OFFICE OF NUCLEAR REACTOR REGULATION

REGULATORY AUDIT TOPICS

REGARDING ELECTRICAL POWER SYSTEMS DESCRIBED IN

OPERATING LICENSE APPLICATION

CONSTRUCTION PERMIT NO. CPMIF-001

SHINE MEDICAL TECHNOLOGIES, LLC

SHINE MEDICAL ISOTOPE PRODUCTION FACILITY

DOCKET NO. 50-608

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

During the NRC staff's review of the SHINE operating license application, questions have arisen related to SHINE's electrical power systems for which additional information is needed to determine that there is reasonable assurance of adequate protection of public health and safety and that applicable regulatory requirements are met. The topics below identify areas where additional information is needed for the NRC staff to continue its review of the SHINE electrical power systems and may become formal requests for additional information following the May 11 to May 15, 2020, regulatory audit.

Regulatory Basis and Applicable Guidance Documents

The SHINE electrical power systems, as described in the SHINE operating license application, are being evaluated using the following regulations in 10 CFR and guidance:

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

Attachment

- Criterion 4 – Environmental and dynamic effects

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

- Criterion 27 - Electric power systems

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

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

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

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

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

- Criterion 28 - Inspection and testing of electric power systems

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

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

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

- Paragraph 50.34(b)(2) of 10 CFR requires a description and analysis of the SSCs of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which such requirements have been established, and the evaluations required to show that safety functions will be accomplished. The description

shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations.

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

- NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content," issued February 1996 (ADAMS Accession No. ML042430055)

- NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria," issued February 1996 (ADAMS Accession No. ML042430048)

Audit Topics

Audit Topic 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, in part, 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 in the design of its NPSS and emergency electrical power systems. It is also not clear to the NRC staff if the use of the NEC satisfies SHINE's design criteria 27 and 28.

The NRC staff requests that that SHINE provide additional detail on how it is applying this code to the design of its NPSS and emergency electrical power system. Additionally, the NRC staff requests that SHINE provide additional information that demonstrates how the design of its NPSS and emergency electrical power system satisfy its design criteria 27 and 28. Such information could include calculations, methodologies, and analyses used in order to determine whether the design of the electrical systems meets the applicable regulations and is commensurate with the design bases of the facility. The following is a list of specific calculations of interest to the NRC staff that would assist in the evaluation of SHINE's electrical power systems 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:

- Load Flow/Voltage Regulation Studies and Under/Overvoltage Protection;
- Short-Circuit Studies (AC and 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;
- Electromagentic interference and radiofrequency interference (EMI/RFI) studies.

Audit Topic 2

Figure 8a2.1-1, "Electrical Distribution System (Simplified)," provides a simplified diagram of the overall electrical power supply system. The diagram shows two safety-related breakers connected to the non-safety-related Neutron Driver Assembly System (NDAS). Section 8a2.1 of the FSAR states, in part, the following:

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

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

The NRC staff requests that SHINE provide a detailed description of why the two circuit breakers connected to the NDAS are categorized as safety-related and describe how these circuit breakers are important to provide and maintain a safe shutdown condition of the facility. This information is necessary for the NRC staff to determine how SHINE is satisfying its design criteria 27 and 28.

Audit Topic 3

Section 8a2.2, "Emergency Electrical Power System," states, in part, 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, maintenance, testing, and qualification of the battery chargers is not addressed in the FSAR.

The NRC staff requests that SHINE describe the methodologies used to perform maintenance, testing, installation, and qualification for the safety-related batteries in the DC system used in the UPSS. In addition, the NRC staff requests descriptions of 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.

Audit Topic 4

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

Provide information describing how SHINE will apply its design criterion 4 for the environmental qualification of electrical equipment and provide a list of equipment that will be qualified. Indicate any methodologies and standards used for the environmental qualification of electrical equipment.

Audit Topic 5

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

Provide additional information on how SHINE has considered the impact of open phase conditions on the safe operation of its facility, including clarification as to whether the loss of phase protection relays are on the high side of the transformer (XFMR1 & XFMR2) and whether there is an alarm in the control room to indicate an open phase condition.

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