ENCLOSURE 1

SHINE MEDICAL TECHNOLOGIES, LLC

SHINE MEDICAL TECHNOLOGIES, LLC OPERATING LICENSE APPLICATION RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

RESPONSE TO FINAL SAFETY ANALYSIS REPORT CHAPTERS 2, 3, AND 8 REQUESTS FOR ADDITIONAL INFORMATION

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The U.S. Nuclear Regulatory Commission (NRC) staff determined that additional information was required (Reference 1) to enable the continued review of the SHINE Medical Technologies, LLC (SHINE) operating license application (Reference 2). The following information is provided by SHINE in response to the NRC staff's request.

Chapter 2 – Site Characteristics

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).

SHINE Response

(1) Subsection 2.2.3.1.1 of the FSAR describes potential explosions that could have an adverse effect on plant operation or would prevent a safe shutdown. Table 2.2-15 of the FSAR identifies those on-site and off-site chemicals that have the potential to explode and require further analysis. Table 2.2-16 of the FSAR provides the results of the stationary explosion analysis.

As described in Subsection 2.2.3.1.1, bounding cases were determined that included the mass of each chemical and the distance from the facility. In the case of ethylene oxide, the bounding source of material based on mass is determined to be a storage tank containing 440,000 lbm located 1.6 miles from the SHINE facility. As described in Subsection 2.2.3.1.1, an explosion would occur from the chemical vapor and not the liquid. It is therefore assumed that the tank contains chemical vapor at the upper explosion limit (UEL), which maximizes the vapor mass available for explosion. For a confined explosion of a tank volume capable of holding 440,000 lbm of liquid ethylene oxide, the corresponding mass of vapor that could be contained at the UEL is calculated to be 896.2 lbm. Since an overpressure of 1 pound per square inch differential pressure (psid) at 0.22 miles would require 2,610 lbm of ethylene oxide vapor, a tank with a 440,000 lbm liquid ethylene oxide capacity was shown to be acceptable at a distance of 0.22 miles.

Similarly, SHINE calculates that a tanker truck with a volume capable of holding 50,000 lbm of liquid ethylene oxide would have a mass of vapor at the UEL of 101.8 lbm. This is well bounded by the vapor mass of 2,610 lbm that would result in a 1 psid overpressure at 0.22 miles.

SHINE has revised Subsection 2.2.3.1.1 of the FSAR to clarify the methodology and results of the off-site stationary explosion analysis. A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

(2) The SHINE analysis considered both confined and unconfined explosions for propane and hydrogen, as described below.

Table 2.2-16 of the FSAR provides the maximum analyzed condition (acceptable instance) which would not exceed a 1 psid overpressure at a distance of 0.22 miles from SHINE safety-related structures. As stated in Subsection 2.2.3.1.1 of the FSAR, a yield factor of 3 percent is applied to account for unconfined explosions. However, a tank filled with compressed or liquified gas is highly pressurized, and thus, any accidental opening in the tank would not allow oxygen into the tank until the pressure drops below atmospheric. Both fuel and oxidizer are required for a confined explosion to occur within the tank. Therefore, a confined explosion is not possible until the tank has reached atmospheric or lower pressure.

To estimate the impact of a confined explosion once these conditions are reached, the mass of propane vapor and hydrogen available is conservatively assumed to consist of the entire volume of the tanker truck at the UEL and at atmospheric pressure. Assuming a typical tanker truck volume of 17,900 gallons, the mass of propane vapor and hydrogen gas are 358.9 lbm and 198.6 lbm, respectively. The mass of vapor or gas that would result in a 1 psid overpressure for a confined explosion with a yield factor of 100 percent is 1,672 lbm for propane vapor and 546 lbm for hydrogen. Therefore, the explosive mass of propane vapor and hydrogen gas in a confined explosion are less than the acceptable instances for these chemicals.

SHINE has revised Subsection 2.2.3.1.1 of the FSAR to clarify the use of a yield factor in determining the acceptable instance for the chemicals identified in Table 2.2-16 of the FSAR. A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

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

SHINE Response

Additional information demonstrating that the five additional toxic chemicals are not considered a hazard to the habitability of the facility control room is provided below.

Ethylene oxide from U.S. Highway 51 (US 51)

A spill from an ethylene oxide tanker truck on US 51 near the SHINE facility was not previously included in Table 2.2-19 of the FSAR as a potential toxic chemical hazard since the local industrial users of ethylene oxide receive the chemical by rail. A deterministic analysis of a spill from a tanker truck carrying 50,000 lbs. of ethylene oxide at 0.22 miles from the SHINE facility was calculated to give an indoor concentration of 4860 ppm, which exceeds the Immediately Dangerous to Life and Health (IDLH) concentration of 800 ppm. Therefore, a probabilistic analysis was performed to determine the likelihood of a spill occurring that would exceed the IDLH concentration in the facility control room. An analysis of the likelihood of an ethylene oxide tanker truck accident that would exceed the IDLH of 800 ppm for ethylene oxide would require 28 shipments per year on US 51 in order to exceed an accident frequency of 1E-6 releases per year as an acceptable risk frequency. Since the local industrial users receive their shipments by rail, the likelihood of exceeding this frequency of shipments is not considered to be credible.

SHINE has revised Subsection 2.2.3.1.3.3 and Table 2.2-19 of the FSAR to provide a discussion of the probabilistic analysis performed for ethylene oxide from US 51. A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

Gasoline from US 51

Gasoline is dispositioned in Table 2.2-19 of the FSAR as “no hazard” for a release from US 51. The bounding case of gasoline is a 50,000 lb. tanker trunk 0.22 miles from the SHINE facility. Gasoline is a mixture of hydrocarbons, in which the vapor is predominantly composed of light C4-C5 hydrocarbons (> 70 percent) and the liquid contains mainly heavier C6–C12 hydrocarbons (> 80 percent).

Assuming that the remaining 20 percent of the liquid phase consists of lighter hydrocarbons which evaporate, and that 70 percent of these are made up of the C4 and C5 hydrocarbons, the total mass of vaporized gasoline is approximately 14,300 lbs. The gasoline release is therefore modeled in ALOHA as a direct, instantaneous release of 14,300 lbs of butane (the simplest C4 hydrocarbon, chosen for conservatism).

A direct instantaneous release of 14,300 lbs of butane is assumed based on the content in 50,000 lbs of gasoline blend. Atmospheric conditions assumed a wind speed of 1 meter per second and a Pasquill Stability Class F (stable). The peak indoor concentration was calculated to be 505 ppm, which is below the 1600 ppm IDLH concentration for butane.

Alternately, the most common chemical constituent of gasoline is toluene. Conservatively modeling the entire contents of the 50,000 lb gasoline truck as toluene in ALOHA, a tank release gives an indoor concentration of 243 ppm, which is below the 500 ppm IDLH concentration for toluene.

Vinylidene chloride from railway

Vinylidene chloride is dispositioned in Table 2.2-19 of the FSAR as "no hazard" for a railway release. An ALOHA analysis was performed of a release of vinylidene chloride from a railcar at 1.6 mi. from the SHINE facility. The analysis assumed a volume of 31,726 gallons at 95 percent liquid for a calculated inventory of 300,966 lbs. The chemical is released as a spill from the bottom of the railcar. Atmospheric conditions assumed a wind speed of 1 meter per second and a Pasquill Stability Class F (stable). The peak indoor concentration was calculated to be 64 ppm, which is below the EPRG-2 limit of 500 ppm.

Sodium hypochlorite from Interstate-90/39 (I-90/39)

Sodium hypochlorite is dispositioned in Table 2.2-19 of the FSAR as "no hazard" for releases from I-90/39. ALOHA analyses were performed for a release of chlorine for the following scenarios from I-90/39:

- A release of 2,000 lbs. of chlorine on I-90/39. This release represents the failure of a single one-ton chlorine container. Based on the users of chlorine in Rock County, this amount is considered the largest container that would be frequently shipped near the SHINE site. This release results in a 0.637 ppm indoor concentration using a wind speed of 2 meters per second and a Pasquill Stability Class F (stable), since the 1 meter per second wind speed conditions do not result in elevated site concentrations in the first hour. This release was also approximated by decreasing the distance to the point source until it could be modeled in ALOHA within one hour. A hypothetical release at a distance of 1.2 mi. was found to result in an indoor concentration of 2.85 ppm, which is below the IDLH concentration of 10 ppm.

- A release of 22 tons of chlorine on I-90/39. This release exceeds the toxicity limit at an indoor concentration of 34.4 ppm at a conservative distance of 1.9 miles, or 14.9 ppm using a wind speed of 2 meters per second and a Pasquill Stability Class F (stable). However, since shipments of this size are not expected to be frequent, a probabilistic calculation was performed. A conservative maximum distance of 5 mi. was used, since the one-hour limit of ALOHA was generally exceeded after 3 mi. A maximum wind speed of 2.8 meters per second at the minimum distance of 2.1 mi. was conservatively applied to all distances. Finally, a minimum spill size of 31 percent was assumed and applied to all cases, since a 30 percent spill only exceeds toxicity limits at distances closer than 1.66 miles with 1 meter per second wind speeds. These estimates give a minimum of 53 cargo tanker shipments per year on I-90 past the SHINE site to exceed a release frequency of 1E-6. Without large producers or users of chlorine in Rock County, there are expected to be fewer than 53 cargo tanker shipments per year; therefore, this release scenario is not considered to be credible.

Carbon monoxide from a stationary source

Table 2.2-5 of the FSAR identified hazardous chemicals potentially transported on highways within 5 mi. of the SHINE facility. Carbon monoxide was previously included in Table 2.2-5 of the FSAR as a generalized model representing a potential asphyxiant since it has a similar molecular weight to nitrogen. An asphyxiant model is included to evaluate the potential for oxygen deprivation in the facility control room due to a potential release of nitrogen. Since there are no toxicity effects from nitrogen, carbon monoxide was modeled in ALOHA to determine concentrations that could result in an oxygen-deficient atmosphere.

SHINE has revised Tables 2.2-5 and 2.2-19 of the FSAR to clarify the asphyxiant model entries evaluate the potential for oxygen deprivation in the facility control room due to a potential release of nitrogen . A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

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 Response

SHINE has revised the approach to determining the impact of on-site chemical hazards on control room habitability. The analysis previously described in Subsection 2.2.3.1.3.4 of the

FSAR modeled releases of chemicals that were stored within the main production facility, as described in Section 13b.3 of the FSAR. This previous analysis assumed that the hazardous chemicals previously listed in Table 13b.3-1 of the FSAR were stored in the main production facility chemical storage room. Chemical exposures for the facility worker and the public were determined for each of the chemicals listed in Table 13b.3-1 of the FSAR.

The revised on-site chemical hazard analysis includes the following two analyses:

1) A hazardous chemical consequence analysis for the public and control room operator from chemicals that meet the definition of "hazardous chemicals produced from licensed materials," as defined in 10 CFR 70.4; and
2) A hazardous chemical release analysis of the on-site bulk storage of chemicals to determine the impact on control room habitability.

The consequence analysis for hazardous chemicals produced from licensed materials is described in the revised Section 13b.3 of the FSAR, provided via Reference 3.

The meteorological conditions assumed in the revised hazardous chemical release analysis of the on-site bulk storage of chemicals are a Pasquill Stability Class F (stable), a wind speed of 1 meter per second, an ambient temperature of 81°F, a relative humidity 50 percent, and a cloud cover 50 percent.

SHINE has revised Subsection 2.2.3.1.3.4 of the FSAR to provide a description of the revised hazardous chemical release analysis of the on-site bulk storage of chemicals. A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

Chapter 3 – Design of Structures, Systems, and Components

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).

SHINE Response

The only structure identified in Section 1.4 of the FSAR that is not part of the main production facility structure and performs, supports, and/or protects a safety function is the nitrogen purge system (N2PS) structure.

(1) The design criteria applicable to N2PS structure are SHINE Design Criteria 1 through 4, which are described in Table 3.1-3 of the FSAR.

(2) SHINE has added Section 3.6 to the FSAR, describing the criteria, parameters, and methodology used for the design of the N2PS structure to ensure that protected safety-related structures, systems, and components (SSCs) can withstand the effects of natural phenomena such as earthquakes, tornadoes, and floods. SHINE has revised Table 3.1-1 of the FSAR to reference Section 3.6 for additional discussion of N2PS SSCs. A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

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.

SHINE Response

(1) (a) The overhead crane servicing the irradiation facility (IF) portion of the main production facility structure (FSTR) is designed as an American Society for Mechanical Engineers (ASME) NOG-1, “Rules for Construction of Overhead and Gantry Cranes” (Reference 4) Type I crane. The overhead crane servicing the radioisotope production facility (RPF) portion of the FSTR is designed in accordance with Crane Manufacturer’s Association of America (CMAA) 70, “Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes” (Reference 5) and designed seismically in accordance with ASME NOG-1 Type II cranes. A deterministic approach to design of the

FSTR is utilized in regard to the crane loads. The rated lift capacity of each crane is based on the crane lifting needs as described in Subsection 9b.7.2 of the FSAR.

The soil-structure interaction (SSI) analysis considers 100 percent of the crane dead load in the parked position but does not consider the crane lifted load because the crane can be decoupled from the response of the FSTR. The SHINE Response to RAI 3.4-13 Part (1)(b) discusses why the crane can be decoupled from the response of the FSTR.

The structural analysis of the FSTR considers the crane dead load as well as crane live loads resulting from the movement of the cranes along their respective rails while loaded at their rated lift capacities. The crane dead loads conservatively consider the trolley to be at the end of the bridge. The crane live loads, including impact loads and crane stop loads, are developed in accordance with ASME NOG-1. Crane seismic loads are developed as distributed wheel loads by multiplying the peak accelerations from the in-structure response spectra (ISRS) by the crane's seismic mass, which includes both the dead loads and full-rated lift capacity. Seismic accelerations are based on seven percent damped response spectra per ASME NOG-1. IF crane loads are applied in the structural analysis model of the FSTR at four different positions along the walls supporting the crane rail. RPF crane loads are applied in the structural analysis model of the FSTR at five different positions along the walls supporting the crane rail. The crane loads are combined with other loads in combinations per American Concrete Institute (ACI) 349-13, "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary" (Reference 6).

The crane seismic loading that is considered in the design of the FSTR is conservative because the maximum potential lifted load is multiplied by the peak seismic accelerations from the ISRS at the crane elevations.

(b) The IF and RPF crane responses are decoupled from their respective runways for the SSI analysis. Consistent with Section 4153.5 of ASME NOG-1, the crane may be decoupled from the runway if either of the following criteria are met:

  i. the total mass of the crane is less than 1 percent of the mass of the runway support system, or
  ii. the mass of the crane is between 1 percent and 10 percent of the mass of the runway support system and the fundamental frequency of the crane is less than 80 percent or greater than 125 percent of the fundamental frequency of the runway support system.

Considering the deterministically derived crane loads described in the SHINE Response to RAI 3.4-13 Part (1)(a), the IF crane responses are decoupled from the FSTR seismic analysis in accordance with criteria (ii), and the RPF crane responses are decoupled from the FSTR seismic analysis in accordance with criteria (i). Use of the deterministic design approach regarding crane loads is conservative because the maximum potential crane load combinations are considered and margin exists.

(c) The IF and RPF crane decoupling is limited to the SSI analysis of the FSTR as described in the SHINE Response to RAI 3.4-13 Part (1)(a). Design crane wheel reactions at the runway girders, based on the overhead crane analysis using deterministically derived loads, are integrated into the FSTR analyses considering

ACI 349-13 load combinations. As such, the crane seismic loads are combined with other seismic effects to analyze the overhead crane supporting structure.

The overhead cranes are not subject to direct abnormal loads such as aircraft impact effects because the crane runway systems are designed to isolate the cranes from the exterior walls in a manner that prevents aircraft impact loading on the cranes. Potential blast and explosion-related impacts for the FSTR are evaluated in Subsections 2.2.3.1.1 and 2.2.3.1.2 of the FSAR and are not considered a critical load.

(2) The crane impactive (live) loads are derived in accordance with Section 4133 of ASME NOG-1. The impact load factors provided by ASME NOG-1 are somewhat less conservative than those provided by Section 4.9 of American Society of Civil Engineers (ASCE) 7-05, “Minimum Design Loads for Buildings and Other Structures” (Reference 7) or Section 1607 of the International Building Code (IBC) (Reference 8) for the vertical and lateral load directions (the impact load factor for the axial direction is the same). However, the crane impact (live) loads are approximately 10 percent of the seismic loads which are derived conservatively using the deterministic design approach. In light of the conservatism associated with the seismic loads and the magnitude of the difference between the impact and seismic loads, the slight difference in impact load factors is negligible.

(3) As described in the SHINE Response to RAI 3.4-13 Part (1)(b), a deterministic approach to design of the FSTR is used. Probabilistic loads are not used.

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.

SHINE Response

(1) Subsections 2.2.3.1.1 and 2.2.3.1.2 of the FSAR describe the specific analysis performed, using the methodology described in NRC Regulatory Guide 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants" (Reference 9), to evaluate explosions postulated to occur near the FSTR. Regulatory Guide 1.91 provides three viable methods to determine that potential explosions will not have an adverse effect on plant operation or prevent a safe shutdown. The three methods involve distance, probability, and blast loads (i.e., see Sections C.1, C.2, and C.3 respectively of Regulatory Guide 1.91). Only the methods involving distance and probability are used in the analysis described in Subsections 2.2.3.1.1 and 2.2.3.1.2 of the FSAR.

    Safety-related areas of the FSTR have been shown to be robust enough to withstand credible external explosions by demonstrating that either:

    - potentially explosive materials are located farther from the FSTR than the minimum safe distance based on conservative assumptions as described in Regulatory Guide 1.91, or
    - the incident rate of explosions, for potentially explosive materials located closer to the FSTR than the minimum safe distance, is less than 1E-6 per year based on conservative assumptions as described in Regulatory Guide 1.91.

Conservative assumptions, as described in Subsections 2.2.3.1.1 and 2.2.3.1.2 of the FSAR, are used in explosion standoff distance calculations (i.e., minimum safe distance) and probability analyses to account for uncertainties.

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 are not relevant to the analysis described in Subsections 2.2.3.1.1 and 2.2.3.1.2 of the FSAR because the analysis described in Subsections 2.2.3.1.1 and 2.2.3.1.2 of the FSAR uses the methodology described in Regulatory Guide 1.91.

(2) ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1 (Reference 10) is used for the overpressure protection design and pressure integrity design to prevent accidental explosion and fragmentation of the of the external liquid nitrogen tanks.

Chapter 8 – Electrical Power Systems

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 instrumentation and control (I&C) 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.

SHINE Response

SHINE fully applies National Fire Protection Association (NFPA) 70-2017, "National Electrical Code" (Reference 11), as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code), in the design of the normal electrical power supply system (NPSS) and emergency electrical power systems, without exception. Variance may be sought by SHINE, as permitted by NFPA 70-2017, where an equivalent degree of safety to the code section to which the variance is being sought can be demonstrated.

The application of NFPA 70-2017 to the design of the NPSS and uninterruptible electrical power supply system (UPSS) ensures reliability. SHINE applies NFPA 70-2017 to satisfy the SHINE Design Criterion 27 requirement to include provisions to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

Application of NFPA 70-2017 to the design of the NPSS and UPSS provides for working clearances and accessibility requirements for junction boxes, wiring, insulation, connections, and switchboards. SHINE applies NFPA 70-2017 to satisfy the SHINE Design Criterion 28 requirement to allow for periodic inspections and testing.

The nonsafety-related standby generator system (SGS) will be sized per NFPA 70-2017 to ensure sufficient capacity to provide for UPSS loads. SHINE applies NFPA 70-2017 to ensure the SGS has sufficient reliability to provide a temporary source of nonsafety-related alternate power to the UPSS and selected additional loads for operational convenience and defense-in-depth. SHINE applies NFPA 70-2017 to satisfy the SHINE Design Criterion 27 requirement to include provisions to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

SHINE applies the guidance of Institute of Electrical and Electronics Engineers (IEEE) Standard C.37.13-2015, "Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures," (Reference 12) to safety-related breakers in the NPSS. IEEE Standard C.37.13-2015 provides guidance for ratings, functional components, temperature limitations, classification of insulating materials, and testing procedures. SHINE applies IEEE Standard C.37.13-2015 to satisfy the SHINE Design Criterion 27 requirement that sufficient capacity and capability is provided to perform required safety functions.

SHINE applies the guidance of IEEE 384-2008, "Standard Criteria for Independence of Class 1E Equipment and Circuits" (Reference 13) to the NPSS and UPSS as described in Subsections 8a2.1.3, 8a2.1.5, and 8a2.2.3 of the FSAR. SHINE applies the referenced sections of IEEE 384-2008 to satisfy the SHINE Design Criterion 27 requirement for independence.

Safety-related SSCs in the NPSS and UPSS, including the UPSS batteries and battery chargers, are seismically qualified per Section 8 and Section 9.3 of IEEE 344-2013, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations" (Reference 14). These sections provide the testing methodology SHINE applies to ensure that safety-related NPSS and UPSS SSCs satisfy their safety function during a seismic event. SHINE applies Section 8 and Section 9.3 of IEEE 344-2013 to satisfy the SHINE Design Criterion 27 requirement to include provisions to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

SHINE applies the guidance of IEEE C.37.20.1-2015, "Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear" (Reference 15) to electrical switchgear in the UPSS. This standard provides ratings, construction, and testing guidance to ensure that the UPSS has sufficient reliability. SHINE applies IEEE C.37.20.1-2015 to satisfy the SHINE Design Criterion 27 requirement to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

The UPSS batteries and battery chargers are designed in accordance with Sections 5.2, 6.2, 6.5, 7.1, 7.3, Table 2 of 7.4, 7.6, and 7.9 of IEEE Standard 946-2004, "IEEE Recommended Practice for the Design of DC Auxiliary Systems for Generating Stations," (Reference 16). These sections of the standard provide guidance related to battery capacity; battery charger rated output; battery charger output characteristics; protective devices; voltage ratings; instrumentation, controls, and alarms; design features to assist in battery testing; and available short circuit current. SHINE applies Sections 5.2, 6.2, 6.5, 7.1, 7.3, Table 2 of 7.4, 7.6, and 7.9 of IEEE Standard 946-2004 to satisfy the SHINE Design Criterion 27 requirements for testability and to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

The UPSS batteries are sized for the UPSS loads provided in Table 8a2.2-2 of the FSAR using the sizing guidance provided in Sections 6.1.1, 6.2.1, 6.2.2, 6.2.3, 6.2.4, 6.3.2, and 6.3.3 of IEEE Standard 485-2010, "Recommended Practice for Sizing Lead-Acid Batteries for Generating Stations" (Reference 17). SHINE applies Sections 6.1.1, 6.2.1, 6.2.2, 6.2.3, 6.2.4, 6.3.2, and 6.3.3 of IEEE Standard 485-2010 to satisfy the SHINE Design Criterion 27 requirement that sufficient capacity and capability is provided to perform required safety functions.

The UPSS batteries are installed in accordance with Section 5 and Section 6 of IEEE Standard 484-2002, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications" (Reference 18). Section 5 of this standard provides guidance for installation design criteria that provides for proper location, mounting, seismic, ventilation, and instrumentation considerations. Section 6 of this standard provides guidance for receiving and storage; assembly; freshening charge, data collection, and testing; and connection to the DC system. SHINE applies Section 5 and Section 6 of IEEE Standard 484-2002 to satisfy the SHINE Design Criterion 27 requirement to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

The UPSS batteries are maintained in accordance with Section 5 of IEEE Standard 450-2010, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid batteries for Stationary Applications" (Reference 19). Section 5 of this standard provides guidance for determining the condition of the battery; guidance on inspections to be performed on a monthly, quarterly, and yearly basis; and guidance on corrective actions for battery problems. SHINE applies Section 5 of IEEE Standard 450-2010 to satisfy the SHINE Design Criterion 27 requirement to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

Factory acceptance testing of the UPSS batteries will include a report of test results, issues, failures, and corrective actions; will include a verification of shop drawings, wiring diagrams, operating manuals, spare parts list, maintenance and calibration requirements; and include installation and operating instructions. Site acceptance testing of the UPSS batteries will verify proper installation and battery function. SHINE applies UPSS battery factory and site acceptance testing to satisfy the SHINE Design Criterion 27 requirement to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

Factory acceptance testing of the UPSS battery chargers will verify that they have the capacity to maintain and charge the batteries while supporting a full load. Site acceptance testing of the UPSS battery chargers will be performed to verify that the system meets installation and functional requirements. SHINE applies UPSS battery charger factory acceptance testing and site acceptance testing to satisfy the SHINE Design Criterion 27 requirement to minimize the probability of losing electrical power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

Performance testing of the UPSS will be done as part of the surveillance requirements required by Limiting Condition for Operation (LCO) 3.6.1 of the technical specifications, which specifies surveillance testing consistent with Section 4.6.2 of American National Standards Institute/American Nuclear Society Standard (ANSI/ANS)-15.1-2007, “The Development of Technical Specifications for Research Reactors” (Reference 20). The UPSS is designed to ensure the ability to perform this testing. The capability exists to install a temporary load bank to perform the required test discharge. SHINE applies the surveillance testing requirements ANSI/ANS-15.1-2007 to satisfy the SHINE Design Criterion 28 requirement to periodically test the operability and functional performance of the components of the UPSS.

For the UPSS battery chargers, SHINE requires technical documentation of the installation, maintenance, calibration, and surveillance activities necessary to ensure the design life. The UPSS battery chargers are designed to be capable of having maintenance performed in place, to be able to be isolated using Lock-Out/Tag-Out requirements, and to facilitate access to internal components for testing and maintenance. SHINE applies these maintenance and testing requirements to satisfy the SHINE Design Criterion 28 requirement to periodically test the operability and functional performance of the components of the UPSS.

Electromagnetic interference (EMI) and radiofrequency interference (RFI) requirements are addressed via equipment specifications for each system. During the procurement phase, SHINE specifications require electrical components to not be a source of, or be susceptible to, EMI and RFI. SHINE specifications require vendor documentation which addresses grounding and noise minimization, as well as EMI/RFI test results for emissions, susceptibility, and power surge withstand capability. Post-installation testing of electrical components will be performed to identify vulnerabilities from portable EMI/RFI emitters, which will be addressed with via the addition of administrative controls. These requirements and the post-installation testing will ensure that EMI/RFI does not impact safety-related instrumentation or control functions.

As described in Subsection 8a2.1.3 of the FSAR, redundancy is provided in the design for the safety-related breakers in the NPSS by having two breakers in series capable of removing power from components as required. As described in Subsection 8a2.2.3 of the FSAR, redundancy is provided in the design of the UPSS by having two independent, isolated divisions that are each sized to provide sufficient load to support safety-related SSCs. This redundancy, along with the independence discussed above, ensures that the safety-related portions of the NPSS and the UPSS will perform the required safety function if there is a single failure on the opposite division.

SHINE has revised Sections 8a2.1 and 8a2.2 of the FSAR to describe the SHINE application of codes and standards to satisfy SHINE Design Criteria 27 and 28. A mark-up of the FSAR incorporating these changes is provided as Attachment 1.

The following is a discussion of the calculations and studies of interest to the NRC, and whether SHINE performed such calculations or studies. Where SHINE is not performing a calculation or study of interest to the NRC, justification for not performing such a calculation or study is provided.

- Load Flow/Voltage Regulation Studies and Under/Overvoltage Protection

  SHINE is performing load flow and voltage regulation studies for the NPSS and emergency power systems. Under/overvoltage protection studies are not performed by SHINE, as there is no explicit requirement for SHINE to perform such studies. Undervoltage and overvoltage protection is provided as described in Subsection 8a2.1.3 of the FSAR.

- 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

  SHINE is performing short-circuit and breaker protection and coordination studies for the NPSS and emergency electrical power systems. Cables in penetrations are sized to accommodate the load and to be capable of withstanding short circuit conditions, which prevents the possibility of a damaged cable impacting the seal and, thus, will ensure confinement integrity is maintained.

- Equipment Sizing Studies

  SHINE is performing equipment sizing studies for the UPSS. Equipment sizing studies for the NPSS are not performed by SHINE, as there is no explicit requirement for SHINE to perform such studies. NPSS equipment sizing is based on wire and bus sizing minimums established in NFPA 70-2017.

- Equipment Protection and Coordination Studies

  SHINE is performing equipment protection and coordination studies for the NPSS and emergency power systems.

- Insulation Coordination (Surge and Lightning Protection)

  Surge and lightning protection studies are not performed be SHINE, as there is no explicit requirement for SHINE to perform such studies. The local utility provides for lightning protection on the supply transformers. Surge protection is provided at the incoming connection to the utility as a part of the low voltage switchgear. SHINE provides a facility grounding and lightning protection system that provides intentional low impedance conductive paths between facility SSCs and earth.

- Power Quality Limits (Harmonic Analysis)

  SHINE is performing harmonic analyses for the NPSS and emergency power systems.

- Grounding Grid Studies

  Grounding grid studies are not being performed by SHINE, as there is no explicit requirement for SHINE to perform such studies. Grounding grid studies are associated with a generation facility or substation facility.

- Grid Stability Studies

  Grid stability studies are not being performed by SHINE, as there is no explicit requirement for SHINE to perform such studies.

- Electromagnetic interference and radiofrequency interference, including conformance to RG 1.180, as applicable

  Calculations and studies relating to EMI/RFI are not being performed by SHINE, as there is no explicit requirement for SHINE to perform such studies. EMI/RFI is being addressed as described above. The regulatory positions of Regulatory Guide 1.180, “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems” (Reference 21) are specific to nuclear power plants, and not applicable to non-power production and utilization facilities.

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.

SHINE Response

A description of the standards and methodologies used to perform maintenance, testing, installation, and qualification for the safety-related batteries in the UPSS, and a description of the maintenance, testing, and qualification of the battery chargers, is provided in the SHINE Response to RAI 8-1.

References

1. NRC letter to SHINE Medical Technologies, LLC, “Issuance of Request for Additional Information Related to the SHINE Medical Technologies, LLC Operating License Application (EPID No. L-2019-NEW-0004),” dated October 16, 2020

2. SHINE Medical Technologies, LLC letter to the NRC, “SHINE Medical Technologies, LLC Application for an Operating License,” dated July 17, 2019 (ML19211C143)

3. SHINE Medical Technologies, LLC letter to NRC, “SHINE Medical Technologies, LLC Operating License Application Supplement No. 5 and Response to Request for Additional Information,” dated December 10, 2020

4. American Society of Mechanical Engineers, “Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder),” NOG-1-2004, 2004

5. Crane Manufactures Association of America, “Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes,” CMAA 70-2004, 2004

6. American Concrete Institute, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary,” ACI 349-13, 2014

7. American Society of Civil Engineers, “Minimum Design Loads for Buildings and Other Structures,” ASCE 7-05, 2006

8. International Code Council, “International Building Code,” IBC, 2015

9. U.S. Nuclear Regulatory Commission, “Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,” Regulatory Guide 1.91, Revision 1, 1978

10. American Society of Mechanical Engineers, Boiler & Pressure Vessel Code - Rules for Construction of Pressure Vessels, Section VIII, Division 1, 2010.

11. National Fire Protection Association, “National Electrical Code,” NFPA 70-2017, Quincy, MA

12. Institute of Electrical and Electronics Engineers, “Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures,” IEEE Std. C37.13-2015, New York, NY

13. Institute of Electrical and Electronics Engineers, “Standard Criteria for Independence of Class 1E Equipment and Circuits,” IEEE Std. 384-2008, New York, NY

14. Institute of Electrical and Electronics Engineers, “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations,” IEEE Std. 344-2013, New York, NY

15. Institute of Electrical and Electronics Engineers, “Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear,” IEEE Std. C37.20.1-2015, New York, NY

16. Institute for Electrical and Electronics Engineers, “Recommended Practice for the Design of DC Auxiliary Systems for Generating Stations,” IEEE Std. 946-2004, New York, NY

17. Institute of Electrical and Electronics Engineers, “Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications,” IEEE Std. 485-2010, New York, NY

18. Institute of Electrical and Electronics Engineers, “Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications,” IEEE Std. 484-2002, New York, NY

19. Institute of Electrical and Electronics Engineers, “Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications,” IEEE Std. 450-2010, New York, NY

20. American National Standards Institute/American Nuclear Society, “The Development of Technical Specifications for Research Reactors” ANSI/ANS-15.1-2007, La Grange Park, IL

21. U.S. Nuclear Regulatory Commission, “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems,” Regulatory Guide 1.180, Revision 2, December 2019

ENCLOSURE 1
ATTACHMENT 1

SHINE MEDICAL TECHNOLOGIES, LLC

SHINE MEDICAL TECHNOLOGIES, LLC OPERATING LICENSE APPLICATION
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

FINAL SAFETY ANALYSIS REPORT CHANGES
(MARK-UP)

23 pages follow

2.2.3.1.1 Explosions

Accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels were considered for facilities and activities in the vicinity of the plant or on-site where such materials are processed, stored, used, or transported in quantity. The effects of explosions are a concern in analyzing structural response to blast pressures. The effects of blast pressure from explosions from nearby railways, highways, or facilities to critical plant structures were evaluated to determine if the explosion would have an adverse effect on plant operation or would prevent a safe shutdown.

The allowable (i.e., standoff) and actual distances of hazardous chemicals transported or stored were determined in accordance with Regulatory Guide 1.91, Revision 1, Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants (USNRC, 1978). 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.

For those chemicals where the standoff distance using the NUREG-1805, Fire Dynamics Tools (FDTs) (USNRC, 2004), methods are greater than the actual distance from the chemical to the nearest safety-related building, a probabilistic analysis is used. The probabilistic analysis must show that “the rate of exposure to a peak positive incident overpressure in excess of 1 psid (6.9 kPa) is less than 1E-6 per year, when based on conservative assumptions, or 1E-7 per year when based on realistic assumptions.”

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. In each of the explosion scenario analyses, conservative yield factors were chosen. The yield factor is an estimation of the available combustion energy released during the explosion as well as a measure of the explosion confinement. For confined explosions, a yield factor of 100 percent was applied to account for an in-vessel confined explosion. This is a conservative assumption because a 100 percent yield factor is not achievable:

- For some atmospheric liquids (e.g., diesel) the entire storage vessel volume was assumed to contain fuel vapors at the upper explosive limit. This is conservative because the upper explosive limit produces the maximum explosive mass, given that it is the fuel vapor, not the liquid fuel that explodes. These assumptions are consistent with those used in Chapter 15 of NUREG-1805, Fire Dynamics Tools (FDTs) (USNRC, 2004).
- For unconfined explosions of compressed or liquefied gases (i.e., propane, hydrogen), it was conservatively assumed that the entire content of the storage vessel is between the upper and lower explosive limits, given that the instantaneous depressurization of the vessel would result in vapor concentrations throughout the explosive range at varying pressures and temperatures that could not be assumed. Therefore, the entire content of the storage vessel was considered ~~as~~in determining the explosive mass with a yield factor of 3 percent.
- For confined explosions, an in-vessel explosion of compressed or liquified gases could not occur until stoichiometric conditions are met. A tank filled with compressed gas is

highly pressurized and thus any accidental opening in the tank would not allow oxygen into the tank until the pressure drops below atmospheric. Both fuel and oxidizer are required for a confined explosion to occur within the tank. Therefore, the vapor mass for a confined explosion is that contained in the tank at atmospheric pressure with a yield factor of 100 percent.

For unconfined explosions of propane~~, methane,~~ or hydrogen, the yield factor is 3 percent from the Handbook of Chemical Hazard Analysis Procedures (FEMA, 1989).

In addition, the site has a liquid nitrogen storage tank located outside the facility buildings. The tank and its associated process piping are designed in accordance with applicable codes, including overpressure protection.

In some cases, chemicals are screened as being bounded by other chemicals. Three properties of the chemical hazard are used to determine if one of the hazards is bounded by another. First, chemicals that are gases at standard conditions will be more volatile and have a larger explosive mass per storage mass than chemicals that are liquids at standard conditions. Second, chemicals with a smaller lower explosive limit (LEL) and a greater upper explosive limit (UEL) will be more explosive. A larger flammable or explosive range will make an explosion more likely and increase the explosive mass per storage mass. Third, chemicals with a greater heat of combustion will have a larger amount of energy released in an explosion. In addition, the mass of the chemical and the distance from the chemical to the facility are screening factors. Where chemicals exhibit similar properties, those chemicals that are closer to the site and in larger tanks are chosen as bounding over chemicals that are farther or smaller.

The on-site and off-site chemicals in Table 2.2-15 are evaluated to ascertain which hazardous materials have the potential to explode, thereby requiring further analysis. The effects of selected explosion events are summarized in Table 2.2-16 and in the following subsections relative to the release source.

2.2.3.1.1.1 Pipelines

A stationary explosion of a pipeline is bounded by the delayed ignition explosion of a pipeline. This is because the constant mass release rate from the pipe results in a much larger total explosive mass, and because the wind is assumed to blow the release towards the site. The distance from the point of the explosion to the facility is therefore much smaller for flammable vapor clouds than for pipeline explosions at the release point.

2.2.3.1.1.2 Waterway Traffic

There is no navigable waterway within 5 mi. (8 km) of the facility.

2.2.3.1.1.3 Highways

Table 2.2-15 includes the hazardous materials potentially transported on US 51 and I-90/39. The materials that were identified as the bounding chemicals for explosive potential were diesel, ethylene oxide, gasoline, and propane on US 51, and hydrogen on I-90/39. The remaining chemicals are either non-explosive or are bounded based on the comparison method discussed in Subsection 2.2.3.1.1 (ammonia, propylene oxide, and styrene).The maximum quantity of the identified chemicals assumed to be transported on the roadway was 50,000 pounds (lb.)

(22,679 kilograms [kg]) per Regulatory Guide 1.91, except for the hydrogen, where at most 3300 lb. (1,496 kg) is on a single truck per 49 CFR 173.318.

~~A~~Table 2.2-16 provides the results of an analysis of the identified chemicals ~~was conducted~~ using the TNT equivalency methodologies, as described in Subsection 2.2.3.1.1. The results ~~indicate that the minimum separation distances (i.e., safe standoff distances) are less than the shortest distance to a safety-related SHINE structure from any point on US 51 or I-90/39. A tank of diesel that contains 1,258,091 lb. (570,660 kg) of diesel is acceptable at 0.22 mi. (0.35 km). A tank of ethylene oxide that contains 440,000 lb. (199,580 kg) of ethylene oxide is acceptable at 0.22 mi. (0.35 km). A tank of gasoline that contains 133,946 lb. (60,756 kg) is acceptable at 0.22 mi. (0.35 km). A tank of jet fuel containing 500,000 lb. (226,796 kg) is acceptable at 0.22 mi. (0.35 km). A tank of propane that contains 55,724 lb. (25,275 kg) is acceptable at 0.22 mi. (0.35 km).~~ identify the acceptable instance for each identified chemical. The acceptable instance represents the analyzed condition that bounds the stationary explosion hazard in both distance and mass for each chemical. It demonstrates a liquid mass of chemical that, if located at the nearest point to SHINE safety-related structures, would not exceed a 1 psid overpressure. The ~~closest~~nearest safety-related SHINE area is located approximately 0.22 mi. (0.35 km) from US 51.

The propane truck was also analyzed for a boiling liquid expansion vapor explosion (BLEVE) overpressure. The standoff distance to a 1 psid (6.9 kPa) overpressure is 332 ft. (101 meters [m]). This is much less than the actual distance from US 51 to the facility (0.22 mi. [0.35 km]).

A tank containing 18,196 lb. (8253 kg) of hydrogen is acceptable at a distance of 0.22 mi. (0.35 km). The closest safety-related SHINE area is 2.1 mi. (3.4 km) from I-90/39.

The limiting stationary explosions are shown in Table 2.2-16.

Based on the above, an explosion involving potentially transported hazardous materials on US 51 or I-90/39, would not adversely affect operation of SHINE.

2.2.3.1.1.4 On-Site Chemicals

On-site stationary chemicals were analyzed using the TNT equivalency methodologies, as described in Subsection 2.2.3.1.1. One chemical was identified as being a potential explosive hazard on-site: deuterium/tritium.

The deuterium and tritium are used in the main production facility and are treated for this analysis as hydrogen gas. The maximum expected mass in one container is 0.39 lbs (0.18 kg) of deuterium and 0.25 lbs (0.10 kg) of tritium. These maximum expected masses are very low; however, because these chemicals are used in production, there is no separation between the hazard and the SHINE safety-related area. The deuterium and tritium gas systems and processes are designed to minimize the probability of an explosion. With safety features, and the very small mass of each chemical, the probability of an explosion causing enough damage to the facility to cause a radiological release to the public is low.

Therefore, an explosion of any of these chemicals would not adversely affect operation of SHINE.

The ALOHA model shows that the vapor pressure of n-butyl alcohol at the analysis temperature of 81°F (27°C) is less than the LEL. Therefore, n-butyl alcohol cannot support a vapor cloud explosion at a distance of 3 mi. from the facility and a quantity of 25,160 lb.

The results of flammable vapor cloud ignition and explosion analyses are summarized in Table 2.2-17.

2.2.3.1.2.6 Flammable Vapor Cloud (Delayed Ignition) Related Impacts Affecting the Design

A facility is acceptable when the calculated rate of occurrence of severe consequences from any external accident is less than 1E-6 occurrences per year and reasonable qualitative arguments can demonstrate that the realistic probability is lower. Regulatory Guide 1.91 (USNRC, 1978) cites 1 psid (6.9 kPa) as a conservative value of peak positive incident overpressure, below which no significant damage would be expected. The facility’s safety-related areas are designed to withstand a peak positive overpressure of at least 1 psid (6.9 kPa) without loss of function.

The analyses presented in this subsection demonstrate that a 1 psid (6.9 kPa) peak positive overpressure is not exceeded at a safety-related structure for any of the postulated flammable vapor cloud, delayed ignition event scenarios.

2.2.3.1.3 Toxic Chemicals

Accidents involving the release of chemicals in the vicinity of the plant or on-site were considered for their potential toxicity and ability to affect personnel in the facility control room.

On-site chemical releases are evaluated using the methodology described in Subsection 2.2.3.1.3.4. Off-site chemical releases are evaluated in this subsection.

The potential for an off-site toxic gas release was evaluated within 5 mi. (8 km) of the site.

SHINE considered stationary sources and mobile sources expected to be transported on US 51, I-90/39, or on local railroads. The effects of a chemical release from a pipeline were considered bounded by the delayed ignition explosion of a pipeline.

Chemicals are screened in several ways. Only chemicals with vapor pressures greater than 10 Torr at 100°F were considered for further evaluation. Mobile sources were not considered if their shipment was not frequent (i.e., less than 10 shipments per year for truck traffic or 30 shipments per year for rail traffic).

In some cases, chemicals are screened as being bounded by other chemicals. A chemical determined to not present a toxic hazard to the site can be considered bounding to other chemicals that meet these four criteria: (1) have similar or lower vapor pressure; (2) have similar or lower toxicity; (3) are located similar or a farther distance away; and (4) are present in a similar or lower quantity. Additionally, to bound some chemicals, it was assumed that given identical meteorological conditions, initial chemical inventories, and travel distances:

a. A chemical that exists as a gas or vapor will result in higher downwind concentrations than one that exists as a liquid.

2.2.3.1.3.3 Highways

Table 2.2-19 provides a bounding list of toxic materials that may be transported on US 51 and I-90/39.

The closest SHINE safety-related area is located approximately 0.22 mi. (0.35 km) from US 51, and approximately 2.1 mi. (3.4 km) from I-90/39. For this analysis, these distances were also used as the distance from US 51 and I-90/39, respectively, to the facility control room.

The hazardous chemicals evaluated were primarily based on those chemicals identified in 2010 Tier II reports in Rock County, Wisconsin (Wisconsin Emergency Management, 2011). The selection of mobile sources for an analysis of potential impact to the facility control room was based on: (1) the mobile sources of hazardous chemicals described in Table 2.2-5; (2) stationary sources within 5 mi. (8 km) where deliveries or shipments could be transported on local roads; (3) large quantities of stationary sources elsewhere in the county where deliveries or shipments could be transported on major roads or rail lines; and (4) direct communication with facilities regarding their types, quantities, and frequencies of shipments.

If a chemical is known to be in a tank (i.e., chemicals transported by rail or on US 51 or I-90/39), the dispersion is modeled in ALOHA as a tank source, with the tank volume set to accommodate the entire mass of the chemical. A hole in the bottom of the tank is sized so that the entire tank inventory is released in one minute (minimum release time for ALOHA), and if the chemical is a liquid, forms a puddle that spreads to a maximum area that can be modeled, as determined by ALOHA. Ground type is the ALOHA default soil and ground temperatures are set to ambient conditions.

Chemicals transported by truck were modeled as release of 50,000 lbs of the chemical except for chlorine and sodium bisulfite.

Chlorine is shipped in 150-lb cylinders, one-ton containers, cargo tankers (15 to 22 tons), and up to 90-ton rail cars. The only users of chlorine within 5 mi. (8 km) of the site are the City of Janesville and the City of Beloit water utilities. The chlorine used is obtained in standard 150-lb cylinders (City of Beloit, 2015 and City of Janesville, 2015a). The maximum amount of chlorine at any one site is 900 lb. Therefore, a release of chlorine on US 51 is considered only for the case of the failure of one 150-lb cylinder. Chlorine releases on I-90/39 were considered for standard-size shipment containers (one ton containers (2,000 lbs) and 22 ton cargo tankers (44,000 lbs)).

Sodium bisulfite (which could generate sulfur dioxide) was modeled as a 15,000 lb release from US 51, since 15,000 lbs is the maximum inventory size of any current stationary location of sodium bisulfite (City of Janesville, 2015b).

Of the releases analyzed deterministically, only the following were found to be a potential hazard to the facility control room:

- Ammonia (50,000 lbs) from US 51
- Chlorine (44,000 lbs) from I-90/39
- Ethylene oxide (50,000 lbs) from US 51
- Propylene oxide (50,000 lbs) from I-90/39
- Sodium bisulfite (15,000 lbs) from US 51

These mobile sources of chemicals were evaluated using a simple probabilistic model, based on shipment or inventory information from local users of those chemicals. The acceptance criteria for releases evaluated in this manner is 1E-6 releases per year because the resultant low levels of radiological risk are considered acceptable.

The following equation was used to determine the maximum number of shipments past the facility before the probability of a release exceeded 1E-6 per year.

$$R_{haz} = P_{spill} \times R_{accident} \times P_{weather} \times D_{trip} \quad \text{(Equation 2.2-6)}$$

Where:

- R_{haz} is the rate of hazards per vehicle trip near the site (hazardous spills/trip)
- P_{spill} is the probability of the spill size (spills/accident)
- $R_{accident}$ is the rate of accidents (accidents/vehicle mile)
- $P_{weather}$ is the adverse wind direction probability (hazardous weather conditions at the site)
- D_{trip} is the hazardous trip length, the total number of miles that a vehicle travels past the site each trip where an accident could result in a hazardous condition (vehicle miles/trip)

Chlorine, ethylene oxide, propylene oxide, and sodium bisulfite were eliminated as a hazard to the facility control room using this probabilistic method.

For chlorine, 53 cargo tanker shipments per year on I-90/39 past the site are required to exceed a release frequency of 1E-6. Without large producers or users of chlorine in the county, there are expected to be fewer than 53 cargo tanker shipments per year, and this release scenario therefore is not considered a hazard to the facility control room.

For ethylene oxide, 28 truck shipments per year on US 51 are required to exceed a release frequency of 1E-6. Since the local industrial users receive their shipments by rail, exceeding this frequency is not considered credible. Ethylene oxide is therefore not considered a hazard to the facility control room.

For propylene oxide, 58 truck shipments per year on US 51 are required to exceed a release frequency of 1E-6. Since the only user of propylene oxide within 5 mi. (Abitec Corporation) that receives shipments via truck has 6 shipments per year (Abitec Corporation, 2015), propylene oxide is not considered a hazard to the facility control room.

For sodium bisulfite, 553 truck shipments per year on US 51 are required to exceed a release frequency of 1E-6. Since the only current user of sodium bisulfite within 5 mi. has a reported storage quantity of 15,000 lbs, it is very unlikely they send or receive 553 shipments per year. Sodium bisulfite is therefore not considered a hazard to the facility control room.

A simple probabilistic analysis is not sufficient to eliminate ammonia from consideration as a hazard to the site. However, in the most limiting case of the closest, maximum inventory release, worst case wind directions, and 5 percent annual exceedance maximum wind speeds and atmospheric stability classes, the indoor toxicity limit is approached approximately one minute after the release, and outdoor concentrations begin to rise about 20 seconds after the release. Although there are only approximately 40 seconds between potential detection on-site and reaching the IDLH limit in the facility control room, the IDLH limit can be tolerated for 2 minutes without physical incapacitation. Therefore, the operators will be able to place the facility in a safe condition prior to the need to use personal protective equipment.

2.2.3.1.3.4 On-Site Chemicals

~~On-site chemical hazards are evaluated in Section 13b.3. This evaluation included exposure concentrations for workers located 328 ft. (100 m) downwind of a potential spill. The worker exposure calculations are considered representative of exposure to control room personnel. The results of this evaluation are presented in Table 13b.3-2.~~

~~These concentrations are calculated for a release of the largest container of each chemical on-site. The chemical dose or concentration for the nearest residence is below the PAC-1 level. For the workers postulated to be located within the boundary 328 ft. (100 m) downwind, the concentrations are below the PAC-1 values. Since the worker concentrations are below the PAC-1 levels for all chemicals considered, on-site chemical releases are not a hazard to the facility control room.~~Bulk chemical storage is provided in the storage building, as described in Subsection 9b.7.10. The location of the storage building relative to the main production facility is identified in Figure 1.3-3. The distance from the north side of the storage building to the ventilation air intake for the main production facility is approximately 233 ft. (71 m). Chemicals that are stored in bulk in the storage building are identified in Table 2.2-20.

The analysis for the impact of an on-site chemical release on control room habitability follows the applicable methodology, as described in Subsection 2.2.3.1.3, using ALOHA, Version 5.4.7 (ALOHA, 2016). Chemicals that are stored in the storage building are evaluated for postulated releases. Only chemicals with vapor pressures greater than 10 Torr at 100°F were considered for further evaluation. Liquid solutions are assumed to form a pool with a depth of approximately 1 cm to maximize vaporization. No credit is taken for the storage building retention or deposition of any chemical.

The meteorological conditions assume a Pasquill Stability Class F (stable), a wind speed of 1 meter per second, an ambient temperature of 81°F, a relative humidity of 50 percent, and a cloud cover of 50 percent.

The control room was assumed to have an air-exchange rate of 1.2 exchanges per hour. Toxicity limits for this analysis are based on the IDLH exposure levels, as described in Subsection 2.2.3.1.3.

The following chemicals that are stored in the storage building were determined to pose a potential hazard to exceed toxicity limits for the control room:

- Acetone
- Ammonium hydroxide
- Chloroform
- Ethyl acetate
- Hydrochloric acid
- Hydrogen peroxide
- Isopropanol
- Methanol
- Nitric acid

The analysis determined the limiting quantity of a solution spill that could result in exceeding the toxicity limits in the control room. The limiting quantity of each chemical determined to pose a potential hazard to control room habitability is provided in Table 2.2-20. The maximum container size used for the storage of each of these chemicals in the storage building is lower than the determined limiting quantities.

2.2.3.1.3.5 Nearby Facilities and Railways

Table 2.2-19 provides stationary sources of bounding toxic chemicals located within 5 mi. (8 km) of the site and bounding toxic chemicals potentially transported by rail near the facility.

The hazardous chemicals evaluated were primarily based on those chemicals identified in Tier II reports in Rock County, Wisconsin. Direct communication with individual facilities was used to augment the stationary source information identified in the Tier II reports.

Releases from rail lines are set at 1.6 mi. (2.6 km), which is the distance of the nearest approach of the Union Pacific Railway to the facility. Chemicals stored or situated at distances greater than 5 mi. (8 km) from the plant need not be considered because, if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action.

The Tier II Report was reviewed for other chemicals used within in the region, not necessarily within 5 mi. (8 km) of the site, in a significant quantity (i.e., over 50,000 lbs), such that they may be frequently shipped by rail near the site. Chemicals already determined to not be hazardous based on vapor pressure or toxicity were not included.

Based on this review, acrylonitrile, which is used by a chemical manufacturer located greater than 5 mi. (8 km) from the site, was also considered for analysis based on the large amounts used by this manufacturer.

Assumptions for a rail line tank release were the same as used for highway tank release, as described in Subsection 2.2.3.1.3.3. The tank size for a rail line release was set to 30,000 gallons, and converted to an equivalent mass based on the estimated density of each material.

No release from a stationary source was determined to be a hazard to the facility control room, as shown in Table 2.2-19. For rail line releases, only ammonia had the potential to exceed toxicity levels in the facility control room under 5 percent annual exceedance probability worst case meteorological conditions. A probabilistic evaluation was not undertaken for rail shipments of ammonia, since this release was bounded by a postulated tanker truck release, as discussed in Subsection 2.2.3.1.3.3.

2.2.3.1.3.6 Toxic Chemical Related Impacts Affecting the Design

Of the chemicals evaluated, only an ammonia release could have a greater than 1E-6 per year potential to result in an uninhabitable control room, based on a simple probabilistic analysis. For the closest ammonia release, the evaluation shows that the control room operators would be able to shut down the facility (i.e., have at least two minutes) by manually tripping the target

The limiting on-site jet fire is from the 3-in. pipeline that feeds the facility. The pressure is 115 pounds per square inch gauge (psig) (793 kilopascal [kPa] gauge) upstream of a pressure reducing station, and 54 psig (372 kPag) downstream of the pressure reducing station. The pressure reducing station is roughly 100 yd. (91.4 m) from the nearest safety-related area. The computer program ALOHA was used to calculate the heat flux for the jet fire. The results show that the maximum heat flux from a fire upstream of the pressure reducing station is 17.9 Btu/hr-ft^2 (0.0565 kW/m^2). This heat flux is negligible compared with the solar heat flux (approximately 317 Btu/hr-ft^2 [1 kW/m^2]).

Downstream of the pressure reducing station, the safe standoff distance to a 317 Btu/hr-ft^2 (1 kW/m^2) is 20 yd. (18 m). The accident rate, release rate and ignition rate apply here as they do in the vapor cloud explosion analysis. Because the standoff distance for a jet fire is substantially less than the standoff distance for a vapor cloud explosion for the on-site pipeline, the jet fire analysis is bounded by the vapor cloud explosion analysis. A single ignition of gas from this pipeline is modeled as a failure for both explosion and fire analysis and would not be counted twice in the total probability.

The limiting heat fluxes due to chemical hazards are shown in Table 2.2-21.

Table 2.2-5 – Hazardous Chemicals Potentially Transported on Highways within 8 km (5 mi.) of the Site

Chemical	Quantity (lbs.)	Highway	D~~I~~istance to Site (mi.)
Ammonia	50,000	US 51	0.22
Asphyxiant Model (~~Carbon Monoxide~~ Nitrogen)	50,000	US 51	0.22
Bounding Amide (Formamide)	50,000	US 51	0.22
Chlorine	150	US 51	0.22
Diesel	50,000	US 51	0.22
Ethylene Oxide	50,000	US 51	0.22
Gasoline	50,000	US 51	0.22
Jet Fuel (Kerosene)	50,000	US 51	0.22
Hydrogen Peroxide	50,000	US 51	0.22
Isopropanol	50,000	US 51	0.22
n-Butyl Alcohol	50,000	US 51	0.22
Propane	50,000	US 51	0.22
Propylene Oxide	50,000	US 51	0.22
Sodium Bisulfite (Sulfur Dioxide)	15,000	US 51	0.22
Styrene	50,000	US 51	0.22
Acetone	50,000	I-90/39	2.1
Chlorine	44,000	I-90/39	2.1
Hydrogen	3,300	I-90/39	2.1
Methyl Acetate	50,000	I-90/39	2.1
n-Heptane	50,000	I-90/39	2.1
Nitric Acid	50,000	I-90/39	2.1
Sodium Bisulfate (Sulfur Dioxide)	50,000	I-90/39	2.1
Sodium Hypochlorite (Chlorine)	50,000	I-90/39	2.1

Table 2.2-16 – Stationary Explosion Analysis

Chemical	Location	Distance	Quantity	Acceptable Instance[(a)]
Diesel Fuel	Bounding Instance	0.5 mi.	1,258,091 lbs.	1,258,091 lbs. at 0.22 mi.
Ethylene Oxide	Abitec / Rail	1.6 mi.	440,000 lbs.	440,000 lbs. at 0.22 mi.
Gasoline	Janesville Jet Center	0.9 mi.	133,946 lbs.	133,946 lbs. at 0.22 mi.
Jet Fuel (Kerosene)	Bounding Instance	0.22 mi.	79,968 lbs.	500,000 lbs. at 0.22 mi.
Deuterium/Tritium	On-site	N/A	280 grams	Low probability; Safety features designed into systems
Diesel Fuel	Truck (Highway 51)	0.22 mi.	50,000 lbs.	1,258,091 lbs. at 0.22 mi.
Ethylene Oxide	Truck (Highway 51)	0.22 mi.	50~~.~~,000 lbs.	~~44~~50,000 lbs. at 0.22 mi.
Gasoline	Truck (Highway 51) bounding	0.22 mi.	50,000 lbs.	133,946 lbs. at 0.22 mi.
Propane	Truck (Highway 51)	0.22 mi.	50,000 lbs.	55,724 lbs. at 0.22 mi.
Propane BLEVE	Truck (Highway 51)	0.22 mi.	50,000 lbs.	50,000 lbs. at 0.22 mi.
Hydrogen	Truck (I-90/39)	2.1 mi.	3300 lbs.	18,196 lbs. at 0.22 mi.

(a) The Acceptable Instance shows the analyzed condition that bounds the stationary explosion hazard in both distance and mass. It demonstrates a liquid mass of chemical that, if located at the nearest point to SHINE safety-related structures, would not exceed a 1 psi overpressure.

Table 2.2-19 – Bounding Toxic Chemical Hazards within 8 km (5 mi.) of the Site (Sheet 1 of 3)

Chemical	Location	Distance (mi.)	Mass (lbs.)	Disposition
Polymer dispersion (1,3-butadiene)	Humane Manufacturing	1	58,800	No Hazard
Polymer dispersion (benzene)	Humane Manufacturing	1	58,800	No Hazard
Asphyxiant Model (~~carbon monoxide~~nitrogen)	Linde Merchant Production	2	5,000,000	No Hazard
Bounding Amide (Formamide)	Abitec Corporation and Evonik Goldschmidt (Bounding Case)	2	640,000	No Hazard
Bounding Amine (diethylamine)	Abitec Corporation and Evonik Goldschmidt (Bounding Case)	2	640,000	No Hazard
Bounding Amine (n-Butylamine)	Abitec Corporation and Evonik Goldschmidt (Bounding Case)	2	640,000	No Hazard
Ethylene Oxide	Abitec Corporation	2	440,000	No Hazard
Isopropanol	Abitec Corporation	2	185,800	No Hazard
Oxygen	Linde Merchant Production	2	2,150,000	No Hazard
Volatile Amine (cyclohexylamine)	WI School for the Visually Handicapped	2	300	No Hazard
Benzyl acetate	Evonik Goldschmidt	3	12,321	No Hazard
Chlorine	Janesville Pump Station #12	3	900	No Hazard
Ethyl Alcohol	Evonik Goldschmidt	3	168,000	No Hazard
Hydrogen Peroxide	Evonik Goldschmidt	3	60,000	No Hazard
Methyl Chloride	Evonik Goldschmidt	3	320,000	No Hazard
n-Heptane	Evonik Goldschmidt	3	125,000	No Hazard
Sodium Bisulfite (as sulfur dioxide)	Evonik Goldschmidt	3	15,000	No Hazard
Sodium Chlorite (as chlorine dioxide)	Evonik Goldschmidt	3	14,000	No Hazard
Styrene	Monterey Mills	3	225,280	No Hazard
Volatile Amine (DMAPA)	Evonik Goldschmidt	3	12,045	No Hazard

Table 2.2-19 – Bounding Toxic Chemical Hazards within 8 km (5 mi.) of the Site (Sheet 2 of 3)

Chemical	Location	Distance (mi.)	Mass (lbs.)	Disposition
Propylene Oxide	Evonik Goldschmidt and Rail (Bounding Case)	1.6	360,000	No Hazard
Acrylonitrile	Rail	1.6	199,852	No Hazard
Ammonia	Rail	1.6	150,054	Additional Evaluation
Bounding Amide (Formamide)	Rail	1.6	282,214	No Hazard
Bounding Amine (diethylamine)	Rail	1.6	175,391	No Hazard
Bounding Amine (n-Butylamine)	Rail	1.6	183,538	No Hazard
Ethylene Oxide	Rail	1.6	216,317	No Hazard
Methyl Chloride	Rail	1.6	227,428	No Hazard
Vinylidene Chloride	Rail	1.6	300,966	No Hazard
Ammonia	Truck (US 51)	0.22	50,000	Additional Evaluation
Asphyxiant Model (~~Carbon Monoxide~~nitrogen)	Truck (US 51)	0.22	50,000	No Hazard
Bounding Amide (Formamide)	Truck (US 51)	0.22	50,000	No Hazard
Chlorine	Truck (US 51)	0.22	150	No Hazard
Ethyl Alcohol	Truck (US 51)	0.22	50,000	No Hazard
Ethylene Oxide	Truck (US51)	0.22	50,000	Additional Evaluation
Gasoline (as butane)	Truck (US 51)	0.22	50,000	No Hazard
Gasoline (as toluene)	Truck (US 51)	0.22	50,000	No Hazard
Hydrogen Peroxide	Truck (US 51)	0.22	50,000	No Hazard
Isopropanol	Truck (US 51)	0.22	50,000	No Hazard
n-Butyl Alcohol	Truck (US 51)	0.22	50,000	No Hazard
Propane	Truck (US 51)	0.22	50,000	No Hazard
Propylene Oxide	Truck (US 51)	0.22	50,000	Additional Evaluation
Sodium Bisulfite (as sulfur dioxide)	Truck (US 51)	0.22	15,000	Additional Evaluation

Table 2.2-20 – Bounding On-Site Chemical Hazards for Control Room Impact

Chemical	Disposition	Limiting Quantity (Liters)
Acetone	Additional evaluation	500
Ammonium hydroxide (30 wt.%)	Additional evaluation	25
Chloroform	Additional evaluation	250
Ethyl acetate	Additional evaluation	2000
Hydrochloric acid (37 wt.%)	Additional evaluation	50
Hydrogen peroxide (30 wt.%)	Additional evaluation	1000
Isopropanol	Additional evaluation	1000
Methanol	Additional evaluation	1000
Nitric acid (70 wt.%)	Additional evaluation	100
Sodium hydroxide (50 wt.%)	No hazard	N/A
Sulfuric acid (98 wt.%)	No hazard	N/A

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2.6.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

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Table 3.1-1 – Safety-Related Structures, Systems, and Components (Sheet 1 of 2)

Structure, System, or Component (SSC)	Acronym	Section	Applicable Design Criteria
Engineered safety features actuation system	ESFAS	7.1.3 7.5	13-19, 37-39
Facility structure	FSTR	3.4.2	29-32, 34
Hot cell fire detection and suppression system	HCFD	9a2.3	29-34, 37
Irradiation cell biological shield	ICBS	4a2.1 4a2.5	29-34, 36
Iodine and xenon purification and packaging	IXP	4b.1.3 4b.3.1	29-34, 36, 37, 39
Light water pool system	LWPS	4a2.1 4a2.4.2	25, 29-32, 36
Molybdenum extraction and purification system	MEPS	4b.1.3 4b.3	29-34, 36, 37, 39
Neutron driver assembly system	NDAS	4a2.1 4a2.3	29-34
Neutron flux detection system	NFDS	4a2.1 7.1.7 7.8	13-19
Nitrogen purge system	N2PS	3.6 6b.2.3 9b.6.2	39
Normal electrical power supply system	NPSS	8a2.1	27, 28
Primary closed loop cooling system	PCLS	4a2.1 5a2.2	9, 12, 21, 29-34
Process vessel vent system	PVVS	4b.1.3 9b.6.1	29-36, 39
Production facility biological shield	PFBS	4b.2	29-34, 36
Radioactive drain system	RDS	9b.7.6	29-34, 36, 37, 39
Radioactive liquid waste immobilization	RLWI	9b.7.3	35-37
Radioactive liquid waste storage	RLWS	4b.1.3 9b.7.4	29-37, 39

3.6 NITROGEN PURGE SYSTEM STRUCTURE

The nitrogen purge system (N2PS) structure is a safety-related structure which contains a portion of the N2PS. The N2PS structure is located adjacent to the main production facility, as shown in Figure 1.3-3.

3.6.1 METEOROLOGICAL DAMAGE

The N2PS structure is designed to withstand the same potential meteorological damage as described in Section 3.2 for the main production facility structure (FSTR). The Regulatory Guides, codes, and standards associated with the FSTR analysis described in Section 3.2 are applicable to the N2PS structure. Rain loading is not considered in the structural design of the N2PS structure as the sloped roof does not result in rain accumulation. As a result of the lack of rain accumulation, load due to ice is anticipated to be minimal and is enveloped by the design snow load. The N2PS structure is categorized as an enclosed building and, as a result, both external and internal pressures are applied to the structure when considering wind loading.

Wind, tornado, and snow loading is applied to the N2PS structure as described in Section 3.2 for the FSTR with the following exceptions:

- The applied N2PS structure uniform snow load of 60 pounds per square foot (psf) is conservative considering 30 psf ground snow load with 1.2 importance factor for the 100-years mean recurrence interval.
- The N2PS structure tornado load includes tornado generated missile load, tornado wind load, and differential pressure consistent with the methodology described in Section 3.2 for the FSTR; however, normal wind load is not considered because the tornado wind load bounds the normal wind load.
- Due to the proximity of the N2PS structure to the main production facility, tornado missile protection is not required for penetrations in the N2PS structure on the west wall facing the FSTR as the FSTR shields that wall from tornado generated missiles.

3.6.2 WATER DAMAGE

3.6.2.1 External Flooding

The main production facility design basis precipitation, flood levels, and ground water levels, provided in Section 3.3, are also applicable to the N2PS structure, and are as follows:

- Design basis flood level: 50 feet (ft.) (15.2 meters [m]) below grade.
- Design basis precipitation level: at grade.
- Maximum ground water level: 50 ft. (15.2 m) below grade.

Per Subsection 2.4.2.3, a local probable maximum precipitation (PMP) event creates a water level about level with grade. The N2PS structure floor is raised at least 4 inches above grade; therefore, water will not infiltrate the door openings in the case of a local PMP event.

Per Subsection 2.4.3, a local probable maximum flood (PMF) event creates a water level approximately 50 ft. (15.2 m) below grade. The lowest point in the N2PS structure is above grade; therefore, flooding does not cause any structural loading in the case of a local PMF event.

3.6.2.2 Internal Flooding

There is no risk of internal flooding as there are no water sources internal to the N2PS structure.

3.6.3 SEISMIC DAMAGE

The N2PS structure seismic analysis is based on the equivalent static load method and uses the seismic analysis of the FSTR described in Section 3.4. The N2PS structure seismic loads are calculated using the in-structure-response-spectra (ISRS) for FSTR grade level with an amplification factor of 1.5. The N2PS structure seismic analysis can be realistically represented by a simple model, and the equivalent static load method with a 1.5 amplification factor produces conservative results in terms of responses. The N2PS structure has a footprint of approximately 42 ft. by 13 ft., and is located adjacent to the FSTR, which has an approximate footprint of 212 ft. by 158 ft. The N2PS structure seismic analysis, based on the equivalent static load method, conservatively accounts for relative motion. Comparing the two structures and locations, the N2PS structure response will be driven by the FSTR response and the N2PS structure will not affect the FSTR response. The use of FSTR grade level ISRS at N2PS structure grade level, with an amplification factor of 1.5, conservatively accounts for the structure-soil-structure interaction (SSSI) effects of the FSTR structure on the N2PS structure.

- Institute of Electrical and Electronics Engineers (IEEE) 384-2008, Standard Criteria for Independence of Class 1E Equipment and Circuits (IEEE, 2008), invoked for isolation and separation of nonsafety-related circuits from safety-related circuits, as described in Subsections 8a2.1.3 and 8a2.1.5.
- IEEE Standard 323-2003, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (IEEE, 2003), invoked for environmental qualification of safety-related equipment as described in Subsection 8a2.1.3.
- IEEE Standard C.37.13-2015, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures (IEEE, 2015a); invoked for ensuring reliability of safety-related breakers, as described in Subsection 8a2.1.3.

8a2.1.2 OFF-SITE POWER SUPPLY DESCRIPTION

The SHINE facility is connected to ~~a~~two single power circuits from the off-site transmission electric network. The power circuits ~~is~~are shared with other utility customers. Th~~is~~e two power circuits feed~~s~~ ~~two~~five local outdoor 12.47 kilovolt (kV) - 480Y/277 VAC 3-phase transformers. The 12.47 kV feeders originate~~s~~ from the Alliant Energy Tripp Road substation, about 2.8 circuit miles from the SHINE facility, and the Alliant Energy Venture substation, about 2.3 circuit miles from the SHINE facility.

~~Each of the t~~Two transformers ~~is~~are each connected to one of the SHINE facility's two main 480 VAC switchgear buses. Figure 8a2.1-1 depicts the off-site connections to the SHINE facility.

8a2.1.3 NORMAL ELECTRICAL POWER SUPPLY SYSTEM DESCRIPTION

The NPSS operates as ~~two~~five separate branches, each receiving utility power at 480Y/277 VAC. The branches automatically physically disconnect from the utility by opening the associated utility power (UP) supply breaker~~s~~ (UP BKR 1, ~~and~~ UP BKR 2, UP BKR 3, or UP BKR 4) on a loss of phase, phase reversal, or sustained overvoltage or undervoltage as detected by protection relays for each utility transformer. This function is not required for safe shutdown, as described in Subsection 8a2.1.6. UP BRK 5, which provides isolation for the resource building, provides overcurrent and surge protection. UP BKR 5 disconnecting from the utility is not required for safe shutdown since it does not impact safety-related equipment in the main production facility.

The two branches, serving loads in the main production facility and the nitrogen purge system (N2PS) structure, can be cross-connected by manually opening one of the UP breakers and manually closing both bus tie (BT) breakers (BT BKR 1 and BT BKR 2) in the event of the loss of a single utility 480Y/277 VAC feed. This cross-connection would be ~~performed at reduced loading and~~ administratively controlled to ensure the remaining utility feed is not overloaded.

The distribution system serving the main production facility and the N2PS structure consists of two line-ups of 480 volts (V) switchgear, two emergency 480 V buses (that are supported by the standby generator), and isolation and cross-tie breakers. The two switchgear line-ups each feed an individual emergency bus and the single SGS switchgear. The two emergency 480 V buses are nonsafety-related, but each provides power to a safety-related uninterruptible electrical power supply system (UPSS) division via division-specific battery chargers and bypass transformers. The SGS and the UPSS are further described in Section 8a2.2.

The distribution system serving the material staging building, storage building, and facility chillers consists of two 480 V switchgear with isolation and bus tie breakers (BT BKR 3 and BT BKR 4).

A single distribution system serves the resource building. There are no safety-related loads powered from these distribution systems.

Surge protection is provided at each electrical service entrance to limit voltage spikes and electrical noise. The electrical services are monitored for voltage, frequency, and loss of phase. When an electrical service exceeds prescribed limits, the facility is disconnected from the utility to prevent damage.

Loss of phase protection is provided by use of a negative sequence relay. The NPSS monitors each phase and disconnects from utility power on a loss of any one of the three incoming phases. Refer to Section 8a2.2 for further discussion of facility response to transient events.

The NPSS complies with NFPA 70 (NFPA, 2017), as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code, Electrical); with Sections 6.1.2.1, 6.1.2.2, and 6.1.2.3 of IEEE 384 (IEEE, 2008) for isolation; ~~and~~ with Section 5.1.1.2, Table 1 of Section 5.1.3.3, and Table 2 of Section 5.1.4 of IEEE 384 (IEEE, 2008) for physical separation between nonsafety-related circuits and safety-related circuits; and with IEEE C.37.13 (IEEE, 2015a) to ensure reliability of safety-related breakers.

Compliance with NFPA 70 (NFPA, 2017) ensures sufficient reliability to minimize the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electric power system. Compliance with NFPA 70 (NFPA, 2017) also ensures adequate accessibility to NPSS components to permit periodic inspection and testing.

Compliance with IEEE C.37.13 (IEEE, 2015a) guidance for ratings, functional components, temperature limitations, classification of insulating materials, and testing procedures ensures that safety-related breakers in the NPSS have a high degree of reliability, the capacity, and the capability to perform their safety functions.

The NPSS contains the following safety-related equipment:

- Two ~~undervoltage trip enclosed~~safety-related breakers are provided for each instance of the NDAS to provide the redundant ability to disconnect power.
- Two ~~undervoltage trip enclosed~~safety-related breakers per vacuum pump to provide the redundant ability to disconnect power from each vacuum pump in the vacuum transfer system (VTS).
- Two ~~undervoltage trip enclosed~~safety-related breakers per extraction feed pump to provide the redundant ability to disconnect power from each (of three) extraction feed pumps in the molybdenum extraction and purification system (MEPS).
- Two ~~undervoltage trip enclosed~~safety-related breakers providing the redundant ability to disconnect power from the radiological ventilation zone 1 (RVZ1) exhaust fans, radiological ventilation zone 2 (RVZ2) exhaust fans and RVZ2 supply air handling units.

The safety functions performed by the specified breakers are related to preventing actions that could initiate or increase the consequences of an accident. The equipment tied to these breakers does not perform an active safety function. Redundant breakers are provided to ensure that the safety function can still be performed in the event of a single active failure.

Safety-related NPSS equipment is located in a mild environment, is not subject to harsh environmental conditions during normal operation or transient conditions, and has no significant

8a2.2.2 UNINTERRUPTIBLE ELECTRICAL POWER SUPPLY SYSTEM CODES AND STANDARDS

The UPSS is designed in accordance with the following codes and standards:

- National Fire Protection Association (NFPA) 70-2017, National Electrical Code (NFPA, 2017), as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code, Electrical)
- IEEE Standard 344 - 20~~04~~13, ~~Recommended Practice~~IEEE Standard for Seismic Qualification of ~~Class 1E~~ Equipment for Nuclear Power Generating ~~Systems~~Stations (IEEE, 20~~04~~13); invoked to meet seismic requirements, as described in Subsection 8a2.2.3
- IEEE Standard 384 - 2008, Standard Criteria for Independence of Class 1E Equipment & Circuits (IEEE, 2008); invoked for separation and isolation of safety-related and nonsafety-related cables and raceways and for associated equipment, as described in Subsection 8a2.2.3
- IEEE Standard 450-2010, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications (IEEE, 2010a); invoked as guidance for the inspection of batteries, as described in Subsection 8a2.2.3
- IEEE Standard 484-2002, Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications (IEEE, 2002); invoked as guidance for the installation of batteries, as described in Subsection 8a2.2.3
- IEEE Standard 485 - 2010, Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications (IEEE, 2010b); invoked for battery sizing of UPSS loads, as described in Subsection 8a2.2.3
- IEEE Standard 323-2003, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (IEEE, 2003); invoked for environmental qualification of safety-related equipment as described in Subsection 8a2.2.3
- IEEE Standard 946-2004, Recommended Practice for the Design of DC Auxiliary Systems for Generating Stations (IEEE, 2004); invoked as guidance for the design of the DC components, as described in Subsection 8a2.2.3
- IEEE Standard C.37.20-2015, Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear (IEEE, 2015b); invoked as guidance for the design of UPSS switchgear, as described in Subsection 8a2.2.3

While the UPSS is not classified as a Class 1E system, portions of Class 1E-related standards, as described in this section, are applied to the design of the UPSS in order to satisfy applicable SHINE design criteria.

8a2.2.3 UNINTERRUPTIBLE ELECTRICAL POWER SUPPLY SYSTEM DESCRIPTION

The safety-related UPSS provides a reliable source of power to the redundant divisions of AC and DC components on the safety-related power buses. Each division of the UPSS consists of a 125 VDC battery subsystem, 125 VDC to 208Y/120 volts alternating current (VAC) inverter, rectifier (battery charger), bypass transformer, static switch and a manual bypass switch, 208Y/120 VAC and 125 VDC distribution panels, and a nonsafety-related 208Y/120 VAC bus system isolated from the safety-related portion of the system by breakers or isolating fuses which meet Section 6.1.2 requirements of IEEE 384 (IEEE, 2008) for isolation devices, ensuring that a failure of nonsafety-related loads does not impact safety-related loads.~~.~~

These loads consist of:

- Main facility stack release monitor (SRM)
- Process vessel vent system (PVVS) carbon delay bed effluent monitor
- TPS secondary enclosure cleanup (SEC) blowers
- Criticality accident alarm system (CAAS)

Additional details about the UPSS loads are provided in Table 8a2.2-1.

Upon a loss of NPSS power and unavailability of SGS power, the AC and DC UPSS buses are powered by the safety-related battery bank for each division. Each UPSS division is located in a separate fire area in the safety-related, seismic portion of the main production facility. The UPSS is required to perform its safety function before, during, and after a seismic event, and is qualified by one of the testing methods described in ~~Chapter 8~~Sections 8 and 9.3 of IEEE 344 (IEEE, 20~~04~~13).

Compliance with NFPA 70-2017 (NFPA, 2017) ensures adequate accessibility to UPSS components to permit periodic inspection and testing.

DC components within the UPSS include the safety-related batteries, battery chargers, and DC switchgear. These DC components are designed in accordance with Sections 5.2, 6.2, 6.5, 7.1, 7.3, Table 2 of 7.4, 7.6, and 7.9 of IEEE 946 (IEEE, 2004). Compliance with these portions of IEEE 946 (IEEE, 2004) ensures DC components have sufficient testability and minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

The battery sizing for the UPSS loads is shown in Table 8a2.2-2, using the sizing guidance provided in Sections 6.1.1, 6.2.1, 6.2.2, 6.2.3, 6.2.4, 6.3.2 and 6.3.3 of IEEE 485 (IEEE, 2010b). Compliance with these sections of IEEE 485 ensures that the battery capacity and capability are sufficient to support UPSS loads. Batteries are vented lead-acid. Transfer of loads from the NPSS to the UPSS is automatic and requires no control power.

UPSS batteries are installed in accordance with Sections 5 and 6 of IEEE 484 (IEEE, 2002). Compliance with these sections of IEEE 484 (IEEE, 2002) ensures the batteries are properly installed and tested, and minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

Battery maintenance will be performed in accordance with Section 5 of IEEE 450 (IEEE, 2010a). Compliance with Section 5 of IEEE 450 (IEEE, 2010a) ensures the batteries are inspected regularly, and any identified issues are corrected, which minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

UPSS switchgear is designed in accordance with IEEE C.37.20.1 (IEEE, 2015b). Compliance with IEEE C.37.20.1 (IEEE, 2015b) ensures that the UPSS has a high degree of reliability, which minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system. UPSS switchgear is designed with the ability to install a temporary load bank to perform required testing.

8a2.3 REFERENCES

~~**IEEE, 2004.** Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Systems, IEEE 344-2004, Institute of Electrical and Electronics Engineers, 2004.~~

IEEE, 2002. Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications, IEEE 484-2002, Institute of Electrical and Electronics Engineers, 2002.

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IEEE, 2015b. Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear, IEEE C37.20.1-2015, Institute for Electrical and Electronics Engineers, 2015.

NFPA, 2017. National Electrical Code, NFPA 70, National Fire Protection Association, 2017.