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ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Subject: **Sequoyah Nuclear Plant, Units 1 and 2 - Resolution of Generic Safety Issue (GSI)-191**

References:

1. TVA letter to NRC, "Sequoyah Nuclear Plant, Units 1 and 2 - Path Forward for Resolution of Generic Safety Issue (GSI)-191," dated May 16, 2013
2. SECY-12-0093, "Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance," dated July 9, 2012.
3. NRC letter to NEI, "NRC Review of Nuclear Energy Institute Clean Plant Acceptance Criteria for Emergency Core Cooling Systems," dated May 2, 2012.
4. NRC Final Safety Evaluation for Pressurized Water Reactor Owners Group Topical Report WCAP-16793-NP, Revision 2, "Evaluation of Long-Term Cooling Considering Particulate Fibrous and Chemical Debris in the Recirculating Fluid," dated April 8, 2013.

In Reference 1, TVA indicated that the approach to resolving GSI-191 for Sequoyah Nuclear Plant, Units 1 and 2, was to use the Option 1 with "clean-plant" criteria approach described in SECY-12-0093 (i.e.; Compliance with 10 CFR 50.46 Based on Approved Models) (Reference 2) and NRC letter to NEI dated May 2, 2012 (Reference 3). Note, TVA uses the terms "clean-plant" and "low-fiber plant" criteria interchangeably.

Also in Reference 1, TVA committed to review and document adherence to the Limitations and Conditions contained in Section 4.0 of the NRC Safety Evaluation for Pressurized Water Reactor Owners Group Topical Report WCAP-16793-NP, Revision 2 (Reference 4).

The enclosure to this letter provides the summary of the review of the Limitations and Conditions of the NRC Safety Evaluation for Pressurized Water Reactor Owners Group Topical Report WCAP-16793-NP, Revision 2, for Sequoyah Nuclear Plant, Units 1 and 2.

There are no new commitments made in this submittal.

If you have any questions concerning this submittal, please contact Russell Thompson at (423) 751-2567.

I declare under penalty of perjury that the foregoing is true and accurate. Executed on this 27th day of June 2014.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosure

Summary of Sequoyah, Units 1 and 2, LOCADM Results and Review of Limitations and Conditions to WCAP-16793-NP, Revision 2

cc (Enclosure):
NRC Regional Administrator – Region II

ENCLOSURE

SUMMARY OF SEQUOYAH (SQN), UNITS 1 AND 2, LOCADM RESULTS AND REVIEW OF LIMITATIONS AND CONDTIONS TO WCAP-16793-NP, REVISION 2

The following provides a response to each of the limitations and conditions with respect to the application of WCAP-16793-NP, Revision 2-A to SQN, Units 1 & 2.

1. *Licensees should confirm that their plants are covered by the PWROG sponsored fuel assembly tests by confirming that the plant available hot-leg break driving head is equal to or greater than that determined as limiting in the proprietary fuel assembly tests and that flow rate is bounded by the testing. Licensees should validate that the fuel types and inlet filters in use at the plant are covered by the test program (with the exception of LTAs). Licensees should limit the amount of fibrous debris reaching the fuel inlet to that stated in Section 10 of the WCAP (15 grams per fuel assembly for a hot-leg break scenario).*

   Alternately, licensees may perform plant specific testing and/or evaluations to increase the debris limits on a site-specific basis. The available driving head should be calculated based on the core exit void fraction and loop flow resistance values contained in their plant design basis calculations, considering clean loop flow resistance and a range of break locations. Calculations of available driving head should account for the potential for voiding in the steam generator tubes. These tests shall evaluate the effects of increased fiber on flow to the core, and precipitation of boron during a postulated cold leg break, and the effect of p/f ratios below 1:1. The NRC staff will review plant specific evaluations, including hot- and cold-leg break scenarios, to ensure that acceptable justification for higher debris limits is provided. (Sections 3.1.2 (c), 3.1.2 (e), 3.3.1, 3.4.2, 3.8, 3.9 and 3.10 of this SE).

   TVA Response

   TVA confirms that SQN, Units 1 and Unit 2, are covered by the PWROG sponsored fuel assembly tests. WCAP-16793-NP, Revision 2A, “Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculation Fluid,” states that the maximum delta (dP) due to the presence of 15 grams of fiber is small and all plants have a driving head greater than this value, so core flow will not be impeded. This statement was based on the AREVA testing conducted in support of WCAP-17057—P, Revision 1, “GSI-191Fuel Assembly Test Report for PWROG,” that demonstrated that 15 grams of fiber per fuel assembly will not cause a blockage that can challenge long-term core cooling.

   SQN, Units 1 and 2, fuel is currently in transition from AREVA Mark-BW fuel to AREVA Advanced W17 HTP fuel. The Mark-BW fuel has a lower tie plate/bottom nozzle TRAPPER™ coarse mesh design, while the AREVA Advanced W17 HTP fuel has the FUELGUARD™ design. Testing established that the AREVA Mark-BW and Advanced W17 HTP fuel are bounded by the limiting fuel used to establish the allowable limits presented in WCAP-16793.

The SQN, Units 1 and 2, fuel fiber content is 14.8 grams per fuel assembly. Because the SQN, Units 1 and 2, fuel fiber content is less than the 15g per fuel assembly limit, SQN, Units 1 and 2, has adequate hot leg driving head to assure core cooling.

2. *Each licensee's GL 2004-02 submittal to the NRC should state the available driving head used in the evaluation of the hot-leg break scenario, the ECCS flow rates, and the results of the LOCADM calculations. Licensees should provide the type(s) of fuel and inlet filters installed in their plants, as well as the amount of fiber (gram per fuel assembly) that reaches the core. (Section 3.3.1 and 3.10 of this SE)*

TVA Response

The available driving head for the hot-leg break scenarios was developed generically, and the results were provided in WCAP-16793-NP, Revision 2A. The WCAP evaluated a minimum available driving head that was acceptable for the fleet of Pressurized Water Reactors. This value was approximately 13 pounds per square inch differential (psid).

The LOCADM evaluation for SQN, Units 1 and 2, used plant-specific conditions and materials to determine a maximum cladding temperature and deposit thickness. The fuel cladding temperature and deposit thickness determined from the evaluation were compared to the conservative maximum deposition thickness of 50 mils (1,270 microns) and maximum acceptable temperature of 800°F as indicated in WCAP-16793-NP, Revision 2A. The final calculated deposition thickness for SQN, Units 1 and 2, is 14.12 mils (358.56 microns), which is less than the recommended upper limit of 50 mils. The calculated maximum temperature of the fuel cladding during recirculation from the containment sump over the 30 days following the LOCA is calculated to be 579.09°F, which is less than the recommended maximum cladding temperature of 800°F.

SQN, Units 1 and 2, fuel is currently in transition from AREVA Mark-BW fuel to AREVA Advanced W17 HTP fuel. The Mark-BW fuel has a lower tie plate/bottom nozzle TRAPPER™ coarse mesh design, while the AREVA Advanced W17 HTP fuel has the FUELGUARD™ design.

The low-fiber plant criterion from "Transmittal of GSI Resolution Criteria for 'Low Fiber' Plants", NEI, dated December 22, 2011, established that SQN, Units 1 and 2, is a low-fiber plant.

Currently, the only fiber that could be present in the sump water is latent fiber. There is no fibrous insulation in the zone of influence (inside the crane wall of the containment buildings or the ice condensers). NUKON commercial fiberglass was assumed to be representative of latent fiber per NUREG/CR-6224. Design reviews and documented walk downs concluded that only latent fibrous debris has potential to reach the sump strainer. A limit of 14 pounds will ensure that any future additions of latent debris remain within the acceptance criteria of WCAP-16793-NP.

The SQN, Units 1 and 2, fuel fiber content is calculated assuming 14 pounds of fiber, 100 percent debris transport, 45 percent strainer bypass and 193 fuel assemblies (i.e., [14lb *1.0*0.45*453.6 gm/lb /193] = 14.8 gm/assembly). The calculation uses NEI generic values adjusted for the plant-specific number of fuel assemblies and the guidance provided in NRC letter to NEI, "NRC Review of Nuclear Energy Institute Clean Plant Acceptance Criteria for Emergency Core Cooling Systems," dated May 2, 2012. SQN, Units 1 and 2, have a fuel fiber content of 14.8 grams per fuel assembly.

3. *Section 3.1.4.3 of the WCAP states that alternate flow paths in the RPV were not credited. The section also states that plants may be able to credit alternate flow paths for demonstrating adequate LTCC. If a licensee chooses to take credit for alternate flow paths, such as core baffle plate holes, to justify greater than 15 grams of bypassed fiber per fuel assembly, the licensee should demonstrate, by testing or analysis, that the flow paths would be effective, that the flow holes will not become blocked with debris during a LOCA, that boron precipitation is considered, and that debris will not deposit in other locations after passing through the alternate flow path such that LTCC would be jeopardized. (Sections 3.3.1 and 3.4.2 of this SE)*

   TVA Response

   Alternate flow paths were not credited in determining the acceptability of the SQN Units 1 and 2, Emergency Core Cooling System (ECCS) design.

4. *Sections 3.2 and 3.3 of the WCAP provide evaluations to show that even with large blockages at the core inlet, adequate flow will enter the core to maintain LTCC. The staff recognizes that these calculations show that significant head loss can occur while maintaining adequate flow. However, the analyses have not been correlated with debris amounts. Therefore, the analyses cannot be relied upon to demonstrate adequate LTCC. (Sections 3.3.3 and 3.4 of this SE)*

   TVA Response

   The determination that SQN, Units 1 and 2, has adequate Long Term Core Cooling (LTCC) was not based on the calculations of acceptable LTCC with large blockages and significant head loss. The SQN, Unit 1 and 2, core inlet head loss is bounded by the generic evaluation and test results for low fiber plants.

5. *In RAI Response number 18 in Reference 13, the PWROG states that numerical analyses demonstrated that, even if a large blockage occurs, decay heat removal will continue. The NRC staff's position is that a plant must maintain its debris load within the limits defined by the testing (e.g., 15 grams per assembly). Any debris amounts greater than those justified by generic testing in this WCAP must be justified on a plant-specific basis. (Sections 3.4.2 and 3.10 of this SE)*

TVA Response

The SQN, Units 1 and 2, fuel fiber content of 14.8 gm/assembly is less than the 15 gm/assembly target value. Thus, the SQN, Units 1 and 2, debris amounts are justified by generic testing in WCAP-16793-NP, Revision 2A, consistent with the NRC's position.

6. *The fibrous debris acceptance criteria contained in the WCAP may be applied to fuel designs evaluated in the WCAP. Because new or evolving fuel designs may have different inlet fittings or grid straps that could exhibit different debris capture characteristics, licensees should evaluate fuel design changes in accordance with 10 CFR 50.59 to ensure that new designs do not impact adequate long term core cooling following a LOCA. (Section 3.4.2 of this SE)*

TVA Response

SQN, Units 1 and 2, fuel is currently in transition from AREVA Mark-BW fuel to AREVA Advanced W17 HTP fuel. The Mark-BW fuel has a lower tie plate/bottom nozzle TRAPPER™ coarse mesh design, while the AREVA Advanced W17 HTP fuel has the FUELGUARD™ design. Testing established that the AREVA Mark-BW and Advanced W17 HTP fuel are bounded by the limiting fuel used to establish the allowable limits presented in WCAP-16793.

7. *Sections 2 and 4.3 of the WCAP establish 800 degrees Fahrenheit as the acceptance limit for fuel cladding temperature after the core has been re-flooded. The NRC staff accepts a cladding temperature limit of 800 degrees Fahrenheit as the long-term cooling acceptance basis for GSI-191 considerations. Each licensee's GL 2004-02 submittal to the NRC should state the peak cladding temperature predicted by the LOCADM analysis. If a licensee calculates a temperature that exceeds 800 degrees Fahrenheit, the licensee must submit data to justify the acceptability of the higher clad temperature. (Sections 3.2, 3.4.3, 3.4.4, and 3.10 of this SE)*

TVA Response

The peak cladding temperature calculated by LOCADM for SQN, Units 1 and 2, is 579.09°F, which is less than the acceptance criterion of 800°F.

8. *As described in the Limitations and Conditions for WCAP-16530-NP (ADAMS Accession No. ML073520891) (Reference 21)[5], the aluminum release rate equation used in TR WCAP-16530-NP provides a reasonable fit to the total aluminum release for the 30-day ICET tests but under-predicts the aluminum concentrations during the initial active corrosion portion of the test. Actual corrosion of aluminum coupons during the ICET 1 test, which used sodium hydroxide (NaOH), appeared to occur in two stages; active corrosion for the first half of the test followed by passivation of the aluminum during the second half of the test. Therefore, while the 30-day fit to the ICET data is reasonable, the WCAP-16530-NP-A model under-predicts aluminum release by about a factor of two during the active corrosion phase of ICET 1. This is*

important since the incore LOCADM chemical deposition rates can be much greater during the initial period following a LOCA, if local conditions predict boiling. As stated in WCAP16530-NP-A, to account for potentially greater amounts of aluminum during the initial days following a LOCA, a licensee's LOCADM input should apply a factor of 2 increase to the WCAP-16530-NP-A spreadsheet predicted aluminum release, not to exceed the total amount of aluminum predicted by the WCAP-16530-NP-A spreadsheet for 30 days. In other words, the total amount of aluminum released equals that predicted by the WCAP-16530-NP-A spreadsheet, but the timing of the release is accelerated. Alternately, licensees may choose to use a different method for determining aluminum release but licensees should not use an aluminum release rate equation that, when adjusted to the ICET 1 pH, under-predicts the aluminum concentrations measured during the initial 15 days of ICET 1. (Section 3.7 of this SE)

TVA Response

The deposit thickness calculated for SQN, Units 1 and 2, 14.12 mils, accounts for under-predicted aluminum release rate during the active corrosion phase by doubling the available aluminum surface area while maintaining the 30-day total aluminum release.

9. *In the response to NRC staff RAIs, the PWROG indicated that if plant-specific refinements are made to the WCAP LOCADM base model to reduce conservatisms, the user should demonstrate that the results still adequately bound chemical product generation. If a licensee uses plant-specific refinements to the WCAP-16530-NP-A base model that reduces the chemical source term considered in the downstream analysis, the licensee should provide a technical justification that demonstrates that the refined chemical source term adequately bounds chemical product generation. This will provide the basis that the reactor vessel deposition calculations are also bounding. (Section 3.7 of this SE)*

TVA Response

No plant-specific refinements were made to the LOCADM base model to reduce conservatism for SQN, Units 1 and 2.

10. *The WCAP states that the material with the highest insulating value that could deposit from post-LOCA coolant impurities would be sodium aluminum silicate. The WCAP recommends that a thermal conductivity of 0.11 BTU/(h-ft-°F) be used for the sodium aluminum silicate scale and for bounding calculations when there is uncertainty in the type of scale that may form. If plant-specific calculations use a less conservative thermal conductivity value for scale (i.e., greater than 0.11 BTU/(h-ft°F)), the licensee should provide a technical justification for the plant-specific thermal conductivity value. This justification should demonstrate why it is not possible to form sodium aluminum silicate or other scales with thermal conductivities less than the selected value. (Section 3.7 of this SE)*

TVA Response

No plant-specific refinements were made to the LOCADM base model to reduce conservatism for SQN, Units 1 and 2. The recommended value of 0.11 BTU/(hr-ft-°F) was used in the SQN, Units 1 and 2, LOCADM deposition evaluation.

11. *Licensees should demonstrate that the quantity of fibrous debris transported to the fuel inlet is less than or equal to the fibrous debris limit specified in the proprietary fuel assembly test reports and approved by this SE. Fiber quantities in excess of 15 grams per fuel assembly must be justified by the licensee. Licensees may determine the quantity of debris that passes through their strainers by (1) performing strainer bypass testing using the plant strainer design, plant-specific debris loads, and plant-specific flow velocities, (2) relying on strainer bypass values developed through strainer bypass testing of the same vendor and same perforation size, prorated to the licensee's plant specific strainer area; approach velocity; debris types, and debris quantities, or (3 assuming that the entire quantity of fiber transported to the sump strainer passes through the sump strainer. The licensee's submittals should include the means used to determine the amount of debris that bypasses the ECCS strainer and the fiber loading expected, per fuel assembly, for the cold-leg and hot-leg break scenarios. Licensees of all operating PWRs should provide the debris loads, calculated on a fuel assembly basis, for both the hot-leg and cold-leg break cases in their GL 2004-02 responses. (Section 3.10 of this SE)*

TVA Response

As presented in response to condition #2 above, low-fiber plant criterion was extracted from "Transmittal of GSI Resolution Criteria for 'Low Fiber' Plants", NEI, dated December 22, 2011, and was addressed by Reference 1 to document that SQN, Units 1 and 2, is a low-fiber plant.

The SQN, Units 1 and 2, fuel fiber content, calculated in accordance with the NEI low-fiber plant criteria, is 14.8 gm/assembly. This value is less than the 15 gm/assembly target value. Thus, no detailed SQN, Units 1 and 2, specific strainer performance bypass evaluations were required.

12. *Plants that can qualify a higher fiber load based on the absence of chemical deposits should ensure that tests for their conditions determine limiting head losses using particulate and fiber loads that maximize the head loss with no chemical precipitates included in the tests. (Section 3.3.1 of this SE) Note that in this case, licensees must also evaluate the other considerations discussed in Item 1 above.*

TVA Response

SQN, Units 1 and 2, do not need to qualify a higher fiber load.

13. *Licensees should verify that the size distribution of fibrous debris used in the fuel assembly testing referenced by their plant is representative of the size distribution of fibrous debris expected downstream of the plant's ECCS strainer(s). (Section 3.4.2.1 of this SE)*

    TVA Response

    The size distribution of fibrous debris for SQN, Units 1 and 2, is appropriate. Currently, the only fiber available in the sump water is latent fiber. There is no fibrous insulation in the zone of influence (inside the crane wall of the containment building or the ice condensers). NUKON commercial fiberglass was assumed to be representative of latent fiber per NUREG/CR-6224. NUKON fiber was also used to represent fiber in WCAP-17057-P, Revision 1.

14. *The "Margin Calculator," referenced in References 11 and 12, has not been submitted to the NRC under formal letter, and NRC staff has not performed a detailed review of the document. Therefore, NRC staff expects licensees to base their GL 2004-02 in-vessel effects evaluations on the information provided in the proprietary test reports and associated RAI responses (References 8, 16, 17, 11 and 12), including the conditions and limitations stated in this SE, and existing plant design-basis calculations and analyses.*

    TVA Response

    SQN, Units 1 and 2, did not use the "Margin Calculator" to determine in-vessel effects. The "Margin Calculator" was available as a tool for use by the PWROG to perform a preliminary evaluation of debris effects on fuel. The SQN, Units 1 and 2, in-vessel effects were determined based on WCAP-17057-P-A, Revision 1, and the plant-specific LOCADM analysis.