ENCLOSURE 2

SHINE TECHNOLOGIES, LLC

SHINE TECHNOLOGIES, LLC APPLICATION FOR AN OPERATING LICENSE
REVISION 1 OF THE SHINE RESPONSE TO REQUESTS FOR
ADDITIONAL INFORMATION 9-8 AND 9-9
PUBLIC VERSION

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The NRC staff determined that additional information was required (Reference 1) to enable the staff's continued review of the SHINE Technologies, LLC (SHINE) operating license application (Reference 2). SHINE provided the response to the NRC staff's request for additional information (RAI) via References 3 and 4. SHINE has determined that the SHINE Response to RAI 9-8, provided via Reference 3, and the SHINE Response to RAI 9-9, provided via Reference 4, require revision. Revision 1 of the SHINE Response to RAI 9-8 and the SHINE Response to RAI 9-9 are provided below.

Chapter 9 – Auxiliary Systems

<u>RAI 9-8</u>

FSAR Section 9a2.3.6, "Regulatory and Code Requirements," states, in part, that "[t]he design, installation, testing, and surveillance of the facility fire protection features, and systems are based on applicable guidance from nationally recognized codes and standards. The codes and standards used, and the code-of-record is as defined in the FPP [fire protection program] and applicable design documentation." Consistent with the guidance in Section 9.3 of NUREG-1537, Parts 1 and 2, for the design of fire protection systems and features, the applicant should use local building fire codes, as applicable, to help ensure that fire damage to structures, systems and components at the facility would not cause or allow an uncontrolled release of radioactive material.

SHINE FSAR Section 9a2.3.6, does not identify the codes and standards used in the development of SHINE's fire protection program or any deviations from such codes and standards. Therefore, additional information is needed for the NRC staff to confirm that SHINE has adequately implemented appropriate codes and standards in the design of its fire protection systems and development of its fire protection program. Provide the following:

a. A list of the building and fire codes and standards that SHINE considered in the design of the facility as related to the development of the fire protection program and implementing procedures, including identification of the edition (year). For codes and standards where more than one edition is used, identify which edition pertains to which areas of the facility.

b. Identify and justify any deviations from the codes and standards for the design and installation of fire protection systems identified in item (a), above.

This information is necessary for the NRC staff to ensure that SHINE is satisfying the elements of 10 CFR 50.48(a) to which it has committed and to make the necessary evaluation findings described in NUREG-1537, Part 2, Section 9.3. Specifically, the requested information will support the NRC staff in concluding the following:

- The plans for preventing fires ensure that the facility meets local and national fire and building codes;

- The systems designed to detect and combat fires at the facility can function as described and limit damage and consequences at any time;

- The potential for radiological consequences of a fire will not prevent safe shutdown, and any fire-related release of radioactive material from the facility to the unrestricted environment has been adequately addressed in the appropriate sections of the facility emergency plan; and

- Any release of radioactive material as a result of fire would not cause radiation exposures that exceeded the requirements of 10 CFR Part 20.

SHINE Response

a. SHINE applies the following building and fire codes and standards in the design of the SHINE facility, as related to the development of the fire protection program (FPP) and implementing procedures:

    - International Building Code (IBC), 2015 Edition (Reference 5), and codes listed therein, as amended by the Wisconsin Administrative Code
    - International Fire Code (IFC), 2015 Edition (Reference 6), as amended by the Wisconsin Administrative Code
    - National Fire Protection Association (NFPA) 1, Fire Code, 2012 Edition (Reference 7), as amended by the Wisconsin Administrative Code
    - NFPA 801, Standard for Fire Protection for Facilities Handling Radioactive Materials, 2014 Edition (Reference 8), and codes listed therein

    There are no instances where SHINE applies more than one edition of a code or standard to the design of the SHINE facility, as related to the development of the FPP and implementing procedures.

b. SHINE has identified the following deviations from those codes and standards applied in the design of the SHINE facility identified in the SHINE Response to Part a of RAI 9-8:

    Deviation: Section 903.2.4 of the IBC (Reference 5) requires an automatic sprinkler system for group F-1 occupancies; however, the SHINE facility does not provide an automatic sprinkler system in the radiologically controlled area (RCA).

    Justification: SHINE will not install an automatic sprinkler system in the RCA because the release of water into the RCA could cause a nuclear criticality hazard or lead to the spread of radioactive contamination. Section 903.3.1.1.1 of the IBC provides exemption from the automatic sprinkler system requirements for certain rooms or areas protected by an approved automatic fire detection system where, in part, application of water, or flame and water, constitutes a serious life or fire hazard. SHINE will seek approval of the exempted condition for the RCA as part of the fire protection plan review for the SHINE facility by the Wisconsin Department of Safety and Professional Services.

Deviation: Section 5.13.1 of NFPA 801-2014 (Reference 8) requires less-hazardous dielectric fluids to be used in place of hydrocarbon-based insulating oils for transformers and capacitors located inside buildings or where they are an exposure hazard to important facilities. SHINE uses a hydrocarbon-based insulating oil within the high-voltage power supply (HVPS) transformers.

Justification: SHINE has determined that the use of a hydrocarbon-based insulating oil within the HVPS transformer does not present an exposure hazard. Each HVPS is installed with an oil catchment assembly installed around the transformer. The HVPS oil catchment is designed to contain the entire contents of the transformer oil and contain any spray or leaking under pressure. Additionally, a worst-case fire for an HVPS was evaluated in a fire modeling calculation, and the calculation determined the worst-case fire involving an HVPS will not cause structural failure of the facility roof trusses or bridge cranes.

RAI 9-9

NUREG-1537, Part 1, Section 9.3, states, in part, that "[t]he applicant should discuss passive design features required by the [facility] design characteristics." In addition, the objectives of the fire protection program should limit fire consequences and provide that the facility is designed, and protective systems exist to prevent the uncontrolled release of radioactive material should a fire occur. Additionally, NUREG-1537, Part 2, Section 9.3, states, in part, that "[t]he fire protection plan should discuss the prevention of fires, including limiting the types and quantities of combustible materials."

SHINE FSAR Section 9a2.3.7, "Facility Fire Protection System Description," does not provide sufficient detail of the use of SHINE's fire hazards analysis and the results. Therefore, additional information is needed to ensure that the passive design features, including fire barriers and facility fire areas and zones, are adequate to limit fire consequences to prevent the uncontrolled release of radioactive material should a fire occur.

a. Discuss means of egress for fire areas and zones and means of egress protection.

b. Describe the types of combustibles found in each fire area.

c. Describe combustible loading in fire areas and zones.

d. Discuss fire hazards and ignition sources that were considered for facility fire areas.

e. Describe the types of fire-resistant coatings and electric raceway fire barriers systems used for the protection of electrical cables and structural steel.

f. Identify the fire modeling tools or methods used in the development of the fire hazard analysis including how these tools or methods were applied. Describe the process to validate and verify the fire models, including any calculational and numerical methods used, used in support of fire hazard analysis. Discuss how the fire modeling uncertainties were accounted in the fire modeling calculations.

g. Describe how the installed cabling in the fire areas was characterized. Specifically, describe the critical damage threshold temperatures and heat fluxes for thermoset and thermoplastic cables consistent with the use of these cables in the facility. Include an explanation of how exposed temperature-sensitive equipment was treated in the fire modeling and justify the damage criteria that was used for such equipment. Alternatively, justify why this information is not necessary.

This information is necessary for the NRC staff to ensure that SHINE is satisfying the elements of 10 CFR 50.48(a) to which it has committed and to make the necessary evaluation findings described in NUREG-1537, Part 2, Section 9.3. Specifically, the requested information will support the NRC staff in concluding the following:

- The plans for preventing fires ensure that the facility meets local and national fire and building codes;
- The systems designed to detect and combat fires at the facility can function as described and limit damage and consequences at any time;
- The potential for radiological consequences of a fire will not prevent safe shutdown, and any fire-related release of radioactive material from the facility to the unrestricted environment has been adequately addressed in the appropriate sections of the facility emergency plan; and
- Any release of radioactive material as a result of fire would not cause radiation exposures that exceeded the requirements of 10 CFR Part 20.

This information is also requested to ensure that SHINE is satisfying its Design Criterion 3, which provides that "noncombustible and heat resistant materials are used whenever practicable…."

<u>SHINE Response</u>

a. Emergency exits are available from all areas of the SHINE facility within a travel distance of 200 feet. Common paths of travel do not exceed 100 feet, and dead-end corridors do not exceed 50 feet. Exit access corridors are constructed to have a fire resistance rating of not less than 1 hour, in accordance with Section 1020 of the IBC (Reference 5). Stairways used as a means of egress from the mezzanine are constructed to have a fire resistance rating of 2 hours.

b. The following table provides the types of combustibles (fixed and stored) found in each fire area of the SHINE facility. Transient combustibles can be present in any fire area in the SHINE facility. The types and quantities of transient combustibles allowed in each fire area of the facility are governed by a combustible loading procedure.

Fire Area	Combustible Types
FA-1	Cellulosics, charcoal, clothing, electrical equipment, cable insulation, hydrocarbon fluids, synthetic polymers
FA-2	Cable insulation, cellulosics, charcoal, clothing, electrical equipment, flammable gases, synthetic polymers, rubber, hydrocarbon fluids,
FA-3	Cellulosics, clothing, flammable and combustible liquids, synthetic polymers
FA-4	Hydrocarbon fluids
FA-5	Cellulosics, [ ]SRI
FA-6	Cable insulation, cellulosics, electrical equipment, synthetic polymers
FA-7	Flammable and combustible liquids, chemicals, electrical equipment, insulation
FA-8	Cable insulation, electrical equipment
FA-9	Cable insulation, hydrocarbon fluids
FA-10	Cable insulation, electrical equipment, resin
FA-11	Flammable gases, cable insulation, cellulosics, electrical equipment, rubber, synthetic polymers
FA-12	Cable insulation, electrical equipment, hydrocarbon fluids
FA-13	Cable insulation, batteries, electrical equipment
FA-14	Cable insulation, batteries, electrical equipment
FA-15	Cable insulation, electrical equipment, cellulosics, synthetic polymers
FA-16	Clothing, synthetic polymers
FA-17	Cellulosics, charcoal, cable insulation, rubber, hydrocarbon fluids
FA-18	Cable insulation, electrical equipment
FA-19	Batteries, cellulosics, synthetic polymers
FA-20	None
FA-21	Cable insulation, electrical equipment
FA-22	None
FA-23	None
FA-24	None
FA-25	Cable insulation, electrical equipment

c. Fire areas in the RCA have their combustible loading (i.e., heat load density, measured in BTU/ft^2) calculated, and are categorized based on the fire loading categorization scheme described in the SHINE Fire Protection Program. The combustible loading of fire areas outside the RCA is determined qualitatively. The following table provides the fire loading categorization of each fire area.

Fire Area	SHINE Fire Loading Category
FA-1	Moderate
FA-2	Moderate
FA-3	Low
FA-4	Very Low
FA-5	Moderate
FA-6	Outside the RCA. See Note 1 below.
FA-7	Outside the RCA. See Note 2 below.
FA-8	Outside the RCA. See Note 1 below.
FA-9	Outside the RCA. See Note 1 below.
FA-10	Outside the RCA. See Note 1 below.
FA-11	Moderate
FA-12	Outside the RCA. See Note 1 below.
FA-13	Outside the RCA. See Note 3 below.
FA-14	Outside the RCA. See Note 3 below.
FA-15	Outside the RCA. See Note 1 below.
FA-16	Very Low
FA-17	Outside the RCA. See Note 1 below.
FA-18	Outside the RCA. See Note 1 below.
FA-19	Very Low
FA-20	Outside the RCA. See Note 1 below.
FA-21	Outside the RCA. See Note 1 below.
FA-22	Outside the RCA. See Note 4 below.
FA-23	Very Low
FA-24	Very Low
FA-25	Outside the RCA. See Note 1 below.

Notes:

1) For FA-6, FA-8, FA-9, FA-10, FA-12, FA-15, FA-17, FA-18, FA-20, FA-21, and FA-25, the combustibility of the materials is low and the associated quantity of combustibles is low.
2) For FA-7, the combustibility of materials is moderate and the associated quantity of combustibles is moderate.
3) For FA-13 and FA-14, the combustibility of the materials is moderate and the associated quantity of combustibles is low.
4) For FA-22, the FA does not have fixed or stored combustibles. Only transient combustibles may be present.

d. The following fire hazards and ignition sources were considered for facility fire areas:

- Leaks of insulating oil from the high voltage power supplies;
- Maintenance or hot work involving transient combustibles or equipment;
- Hydrogen deflagration in process vessels due to loss of sweep gas;
- Ignition of carbon delay beds due to high moisture or high temperature;

- Electrical short-circuits in equipment (e.g., switchgear, electrical cabinets);
- Internal over-pressurization of high voltage power supplies;
- Human error during laboratory work; and
- Battery ignition.

e. Where cables or circuits of different divisions are required to be installed in a single conduit or enclosure, high temperature glass sleeving is used. The wires/circuit of one division is enclosed in a high temperature sleeve to provide protection of hot-shorts or heat from the opposite division. The sleeves are typically made of braided glass or fiberglass.

   Electric raceway fire barriers systems are not used in the SHINE facility.

   Structural steel in the SHINE facility does not have any fire-resistant coatings. The SHINE facility is IBC Type II-B construction. Table 601 of the IBC (Reference 5) specifies a 0-hour fire resistance rating for buildings with Type II-B construction.

f. SHINE used the National Institute of Standards and Technology (NIST) Consolidated Model of Fire and Smoke Transport (CFAST) (Versions 7.5.2 and 7.7.2) in the development of the fire hazards analysis. The following two fire modeling analyses are performed using CFAST:

   - Determination of whether the hot gas layer (HGL) temperature for a fire within the RCA could reach temperatures high enough to impact the structural integrity of the roof or the cranes within the RCA. (CFAST Version 7.5.2)
   - Determination of the zone of influence (ZOI) of a fire in a TOGS MCC and a transient fire within FA-2 to evaluate whether both trains of TOGS can be damaged from a single fire. (CFAST Version 7.7.2)

   CFAST Version 7.0.0 was verified and validated, as documented in NUREG-1824, Supplement 1, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications" (Reference 9). NIST Technical Note 1889v3 (References 10 and 11) detail the verification and validation actions performed for CFAST Versions 7.5.2 and 7.7.2.

   The CFAST analyses were performed within the limits of applicability and within validated ranges of NUREG-1824, Supplement 1. The normalized parameters, where applicable, are within the validated ranges for the use of CFAST.

   Regarding model uncertainty, NUREG-1824, Supplement 1 analyzed validation tests for HGL temperature, HGL depth, and target temperature. The uncertainty of the validation results was numerically characterized using a bias factor and standard deviation to indicate the propensity of the model to either over-predict or under-predict the calculated quantity. A bias factor of 1 indicates the model predictions are the same as the measured values, so the model is accurate compared to the measured values the model was validated against. These bias factors and standard deviations were originally published in Table 6-1 of NUREG-1824, Supplement 1 for CFAST Version 7.0.0.

   NUREG-1824, Supplement 1 recommends that when using a newer version of CFAST, the user needs to confirm that the model developers have published updates to the accuracy metrics that are listed in Table 6-1. Updated uncertainty metrics for HGL temperature and depth and target temperature using CFAST Version 7.5.2 and 7.7.2 were published in NIST Technical Note 1889v3 (References 10 and 11). Based on the validation tests, both versions of CFAST used show a propensity to overpredict target temperature and HGL temperature, which is conservative when considering target failures. CFAST may slightly under-predict the HGL depth based on the validation experiments; however, the bias factor for this parameter is very close to 1, and for the purposes of the SHINE fire modeling analysis, is not expected to have a significant impact on the results since the HGL depth isn't a key parameter used to determine target failures in the analysis.

g. Cable materials are typically classified as either thermoset or thermoplastic when determining which damage criteria to use. Appendix A to NUREG-1805, "Fire Dynamics Tools (FDTs), Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program" (Reference 12), provides damage criteria for thermoset and thermoplastic cables typically found in nuclear power plants. When there is a mixture of cable materials within a raceway, the lower failure damage criteria are typically utilized.

   There is a mixture of thermoset and thermoplastic materials being used at SHINE. For cables with a mixture of thermoplastic and thermoset cables, or when the cable types within each raceway are not known, the cable failure criteria for thermoplastic was conservatively applied for fire modeling. Consistent with Appendix A of NUREG-1805, the following generic screening thermal damage criteria has been used for cable targets:

   - Critical Temperature: 205°C (400°F)
   - Critical Heat Flux: 6 kW/m^2 (0.5 BTU/ft^2s)

   For cables known to contain only thermoset material, and without thermoplastic or unknown jacketing or insulation, the following thermoset damage criteria are used:

   - Critical Temperature: 330ºC (625ºF)
   - Critical Heat Flux: 11 kW/m^2 (1.0 BTU/ft^2s)

   Ignition of bulk cables and cable trays utilizes the guidance in Fire Probabilistic Risk Assessment (PRA) Frequently Asked Question (FAQ) 16-0011 (Reference 13). The ignition of both thermoplastic and thermoset bulk cables and cable trays applies the following ignition criteria:

   - Critical Temperature: 500°C (932°F)
   - Critical Heat Flux: 25 kW/m^2 (2.2 BTU/ft^2s)

   Equipment needed for safe shutdown are on redundant trains. With the exception of the TOGS MCCs, separation of redundant equipment has been analyzed and shown to be adequate without the use of calculations or modeling. Therefore, it is not necessary for SHINE to establish quantitative damage criteria for temperature-sensitive equipment.

References

1. NRC letter to SHINE Medical Technologies, LLC, "SHINE Medical Technologies, LLC – Request for Additional Information Related to Fire Protection (EPID No. L-2019-NEW-0004)," dated June 23, 2021 (ML21162A318)

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 Technologies, LLC letter to the NRC, “SHINE Technologies, LLC Application for an Operating License Response to Request for Additional Information,” dated December 30, 2021 (ML21364A055)

4. SHINE Technologies, LLC letter to the NRC, “SHINE Technologies, LLC Application for an Operating License Response to Request for Additional Information,” dated February 28, 2022 (ML22059A017)

5. International Code Council, Inc., “International Building Code,” IBC-2015, Country Club Hills, IL

6. International Code Council, Inc., “International Fire Code,” IFC-2015, Country Club Hills, IL

7. National Fire Protection Association, “Fire Code,” NFPA 1-2012, Quincy, MA

8. National Fire Protection Association, “Standard for Fire Protection for Facilities Handling Radioactive Materials,” NFPA 801-2014, Quincy, MA

9. U.S Nuclear Regulatory Commission, “Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications,” NUREG-1824, Supplement 1, November 2016 (ML16309A011)

10. National Institute of Standards and Technology, “CFAST – Consolidated Fire And Smoke Transport (Version 7), Volume 3: Verification and Validation Guide,” NIST Technical Note 1889v3, CFAST Version 7.5.0, April 2020

11. National Institute of Standards and Technology, “CFAST – Consolidated Fire And Smoke Transport (Version 7), Volume 3: Verification and Validation Guide,” NIST Technical Note 1889v3, CFAST Version 7.7.0, August 2021

12. U.S. Nuclear Regulatory Commission, “Fire Dynamics Tools (FDTs), Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program,” NUREG-1805, December 2004 (ML043290075)

13. U.S. Nuclear Regulatory Commission Memorandum, “Close-Out of Fire Probabilistic Risk Assessment Frequently Asked Question 16-0011 on Alternative Methodology to NUREG/CR-6850 for Bulk Cable Tray Ignition Criteria,” dated March 20, 2018 (ML18074A020)