



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION**  
WASHINGTON, D.C. 20555-0001

January 27, 2017

Mr. Joseph W. Shea  
Vice President, Nuclear Licensing  
Tennessee Valley Authority  
1101 Market Street, LP 3R-C  
Chattanooga, TN 37402-2801

**SUBJECT:   BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2 AND 3 - STAFF REVIEW OF  
SPENT FUEL POOL EVALUATION ASSOCIATED WITH REEVALUATED  
SEISMIC HAZARD IMPLEMENTING NEAR-TERM TASK FORCE  
RECOMMENDATION 2.1 (CAC NOS. MF3764, MF3765 AND MF3766)**

Dear Mr. Shea:

The purpose of this letter is to inform Tennessee Valley Authority (TVA, the licensee) of the results of the U.S. Nuclear Regulatory Commission (NRC) staff's review of the spent fuel pool (SFP) evaluation for Browns Ferry Nuclear Plant, Units 1, 2 and 3 (Browns Ferry), which was submitted in response to Item 9 of Enclosure 1 of the NRC's March 12, 2012, request for information (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340) issued under Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The NRC staff concludes that the licensee's assessment was performed consistent with the NRC-endorsed SFP Evaluation Guidance Report and that the licensee has provided sufficient information to complete the response to Item 9 of the 50.54(f) letter.

**BACKGROUND**

On March 12, 2012, the NRC issued a 50.54(f) letter as part of implementing lessons learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 1 to the 50.54(f) letter requested that licensees reevaluate seismic hazards at their sites using present-day methodologies and guidance. Enclosure 1, Item 4, of the 50.54(f) letter requested that licensees perform a comparison of the ground motion response spectrum (GMRS) and the safe shutdown earthquake (SSE). The staff's assessment of the information provided in response to Items 1-3 and 5-7 of the 50.54(f) letter is provided by letter dated April 21, 2015 (ADAMS Accession No. ML15090A745). Enclosure 1, Item 9, of the 50.54(f) letter requested that, when the GMRS exceeds the SSE in the 1 to 10 Hertz frequency range, a seismic evaluation be made of the SFP. More specifically, plants were asked to consider "...all seismically induced failures that can lead to draining of the SFP."

By letter dated February 23, 2016 (ADAMS Accession No. ML16055A021), the Nuclear Energy Institute (NEI) staff submitted Electric Power Research Institute (EPRI) Report No. 3002007148 entitled, "Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation" (SFP Evaluation Guidance Report). The SFP Evaluation Guidance Report provides criteria for evaluating the seismic adequacy of an SFP to the reevaluated GMRS hazard levels. This report supplements the guidance in EPRI Report 1025287, "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID)" (ADAMS Accession No. ML12333A170), for plants where the GMRS peak spectral acceleration is less than or equal to 0.8g (low GMRS sites). The NRC endorsed the SFP Evaluation Guidance Report by letter dated March 17, 2016 (ADAMS Accession No. ML15350A158), as an acceptable method for licensees to use when responding to Item 9 in Enclosure 1 of the 50.54(f) letter.

By letter dated October 27, 2015 (ADAMS Accession No. ML15194A015), the NRC staff stated that SFP evaluation submittals for low GMRS sites are expected by December 31, 2016.

### REVIEW OF LICENSEE SPENT FUEL POOL EVALUATION

By letter dated December 21, 2016 (ADAMS Accession No. ML16356A596), the licensee submitted its SFP evaluation for Browns Ferry for NRC review. The NRC staff assessed the licensee's implementation of the SFP Evaluation Guidance Report through the completion of a reviewer checklist, which is included as an enclosure to this letter.

### TECHNICAL EVALUATION

Section 3.0 of the SFP Evaluation Guidance Report develops SFP evaluation criteria for plants with GMRS peak spectral acceleration less than or equal to 0.8g. These criteria address SFP structural elements (e.g., floors, walls, and supports); non-structural elements (e.g., penetrations); seismically-induced SFP sloshing; and water losses due to heat-up and boil-off. Section 3.0 also provides applicability criteria, which will enable licensees to determine if their site-specific conditions are within the bounds considered in developing the evaluation criteria for this report. The staff's review consists of confirming that these SFP site-specific conditions are within the bounds considered for the evaluation criteria specified in the SFP Evaluation Guidance Report.

#### 1.1 Spent Fuel Pool Structural Evaluation

Section 3.1 of the SFP Evaluation Guidance Report provides a SFP structural evaluation approach used to demonstrate that the SFP structure is sufficiently robust against the reevaluated seismic hazard. This approach supplements the guidance in Section 7 of the SPID and followed acceptable methods used to assess the seismic capacity of structures, systems, and components (SSCs) for nuclear power plants as documented in EPRI NP-6041, "A Methodology for Assessment of Nuclear Plant Seismic Margin, Revision 1." Table 3-2 of the SFP Evaluation Guidance Report (reproduced from Table 2.3 of EPRI NP-6041) provides the structural screening criteria to assess the SFPs and their supporting structures.

The licensee stated that it followed the SFP structural evaluation approach presented in the SFP Evaluation Guidance Report and provided site-specific data to confirm its applicability.

The NRC staff reviewed the structural information provided, which included the requested site-specific data in Section 3.3 of the SFP Evaluation Guidance Report, and confirmed that the evaluation criteria are applicable to the Browns Ferry site. The staff concludes that SFP SSCs were appropriately evaluated and screened based on the seismic capacity criteria in EPRI NP-6041, and that the licensee has demonstrated that the SFP structure is sufficiently robust and can withstand ground motions with peak spectral acceleration less than or equal to 0.8g.

## 1.2 Spent Fuel Pool Non-Structural Evaluation

Section 3.2 of the SFP Evaluation Guidance Report provides criteria for evaluating the non-structural aspects of the SFP, such as piping connections, fuel gates, and anti-siphoning devices, as well as SFP sloshing and heat up and boil-off of SFP water inventory. Specifically, Table 3-4 of the SFP Evaluation Guidance Report provides a summary of the SFP non-structural evaluation criteria derived in Section 3.2, along with applicability criteria to demonstrate that site-specific conditions are suitable for applying the evaluation criteria.

The licensee stated that it followed the SFP non-structural evaluation approach presented in the guidance report and provided site-specific data to confirm its applicability. The staff reviewed the non-structural information provided, which included the requested site-specific data in Table 3-4 of the SFP Evaluation Guidance Report, and confirmed that the evaluation criteria are applicable to the Browns Ferry site. Therefore, the staff concludes that the licensee adequately evaluated the non-structural considerations for SSCs whose failure could lead to potential drain-down of the SFP due to a seismic event.

## CONCLUSION

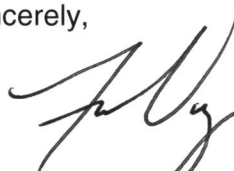
The NRC staff reviewed the licensee's SFP evaluation report. Based on its review, the NRC staff concludes that the licensee's implementation of the SFP integrity evaluation met the criteria of the SFP Evaluation Guidance Report for Browns Ferry and therefore, the licensee responded appropriately to Item 9 in Enclosure 1 of the NRC's 50.54(f) letter.

J. Shea

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If you have any questions, please contact me at (301) 415-1617 or via e-mail at Frankie.Vega@nrc.gov.

Sincerely,

A handwritten signature in black ink, appearing to read 'F. Vega', with a stylized flourish at the end.

Frankie Vega, Project Manager  
Hazards Management Branch  
Japan Lessons-Learned Division  
Office of Nuclear Reactor Regulation

Docket Nos. 50-259, 50-260 and 50-296

Enclosure:  
Technical Review Checklist

cc w/encl: Distribution via Listserv

TECHNICAL REVIEW CHECKLIST  
BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
RELATED TO SPENT FUEL POOL EVALUATIONS FOR LOW GROUND MOTION  
RESPONSE SPECTRUM SITES  
IMPLEMENTING NEAR-TERM TASK FORCE RECOMMENDATION 2.1 SEISMIC  
BROWNS FERRY NUCLEAR PLANT, UNITS 1,2 AND 3  
DOCKET NOS. 50-259, 50-260 AND 50-296

BACKGROUND

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), (hereafter referred to as the "50.54(f) letter"). Enclosure 1 of the 50.54(f) letter requests addressees to reevaluate the seismic hazard at their site using present-day methods and guidance for licensing new nuclear power plants, and identify actions to address or modify, as necessary, plant components affected by the reevaluated seismic hazards. Enclosure 1, Item 4, of the 50.54(f) letter requested that licensees perform a comparison of the ground motion response spectrum (GMRS) with the safe shutdown earthquake (SSE). Enclosure 1, Item 9, requests that, when the GMRS exceeds the SSE in the 1 to 10 Hertz (Hz) frequency range, a seismic evaluation be made of the spent fuel pool (SFP). More specifically, plants were asked to consider "...all seismically induced failures that can lead to draining of the SFP."

Additionally, by letter dated February 23, 2016 (ADAMS Accession No. ML16055A021), the Nuclear Energy Institute (NEI) submitted Electric Power Research Institute (EPRI) Report No. 3002007148 entitled, "Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation" (SFP Evaluation Guidance Report). The SFP Evaluation Guidance Report supports the completion of SFP evaluations for sites with reevaluated seismic hazard exceedance in the 1 to 10 Hz frequency range. Specifically, the SFP Evaluation Guidance Report addressed those sites where the GMRS peak spectral acceleration ( $S_a$ ) is less than or equal to 0.8g (low GMRS sites). The NRC endorsed the SFP Evaluation Guidance Report by letter dated March 17, 2016 (ADAMS Accession No. ML15350A158), as an acceptable method for licensees to use when responding to Item 9 in Enclosure 1 of the 50.54(f) letter. Licensee deviations from the SFP Evaluation Guidance should be discussed in their SFP evaluation submittal.

By letter dated December 21, 2016 (ADAMS Accession No. ML16356A596), Tennessee Valley Authority (TVA, the licensee), provided an SFP report in a response to Enclosure 1, Item 9, of the 50.54(f) letter, for Browns Ferry Nuclear Plant, Units 1, 2 and 3 (Browns Ferry). The NRC staff performed its review of the licensee's submittal to assess whether the licensee responded appropriately to Item 9 in Enclosure 1 of the 50.54(f) letter. The NRC staff checked whether the site-specific parameters are within the bounds of the criteria considered in the SFP Evaluation Guidance Report, verified the SFP's seismic adequacy to withstand the reevaluated GMRS hazard levels, and confirmed that the requested information in response to Item 9 of the 50.54(f) letter was provided.

Enclosure

A review checklist was used for consistency and scope. The application of this staff review is limited to the SFP evaluation as part of the seismic review of low GMRS sites as part of the Near-Term Task Force (NTTF) Recommendation 2.1.

**NTTF Recommendation 2.1 Spent Fuel Pool Evaluations**  
**Technical Review Checklist for Browns Ferry Nuclear Plant, Units 1, 2 and 3**

**Site Parameters:**

***I. Site-Specific GMRS***

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>• Provided the site-specific GMRS consistent with the information provided in the Seismic Hazard and Screening Report (SHSR), or its update, and evaluated by the staff in its staff assessment.</li> <li>• Stated that the GMRS peak <math>S_a</math> is less than or equal to 0.8g for any frequency.</li> </ul>	<p>Yes</p> <p>Yes</p>
<p><b>Notes from the reviewer:</b></p> <p>1. The NRC staff confirmed that the site-specific peak <math>S_a = 0.58g</math> (SHSR - ADAMS Accession No. ML14098A478).</p> <p><b>Deviation(s) or Deficiency(ies), and Resolution:</b></p> <p>No deviations or deficiencies were identified.</p>	
<p><b>The NRC staff concludes:</b></p> <ul style="list-style-type: none"> <li>• The site-specific GMRS peak <math>S_a</math> at any frequency is less than 0.8g.</li> <li>• The licensee's GMRS used in this evaluation is consistent with the information provided in the SHSR.</li> </ul>	<p>Yes</p> <p>Yes</p>

**Structural Parameters:**

***II. Seismic Design of the SFP Structure***

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>• Specified the building housing the SFP.</li> <li>• Specified the plant's peak ground acceleration (PGA).</li> <li>• Stated that the building housing the SFP was designed using an SSE with a PGA of at least 0.1g.</li> </ul>	<p>Yes</p> <p>Yes</p> <p>Yes</p>
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**Notes from the reviewer:**

1. The NRC staff confirmed that the SFPs are housed in the reactor building, which is seismically designed to the site SSE with a PGA of 0.20g (SHSR Section 3.1 and Final Safety Analysis Report (FSAR), Sections 2.5 and 12.1)

**Deviation(s) or Deficiency(ies), and Resolution:**

No deviations or deficiencies were identified.

**The NRC staff concludes that:**

- The structure housing the SFP was designed using an SSE with a PGA of at least 0.1g.

Yes

**III. Structural Load Path to the SFP****The licensee:**

- Provided a description of the structural load path from the foundation to the SFP.
- Performed screening based on EPRI NP-6041 Table 2-3 screening criteria.

Yes

Yes

**Notes from the reviewer:**

1. The staff verified the structural load path to the SFP. The staff confirmed that the structural load path from the foundation to the SFP consists of reinforced concrete shear wall elements and reinforced concrete frame elements (FSAR Section 12.2)

**Deviation(s) or Deficiency(ies), and Resolution:**

No deviations or deficiencies were identified.

**The NRC staff concludes that:**

- Licensee appropriately described the structural load path to the SFP.
- Structures were appropriately screened based on the screening criteria in EPRI NP-6041.

Yes

Yes



**IV. SFP Structure Included in the Civil Inspection Program Performed in Accordance with Maintenance Rule**

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>Stated that the SFP structure is included in the Civil Inspection Program performed in accordance with Maintenance Rule (10 CFR 50.65).</li> </ul>	<p>Yes</p>
<p><b>Notes from the reviewer:</b></p> <p>None</p> <p><b>Deviation(s) or Deficiency(ies), and Resolution:</b></p> <p>No deviations or deficiencies were identified.</p>	
<p><b>The NRC staff concludes that:</b></p> <ul style="list-style-type: none"> <li>The SFP structure is included in the Civil Inspection Program performed in accordance with Maintenance Rule (10 CFR 50.65).</li> </ul>	<p>Yes</p>

**Non-Structural Parameters:**

**V. Applicability of Piping Evaluation**

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>Stated that piping attached to the SFP is evaluated to the SSE.</li> </ul>	<p>Yes</p>
<p><b>Notes from the reviewer:</b></p> <p>1. The licensee stated that piping attached to the SFP is evaluated to the SSE (FSAR Section 10.5 and Appendix C).</p> <p><b>Deviation(s) or Deficiency(ies), and Resolution:</b></p> <p>No deviations or deficiencies were identified.</p>	
<p><b>The NRC staff concludes that:</b></p> <ul style="list-style-type: none"> <li>The piping attached to the SFP is evaluated to the SSE.</li> <li>Applicability criteria specified in Table 3-4 of SFP evaluation guidance have been met.</li> </ul>	<p>Yes Yes</p>

## VI. Siphoning Evaluation

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>• Stated that anti-siphoning devices are installed on piping systems that could lead to siphoning inventory from the SFP.</li> <li>• In cases where anti-siphoning devices were not included on the applicable piping, a description documenting the evaluation performed to determine the seismic adequacy of the piping is provided.</li> <li>• Stated that the piping of the SFP cooling system cannot lead to rapid drain down due to siphoning.</li> <li>• Provided a seismic adequacy evaluation, in accordance with NP-6041, for cases where active siphoning devices are attached to 2" or smaller piping with extremely large extended operators.</li> <li>• Stated that no anti-siphoning devices are attached to 2" or smaller piping with extremely large extended operators.</li> </ul>	<p>Yes</p> <p>N/A</p> <p>No</p> <p>N/A</p> <p>Yes</p>
<p><b>Notes from the reviewer:</b></p> <ol style="list-style-type: none"> <li>1. The licensee stated that anti-siphoning devices are installed on all SFP piping that could lead to siphoning. FSAR Section 10.5.5 states that each check valve in the fuel pool cleanup return diffuser lines is provided with a siphon breaking vent pipe in order to prevent siphoning of fuel pool water to no more than 6 inches below the normal water level.</li> <li>2. Piping of the SFP cooling system is not likely to lead to rapid draindown due to siphoning.</li> </ol> <p><b>Deviation(s) or Deficiency(ies), and Resolution:</b></p> <p>No deviations or deficiencies were identified.</p>	
<p><b>The NRC staff concludes:</b></p> <ul style="list-style-type: none"> <li>• Anti-siphoning devices exist in applicable piping systems that could lead to siphoning water from the SFP.</li> <li>• Piping of the SFP cooling system is not likely to lead to rapid draindown due to siphoning.</li> <li>• No active anti-siphoning devices are attached to 2" or smaller piping with extremely large extended operators.</li> <li>• Applicability criteria specified in Table 3-4 of SFP evaluation guidance have been met.</li> </ul>	<p>Yes</p> <p>Yes</p> <p>Yes</p> <p>Yes</p>

## VII. Sloshing Evaluation

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>Specified the SFP dimensions (length, width, and depth).</li> <li>Specified that the SFP dimensions are bounded by the dimensions specified in the report (i.e., SFP length and width &lt;125ft.; SFP depth &gt;36ft.).</li> <li>Stated that the peak Sa in the frequency range less than 0.3 Hz is less than 0.1g.</li> </ul>	<p>Yes</p> <p>Yes</p> <p>Yes</p>
<p><b>Notes from the reviewer:</b></p> <ol style="list-style-type: none"> <li>SFP dimensions (FSAR Figure 10.3-1) <ul style="list-style-type: none"> <li>SFP Length – 40 ft.</li> <li>SFP Width – 35.33 ft.</li> <li>SFP Depth – 38.75 ft.</li> </ul> </li> <li>The staff confirmed in the SHSR that the peak Sa in the frequency range less than 0.3 Hz is less than 0.1g (SHSR).</li> </ol> <p><b>Deviation(s) or Deficiency(ies), and Resolution:</b></p> <p>No deviations or deficiencies were identified.</p>	
<p><b>The NRC staff concludes:</b></p> <ul style="list-style-type: none"> <li>SFP dimensions are bounded by the dimensions specified in the report (i.e., SFP length and width &lt;125ft.; SFP depth &gt;36ft.).</li> <li>The peak Sa in the frequency range less than 0.3 Hz is less than 0.1g.</li> <li>Applicability criteria specified in Table 3-4 of SFP evaluation guidance have been met.</li> </ul>	<p>Yes</p> <p>Yes</p> <p>Yes</p>

## VIII. Evaporation Evaluation

<p><b>The licensee:</b></p> <ul style="list-style-type: none"> <li>Provided the surface area of the plant's SFP.</li> <li>Stated that the surface area of the plant's SFP is greater than 500 ft<sup>2</sup>.</li> <li>Provided the licensed reactor core thermal power.</li> <li>Stated that the reactor core thermal power is less than 4,000 megawatt thermal (MW<sub>t</sub>) per unit.</li> </ul>	<p>Yes</p> <p>Yes</p> <p>Yes</p> <p>Yes</p>
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**Notes from the reviewer:**

1. Surface area of pool = 1,400 ft<sup>2</sup>
2. Reactor thermal power = 3,458 MW<sub>t</sub> (FSAR Section 1.1)

**Deviation(s) or Deficiency(ies), and Resolution:**

No deviations or deficiencies were identified.

**The NRC staff concludes:**

- The surface area of the plant's SFP is greater than 500 ft<sup>2</sup>.
- The reactor core thermal power is less than 4,000 MW<sub>t</sub> per unit.
- Applicability criteria specified in Table 3-4 of SFP evaluation guidance have been met.

Yes  
Yes  
Yes

**Conclusions:**

The NRC staff reviewed the licensee's SFP evaluation report. Based on its review, the NRC staff concludes that the licensee's implementation of the SFP integrity evaluation met the criteria of the SFP Evaluation Guidance Report for Browns Ferry and therefore the licensee responded appropriately to Item 9 in Enclosure 1 of the 50.54(f) letter.

BROWNS FERRY NUCLEAR PLANT, UNITS 1,2 AND 3- STAFF REVIEW OF SPENT FUEL  
POOL EVALUATION ASSOCIATED WITH REEVALUATED SEISMIC HAZARD  
IMPLEMENTING NEAR-TERM TASK FORCE RECOMMENDATION 2.1  
DATED January 27, 2017

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**ADAMS Accession No.: ML17024A164****\* via e-mail**

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