Stevenson & Associates
Engineering Solutions for Nuclear Energy

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Spent Fuel Pool Evaluation for Fukushima R2.1

Prepared for:

Nebraska Public Power District
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Revision History

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1. Purpose

The purpose of this report is to provide a description of the methods used to evaluate the Cooper Nuclear Station Spent Fuel Pool (SFP) integrity, provide the results of the evaluation and identify actions required to address vulnerabilities associated with SFP integrity in response to Item (9) of the NRC Request for Information dated March 12, 2012 (Reference 1).

Background

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued a Request for Information per 10 CFR 50.54(f) (Reference 1) to all power reactor licensees. Enclosure 1, Item (9) of the 50.54(f) letter requested addressees to provide limited scope spent fuel pool (SFP) evaluations. By letter dated October 27, 2015 (Reference 2), the NRC transmitted final seismic information request tables which identified that Cooper Nuclear Station is to conduct a limited scope SFP Evaluation. By Reference 3, Nuclear Energy Institute (NEI) submitted an Electric Power Research Institute (EPRI) report entitled, Seismic Evaluation Guidance Spent Fuel Pool Integrity Evaluation (EPRI 3002007148) (Reference 4) for NRC review and endorsement. NRC endorsement was provided by Reference 5.

EPRI 3002007148 provides criteria for evaluating the seismic adequacy of a SFP to the reevaluated ground motion response spectrum (GMRS) hazard levels. This report supplements the guidance in the Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details (SPID) (Reference 8), for plants where the GMRS peak spectral acceleration is less than or equal to 0.8g. Section 3.3 of EPRI 3002007148 lists the parameters to be verified to confirm that the results of the report are applicable to Cooper Nuclear Station, and that the SFP is seismically adequate in accordance with NTTF 2.1 Seismic evaluation criteria.

The evaluation performed in Section 5 of this report provides the data for Cooper Nuclear Station that confirms applicability of the EPRI 3002007148 criteria, confirms that the SFP is seismically adequate, and provides the requested information in response to Item (9) of the 50.54 (f) letter associated with NTTF Recommendation 2.1 Seismic evaluation criteria.

2. Acceptance Criteria

The SFP is seismically adequate using the guidance of EPRI 3002007148 (Reference 4) if all criteria identified in Section 3.3 of the document are satisfied.

3. Conclusions

The Cooper Nuclear Station SFP in its current configuration is seismically adequate based on all criteria identified in Section 3.3 of Reference 4 being satisfied per the requirements of the guidance. The methodology presented in the guidance has been accepted by the NRC per Reference 5. No vulnerabilities have been identified.

4. References

1 NRC Letter, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", dated March 12, 2012 ADAMS Accession Number ML12053A340 (Letter) ML12056A046 (Pkg)

2 NRC Letter, "Final Determination of Licensee Seismic Probabilistic Risk Assessments Under the Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Recommendation 2.1 "Seismic" of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", dated October 27, 2015, ADAMS Accession Number ML15194A015

3 NEI Letter, "Request for Endorsement of Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation (EPRI 3002007148)", dated February 23, 2016, ADAMS Accession Number ML16055A017

4 EPRI 3002007148, "Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation", February 2016

5 NRC Letter, "Endorsement of Electric Power Research Institute Report 3002007148, *Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation*", dated March 17, 2016, ADAMS Accession Number ML15350A158

6 Seismic Hazard Evaluation and Screening Report for Cooper Nuclear Station, March 31, 2014, ADAMS Accession Number ML14094A042

7 Cooper Nuclear Station - Staff Assessment of Information provided Pursuant to Title 10 of the Code of Federal Regulations Part 50, Section 50.54(f), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima DAI-ICHI Accident (TAC NO. MF3734), dated September 8, 2015, ADAMS Accession Number ML15240A030

8 EPRI 1025287, "Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details [SPID] for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic", February 2013

9 Cooper Nuclear Station, "Updated Safety Analysis Report", December 14, 2015

10 Cooper Nuclear Station drawings:

2030 Sh. 1 Rev. N33, Flow Diagram – Fuel Pool Cooling and Clean-Up System
2038 Sh. 1 Rev. N54, Flow Diagram – Reactor Building Floor & Roof Drain Systems
4228 Rev. N01, Structural – Reactor Building – Fuel Storage Pool Plan & Elevations
4230 Sh. 1 Rev. 14 Structural – Reactor Building – Misc. Pool Sections and Dets.
2706-1 Rev. N05, 8" FC-1S to Fuel Storage Pool
2707-6 Rev. 8, 4" FC-2 to Skimmer Surge Tank 1-A From Fuel Storage Pool
2707-7 Rev. 9, 4" FC-2 From Fuel Storage Pool to Skimmer Surge Tank 1-B
X2709-210 Rev. 1, FDR-2 Radioactive Floor Drains
2066 Rev. N05, General Arrangement – Reactor Building – Section B-B

11 CED 6036741, Reliable Spent Fuel Pool Level Instrumentation

5. Evaluation

The 50.54(f) letter requested that, in conjunction with the response to NTTF Recommendation 2.1, 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." Such an evaluation would be needed for any plant in which the ground motion response spectrum (GMRS) exceeds the safe shutdown earthquake (SSE) in the 1 to 10 Hz frequency range. The staff confirmed through References 2 and 7 that the GMRS exceeds the SSE and concluded that a SFP evaluation is merited for Cooper Nuclear Station. By letter dated 3/17/16 (Reference 5) the staff determined that EPRI 3002007148 was an acceptable approach for performing SFP evaluations for plants where the peak spectral acceleration is less than or equal to 0.8g.

The table below lists the criteria from Section 3.3 of EPRI 3002007148 along with data for Cooper Nuclear Station that confirms applicability of the EPRI 3002007148 criteria and confirms that the SFP is seismically adequate and can retain adequate water inventory for 72 hours in accordance with NTTF 2.1 Seismic evaluation criteria.

SFP Criteria from EPRI 3002007148	**Site-Specific Data**
Site Parameters	
1. The site-specific GMRS peak spectral acceleration at any frequency should be less than or equal to 0.8g.	The GMRS peak spectral acceleration in the Seismic Hazard Evaluation and Screening Report (Reference 6) as accepted by the NRC site-specific response letter (Reference 7) is 0.304g, which is $\leq$ 0.8g, therefore, this criterion is met.
Structural Parameters	
1. The structure housing the SFP should be designed using an SSE with a peak ground acceleration (PGA) of at least 0.1g.	The SFP is housed in the Reactor Building (see USAR Section XII-2.2.1, Reference 9), which is seismically designed to the site SSE with a PGA of 0.20g per USAR Section II-5.2.4. The Cooper Nuclear Station PGA is greater than 0.1g, therefore, this criterion is met.

SFP Criteria from EPRI 3002007148	Site-Specific Data
2. The structural load path to the SFP should consist of some combination of reinforced concrete shear wall elements, reinforced concrete frame elements, post-tensioned concrete elements and/or structural steel frame elements.	Per USAR Section X-3.5.1 (Reference 9) the spent fuel pool has been designed to withstand earthquake loading as a Class I structure. It is a reinforced concrete structure, completely lined with seam-welded, stainless steel plates welded to reinforcing members (channels, I-beams, etc.) embedded in concrete. The structural load path from the Reactor Building foundation to the SFP has been designed to resist SSE-induced shear stresses per Section XII-2.3.5.1.4 of the USAR. Refer to the Reactor Building section shown in Figure 1 on page 11 of this report for a general overview of the load path. The primary structural elements of the SFP itself are discussed in USAR Section XII-2.2.1. The ends of the north-south SFP walls are supported at the north end by the Drywell Biological Shield Wall and at the south end by the exterior concrete walls of the Reactor Building. These walls are designed as deep beams carrying the dead and live loads of the refueling floor in addition to the loads from the SFP. The SFP slab is designed as a two-way slab supported by the Drywell Biological Shield Wall and the enclosing SFP walls. Based on the above discussion the load path criterion is met for Cooper Nuclear Station.
3. The SFP structure should be included in the Civil Inspection Program performed in accordance with Maintenance Rule.	The SFP structure is included in the Cooper Nuclear Station Structures Monitoring Program (see USAR Section K-2.1.36, Reference 9) in accordance with 10 CFR 50.65, which monitors the performance or condition of structures, systems, or components (SSCs) in a manner sufficient to provide reasonable assurance that these SSCs are capable of fulfilling their intended functions. Therefore, this criterion is met for Cooper Nuclear Station.

<table>
<tr><th>SFP Criteria from EPRI 3002007148</th><th>Site-Specific Data</th></tr>
<tr><td colspan="2">Non-Structural Parameters</td></tr>
<tr><td>1. To confirm applicability of the piping evaluation in Section 3.2 of EPRI 3002007148, piping attached to the SFP up to the first valve should have been evaluated for the SSE.</td><td>Flow diagrams 2030 Sh. 1 (Reference 10) shows two piping systems attached to the SFP, which are:

<table><tr><th>Line</th><th>Function</th><th>Isometric Dwg. (Ref. 10)</th></tr><tr><td>6" FC-1S</td><td>Fuel Pool Cooling</td><td>2706-1</td></tr><tr><td>4" FC-2</td><td>Skimmer Drains</td><td>2707-6 & 2707-7</td></tr></table>
Note that the 2" FDR-2 sump and liner drains shown on drawing 2030 Sh. 1 do not penetrate the SFP liner, as indicated in sections 852 and 853 of drawing 4230 Sh. 1 (Reference 10).

Isometric drawings for lines 6" FC-1S and 4" FC-2 show that subject segments of these two lines are designated seismic Class IIS (shown on the drawing's title block). Per USAR Section A-2.2.2 (Reference 9), seismic Class IIS piping may be required for the operation of the station, but is not required for a safe shutdown. Therefore, the attached piping cannot be confirmed as having been evaluated to the SSE with regard to its post-accident functionality.

However, USAR Section X-3.5.1 states that "To avoid unintentional draining of the pool, there are no penetrations that would permit the pool to be drained below a safe storage level (approximately 10 feet above the top of the fuel). Lines extending below this level are equipped with check valves and siphon breaker holes (in the event of check valve failure)". Since the safe storage level of the SFP is 10 feet above the fuel (per USAR Section X-3.5.1) and there are no piping attachments below this level, the requirement that piping be evaluated for SSE is not applicable because draining below this level is not possible.

The intent of EPRI 3002007148 Section 3.2 can therefore be considered satisfied for Cooper Nuclear Station because the SFP configuration precludes the possibility of rapid draindown.</td></tr>
</table>

SFP Criteria from EPRI 3002007148	Site-Specific Data
2. Anti-siphoning devices should be installed on any piping that could lead to siphoning water from the SFP. In addition, for any cases where active anti-siphoning devices are attached to 2-inch or smaller piping and have extremely large extended operators, the valves should be walked down to confirm adequate lateral support.	The previous section identified line 6" FC-1S as the only piping that could potentially lead to draindown of SFP inventory. Note 10 of flow diagram 2030 Sh. 1 (Reference 10) shows one syphon breaker on each leg of line 6" FC-1S (two breakers total) at elevation 996'-10". As described, anti-siphoning devices are installed on all SFP piping that could lead to siphoning; therefore, this criterion is met for Cooper Nuclear Station. Per USAR Section X-3.5.1 (Reference 9), lines extending below 10 feet above the top of fuel are equipped with check valves and siphon breaker holes to prevent siphon backflow Per CED 6036741 (References 11), the SFP skimmers are located near the top of the pool, with the bottom of the skimmer weir located 2.5 inches below the normal water elevation. This configuration limits the risk of siphoning through the skimmer drain lines to only 2.5 inches of water and is therefore not a concern for rapid draindown. Based on the above discussion, the only pipe which could siphon water from the spent fuel pool is equipped with anti-siphoning devices. No pipes 2" or smaller extend into the spent fuel pool. The criteria relative to anti-siphoning devices on pipes 2" and under is not applicable. Therefore, this criterion is met for Cooper Nuclear Station.
3. To confirm applicability of the sloshing evaluation in Section 3.2 of EPRI 3002007148, the maximum SFP horizontal dimension (length or width) should be less than 125 ft, the SFP depth should be greater than 36 ft, and the GMRS peak Sa should be <0.1g at frequencies equal to or less than 0.3 Hz.	The Cooper Nuclear Station SFP has a length of 40 ft and width of 28 ft based on drawing 4228 (Reference 10). The normal water depth is 37.54 ft based on CED 6036741 (References 11). Therefore, this criterion is met. The Cooper Nuclear Station GMRS maximum spectral acceleration in the frequency range less than 0.3 Hz is 0.0317 g from the Seismic Hazard Evaluation and Screening Report (Reference 6) which is less than 0.1g, therefore, this criterion is met.

SFP Criteria from EPRI 3002007148	Site-Specific Data
4. To confirm applicability of the evaporation loss evaluation in Section 3.2 of EPRI 3002007148, the SFP surface area should be greater than 500 ft^2 and the licensed reactor core thermal power should be less than 4,000 MWt per unit.	The surface area of the Cooper Nuclear Station SFP is 1,120 ft^2 based on drawing 4228 (Reference 10), which is greater than 500 ft^2; and licensed reactor thermal power for Cooper Nuclear Station is 2419 MWt per unit (USAR Section I-1.1.0, Reference 9) which is less than 4,000 MWt per unit, therefore, these criteria are met.

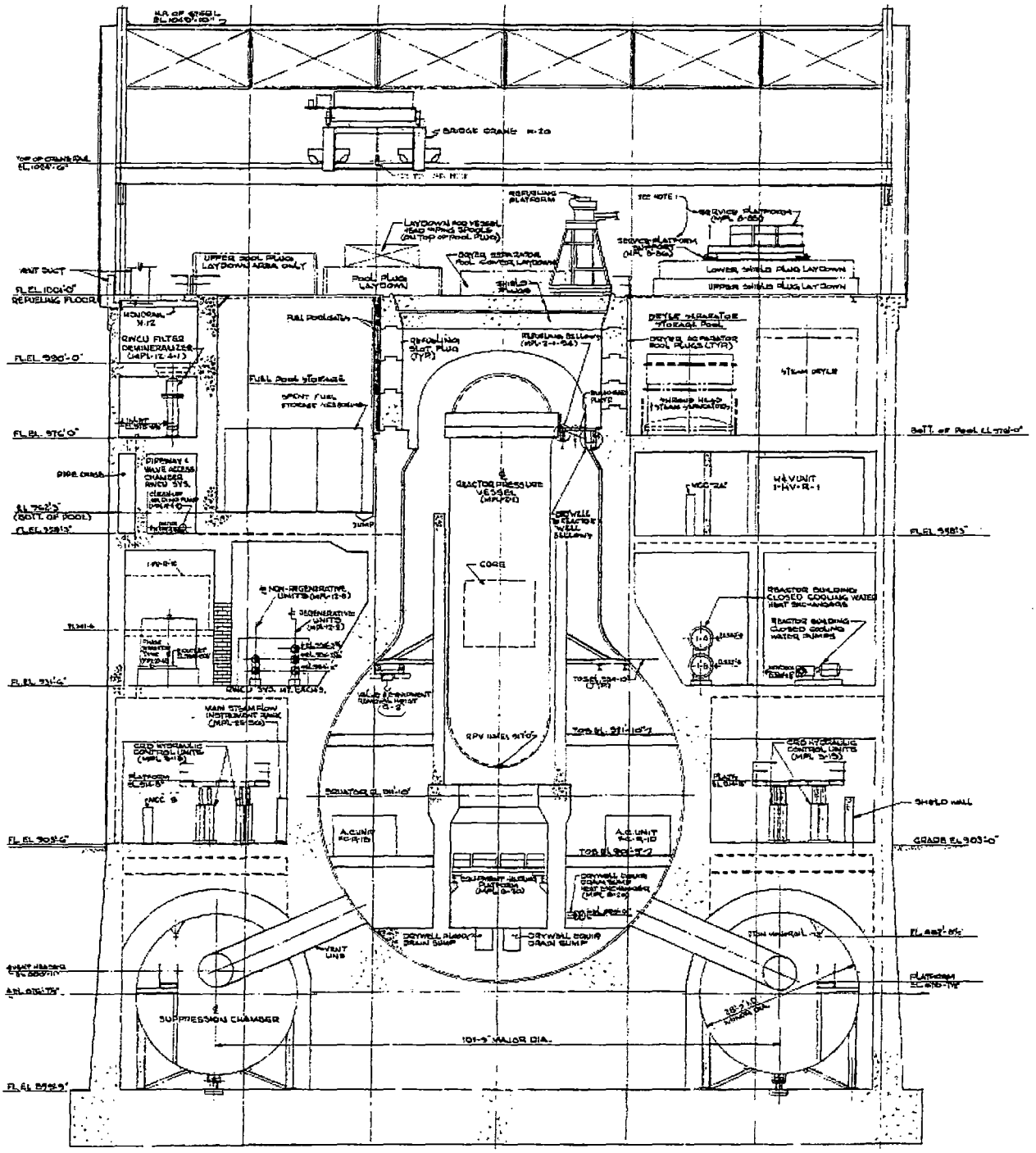

Figure 1: Reactor Building Section from Dwg. 2066 (Reference 10)