June 7, 2004

Mr. Karl W. Singer
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2, EXEMPTION FROM THE REQUIREMENTS OF 10 CFR PART 50, SECTION 50.68(b)(1) (TAC NOS. MC1871 AND MC1872)

Dear Mr. Singer:

The Commission has approved the enclosed exemption from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.68(b)(1) for the Sequoyah Nuclear Plant (SQN), Units 1 and 2. This action is in response to your letter of application dated February 20, 2004, as supplemented by letter dated April 27, 2004, that submitted a request for an exemption from the requirements of 10 CFR 50.68(b)(1) for loading, unloading, and handling of the components of the Holtec HI-STORM 100 dry cask storage system at SQN.

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

Sincerely,

/RA/

Michael L. Marshall, Jr., Senior Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-327 and 50-328

Enclosure: Exemption

cc w/enclosure: See next page

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Tennessee Valley Authority

SEQUOYAH NUCLEAR PLANT

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT, UNIT NOS. 1 AND 2

DOCKET NOS. 50-327 AND 50-328

EXEMPTION

1.0 BACKGROUND

The Tennessee Valley Authority (the licensee) is the holder of Facility Operating License Nos. DPR-77 and DPR-79, which authorize operation of the Sequoyah Nuclear Plant (facility or SQN), Unit Nos. 1 and 2, respectively. The licenses provide, among other things, that the facility is subject to all rules, regulations, and orders of the Nuclear Regulatory Commission (NRC, the Commission) now or hereafter in effect.

The facility consists of two pressurized water reactors located in Hamilton County, Tennessee.

2.0 REQUEST/ACTION

Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.68(b)(1) sets forth the following requirement that must be met, in lieu of a monitoring system capable of detecting criticality events.

> Plant procedures shall prohibit the handling and storage at any one time of more fuel assemblies than have been determined to be safely subcritical under the most adverse moderation conditions feasible by unborated water.

The licensee is unable to satisfy the above requirement for handling of the 10 CFR Part 72 licensed contents of the Holtec HI-STORM 100 Cask System. Section 50.12(a) allows

licensees to apply for an exemption from the requirements of 10 CFR Part 50 if the regulation is not necessary to achieve the underlying purpose of the rule and other conditions are met. The licensee stated in the application that compliance with 10 CFR 50.68(b)(1) is not necessary for handling the 10 CFR Part 72 licensed contents of the cask system to achieve the underlying purpose of the rule.

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. Therefore, in determining the acceptability of the licensee's exemption request, the staff has performed the following regulatory, technical, and legal evaluations to satisfy the requirements of 10 CFR 50.12 for granting the exemption.

3.1 Regulatory Evaluation

The SQN Technical Specifications (TSs) currently permit the licensee to store spent fuel assemblies in high-density storage racks in each spent fuel pool (SFP). In accordance with the provisions of 10 CFR 50.68(b)(4), the licensee takes credit for soluble boron for criticality control and ensures that the effective multiplication factor (k_{eff}) of the SFP does not exceed 0.95, if flooded with borated water. As stated in 10 CFR 50.68(b)(4), it also requires that, if credit is taken for soluble boron, the k_{eff} must remain below 1.0 (subcritical), if flooded with unborated water. However, the licensee is unable to satisfy the requirement to maintain the k_{eff} below 1.0 (subcritical) with unborated water, which is also the requirement of 10 CFR 50.68(b)(1). Therefore, the licensee's request for exemption from 10 CFR 50.68(b)(1)

proposes to permit the licensee to perform spent fuel loading, unloading, and handling operations related to dry cask storage, without being subcritical under the most adverse moderation conditions feasible by unborated water.

Title 10 of the *Code of Federal Regulations*, Part 50, Appendix A, "General Design Criteria (GDC) for Nuclear Power Plants," provides a list of the minimum design requirements for nuclear power plants. According to GDC 62, "Prevention of criticality in fuel storage and handling," the licensee must limit the potential for criticality in the fuel handling and storage system by physical systems or processes.

Section 50.68 of 10 CFR Part 50, "Criticality accident requirements," provides the NRC requirements for maintaining subcritical conditions in SFPs. Section 50.68 provides criticality control requirements which, if satisfied, ensure that an inadvertent criticality in the SFP is an extremely unlikely event. These requirements ensure that the licensee has appropriately conservative criticality margins during handling and storage of spent fuel. Section 50.68(b)(1) states, "Plant procedures shall prohibit the handling and storage at any one time of more fuel assemblies than have been determined to be safely subcritical under the most adverse moderation conditions feasible by unborated water." Specifically, 10 CFR 50.68(b)(1) ensures that the licensee will maintain the pool in a subcritical condition during handling and storage operations without crediting the soluble boron in the SFP water.

The licensee has received a license to construct and operate an Independent Spent Fuel Storage Installation (ISFSI) at SQN. The ISFSI would permit the licensee to store spent fuel assemblies in large concrete dry storage casks. In order to transfer the spent fuel assemblies from the SFP to the dry storage casks, the licensee must first transfer the assemblies to a Multi-Purpose Canister (MPC) in the cask pit area of the SFP. The licensee performed criticality analyses of the MPC fully loaded with fuel having the highest permissible reactivity, and determined that a soluble boron credit was necessary to ensure that the MPC

would remain subcritical in the SFP. Since the licensee is unable to satisfy the requirement of 10 CFR 50.68(b)(1) to ensure subcritical conditions during handling and storage of spent fuel assemblies in the pool with unborated water, the licensee identified the need for an exemption from the 10 CFR 50.68(b)(1) requirement to support MPC loading, unloading, and handling operations, without being subcritical under the most adverse moderation conditions feasible by unborated water.

The staff evaluated the possibility of an inadvertent criticality of the spent nuclear fuel at SQN during MPC loading, unloading, and handling. The staff has established a set of acceptance criteria that, if met, satisfy the underlying intent of 10 CFR 50.68(b)(1). In lieu of complying with 10 CFR 50.68(b)(1), the staff determined that an inadvertent criticality accident is unlikely to occur if the licensee meets the following five criteria:

1. The cask criticality analyses are based on the following conservative assumptions:
    a. All fuel assemblies in the cask are unirradiated and at the highest permissible enrichment,
    b. Only 75 percent of the Boron-10 in the Boral panel inserts is credited,
    c. No credit is taken for fuel-related burnable absorbers, and
    d. The cask is assumed to be flooded with moderator at the temperature and density corresponding to optimum moderation.
2. The licensee's ISFSI TS requires the soluble boron concentration to be equal to or greater than the level assumed in the criticality analysis and surveillance requirements necessitate the periodic verification of the concentration both prior to and during loading and unloading operations.
3. Radiation monitors, as required by GDC 63, "Monitoring Fuel and Waste Storage," are provided in fuel storage and handling areas to detect excessive radiation levels and to initiate appropriate safety actions.

4. The quantity of other forms of special nuclear material, such as sources, detectors, etc., to be stored in the cask will not increase the effective multiplication factor above the limit calculated in the criticality analysis.

5. Sufficient time exists for plant personnel to identify and terminate a boron dilution event prior to achieving a critical boron concentration in the MPC. To demonstrate that it can safely identify and terminate a boron dilution event, the licensee must provide the following:

   a. A plant-specific criticality analysis to identify the critical boron concentration in the cask based on the highest reactivity loading pattern.

   b. A plant-specific boron dilution analysis to identify all potential dilution pathways, their flowrates, and the time necessary to reach a critical boron concentration.

   c. A description of all alarms and indications available to promptly alert operators of a boron dilution event.

   d. A description of plant controls that will be implemented to minimize the potential for a boron dilution event.

   e. A summary of operator training and procedures that will be used to ensure that operators can quickly identify and terminate a boron dilution event.

3.2 Technical Evaluation

In determining the acceptability of the licensee's exemption request, the staff reviewed three aspects of the licensee's analyses: (1) criticality analyses submitted to support the ISFSI license application, (2) boron dilution analysis, and (3) legal basis for approving the exemption. For each of the aspects, the staff evaluated whether the licensee's analyses and methodologies provide reasonable assurance that adequate safety margins are developed and can be maintained in the SQN SFP during loading of spent fuel into canisters for dry cask storage.

3.2.1 Criticality Analyses

For evaluation of the acceptability of the licensee's exemption request, the staff reviewed the criticality analyses provided by the licensee in support of its ISFSI license application. Chapter 6, "Criticality Evaluation," of the HI-STORM Final Safety Analysis Report (HI-STORM FSAR) contains detailed information regarding the methodology, assumptions, and controls used in the criticality analysis for the MPCs to be used at SQN. The staff reviewed the information contained in Chapter 6 as well as information provided by the licensee in its exemption request to determine if Criteria 1 through 4 of Section 3.1 were satisfied.

First, the staff reviewed the methodology and assumptions used by the licensee in its criticality analysis to determine if Criterion 1 was satisfied. The licensee provided a detailed list of the assumptions used in the criticality analysis in Chapter 6 of the HI-STORM FSAR as well as in its exemption request. The licensee stated that it took no credit in the criticality analyses for burnup or fuel-related burnable absorbers. The licensee also stated that all assemblies were analyzed at the highest permissible enrichment. Additionally, the licensee stated that all criticality analyses for a flooded MPC were performed at temperatures and densities of water corresponding to optimum moderation conditions. Finally, the licensee stated that it only credited 75 percent of the Boron-10 content for the fixed neutron absorber, Boral, in the MPC. Based on its review of the criticality analyses contained in Chapter 6 of the HI-STORM FSAR, the staff finds that the licensee has satisfied Criterion 1.

Second, the staff reviewed the proposed SQN ISFSI TS. The licensee's criticality analyses credit soluble boron for reactivity control during MPC loading, unloading, and handling operations. Since the boron concentration is a key safety component necessary for ensuring subcritical conditions in the pool, the licensee must have a conservative TS capable of ensuring that sufficient soluble boron is present to perform its safety function. The most limiting loading configuration of an MPC requires 2600 parts-per-million (ppm) of soluble boron to ensure the

k_{eff} is maintained below 0.95, the regulatory limit relied upon by the staff for demonstrating compliance with the requirements of 10 CFR 72.124(a). SQN's ISFSI TSs require the soluble boron concentration in the MPC cavity be greater than or equal to the concentrations assumed in the criticality analyses under a variety of MPC loading configurations. In all cases, the boron concentration required by the proposed ISFSI TS ensures that the k_{eff} will be below 0.95 for the analyzed loading configuration. Additionally, the licensee's proposed ISFSI TS contains surveillance requirements which ensure it will verify that the boron concentration is above the required level both prior to and during MPC loading, unloading, and handling operations. Based on its review of the proposed SQN ISFSI TS, the staff finds that the licensee has satisfied Criterion 2.

Third, the staff reviewed the SQN FSAR Update and the information provided by the licensee in its exemption request to ensure that it complies with GDC 63. GDC 63 requires that licensees have radiation monitors in fuel storage and associated handling areas to detect conditions that may result in a loss of residual heat removal capability and excessive radiation levels and initiate appropriate safety actions. As a condition of receiving and maintaining an operating license, the licensee must comply with GDC 63. The staff reviewed the SQN FSAR Update and exemption request to determine whether it had provided sufficient information to demonstrate continued compliance with GDC 63. Based on its review of both documents, the staff finds that the licensee complies with GDC 63 and has satisfied Criterion 3.

Finally, as part of the criticality analysis review, the staff evaluated the storage of nonfuel related material in an MPC. The staff evaluated the potential to increase the reactivity of an MPC by loading it with materials other than spent nuclear fuel and fuel debris. SQN's spent fuel and nonfuel hardware are bounded by the spent fuel and non-fuel hardware analyzed and represented in Holtec Hi-Storm 100 Certificate of Compliance (COC) No. 1014, Appendix B, "Approved Content and Design Features." The COC provides limitations on the

materials that can be stored in the MPC design intended to be used at the SQN ISFSI. The staff determined that the loading limitations described in the COC will ensure that nonfuel hardware loaded in the MPCs will not result in a reactivity increase. Based on its review of the loading restrictions for nonfuel hardware, the staff finds that the licensee has satisfied Criterion 4.

3.2.2 Boron Dilution Analysis

Since the licensee's ISFSI application relies on soluble boron to maintain subcritical conditions within the MPCs during loading, unloading and handling operations, the staff reviewed the licensee's boron dilution analysis to determine whether appropriate controls, alarms, and procedures were available to identify and terminate a boron dilution accident prior to reaching a critical boron concentration.

By letter dated October 25, 1996, the staff issued a safety evaluation of licensing topical report WCAP-14416, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology." This safety evaluation specified that the following issues be evaluated for applications involving soluble boron credit: the events that could cause boron dilution, the time available to detect and mitigate each dilution event, the potential for incomplete boron mixing, and the adequacy of the boron concentration surveillance interval.

The TS requirements for the HI-STORM 100 Cask System include a minimum boron concentration of 1900 ppm boron when spent fuel assemblies with enrichments less than or equal to 4.1 weight-percent (wt-percent) U-235 are loaded into an MPC-32 canister. When fuel assemblies are enriched to greater than 4.1 wt-percent U-235 and less than or equal to 5.0 wt-percent U-235 and loaded into an MPC-32, the minimum boron concentration is 2600 ppm. These TS requirements ensure that k_{eff} is maintained less than 0.95. TS surveillance requirements require the boron concentration in the MPC water to be verified by two independent measurements within 4 hours prior to commencing any loading or unloading of

fuel; verified when one or more fuel assemblies are installed if water is to be added or recirculated through the MPC; and verified every 48 hours thereafter while the MPC is in the SFP when one or more fuel assemblies are installed.

The licensee contracted with Holtec International to perform a criticality analysis to determine the soluble boron concentration that results in a k_{eff} equal to 1.0 for both 4.1 wt-percent and 5.0 wt-percent U-235 fuel enrichments using the same methodology as approved in the HI-STORM 100 Cask System Final Safety Analysis. The analysis determined the critical boron concentration level for 4.1 wt-percent U-235 enriched fuel was 1180 ppm and for 5.0 wt-percent U-235 enrichment was 1780 ppm. Therefore, the boron concentration within the canister would have to decrease from the TS limit to the respective critical boron concentration before criticality is possible. The licensee based its boron dilution analyses and its preventive and mitigative actions on dilution sources with the potential to reduce the boron concentration from the TS minimum values for the two fuel enrichment bands to the respective concentration for criticality.

The licensee reviewed plant drawings to identify potential dilution sources and performed a plant walk-down to verify the drawing review. This review identified that, with the exception of the raw cooling water (RCW) system piping, large diameter piping with the potential to dilute the spent fuel pool boron concentration was seismically qualified to assure the piping would adequately maintain its position and pressure boundary integrity during the design basis safe-shutdown earthquake. Subsequently, the licensee evaluated the RCW piping and components on the refueling floor and concluded the RCW system would also adequately maintain its position and pressure boundary integrity during the design basis safe-shutdown earthquake. Therefore, an instantaneous complete severance of these piping systems is not credible. However, the licensee reviewed its calculation for moderate energy line breaks and performed calculations for these piping systems in the refueling pool area to determine dilution

potentials from postulated critical cracks in the piping. Numerous smaller piping systems may experience critical cracks; however, the most limiting critical crack flow rate is the calculated value of 314 gallons per minute (gpm) for the RCW system.

The licensee identified the following additional credible bounding dilution sources and their flow rates: 250 gpm from the demineralized water system through an open isolation valve to the SFP cooling system; 5 gpm from the demineralized water system to make up for undetected, small leaks from the SFP or its cooling system; and 150 gpm from the fire protection system through a fire hose station to the spent fuel pool. The staff found the scope and results of the dilution source evaluation acceptable.

To demonstrate that it has ample time and opportunity to identify and terminate a boron dilution event, the licensee calculated the time necessary for dilution from the TS boron concentration to the critical boron concentration for each fuel enrichment range and described the alarms, procedures, and administrative controls it has in place. The RCW critical crack flow rate of 314 gpm, which is the limiting high flow-rate dilution event, would require more than 8 hours to dilute the SFP to the critical boron concentration. The licensee modified the SFP high level setpoint and procedural limits for initial SFP water level prior to cask loading operations to assure the SFP high level alarm would be effective in detecting dilution during cask loading operations. The RCW critical crack would cause the SFP water level to reach the high level alarm setpoint within several minutes of water beginning to spill into the pool, allowing operators ample time to stop the dilution after the alarm. The indications and response to a high-rate dilution event from the demineralized water system through the spent fuel cooling system would be similar, but the licensee committed to the additional action of tagging closed the demineralized and primary water supplies to the spent fuel cooling system during cask loading and unloading operations.

Dilution to the critical boron concentration resulting from addition of water to

compensate for an undetected slow loss of SFP coolant is also not credible. The licensee calculated that the dilution from the TS required boron concentration would require hundreds of hours at leakage rates that could credibly go unnoticed. The 48-hour TS surveillance interval for boron concentration measurement provides strong assurance that such a dilution would be detected and corrected well before the critical boron concentration could be reached.

The configuration of the cask pit could allow localized boron dilution and stratification because the pit is open to the SFP only through a narrow transfer path above the level of stored fuel. Addition of cold water directly to the cask pit (e.g., through a fire hose) that is denser than the warm, borated pool water could fill the bottom of the cask pit with water having a low boron concentration. However, the licensee stated that the spent fuel cooling system with a normal flow rate of 2300 gpm discharges flow through one 4-inch line into the cask pit and one 10-inch line into the SFP. The cooled return flow to the cask pit provides assurance that localized boron dilution and stratification would not occur within the cask pit during canister loading operations.

In addition to the conservative criticality and boron dilution analyses it performed, the licensee will enhance its procedures and operator training to ensure that the casks can be safely loaded, unloaded, and handled in the SQN spent fuel pool. The licensee committed to enhance its operation procedures to explicitly describe reaction to alarms and indications which are indicative of a boron dilution event prior to initial dry cask loading operations. Additionally, SQN committed to provide training on the new procedures to ensure that operators can effectively identify and terminate boron dilution sources in a minimum amount of time prior to reaching a critical boron limit. The licensee stated in its supplement that the training will emphasize the importance of avoiding any inadvertent additions of unborated water to the SFP, responses to be taken for notification or alarms that may be indicative of a potential boron dilution event during cask loading and fuel movement in the SFP, and identification of the

potential for a boron dilution event during decontamination rinsing activities and abnormal SFP make-up with the fire protection system. Finally, in order to ensure rapid identification of an ongoing boron dilution event, the licensee committed either to increase the frequency of its normal rounds or station a trained monitor who is assigned to watch for a dilution event in SFP area.

Based on the staff's review of the licensee's exemption request dated February 20, 2004, the supplemental information provided by letter dated April 27, 2004, and its boron dilution analysis, the staff finds the licensee has provided sufficient information to demonstrate that an undetected and uncorrected dilution from the TS required boron concentration to the calculated critical boron concentration is not credible. Based on its review of the boron dilution analysis and enhancements to the operating procedures and operator training program, the staff finds that the licensee has satisfied Criterion 5.

Therefore, in conjunction with the conservative assumptions used to establish the TS required boron concentration and critical boron concentration, the boron dilution evaluation demonstrates that the underlying intent of 10 CFR 50.68(b)(1) is satisfied.

3.3 Legal Basis for the Exemption

Pursuant to 10 CFR 50.12, "Specific Exemption," the staff reviewed the licensee's exemption request to determine if the legal basis for granting an exemption had been satisfied, and concluded that the licensee has satisfied the requirements of 10 CFR 50.12. With regards to the six special circumstances listed in 10 CFR 50.12(a)(2), the staff finds that the licensee's exemption request satisfies 50.12(a)(2)(ii), "Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule." Specifically, the staff concludes that since the licensee has satisfied the five criteria in Section 3.1 of this exemption, the application of the rule is not necessary to achieve its underlying purpose in this case.

3.4 Staff Conclusion

Based upon the review of the licensee's exemption request to credit soluble boron during MPC loading, unloading, and handling in the SQN SFP, the staff concludes that pursuant to 10 CFR 50.12(a)(2) the licensee's exemption request is acceptable. However, the staff limits its approval to the loading, unloading, and handling of the components of the HI-STORM 100 dual-purpose dry cask storage system at SQN.

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 Tennessee Valley Authority an exemption from the requirements of 10 CFR 50.68(b)(1) for the loading, unloading, and handling of the components of the HI-STORM 100 dual-purpose dry cask storage system at SQN. Any changes to the cask system design features affecting criticality or its supporting criticality analyses will invalidate this exemption.

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 (69 FR 31849).

This exemption is effective upon issuance.

Dated at Rockville, Maryland, this 7th day of June 2004.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Ledyard B. Marsh, Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation