From:	Lynch, Steven
To:	Jeff Bartelme
Cc:	Casto, Greg; Balazik, Michael
Subject:	Issuance of Request for Additional Information Related to the SHINE Medical Technologies, LLC Operating License Application (EPID No. L-2019-NEW-0004)
Date:	Friday, October 16, 2020 4:41:30 PM
Attachments:	SHINE Chapters 2 3 and 8 Requests for Additional Information.pdf

Jeff,

By letter dated July 17, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19211C044), as supplemented by letters dated November 14, 2019 (ADAMS Accession No. ML19337A275), March 27, 2020 (ADAMS Accession No. ML20105A295), and August 28, 2020 (ADAMS Accession No. ML20255A027), SHINE Medical Technologies, LLC (SHINE) submitted to the U.S. Nuclear Regulatory Commission (NRC) an operating license application for its proposed SHINE Medical Isotope Production Facility in accordance with the requirements contained in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."

During the NRC staff's review of SHINE's operating license application, questions have arisen for which additional information is needed. The enclosed request for additional information (RAI) identifies information needed for the NRC staff to continue its review of the SHINE final safety analysis report (FSAR), submitted as part of the operating license application, and prepare a safety evaluation report. Specific chapters and technical areas of the SHINE operating license application covered by this RAI include the following:

- Chapter 2, "Site Characteristics"
- Chapter 3, "Design of Structures, Systems, and Components"
- Chapter 8, "Electrical Power Systems"

It is requested that SHINE provide responses to the enclosed RAI within 60 days from the date of this electronic mail. In accordance with 10 CFR 50.30(b), "Oath or affirmation," SHINE must execute its response in a signed original document under oath or affirmation. The response must be submitted in accordance with 10 CFR 50.4, "Written communications." Information included in the response that is considered sensitive or proprietary, that SHINE seeks to have withheld from the public, must be marked in accordance with 10 CFR 2.390, "Public inspections, exemptions, requests for withholding." Any information related to safeguards should be submitted in accordance with 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements." Following receipt of the additional information, the NRC staff will continue its evaluation of the subject chapters and technical areas of the SHINE operating license application.

As the NRC staff continues its review of SHINE's operating license application, additional RAIs for other chapters and technical areas may be developed. The NRC staff will transmit any further questions to SHINE under separate correspondence. If you have any questions, or need additional time to respond to this request, please contact me at 301-415-1524, or by electronic mail at Steven.Lynch@nrc.gov.

Steve Lynch, Senior Project Manager
Non-Power Production and Utilization Facility Licensing Branch
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OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ADDITIONAL INFORMATION

REGARDING OPERATING LICENSE APPLICATION FOR

SHINE MEDICAL TECHNOLOGIES, LLC

CONSTRUCTION PERMIT NO. CPMIF-001

SHINE MEDICAL ISOTOPE PRODUCTION FACILITY

DOCKET NO. 50-608

By letter dated July 17, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19211C044), as supplemented by letters dated November 14, 2019 (ADAMS Accession No. ML19337A275), March 27, 2020 (ADAMS Accession No. ML20105A295), and August 28, 2020 (ADAMS Accession No. ML20255A027) SHINE Medical Technologies, LLC (SHINE) submitted to the U.S. Nuclear Regulatory Commission (NRC) an operating license application for its proposed SHINE Medical Isotope Production Facility in accordance with the requirements contained in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."

During the NRC staff's review of the SHINE operating license application, questions have arisen for which additional information is needed. This request for additional information (RAI) identifies information needed for the NRC staff to continue its review of the SHINE final safety analysis report (FSAR), submitted as part of the operating license application, and prepare a safety evaluation report. Specific chapters and technical areas of the SHINE operating license application covered by this RAI include the following:

- Chapter 2, "Site Characteristics"
- Chapter 3, "Design of Structures, Systems, and Components"
- Chapter 8, "Electrical Power Systems"

Applicable Regulatory Requirements and Guidance Documents

The NRC staff is reviewing the SHINE operating license application, which describes the SHINE irradiation facility, including the irradiation units, and radioisotope production facility , using the applicable 10 CFR regulations, as well as the guidance contained in NUREG-1537 Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996 (ADAMS Accession No. ML042430055), and 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 (ADAMS Accession No. ML042430048). The NRC staff is also using the "Final Interim Staff Guidance [ISG] 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 (ADAMS Accession No. ML12156A069), and "Final Interim Staff Guidance [ISG] 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 (ADAMS Accession No. ML12156A075). As applicable, additional guidance cited in SHINE's FSAR or referenced in NUREG-1537, Parts 1 and 2, or the ISG Augmenting NUREG-1537, Parts 1 and 2, has been utilized in the review of the SHINE operating license application.

For the purposes of this review, the term "reactor," as it appears in NUREG-1537, the ISG Augmenting NUREG-1537, and other relevant guidance can be interpreted to refer to SHINE's "irradiation unit," "irradiation facility," or "radioisotope production facility," as appropriate within the context of the application and corresponding with the technology described by SHINE in its application. Similarly, for the purposes of this review, the term "reactor fuel," as it appears in the relevant guidance listed above, may be interpreted to refer to SHINE's "target solution."

Responses to the following request for additional information (RAI) are needed to continue the review of the SHINE operating license application.

Chapter 2 – Site Characteristics

The following regulatory requirement is applicable to RAIs 2.2-1 through 2.4-3:

> Section 50.34(b)(2) of 10 CFR Part 50 requires, in part, that an FSAR include a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements, the bases, 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.

<u>SHINE FSAR Section 2.2, "Nearby Industrial, Transportation, and Military Facilities"</u>

For RAIs 2.2-1 and 2.2-3, the NRC staff requesting additional information to conclude that, consistent with the evaluation findings in Section 2.2 of NUREG-1537, Part 2, SHINE's analyses show that none of the expected manmade facilities could cause damage or other hazards to the SHINE facility sufficient to pose undue radiological risks to the operating staff, the public, or the environment. Consequences of events from nearby facilities are analyzed in or are shown to be bounded by accidents considered in Chapter 13 of the FSAR.

RAI 2.2-1 SHINE analyzed explosive chemicals in FSAR Section 2.2.3.1.1, using NUREG-1537, which states in Section 2.2, "Nearby Industrial, Transportation, and Military Facilities," that the information provided in the application should sufficient to support analyses to evaluate potential manmade hazards to the proposed facility due to nearby facilities.

The analyzed explosive chemicals results are presented in FSAR Tables 2.2-15 and 2.2-16. For an ethylene oxide tanker truck carrying 50,000 pounds (lbs) travelling on Highway 51 at a distance of 0.22 miles (mi.) from the facility, the evaluation is concluded to be acceptable by SHINE because it is bounded by a potential explosion of a storage tank of 44,0000 lbs at a distance of 2 mi. from the facility. The NRC staff, however, finds that the minimum safe (standoff) distance determined for this truck transport (0.54 mi.) exceeds the actual distance of 0.22 mi. from the closest point of roadway to the shortest distance to a safety-related structure at the SHINE Facility.

For propane and hydrogen, SHINE only used an unconfined explosion scenario with yield factor of 0.03. However, there is vapor in the tank that could explode as a confined vapor with a 100% yield factor. The NRC staff's analysis finds that this scenario results in minimum safe distance that exceeds the actual roadway distance of 0.22 mi. for both propane and hydrogen.

(1) Justify and demonstrate how the impact from the oxide tanker truck is bounded by potential explosion of a storage tank impact.

(2) Justify and demonstrate how the confined explosion for propane and hydrogen with a yield factor of 100% is not evaluated.

This information is necessary for the NRC staff to conclude that potential explosions would not cause damage to safety-related equipment at the SHINE facility sufficient to pose undue radiological risks to the SHINE staff, the public, or the environment consistent with the evaluation findings in NUREG-1537, Part 2,

Section 2.2. This information is also necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by an explosion consistent with 10 CFR 50.34(b)(2).

RAI 2.2-2 SHINE evaluated toxic chemicals in FSAR Section 2.2.3.1.3, using NUREG-1537, which states in Section 2.2, that the information provided in the application should be sufficient to support analyses to evaluate potential manmade hazards to the proposed facility due to nearby facilities.

Additionally, SHINE Design Criterion 6, "Control Room," states that "[a] control room is provided from which actions can be taken to operate the irradiation units safely under normal conditions and to perform required operator actions under postulated accident conditions."

In FSAR Section 2.2.3.1.3, SHINE identified four toxic chemicals that were found to be a potential hazard to the control room of the facility, including Ammonia from US 51, Chlorine from I-90/39, Propylene oxide from I90/39, and Sodium bisulfite from US 51.

The NRC staff identified five additional toxic chemicals listed in FSAR Table 2.2-19 that have potential to be hazards to control room habitability, including Ethylene Oxide from US 51, Gasoline from US 51, Vinylidene chloride from rail (1.6 mi), Sodium hypochlorite from I-90/39, and Carbon Monoxide from a stationary source. The concentration of each of these chemicals was found by the NRC staff to exceed the respective IDLH (Immediately Dangerous Life and Health) concentrations of chemicals in the control room[1]. As stated in FSAR Section 2.2.3.1.3, a two-minute exposure to NIOSH IDLH chemical concentration limits could result in uninhabitability of the control room, which could prevent operators from having the necessary time (i.e., two minutes) to take required actions.

Provide additional information to demonstrate that the respective chemical potential concentrations from the five additional toxic chemicals do not exceed the respective chemical limiting IDLH concentrations.

This information is necessary for the NRC staff to conclude that potential toxic chemical exposures would not result in the uninhabitability of the control room and prevent the performance of required operator actions, as specified in SHINE Design Criterion 6. The continued habitability of the control room in the event of a toxic chemical release would further demonstrate that operators would be available to take required actions to ensure that safety-related equipment at the SHINE facility would not be damaged sufficient to pose undue radiological risks to the SHINE staff, the public, or the environment consistent with the evaluation findings in NUREG-1537, Part 2, Section 2.2. This information is also necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be

[1] The National Institute for Occupational Safety and Health (NIOSH) Table of IDLH Values may be found online at https://www.cdc.gov/niosh/idlh/intridl4.html.

potentially impacted by toxic chemicals which could be hazards to control room habitability consistent with 10 CFR 50.34(b)(2).

RAI 2.2-3 In FSAR Section 2.2.3.1.3.4, SHINE addressed the on-site chemical hazards by referencing FSAR Section 13b.3, using NUREG-1537, which states in Section 2.2, "Nearby Industrial, Transportation, and Military Facilities," that the information provided should be sufficient to support analyses to evaluate potential manmade hazards to the proposed facility due to nearby facilities.

Additionally, SHINE Design Criterion 6, "Control Room," states that "[a] control room is provided from which actions can be taken to operate the irradiation units safely under normal conditions and to perform required operator actions under postulated accident conditions."

In FSAR Section 2.2.3.1.3.4, SHINE addressed on-site toxic chemicals by stating that they are evaluated in FSAR Section 13b.3 (see: Table 13b.3-2). SHINE also stated that worker exposures are representative of exposure to control room personnel. Based on the NRC staff review of the SHINE analyses and results, the evaluation methodology used in FSAR Section 13b.3 is different from that used in FSAR Section 2.2.3.1.3. Using a methodology consistent with that used in FSAR Section 2.2.3.1.2 (i.e., wind speed of 1m/s and Pasquill stability class F; use of IDLH concentration as limiting value), the NRC staff finds the chemicals Ammonia, Nitric acid, Sodium hydroxide could be a potential hazard to control room habitability as each of chemical concentration exceed respective chemical IDLH concentration. As stated in FSAR Section 2.2.3.1.3, a two-minute exposure to NIOSH IDLH chemical concentration limits could result in uninhabitability of the control room, which could prevent operators from having the necessary time (i.e., two minutes) to take required actions.

Provide information to justify in using average meteorological conditions as opposed to 1 m/s wind speed and F stability (representative of 5% percentile met conditions used conservatively), for the analysis and considering worker exposures representative to the control room operators.

This information is necessary for the NRC staff to conclude that potential toxic chemical exposures would not result in the uninhabitability of the control room and prevent the performance of required operator actions, as specified in SHINE Design Criterion 6. The continued habitability of the control room in the event of a toxic chemical release would further demonstrate that operators would be available to take required actions to ensure that safety-related equipment at the SHINE facility would not be damaged sufficient to pose undue radiological risks to the SHINE staff, the public, or the environment consistent with the evaluation findings in NUREG-1537, Part 2, Section 2.2. This information is also necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by toxic chemicals which could be hazards to control room habitability consistent with 10 CFR 50.34(b)(2).

SHINE FSAR Section 2.4, "Hydrology"

RAI 2.4-1 The evaluation findings in NUREG-1537, Part 2, Section 2.4 state that the information provided by an applicant should be sufficient to support a finding that hydrologic events of credible frequency and consequence have been considered for the site. Additionally, credible hydrologic events have been considered in the development of the design bases for the facility to mitigate or avoid significant damage so that safe operation and shutdown of the facility would not be precluded by a hydrologic event.

Additionally, SHINE Design Criterion 2, "Natural Phenomena Hazards," states that "[t]he facility structure supports and protects safety-related SSCs and is designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches as necessary to prevent the loss of capability of safety-related SSCs to perform their safety functions."

Section 2.4.2.3, "Effect of Local Intense Precipitation (LIP)," of the SHINE FSAR states that the site is designed to withstand the effects of "a local probable maximum precipitation (PMP) 100-year event," and that "the maximum water levels due to local PMP were determined near the safety-related structures of the facilities."

The NRC staff notes that SHINE uses the 1-in-100-year rainfall event in its LIP flood analysis to evaluate the effects of onsite flooding. The World Meteorological Organization (WMO) defines "probable maximum precipitation" as "the greatest depth of precipitation for a given duration meteorologically possible for a design watershed or a given storm area at a particular time of year." PMP depth in general is larger than that of 1-in-100-year rainfall. However, it is unclear to the NRC whether SHINE is applying this WMO definition of PMP to its LIP flood analysis and how this relates to a 1-in-100-year rainfall event.

Confirm the definition of PMP SHINE uses in its LIP flood analysis and describe how this relates to a 1-in-100-year rainfall event. Revise FSAR Section 2.4.2.3 and Table 2.4-7, as necessary to reflect SHINE's definition of PMP.

This information is necessary for the NRC staff to confirm that the SHINE facility is designed to withstand the effects of floods to prevent the loss of capability of safety-related SSCs to perform their safety-related functions, consistent with SHINE Design Criterion 2. This information is also necessary for the NRC staff to conclude that no credible predicted hydrologic event or condition would render the SHINE site unsuitable for operation or safe shutdown of the facility, consistent with the evaluation findings in NUREG-1537, Part 2, Section 2.4. Additionally, this information is necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by floods consistent with 10 CFR 50.34(b)(2).

RAI 2.4-2 The evaluation findings in NUREG-1537, Part 2, Section 2.4 state that the information provided by an applicant should be sufficient to support a finding that hydrologic events of credible frequency and consequence have been considered for the site. Additionally, credible hydrologic events have been considered in the

development of the design bases for the facility to mitigate or avoid significant damage so that safe operation and shutdown of the facility would not be precluded by a hydrologic event.

Additionally, SHINE Design Criterion 2, “Natural Phenomena Hazards,” states that “[t]he facility structure supports and protects safety-related SSCs and is designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches as necessary to prevent the loss of capability of safety-related SSCs to perform their safety functions.”

Section 2.4.2.3, “Effect of Local Intense Precipitation (LIP)” of the SHINE FSAR describes a drainage system designed to carry onsite and offsite runoffs generated from a 100-year frequency rainfall event. FSAR Figure 2.4-11 displays the elevation contour lines for the post construction ground surface condition and the boundary of offsite drainage basin. FSAR Figure 2.4-12 shows the drainage boundaries for onsite sub-basins with the direction of local runoffs. However, the resolution of these contour lines is not sufficient to allow the staff to determine the adequacy of basin/sub-basin boundaries and the direction of runoffs, especially the runoffs from the offsite area east to the Onsite Sub-basin Numbers 6 and 9.

To support the NRC staff’s understanding of whether SHINE has adequately considered the onsite and offsite drainage pattern in their LIP flood analysis, provide a higher-resolution map or maps showing detailed elevation contour lines for the post-construction ground surface condition with best available data, particularly at critical off-site areas that may govern the runoff process.

This information is necessary for the NRC staff to confirm that the SHINE facility is designed to withstand the effects of floods to prevent the loss of capability of safety-related SSCs to perform their safety-related functions, consistent with SHINE Design Criterion 2. This information is also necessary for the NRC staff to conclude that no credible predicted hydrologic event or condition would render the SHINE site unsuitable for operation or safe shutdown of the facility, consistent with the evaluation findings in NUREG-1537, Part 2, Section 2.4. Additionally, this information is necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by floods consistent with 10 CFR 50.34(b)(2).

Chapter 3 – Design of Structures, Systems, and Components

The following regulatory requirement is applicable to RAIs 3.2-1 through 3.4-18:

> Section 50.34(b)(2) of 10 CFR Part 50 requires, in part, that an FSAR include a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements, the bases, 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.

The following considerations from NUREG-1537 are applicable to RAIs 3.2-1 through 3.4-18:

> Chapter 3, "Design of Structures, Systems, and Components," of NUREG-1537, Part 1, and the corresponding ISG Augmenting NUREG-1537, state in part that:
>
> > The material presented [in the Final Safety Analysis Report - SHINE OLA] **should** emphasize the safety and protective functions and related design features that help provide defense-in-depth against uncontrolled release of radioactive material. The bases for the design criteria for some of the systems discussed in this chapter may be developed in other chapters and should be appropriately cross referenced […F]acility and system design **must** be based on defense-in-depth practices. Defense-in-depth practices means a design philosophy, applied from the outset and through completion of the design, that is based on providing successive levels of protection such that health and safety will not be wholly dependent upon any single element of the design, construction, maintenance, or operation of the facility. The net effect of incorporating defense-in-depth practices is a conservatively designed facility and system that will exhibit greater tolerance to failures and external challenges.
>
> The NRC staff evaluates the adequacy of design criteria for all SSCs that have been identified to perform an operational or safety function by using the guidance and acceptance criteria described in Chapter 3 of NUREG-1537, Part 2, and the ISG Augmenting NUREG-1537. Consistent with the guidance of Chapter 3 of NUREG-1537, all safety-related SSCs that could suffer effects of natural and "man-made" phenomena are reviewed and evaluated for adequacy such that there is a reasonable assurance that they would continue to perform their safety and protective functions so that, as noted in NUREG-1537, Part 1, a defense-in-depth "against uncontrolled release of radioactive material is maintained."

SHINE FSAR Section 3.2, "Meteorological Damage"

RAI 3.2-1 The NRC staff reviewed the design criteria for the N2PS system as documented in DCD-N2PS-0001, Revision 1. This document describes the N2PS system as a safety-related system that is required for safe shutdown of the facility after a loss of offsite power or station blackout, and it establishes, in part, that SHINE's design criteria for natural phenomena hazards, Criterion 2, is applicable to the N2PS system. The document also describes the N2PS structure as a structure that supports and protects safety-related SSCs, and states that it is designed to withstand the effects of natural phenomena such as earthquakes, tornadoes,

hurricanes, floods, tsunami, and seiches as necessary to prevent the loss of capability of safety-related SSCs protected by the structure.

Based on the review of Chapter 3 of the FSAR, it is not clear where the design criteria and parameters for other structures not physically part of the main production facility structure are discussed in the FSAR. The staff notes that design criteria and parameters discussed under Chapter 3 are focused on the main production facility structure and do not clearly identify or discuss the design criteria and parameters applicable to other SSCs that perform an operational or safety function (e.g., N2PS structure). In addition, the staff also noted that Section 3.4.2.6.1 describes the SHINE facility as a boxtype shear wall system of reinforced concrete, which refers to the main production facility structure. However, this description contradicts the description provided in Section 1.4 for the SHINE facility. Therefore, it is not clear what structure(s) are being considered (or need to be considered) in Chapter 3 of the FSAR.

To clarify the issues described above provide the following information, updating the FSAR as necessary:

For each structure identified in FSAR Section 1.4 (i.e., resource building material staging building; storage building; and N2PS structure) that is not part of the main production facility structure and performs, supports, and/or protects a safety function address the following:

(1) Specify the applicable SHINE design criteria(s);

(2) Describe the criteria, parameters and methodology used for its design to ensure that protected safety-related SSCs can withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches (i.e., SHINE Design Criterion 2).

This information is necessary for the NRC staff to conclude that the design bases to protect against meteorological damage provides reasonable assurance that the facility structures, systems, and components will perform the safety functions discussed in the FSAR, consistent with the evaluation findings of Section 3.2, "Meteorological Damage," of NUREG-1537, Part 2. Additionally, this information is necessary for the NRC staff to conclude that SHINE is satisfying its Design Criterion 2, which states that "[t]he facility structure supports and protects safety-related SSCs and is designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches as necessary to prevent the loss of capability of safety-related SSCs to perform their safety functions." Further, this information is necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by the effects of natural phenomena consistent with 10 CFR 50.34(b)(2).

RAI 3.2-2 Based on the review of Section 3.2 of the FSAR, it is noted that some of the design criteria/parameters used for the SHINE facility are not sufficiently described in the FSAR to make a safety determination. Specifically, the following design criteria/parameters require further clarification:

- Section 3.2.1, “Wind Loading,” defines equation no. 3.2-1 as the equation used to transform the wind speed into an equivalent pressure, however the values applicable to the site for exposure coefficient and other factors used in the equation were not defined in the FSAR. In addition, the values applicable to the site for the referenced gust factor and pressure coefficient were not defined in the FSAR.

- Section 3.2.1, “Wind Loading,” defines “V” as the basic wind speed (3 second gust) obtained from Figure 61 of ASCE 705 for Wisconsin. However, additional clarification is needed because the ASCE figure provides wind speed for a 50-year return period which is not consistent with the mean recurrence interval of 100 years intended for the design of the SHINE Facility, as identified in FSAR Section 3.2.1.1.

- Section 3.2.2, “Tornado Loading,” states that the design parameters are listed in Table 1 of NRC Regulatory Guide 1.76, however the values applicable to the site for the tornado rotational speed, translation speed, radius of maximum rotation, pressure drop, and rate of pressure drop were not defined in the FSAR. Similarly, Table 2 of NRC Regulatory Guide 1.76 was referenced for the applicable design basis tornado missile spectrum and maximum horizontal speed for the site, however these values were also not defined in the FSAR.

- Section 3.2.3, “Snow, Ice, and Rain Loading,” references Chapter 7 of the ASCE7-05 standards as the applicable design parameter to the SHINE Facility, however it does not specify the snow load, recurrence interval and safety factor applicable to the site. Also, the section defines equation no. 3.2-3 as the equation used to determine the applied forces, however the values applicable to the site for the factors used in the equation were not defined in the FSAR.

For those design criteria and parameters described above, provide the applicable values for the site as considered for in the design of the SHINE facility to cope with meteorological damage. Update the FSAR as necessary.

This information is necessary for the NRC staff to conclude that the design bases to protect against meteorological damage provides reasonable assurance that the facility structures, systems, and components will perform the safety functions discussed in the FSAR, consistent with the evaluation findings of Section 3.2 of NUREG-1537, Part 2. Additionally, this information is necessary for the NRC staff to conclude that SHINE is satisfying its Design Criterion 2. Further, this information is necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by the effects of natural phenomena consistent with 10 CFR 50.34(b)(2).

RAI 3.2-3 The staff evaluates the adequacy of the design criteria of all SSCs that have been identified to perform an operational or safety function by using the guidance and acceptance criteria described in Chapter 3, “Design of Structures, System, and Components,” of NUREG-1537, Parts 1 and 2. Specifically, Section 3.2 of

Part 2 instructs the staff, in part, to ensure that the information provided on meteorological damage include the design criteria and design to provides reasonable assurance that SSCs would continue to perform the safety function under potential meteorological damage conditions.

Section 3.2.2.2 of the FSAR states that the procedure used for transforming the tornado generated missile impact into an effective or equivalent static load on the structures is consistent with Section 3.5.2, Subsection II, of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants."

However, based on the NRC staff's review of Section 3.2.2.2 of the FSAR, it is not clear what procedure or criteria were followed to transform the tornado generated missile impact into an effective or equivalent static load on the structures because Section 3.5.2, Subsection II, of NUREG-0800 does not define a procedure or criteria for transforming tornado generated missile impact into an effective or equivalent static load.

Describe the methodology or procedure used for transforming tornado generated missile impact into an effective or equivalent static load on the structures, and state how it is acceptable to ensure that safety-related SSCs are protected from tornado generated impacts in accordance with SHINE Design Criteria 2 and 4. Update the FSAR as necessary.

This information is necessary for the NRC staff to conclude that the design bases to protect against meteorological damage provides reasonable assurance that the facility structures, systems, and components will perform the safety functions discussed in the FSAR, consistent with the evaluation findings of Section 3.2 of NUREG-1537, Part 2. Additionally, this information is necessary for the NRC staff to conclude that SHINE is satisfying its Design Criteria 2 and 4. Further, this information is necessary to demonstrate that SHINE has performed the appropriate evaluations required to show that safety functions will be accomplished by equipment that would be potentially impacted by the effects of natural phenomena consistent with 10 CFR 50.34(b)(2).

<u>SHINE FSAR Section 3.3, "Water Damage"</u>

RAI 3.3-1 Section 3.3 of NUREG-1537, Part 2, notes that facility designs should provide reasonable assurance that structures, systems, and components will continue to perform required safety functions under water damage conditions.

- FSAR Section 3.3 notes that the bounding internal flood is due to fire protection and that it will result in a maximum depth of water in the radiologically controlled area (RCA) of 2 inches. The FSAR further notes that water sensitive safety-related equipment is raised 8 inches from the floor; however, Table 9-1 in calculation CALC-2020-0001 summarizes water depths in the RCA during manual fire suppression and notes values greater than 8 inches. The NRC staff notes that internal flood levels in excess of 8 inches could damage and impact the performance of water-sensitive safety-related equipment.

- CALC-2020-0001 identifies internal flood water depths in the radioisotope process facility cooling system (RPCS) room based on breaks in either the RPCS or process chilled water system (PCHS) line in the RPCS room. The calculation further notes that these water depths are not a concern because the RPCS room has an appropriately sized manual flood barrier.

(1) Explain how water-sensitive safety-related equipment in the RCA will be protected from internal flood waters that may rise above 8 inches. Update the FSAR, as necessary.

(2) Explain how water-sensitive safety-related equipment within the RPCS room will be protected from water that rises to the depths identified in CALC-2020-0001. If the manual flood barrier is being relied on to keep RPCS or PCHS leakage from leaving the RPCS room, explain how it is ensured that the barrier will be in place if there is an accident. Update the FSAR, as necessary.

Consistent with the evaluation findings in NUREG-1537, Part 2, Section 3.3 and 10 CFR 50.34(b)(2), the this information is requested for the NRC staff to conclude that the design bases of the SHINE facility protects against potential hydrological damage and provides reasonable assurance that the facility structures, systems, and components (SSCs) will perform the functions necessary to allow any required operation to continue safely, to allow safe shutdown, and to protect the health and safety of the public from radioactive materials and radiation exposure.

RAI 3.3-2

Section 3.3 of NUREG-1537, Part 2, notes that facility designs should provide reasonable assurance that structures, systems, and components will continue to perform required safety-related functions under water damage conditions.

FSAR Section 3.3.1.1.2 notes 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 fire protection system (FPS). However, the FSAR does not discuss how other water-sensitive safety-related equipment in the RCA is protected from damage due to discharge of the FPS.

Explain how safety-related, water sensitive equipment in the RCA is protected from damage due to discharge of the FPS. Update the FSAR, as necessary.

Consistent with the evaluation findings in NUREG-1537, Part 2, Section 3.3 and 10 CFR 50.34(b)(2), the this information is requested for the NRC staff to conclude that the design bases of the SHINE facility protects against potential hydrological damage and provides reasonable assurance that the facility SSCs will perform the functions necessary to allow any required operation to continue safely, to allow safe shutdown, and to protect the health and safety of the public from radioactive materials and radiation exposure.

SHINE FSAR Section 3.4, "Seismic Damage"

For RAIs 3.4-1 through 3.4-11 and RAIs 3.4-13 through 3.4-16, the NRC staff is requesting additional information to conclude the following, consistent with the evaluation findings in Section 3.4, "Seismic Damage," of NUREG-1537, Part 2:

- The SHINE facility has been designed to protect against seismic damage;
- There is reasonable assurance that the facility structures, systems, and components (SSCs) will perform the necessary safety functions described and analyzed in the SHINE FSAR; and
- There is reasonable assurance that the consequences of credible seismic events at the facility are considered (or bounded) by the results of the accident analysis, ensuring acceptable protection of the public health and safety.

RAI 3.4-1 In FSAR Section 3.4.1, "Seismic Input," SHINE discusses how the design time histories for the seismic analysis of the SHINE facility structures (FSTR) are generated and states that the structural damping values for various structural elements used in the seismic analysis are provided in Section 1.1 of Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," Revision 1. The applicant further states that, in the modal analysis of structures composed of different materials (having different damping values), the composite modal damping is calculated using either the stiffness-weighted method or mass-weighted method based on NUREG-0800, SRP Section 3.7.2. In FSAR Section 3.4.2.2, "Soil-Structure Interaction Analysis," SHINE discusses three bounding soil properties (best estimate (BE), upper bound (UB), and lower bound (LB)) used in the seismic analysis of the FSTR accounting for potential variations in in-situ and backfill soil conditions around the building. However, the staff notes that SHINE did not provide actual numerical data for these input parameters used in the seismic analysis of the FSTR. This information is important for the staff to assess the adequacy of the input used in the seismic analysis of the FSTR. Therefore, SHINE is requested to provide the following information, updating the FSAR with a summary of results, as necessary:

(1) Numerical data (in figures or tabular form) for the input ground motion time histories used in the seismic analysis of the FSTR. Also, a comparison of the response spectra obtained from the input ground motion time histories with the target design response spectra (i.e., the Safe Shutdown Earthquake or SSE), demonstrating that the enveloping criteria of NUREG-0800, SRP 3.7.1 are satisfied, as applicable.

(2) Critical damping values used for various structural elements (or element groups) and the composite modal damping method used in the seismic analysis of the FSTR.

(3) Numerical data (in figures or tabular form) for the three bounding soil columns (BE, UB, and LB) used in the seismic analysis of the FSTR.

RAI 3.4-2 In FSAR Section 3.4.2.1, “Seismic Analysis Methods,” SHINE discusses the general equations of motion and the finite element model used for the seismic analysis of the FSTR. However, the staff notes that SHINE did not specifically identify the seismic analysis methods used in the seismic analysis of the FSTR. In FSAR Section 3.4.2.1, the applicant also indicates that the finite element model consists of shell, solid, beam, or a combination of these elements. In FSAR Section 3.4.2.2, the applicant explains that shell elements are used to represent concrete slabs and walls and beam elements to represent steel members; however, the applicant did not explain how the solid elements are used. Therefore, SHINE is requested to address the following and update the FSAR as appropriate:

(1) Identify and describe in the FSAR the seismic analysis methods (e.g., response spectrum method, time history method, equivalent static load method, etc.) used in the seismic analysis of the FSTR.

(2) Update the FSAR by describing the usage of solid elements in finite element discretization of the soil-structure interactive system for the safety-related SSCs of the SHINE facility.

RAI 3.4-3 In FSAR Section 3.4.2.2, “Soil-Structure Interaction Analysis,” the applicant states that, in addition to self-weight of the structure, floor loads and equipment loads are converted to mass and included in the model and that a portion of the loads are considered mass sources in the following manner according to NUREG-0800, SRP Section 3.7.2: Dead Load - 100 percent; Live Load - 25 percent; Snow Load - 75 percent. The staff notes Acceptance Criteria 3.D of SRP Section 3.7.2 states, in part, that “In addition to the structural mass, mass equivalent to a floor load of 50 pounds per square foot should be included, to represent miscellaneous dead weights such as minor equipment, piping, and raceways. Also, mass equivalent to 25 percent of the floor design live load and 75 percent of the roof design snow load, as applicable, should be included.” In view of these SRP acceptance criteria, it appears that the applicant did not consider the mass equivalent to a floor load of 50 pounds per square foot to represent miscellaneous dead weights on the floor. The staff also notes that FSAR Section 3.4.2.6.4.5 addresses this topic but includes two additional items in the bulleted list there: “Parked Crane Load - 100 percent; Hydrodynamic Load - 100 percent”. Therefore, the applicant is requested to address the following questions and update the FSAR as appropriate:

(1) Explain whether the mass equivalent to a floor load of 50 pounds per square foot to represent miscellaneous dead weights on the floor is considered in the seismic analysis of the FSTR; if not, provide justification for not considering it.

(2) Explain an apparent discrepancy between FSAR Sections 3.4.2.2 and 3.4.2.6.4.5 in the information about percentages of the loads considered as mass sources in the seismic analysis of the FSTR.

RAI 3.4-4 In FSAR Section 3.4.2.4, “Seismic Analysis Results,” the applicant discusses seismic loads for structural design and in-structure response spectra for sizing equipment and components. However, the staff notes that the applicant did not include analysis results (in tabular form or figures) which provide design-basis

demands for the seismic design of the FSTR and seismic qualification of safety-related equipment. Further, the staff notes SHINE's creation of an item in the Issues Management Report (IMR; documented in NUREG-2189, "Safety Evaluation Report related to SHINE Construction Permit Application") System, which is associated with RAI 3.4-1 from the staff's construction permit application review. This IMR item, which tracks "the inclusion of the final seismic analysis results into the FSAR", is an applicant's regulatory commitment and the staff verifies its implementation during the review of the SHINE Operating License (OL) application. However, the staff notes that final seismic analysis results for the FSTR are not included in FSAR Section 3.4.2.4 or any other location in the FSAR.

Therefore, update the SHINE FSAR by including final results from the seismic analysis of the FSTR, such as element forces and moments, nodal accelerations, seismic soil pressures, in-structure response spectra, and any other response quantities as appropriate, for representative structural elements and at key equipment locations.

RAI 3.4-5 In FSAR Section 3.4.2.5, "Assessment of Structural Seismic Stability," the applicant states that the seismic stability of the SHINE facility is evaluated for sliding and overturning considering the load combinations and factors of safety in accordance with American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) Standard 43-05 and NUREG-0800, SRP Section 3.8.5. However, the staff notes that the applicant did not provide a summary of the results or conclusions of such evaluation, which are needed for the staff to make its safety findings with respect to the stability of the SHINE facility structures during the design-basis earthquake.

Therefore, provide in the FSAR a summary of the results or conclusions from the applicant's seismic stability assessment of the SHINE facility structures.

RAI 3.4-6 Section 3.4.2.6.3.1, "Soil Parameters," of the SHINE operating license application does not include all necessary parameters and does not provide sufficient information regarding the stability of the foundations and subsurface materials for the SHINE facility for NRC staff to confirm the acceptability of the site. The section provided some soil parameters that were used in a soil-structure interaction (SSI) analysis, such as the minimum average shear wave velocity, minimum unit weight, and Poisson's ratio. It also provided other parameters, such as net allowable static bearing pressure at 3 feet below grade and net allowable static bearing pressure at 17 feet below grade. However, the soil parameters necessary for the use of an SSI analysis and foundation stability assessment do not include information on how these net allowable static bearing pressures were determined. In addition, there are no details on the safety-related foundation settlements (total and differential settlements) evaluation.

In order for the NRC staff to determine whether SHINE has adequately evaluated the stability of the foundations and subsurface materials for SHINE facility, update the application to provide information on allowable soil bearing capacities at designated elevations and allowable settlements (i.e., total and differential settlements) for the specific designed structures, and a comparison of maximum structural foundation responses with soil/foundation capacities (e.g. maximum

foundation pressure vs. allowable soil bearing capacity, maximum foundation settlements vs allowable settlements).

RAI 3.4-7 Section 3.4, "Seismic Damage," of NUREG-1537 Parts 1 and 2, as well as the ISG Augmenting NUREG-1537, state that seismic design for non-power reactors should, at a minimum, be consistent with local building codes and other applicable standards to provide assurance that significant damage to the facility and associated safety functions is unlikely.

Section 2.5.5.3, "2015 International Building Code Seismic Design Ground Motion Parameters," of the SHINE operating license application (OLA) references the International Building Code (IBC) of the International Code Council (ICC) and the American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) 7, "Minimum Design Loads for Buildings and Other Structures." The local building code Wisconsin Administrative Code for Safety and Professional Services (SPS), Chapter 362, "Building and Structures," also references ASCE/SEI 7 and IBC for the design of building and structures.

Section 3.4 of the SHINE OLA, however, supplements the requirements listed in the above local and national codes and standards for the design of the main production facility structure (FSTR) and its safety-related SSCs with IAEA-TECDOC-1347, "Consideration of External Events [EE] in the Design of Nuclear Facilities other than Nuclear Power Plants, with Emphasis on Earthquakes," for "seismic analysis criteria [and…] generic requirements and guidance for the seismic design of nuclear facilities other than nuclear power plants." Section 3.4 also references additional national codes and standards, as well as regulatory guides (RGs) and nuclear regulatory reports (NUREGs) used in the structural design of the FSTR and its SSCs.

The staff reviewed IAEA-TECDOC-1347, but was not clear whether the applicant has used its generic requirements to supplement or replace requirements imposed by IBC and/or ASCE/SEI 7-05 referenced in SPS 362 or other pertinent local and national building codes for the overall design, including seismic design, of FSTR and its SSCs. It also was not clear to the NRC staff to what extent the guidance of IAEA-TECDOC-1347 was used in lieu of that contained in the referenced NRC RGs and NUREGs.

Clarify to what extent IAEA-TECDOC-1347 has been used in the analysis and design, including seismic design, of the FSTR and its SSCs. If it was used in lieu of the SHINE OLA referenced RGs and NUREGs or to supplement requirements delineated in local building codes, such as SPS 362 or other local and national codes standards, state where. Update the FSAR, as appropriate.

RAI 3.4-8 Section 3.4, "Seismic Damage," of the SHINE OLA states that the FSTR includes "the irradiation facility (IF), the radioisotope production facility (RPF), the non-radiologically controlled seismic area, and a non-safety-related area." The Section succinctly describes the FSTR to be built as a reinforced concrete box shear wall system on soil, with a mezzanine floor, and a roof slab supported by steel trusses. The FSTR design includes SSCs such as a tall exhaust stack, below grade reinforced concrete vaults, tanks, and supercell(s). Additional details for FSTR SSCs can be found, for example, in:

- Section 1.2.1, “Consequences from the Operation and Use of the Facility,” for internal structures including supercells.

- Section 2.1.1.2, “Boundary and Zone Area Maps,” for the free-standing exhaust stack to discharge filtered air (e.g., see Chapters 4, 6, 7, 9, 11, 13) to the atmosphere.

- Section 3.4.2.6.4.1, “Dead Load,” for precast tanks in radioisotope production facility (RPF) vaults.

- Section 4b.2.2.2, “Geometry and Configuration,” for pits, trenches, and cover plugs.

- Tables 7.7-2 and 7.7-3 of the SHINE OLA, “Radiation Area Monitor Locations” and “Continuous Airborne Monitor Locations,” respectively, for the facility mezzanine “safety-related area.”

Section 3.4, “Seismic Damage,” of the SHINE OLA also references IAEA-TECDOC-1347, “Consideration of External Events in the Design of Nuclear Facilities other than Nuclear Power Plants, with Emphasis on Earthquakes.” Chapter 6, “Building Design,” of IAEA-TECDOC-1347 provides “seismic analysis criteria [and…] generic requirements and guidance for the seismic design.” In part, it states:

> Inverted pendulum structures are not allowed for EEC1 [External Event Class 1 safety structures which during and after an external event interact with other safety related SSCs] in the structures […] Precast panels (or other prefabricated elements) need to be connected in such a way that they behave as an integral unit during an earthquake.

Some non-structural elements may affect the dynamic behavior of the structure and its capacity. It is typically the case of masonry filling in framed reinforced concrete structures which can lead to shear damage (and rupture) of the so called ‘short column’ configuration. In the case of design of new buildings, this solution needs to be avoided.

The TECDOC also states, in part, that the probability of an EE to generate a radiological consequence depends on characteristics of the facility and the EE, particularly “for facilities subjected to frequent configuration and layout changes (such as activities associated to new product developments).”

Section 3.4 of the SHINE OLA provides limited information to assess the adequacy of structural design of the FSTR and its structural safety significant SSCs (or non-safety SSCs that could affect those that are safety related) so that a reasonable assurance for safety determination can be made. It does not state how these structural SSCs are integrated in the FSTR seismic design to provide a defense-in-depth against radiological release and to provide reasonable

assurance that significant damage to the facility and associated safety functions is unlikely.

As noted in IAEA-TECDOC-1347, the probability of the FSTR to generate a radiological consequence depends on characteristics of the facility and the EE, particularly “for facilities subjected to frequent configuration and layout changes (such as activities associated to new product developments).” It is not clear how structural design changes at the FSTR and its SSCs during plant operation would be assessed for regulatory compliance.

The SHINE OLA does not state what specific construction materials (e.g., ASTM designations, their yield/compressive/tensile strengths, etc.) have been used in the current design configuration, including seismic design, for the construction of the FSTR and its safety-related SSCs and how future configuration changes will be controlled. It is not clear whether adequate safety margins were introduced to accommodate structural alterations/configuration changes during facility operation so that defense-in-depth will be maintained for potential new configurations.

Additionally, it is not clear whether, in the current design configuration, the exhaust stack is designed as an isolated self-supporting cantilever structure or one framed/anchored in part or in whole into the FSTR. It is also not clear what specific materials have been selected for its construction. It is not clear whether the stack is designed as a cast in place/precast concrete structure, a steel framed cantilever structure, or a composite structure to resist seismic forces. In addition, it is not clear whether and how the identified precast tanks, supercells, cover plugs are integrated in the current design configuration of the FSTR to sustain abnormal loads (seismic, aircraft impact, blast effects). Furthermore, it is not clear to what extent masonry structures have been used in the design of the SHINE facility and if so, whether they are safety related and further integrated within the FSTR seismic design. Similar arguments are made for the FSTR safety related area of mezzanine floor, referenced in Table 7.7-3, of the SHINE OLA, and its ability as a diaphragm to carry loads and distribute seismic forces.

(1) Clarify how future configuration/layout changes, if any, to the FSTR and (safety/non-safety affecting safety) SSCs noted above for activities associated with process/product developments will be controlled.

(2) Provide a complete description of the current FSTR and aforementioned SSCs’ configuration that includes descriptions and locations of the exhaust stack, precast tanks, supercells, cover plugs, and masonry structures. Include in the description information such as the dimensions of major safety related structural components and structural materials used in their design/construction and how they were integrated in the overall FSTR design to resist seismic, aircraft impact, and blast loads.

(3) For non-safety structural components that could affect a safety function that are not integrated in the overall structural design of the FSTR, describe their capacity to resist seismic, aircraft impact, and blast loads without undue risk to health and safety of the public and damage to the environment.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-9 Section 3.4.2.1, “Seismic Analysis Methods,” of the SHINE OLA states that the finite element analysis (FEA) methodology was used as part of the facility seismic analysis. It also states that “the finite element model consists of plate/shell, solid, beam, or a combination of finite elements.” Section 3.4.2.2, “Soil-Structure Interaction (SSI) Analysis,” of the SHINE OLA, however, states that the FEA “model uses thick shell elements to represent concrete slabs and walls, and beam elements to represent steel members, mostly comprising the truss components in the facility.” Section 3.3.1.1.2, “Flood Protection from Internal Sources,” of the SHINE OLA states that the light water pool is approximately 4 feet thick.

The SRP acceptance criteria to NUREG-0800, Section 3.7.2, “Seismic System Analysis,” referenced by the applicant in section 3.4.2.1 as guidance to FEA modeling, identify finite element modeling as a method acceptable to the NRC for seismic analysis, and states:

> The type of finite element used for modeling a structural system should depend on the structural details, the purpose of the analysis, and the theoretical formulation upon which the element is based. The mathematical discretization of the structure should consider the effect of element size, shape, and aspect ratio on solution accuracy. The element mesh size should be selected on the basis that further refinement has only a negligible effect on the solution results […] In general, three-dimensional models should be used for seismic analyses.

However, simpler models can be used if justification can be provided that the coupling effects of those degrees of freedom that are omitted from the three-dimensional models are not significant […] The effects of concrete cracking on membrane, bending, and shear stiffness should be considered as appropriate in the mathematical model. Because the effect of cracking on the stiffness of concrete members is complex and depends on a number of factors, the approach used should be shown to be conservative.

As noted in NUREG-0800, there are distinct differences in the mathematical formulation of finite elements. Element selection and discretization of the structural domain (modeling of structure) should be made to fit the characteristics of the structure and the loading conditions.

It is not clear where solid elements are used in the finite element analysis model of the soil and of the structure. It is also not clear whether the “simpler” modeling of concrete structural components (e.g., walls/slabs) with plate/shell elements is adequate for analyses of field effects (e.g., distribution of internal forces, damage, cracking, reduction in overall FSTR structural stiffness) due to seismic, aircraft impact, and blast loads. In addition, it is not clear whether the same model was sufficiently discretized to capture the salient features of applied loads due to seismic, aircraft impact, and blast effects.

(1) Discuss the discretized FEA model and elements used (including solid elements) in the analysis of the FSTR, its connected structures, foundations, and elastic half-space to predict field quantities (forces/stresses, moments) including deformation, cracking, damage, consistent with Section 3.7.2 of NUREG-0800.

(2) Justify where the approach departs from Section 3.7.2 of NUREG-0800, and if so, whether it aligns with broadly accepted engineering practices.

(3) State whether the same FEA model was used for seismic, aircraft impact, and blast effects analyses. If so, justify the FEA model sufficiency to capture the salient effects for each of the applied loads.

Update the FSAR as appropriate to reflect the above clarifications and justifications.

RAI 3.4-10 Section 3.4.2.6.2, "Applicable Codes and Standards," of the SHINE OLA states that SHINE designed the FSTR consistent with the national code/standard ACI 349-13, "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary."

Consistent with NRC RG 1.69, Revision 1, "Concrete Radiation Shields and Generic Shield Testing for Nuclear Power Plants," Section 4a2.5.4.1.6, "Exceptions for Use of ACI 349-13," of the SHINE OLA itemizes several exceptions to ACI 349-13. For the exception taken to Section 5.6.2.3 of ACI 349-13, the application states that Regulatory Position 5 of Revision 2 to NRC Regulatory Guide (RG) 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)" for concrete strength testing is used.

The NRC endorses national codes and standards, such ACI 349, through regulatory guides and enhances the performance of standards with certain provisions/regulatory positions so that defense-in-depth is maintained in the design of applicable nuclear facilities. Regulatory Guide 1.142, in addition to the enhancement for concrete strength testing that the applicant chose to follow, also provides guidance as regulatory positions, to further strengthen the code philosophy that design of nuclear facility structures other than reactors have an increased capacity to function as a direct barrier or support a direct barrier against the release of radioactivity to the atmosphere for code addressed loads and loading conditions.

RG 1.142, Revision 2, endorses ACI-349-97, "Code Requirements for Nuclear Safety Related Concrete Structures," and provides additional guidance to licensees and applicants through regulatory positions on methods acceptable to the NRC staff for complying with the NRC's regulations in the design, evaluation, and quality assurance of safety-related nuclear concrete structures.

It is not clear whether sections of ACI 349-13, other than those itemized in Section 4a2.5.4.1.6 of the FSAR, as modified or considered inapplicable to the FSTR concrete structural design (e.g., loading combinations, load factors, seismic detailing) are consistent with the NRC philosophy for defense-in-depth

promulgated in RG 1.142 and review and acceptance procedures of NUREG-1537. It is not clear whether regulatory positions in Revision 2 to RG 1.142 are included in the design of the FSTR so that facility defense-in-depth can be maintained for seismic, aircraft impact, blast loading designs.

(1) State whether any modifications and/or exceptions taken to ACI 349-13 (other than those itemized in Section 4a2.5.4.1.6 of the FSAR) for the design of the FSTR and its associated concrete SSCs..

(2) If none, state how the current concrete design of the FSTR and its SSCs as implemented based on ACI 349-13 provides an appropriate level of conservatism with successive levels of protection (defense-in-depth), such that health and safety of the public is not wholly dependent upon a structural failure of a single element of the design for seismic, aircraft impact, and blast (explosion effects) loads.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-11 Section 1.2.2, "Safety Considerations," of the SHINE OLA states that "[t]he building structure is robust enough to remain intact following an aircraft impact." Section 3.4, "Seismic Damage," states that "[t]he roof of the facility is supported by a steel truss system." Section 3.4.2.6.2, "Applicable Codes and Standards," states that ANSI/AISC N690-12, "Specification for Safety-Related Steel Structures for Nuclear Facilities" is the applicable code and standard for the design of the SHINE main production facility structural steel SSCs.

The SHINE OLA referenced U.S. Department of Energy (DOE) Standard DOE-STD-3014-2006, "Accident Analysis for Aircraft Crash into Hazardous Facilities," which discusses aircraft impacts and potentially ensuing fuel fires and explosions and the capacity of existing (or proposed) barriers to dissipate their energy. It emphasizes that fire can spread through ducts and along wiring conduits. It limits fire barriers and breaks credits to those that remain undamaged by the crash. The standard further, states:

> The basis for taking credit (e.g., short duration of the fire) should be documented. Therefore, a characterization of fire duration will almost certainly be required, although the level of detail will depend on how much sophistication is required to determine the duration of the fire relative to the capability of the fire barriers. Due to the difficulty of demonstrating that active systems can function following a crash, credit should not be allowed for fire suppression systems unless an explicit analysis shows that they will remain effective […] In calculating an effective [aircraft impact/skidding target] area, the analyst needs to be cognizant of the "critical areas" of the facility. Critical areas are locations in a facility that contain hazardous material and/or locations that, once impacted by a crash, can lead to cascading failures, e.g., a fire, collapse, and/or explosion that would impact the hazardous material.

It is not clear to the NRC staff whether applicable specifications of ANSI/AISC N690-12, are met in their entirety, including those related to fire in Appendix N4 to ANSI/AISC N690-12. The Appendix discusses carbon steel material properties at elevated temperatures. It states, "material properties at elevated temperatures are short-term properties intended for fire design by analysis only." It also states that the "specification does not address either 'Important to Safety' structural steel members or loading conditions associated with a facility fire." It is not clear to the NRC staff whether a fuel fire due to an aircraft impact was considered for an aircraft global response analysis but ruled out because of its potential short duration and lack of damage to the external concrete building envelope (external walls, roof, exhaust stack). If so, it is not clear how that was determined so that fuel fire and aircraft combustible material would remain localized and external to the FSTR and its SSCs. If not, it is not clear whether a structural steel analysis was performed taking into consideration aircraft fuel fire. If so, it is not clear whether the analysis appropriately considered for the roof steel truss system (including steel decking, if any) thermal effects and material properties at elevated temperatures. Given the proximity/connection of the exhaust stack to the FSTR, it is also not clear whether the stack could function as an intake duct for the spreading of fuel fire in the facility that could affect critical areas that contain hazardous/radioactive material and/or locations that, once impacted by a crash, can lead to cascading failures. This information is requested to verify that SHINE has performed the necessary evaluations required to show that safety functions will be accomplished, as required by 10 CFR 50.34(b)(2).

(1) Clarify, whether any deviations were made to applicable specifications of ANSI/AISC N690-12 in the design of the SHINE main production facility structural steel SSCs. If so, justify their exclusion.

(2) Clarify whether an aircraft fuel fire was considered in aircraft impact global response analysis but ruled out. Justify ruling out such fires that could affect the integrity of FSTR structural steel members and steel decking, if any.

(3) If the aircraft impact global response analysis included an aircraft fuel fire, discuss whether requirements of ANSI/AISC N690-12 for structural steel performance at elevated temperatures were considered in the steel design of FSTR and its "Important to Safety" structural steel members. If excluded, justify the exclusion.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-12 Section 1.3.3.3, "Facility Systems," of the SHINE OLA states that the neutron driver assembly system (NDAS) is an "accelerator-based assembly that accelerates a deuterium ion beam into a tritium gas target chamber. The resulting fusion reaction produces 14 million electron volt (MeV) neutrons, which move outward from the tritium target chamber in all directions."

Section 4a2.3, "Neutron Driver Assembly System," states that "[s]tructural support beams support the neutron driver in the IU cell, with components installed above and adjacent to safety-related equipment. Neutron driver

components within the IU cell are classified as a Seismic Category II component." It also states that "[t]he target chamber generates up to 1.5E+14 neutrons per second (n/s) during operation."

Guidance documents such as NUREG-7171, "A Review of the Effects of Radiation on Microstructure and Properties of Concretes Used in Nuclear Power Plants," discussed in 4a2.5.3.2 "Radiation Damage," and referenced by the applicant in Chapter 4 of the SHINE OLA and the industry standard ACI 349.3R-18, "Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures," provide radiation thresholds for concrete and insights beyond which the compressive strength of concrete appears to rapidly decline while its crack density increases.

To effectively accomplish their intended function, nuclear safety-related SSCs are designed to resist operating loads, severe environments such as seismic events, and postulated accidents. To prevent lifetime-radiation related degradation of concrete SSCs and maintain an acceptable level of serviceability, NUREG-7171 limits the lifetime reinforced concrete neutron fluence exposure of 0.1 (and above) MeVs to 1×10^{19} neutrons/cm^2 and for gamma dose to 10^{10} rads. ACI 349.3R-18, which is more relevant to long term operation of nuclear facilities, also states that neutron fluence can change the mechanical properties of carbon steel resulting in an increase in yield strength and a rise in the ductile to brittle transition temperature.

Given the projected hours of operation for the SHINE facility, the high neutron flux and gamma dose exposures at NDAS or at other locations exposed to intense radiation within the facility, it is not clear whether concrete or steel structural support members or components, such as the IU driver supporting beams, have been evaluated for neutron fluence and gamma dose damage for the life of the facility. It is also not clear whether conservatively a reduction in strength due to radiation for materials used in the construction of the facility was considered and factored where applicable in the concrete or structural steel designs for seismic, aircraft impact, blast loadings.

(1) Discuss whether the radiation limits provided in NUREG-7171 were used to determine that safety related concrete or steel support structures or SSCs exposed to radiation (e.g., the IU driver support beams) will maintain their safety function during seismic, aircraft impact, or blast loading scenarios during the intended licensing period. Provide a discussion of any relevant evaluations used to support a conclusion that irradiation will not affect the safety functions described above.

(2) If applicable, state what actions are taken to ensure that potential damage to safety related concrete or steel support structures or SSCs that have radiation exposure above the previously discussed radiation limits will not adversely affect safe facility operability and its defense-in-depth.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-13 Section 3.4.2.6.4.6, "Crane Load," of the SHINE OLA states that the building is evaluated for loads associated with two overhead bridge cranes, one servicing

the Irradiation Facility (Irradiation Unit cell) area (IF/IU) and one servicing the Radioisotope Production Facility area (RPF). It also states that crane loading is evaluated in accordance with American Society for Mechanical Engineers (ASME) NOG-1, "Rules for Construction of Overhead and Gantry Cranes" (ASME, 2004).

Section 9b.7.2, "Material Handling," of the SHINE OLA states that crane hooks are rated at 40 and 15-ton lifts and for the IF and RPF designated as ASME NOG-1 Type I and II, respectively.

Sections 1000, "Introduction," to ASME NOG-1 define/discuss crane loads as "superimposed weight" and "credible critical loads." The "Non-Mandatory Appendix B Commentary" to ASME NOG-1, further clarifies that crane loads the structure sustains can be assessed either deterministically or probabilistically (credible critical loads). ASME NOG-1 also states that probabilistic calculations "establish the weight of lifted load that should be considered in combination with OBE, and that should be considered in combination with SSE, or of specifying the range of loads that should be considered for varying magnitudes of earthquakes, from magnitude less than OBE up to SSE."

Section 4000, "Requirements for Structural Components," of ASME NOG-1 further defines loads, loading combinations, restraint conditions at nodes to be used in static, dynamic, seismic, and abnormal events analyses and design of crane hardware systems. It also provides added guidance to calculate the maximum structural response values for the three-directional components of an earthquake motion. Guidance on loading combinations and structural responses include impactive vertical loads, and horizontal (i.e., longitudinal and transverse) loads. When performing seismic analyses, the ASME NOG-1 provides specific criteria to decouple the crane from its runway.

As noted in Chapters 2 and 3 of the SHINE OLA, structural design of FSTR, including its design of the structures for seismic and abnormal loads, is in accordance with ASCE 7/IBC, ACI 349, and AISC N690-12 national codes and standards.

The descriptions provided in the SHINE OLA do not provide adequate information of how the crane loads were derived (deterministically or probabilistically) and subsequently used in seismic and other abnormal load (dynamic/impact) analyses consistent with ASME NOG-1. In addition, structural codes and national standards used in the design of the FSTR address crane loads (e.g., Chapters 4 of ASCE 7/1607 of IBC, with loading combinations further elaborated in Chapters 9 and Appendix C of ACI 349-13 and Chapter NB of ANSI/AISC N690-12). These codes/national standards differ in some respects (e.g., impactive loads) with the ASME NOG-1 in the assessment of crane loads and loading combinations. It is not clear whether the FSTR was designed based on IF and RPF crane loads derived consistent to ASME NOG-1 or the structural design codes/national standards.

(1) Clarify how SHINE is applying ASME NOG-1 to crane loads at the facility. As applicable, consistent with ASME NOG-1, provide the following:

(a) Describe whether the IF and RPF crane loads were derived deterministically or probabilistically and included as such in the loading combinations used. Justify the approach taken, discuss their use, adequacy and conservatism for seismic and abnormal load analyses/design.

(b) Describe whether the IF and RPF crane response was decoupled from their respective runways for seismic analyses. If so, state type of loads considered (deterministic or probabilistic) in the decoupling and whether such selection provided conservatism in crane/FSTR structural analyses and design.

(c) Describe whether the IF and RPF crane decoupling from their runways was limited only to seismic analyses and if so, why. Otherwise, describe how the (deterministic, probabilistic) crane loads were integrated in the facility analysis and design for seismic as well as for abnormal (aircraft impact, blast effects) load structural analyses.

(2) If ASME NOG-1 derived crane loads were applied to the FSTR design, clarify whether the use of such loads provide "an additional design conservatism" than those derived based on the aforementioned structural codes and standards.

(3) If credible critical crane (probabilistic) loads were used in the structural and seismic analyses and design of the FSTR, describe how they are integrated with the "load resistant factor design" philosophy of ACI and AISC structural design codes and standards.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-14 Section 1.2.1, "Consequences from the Operation and Use of the Facility," of the SHINE OLA states that "[t]he IF and RPF within the main production facility constitute the radiologically controlled area (RCA)" where radioactive materials are present. Section 4b.4, "Special Nuclear Material [SNM] Processing and Storage," states that SNM "is used throughout the radioisotope production facility (RPF) radiologically controlled area (RCA) in both unirradiated and irradiated forms."

Section 3.4.2.6.4.6, "Crane Load," of the SHINE OLA states that the "building is evaluated for loads associated with two overhead bridge cranes, one servicing the IU cell area and one servicing the RPF area." It also states that "[c]rane loading is evaluated in accordance with […] ASME NOG-1."

Section 9b.7.2, "Material Handling," of the SHINE OLA states that the IF and RPF cranes are ASME NOG-1 Type I and Type II cranes rated at 40 and 15-tons, respectively. Both cranes are to perform at a Service Level B (Light Service) consistent with CMAA 70. Consistent also with ASME NOG-1, the IF crane includes in its design single failure-proof features while the RPF crane does not and hence it may not support a critical load during a seismic event. This Section also states that safeguards consistent to NUREG-0612, Section 5.1.1, would be developed to limit consequences of radiological release

as promulgated in 10 CFR Part 20, if a heavy load was dropped on safety-related SSCs.

Sections 1000, "Introduction," and 5000, "Mechanical," and others to ASME NOG-1 address exposure of cranes to radiation and other environmental conditions that could reduce normal life of their components including the loss of single failure-proof features potentially could result in load drops. In the RCA, such unexpected crane load drops could result in radiological consequences. Such code sections also state that select crane components need to be designed to withstand maximum facility lifetime radiation exposure. In its non-mandatory Appendix B, the Code emphasizes that nuclear facilities of new or unforeseen designs should consider special fracture toughness acceptance criteria for ASME NOG-1 acceptable materials (reference ASME NOG-1, Table 4212-1) used as structural components, including bolts and welds, exposed to unusual radiation. It is not clear whether the IF and RPF cranes were designed consistent with ASME NOG-1 Section 1000 guidance to withstand lifetime gamma and/or neutron radiation.

Because of the unpredictability of such failures, it is not clear whether planned safeguards consistent with Section 5.1.1 of NUREG-0612 would be adequate to limit effects of unexpected drops of heavy loads on safety related SSCs due to radiation induced critical crane component malfunctions/brittle fractures during normal operation of the FSTR as well as during a safe shutdown seismic event so that that defense-in-depth is maintained.

(1) Discuss, consistent with guidance (for example, Sections 1000, "Introduction" to ASME NOG-1), whether detrimental effects of lifetime radiation on critical and structural components (including fracture toughness assessments, for members, fasteners, and welds) for RCA cranes were considered.

(2) State whether RCA cranes would be radiation hardened and/or periodically inspected for effects of radiation to ensure that their service life (lift cycles allowed) consistent with CMAA-70 remain as noted in the FSAR and their critical/structural components, particularly those associated with single failure-proof features of the IF crane, remain unaffected from radiation throughout their operating life to minimize potential drops on FSTR critical structural components and its safety related SSCs and defense-in-depth of the facility remains during seismic and other abnormal loading conditions.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-15 Section 3.4.2.6.4.8, "Fluid Load," of the SHINE OLA states that "[t]he hydrostatic loading is calculated based on the actual dimensions of the IU cells and applied in the model as lateral hydrostatic pressure on the walls and vertical hydrostatic pressure on the bottom slabs." Section 3.4.2.6.4.5, "Earthquake Load," states that 100 percent of hydrodynamic loads are accounted for in earthquake analysis.

Section 1.2.1, "Consequences from the Operation and Use of the Facility" states that "[w]ithin the irradiation facility (IF), the [low enriched uranium] LEU in the target solution is in the form of a uranyl sulfate."

Section 4.a2, “Irradiation Facility Description,” states that the stainless-steel target solution vessel (TSV) contains the uranyl sulfate target solution undergoing irradiation to produce Mo-99 and other fission products and is attached to the floor of the light water stainless steel lined pool via seismic anchorages. It also states that the subcritical assembly support structure (SASS) and primary system boundary (PSB) “components are designed to withstand the design basis loads, including thermal, seismic, and hydrodynamic loads imposed by the light water pool during a seismic event.” In addition, it states that “The SASS does not normally contact the target solution. In the event of a breach in the TSV, the SASS provides a defense-in-depth fission product boundary between the target solution and the light water pool.” The section also states that the pool has minimum acceptable water levels that are assumed for safety analysis accident scenarios for normal operation and for loss of cooling conditions and that the target stage of the neutron driver is partially submerged.

The staff noted that Sections 3.4.2.6.4.5, 3.4.2.6.4.8, and 4.a2 of the FSAR discuss general application of hydrodynamic loads, hydrostatic loads for the pool, and pool submerged/semi-submerged equipment, under seismic conditions. It is not clear whether the light water pool is the only area of concern in the FSTR where hydrostatic and hydrodynamic loads are applied. It is also not clear where else in the FSTR fluid-equipment/structure interaction may have been addressed. Chapter 3 of FSAR references ASCE 4-98, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary.” The standard addresses horizontal and vertical fluid motion (hydrodynamic loads - impulsive and convective) and their effects on submerged structures in a basin. It is not clear, however, whether ASCE 4-98 was used for hydrodynamic load estimations and for structural stability analyses in fluid-structure interactions during seismic events. It is not clear what was the method followed to derive the hydrodynamic loads and their effects on the stability of totally or partially submerged structures during seismic loads or other abnormal events.

It is also not clear whether the hydrostatic/hydrodynamic loads/analyses were limited to water as a fluid or extended to include dilution of uranyl sulfate solution into the pool. Material DATA Sheets indicate that uranyl sulfate in its solid form has a specific gravity of 3.28. Consistent with this data, the uranyl sulfate solution specific gravity is anticipated to be greater than that of water. Although it is noted that the SASS provides a defense-in-depth against uranyl sulfate solution release, it is not clear what constitute the echelons of defense to preclude leakage of uranyl sulfate solution into the pool during a seismic or other abnormal loading events that could alter hydrodynamic loads on the pool and their effects on submerged structures during a design basis earthquake.

(1) Discuss the method followed/standard(s) used to derive the hydrodynamic loads, their effects on submerged equipment/structures within the pool, and analyses performed for seismic or other abnormal loading events. Identify other locations in the FSTR where these loads/analyses were applied.

(2) Briefly describe the echelons of defense claimed in SASS/TSV equipment/structure against the release of uranyl sulfate solution into the

pool. Justify their adequacy consistent with the defense-in-depth philosophy of NUREG-1537 during seismic or other abnormal loading events.

(3) If a breach of the SASS/TSV equipment/structure would occur, discuss whether effects of an increased density fluid on hydrodynamic loads and semi/submerged structures were considered for seismic or other abnormal loadings and steps taken so that defense in depth of the facility remains.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-16 Section 1.2.2, "Safety Considerations," of the SHINE OLA states that "[t]he building structure is robust enough to remain intact following an aircraft impact as described in Section 3.4." Section 3.4.5.1, "Aircraft Impact Analysis," of the SHINE OLA states that safety-related structures at the SHINE facility are evaluated for global and local aircraft impact loadings resulting from small aircraft. It also states that the Challenger 605 was selected as a "design basis aircraft impact" based on airport operation data. It further states that the performed global impact response analysis the energy balance method was used with ductility limits in accordance with ACI 349-13 and ANSI/AISC N690-12, for reinforced concrete elements and steel truss members, respectively. For the local impact it states that "[b]ecause engine diameter and engine weight are both critical for the local evaluation, the local impact evaluation was performed for the Hawker 400 as well as the Challenger 605 aircraft […which were...] evaluated as design basis aircraft impacts." The section subsequently references U.S. Department of Energy (DOE) Standard DOE-STD-3014-2006, which provides guidance for screening and evaluating global, local, and vibration damage to FSTR and its SSCs.

The DOE Standard provides functional assessments of safety related SSCs for fuel fire, missile impact shock, and structural damage/collapse that when followed could minimize the "risk posed to the health and safety of the public and onsite workers from a release of hazardous material following an aircraft crash." The standard considers deformable/soft (e.g., entire aircraft, wings, fuselage) and nondeformable/rigid (e.g., landing gear, engine shaft) aircraft components (missiles) that could impact a target directly or after skidding. It states that the selection of missiles should be bounding based on all applicable categories/subcategories and types of aircraft having the highest kinetic energy and provides methodologies to evaluate global and local impact damage. It further recommends impact assessments to include for global response aircraft-target interactions (including soil-structure interaction - SSI) and for local spalling, scabbing, perforation.

The applicant's statement in Section 1.2.2 regarding the design robustness of the building structure, stems from its summary of an aircraft impact analysis based on the DOE Standard described in Section 3.4.5.1. In evaluating this section, however, the staff was not clear on how the two aircrafts were selected or what methodology was used to assess missile mass and velocities at impact for momentum transfer and kinetic energy estimations for global and local impact damage. This information is requested to verify that SHINE has performed the necessary evaluations required to show that safety functions will be accomplished, as required by 10 CFR 50.34(b)(2).

(1) Clarify what airport operation data were used and how such data were applicable for the selection of Challenger 605 as a global impactor.

(2) Clarify which mode of Challenger 605 global impact at contact with the walls and roof of the FSTR (e.g., direct impact, oblique impact, skidding) was considered in the global response/damage analysis. For the excluded modes, justify their exclusion.

(3) For global response mode of impact having a horizontal velocity component, state whether its effects/traction were considered in the design of the concrete roof and supporting steel truss, including stability analyses of truss compression flanges.

(4) State whether the global response/damage analysis included the total aircraft mass (including fuel), aircraft-target interaction, and SSI. If not, state reasons for exclusions.

(5) Clarify when considering rigid impactors for local damage analysis, whether their mass was reduced. If so, justify the basis for the mass reduction.

Update the FSAR as appropriate to reflect the above requested information.

RAI 3.4-17 Section 3.4.5.2, "Explosion Hazards," of the SHINE OLA states that the maximum overpressure at any safety-related area of the facility from any credible external source is discussed in its Section 2.2.3, which states:

> Regulatory Guide 1.91 cites 1 pound per square inch differential pressure (psid) (6.9 kilopascal [kPa]) as a conservative value of peak positive incident overpressure, below which no significant damage would be expected. Regulatory Guide 1.91 defines this standoff distance by the relationship $R \geq kW^{1/3}$ where R is the distance in feet from an exploding charge of W pounds of trinitrotoluene (TNT); and the value k is a constant. The TNT mass equivalent, W, was determined by comparing the heat of combustion of the chemical to the heat of combustion of TNT.

ALOHA was used to model the worst-case accidental vapor cloud explosion, including the standoff distances and overpressure effects at the nearest SHINE safety-related area.

Section 2.2.3 of the SHINE OLA states that in addition to multiple external explosion sources, their yield and overpressures on the SHINE facility were evaluated. It also states that "a liquid nitrogen storage tank [is] located outside the facility buildings. The tank and its associated process piping are designed in accordance with applicable codes, including overpressure protection." The Section further states that "safety-related areas are designed to withstand a peak positive overpressure of at least 1 psid (6.9 kPa) without loss of function/significant damage […] Conservative assumptions were used to determine a standoff distance, or minimum separation distance, required for an explosion to have less than 1 psid (6.9 kPa) peak incident pressure."

Section 3.4.5.2 of the SHINE OLA then concludes by stating “[t]he seismic area is protected by outer walls and roofs consisting of reinforced concrete robust enough to withstand credible external explosions,” as defined in RG 1.91, Revision 2.

It is not clear what guidance, or applied safety factors, were considered to increase the degree of conservatism for the blast loads applied to the FSTR in order to account for the uncertainties involved in calculating the TNT equivalent mass for each evaluated chemical explosion and the standoff distance for 1 psid incident overpressure. It is also not clear whether the applicant used reflected peak pressure for the nearby chemical explosions and associated impulse for the review of FSTR seismic design effectiveness to resist blast loads. In addition, it is not clear what codes have been used for the design of the external nitrogen tank in proximity to the FSTR for overpressure protection and whether a consideration was given for additional blast loads to the FSTR, in case of its accidental explosion. This information is requested to verify that SHINE has performed the necessary evaluations required to show that safety functions will be accomplished, as required by 10 CFR 50.34(b)(2).

(1) Clarify how it was concluded that the FSTR “reinforced concrete [seismic design is] robust enough to withstand credible external explosions,” given the uncertainties involved in calculating external blast loads, their time scale in comparison to those associated with a seismic disturbance, and the philosophical differences between the approaches for seismic and blast load designs. State what specific design guidance was followed, safety factors applied, or specific analyses performed to reach that conclusion.

(2) State what codes have been used for the design of the external nitrogen tank in proximity to the FSTR for overpressure and fragment protection of safety-related areas when evaluating adequacy of the FSTR seismic design, in case of accidental tank explosion.

Update the FSAR as appropriate to reflect the above requested information.

Chapter 8 – Electrical Power Systems

The following regulatory requirements are applicable to RAIs 8-1 through 8-7:

- Paragraph 50.34(b) of 10 CFR *states, in part, that* the final safety analysis report shall include information that describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems, and components and of the facility as a whole. As part of presenting its design bases, SHINE has established the following principal design criteria relevant to its electrical power systems:

    - Criterion 4 – Environmental and dynamic effects

      Safety-related structures systems and components (SSCs) are designed to perform their functions with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. These SSCs are appropriately protected against dynamic effects and from external events and conditions outside the facility.

    - Criterion 27 - Electric power systems

      An on-site electric power system and an off-site electric power system are provided to permit functioning of safety-related SSCs. The safety functions are to provide sufficient capacity and capability to assure that:

        1) target solution design limits and primary system boundary design limits are not exceeded as a result of anticipated transients, and

        2) confinement integrity and other vital functions are maintained in the event of postulated accidents.

      The on-site uninterruptible electric power supply and distribution system has sufficient independence, redundancy, and testability to perform its safety functions assuming a single failure.

      Provisions are included to minimize the probability of losing electric power from the uninterruptible power supply as a result of or coincident with, the loss of power from the off-site electric power system.

    - Criterion 28 - Inspection and testing of electric power systems

      The safety-related electric power systems are designed to permit appropriate periodic inspection and testing of important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components. The systems are designed with a capability to test periodically:

        1) the operability and functional performance of the components of the systems, such as on-site power sources, relays, switches, and buses; and

2) the operability of the systems as a whole and, under conditions as close to design as practical, the full operation sequence that brings the systems into operation, including operation of applicable portions of the protection system, and the transfer of power among the on-site and off-site power supplies.

- Paragraph 50.34(b)(2) of 10 CFR requires 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.

- Paragraph 50.34(b)(2)(ii) of 10 CFR states, in part, that for facilities other than nuclear reactors, such items as the…electrical systems…shall be discussed insofar as they are pertinent.

For RAIs 8-1 through 8-5, the NRC staff has considered guidance in Section 8.1, "Normal Electrical Power Systems," of NUREG-1537, Part 2, and is requesting information to support the following evaluation findings:

  - The design bases and functional characteristics of the normal electrical power systems for the facility have been reviewed, and the proposed electrical systems will provide all required services; and

  - The design of the normal electrical power system provides that in the event of the loss or interruption of electrical power the reactor can be safely shut down.

  - The design and location of the electrical wiring will prevent inadvertent electromagnetic interference between the electrical power service and safety-related instrumentation and control circuits.

RAI 8-1 Section 8a2.1, "Normal Electrical Power Supply System," of the SHINE FSAR provides a general description of the SHINE normal electrical power supply system (NPSS). Section 8a2.1.1, "Design Basis," states that:

> The design of the NPSS provides sufficient, reliable power to facility and site electrical equipment as required for operation of the SHINE facility and to comply with applicable codes and standards.

SHINE states that National Fire Protection Association (NFPA) 70-2017, National Electrical Code (NEC) is used as the code for the design of the NPSS. However, it is not clear to the NRC staff to what extent SHINE is applying or taking exception to NFPA 70-2017 and other referenced standards in the design of its NPSS and emergency electrical power systems. Additionally, during the May 11 to May 15, 2020 regulatory audit of SHINE's electrical power systems, SHINE indicated that it intends to partially conform to Regulatory Guide (RG) 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," which provides guidance to licensees and applicants on additional methods acceptable to the NRC staff

for addressing the effects of electromagnetic interference and radiofrequency interference (EMI/RFI) and power surges on safety-related electrical systems. However, it is not clear to the NRC staff to what extent SHINE is applying or taking exception to this regulatory guide. It is also not clear to the NRC staff how use of the NEC and other referenced standards satisfy SHINE's design criteria 27 and 28.

Provide additional detail on how SHINE is applying codes and standards to the design of its NPSS and emergency electrical power system. Specifically, provide references in the FSAR to documents that calculate and/or evaluate electrical design such that correlation is evident that demonstrates how the design of its NPSS and emergency electrical power system satisfy its principal design criteria 27 and 28. Such information could include descriptions of how standards, calculations, methodologies, and analyses are used in order to determine whether the design of the electrical systems meet the applicable regulations and is commensurate with the design bases of the facility. Clarify what calculations and studies were performed. If SHINE is not performing one or more the following calculations, provide justification why the calculation or study is not applicable for the electrical design of the SHINE facility:

- Load Flow/Voltage Regulation Studies and Under/Overvoltage Protection;
- Short-Circuit Studies (alternating current (AC) and direct current (DC) systems), including faults on cables in the penetrations to ensure that confinement integrity is maintained;
- Equipment Sizing Studies;
- Equipment Protection and Coordination Studies;
- Insulation Coordination (Surge and Lightning Protection);
- Power Quality Limits (Harmonic Analysis);
- Grounding Grid studies;
- Grid Stability studies; and
- Electromagnetic interference and radiofrequency interference, including conformance to RG 1.180, as applicable.

This information is important for the NRC staff to determine how SHINE is satisfying its design criteria 27 and 28. The above is a list of specific calculations of interest to the NRC staff that would assist in the evaluation of SHINE's electrical design to ensure that on-site uninterruptible electric power supply and distribution system has sufficient independence, redundancy, testability, capacity, and capability to perform its safety functions consistent with SHINE's design criterion 27.

RAI 8-2 Section 8a2.1.3, "Normal Electrical Power Supply System Description," provides a description of the protection of safety-related systems, which includes undervoltage trip enclosed breakers for the Neutron Driver Assembly System (NDAS), the vacuum transfer system (VTS), extraction feed pumps in the molybdenum extraction and purification system (MEPS), and the radiological ventilation exhaust fans (RVZ1, RVZ2, and RVZ3). Figure 8a2.1-1, "Electrical Distribution System (Simplified)," provides a simplified diagram of the overall electrical power supply system. The diagram shows two safety-related

breakers connected to the non-safety-related NDAS. Section 8a2.1 of the FSAR states the following:

> The NPSS is sized for safe operation of the facility. The largest loads on the NPSS are the process chilled water system (PCHS), neutron driver assembly system (NDAS), and the facility chilled water system (FCHS); however, those loads are not required for safe shutdown of the facility. Refer to Section 8a2.2 for a tabulation of emergency electrical load requirements.

Section 8a2.1.3, "Normal Electrical Power Supply System Description," provides a list of safety-related equipment in the NPSS. However, it is not clear to the NRC staff why two safety-related breakers are connected to a non-safety-related NDAS, the VTS, the MEPS, and the RVZs.

Provide a detailed description of why the two circuit breakers connected to the systems mentioned above are categorized as safety-related, why the safety related breakers are specified only for undervoltage protection, and how these circuit breakers are important to providing and maintaining a safe shutdown condition of the facility. This information is necessary for the NRC staff to determine how SHINE is satisfying its design criteria 27 and 28. Update the FSAR, as necessary.

RAI 8-3 Section 8a2.2, "Emergency Electrical Power System," states the following:

> The emergency electrical power systems for the SHINE facility consist of the safety-related uninterruptible electrical power supply system (UPSS), the nonsafety-related standby generator system (SGS), and nonsafety-related local power supplies and unit batteries. The UPSS provides reliable power for the safety-related equipment required to prevent or mitigate the consequences of design basis events.

Section 8a2.2.2, "Uninterruptible Electrical Power Supply System Codes and Standards," provides the list of standards used for the design of the UPSS. However, SHINE does not provide standards used for the maintenance, testing, installation and qualification for the safety-related batteries used in the DC system. In addition, for the battery chargers, maintenance, testing, and qualification of the battery chargers is not addressed in the FSAR.

Describe the standards and/or methodologies used to perform maintenance, testing, installation, and qualification for the safety-related batteries in the DC system used in the UPSS. In addition, Describe the maintenance, testing, and qualification of the battery chargers. This information is necessary for the NRC staff to determine how SHINE is satisfying its design criteria 27 and 28.

RAI 8-4 It is not clear to the NRC staff how SHINE is applying its Principal Design Criterion 4, "Environmental and dynamic effects," to the safety-related SSCs associated with its electrical power systems. This information is necessary for the NRC staff to ensure that the SHINE facility will be maintained in a safe condition during and following design-basis events.

Provide information describing how SHINE will apply its Principal Design Criterion 4 for the environmental qualification of electrical equipment. In addition, provide a list of equipment or the types of equipment that will be qualified, including the environmental conditions to which the equipment will be subjected. Indicate any methodologies and standards used for the environmental qualification of electrical equipment. Update the FSAR, as necessary.

RAI 8-5 SHINE states in Section 8a2.1.3, "Normal Electrical Power Supply System Description," that the NPSS operates as two separate branches, and that the branches automatically physically disconnect from the utility by opening the utility power supply breakers on a loss of phase, phase reversal, or sustained overvoltage or undervoltage as detected by protection relays for each utility transformer. However, SHINE does not address the electric power system design vulnerability to open phase conditions in the FSAR. This information is necessary to ensure that SHINE has designed its electrical power systems consistent with its Principal Design Criterion 27 to permit functioning of safety-related SSCs and minimize the probability of losing electric power from the uninterruptible power supply as a result of or coincident with, the loss of power from the off-site electric power system.

Provide additional information on how SHINE has considered the impact of open phase conditions on the safe operation of its facility, including clarification of the location of the loss of phase protection relays and whether there is an alarm in the control room to indicate an open phase condition[2]. Update the FSAR, as necessary.

RAI 8-6 Section 8a2.2, "Emergency Electrical Power System," states, "The UPSS consists of a 125-volt direct current (VDC) battery subsystem, inverters, bypass transformers, distribution panels, and other distribution equipment necessary to feed safety-related alternating current (AC) and direct current (DC) loads and select non-safety-related AC and DC loads." However, SHINE does not provide a description of the technical specifications for the electrical equipment comprising the UPSS. This information is necessary for the NRC staff to determine how SHINE is satisfying its design criteria 27 and 28.

Provide a description of the specifications for the electrical equipment comprising the UPSS. The information should include voltage, current, and frequency specifications including acceptable tolerances for these parameters. In addition, provide a description of how SHINE will ensure the failure of nonsafety-related loads do not impact safety-related loads. Update the FSAR and technical specifications, as necessary.

RAI 8-7 Section 8a2.2.2, "Uninterruptible Electrical Power System Codes and Standards," states the UPSS is designed in accordance with IEEE Standard 384-2008, "Standard Criteria for Independence of Class 1E Equipment." IEEE

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2 For reference, the NRC staff has considered electric power system design vulnerability to open phase conditions in offsite electric power systems at nuclear power plants in Bulletin 2012-01, "Design Vulnerability in Electric Power System" (ADAMS Accession No. ML12074A115) and subsequently issued Branch Technical Position 8-9, "Open Phase Conditions in Electric Power System" (ADAMS Accession No. ML15057A085), dated July 2015.

Std. 384-2008, Section 3.6 defines Class 1E as, "the safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing a significant release of radioactive material to the environment." For electrical systems, the staff considers 'safety-related' and 'Class 1E' as synonymous terms and classifications. However, it is unclear to the NRC staff whether SHINE is classifying its UPSS as Class 1E. This information is necessary for the NRC staff to determine how SHINE is satisfying its design criteria 27 and 28.

Clarify whether SHINE classifies the UPSS as Class 1E. If the UPSS is not considered Class 1E, describe why not and how the criteria or standards, including IEEE Std. 384-2008, are applied to the design and classification of the UPSS. Update the FSAR, as necessary.