used to ensure that all design criteria are satisfied up to the projected end of cycle 18 (EOC18) burnup. The licensee states that if either the PIE shows anomalous behavior or predicted performance is outside acceptable bounds, the LTA will not be inserted into Cycle 18. Based upon the limited number of advanced alloy fuel rods, the PIE (which would detect anomalous behavior), and the use of approved models (tuned to the latest PIE data) to ensure that all design criteria remain satisfied, the NRC staff finds the LTA mechanical design acceptable for VCSNS. In regard to the core reload and accident analysis, the NRC staff finds that, based on current LTA performance and testing to date, it is not anticipated that any of the advanced cladding fuel rods would fail during normal operation and anticipated operational events. In the event of unforeseen failures in this limited population, plant instrumentation is capable of detecting increased reactor coolant activity and reasonable operator action would ensure TS limits would not be violated. Further, due to their limited number, failure of the advanced alloy fuel rods during an accident would neither challenge docketed dose consequences nor coolable geometry. The licensee will continue to use approved core physics and reload methodologies to model the LTA up to the projected EOC18 burnup. The NRC staff finds the use of these methods acceptable.

The licensee stated in its May 31, 2007, letter that the assessment contained in Westinghouse Commercial Atomic Power-12610-P-A, “VANTAGE + Fuel Assembly Reference Core Report,” dated April 1995, concluded that the fuel handling accident (FHA) thyroid doses are not adversely affected by extended burnup. However, the amount of fission gas release (from the fuel pellet) is sensitive to burnup and power history. As such, the fission product gap inventory may be affected by the higher burnup and power history of the LTA. The NRC staff requested additional information (RAI)

regarding the limited empirical database of fission gas measurements at 75 GWd/MTU burnups, to be able to verify that the FHA dose analysis is not impacted. The licensee's October 11, 2007, response identified a number of conservatisms within the existing dose calculations which, if credited, could result in a significant reduction in the limiting FHA dose for the extended burnup LTA and thus compensate for the uncertainty in fission product gap inventory within the high burnup LTA rods. These included the pool decontamination factor, the relative power factor for this particular LTA in fuel cycle 18, the thyroid dose conversion factors, offloading time, reactor building purge isolation, and mechanical fuel damage due to impact. Consistent with Regulatory Guide (RG) 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors (Safety Guide 25)," an overall effective decontamination factor of 100 is used in the current analysis to determine the percentage of iodine activity within the fuel rod gap that is released to the reactor building atmosphere. As described in the UFSAR Section 15.4.5.1.2.2, this value is a factor of five or more below the expected value. The licensee stated that although not fully credited, this conservatism is recognized in Appendix B to RG 1.195, "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents (DBA) at Light-Water Nuclear Power Reactors", which outlines an acceptable methodology for evaluating the radiological consequences of a FHA. Provided the depth of the water above the damaged fuel is 23 feet or greater, the accepted decontamination factors for the elemental and organic species of iodine are 400 and 1, respectively, giving an overall effective decontamination factor of 200 (i.e., 99.5 percent of the total iodine release from the damaged rods is retained by the water). The NRC staff confirms that VCSNS Technical Specifications (TSs) 3.7.10 and 3.9.7 require the water level to be a minimum of 23 feet for the spent

fuel pool and the reactor vessel during refueling, respectively. Because of these controls, the NRC staff is confident that the overall effective decontamination factor will not increase above 200. If the RG 1.195 overall effective decontamination factor is credited within the VCSNS FHA analysis, the calculated thyroid dose would decrease by 50 percent. The NRC staff finds that the licensee has appropriately applied RG 1.195, Appendix B, and that this conservatism exists in the current licensing basis FHA analysis.

The licensee presented information showing that the relative assembly power factor for both the LTA and the assembly impacted by the LTA during an FHA will not approach the 1.7 peaking limit assumed in the VCSNS FSAR analysis. The assumptions in RG 1.195 are conservative to account for the fact that in a general analysis, it is unknown which assembly out of any assembly in the core may be dropped. Therefore, the highest peaking factor out of all the assemblies in the core and the highest burnup out of all the assemblies in the core are assumed to be applied in the same postulated dropped assembly. One assembly would be unlikely to have both the highest burnup and the highest peaking factor. Therefore, in this specific case, with more realistic and appropriate relative assembly powers credited for both the LTA and other potentially impacted assemblies, the licensee states the limiting dose would decrease by approximately 37 percent. Although relative assembly powers are not generally credited in DBA radiological consequences analyses, the NRC staff finds that the specific situation described above does show that conservatism exists in the current licensing basis FHA analysis when compared to the expected impact of dropping the extended burnup LTA.

As regards the thyroid dose conversion factors, the current VCSNS dose analysis for the FHA is conservatively based on thyroid dose conversion factors from

"Calculation of Distance Factors for Power and Test Reactor Sites," TID-14844, March 1962. If conversion factors from International Commission on Radiation Protection, ICRP-30, "Limits for Intakes of Radionuclides by Workers," 1980, were used instead, the licensee states that this would result in approximately a 29 percent reduction in the limiting dose. Use of ICRP-30 thyroid dose conversion factors is acceptable to the staff as documented in RG 1.195. The NRC staff accepts that this conservatism exists in the current licensing basis FHA analysis.

For LTA offloading time, the licensee discussed the additional decay time that would be expected for the movement of the extended burnup LTA as compared to the DBA dose analysis assumption. The VCSNS TSs allow a core offload to begin no sooner than 72 hours after shutdown. The licensee presented a basis for concluding that, in actual practice, core offload would begin no sooner than 144 hours, which would further reduce the radiological doses from a DBA. However, because the licensee did not provide how it would control the expected 144 hours to start core offload (i.e. TS, procedural change, etc.), the NRC staff finds that this conservatism can not be credited. Following a postulated accident inside the reactor building, the radioactivity is assumed to be released to the environment through the reactor building purge system, and if the system isolates before release to the environment, it likely would significantly reduce the FHA dose. However, since the system is not fully safety grade, the staff finds that this conservatism can not be credited in this analysis.

As regards the mechanical fuel damage due to an FHA, the VCSNS FSAR analysis assumes all rods of the dropped assembly and 50 rods on an impacted assembly fail. The licensee states that this is a very conservative assumption given the broad spectrum of loads (e.g., shipping, thermal, deadweight, loss-of-coolant accident, and seismic loads) considered and the resulting high structural strength of the fuel

assembly and other core components. In its October 11, 2007, RAI response, the licensee stated that the irradiated fuel assembly drop events have also yielded no increase in local area dose rates. The NRC staff agrees with the licensee that the amount of assumed cladding failure per RG 1.195 guidance is intended to be generally conservative, based on industry experience, but it is not expected to be any more or less conservative for the extended burnup LTA than for any other type of fuel.

Contingent on these conservatisms being applicable only to the one LTA, the NRC staff finds that the acceptable conservatisms identified do compensate for the uncertainties in the gap fractions. Therefore, the fission product gap inventory assumed in the current licensing basis FHA radiological assessment remains bounding for the extended burnup LTA.

For accidents other than FHA, even though extended burnup to 75 GWD/MTU for the one LTA would cause a variation in the core inventory compared to the current fuel, there are no significant increases to isotopes that are major contributors to accident doses. Thus, the NRC staff finds that current licensing basis DBA results remain bounding for estimated offsite and control room operator doses and the radiation dose limitations of Part 100 and GDC-19 will not be exceeded. The NRC staff finds that the licensee used assumptions, inputs, and methods that are consistent with the conservative regulatory requirements and guidance identified above. Based on the VCSNS current licensing bases, and the acceptable conservatisms discussed above, the NRC staff finds with reasonable assurance, that the licensee's estimates of the exclusion area boundary, low-population zone, and control room doses will continue to comply with the applicable regulatory criteria. Therefore, the proposed extension of the fuel rod average burnup limit for one LTA is acceptable with regard to the radiological consequences of postulated design basis accidents.

The underlying purpose of 10 CFR 50.46 is to establish acceptance criteria for ECCS performance. The applicability of these ECCS acceptance criteria has been demonstrated by Westinghouse. Ring compression tests performed by Westinghouse on Optimized ZIRLO™ (documented in Appendix B of Addendum 1 to WCAP-12610-P-A) demonstrate an acceptable retention of Post-LOCA ductility up to 10 CFR 50.46 limits of 2200 degrees Farenheit and 17 percent equivalent cladding reacted (ECR). Based on an ongoing LOCA research program at Argonne National Laboratory, cladding corrosion has a more significant impact on post-quench ductility than fuel rod burnup. The oxidation measurements provided by the licensee illustrate that the oxide thickness (and associated hydrogen pickup) for an LTA up to 75 GWd/MTU would be below the measured oxide for both Zircaloy-4 and ZIRLO™ at current burnup limits. Hence, the effect of corrosion on the LTA fuel rods up to the higher burnup would not invalidate the applicability of the ECCS acceptance criteria for Optimized ZIRLO™. Due to their limited number, any change in the Post-LOCA ductility characteristics of the advanced alloy fuel rods (relative to the 2200 degrees Farenheit peak cladding temperature and 17 percent ECR) would not challenge core coolable geometry. Utilizing currently approved LOCA models and methods, Westinghouse will perform cycle-specific reload evaluations to ensure that the LTA satisfies 10 CFR 50.46 acceptance criteria. Therefore, the exemption to expand the application of 10 CFR 50.46 to include Optimized ZIRLO™ is acceptable.

Paragraph I.A.5 of Appendix K states that the rates of energy, hydrogen concentration, and cladding oxidation from the metal-water reaction shall be calculated using the Baker-Just equation. Since the Baker-Just equation presumes the use of zircaloy clad fuel, strict application of the rule would not permit use of the equation for the LTA cladding for determining acceptable fuel performance. Metal-water reaction

tests performed by Westinghouse on Optimized ZIRLO™ (documented in Appendix B of Addendum 1 to WCAP-12610-P-A) demonstrate conservative reaction rates relative to the Baker-Just equation. As for the limited advanced alloy fuel rods, their similar material composition is expected to yield similar high temperature metal-water reaction rates. The reaction rate should not be impacted by the higher burnup. Thus, application of Appendix K, Paragraph I.A.5, is not necessary to achieve its underlying purpose in these circumstances.

Based upon results of metal-water reaction tests and ring-compression tests which ensure the applicability of ECCS models and acceptance criteria, the limited number and anticipated performance of the advanced cladding fuel rods, and the use of approved LOCA models to ensure that the LTAs satisfy 10 CFR 50.46 acceptance criteria, the staff finds it acceptable to grant an exemption from the requirements of 10 CFR 50.46, and Appendix K to 10 CFR Part 50 for the use of an LTA up to 75 GWd/MTU in the VCSNS.

Consistent with Common Defense and Security

The proposed exemption would allow the use of one LTA with advanced cladding materials. This change to the plant core configuration has no relation to security issues. Therefore, the common defense and security is not impacted by this exemption.

Special Circumstances

Special circumstances, in accordance with 10 CFR 50.12(a)(2)(ii), are present whenever application of the regulation in the particular circumstances is not necessary to achieve the underlying purpose of the rule. The underlying purpose of 10 CFR 50.44 is to ensure that means are provided for the control of hydrogen gas that may be generated following a LOCA. The underlying purpose of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 is to establish acceptance criteria for ECCS performance. The

wording of the regulations in 10 CFR 50.46 and Appendix K is not directly applicable to these advanced cladding alloys, even though the evaluations discussed above show that the intent of the regulations are met. Therefore, since the underlying purposes of 10 CFR 50.46 and Appendix K are achieved with the use of these advanced cladding alloys, the special circumstances required by 10 CFR 50.12(a)(2)(ii) for granting of an exemption from 10 CFR 50.46 and Appendix K exist.

4.0 CONCLUSION

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12(a), the exemption is authorized by law, will not present an undue risk to the public health and safety, and is consistent with the common defense and security. Also, special circumstances are present. Therefore, the Commission hereby grants SCE&G exemptions from the requirements of 10 CFR 50.46, and 10 CFR Part 50, Appendix K, to allow one LTA containing either all Optimized ZIRLO™ fuel rods or a combination of Optimized ZIRLO™ and AXIOM™ fuel rods to continue to be irradiated up to a burnup of 75 GWd/MTU.

Pursuant to 10 CFR 51.32, the Commission has determined that the granting of this exemption will not have a significant effect on the quality of the human environment (73 FR 10069; February 25, 2008).

This exemption is effective upon issuance.

Dated at Rockville, Maryland, this 13th day of March 2008.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Catherine Haney, Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation