December 10, 2007

Mr. William R. Campbell, Jr.
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 - CORRECTED PAGES TO SAFETY EVALUATION FOR AMENDMENTS REGARDING INCREASED TEMPERATURE AND LEVEL LIMITS OF ULTIMATE HEAT SINK (TAC NOS. MD2621 AND MD2622)

Dear Mr. Campbell:

On September 30, 2007, the U.S. Nuclear Regulatory Commission (NRC) issued Amendment No. 317 to Facility Operating License No. DPR-77 and Amendment No. 307 to Facility Operating License No. DPR-79 for the Sequoyah Nuclear Plant, Units 1 and 2, respectively. These amendments revised the technical specifications regarding the ultimate heat sink level and temperature.

Subsequently, the Sequoyah licensing staff informed the NRC staff of some apparent errors in the safety evaluation (SE) supporting the amendments. Specifically, the discussion of peak cladding temperature incorrectly cited a previous NRC safety evaluation, the component cooling system was stated to be part of the emergency core cooling system, and the discussion of downstream dam failure incorrectly stated that the wider breach would result in a slower recession time. There were also a few instances where the references listed in the SE were incorrectly cited in the discussion section.

The NRC staff reviewed these comments and agreed that the SE should be corrected. The NRC staff also concluded that the changes correct inaccuracies or misstatements in the SE, but do not change the technical evaluation or conclusions of the SE.

The enclosed SE pages 6, 10, 11 and 22 correct the errors and are annotated to show the corrections. The pages previously issued with the amendments should be replaced with the enclosed pages.

We appreciate this constructive input from the Sequoyah licensing staff and apologize for any inconvenience resulting from the changes.

Sincerely,

/RA/

Brendan T. Moroney, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-327 and 50-328

Enclosures: Revised SE pages

cc w/enclosures: See next page

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Sincerely,
/RA/

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Plant Licensing Branch II-2
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William R. Campbell, Jr.
Tennessee Valley Authority

SEQUOYAH NUCLEAR PLANT

cc:
Mr. Ashok S. Bhatnagar
Senior Vice President
Nuclear Generation Development
and Construction
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. James R. Douet
Senior Vice President
Nuclear Support
Tennessee Valley Authority
3R Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Walter M. Justice II
Interim Vice President
Nuclear Engineering & Technical Services
Tennessee Valley Authority
3R Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Mr. Timothy P. Cleary, Site Vice President
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

General Counsel
Tennessee Valley Authority
6A West Tower
400 West Summit Hill Drive
Knoxville, TN 37902

Mr. John C. Fornicola, Manager
Nuclear Assurance
Tennessee Valley Authority
3R Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

Ms. Beth A. Wetzel, Manager
Corporate Nuclear Licensing and
Industry Affairs
Tennessee Valley Authority
4X Blue Ridge
1101 Market Street
Chattanooga, TN 37402-2801

Mr. James D. Smith, Manager
Licensing and Industry Affairs
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

Mr. Christopher R. Church, Plant Manager
Sequoyah Nuclear Plant
Tennessee Valley Authority
P.O. Box 2000
Soddy Daisy, TN 37384-2000

Senior Resident Inspector
Sequoyah Nuclear Plant
U.S. Nuclear Regulatory Commission
2600 Igou Ferry Road
Soddy Daisy, TN 37379

Mr. Lawrence E. Nanney, Director
Division of Radiological Health
Dept. of Environment & Conservation
Third Floor, L and C Annex
401 Church Street
Nashville, TN 37243-1532

County Mayor
Hamilton County Courthouse
Chattanooga, TN 37402-2801

Mr. Robert H. Bryan, Jr., General Manager
Licensing and Industry Affairs
Tennessee Valley Authority
4X Blue Ridge
1101 Market Street
Chattanooga, TN 37402-2801

Ms. Ann P. Harris
341 Swing Loop Road
Rockwood, TN 37854

based on a minimum long-term UHS level of 639 ft-msl. In Ref. 2 (Response to Question 5), the licensee explained that the minimum UHS water level of 639 ft-msl was established to minimize sediment uptake into the ERCWS. Section 4.2.11.1 of the SQN UFSAR states that an elevation of 639 ft-msl would be reached within about 36 hours after LODD. The 639 ft-msl level will be maintained by releasing sufficient water, 14,000 cfs, through the upstream Watts Bar Dam approximately 12 hours after the LODD occurs. The ERCWS pump sumps are located 14 feet below the 639 ft-msl elevation. Recession curves predict long-term river elevation to be 641 feet at the intake pumping station. Therefore, the licensee's use of 639 ft-msl for the long-term ERCWS flow balance is acceptable.

Based on a review of the information that was provided, the NRC staff finds that the licensee has adequately evaluated and addressed the impact of the proposed UHS level requirement on ERCWS flow rate and NPSH considerations. The ERCWS flow rates that are assumed by TVA for short-term and long-term cooling following LOCA coincident with LODD are consistent with those that are currently assumed for the 83 °F UHS temperature limit as approved previously by the NRC in a letter dated August 15, 1988. Also, because a minimum UHS level of 639 ft-msl is assured for long-term cooling, the NPSH for the ERCWS pumps will be increased by three feet which provides additional margin. Therefore, the NRC staff considers the proposed UHS level requirement to be acceptable with respect to ERCWS flow rate and NPSH considerations.

3.1.3 Proposed Change to the UHS Temperature Requirement

NRC review considerations that could be affected by proposed changes to the maximum allowed UHS temperature include the capability of the UHS to provide long-term cooling without exceeding the maximum allowed temperature; containment response; peak fuel cladding temperature; impact on SSCs important to safety; station blackout; environmental qualification of SSCs important to safety; resolution of Generic Letter (GL) 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions," and other considerations that are identified during the course of the NRC staff's review.

3.1.3.1 Peak Fuel Clad Temperature

The function of the ECCS is to cool the reactor core by removing stored and fission product decay heat so that fuel damage remains within prescribed limits. The UFSAR analysis demonstrates compliance to the requirements of 10 CFR 50.46, showing the peak clad temperatures and core reflood/quenching occur many minutes before any heat removal from the core to the UHS begins. Licensee analysis shows that, following a LOCA, peak clad temperatures occur approximately 100 seconds into the ECCS event and core re-flood occurs approximately 600 seconds into the event. During this time period, the peak cladding temperature is mitigated by ECCS using on site emergency cooling water from the Refueling Water Storage Tank (RWST). The parameters that demonstrate compliance to 10 CFR 50.46 are not adversely affected by the UHS temperature.

The NRC staff finds that the licensee has adequately evaluated and addressed the impact of the proposed UHS temperature increase on the peak fuel cladding temperature. The proposed change in UHS temperature does not adversely impact the initial ECCS parameters and the SQN UFSAR analysis remains bounding. Therefore, the proposed increase in the UHS temperature limit is considered to be acceptable with respect to the peak fuel cladding temperature.

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c. CCS Heat Exchangers

Within the SQN site program for implementing the provisions of GL 89-13, “Service Water System Problems Affecting Safety-Related Equipment,” all safety related heat exchangers that are served by ERCWS are listed and their performance monitoring method and frequency of test are specified. Additional information was provided relative to heat exchanger performance monitoring in Ref. 2 (Response to Question 2), and clarification was provided relative to the description of the CCS heat exchangers in Ref. 5 (Response to Question 2). The licensee indicated that the thermal performance of the CCS heat exchangers is periodically monitored to verify that the heat transfer capability is adequate to meet design basis heat loads. Other heat exchangers receive periodic inspection and maintenance. Although the CCS heat exchanger is a plate heat exchanger (PHE), it is modeled by Westinghouse as a shell and tube heat exchanger in the containment analysis due to software limitations. The licensee confirmed that the CCS plate heat exchangers meet or exceed the heat transfer capability that is assumed in the Westinghouse containment analysis.

The CCS is designed for all phases of plant operation and shutdown. The CCS is designed to provide cooling water in the temperature range of 35 °F to 95 °F. Calculations 70D530HCGKBO102287, “SQN-CCS Plate Heat Exchangers (PHE) Train 1A/2A ERCW Flow Requirements,” and 70D53EPMMCG021290, “SQN-CCS Plate Heat Exchangers OB1 & OB2 Train B ERCW Flow Requirements,” specify the following design limitations for the CCS heat exchangers: 1) a maximum ERCWS exit temperature of 126 °F for piping design considerations, 2) a maximum CCS return temperature of 145 °F for CCS piping and support design considerations, 3) a maximum CCS exit temperature of 104.5 °F during the LOCA-Recirculation phase for containment pressurization considerations, and 4) a maximum CCS exit temperature of 95 °F for normal plant operation and for refueling heat load considerations. The calculations also indicated that in order to preclude long term fouling during normal operation, the ERCWS flow velocity should be maintained greater than 1.5 ft/sec. This equates to 4330 gpm with two CCS heat exchangers in operation or 2165 gpm with one CCS heat exchanger in operation.

The licensee’s calculations showed that the minimum ERCWS flow rate that is required for PHEs 1A1/1A2 to support one unit in LOCA-Recirculation phase was 3605 gpm; whereas the available flow rate (reduced by 5 percent for measurement uncertainty) was 3671 gpm. The minimum required ERCWS flow rate for PHEs 2A1/2A2 with the opposite unit in hot standby was 1350 gpm; whereas the available flow rate (reduced by 5 percent for measurement uncertainty) was 1601 gpm. The minimum required ERCWS flow rate for swing PHEs OB1/OB2 to support spent fuel pit loads was 3365 gpm; whereas the available flow (reduced by 5 percent for measurement uncertainty) was 5286 gpm. These ERCWS flow rates represented an increase over those that are currently specified in order to compensate for an additional CCS flow tolerance allowance along with the increased UHS temperature of 87 °F in order to prevent PHE inlet and outlet piping temperatures from exceeding the specified limits. However, as discussed in Ref. 2 and Ref. 5 (Response to Questions 8 and 7, respectively), there are circumstances where the heat removal rate has to be controlled by plant operators in order to keep from exceeding the 126 °F and 145 °F criteria. Procedural controls for this purpose are contained in Operations Procedure 0-SO-74-1, “Residual Heat Removal System (RHR),” which directs plant operators to adjust CCS or RHR flow rates accordingly. These procedural controls are part of the normal process for placing RHR in service, and do not represent new procedural requirements.

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Based upon a review of the information that was provided, the NRC staff finds that the licensee has adequately evaluated and addressed the impact of the proposed UHS temperature increase on the capability of the CCS to perform its safety functions. The licensee has demonstrated that sufficient ERCWS flow margin for the CCS heat exchangers is available to compensate for the proposed temperature increase such that CCS will not be adversely affected. Therefore, the NRC considers the proposed increase in the UHS temperature limit to be acceptable relative to the CCS.

d. Emergency Diesel Generator (EDG) Heat Exchangers

The ERCWS is used to reject heat from the EDG jacket water heat exchangers. The normal EDG jacket water exit temperature (process side) ranges from 165 to 170 °F, and no derating is required if the jacket water exit temperature is kept below 190 °F. Using commercial heat exchanger evaluation software, Tubular Exchanger Manufacturers Association (TEMA) standards, vendor design information, and actual thermal performance data, the licensee developed calculation MDQ00006720030142, "Emergency Diesel Generator (EDG) ERCW Heat Exchanger Evaluation for 87 °F." The licensee determined that the minimum required ERCWS flow rate for the EDG jacket water coolers that was necessary in order to avoid derating ranged from 365 gpm with no tubes plugged to 425 gpm with 5 percent of the tubes plugged. Based upon flow modeling, the licensee found that the available ERCWS flow rate to the ERCWS heat exchangers ranged from 452 gpm for the most limited heat exchanger to 530 gpm. However, the licensee's calculations were based upon jacket water heat exchanger fouling factors in the range of 0.0016 hr-°F-ft^2/BTU compared to the TEMA recommended average fouling factor of 0.0020 hr-°F-ft^2/BTU that applied to SQN.

The licensee provided additional information concerning the most limiting scenario for the EDGs relative to the higher UHS temperature of 87 °F and the fouling factors that were used in the analysis in Ref. 2 (Response to Question 11) and Ref. 5 (Response to Questions 6 and 19). The licensee explained that the lower fouling factors that were used in the evaluation were based upon actual operating conditions and previous plant experience. The NRC staff felt that in the absence of compelling heat exchanger performance data, there was no basis for accepting fouling factors that are less than those recommended by TEMA. In this case, since the EDG heat exchangers are operated infrequently and for relatively short periods of time, it would be very difficult for the licensee to justify the use of the lower fouling factors. Consequently, the licensee performed the calculation again using the TEMA recommended average fouling factor of 0.0020. hr-°F-ft^2/BTU that were applicable for the EDG jacket water heat exchanger flow velocities. With no allowance for tube plugging, the results of this calculation indicated that the minimum required ERCWS flow rate for the jacket water heat exchangers necessary to avoid derating is 400 gpm (includes 5 percent margin for measurement uncertainty). In Ref. 5, the licensee made a regulatory commitment to revise their design configuration controls to ensure that the minimum ERCWS flow rate to each EDG jacket water heat exchanger is at least 400 gpm, and to revise EDG calculation MDQ00006720030142 to reflect the revised fouling factor assumptions and the TEMA reference.

Based upon a review of the information that was provided, the NRC staff finds that the licensee has adequately evaluated and addressed the impact of the proposed UHS temperature limit increase on the EDGs. The licensee's analyses show that with a minimum required ERCWS flow rate of 400 gpm to the jacket water heat exchangers, the EDGs will continue to be capable of performing their safety functions following the proposed increase in the UHS temperature

The licensee noted in its response to RAI #2 in Ref. 3 that the small database of large-dam failures tends to indicate 500 feet as a possible upper bound for breach width (page 15 of Ref. 6). However, the staff investigation of the U.S. Bureau of Reclamation database cited by Ref. 9 revealed that 10 out of 410 listed dam breach events exceed a breach width of 500 feet. In the same database, the reported maximum breach width is 5800 feet. Therefore, the staff concluded that the breach width of 400 feet at the Chickamauga Dam is not conservative. Instead, the staff evaluated breach widths and times using the same four equations as the licensee did but with an initial reservoir level of 675 ft-msl (Table 1). The reason for estimating breach times is to investigate the margin in the reservoir recession rates. The table also includes elapsed times from 674 ft-msl to 670 ft-msl for the estimated breach width equations. The elapsed times were computed based on a relationship between breach width and elapsed time given in Figure 4 (attached), which was constructed by the licensee's reservoir recession rates simulated with the SOCH model.

Table 1. Staff estimates of breach width, breach time, and time elapsed from 674 ft-msl to 670 ft-msl, with an initial reservoir level of 675 ft-msl, initial reservoir storage volume of 392,000 acre-feet, and upstream inflow of 14,000 cubic feet per second.

Equation	Estimated Breach Width (foot)	Estimated Breach Time (Hours)	Time Elapsed 674-670 ft-msl (Hours)
Von Thun and Gillette (1990)	297	0.20	4.37
U.S. Bureau of Reclamation	135	0.45	4.70
Federal Energy Regulatory Commission	380	1.27	4.21
Froehlich (1995)	645	6.02	3.68

It should be noted that the staff's breach width estimates are nearly identical to those of the licensee. The first three equations in the table use the breach height as an independent variable while the Froehlich equation uses both the breach width and the storage volume as independent variables.

The result shows that the estimated breach widths and times vary noticeably from equation to equation. The breach time by the Froehlich equation is about 30 times longer than the minimum. The elapsed times of the first three equations meet the 4-hour-above-670-foot limiting condition, while that of the Froehlich equation violates the limiting condition. However, the breach time by the Froehlich equation is substantially longer than those of the other three equations, implying that the actual recession time from 674 ft-msl to 670 ft-msl by the Froehlich equation will be delayed substantially if the simulation of the reservoir drawdown considers the estimated breach time instead of assuming an instantaneous breaching. Therefore, the staff concluded that the UHS system with the proposed TS changes meets the 4-hour-above-670-foot limiting condition.

3.3.5 Long-term Recessions

The licensee performed a comprehensive sensitivity analysis with the SOCH model to investigate a variability of recession rates with a range of potential breach parameters and varying upstream inflows. The licensee found that the wider breach (W=1000 feet) results in recession times shorter than that of the narrower breach width (W=300 feet), but the initial (t<12 hours) and final (t>60 hours) recessions of two different breach widths are nearly identical. Based on the results of the sensitivity tests, the licensee concluded that the breach

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