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8.0 ELECTRICAL POWER SYSTEMS

Electrical power systems are designed to support operation of the SHINE Medical Technologies, Inc. (SHINE), irradiation facility (IF) and radioisotope production facility (RPF). In addition to normal electrical service, emergency electrical service ensures that, given a loss of normal electric service, sufficient power will be available to mitigate accidents in order to: (1) shut down the facility and maintain it in a safe shutdown condition, and (2) prevent or minimize the offsite release of radioactivity in excess of applicable regulatory requirements and guidance.

This chapter of the SHINE construction permit (CP) safety evaluation report (SER) describes the review and evaluation of the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) of the preliminary design of the SHINE IF and RPF electrical power systems, as presented in Chapter 8, "Electrical Power Systems," of the SHINE Preliminary Safety Analysis Report (PSAR), as supplemented by the applicant's response to the staff's request for additional information (RAI).

8a Irradiation Unit Electrical Power Systems

SER Section 8a, "Irradiation Facility Electrical Power Systems," provides an evaluation of the preliminary design of SHINE's IF electrical power systems as presented in SHINE PSAR Section 8a2, "Irradiation Unit Electrical Power Systems," within which SHINE describes the irradiation unit (IU) normal electrical power systems and emergency electrical power systems.

8a.1 Areas of Review

SHINE PSAR Section 8b, "Radioisotope Production Facility Electrical Power Systems," nominally addresses RPF electrical power systems. However, as described in SHINE PSAR Sections 8b.1, "Normal Electrical Power Systems," and 8b.2, "Emergency Electrical Power Systems," respectively, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, which serve both the IF and the RPF. Therefore, the areas of review described below are applicable to both the SHINE IF and RPF.

The staff reviewed PSAR Chapter 8 against applicable regulatory requirements using appropriate regulatory guidance and standards to assess the sufficiency of the preliminary design of the SHINE facility electrical power systems. As part of this review, the staff evaluated descriptions and discussions of SHINE's electrical power systems, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations. The preliminary design of SHINE's electrical power systems was evaluated to ensure the sufficiency of principle design criteria; design bases; and information relative to materials of construction, general arrangement, and approximate dimensions, sufficient to provide reasonable assurance that the final design will conform to the design bases. In addition, the staff reviewed SHINE's identification and justification for the selection of those variables, conditions, or other items that are determined to be probable subjects of technical specifications for the facility, with special attention given to those items that may significantly influence the final design.

Areas of review for this section included normal and emergency electrical power systems. Within these review areas, the staff assessed the preliminary analysis of the normal electrical power systems to ensure the safe operation and shutdown of the SHINE IUs, including the response of the facility to interruptions of normal electrical service, the ability of the facility to be maintained in a safe condition with and without the availability of normal electrical service, the monitoring and control of routine releases, and the prevention of uncontrolled releases of radioactive material in the event that normal electrical power service is interrupted. The staff examined the ranges of power required, schematic diagrams, design and performance specifications, deviations from guidance and their justifications, and probable subjects for technical specifications.

The staff also assessed the preliminary design and analysis of the SHINE emergency electrical power systems, including the design and functions of the emergency electrical power systems and their support of related systems required for protecting the health and safety of the public.

8a.2 Summary of Application

As stated above and described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, which serve both the IF and the RPF. Therefore, the summary provided below applies to both the IF and RPF.

The normal electrical power supply consists of 480-volts alternating current (VAC) offsite power service from the local utility, Alliant Energy and an onsite commercial standby diesel generator (SDG). The normal power is used for normal operation and normal shutdown of the facility. The parts of the normal electrical power supply are described in detail in SHINE PSAR Sections 8a2.1.1, “SHINE Facility Off-site Power Service,” through 8a2.1.12, “SHINE Facility Irradiation Units.” SHINE PSAR Section 8a2.1.2, “SHINE Facility Power Distribution System,” provides a description of the distribution and outdoor lighting systems. The facility power distribution system voltages are 480Y/277 VAC and 208Y/277 VAC, 3-phase, 60 hertz (Hz). The SDG and the loads supported by the SDG are described in SHINE PSAR Sections 8a2.1.3, “SHINE Facility Standby Diesel Generator,” and 8a2.1.4, “SHINE Facility Loads Supported by SDG.” SHINE PSAR Section 8a2.1.5, “Power Distribution Equipment,” provides a description of the power distribution equipment in the facilities. The remaining subsections of SHINE PSAR Section 8a2.1 also cover distribution systems, motor control centers (MCCs), distribution panels, and other electrical components. The SHINE PSAR also provides a description of the grounding systems, lightning protection system, cathodic protection system, freeze protection, cable and raceway components, and raceway and cable routing.

The design basis of the normal electrical power system is to provide sufficient and reliable power to all systems and components requiring electrical power for normal operations and for safe shutdown of the facility. The normal electrical power system is not safety-related, but it supports safety-related systems during normal operations. During an event of loss of normal power, a safety-related, uninterruptible power supply system (UPSS) will provide power to the safety-related systems and components.

Emergency electrical power is the temporary substitute of normal electric power in the event of a loss-of-offsite power (LOOP). Emergency electrical systems are designed to prevent damage to IUs and releases of radioactive material to the environment. While the IUs are designed for

passive shutdown, if normal electrical service is interrupted, certain IU functions require emergency electrical power for maintaining the facility in a safe condition following shutdown. As described in SHINE PSAR Section 8a2.2, the emergency electrical power system consists of the UPSS and is designed to provide reliable power for the safety-related equipment required for facility instrumentation, control, monitoring, and other vital functions needed for shutdown of the SHINE facility. The UPSS contains a 250- volts-direct current (VDC) battery subsystem, battery chargers, inverters, bypass voltage regulating transformers, distribution panels, and other distribution equipment necessary to maintain power to safety-related AC or DC loads. The UPSS will be expected to provide emergency power to safety-related loads for the duration necessary per the PSAR analysis. However, this aspect will require further evaluation during the final design review. PSAR Section 8a2.2.3, "SHINE Facility Systems Served by the Class 1E UPSS," provides the list of the SHINE facility systems served by the Class 1E UPSS. The systems specifically associated with the RPF that are served by the UPSS are the process vessel vent system (PVVS), the continuous air monitoring system (CAMS), and the criticality accident alarm system (CAAS). All other systems associated with the RPF are designed to fail safe in the event of a LOOP.

8a.3 Regulatory Basis and Acceptance Criteria

As previously stated and described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, respectively. Therefore, the regulatory basis and acceptance criteria provided below apply to both the IF and RPF.

The staff reviewed SHINE PSAR Sections 8a2 and 8b against applicable regulatory requirements, using appropriate regulatory guidance and standards, to assess the sufficiency of the preliminary design and performance of SHINE's electrical power systems in support of the issuance of a construction permit. In accordance with paragraph (a) of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.35, "Issuance of Construction Permits," a construction permit authorizing SHINE to proceed with construction may be issued once the following findings have been made:

(1) SHINE has described the proposed design of the facility, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public.
(2) Such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be supplied in the final safety analysis report (FSAR).
(3) Safety features or components, if any, which require research and development have been described by SHINE and a research and development program will be conducted that is reasonably designed to resolve any safety questions associated with such features or components.
(4) On the basis of the foregoing, there is reasonable assurance that: (i) such safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility, and (ii) the proposed facility can be constructed at the proposed location without undue risk to the health and safety of the public.

The staff's evaluation of the preliminary design of SHINE's electrical power systems does not constitute approval of the safety of any design feature or specification. Such approval will be made following the evaluation of the final design of SHINE's electrical power systems, as described in the FSAR as part of SHINE's operating license application.

8a.3.1 Applicable Regulatory Requirements

The applicable regulatory requirements for the evaluation of SHINE's electrical power systems are as follows:

> 10 CFR 50.34, "Contents of applications; technical information," paragraph (a), "Preliminary safety analysis report."

8a.3.2 Regulatory Guidance and Acceptance Criteria

The NRC staff evaluated SHINE's electrical power systems against the applicable regulatory requirements listed above primarily using the guidance and acceptance criteria contained in Chapter 8, "Electrical Power Systems" of NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996 (Reference 4), and NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria," issued February 1996 (Reference 5), as well as the "Final Interim Staff Guidance [ISG] Augmenting NUREG-1537, Part 1, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content,' for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," dated October 17, 2012 (Reference 6), and "Final Interim Staff Guidance Augmenting NUREG-1537, Part 2, 'Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,' for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors," dated October 17, 2012 (Reference 7).

As appropriate, additional guidance (e.g., NRC regulatory guides, Institute of Electrical and Electronics Engineers [IEEE] standards, American National Standards Institute/American Nuclear Society [ANSI/ANS] standards) has been utilized in the review of SHINE's electrical power systems. The use of additional guidance is based on the technical judgement of the reviewer, as well as references in NUREG-1537, Parts 1 and 2; the ISG Augmenting NUREG-1537, Parts 1 and 2; and the SHINE PSAR.

Specific acceptance criteria are provided in the section-by-section technical evaluation in Section 8a.4, "Review Procedures, Technical Evaluation, and Evaluation Findings" of this SER. Additional guidance documents used to evaluate SHINE's electrical power systems are provided as references in Appendix B.

8a.4 Review Procedures, Technical Evaluation, and Evaluation Findings

As described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system that serve both the IF and the RPF. While the technical evaluation of these systems provided in this section is specific to the SHINE IF, the staff's review considers the interface of these systems between the IF and RPF as part of a comprehensive technical evaluation.

The staff performed a thorough and complete section-by-section evaluation of the technical information presented in SHINE PSAR Section 8a2, as supplemented by the applicant's responses to RAIs, to assess the sufficiency of the preliminary design and performance of SHINE's electrical power systems in the IF in support of the issuance of a CP, in accordance with 10 CFR 50.35(a). The sufficiency of the preliminary design and performance of SHINE's electrical power systems is demonstrated by compliance with applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 8a.3, "Regulatory Basis and Acceptance Criteria," of this SER. The results of this section-by-section technical evaluation are described in SER Section 8a.5, "Summary and Conclusion."

For the purposes of issuing a CP, the preliminary design of the SHINE normal and emergency power systems may be adequately described at a functional or conceptual level. The staff evaluated the sufficiency of the preliminary design of the SHINE normal and emergency electrical power systems based on the applicant's design methodology and ability to provide reasonable assurance that the final design will conform to the design bases with adequate margin for safety. As such, the staff's evaluation of the preliminary design of SHINE's electrical power systems does not constitute approval of the safety of any design feature or specification. Such approval will be made following the evaluation of the final design of SHINE's electrical power systems, as described in the FSAR, as part of SHINE's operating license application.

8a.4.1 Normal Electrical Power Systems

The staff evaluated the sufficiency of the preliminary design of SHINE's normal electrical power systems, as described in SHINE PSAR Section 8a2.1, in part, by reviewing the off-site power service, power distribution system, standby diesel generator and supported loads, distribution equipment, facility grounding system, lightning protection system, cathodic protection system, freeze protection, and cable and raceway components and routing, using the guidance and acceptance criteria from Section 8.1, "Normal Electrical Power Systems," of NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of NUREG-1537, Part 2, Section 8.1, "Normal Electrical Power Systems," the staff: (1) compared the design bases of the normal IU electrical systems with the requirements of IU systems and components that rely on electrical power, (2) confirmed that the design characteristics and components of the normal IU electrical system could provide the projected range of services, (3) analyzed possible malfunctions, accidents, and interruptions of electrical services to determine their effect on safe facility operation, and (4) determined if proposed redundancy of electrical circuits are sufficient to ensure safe IU operation and shutdown and to avoid uncontrolled release of radioactive material.

On the basis of its review, the staff finds that the level of detail provided on SHINE's normal electrical power systems demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 8.1, allowing the staff to make the following relevant findings: (1) the design bases and functional characteristics of the normal electrical power systems will support all required loads, and (2) the design of the normal electrical power system provides that, in the event of the loss or interruption of electrical power, the facility can be safely shut down and maintained in a safe shutdown condition.

Therefore, the staff finds that the preliminary design of the SHINE normal electrical power systems in the IF, as described in SHINE PSAR Section 8a2.1, is sufficient and meets the

applicable regulatory requirements and guidance to support of the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis (e.g., the design and location of electrical wiring that prevents inadvertent electromagnetic interference between the electrical power service and safety-related instrumentation and control circuits) may reasonably be left for later consideration. The staff will confirm that the final design conforms to this design basis during the evaluation of SHINE's FSAR.

8a.4.2 Emergency Electrical Power Systems

The staff evaluated the sufficiency of the preliminary design of SHINE's emergency electrical power systems in the IF, as described in PSAR Section 8a2.2 and supplemented by a response to a RAI, in part, by reviewing the Class 1E UPSS; 250-VDC, Class 1E battery subsystem; nonsafety-related loads, maintenance and testing; surveillance methods; seismic qualification; independence; single-failure criterion; safe shutdown of the IU; and monitoring systems on UPSS; using the guidance and acceptance criteria from Section 8.2, "Emergency Electrical Power Systems," of NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of NUREG-1537, Part 2, Section 8.2, the staff compared the design bases of the emergency electrical power system with the requirements for emergency electrical power for IU systems and components requiring electrical power and compared the design and functional characteristics with the design bases to verify compatibility. The staff noted that SHINE PSAR, Section 8a2.2.1, "Class 1E UPSS," references SHINE PSAR Figure 8a2.2-1, "One-Line Diagram – Uninterruptible Electrical Power Supply System" (Reference 47), for UPSS components configuration. SHINE PSAR Section 8a2.1.11, "Raceway and Cable Routing," states, in part, "Non-Class 1E circuits are electrically isolated from Class 1E circuits by isolation devices in accordance with IEEE 384 (IEEE, 2008)."

SHINE PSAR, Figure 8a2.2-1 shows the Class 1E/non-Class 1E boundaries for UPSS Divisions A and B as horizontal dashed lines with arrows pointing upward toward what the annotation indicates is the non-Class 1E side. For both divisions, the drawing shows the Class 1E/non-Class 1E boundaries to be situated between the first load circuit breakers from the respective facility 480-VAC SDG bus supplying each division's Class 1E battery charger and Class 1E 480V-208Y/120V voltage-regulating transformer and the respective input/supply circuit breakers for those battery chargers and voltage-regulating transformers.

Class 1E isolation devices are located and designed to function to isolate non-Class 1E circuits with sustained overloads or faults from otherwise unaffected Class 1E circuits powered from a common source to preserve the continuity of power to the otherwise unaffected Class 1E circuits.

Because the SDG buses normally provide power to both Class 1E and non-Class 1E loads, then theoretically, all the non-Class 1E load circuit breakers from the SDG busses, or their respective local supply breakers, could be considered Class 1E isolation devices that must trip open to clear faults or sustained overloads on the non-Class1E loads to preserve continuity of power to the Class 1E loads.

However, based on the information provided in the SHINE PSAR, it was not clear which circuit breakers are considered Class 1E isolation devices. It is necessary to know which circuit breakers serve as Class 1E isolation devices, because even though they may be enclosed in

the switchgear for non-Class 1E busses, and are considered physically part of the non-Class 1E portion of the electrical power distribution system, they must perform a Class 1E function, and therefore, be classified as Class 1E themselves.

Accordingly, in RAI 8a2.2-1 (Reference 14), the staff requested that the applicant provide additional information to further explain the design approach to Class 1E isolation and to designate which circuit breakers in the electrical power distribution systems for the SHINE facility are to serve as Class 1E isolation devices. Additionally, the staff requested that the applicant explain the bases for those designations, how the type of circuit breakers designated as Class 1E isolation devices will be reasonably assured of meeting the specifications for such devices in accordance with IEEE Std. 384-2008, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," (IEEE 2008). This information is necessary to demonstrate the adequacy of the design basis of the SHINE emergency electrical power system and satisfy the acceptance criteria of NUREG-1537, Part 2, Section 8.2, which states, in part, that "[a]ny non-safety-related uses of an emergency electrical power system should not interfere with performance of its safety-related functions."

In its response to RAI 8a2.2-1 (Reference 21), the applicant stated the following:

> The 480-VAC SDG buses shown on Figure 8a2.1-1 and Figure 8a2.2-1 of the PSAR are non-Class 1E buses. These buses provide the normal power supply to the Class 1E systems and are not designed to maintain continuity of power to the Class 1E systems upon a loss of off-site power (LOOP) or a fault on the buses. Therefore none of the circuit breakers on these buses are considered Class 1E isolation devices that must trip open to clear faults or sustained overloads on the non-Class 1E loads.
>
> The Class 1E isolation devices are described in PSAR Section 8a2.2.2 and shown in PSAR Figure 8a2.2-1 as "Class 1E Battery Charger A," "Voltage Regulating Xfmr Assembly A Class 1E," "Class 1E Battery Charger B," and "Voltage Regulating Xfmr Assembly B Class 1E." These devices isolate the Class 1E 250 volts-direct current (VDC) and Class 1E 120 VAC UPSS busses from the non-Class 1E 480 VAC SDG busses.
>
> The Class 1E battery chargers and voltage regulating transformers are Class 1E isolation devices that meet the requirements of Section 6.1.2.3 of IEEE Std. 384-2008 (IEEE 2008) by limiting the input current to an acceptable value under faulted conditions.
>
> During detailed design, the Class 1E battery chargers and voltage regulating transformers are to be specified to include electrical isolation requirements in accordance with IEEE 384-2008. The suppliers of these devices are to submit test reports to demonstrate compliance with the electrical isolation requirements of IEEE 384-2008. An IMR [Issue Management Report] has been initiated to track receipt of these reports.

The staff finds that this response satisfies the acceptance criteria of NUREG-1537, Part 2, Section 8.2, and demonstrates an adequate design basis in support of a preliminary design. The staff will confirm that the final design conforms to this design basis during the evaluation of SHINE's FSAR.

On the basis of its review, the staff finds that the level of detail provided on SHINE's emergency electrical power systems demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 8.2, allowing the staff to make the following relevant findings: (1) the design bases and functional characteristics of the IU emergency electrical power systems are sufficient to support the necessary range of safety-related services, (2) the design and operating characteristics of the source of emergency electrical power are basic and reliable, ensuring availability if needed, and (3) the design of the emergency electrical power system should not interfere with safe facility shutdown or lead to IU damage if the system malfunctions during normal IU operation.

Therefore, the staff finds that the preliminary design of the SHINE emergency electrical power systems in the IF, as described in SHINE PSAR Section 8a2.2 and supplemented by the applicant's response to an RAI, is sufficient and meets the applicable regulatory requirements and guidance to support of the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis (e.g., the adequacy of emergency electrical power system design features that ensure availability, including the mechanisms of startup, source of generator fuel, routing of wiring, and methods of isolation from normal services), may reasonably be left for later consideration. The staff will confirm that the final design conforms to this design basis during the evaluation of SHINE's FSAR.

8a.4.3 Probable Subjects of Technical Specifications

As stated above and described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, which serve both the IF and the RPF. Therefore, the evaluation of probable subjects of technical specifications provided below applies to both the IF and RPF.

In accordance with 10 CFR 50.34(a)(5), the staff evaluated the sufficiency of the applicant's identification and justification for the selection of those variables, conditions, or other items which are determined to be probable subjects of technical specifications for the SHINE electrical power systems, with special attention given to those items which may significantly influence the final design.

Section 8a2.1.14, "Technical Specifications," of the SHINE PSAR states that "[t]here are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the normal electrical power system." Section 8a2.2.12, "Technical Specifications," and Section 8b.3, "Radioisotope Production Facility Electrical Power Systems Technical Specifications," indicate that probable subjects of technical specifications associated with the emergency electrical power system are provided in PSAR Chapter 14, "Technical Specifications." SHINE PSAR Section 14b.3.4, "Emergency Electrical Power," states that the "power supply is listed as a[limiting condition for operation] pursuant to 10 CFR 50.36(c)(1)."

Based on the information provided in Sections 8a2.1.14, 8a2.2.12, 8b.3, and 14b.3.4 of the SHINE PSAR, the staff finds that the identification and justification of the power supply as a limiting condition for operation (LCO) for the SHINE emergency electrical power systems is sufficient and meets the applicable regulatory requirements to support of the issuance of a construction permit in accordance with 10 CFR 50.35. A complete evaluation of technical specifications, LCOs, and surveillance requirements will be performed during the review of SHINE's operating license application.

8a.5 Summary and Conclusions

The staff evaluated descriptions and discussions of SHINE's electrical power systems in the IF, including probable subjects of technical specifications, as described in PSAR Section 8a2 and supplemented by the applicant's responses to RAIs, and finds that the preliminary design of SHINE's electrical power systems in the IF, including the principle design criteria; design bases; and information relative to materials of construction, general arrangement, and approximate dimensions: (1) provides reasonable assurance that the final design will conform to the design basis, and (2) meets all applicable regulatory requirements and acceptance criteria in or referenced in NUREG-1537.

On the basis of these findings, the staff has made the following conclusions to support of the issuance of a construction permit in accordance with 10 CFR 50.35:

(1) SHINE has described the proposed design of electrical power systems in the IF, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public;

(2) Further technical or design information required to complete the safety analysis of the electrical power systems in the IF may reasonably be left for later consideration the FSAR;

(3) There is reasonable assurance that the proposed facility can be constructed at the proposed location without undue risk to the health and safety of the public.

8b <u>Radioisotope Production Facility Electrical Power Systems</u>

SER Section 8b, "Radioisotope Production Facility Electrical Power Systems," provides an evaluation of the preliminary design of SHINE's RPF electrical power systems as presented in SHINE PSAR Section 8b, "Radioisotope Production Facility Electrical Power Systems."

8b.1 Areas of Review

SHINE PSAR Section 8b nominally addresses RPF electrical power systems. However, as described in SHINE PSAR Sections 8b.1 and 8b.2, respectively, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, which serve both the IF and the RPF. Therefore, the areas of review described in SER Section 8a.1, "Areas of Review," are applicable to both the SHINE IF and RPF.

8b.2 Summary of Application

As stated above and described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, which serve both the IF and the RPF. Therefore, the summary of these systems

provided in SER Section 8a.2, "Summary of Application," is applicable to both the SHINE IF and RPF.

8b.3 Regulatory Basis and Acceptance Criteria

As previously stated and described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, respectively. Therefore, the regulatory basis and acceptance criteria provided in SER Section 8a.3, "Regulatory Basis and Acceptance Criteria," applies to both the IF and RPF.

8b.4 Review Procedures, Technical Evaluation, and Evaluation Findings

As described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system that serve both the IF and the RPF. While the technical evaluation of these systems provided in this section is specific to the SHINE IF, the staff's review considers the interface of these systems between the IF and RPF as part of a comprehensive technical evaluation. The staff notes that PSAR Section 8b has no unique content. The staff evaluated the content of PSAR Section 8a2 as it pertains to the preliminary design of functions and equipment necessary to support RPF electrical power loads.

The staff performed a thorough and complete section-by-section evaluation of the technical information presented in SHINE PSAR Section 8a2, as supplemented by the applicant's responses to RAIs, to assess the sufficiency of the preliminary design and performance of SHINE's electrical power systems in the RPF to support of the issuance of a CP, in accordance with 10 CFR 50.35(a). The sufficiency of the preliminary design and performance of SHINE's electrical power systems is demonstrated by compliance with applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 8a.3, "Regulatory Basis and Acceptance Criteria," of this SER. The results of this section-by-section technical evaluation are described in SER Section 8b.5, "Evaluation Findings and Conclusion."

For the purposes of issuing a CP, the preliminary design of the SHINE normal and emergency power systems may be adequately described at a functional or conceptual level. The staff evaluated the sufficiency of the preliminary design of the SHINE normal and emergency electrical power systems based on the applicant's design methodology and ability to provide reasonable assurance that the final design will conform to the design bases with adequate margin for safety. As such, the staff's evaluation of the preliminary design of SHINE's electrical power systems does not constitute approval of the safety of any design feature or specification. Such approval will be made following the evaluation of the final design of SHINE's electrical power systems, as described in the FSAR, as part of SHINE's operating license application.

8b.4.1 Normal Electrical Power Systems

The staff evaluated the sufficiency of the preliminary design of SHINE's normal electrical power systems in the RPF, as described in SHINE PSAR Section 8a2.1, in part, by reviewing the off-site power service; power distribution system; standby diesel generator and supported loads; distribution equipment; facility grounding system; lightning protection system; cathodic

protection system; freeze protection; and cable and raceway components and routing; using the guidance and acceptance criteria from Section 8.1 of NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of NUREG-1537, Part 2, Section 8.1, the staff:

(1) compared the design basis of the normal electrical systems in the RPF with the requirements discussed in other chapters of the PSAR, specifically Sections 4b, "Radioisotope Production Facility Description;" 5b, "Radioisotope Production Facility Cooling Systems;" 7b, "Radioisotope Production Facility Instrument & Control System;" 9b, "Radioisotope Production Facility Auxiliary Systems;" and 13b, "Radioisotope Production Facility Accident Analyses;"

(2) confirmed that the design characteristics and components of the RPF normal electrical systems could provide the projected range of services;

(3) analyzed possible malfunctions, accidents, and interruptions of electrical services to determine their effect on the safe RPF operation and shutdown; and

(4) determined that the proposed redundancy of electrical circuits is sufficient to ensure safe RPF operation and shutdown and to avoid uncontrolled release of radioactive material.

The staff reviewed SHINE PSAR Section 4b to verify that the design and functional characteristics of the RPF are commensurate with the design basis. PSAR Tables 4b.3-1, "Mo Extraction and Purification System Interfaces;" 4b.4-2, "System Interfaces - Uranyl Nitrate Preparation;" 4b.4-3, "System Interfaces - Uranium Extraction;" and 4b.4-4, "System Interfaces - Thermal Denitration;" provide the system interfaces between the normal electrical power system and the processes within the RPF.

The staff reviewed SHINE PSAR Section 5b, "Radioisotope Production Facility Cooling Systems," to verify the normal electrical power systems related to the RPF. The radioisotope process facility cooling system (RPCS) provides cooling to the RPF. PSAR Section 5a2.3.10, "RPCS Other Users," and Table 5a2.3-3, "RPCS Interfaces," describe the processes within the RPF that require cooling water. SHINE PSAR Table 5a2.3-3 describes the interface between the RPCS and the normal electrical power system.

The staff reviewed SHINE PSAR Section 7b, "Radioisotope Production Facility Instrument and Control System," to verify compliance with the electrical wiring to prevent inadvertent electromagnetic interference between the electrical power system and the safety-related instrumentation and control circuits. Based on NRC Regulatory Guide 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety Related Instrumentation and Control Systems" (Reference 48), the staff finds that the preliminary design and location of the electrical wiring will prevent inadvertent electromagnetic interference between the electrical power system and the safety-related instrumentation and control circuits. As discussed in SER Section 8a.4.1, a more detailed evaluation of this information will occur during the review of SHINE's FSAR.

Additionally, the staff evaluated the design criteria for instrumentation and control systems in the RPF to ensure the proper electrical standards are used in the systems. SHINE PSAR Table 7b.2-1, "Design Criteria for the RPF Instrumentation and Control System," provides the electrical codes used for the design of the RPF instrumentation and control system.

The staff reviewed SHINE PSAR Section 9b, "Radioisotope Production Facility Auxiliary Systems," to verify the design basis of the RPF auxiliary systems. The auxiliary systems that interface with the normal electrical power system are: the PVVS, the noble gas removal system (NGRS), the radioactive liquid waste evaporation and immobilization system (RLWE) equipment, the radioactive liquid waste storage (RLWS), and the radioactive drain system (RDS).

The staff reviewed PSAR Section 13b.2, "Analyses of Accidents with Radiological Consequences," to analyze any possible malfunction, accidents, and interruption of electrical services to determine their effect on safe facility operation on safe shutdown. The PSAR describes two accidents that could end up with radiological consequences; the release of inventory stored in the NGRS storage tanks (considered maximum hypothetical accident (MHA) in the RPF), and fire in the RPF due to an electrical equipment failure. Ducts and electrical cable penetrations will be sealed to limit the release of radioactive materials in an MHA event. In addition, to prevent the event of a fire in the RPF, SHINE will separate power and control cables for redundant trains and electrical cables will be qualified to IEEE Std. 1202, "IEEE Standard for Flame-Propagation Testing of Wire and Cable" (Reference 51), to ensure limited combustibility and limit the potential for fire ignition, growth, and spread.

The staff reviewed PSAR Section 8a2.1, "Normal Electrical Power Systems," to verify that the content of the PSAR meets the criteria described in Chapter 8 of NUREG-1537. Normal electrical power systems at the RPF are designated for safe operations and shutdown of the facility. The proposed RPF is designated for fail-safe passive shutdown in the event of a LOOP. The normal electrical power systems consist of the off-site power system, PSAR Section 8a2.1.1, and onsite normal power systems, PSAR Sections 8a2.1.2 through 8a2.1.12, including the SDG, PSAR Section 8a2.1.3.

PSAR Section 8a2.1.1 describes the off-site power service. The SHINE PSAR provides a description of the substation. The system consist of a 12 kilovolts (kV) single, independent off-site circuit that feeds two utility owned 12kV - 480Y/277 VAC 3-phase transformers at 2000 kilovolt ampere (kVA) each. The loads connected to each transformer will be approximately 1500 kVA. A description of the loads that will be connected in each transformer is provided in PSAR Table 8a2.1-1, "Standby Diesel Generator Load List."

PSAR Section 8a2.1.3, "SHINE Facility Standby Diesel Generator," provides a description of the SDG that will supply power to selected loads in the event of a LOOP. The availability of the SDG is not required for any of the safety functions in the SHINE facility.

The staff reviewed the cable and raceway components, as described in SHINE PSAR Section 8a2.1.10, "Cable and Raceway Components," and the raceway and cable routing, as described in SHINE PSAR Section 8a2.1.11, "Raceway and Cable Routing," using the National Fire Protection Association (NFPA) 70, National Electric Code (NEC) (Reference 49), as well as local codes for the design, installation, and separation of the cable raceway components. SHINE proposes to separate safety-related and nonsafety-related cables and raceway in accordance with IEEE Std. 384 (Reference 50). Regulatory Guide 1.180, Revision 1 (NRC 2003b) provides reasonable assurance that the design will prevent inadvertent electromagnetic interference between the electrical power system and safety-related instrumentation and control circuits in the final design. A more detailed evaluation of this information will occur during the review of SHINE's FSAR.

On the basis of its review, the staff finds that the level of detail provided on SHINE's normal electrical power systems in the RPF demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 8.1, allowing the staff to make the following relevant findings: (1) the design bases and functional characteristics of the normal electrical power systems will support all required loads and (2) the design of the normal electrical power system provides that, in the event of the loss or interruption of electrical power, the facility can be safely shut down and maintained in a safe shutdown condition.

Therefore, the staff finds that the preliminary design of the SHINE normal electrical power systems in the RPF, as described in SHINE PSAR Section 8a2.1, is sufficient and meets the applicable regulatory requirements and guidance to support of the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis (e.g., the design and location of electrical wiring that prevents inadvertent electromagnetic interference between the electrical power service and safety-related instrumentation and control circuits) may reasonably be left for later consideration. The staff will confirm that the final design conforms to this design basis during the evaluation of SHINE's FSAR.

8b.4.2 Emergency Electrical Power Systems

The staff evaluated the sufficiency of the preliminary design of SHINE's emergency electrical power systems in the RPF, as described in SHINE PSAR Section 8a2.2 and supplemented by a response to a RAI, in part, by reviewing the Class 1E UPSS; 250–VDC, Class 1E, battery subsystem; nonsafety-related loads, maintenance and testing; surveillance methods; seismic qualification; independence; single-failure criterion; and monitoring systems on the UPSS; using the guidance and acceptance criteria from Section 8.2 of NUREG-1537, Parts 1 and 2.

Consistent with the review procedures of NUREG-1537, Part 2, Section 8.2, the staff reviewed: (1) the design bases of the emergency electrical power systems, (2) the design and operating characteristics of the UPSS and equipment using IEEE standards to verify independence and isolation of circuits, for single failure criteria, and for seismic qualification of the equipment, and (3) the design of the emergency electrical power system.

On the basis of its review, the staff finds that the level of detail provided on SHINE's emergency electrical power systems demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 8.2, allowing the staff to make the following relevant findings:

(1) the design bases and functional characteristics of the RPF emergency electrical power systems are sufficient to provide the necessary range of safety-related services,

(2) the design and operating characteristics of the source of emergency electrical power are basic and reliable, ensuring availability if needed, and

(3) the design of the emergency electrical power system should not interfere with safe facility shutdown or lead to RPF damage if the system malfunctions during normal RPF operation.

Therefore, the staff finds that the preliminary design of the SHINE emergency electrical power systems in the RPF, as described in SHINE PSAR Section 8a2.2 and supplemented by the applicant's response to an RAI, is sufficient and meets the applicable regulatory requirements and guidance to support of the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis (e.g., hydrogen generation rates) may reasonably be left for later consideration. The staff will confirm that the final design conforms to this design basis during the evaluation of SHINE's FSAR.

8b.4.3 Probable Subjects of Technical Specifications

As stated above and described in SHINE PSAR Sections 8b.1 and 8b.2, the SHINE facility has one common normal electrical power system and one common emergency electrical power system, which serve both the IF and the RPF. Therefore, the evaluation of probable subjects of technical specifications provided in SER Section 8a.4.3, "Probable Subjects of Technical Specifications," applies to both the IF and RPF.

8b.5 Evaluation Findings and Conclusions

The staff evaluated descriptions and discussions of SHINE's electrical power systems in the RPF, including probable subjects of technical specifications, as described in PSAR Section 8a2 and 8b.3 and supplemented by the applicant's responses to RAIs, and finds that the preliminary design of SHINE's electrical power systems in the RPF, including the principle design criteria; design bases; and information relative to materials of construction, general arrangement, and approximate dimensions: (1) provides reasonable assurance that the final design will conform to the design basis, and (2) meets all applicable regulatory requirements and acceptance criteria in or referenced in NUREG-1537.

On the basis of these findings, the staff has made the following conclusions to support of the issuance of a construction permit in accordance with 10 CFR 50.35:

(1) SHINE has described the proposed design of electrical power systems in the RPF, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public;

(2) Further technical or design information required to complete the safety analysis of the electrical power systems in the RPF may reasonably be left for later consideration the FSAR;

(3) There is reasonable assurance that the proposed facility can be constructed at the proposed location without undue risk to the health and safety of the public.

APPENDIX 8A REFERENCES