3.0 DESIGN OF STRUCTURES, SYSTEMS, AND COMPONENTS

This chapter reviews the structures, systems, and components (SSCs) considered in the final design of the SHINE facility for its safe operation and for the protection of the public. The U.S. Nuclear Regulatory Commission (NRC, the Commission) staff evaluated these SSCs for their protective functions and related design features to ensure the adequacy of the facility defense-in-depth against uncontrolled release of radioactive material to the environment. The bases for the design criteria for some of the SSCs discussed in this chapter may have been developed in other chapters of the SHINE Medical Technologies, LLC (SHINE, the applicant) Final Safety Analysis Report (FSAR) and were considered in this chapter's review as deemed necessary.

This chapter of the SHINE operating license application safety evaluation report (SER) describes the review and evaluation of the NRC staff of the final design of the SHINE main production facility structure (FSTR) with its irradiation facility (IF) and radioisotope production facility (RPF), non-radiologically controlled seismic area, relevant non-safety areas, and the nitrogen purge system (N2PS) structure. In addition to the information in SHINE FSAR Chapter 3, "Design of Structures, Systems, and Components," this review also includes additional relevant information from other chapters of the FSAR and the applicant's responses to the staff's requests for additional information (RAIs).

3.1 Areas of Review

SHINE FSAR Sections 3.1, "Design Criteria," through 3.6, "Nitrogen Purge System Structure," are the applicable areas for the NRC staff's safety review of the SHINE FSTR, its IF, RPF, safety and non-safety areas, and the N2PS structure as discussed below.

The NRC staff reviewed SHINE FSAR Chapter 3 and other chapters for material and information regarding the SSCs to safely operate the SHINE facility including during and/or after meteorological, water, and seismic events. The review considered applicable regulatory requirements and appropriate regulatory guidance and acceptance criteria.

Specifically, the NRC staff reviewed the description and analysis of the SSCs of the SHINE facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which such requirements have been established, and the evaluations required to show that safety functions will be accomplished. The staff also reviewed the final analysis and evaluation of the design and performance of SSCs with the objective of assessing the risk to public health and safety resulting from the operation of the SHINE facility and the adequacy of the SSCs provided for the prevention of accidents and the mitigation of the consequences of accidents. The staff reviewed whether there is reasonable assurance that the final design is adequate to remain safe during operation and capable of safe shutdown, as defined in SHINE's Technical Specifications (TS), Section 1.3, "Definitions," during environmental events and accident conditions. Special attention was provided to facility design and operating characteristics having unusual or novel design features to ensure that they remain safe and functional so that they can fulfill their intended function during facility operation.

3.2 Summary of Application

SHINE FSAR Chapter 3 describes the design bases of SSCs for the IF and RPF established to ensure facility safety and protection of the public. With the exception of discussions related to IF- or RPF-specific systems, the following summary applies to both the IF and the RPF.

SHINE FSAR Section 3.1, “Design Criteria,” discusses areas of the SHINE facility and its SSCs subject to this review for its safe operation including during and/or after meteorological or hydrological events, water impact, abnormal loads, design-basis accidents, or a design-basis earthquake. This section includes relevant requirements, standards, and documentation. It also includes a “road map” where the specifics of the design criteria are discussed in detail.

SHINE FSAR Section 3.2, “Meteorological Damage,” includes historical data and predictions as specified in FSAR Chapter 2, “Site Characteristics,” and discusses the criteria used to design the SHINE facility to withstand the site characteristics of wind, tornado, snow, and ice. The combination of meteorological loads with other loads (i.e., dead loads and earthquake loads) essential for the facility structural analysis are provided in FSAR Section 3.4, “Seismic Damage” and are further outlined below.

SHINE FSAR Section 3.3, “Water Damage,” provides information on the hydrological conditions found at the SHINE facility and discusses the criteria used to design against flooding. The combination of water-related loads with other loads (i.e., dead loads and earthquake loads) essential for the facility structural analysis are provided in FSAR Section 3.4, further outlined below.

SHINE FSAR Section 3.4, “Seismic Damage,” includes an outline of the FSTR layout and describes its safety-related SSCs in the IF, RPF, the non-radiologically controlled seismic area, and a non-safety-related area and describes their performance to seismic and abnormal (e.g., aircraft impact) loadings. Safety-related and non-safety-related SSCs, which are classified in two seismic categories, Seismic Category I and Seismic Category II, are reviewed. FSAR Section 3.4 includes descriptions of the overall facility, its response to site seismicity, and analyses of potential accidents and hazards internal and external (e.g., damage analysis due to aircraft accidents from the nearby airport) to the FSTR. FSAR Section 3.4 refers to FSAR Chapter 2, which includes several sections on site seismicity, seismic input, and hazards essential to soil-structure interaction (SSI) analysis.

SHINE FSAR Section 3.5, “Systems and Components,” includes a high-level discussion on the design basis (e.g., separation, isolation, redundancy) and operation (e.g., condition of operation, setpoints, design features) of SHINE SSCs. The NRC staff’s review of the safety- and non-safety-related SSCs whose failure could affect safety-related SSCs is included in the appropriate sections of this chapter of the SER.

SHINE FSAR Section 3.6, “Nitrogen Purge System Structure,” discusses the N2PS structure and its SSCs. It also describes their design attributes, capacity, and performance associated with meteorological, water, and seismic events.

Additionally, this chapter of the SER includes the NRC staff’s review of the SHINE facility safety-related SSCs and those SSCs that are non-safety-related but that perform functions that may impact safety-related SSCs. These SSCs are identified in SHINE FSAR Tables 3.1-1 and 3.1-2, “Safety-Related Structures, Systems, and Components,” and “Nonsafety-Related Structures, Systems, and Components,” respectively.

Tables in SHINE FSAR Chapter 3 list the applicable design criteria for the SSCs discussed in other FSAR chapters but are referenced in Chapter 3 for consideration as appropriate to ensure their adequate protection against hazards. FSAR Table 3.1-3, Criterion 2, "Natural Phenomena Hazards," ensures that the facility structure protects the safety-related SSCs. That is, the facility is designed to withstand natural phenomena that include, for example, earthquakes and tornado strikes.

3.3 Regulatory Requirements and Guidance and Acceptance Criteria

The NRC staff reviewed SHINE FSAR Chapter 3 against the applicable regulatory requirements, using appropriate regulatory guidance and acceptance criteria, to assess the sufficiency of the bases and the information provided by SHINE for the issuance of an operating license.

3.3.1 Applicable Regulatory Requirements

The applicable regulatory requirements for the evaluation of SHINE's SSC design criteria are as follows:

> 10 CFR 50.34, "Contents of applications; technical information," paragraph (b), "Final safety analysis report," which states, in part:
>
> > (2) A description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which such requirements have been established, and the evaluations required to show that safety functions will be accomplished. The description shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations.
> >
> > ….
> >
> > (4) A final analysis and evaluation of the design and performance of structures, systems, and components with the objective stated in paragraph (a)(4) of this section and taking into account any pertinent information developed since the submittal of the preliminary safety analysis report.
>
> 10 CFR 50.40, "Common standards."
>
> 10 CFR 50.57, "Issuance of operating license."

3.3.2 Applicable Regulatory Guidance and Acceptance Criteria

In determining the regulatory guidance and acceptance criteria to apply, the NRC staff used its judgment, as the available guidance and acceptance criteria were typically developed for nuclear reactors. Given the similarities between the SHINE facility and non-power research reactors, the staff determined to use the following regulatory guidance and acceptance criteria:

> NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996 (Reference 4);
>
> NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria," issued February 1996 (Reference 5);

“Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, ‘Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content,’ for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors,” dated October 17, 2012 (Reference 6); and

“Final Interim Staff Guidance Augmenting NUREG-1537, Part 2, ‘Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,’ for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors,” dated October 17, 2012 (Reference 7).

As stated in the interim staff guidance (ISG) augmenting NUREG-1537, the NRC staff determined that certain guidance originally developed for heterogeneous non-power research and test reactors is applicable to aqueous homogenous facilities and production facilities. SHINE used this guidance to inform the design of its facility and to prepare its FSAR. The staff’s use of reactor-based guidance in its evaluation of the SHINE FSAR is consistent with the ISG augmenting NUREG-1537.

As appropriate, the NRC staff used additional guidance (e.g., NRC regulatory guides, Institute of Electrical and Electronics Engineers (IEEE) standards, American National Standards Institute/American Nuclear Society (ANSI/ANS) standards, American Society of Civil Engineers (ASCE) standards, etc.) in the review of the SHINE FSAR. The additional guidance was used based on the technical judgment of the reviewer, as well as references in NUREG-1537, Parts 1 and 2; the ISG augmenting NUREG-1537, Parts 1 and 2; and the SHINE FSAR. Following such guidance as well as local building codes and recognized industry practices, as applicable, provides reasonable assurance that significant meteorological, water, and seismic damage to the facility is unlikely and that any potential damage would not cause unsafe operations, prevent safe shutdown, or allow uncontrolled release of radioactive material. Additional guidance documents used to evaluate the SHINE FSAR are provided as references in Appendix B, “References,” of this SER.

In its review, the NRC staff also noted the applicant’s voluntary adoption of guidance in specific sections of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light-Water Reactor] Edition,” including Section 3.7.1, “Seismic Design Parameters” and Section 3.7.2, “Seismic System Analysis,” for developing seismic input and performing seismic analysis of the FSTR. The approach taken by SHINE is acceptable because the guidance of NUREG-0800 is more stringent than that of NUREG-1537.

3.4 Review Procedures, Technical Evaluation, and Evaluation Findings

The NRC staff performed a review of the technical information presented in SHINE FSAR Chapter 3 to assess the sufficiency of the design bases for the SHINE facility and its safety-related SSCs for the protection of the public and the environment in support of the issuance of an operating license. The sufficiency of the design bases is determined by ensuring that they meet applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 3.3, “Regulatory Requirements and Guidance and Acceptance Criteria,” of this SER. The findings of the staff review are described in SER Section 3.5, “Review Findings.”

3.4.1 Design Criteria

The NRC staff evaluated the sufficiency of the design criteria, as described in SHINE FSAR Section 3.1, using the guidance and acceptance criteria from Section 3.1, “Design Criteria,” of NUREG-1537, Parts 1 and 2.

3.4.2 Meteorological Damage

The NRC staff evaluated the sufficiency of the facility design features to cope with meteorological damage, as described in SHINE FSAR Section 3.2, using the guidance and acceptance criteria from Section 3.2, “Meteorological Damage,” of NUREG-1537, Part 2.

Consistent with the review procedures of NUREG-1537, Part 2, Section 3.2, the NRC staff considered the description of the site meteorology to ensure that all SSCs that could suffer meteorological damage are considered, as presented in SHINE FSAR Sections 3.2 and 3.6 and other relevant chapters of the FSAR. The design criteria are compatible with local architectural and building codes for similar structures. The design specifications for SSCs are compatible with the functional requirements and capability to maintain their function throughout the predicted meteorological conditions. The methods for determining the wind, tornado, and snow and ice loadings are summarized. In SHINE FSAR Section 3.4.2.6.3, “Site Design Parameters,” these loads are provided as site design parameters rather than as structural design loads. The combinations of the meteorological loads with other loads (i.e., dead loads and earthquake loads) for the structural analysis are discussed in SHINE FSAR Section 3.4.2.6.4, “Design Loads and Loading Combinations.”

In its review of SSCs considered for meteorological damage, the NRC staff noted that SHINE FSAR Sections 3.2 and 3.4.2.6.3 describe the design criteria, methodology, and parameters used for the main production facility structure. However, based on the staff review of SHINE FSAR Section 1.4, “Shared Facilities and Equipment,” and audited documents, the staff noted that other structures that may support and protect safety-related SSCs from meteorological damage may have not been properly described in the FSAR. The staff also noted that the FSAR inconsistently used the term “SHINE facility” to either refer to the main production facility structure (alone) or to refer to all of the structures within the SHINE facility, as described in SHINE FSAR Section 1.4.

During its evaluation of the applicant’s response to NRC staff RAI 3.2-1 (ADAMS Accession No. ML21029A103), the staff noted that SHINE stated that the N2PS structure is the only structure described in SHINE FSAR Section 1.4 that is not part of the main production facility structure, and that it performs a safety-related function. Since this structure is not considered part of the main production facility structure, SHINE added Section 3.6 to its FSAR to incorporate the design criteria, parameters, and methodology for evaluating meteorological damage that is applicable to the N2PS structure and to describe how that structure is designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, and floods. The staff also noted that the design criteria applicable to the N2PS structure are SHINE Design Criteria 1 through 4, as described in SHINE FSAR Table 3.1-3. During its review of SHINE FSAR Section 3.6, the staff noted that the N2PS structure is designed to withstand the same potential meteorological damage described in FSAR Section 3.2 for the main production facility structure. Therefore, the staff’s evaluation of the main production facility structure also applies to the N2PS structure.

The NRC staff finds the applicant’s response, addition of Section 3.6 to the SHINE FSAR, and changes to FSAR Table 3.1-1 acceptable because SHINE: (a) confirmed that the N2PS structure is the only structure described in FSAR Section 1.4 that has a safety-related function and is not part of the main production facility structure and (b) provided a description, included in the FSAR, of the design criteria, parameters, and methodology applicable to the N2PS structure.

During its review of the design criteria and parameters considered for coping with meteorological damage, the NRC staff noted that some of the criteria, parameters, and methodology defined in SHINE FSAR Sections 3.2 and 3.4 were not sufficiently described to understand how the structures were designed for protection from the meteorological condition. To ensure that the applicable design criteria, parameters, and methodology to cope with meteorological damage are sufficiently described in the FSAR, and to provide reasonable assurance that SSCs would continue to perform necessary operational and safety functions throughout the predicted meteorological conditions, the staff issued RAIs 3.2-2 and 3.2-3.

During its evaluation of the applicant's response to RAI 3.2-2 (ADAMS Accession No. ML21011A240), the NRC staff noted that SHINE FSAR Sections 3.2 and 3.4 were revised to also include the following design criteria/parameters:

(1) the exposure coefficient and other factors used in FSAR Equation 3.2-1 for the wind loading design, including the gust factor and pressure coefficient;

(2) the basic wind speed for Wisconsin, including a description of the applied factor to account for a 100-year recurrence interval;

(3) the values applicable to the site for the tornado rotational speed, translation speed, differential pressure, and rate of differential pressure, including additional discussion of the site's design basis tornado missile spectrum and maximum horizontal speed, used for the tornado loading design; and

(4) the values applicable to the site for the factors used in FSAR Equation 3.2-3 for snow, ice, and rain loading, including the snow load and recurrence interval.

During its evaluation of the applicant's response to RAI 3.2-3, the NRC staff noted that SHINE clarified that the methodology and acceptance criteria described in NUREG-0800, Section 3.5.3, "Barrier Design Procedures," were used to transform the tornado generated missile impacts into an effective or equivalent static load on the structures. In its response, SHINE also stated that SHINE FSAR Section 3.2.2.2 had been revised to correct the reference to NUREG-0800, Section 3.5.3 and to add additional information related to the tornado missiles considered in the analysis.

The NRC staff finds the applicant's response and changes to SHINE FSAR Sections 3.2.1, 3.2.2, 3.2.3, and 3.4.2.6.3 acceptable because the additional design criteria provided by the applicant for meteorological damages: (a) are consistent with applicable local building codes, national standards, guidelines and recognized industry practices and (b) are sufficient to provide reasonable assurance that SSCs would continue to perform necessary operational and safety functions throughout the predicted meteorological conditions. The staff also finds the applicant's response and changes to FSAR Section 3.2.2.2 acceptable because they clarify that the methodology used by SHINE is consistent with NUREG-0800, Section 3.5.3, which provides an acceptable methodology and criteria for transforming tornado generated missile impacts into an effective or equivalent static load on the structures.

In its review of the methodology used for determining loading and its design, the NRC staff noted that potential meteorological conditions are considered in the design of the SHINE facility by analyzing the pressure effects of wind loads, tornado loads (including tornado generated missiles), snow loads, ice loads, and rain loads, using a 100-year return period, as described in SHINE FSAR Sections 3.2 and 3.4.2.6.3. These loads are determined by the methodology and guidelines provided in ASCE Standard 7-05, "Minimum Design Loads for Building and Other Structures," and the NRC Regulatory Guide (RG) 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants" (ADAMS Accession No. ML070360253). As stated in SHINE FSAR Sections 3.2.3 and 3.4.2.6.3.9, rain loading was not considered to be a potential concern because the SHINE facility is designed with a sloped roof and a building configuration that precludes the accumulation of rainwater. Also, as stated in its previous response to RAI 3.2-1 for the construction permit application, by letter dated December 3, 2014 (ADAMS Accession No. ML14357A345), rain-on-snow surcharge load was not considered in the structural analysis because the SHINE facility is located in an area where the ground snow load (as determined from Figure 71 of ASCE 7-05) is greater than 20 pounds per square foot. The NRC staff also noted that SHINE FSAR Section 3.4.2.6.2 states that the following codes and standards are used for the design of the SHINE facility: (a) American Concrete Institute (ACI) 349-13, "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary," and (b) the ANSI/American Institute of Steel Construction (AISC) N690-12, "Specification for Safety-Related Steel Structures for Nuclear Facilitates." Based on the information provided, the NRC staff finds that the design, methodology, and parameters used are consistent with local applicable architectural and building codes for similar structures and are compatible with the SHINE facility functional requirements and capability to retain function throughout the predicted meteorological conditions.

Based on its review, the NRC staff determined that the level of detail provided on meteorological damage is adequate and supports the applicable acceptance criteria of NUREG-1537, Part 2, Section 3.2. The staff concludes that the design criteria and the design for protection from meteorological damage conditions are based on applicable local building codes, standards, and criteria, which provide assurance that SSCs will continue to perform their safety functions as specified in the SHINE FSAR. Therefore, the SHINE facility design features for coping with meteorological damage meet the applicable regulatory requirements and guidance and acceptance criteria for the issuance of an operating license.

3.4.3 Water Damage

The NRC staff evaluated the sufficiency of the facility design features to cope with predicted hydrological conditions, as described in SHINE FSAR Section 3.3, using the guidance and acceptance criteria from Section 3.3, "Water Damage," of NUREG-1537, Part 2.

Consistent with the review procedures of Section 3.3 of NUREG-1537, Part 2, the NRC staff considered the site description and facility designs to ensure that all safety-related SSCs with the potential for water damage, including damage due to external and internal flood hazards, are considered in the SHINE FSAR. For any such safety-related SSC, the staff reviewed the design bases to verify that the consequences are addressed and described in detail in the appropriate chapters of the FSAR.

3.4.3.1 Flood Protection from External Sources

SHINE FSAR Section 3.3 describes that the design basis precipitation level is at site grade, the design basis flood level is at 50 feet below grade, and the maximum ground water level is at 50 feet below grade. These levels are associated with the local probable maximum precipitation (PMP) and the local probable maximum flood (PMF) and are quantified in FSAR Section 2.4.2.3, "Effect of Local Intense Precipitation," and Section 2.4.3, "Probable Maximum Flood on Streams and Rivers."

SHINE FSAR Section 2.4.2.3 states that the effect of the local PMP on the areas adjacent to the safety-related structures of the facility, including the drainage from the roofs of the structures, was evaluated. The maximum water levels due to the PMP were estimated near the safety-related structures of the facility based on the site topographic survey map. A drainage system designed to carry runoff from the site consists of conveying water from roofs, as well as runoff from the site and adjacent areas, to peripheral ditches. The facility is surrounded by berms with interior ditches along the berms and the grade around the structures slopes towards the peripheral ditches. However, during a PMP event, the stormwater drainage system is conservatively assumed to be nonfunctional. During a PMP event, the water level is estimated to be at grade and the top of the finished foundation elevation is at least 4 inches (in.) above grade.

SHINE FSAR Section 2.4.3 notes that a local PMF event creates a water level approximately 50 feet below grade. The lowest point of the facility is 29 feet below grade; therefore, flooding would not cause any structural loading in the case of a local PMF event and there is no dynamic force on the structure due to precipitation or flooding. The lateral surcharge pressure on the structures due to the design PMP water level is calculated and does not govern the design of the below grade walls.

In its response to RAI 3.2-1 (ADAMS Accession No. ML21029A103), the applicant noted that the N2PS structure performs a safety function and, therefore, added Section 3.6 to the FSAR to discuss the design of this structure. The applicant also noted that the external flooding assumptions (i.e., PMP and PMF water levels) are the same for the N2PS structure as for the main production facility and that the N2PS structure has been designed to ensure that water does not infiltrate the structures and cause damage to safety-related SSCs.

The NRC staff reviewed the information on the site PMP and PMF provided in SHINE FSAR Sections 2.4.2.3, 2.4.3, 3.3, and 3.6.2. The staff noted that the design PMP elevation is at plant grade and that the PMF is approximately 50 feet below grade and approximately 21 feet below the lowest point of the facility. In addition, the staff noted that the finished foundation level is at least 4 in. above site grade. Based on its review, the staff finds that there is no dynamic force applied to the structures due to precipitation or flooding, and that a PMP or a PMF event will not cause water to infiltrate the structures and result in damage to safety-related SSCs.

3.4.3.2 Flood Protection from Internal Sources

SHINE FSAR Section 3.3.1.1.2, "Flood Protection from Internal Sources," states that the bounding flood volume in the radiologically controlled area (RCA) is from the fire protection system (FPS). The credible volume of discharge from the FPS is due to a manual fire-fighting flow rate of 500 gallons per minute (1893 liters per minute) for a duration of 30 minutes, in accordance with the guidance in Section 5.10 of National Fire Protection Association (NFPA) 801, "Standard for Fire Protection for Facilities Handling Radioactive Materials." Therefore, the total discharge volume is 15,000 gallons (56,782 liters). The resulting flooded water depth in the RCA from this fire protection discharge is less than 2 in., which bounds the total water available in the process chilled water system (PCHS) and the radioisotope process facility cooling system (RPCS) that could cause internal flooding. The floors of the uranium receipt and storage system/target solution preparation system rooms are elevated to prevent water intrusion in the event of an internal flood and water sensitive safety-related equipment in the RCA is raised 8 in. from the floor. Safety-related functions of systems that are subject to the effects of a discharge of the fire suppression system are appropriately protected by redundancy and separation. SHINE FSAR Section 3.3.2 notes that the load from build-up of water due to FPS discharge is supported by slabs on grade except for the mezzanine floor. However, the mezzanine floor includes openings that will ensure that the slab is not significantly loaded and it is designed with a live load value of 250 pounds per square foot.

SHINE FSAR Section 3.3.1.1.2 also notes that flood scenarios have been considered for the pipe trenches and vaults. Process piping, vessels, and tanks containing special nuclear material or radioactive liquids are seismically qualified. There is no high-energy piping within these areas and any pipe or tank rupture in the RPF vaults is routed to the radioactive drain system (RDS). The RDS is sized for the maximum postulated pipe or tank failure as described in SHINE FSAR Section 9b.7.6. The design of the shield plugs over the pipe trenches and vaults prevents bulk leakage of liquid into the vaults from postulated flooding events within the remainder of the RCA.

The NRC staff reviewed the information provided in SHINE FSAR Section 3.3.2 and noted that the loads due to possible water build-up are supported by slabs on grade, which will be able to support the additional water load. The mezzanine floor is not on grade; however, it has been designed to limit the possible water load to less than the design live load of the floor. Therefore, the structures have been properly designed to support any additional loads from water due to FPS discharge. The staff also reviewed Section 3.3.1.1.2 and noted that the bounding volume of water in the RCA was due to a manual discharge of the FPS. As part of its review of internal flooding, the staff conducted an audit, during which it reviewed calculations associated with postulated flooding depths in the RCA to understand how equipment would be protected from flooding. The staff also noted in the audit that manual flood barriers will be used to control flooding.

In its response to NRC staff RAI 3.3-1 (ADAMS Accession No. ML21011A240), the applicant stated that the bounding internal flood volume of 15,000 gallons distributed over the minimum open floor space in the IF results in a maximum flood height of approximately 11.7 in. The minimum height of water-sensitive, safety-related equipment in the RCA is 12 in. above the floor. The RAI response also describes that the bounding flood scenario in the RPCS room results in a flood height of approximately 22.9 inches. In this room, the minimum height for water-sensitive, safety-related equipment is 24 inches above the floor. The RAI response further notes that the manual flood barrier in the RPCS room is not relied on in the safety analysis to keep leakage from leaving the room.

The NRC staff reviewed the information in SHINE FSAR Section 3.3.1.1.2 and finds it acceptable because the applicant clearly identified the maximum flood heights in the building and that the minimum heights of water-sensitive, safety-related equipment ensures that the equipment remains above the postulated internal flood levels.

While reviewing the information provided in SHINE FSAR Section 3.3.1.1.2, the NRC staff also noted that the uninterruptible electrical power supply system (UPSS) has two redundant and isolated trains to prevent both trains from being damaged by discharge of the FPS.

In its response to NRC staff RAI 3.3-2 (ADAMS Accession No. ML21011A240), the applicant stated that safety-related functions of equipment subject to discharge of the FPS are protected by redundancy and separation, where practicable. Where equipment cannot be effectively separated, fire response plans are established to ensure that redundant FPS trains are not simultaneously damaged from fire.

The NRC staff reviewed the information in SHINE FSAR Section 3.3.1.1.2 and finds it acceptable because it describes that water-sensitive, safety-related equipment is protected from discharge of the FPS either by redundancy and separation, or with an appropriate fire response plan.

The NRC staff reviewed SHINE FSAR Section 3.6 that describes the design of the N2PS structure. The staff reviewed the information provided in FSAR Section 3.6.2 related to water damage of the N2PS structure and noted that there are no water sources internal to the N2PS structure and so there is no risk of internal flooding. Since there are no internal water sources, the staff finds that there is no potential internal flooding hazard that would cause damage to safety-related SSCs in the N2PS structure.

Based on its review, the NRC staff finds that the safety-related SSCs are adequately protected from internal flooding hazards and that the structures are adequately designed to withstand additional loads from postulated internal flooding.

3.4.3.3 Water Damage Evaluation Summary

Based on its review, the NRC staff determined that the level of detail provided on water damage is adequate and supports the applicable acceptance criteria of NUREG-1537, Part 2, Section 3.3. The staff concludes that the design criteria and the designs would protect against potential water damage and would provide reasonable assurance that SSCs would continue to perform their required safety functions, would not cause unsafe facility operation, would not prevent safe shutdown of the facility, and would not cause or allow uncontrolled release of radioactive material. Therefore, the SHINE facility design features for coping with postulated water damage meet the applicable regulatory requirements and guidance and acceptance criteria for the issuance of an operating license.

3.4.4 Seismic Damage

SHINE FSAR Section 3.4 describes the general arrangement of the SHINE FSTR, its IF, RPF, the non-radiologically controlled seismic area, and a non-safety-related area. The IF, RPF, and non-radiologically controlled seismic area are within the seismic boundary of the facility and are classified as Seismic Category I SSCs.

The NRC staff evaluated the sufficiency of the FSTR design and its features to cope with potential seismic damage, as described in SHINE FSAR Section 3.4. The staff's review used the guidance and acceptance criteria from Section 3.4, "Seismic Damage," of NUREG-1537, Part 2, the ISG augmenting NUREG-1537, Part 2, applicable references listed in FSAR Section 3.7, and, when and where applicable and as deemed necessary, the additional guidance from Sections 3.7.1 and 3.7.2 of NUREG-0800. Consistent with the review procedures of Section 3.4 of NUREG-1537, Part 2, the staff also considered the site description and facility design to ensure that all safety-related SSCs with a potential for seismic damage were considered.

SHINE described the FSTR as a reinforced concrete box shear wall system on soil. Its major structural elements include the foundation mat, mezzanine floor, roof slab, and shear walls. Steel roof trusses support the concrete roof slab of the IF and RPF. The mezzanine floor is made of reinforced concrete on metal deck. The floor is vertically supported by structural steel beams and columns, and laterally restrained by reinforced concrete partition walls. A large section of the basemat in the RPF is recessed below-grade to accommodate a series of tanks, valve pits, and other mechanical systems. The tanks are separated by cast-in-place reinforced concrete walls and are covered by precast concrete shield plugs. Depending on their function, interior FSTR walls are made of cast-in-place reinforced concrete, reinforced masonry, or gypsum boards mounted to metal studs. Additional details of facility SSCs and equipment that include an exhaust stack, supercells, below grade reinforced concrete vaults and tanks are also found in other FSAR Chapters (e.g., Sections 1.2.1, 2.1.1.2, 3.4.2.6.4.1, and 4b.2.2.2 and Tables 7.7-2 and 7.7-3).

To ensure that all applicable design criteria, parameters, and methodology to cope with seismic/transient and other abnormal loads are sufficiently addressed in the FSAR, and to obtain reasonable assurance that SSCs would continue to perform their operational and safety functions during seismic events and for abnormal loads, the NRC staff issued RAIs. The staff reviewed SHINE's response to RAI 3.4-7 (ADAMS Accession No. ML21011A240) and finds it acceptable because consistent with NUREG-1537, the applicant's design follows the applicable guidance of RGs, NUREGs, local building codes, and national codes and standards that includes provisions for materials testing. The staff also finds the applicant's revision to SHINE FSAR Sections 3.4 and 3.7 acceptable because they reflect references to RGs, NUREGs, local building codes, and national codes and standards that are applicable to the facility design.

To further clarify how various FSTR SSCs (e.g., the stack, walls, tanks, vaults, supercells, etc.) are configured and integrated into the seismic design and because of concern that potential future internal rearrangement of FSTR SSCs and relocation of equipment could alter the intent of the original structural design and to ensure that the facility would continue to maintain its defense-in-depth, the NRC staff issued RAIs. The NRC staff reviewed the applicant's response to RAI 3.4-8 (ADAMS Accession No. ML21011A240) and finds its discussion of configuration control acceptable because Section 5.5.4 of SHINE's Technical SpecificTS), "Configuration Management," includes an oversight and controls program that addresses changes made to the facility design, to its physical configuration, and to its documentation so that these are in accordance with the 10 CFR 50.59 process.

The staff noted that although SHINE updated its FSAR to include additional FSTR design details such as its size and seismic isolation, other key design information on the FSTR (e.g., its height, thickness of its walls, materials used for its construction) and its SSCs (e.g., anchorage) was still lacking. This level of detail is needed to better evaluate future changes that may be made to the facility or its reconfiguration consistent with the 10 CFR 50.59 process and to confirm the conservatisms in the FSTR design and that of its SSCs. Therefore, the NRC staff issued RAIs.

The NRC staff reviewed SHINE's response to RAI 3.4-18 (ADAMS Accession No. ML21208A135) and noted that the applicant expanded upon the FSAR description of the FSTR and clarified that the collapse of the exhaust stack would not endanger the FSTR, its safety-related SSCs, or the N2PS facility, as these are either designed to withstand substantial loads, such as aircraft impacts, or are removed from harm's way. In its RAI response, the applicant also clarified that the collapse of the stack on the non-safety-related portion of the facility or on the Seismic Category II interior partitions, would not affect safety-related SSCs or create a risk exceeding established facility safety criteria. Furthermore, the applicant clarified that supercells are integrated in the FSTR design and that the concrete shield plugs are properly sized and accounted for in the design. The staff finds that the applicant's finalized facility configuration description and statement that safety-related SSCs are qualified to be functional during and after a transient or abnormal loadings is adequate and consistent with the regulatory framework and, therefore, acceptable. The staff also finds that SHINE's revisions to FSAR Sections 3.4, 3.7, 9a2.1.1.1, and 4b.2.2.2.1 are adequate as they provide more detailed descriptions of the facility and of its SSCs and, therefore, are acceptable.

3.4.4.1 Seismic Input

SHINE FSAR Section 3.4.1, "Seismic Input," provides and overview of the site seismicity and seismic input for the seismic analysis of the facility. It provides information for the peak ground acceleration for the safe shutdown earthquake (SSE), its design response spectra, synthetic time histories for SSI analyses, and critical damping values for structural components. SHINE FSAR 3.4.1.1, "Design Response Spectra," states that the SSE is defined by a maximum ground acceleration of 0.2 g (seismic acceleration, rate of change of velocity per unit time, e.g., ft/sec^2) and design response spectra in both vertical and horizontal directions, as per RG 1.60, Revision 2, "Design Response Spectra for Seismic Design of Nuclear Power Plants" (ADAMS Accession No. ML13210A432). The ground motion response spectrum (GMRS) is defined as an outcrop motion at a depth of 2.3 meters (m) (7.5 feet (ft)) below the grade, the location of competent materials with a minimum shear wave velocity of 305 meters per second (m/s) (1,000 feet per second (ft/s)) at the site. This approach follows Section 3.7.1 of NUREG-0800. The peak ground acceleration (PGA) of 0.2 g for both vertical and horizontal directions is developed for the site and exceeds the designated minimum free-field PGA value of at least 0.1 g to be used, per acceptance criterion 1.A. of Section 3.7.1 of NUREG-0800. For these reasons, the NRC staff finds that the design response spectra used for analyzing the FSTR is acceptable.

To ensure that the SHINE FSAR provides sufficient information that conditions due to a seismic event will not pose significant risk to the health and safety of the public and to conclude that the facility design will perform adequately during a design basis seismic event with its SSCs performing the necessary safety functions as described in the application, the NRC staff issued RAIs 3.4-1 and 3.4-2. Through its responses to RAIs 3.4-1 and 3.4-2 (ADAMS Accession No. ML21011A240), SHINE supplemented SHINE FSAR Section 3.4.1, "Seismic Input," as noted above, and Section 3.4.2, "Seismic Analysis of Facility Structures," which the staff reviewed and evaluated as noted below.

Synthetic acceleration-time histories are generated enveloping the design response spectra in three mutually orthogonal directions, using the seed recorded time histories from the El Centro earthquake in 1940, for SSI analysis and developing the in-structure response spectra (ISRS). They are shown in Figures 3.4-1-1 through 3.4-1-3 of the applicant's response to RAI 3.4-1. The NRC staff finds this approach to be consistent with acceptance criterion 1.A(ii) of NUREG-0800, Section 3.7.2. Based on this observation, the staff concludes that the approach to generate synthetic acceleration-time histories is acceptable. These artificial time histories are used in site response analysis to develop strain-compatible soil properties and in-profile ground motions for seismic analysis.

Each of the time histories meets the design response spectra consistent with Option 1, Single Set of Time Histories, Approach 2 of NUREG-0800, Section 3.7.1 and, therefore, is acceptable. The calculated correlation coefficient between any pairs of the two horizontal and one vertical SSE motions generated, as given in the applicant's response to RAI 3.4-1, is significantly smaller than the maximum allowable correlation coefficient of 0.16 given in acceptance criterion 1.B, "Design Time Histories," of Section 3.7.1 of NUREG-0800. This shows that the generated acceleration spectrum in one direction is independent of those in the other two mutually orthogonal directions. Additionally, the duration of the generated pulse is approximately 40 seconds long, as stated in the applicant's response to RAI 3-4-1 and as provided in Figures 3.4-1-1 through 3.4-1-3, which is significantly larger than the 20 seconds as stated in acceptance criterion 1.B.ii.(a) of Section 3.7.1 of NUREG-0800. In addition, the NRC staff finds that the duration of the strong motion portion in each orthogonal direction is significantly longer than the minimum 6 seconds given in acceptance criterion 1.B of Section 3.7.1 of NUREG-0800. Based on these observations, the staff concludes that the generated SSE design spectra are acceptable to conduct the SSI analysis.

3.4.4.2 Seismic Analysis of Facility Structures

SHINE FSAR Section 3.4.2, “Seismic Analysis of Facility Structures,” addresses modeling and analysis of the FSTR performed by the SASSI2010 and SAP2000 finite element analysis (FEA) codes. It includes applied loads to the structure (e.g., dead, live – including meteorological, crane, fluid, soil pressure, and seismic), discussions of structural response to multidirectional seismic input, structural seismic stability, etc.

SHINE FSAR Section 3.4.2.4, “Seismic Analysis Results,” includes seismic loads that have been applied to the structural analysis model and used to develop the ISRS for use in sizing equipment and structural components. As stated in Section 3.4.2.1, “Seismic Analysis Methods,” and further confirmed by SHINE in its response to NRC staff RAI 3.4-2, the seismic analysis of the FSTR used SASSI2010 (version 1.0) and SAP2000 (version 17.2) computer programs. The staff’s RAI 3.4-2 questions on seismic analysis methods and soil-structure modeling and SHINE’s public responses are documented in ADAMS Accession No. ML21011A240. The staff finds the use of SASSI2010 and SAP2000 for estimating the SSI response and for the structural analysis, respectively, of the FSTR acceptable for the following reasons:

(1) The SASSI2010 and SAP2000 codes are commercially available and widely used for analyses in the nuclear industry.

(2) The SASSI2010 software performs a complex frequency response analysis using the input acceleration time histories, consistent with the defined SSE response spectra, to determine the response of the structure and to generate the ISRS, element force and moments, maximum seismic acceleration (zero-period acceleration (ZPA)), and nodal accelerations for different damping values.

(3) SAP2000 (version 17.2) is a finite element (FE) code commercially available and widely used for analyses in the nuclear industry. By using the earthquake-generated forces as static loads, it performs an equivalent static analysis to determine in-plane shear force in a wall (diaphragm), wall overturning, and stability of the FSTR.

The SHAKE2000 program (version 3.5) was used to generate the strain-dependent soil properties. The SHAKE2000 program is commercially available and widely used for analyses in the nuclear industry.

In addition to the information provided on the structure, the SSI analysis also includes detailed information of the soil layers supporting the structure obtained in the site geotechnical investigation, as summarized in SHINE FSAR Section 2.5.2.3, “Site Soil Conditions,” and Section 2.5.7.1, “Site Soil Conditions.” The NRC staff reviewed and evaluated the applicant’s information on the SSE ground motion response spectra for the SHINE site in Section 2.5 of this SER and found it to be acceptable, because it is consistent with the United States Geological Survey (USGS) Hazards Map. However, the staff noted that soil parameters necessary for SSI analysis and foundation assessment were not sufficiently clear to determine soil bearings at specific elevations, settlements, and stability of the FSTR discussed in SHINE FSAR Sections 3.4.2.5 and 3.4.2.6.3.1 and issued RAIs 3.4-5 and 3.4-6. The NRC staff conducted a regulatory audit (ADAMS Accession No. ML21089A334) to review the analysis supporting the geotechnical evaluation. As a result of the audit, the applicant revised its FSAR and supplemented its response to RAI 3.4-6. The RAIs and SHINE’s public responses are documented in ADAMS Accession Nos. ML21011A240 and ML21106A136, respectively. The staff reviewed the applicant’s RAI responses and finds them acceptable because the computed factors of safety against sliding and overturning are greater than the minimum values required, the allowable soil bearing capacity is higher than the maximum foundation contact pressures, and the differential and total settlements are accounted for in the FSTR FEA through the resulting generalized forces, so the facility structure is designed to accommodate the potential differential and total settlements.

Horizontal soil layers in SASSI2010 model the soil column down to an elastic half-space representing the bedrock. Strain-dependent soil properties are determined from geotechnical investigations and free-field site response analysis using the SHAKE2000 program (version 3.5). The free-field site response analysis is performed using the mean or best estimate (BE), the upper bound (UB), and the lower bound (LB) soil properties to represent potential variations of the in-situ soil conditions. The NRC staff finds this approach to be consistent with Section 3.7.2 of NUREG-0800 and ASCE 4-16 (Section 5.1.7 "Uncertainties in SSI Analysis") to treat potential variation in soil properties, and, therefore, is acceptable.

The UB and LB soil properties are generated from the mean soil properties (BE) assuming a coefficient of variation (COV) of 0.5, because the site is well investigated, which the NRC staff acknowledges to have occurred during the site characterization phase. Additionally, this approach is consistent with Section 3.7.2 of NUREG-0800 and ASCE 4-16, "Seismic Analysis of Safety-Related Nuclear Structures," Section 5.1.7, "Uncertainties in SSI Analysis," and, therefore, is acceptable.

The SSI analysis was performed using LB, BE, and UB soil columns with strain-compatible properties and the corresponding SSE earthquake motion. Major structural elements of the FSTR were modeled with appropriate mass and stiffness properties to analyze the SSI effects using SASSI2010, as stated in SHINE FSAR Section 3.4.2.2. FSAR Section 3.4.2.2 considers loads as mass equivalents for seismic analysis. The approach is consistent with NRC guidance (i.e., NUREG-0800, Section 3.7.2) and industry standards and, therefore, is acceptable.

The nature of miscellaneous dead weights as equivalent masses and those associated with hydrodynamic and crane masses is further discussed in the applicant's response to RAI 3.4-3 (ADAMS Accession No. ML21011A240). The NRC staff's acceptance of the applicant's response is detailed next. The structural model of the FSTR accounts for the self-weight of the structure. In addition, mass equivalent of 25% of the floor live loads and 75% of the roof design snow loads are included in the model. In addition, following Section 3.7.2 of NUREG-0800, a mass equivalent of 50 pounds per square foot floor load is added to represent the dead load from minor equipment, etc. Floor loads and equipment loads, as previously noted, are converted to mass and included in the model along with the self-weight of the structure. Additionally, 100% of the hydrodynamic mass of the water in the irradiation units (IU) cells and 100% of the crane mass are included in the model. The staff finds that the SSI model of the FSTR appropriately accounts for different dead and live loads including loads from major equipment or other major components (e.g., water in IU cells). Because the loads are consistent with acceptance criterion 3.D in Section 3.7.2 of NUREG-0800, the staff finds that the applicant has appropriately included all different load types in the SSI model of the FSTR.

In addition, a cracked case is analyzed with BE soil profile and assumed cracked structural components from an SSE, as stated in the applicant's response to RAI 3.4-9 (ADAMS Accession No. ML21011A240). The modulus of elasticity of the modeled concrete elements is reduced by 50% of its nominal values, based on ASCE/(Structural Engineering Institute) SEI 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities." The NRC staff finds that the reduction of modulus is also consistent with Table 3-2, "Effective Stiffness of Reinforced Concrete Element" of ASCE/SEI 4-16, "Seismic Analysis of Safety-

Related Nuclear Structures," and Section 3.7.2 of NUREG-0800. Based on this discussion, the staff finds that the applicant has followed the recommended approach for degradation of stiffness of modeled structural components following acceptable national standards for use in the seismic analysis, hence the degraded modulus value is acceptable. Therefore, the staff finds that the applicant's modeling approach satisfies acceptance criterion 3.C of NUREG-0800, Section 3.7.2 and, therefore, is acceptable.

Damping values of concrete and steel components of the FSTR for LB, BE, and UB analyses (uncracked cases) are given in Table 2 of RG 1.61, Revision 1, "Damping Values for Seismic Design of Nuclear Power Plants" (ADAMS Accession No. ML070260029), with the Operating Basis Earthquake (OBE). As no cracking is expected in an OBE excitation, the corresponding damping values excitation (4% for concrete and 3% for steel) have been used to analyze the uncracked LB, BE, and UB scenarios. In the cracked case, cracking of components is assumed to occur. The cracked case uses increased values for damping (7% for concrete and 4% for steel), consistent with those given in Table 1 of RG 1.61, Revision 1, for an SSE. Based on this discussion, the NRC staff finds that the damping values used for uncracked scenarios are acceptable as they are from RG 1.61, Revision 1, and, therefore, concludes that acceptance criterion 2, "Percentage of Critical Damping Values," of Section 3.7.1 of NUREG-0800 has been satisfied. In addition, the cracked case uses damping values associated an SSE excitation contained in RG 1.61, Revision 1. As the damping values used are consistent with RG 1.61, Revision 1 and ASCE/SEI 43-05, the staff concludes that that appropriate structural damping values have been used in conducting the SSI of the FSTR and, therefore, that acceptance criterion 3.C.iv. of Section 3.7.2 of NUREG-0800 has been satisfied as well, in addition to acceptance criterion 2 of Section 3.7.1 of NUREG-0800.

Major openings within the walls and slabs are incorporated in the SSI model. Thick shell elements are used to model the concrete walls, slabs, and basemats. Three-dimensional beam elements are used to model the steel structural elements, such as trusses. Thick shell elements are used to model the interior partition walls made of concrete. Interior partition walls made of masonry or gypsum are not explicitly modeled as they are isolated from the lateral load-resisting system; however, their mass is accounted for in the analysis. Beam elements are used to model the steel truss components. These modeling practices are outlined in the applicant's response to NRC staff RAI 3.4-9 (ADAMS Accession No. ML21011A240). The excavated soil volume is modeled with solid elements in the SSI model to assess the soil-structure interaction effects as described in the applicant's response to RAI 3.4-2. The vertical dimension of the elements matches the thickness of the corresponding soil layers. The equivalent linear strain-compatible soil properties determined at the site are assigned to these solid elements. The maximum dimension of these elements is small enough to propagate the highest frequency of interest in the model used in the analysis, as stated in the applicant's response to RAI 3.4-9 (ADAMS Accession No. ML21011A240). The finite element model is acceptable because it was developed following regulatory guidance (NUREG-0800, SRP Section 3.7.2) and accepted engineering practice.

The SASSI2010 SSI analysis of the FSTR produces acceleration response in three mutually orthogonal directions from the input motion in each direction, for example, acceleration response in X, Y, and Z directions from input motion only in X direction, Y direction, or Z direction. These codirectional response values were calculated at selected nodes (points) located on different structural elements/locations of the FSTR. The response spectra locations are as shown for example in Figures 3.4-4-1 and 3.4-4-9 of the applicant's response to the NRC staff RAI 3.4-4 (ADAMS Accession No. ML21011A240). Output from the SASSI 2010 SSI analysis includes response spectra accelerations at the 75 standard frequencies between

0.2 Hertz (Hz) and 34 Hz, consistent with Table 2 of RG 1.122, Revision 1, “Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components” (ADAMS Accession No. ML003739367). In addition, output also includes response spectra accelerations at 37 Hz, 40 Hz, 43 Hz, 46 Hz, and 50 Hz frequencies, as given in SHINE FSAR Section 3.4.2.4. These spectra are generated at six critical damping ratios: 2%, 3%, 4%, 5%, 7%, and 10%, as stated in the applicant’s response to RAI 3.4-4. The ordinate of the calculated response spectrum is at frequencies sufficiently close to produce an accurate response spectrum following RG 1.122, Revision 1. In addition, several high frequencies are included in developing the ISRS. These codirectional responses are combined using the square-root of the sum of the squares (SRSS) method following RG 1.92, Revision 3, “Combining Modal Responses and Spatial Components in Seismic Response Analysis” (ADAMS Accession No. ML12220A043), and is consistent with acceptance criterion 5.A of Section 3.7.2 of NUREG-0800. Therefore, the NRC staff finds that the method used to develop the ISRS of the FSTR is acceptable.

As stated previously, the ISRS from the SSI analysis for each soil model has been calculated at various nodes/locations shown in FSAR Figures 3.4-4-1 and 3.4-4-9 and pointed out also in captions of missing figures, given in the applicant’s response to NRC staff RAI 3.4-4, as noted above. The combined response from the LB, BE, UB, and cracked seismic analysis cases at each node are enveloped to develop the bounding response at that node. The output response spectra are combined into 39 groups, given in Table 3.4-4-1 of the applicant’s response to RAI 3.4-4. Responses of nodes in each group have been enveloped to determine the bounding response spectra at these structural elements/locations. The resulting bounding response spectra are smoothed, and the peaks of the spectra are broadened by ± 15% to account for approximations in the modeling techniques and uncertainties in the parameters used in structural analysis. The resulting ISRS plots for each of the 39 groups are shown in Figures 3.4-4-10 through 3.4-4-48 of the applicant’s response to RAI 3.4-4. The peak acceleration or ZPA for each of the 39 groups has been taken from the corresponding ISRS plot at the maximum frequency point and is given in Table 3.4-4-2 of the applicant’s response to RAI 3.4-4. As the response has been calculated on different structural components and major facility equipment of the FSTR, the NRC staff finds that the analysis is acceptable because it satisfies acceptance criterion 2.B of Section 3.7.2 of NUREG-0800. The approach to smoothing and broadening the spectrum to account for uncertainty follows RG 1.122, Revision 1, and the staff finds that the approach is consistent with acceptance criterion 5.C of Section 3.7.2 of NUREG-0800. Therefore, based on the above discussion, the method used to develop the bounding ISRS is acceptable.

SHINE FSAR Section 3.4.2.6, “Structural Analysis of Facility,” and Section 3.4.2.6.2, “Applicable Codes and Standards,” provide a succinct listing of applicable codes and standards used for the structural design of the facility. SHINE FSAR Section 3.4.2.6.2 states that the facility concrete design is based on ACI 349-13, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary,” and for structural steel design on ANSI/AISC N690-12. RG 1.142, Revision 2, “Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)” (ADAMS Accession No. ML013100274), endorses ACI 349 with certain exceptions and modifications so that defense-in-depth is maintained in the design of nuclear concrete facilities.

During its review of SHINE FSAR Section 3.4.2.6.2, the NRC staff noted that there is no information in the FSAR regarding whether the applicant considered the guidance of RG 1.142 to further enhance its ACI 349-13 based concrete design so that the defense-in-depth philosophy included in NUREG-1537 is maintained. Concerned that such modifications and omissions from the structural design may have resulted in an overall nonconservative structural design, the staff issued RAI 3.4-10. The staff finds the applicant's response to RAI 3.4-10 (ADAMS Accession No. ML21011A240) acceptable because the design of the FSTR concrete box and its structural concrete SSCs to transient and/or abnormal loads: (a) is in accordance with the ACI 349-13 as modified by the RG 1.142, Revision 2, regulatory positions for successive levels of protection to act as direct or indirect barriers against the release of radioactive material to the environment and (b) ensures that failure of a single SSC would not impair protection of the health and safety of the public or from the uncontrolled release of radioactive material to the environment.

SHINE FSAR Section 3.4.2.6.2 also states that the FSTR structural steel design follows ANSI/AISC N690-12. The NRC staff noted that the limited information provided in this section was not adequate to demonstrate that the requirements of the steel design code ANSI/AISC N690-12 are met, including those related to fire. The staff was concerned with the potential for fires, particularly those associated with an aircraft impact, to generate elevated temperatures and how this could damage the safety-related structural steel used in the FSTR SSCs and issued RAI 3.4-11. The staff's RAI and the applicant's public response are in ADAMS Accession No. ML21011A240 and are discussed below.

The NRC staff reviewed the applicant's response to RAI 3.4-11 and noted that SHINE clarified that the safety-related FSTR structural steel SSCs (i.e., the mezzanine and roof trusses) are designed in strict accordance with ANSI/AISC N690-12 to applicable loads/loading conditions. SHINE also clarified that it used the stepwise screening approach detailed in U.S. Department of Energy (DOE) Standard DOE-STD-3014-2006, "Accident Analysis for Aircraft Crash into Hazardous Facilities," to programmatically reduce the risk for facility damage and to eliminate the need to further examine consequences of elevated temperatures due to aircraft impact generated fires on the safety-related FSTR structural steel SSCs. The staff finds SHINE's design approach based on national standards and building codes to be consistent with NUREG-1537 and, therefore, it is acceptable. Additional concerns regarding postulated aircraft impact locations on the FSTR external envelope were resolved through RAI 3.4-19, which is discussed below in Section 3.4.4.5, "Seismic Envelope Design of External Hazards," of this SER.

To ensure that: (a) the consequences of elevated temperatures to FSTR structural steel would be minimal (if any) from postulated aircraft crash fires, (b) the facility would continue to maintain its defense-in-depth, and (c) the DOE-STD-3014-2006 limits to active fire and/or suppression systems following such events had been considered, the NRC staff also reviewed SHINE FSAR Section 9a2.3, "Fire Protection Systems and Programs," and the associated applicant responses to RAIs in ADAMS Accession No. ML21364A055. In particular, the staff noted that the applicant's response to RAI 9-5 outlines facility passive design features to limit fire consequences. The staff also noted that the facility is designed with protective systems such as 1, 2, or 3 hours of fire-resistant barriers separating individual fire areas consistent with NUREG-1537, Part 1, Section 9.3, "Fire Protection Systems and Programs," to prevent the uncontrolled release of radioactive material to the environment, should a fire occur. The applicant's response to RAI 9-5 clarifies the basis for the fire barrier ratings (e.g., analysis, regulatory requirements, assessments of fire area contents, means of egress considerations, equipment separation, area considerations). The staff notes that additional safety measures exist, such as manual firefighting capability from nearby fire brigades including those from the adjacent airport. Based on the above, the staff finds the applicant's response regarding fires in RAI 3.4-11, as supplemented by the applicant's responses to RAIs regarding SHINE FSAR Section 9a2.3.1, "Fire Protection Plan and Program," adequate and, therefore, acceptable for its safety determination.

For the review of SHINE FSAR Section 3.4.2.6, “Structural Analysis of Facility,” consistent with the guidance of NUREG-1537, the NRC staff also reviewed other sections of the FSAR to determine how the effects of irradiated environments could affect the performance of structural materials (i.e., concrete and steel) under normal and overload conditions such as those encountered during earthquakes, aircraft impact, and blast loads. Such reviews included discussions on neutron driver assembly system (NDAS) irradiated structural support beams in FSAR Sections 1.3.3.3 and 4a2.3 and neutron and gamma fluxes in the subcritical assembly in FSAR Section 4a2.5.3.2. The staff reviewed the structural performance of irradiated concrete and structural steel affected by radiation exposure exceeding the threshold limits of NUREG/CR-7171, “A Review of the Effects of Radiation on Microstructure and Properties of Concretes Used in Nuclear Power Plants” (ADAMS Accession No. ML13325B077), and ACI 349.3R, “Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures,” in these areas during facility operation and issued RAI 3.4-12.

The NRC staff reviewed the applicant’s response to RAI 3.4-12, Revision 1 (ADAMS Accession No. ML21271A076), and noted that its analyses indicated that FSTR fluence is below the threshold acceptance limits of NUREG/CR-7171 and those of ACI 349.3R for concrete and its steel embedments, respectively. For gamma heating on concrete, although the analyses indicated an elevated exposure below the target solution vessel (TSV), the staff finds its effects on concrete pool acceptable because pool light water surrounding the TSV provides significant shielding, thereby reducing the temperature rise in the general and local concrete areas to below the threshold values allowed in ACI 349.3R.

In its response to RAI 3.4-12, the applicant also determined, based on UB effects of fluence on the austenitic stainless steel used in the subcritical assembly support structure (SASS), that safety-related austenitic stainless steel SASS components in the IU cells, near the TSV and NDAS, also exhibit adequate ductility and strength to resist anticipated transients and abnormal loads. In addition, the NRC staff noted that stainless steel used in the design (see SHINE FSAR Sections 4a2.4.1.1 and 4a2.4.1.5) was tested for radiation and corrosion at Oak Ridge National Laboratory (ORNL). Furthermore, the staff noted that the FSAR states that the surveillance and inspection program ensures that the integrity of the primary system pressure boundary components (PSB) is not degraded below acceptable limits due to radiation. The staff finds the capacity of the aforementioned components adequate to perform their intended functions because their evaluation was based on recognized industry practices, as noted in FSAR Section 4a2.4.1.5. The staff also finds that the FSAR surveillance and inspection measures for the effects of fluence on safety-related austenitic stainless steel SASS components are adequate. Based on the above, staff finds the evaluation and measures taken to ensure that the aforementioned austenitic stainless steel components perform their intended functions during the facility operating life to be consistent with the regulatory framework and, therefore, acceptable.

The NRC staff, in its review of SHINE FSAR Section 3.4.2.6.4, “Design Loads and Loading Combinations,” noted that this section addresses several loads including dead, live, and earthquake loads. For dead loads, the FSAR includes concrete cover blocks for below grade tanks and trenches. The staff noted that this FSAR section considers the concrete blocks to be live loads, which may indicate that they are not integrated in the facility seismic design. To clarify and resolve the size and anchorage of these blocks, whether the facility incorporates them into its design precast vaults in the RPF, what the “minimum” live loads are, and whether the roof live loads align with those referenced in ASCE 7-05 or International Building Code (IBC) 1607, the staff issued RAIs 3.4-7 and 3.4-8. Earthquake loads in the seismic analysis are addressed in RAI 3.4-4.

Further, in its review of SHINE FSAR Section 3.4.2.6.4.6, “Crane Load,” the NRC staff noted that crane loading was evaluated in accordance with American Society of Mechanical Engineers (ASME) NOG-1, “Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder).” The staff also noted the limited description of how crane loads were defined and subsequently incorporated in the crane systems designs. The staff reviewed the applicant’s response to RAIs 3.4-13 and 3.4-21 (ADAMS Accession Nos. ML21011A240 and ML21208A135, respectively) and noted the following:

(1) For crane loads and loading conditions, SHINE clarified that the IF and RPF crane systems design loads (seismic, dead, impact, stop, lift capacities) are conservatively calculated deterministically consistent with ASME NOG-1. Additionally, SHINE clarified that it used the calculated loads also for the FSTR design but ensured that for crane loading there was conservatism in the building design consistent overall with ASCE 7-05 or IBC 1607 building codes and requirements. Specifically, SHINE calculated the crane seismic loads as distributed loads based on ISRS peak acceleration, crane mass, and full lift load. For the facility crane runway system horizontal impactive design loads, SHINE used those considered for a design basis earthquake (DBE), which are more conservative than those of ASME NOG-1 and those required by the aforementioned building codes. The NRC staff finds these approaches based on local building codes, standards, and recognized industry practices to be consistent with NUREG-1537 and, therefore, acceptable.

(2) For crane runway systems design, SHINE clarified that for the SSI analysis, consistent with ASME NOG-1, it decoupled the IF and RPF crane responses from their runways. SHINE also clarified that all building facility sections, including walls supporting the IF and RPF cranes, are designed with a minimum of 10 percent margin for all loading conditions and modes of failure. It also stated that a minimum 7 percent design margin exists for any of the designed IF and RPF crane runway systems components. SHINE then stated that the conservatism used in the estimated deterministic loads further increases the aforementioned two design margins. It then described how the crane runway systems are attached to the facility external walls to help isolate external impact or base induced shear loads. Although the cranes are not considered to be critical or safety-related equipment, as noted in the applicant’s RAI response (see also SHINE FSAR Section 9b.7.2.3), nonetheless a failure of their runway systems could potentially affect safety-related SSCs. The NRC staff finds that there is reasonable assurance that such a failure would be highly unlikely because the design of the runways has adequate margins and follows the conservatisms of local building codes, national standards, and recognized industry design practices consistent with NUREG-1537 and, therefore, is acceptable.

Based on the above, the NRC staff finds the revised SHINE FSAR Section 9b.7.2.1 clarifying that the IF and RPF cranes are designed to remain in-place and on the runway girder, with or without a load, during and after a seismic event, acceptable.

The NRC staff also reviewed SHINE FSAR Section 9b.7.2 and noted that the cranes meet ASME B30.2, “Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist),” and Crane Manufacturers Association of America, Inc. (CMAA) 70, “Multiple Girder Cranes,” service level (class) B requirements. The staff noted that both cranes serve the RCA of the FSTR and are used to move or manipulate radioactive material within the radiologically controlled area. The staff also noted that CMAA-70 Class B cranes are limited to light service requirements (e.g., repair shops, light assembly operations, light warehousing) and limited in height of lifts. In addition, the staff noted that the RPF crane is a 15-ton ASME NOG-1 Type II, double girder bridge style crane with no single failure-proof features to support its lift during a seismic event. However, there was a limited discussion on the effects of radiation and usage of cranes and crane systems during the operating life of the facility. Therefore, the staff issued RAI 3.4-14 regarding the potential detrimental effects of radiation on each crane's structure and increased usage that could affect crane performance, such as dropped lifts on safety-related SSCs and potentially challenge the facility's defense-in-depth and the radiological release limits of 10 CFR Part 20 during facility operating life.

In its response to RAI 3.4-14 (ADAMS Accession No. ML21011A240), SHINE clarified that the crane purchase specifications included environmental conditions in their design criteria that account for radiation exposure to 30 years. SHINE also stated that the IF and RPF cranes are constructed consistent with ASME NOG-1 Type I and Type II design requirements for seismic loads, fracture toughness, and radiation hardening, as applicable. SHINE further clarified that load cycle limits are those of CMAA 70-2004 and inspection, testing, and maintenance are in accordance with ASME B30.2 and/or ANSI N14.6-1993, "Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More," as applicable. The NRC staff finds the applicant's approach for the design of cranes with respect to radiation resistance and usage to be in accordance with national codes and standards consistent with NUREG-1537 and, therefore, is acceptable.

In its review of SHINE FSAR Section 3.4.2.6.4.8, "Fluid Load," the NRC staff noted the existence and application of hydro loads to critical equipment. Additional details for this fluid loading condition are in FSAR Chapter 4, which details the fluid-structure interaction of water with submerged or semi-submerged equipment containing uranyl sulfate solution within the light water pool during seismic/abnormal loading events. SHINE FSAR Chapter 3 references ASCE 4-98, which provides guidance for hydrostatic and hydrodynamic analysis of equipment or structures loaded with hydrostatic and hydrodynamic pressures/forces, assessments of fluid-structure interaction, and the stability of structures in a fluid (water) basin. Although the applicant referenced this standard, it is not clear to what extent the standard was used for the water (fluid), pool (basin), and equipment interactions, and whether the analyses were extended to include comingling of uranyl sulfate solution into the pool in the event of a breach of the TSV tank containing this solution. Material Data Sheets indicate that uranyl sulfate in its solid form has a specific gravity considerably higher than that of water. Consistent with these data, in this case the calculated hydrodynamic loads and stability analyses would differ from a hydrodynamic analysis using solely water as a fluid load.

To clarify what methodology was used to derive the hydrodynamic loads and their effects on submerged equipment/structures/pool and to identify the echelons of defense considered against the release of uranyl sulfate solution into the pool and the subsequent consequences if such a release were to occur, the NRC staff determined the need for additional information and issued RAI 3.4-15.

The NRC staff reviewed the applicant's response to RAI 3.4-15 (ADAMS Accession No. ML21011A240) and noted that SHINE evaluated the IU structure and its light water pool submerged or semi-submerged safety-related equipment to hydrodynamic loads composed of sloshing forces and those attributed to added masses during seismic excitation consistent with applicable national standards (i.e., ASCE 4-98, TID-7024, ACI 350.3-06, and ANSI/AISC N690-12). In its response, SHINE also clarified the defense-in-depth echelons against the release of uranyl sulfate target solution and associated fission material, including the TSV and the light-water pool as barriers, which are part of the PSB. SHINE further clarified that it did not consider the release of uranyl sulfate solution into the pool to be a postulated event, nonetheless it designed the PSB to withstand seismic/abnormal loadings. Furthermore, SHINE observed that a potential leakage into the pool would insignificantly increase the density of the large body of water in the pool and the associated hydrodynamic loads and their effects on submerged/semi-submerged equipment during a seismic event. The NRC staff finds the applicant's response to the RAI to be acceptable for the following reasons: (a) the calculation of the hydrodynamic forces was done in accordance with national standards, codes, and recognized industry practice, (b) the PSB was designed to resist transient and abnormal loads and with a defense-in-depth philosophy to contain the release of radioactive material, and (c) the calculated increase in the hydrodynamic forces resulting from an increased water density due to a trace of uranyl solution released into the light water pool was insignificant. The staff also finds the revision to SHINE FSAR Sections 3.4.2.6.4.8 and 4a2.2.5 regarding hydrodynamic loading and its effects on the SASS acceptable as the methodologies considered in the analyses are in accordance with national standards, codes, and recognized industry practices consistent with NUREG-1537.

3.4.4.3 Seismic Classification and Qualification

SHINE FSAR Section 3.4.3, "Seismic Classification and Qualification," identifies categories of SSCs and presents the seismic qualification of the SHINE facility's systems and equipment. It includes the definition of category I and II SSCs and details of the methodologies used for their seismic qualification. The NRC staff reviewed the methodologies that the applicant used for seismic qualification of equipment/components achieved with analytical methods (including static analysis, simplified dynamic analysis, or detailed dynamic analysis), testing (e.g., material qualification testing), or a combination of the analytical and testing methods and found them acceptable. These are discussed in Section 3.4.4 of this SER.

3.4.4.4 Seismic Instrumentation

SHINE FSAR Section 3.4.4, "Seismic Instrumentation," summarizes the seismic instrumentation at the facility. The NRC staff reviewed the summary and noted that SHINE has in place non-safety-related seismic instrumentation to assess the effects of accelerations experienced at the facility following a seismic event so that the facility and its safety-related SSCs continue to operate safely. The measurement of seismic acceleration at the facility using non-safety-related instrumentation is reasonable and acceptable because the NRC's regulations do not require seismic instrumentation for this facility.

3.4.4.5 Seismic Envelope Design of External Hazards

SHINE FSAR Section 3.4.5, "Seismic Envelope Design for External Hazards," provides input for an aircraft impact analysis, which is necessary because the SHINE facility is located near the Southern Wisconsin Regional Airport (SWRA). It also discusses external facility explosions. FSAR Section 3.4.5.1, "Aircraft Impact Analysis," outlines the effects of global and local small aircraft crashes (impact loadings) on the facility from the nearby SWRA. It states that the Challenger 605 was selected as a "design basis aircraft" for global impact response analysis based on airport operations data. It also states that the analysis used the energy balance method of DOE-STD-3014-2006 while taking into consideration the ductility limits of ACI 349-13 and ANSI/AISC N690-12 for reinforced concrete and steel truss elements, respectively. For local impacts, it states that the Hawker and the 605 Challenger were the two aircraft considered as design basis aircrafts. FSAR Section 3.4.5.1 then references DOE-STD-3014-2006, which provides guidance for functional assessments, screening, and evaluating global, local, and vibration damage to the FSTR and its SSCs. The NRC staff notes that the applicant's statement in FSAR Section 1.2.2, claiming design robustness of the building structure, stems from a postulated aircraft impact analysis based on criteria and guidance of DOE-STD-3014-2006.

In evaluating SHINE FSAR Section 3.4.5.1, the NRC staff sought clarifications through its RAIs 3.4-16 and 3.4-20 on how the two aircrafts were selected, what was the perceived mode of impact, and how potential global and local impact loads, damage estimates, and resulting consequences on the FSTR and its SSCs were assessed.

The NRC staff reviewed SHINE's responses to RAIs 3.4-16 and 3.4-20 (ADAMS Accession Nos. ML21011A240 and ML21208A135, respectively) and noted that the selected aircraft for local and global impact analysis was the Challenger 605 aircraft based on SWRA operations data and because it had the heaviest engines of all aircraft frequenting the airport. The staff also noted that SHINE's analyses used national standards and codes to assess the effects of postulated impacts (e.g., DOE-STD-3014-2006 and ACI 349-13, Appendix F) on the design of the entire exterior envelope of the FSTR as well as on several of its interior walls that act as barriers to exterior wall openings. Regarding potential skidding of the aircraft on the roof, SHINE stated that while this was not explicitly accounted for in the impact analysis, the seismic qualification of the roof slab bounds the skidding aircraft impact scenario. The staff finds SHINE's approach for the aircraft selection based on airport historical data and the analysis performed that conservatively addresses the entire external facility envelope and internal walls for local and global impacts based on national standards and codes adequate and consistent with the guidance of NUREG-1537 and, therefore, acceptable. The NRC staff accordingly finds the revision to SHINE FSAR Section 3.4.5.1 clarifying that the FSTR seismic loading bounds any aircraft impact scenario that produces lateral forces acceptable.

Aside from aircraft impacts on the external facility envelope, the NRC staff also examined potential effects of such impacts on safety-related SSCs attached to the facility envelope. The staff followed-up on the applicant's response to RAI 3.4-11, which stated that there was no safety-related equipment supported from the building in the vicinity of postulated impacts and that the risk to damage and resulting consequences were "deemed small and the results are documented." To better assess SHINE's response, the staff issued RAI 3.4-19 requesting that the applicant provide additional clarifications on the analysis methodology used to evaluate the structural behavior at critical areas of the impacted structure and on the overall robustness and structural integrity of the facility based on the structural response at postulated impact locations.

In its response to RAI 3.4-19 (ADAMS Accession No. ML21029A103), SHINE clarified that the only components attached to facility exterior walls are the crane runways, with the cranes classified as non-safety-related SSCs. SHINE also clarified that the impact analysis methodology used to evaluate the response of the facility structure is in accordance with DOE-STD-3014-2006 with critical facility areas (e.g., exterior and labyrinth walls, missile barriers, roof, wall corners) of impacted concrete sections designed to ACI 349-13. The NRC staff finds the applicant's response acceptable because it reaffirmed that there is no safety-related equipment on the facility envelope and that the methodology used to assess the response, robustness, and structural integrity of the facility due to aircraft impacts is based on national standards, building codes, and recognized industry practices consistent with the guidance of NUREG-1537. The NRC staff also finds SHINE's revision to SHINE FSAR Section 3.4.5.1 acceptable because it clarifies the reason why punching shear damage was not considered in the analysis.

SHINE FSAR Section 3.4.5.2, "Explosion Hazards," discusses external explosions/blast effects on the FSTR and references FSAR Section 2.2.3 for details on the source and derivation of blast overpressures, including the regulatory guidance and software used for the hazards evaluation. The NRC staff had questions concerning the validity of software and uncertainties in the methodologies used for the design of the FSTR with respect to blast effects, and whether the external nitrogen tank in the proximity to the FSTR was designed to code for potential accidental explosions and, therefore, issued RAI 3.4-17.

The NRC staff reviewed the applicant's response to RAI 3.4-17 (ADAMS Accession No. ML21029A103) and noted that SHINE followed the methodology described in RG 1.91, Revision 2, "Evaluations of Explosions Postulated to Occur at Nearby Facilities and on Transportation Routes Near Nuclear Power Plants" (ADAMS Accession No. ML12170A980), to determine that potential explosions would not have adverse effects on facility operations or prevent a safe shutdown of the facility. SHINE also clarified that potential explosive materials are located at a safe distance from the FSTR and that those that are located closer have an explosion incident rate of 1E-6 per year. SHINE further stated that the externally located liquid nitrogen tanks are designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 to prevent their accidental explosion and fragmentation. The staff finds that these approaches based on the guidance in RG 1.91, Revision 2, and national codes are consistent with NUREG-1537 and, therefore, acceptable.

3.4.4.6 Seismic and External Hazards Damage Evaluation Summary

Based on its review, the NRC staff finds that the applicant used acceptable methods to perform the SSI analyses, assess challenging transient and abnormal loads, and evaluate conditions and external hazards that could challenge the defense-in-depth of the facility and its SSCs. Based on its review, the staff determined that the level of detail provided in the FSAR, as supplemented, regarding damage due to earthquakes, abnormal loads, and internal/external hazards is adequate and supports the final design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 3.4. The staff concludes that the applicant's design criteria and designs would protect against potential seismic or abnormal loads damages and provide reasonable assurance that SSCs would continue to perform their required safety functions, would not cause unsafe facility operation, would not prevent safe shutdown of the facility, and would not cause or allow uncontrolled release of radioactive material. Therefore, the staff finds that the facility design is adequate to cope with postulated seismic or external hazards damages and meets the applicable regulatory requirements and guidance and acceptance criteria for the issuance of an operating license.

3.4.5 Systems and Components

The NRC staff evaluated the sufficiency of the facility design features for systems and components, as described in SHINE FSAR Section 3.5. The staff's review used the guidance and acceptance criteria from Section 3.5, "Systems and Components," of NUREG-1537, Part 2 and the ISG augmenting NUREG-1537, Part 2.

3.4.6 Nitrogen Purge System Structure

SHINE FSAR Section 3.6 discusses the N2PS structure. It addresses design considerations to avert potential damages due to meteorological, water (flooding), and seismic events. Meteorological and water (flooding) related design considerations are addressed in Sections 3.4.2 and 3.4.3 of this SER. Design considerations for seismic damage are discussed below.

The N2PS structure contains a portion of the N2PS system, which is a high-pressure nitrogen gas system. In its response to RAI 3.2-1 (ADAMS Accession No. ML21029A103), SHINE explained that the seismic analysis is based on the equivalent static load method and uses the seismic analysis of FSTR. The seismic loads are calculated using the FSTR grade level in-structure-response spectra with an amplification factor of 1.5.

The NRC staff reviewed the information provided in SHINE FSAR Section 3.6.3 related to seismic damage of the N2PS structure, and finds it acceptable because the equivalent static load method with an amplification factor of 1.5 provides a conservative seismic response and accounts for possible structure-soil-structure interaction effects between the FSTR and the N2PS structure. FSAR Section 9b.6.2.3 describes that the N2PS structure, and the associated supports, are designed to withstand Seismic Class I seismic events. Therefore, the staff finds that the N2PS pipe and high-pressure tube supports are seismically qualified.

3.5 Review Findings

The NRC staff reviewed SHINE's design of SSCs against the applicable regulatory requirements and appropriate regulatory guidance and acceptance criteria. Based on its review of the information in the FSAR and independent confirmatory review, the staff determined that the SHINE facility:

(1) Adequately protects against potential meteorological, water, and seismic or external hazards damages.

(2) Provides reasonable assurance that its SSCs would continue to perform their required safety functions, would not cause unsafe facility operation, and would not prevent safe shutdown of the facility.

(3) Provides adequate levels for defense-in-depth against uncontrolled release of radioactive material to the environment.

Therefore, the issuance of an operating license for the facility would not be inimical to the common defense and security or to the health and safety of the public.

Based on the above determinations, the NRC staff finds that the descriptions and discussions of SHINE's design of SSCs are sufficient and meet the applicable regulatory requirements and guidance and acceptance criteria for the issuance of an operating license.