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5.0 COOLING SYSTEMS

The principal purpose of the cooling systems is to safely remove fission and decay heat from the target solution and dissipate it to the environment under normal and accident conditions. Cooling systems, including auxiliary and subsystems that use and contribute to the heat load of the primary or secondary cooling systems, should be shown to safely remove and transfer heat to the environment from all significant heat sources identified in the SHINE Medical Technologies, Inc. (SHINE) Preliminary Safety Analysis Report (PSAR). The design of the cooling systems is based on interdependent parameters, including thermal power level, type and form of special nuclear material, neutronic physics, and radiation shielding.

This chapter of the SHINE construction permit 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 irradiation facility (IF) and radioisotope production facility (RPF) cooling systems as presented in Chapter 5, "Cooling Systems," of the SHINE PSAR, as supplemented by the applicant's responses to requests for additional information (RAIs).

5a Irradiation Unit Cooling Systems

SER Section 5a, "Irradiation Unit Cooling Systems," provides an evaluation of the preliminary design of SHINE's irradiation unit (IU) cooling systems, as presented in SHINE PSAR Section 5a2, "Irradiation Unit Cooling Systems," within which, SHINE describes the primary cooling system, secondary cooling system, primary coolant cleanup, primary coolant makeup water system, nitrogen-16 (N-16) control, and auxiliary systems using primary coolant.

5a.1 Areas of Review

SHINE PSAR Sections 5b, "Radioisotope Production Facility Cooling Systems," and 5a2.3, "Secondary Cooling System," describe the radioisotope process facility cooling system (RPCS), which serves as a secondary cooling system for the IUs and provides cooling to the RPF. Therefore, the areas of review related to the RPCS presented in this section are applicable to both the SHINE IUs and RPF.

The staff reviewed PSAR Section 5a, "Irradiation Unit Cooling Systems," against applicable regulatory requirements using appropriate regulatory guidance and standards to assess the sufficiency of the preliminary design of the SHINE IU cooling systems. As part of this review, the staff evaluated descriptions and discussions of SHINE's IU cooling systems, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations. The preliminary design of SHINE's IU cooling 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. The staff also considered the preliminary analysis and evaluation of the design and performance of the structures, systems, and components (SSCs) of the SHINE facility, including those SSCs shared by both the IF and RPF, with the objective of assessing the risk to public health and safety resulting from operation of the facility.

Areas of review for this section included IU primary and secondary cooling systems, primary coolant cleanup and makeup water systems, N-16 control, and auxiliary systems using primary coolant. Within these review areas, the staff assessed the following capabilities of SHINE's IU cooling systems:

- The capability of the primary coolant system to remove fission and decay heat during normal operation, possible accident conditions and shut down, and transfer such heat to the secondary coolant system.
- The capability of the primary coolant system to provide shielding.
- The capability of the secondary coolant system to provide controlled heat dissipation to the environment.
- The capability of the primary coolant cleanup system to maintain high water quality to limit corrosion of essential components and the concentrations of particulates and dissolved contaminants that might become radioactive by neutron irradiation and to maintain high transparency of the water for observation of submerged operational and utilization components.
- The capability of the primary coolant makeup water system to replenish coolant, as necessary, to maintain operability.
- The capability of the primary coolant system to cool auxiliary systems, as required.

5a.2 Summary of Application

As stated above and described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. Therefore, the summary provided below applies to both the IF and RPF.

The IU cooling systems include the primary cooling system and secondary cooling system. The primary cooling system comprises the primary closed-loop cooling system (PCLS) and light-water pool system (LWPS). The PCLS and LWPS provide the heat removal to the IU equipment that is submerged within the light water pool. There are eight IUs that each includes a PCLS and LWPS. The secondary cooling system is referred to as the RPCS. The RPCS removes heat from the LWPS/PCLS and transfers it to the facility chilled water supply and distribution system (FCHS). The RPCS is a closed loop system that provides cooling water to all of the process areas within the radiologically controlled area (RCA). The thermal partitions between the LWPS/PCLS and RPCS cooling systems are the heat exchangers at the system interfaces. The primary coolant cleanup loops provide treatment of the PCLS and LWPS coolant to meet water quality limits. The light water pool and primary closed loop cooling make-up system (MUPS) provides makeup water to the PCLS and LWPS cooling loops. In addition to providing secondary cooling function for the IF, the RPCS also provides cooling to the RPF. There is no independent N-16 control system.

SHINE PSAR Section 5a provides the preliminary design of the SHINE IU cooling systems, including physical descriptions, design bases, process functions and operation, safety functions, interfaces, and probable subjects of technical specifications. There is no independent N-16 control system and IU auxiliary systems are not cooled by the primary coolant system. The preliminary design of the SHINE IU cooling systems is supported by the following PSAR figures, which show flow paths between system components:

- Figure 5a2.1-1, “Cooling Systems Heat Flow Pathway Diagram.”
- Figure 5a2.2-1, “LWPS Process Flow Diagram.”
- Figure 5a2.2-2, “PCLS Process Flow Diagram.”
- Figure 5a2.4-1, “Primary Coolant Cleanup Loop Flow Diagram.”

Additionally, the following PSAR tables describe specifications, components, and interfaces of the IU cooling systems. The specifications provide nominal values for different parameters, and the component tables provide descriptions and the codes or standards to which the components are designed.

- Table 5a2.2-1, “PCLS Specifications.”
- Table 5a2.2-2, “LWPS Specifications.”
- Table 5a2.2-3, “PCLS and LWPS Components.”
- Table 5a2.2-4, “PCLS and LWPS System Interfaces.”
- Table 5a2.3-1, “RPCS Specifications.”
- Table 5a2.3-2, “RPCS Components.”
- Table 5a2.3-3, “RPCS Interfaces.”
- Table 5a2.5-1, “MUPS Specifications.”

5a.3 Regulatory Basis and Acceptance Criteria

As previously stated and described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. Therefore, the regulatory basis and acceptance criteria provided below apply to both the SHINE IF and RPF.

The staff reviewed SHINE PSAR Section 5a against applicable regulatory requirements, using appropriate regulatory guidance and standards, to assess the sufficiency of the preliminary design and performance of SHINE’s IU cooling 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 IU cooling 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 IU cooling systems, as described in the FSAR, as part of SHINE's operating license application.

5a.3.1 Applicable Regulatory Requirements

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

- 10 CFR 50.34, "Contents of applications; technical information," paragraph (a), "Preliminary safety analysis report."
- 10 CFR 20.1201, "Occupational dose limits for adults."
- 10 CFR 20.1301, "Dose limits for individual members of the public."

5a.3.2 Regulatory Guidance and Acceptance Criteria

The NRC staff evaluated SHINE's IU cooling systems against the applicable regulatory requirements listed above, primarily using the guidance and acceptance criteria contained in Chapter 5, "Reactor Coolant 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 IU cooling systems. The use of additional guidance is based on the technical judgment 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 5a.4, "Review Procedures, Technical Evaluation, and Evaluation Findings," of this SER. Additional guidance documents used to evaluate SHINE's IU cooling systems are provided as references in Appendix B.

5a.4 Review Procedures, Technical Evaluation, and Evaluation Findings

As described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. The technical evaluation of this system provided below in Section 5a.4.3, "Secondary Cooling System," applies to both the SHINE IF and RPF. The staff's review of the RPCS considers the interface of this system 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 5a, as supplemented by the applicant's responses to RAIs, to assess the sufficiency of the preliminary design and performance of SHINE's IU cooling systems in support of the issuance of a construction permit, in accordance with 10 CFR 50.35(a). Additionally, the staff reviewed portions of sections throughout the PSAR that dealt with SSCs requiring cooling from the RPCS. The sufficiency of the preliminary design and performance of SHINE's IU cooling systems is demonstrated by compliance with applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 5a.3, "Regulatory Basis and Acceptance Criteria," of this SER. The results of this section-by-section technical evaluation are described in SER Section 5a.5, "Summary and Conclusion."

For the purposes of issuing a construction permit, the preliminary design of the SHINE cooling systems may be adequately described at a functional or conceptual level. The staff evaluated the sufficiency of the preliminary design of the SHINE cooling 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 cooling 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 cooling systems, as described in the FSAR, as part of SHINE's operating license application.

5a.4.1 Summary Description

The staff evaluated the sufficiency of SHINE's summary description of its IU cooling systems, as described in SHINE PSAR Section 5a2.1, "Summary Description," using the guidance and acceptance criteria from Section 5.1, "Summary Description," of NUREG-1537, Parts 1 and 2, and Section 5a2.1, "Summary Description," of the ISG Augmenting NUREG-1537, Parts 1 and 2.

As stated, in part, in Section 5a2.1 of the ISG Augmenting NUREG-1537, Part 2, the summary description of the cooling systems should include the type of coolant, type of cooling system, type of coolant flow in the primary and secondary cooling systems and the method of heat disposal to the environment, capability to provide sufficient heat removal to support continuous operation at full licensed power, and any special or facility-unique features. SHINE PSAR Section 5a2.1 provides descriptions of the primary and secondary cooling systems, primary coolant cleanup and makeup water systems, and N-16 control.

Based on the information provided in Section 5a2.1 of the SHINE PSAR, the staff finds that the summary description of the SHINE IU cooling systems meets the applicable regulatory requirements and acceptance criteria of NUREG-1537 and ISG Augmenting NUREG-1537 in support of the issuance of a construction permit in accordance with 10 CFR 50.35.

5a.4.2 Primary Cooling System

The staff evaluated the sufficiency of the preliminary design of SHINE's primary cooling system, as described in SHINE PSAR Section 5a2.2, "Primary Cooling System," in part, by reviewing the design basis, PCLS process functions, system process and safety functions, probable subjects of technical specifications, primary cooling system components and interfaces, PCLS cooling functions and operation, LWPS cooling functions and operation, instrumentation and sampling, secondary cooling system interaction, and radiation exposure protection using the guidance and acceptance criteria from Section 5.2, "Primary Coolant System," of NUREG-1537, Parts 1 and 2, and Section 5a2.2, "Primary Cooling System," of the ISG Augmenting NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2, the staff compared the preliminary design and operating characteristics of the primary cooling system with the bases for the design, as presented in SHINE PSAR Section 5a2.2 and other relevant chapters of the PSAR.

The ISG Augmenting NUREG-1537, Part 1, Section 5a2, "Aqueous Homogeneous Reactor [AHR] Cooling System," states, in part, that "the applicant should give the design bases, descriptions, and functional analyses of the AHR cooling systems. The principal purpose of the cooling systems is to safely remove the fission heat and decay heat from the reactor and dissipate it to the environment. The discussions should include all significant heat sources in the reactor and should show how the heat is safely removed and transferred to the environment." As described in SHINE PSAR Section 5a2.2, each PCLS is designed to remove heat from each IU during full-power operation. The LWPS is also designed to remove heat from each IU during full-power operation. The light water pool is designed to passively remove decay waste heat (post-IU shut down) during design-basis accidents that result in a loss of PCLS and LWPS active cooling. A small amount of heat is also removed by the target solution vessel off-gas system. Based on the total heat load of the facility during normal operation and the thermal inertia of the light water pool, the staff finds the passive removal of decay heat sufficient. As such, active heat removal from the IUs is not required for emergency cooling.

It is recognized that the RPCS provides cooling to both the IUs and the RPF and shutdown of the RPCS may leave some facility components without access to the passive cooling provided by the light water pools. One area of concern is, that after shutdown of the IUs, hydrogen production will continue for some time at reduced rates and the off-gas condensers may require continued cooling. Analysis of this operational scenario and other scenarios that may require additional cooling have not been provided by the applicant. However, they can reasonably be deferred for consideration after a final design has been presented in the FSAR.

Additionally, SHINE PSAR Section 5a2.2 provides a discussion of leak detection and allowable leakage limits, if any, and specifies the inclusion of schematic and flow diagrams of the system, showing such essential components as the heat source, heat sink, pumps, piping, valves, control and safety instrumentation, interlocks, and other related subsystems.

In SHINE PSAR Section 5a2.2.9, "Secondary Cooling System Interaction," Section 5a2.3.5, "RPCS [Radioisotope Process Facility Cooling System] Cooling Functions and Operation," and Section 5a2.3.9, "Instrumentation and Control," pressure, flow, temperature, conductivity, and radiation detection instrumentation are discussed, with pressure being the apparent measurement used to identify system leaks. However, the staff determined that additional information was needed to evaluate the adequacy of pressure measurement to identify system

leaks and instrumentation for cooling system functions. This information is necessary to satisfy the acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2, "Primary Cooling System," related to the sufficiency of cooling system instrumentation, sensors, and control systems and demonstrate the adequacy of the design basis of the SHINE primary cooling system.

Therefore, in RAI 5a2.2-1 (Reference 14), staff asked the applicant to discuss the ability of pressure measurements to identify the presence of small leaks and address how the location of leaks would be determined.

In response to RAI 5a2.2-1 (Reference 20), the applicant stated that there were no plans to use pressure measurements to detect the presence of small leaks in the RPCS. The applicant stated that the pressure in the RPCS is greater than the pressure in the PCLS and LWPS to prevent the transfer of contaminated liquid in the event of a heat exchanger leak and the pressure measurement instrumentation on the PCLS, LWPS, and RPCS ensures that this function is maintained. An alarm will notify the operators if pressures for the PCLS, LWPS, or RPCS are outside of their allowable ranges.

SHINE also stated that small leaks out of the RPCS will be detected through one of the following methods:

- Rise in the level in the expansion tank (PCLS) or pool (LWPS) for that system over time.
- Periodic sampling and analysis for contaminants is performed on the PCLS and LWPS. The presence of contaminants (such as corrosion inhibitor agents from the RPCS) implies possible leakage and will be investigated.
- Other small leaks from the cooling system to the building environment would be detected and located visually during walk downs and tours of accessible areas.

The applicant stated that these three methods also assist in identifying a specific leaking heat exchanger or component. The staff finds this response satisfies the acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2, 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.

Furthermore, in RAI 5a2.2-2 (Reference 14), the staff requested additional detail on the instrumentation for the cooling system functions to ensure the intended functions are performed. This information is necessary to satisfy the acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2, "Primary Cooling System," related to the sufficiency of cooling system instrumentation, sensors, and control systems and demonstrate the adequacy of the design basis of the SHINE primary cooling system.

In response to RAI 5a2.2-2 (Reference 20), the applicant committed to install adequate instrumentation to identify and quantify leakage rates, including very small leaks. Instrumentation will have the ability to identify leak locations as they relate to allowable leakage limits and the safety functions of the systems. The details on the type and accuracy of the instrumentation will be provided in the FSAR. The staff finds this response satisfies the acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2, 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.

SHINE PSAR, Section 5a.2.2.2, "PCLS Process Functions," indicates that water quality will be maintained to reduce corrosion and scaling, but this section does not indicate how this will be done. Therefore, the staff determined that additional information was needed to evaluate the impact of potentially toxic additives used to maintain water quality on corrosion and scaling. Chemicals are commonly added to nuclear plant water systems to adjust nuclear reactivity (e.g., boric acid), to control pH (e.g., lithium hydroxide, ammonia/amines), to remove oxygen (e.g., hydrazine), as a biocide (e.g., chlorine), etc.

Therefore, in RAI 5a2.2-3 (Reference 14), the staff requested that the applicant provide a list of all potentially toxic chemicals expected to be on the SHINE site for water quality control or for other purposes, including locations and quantities. This information is necessary to demonstrate the adequacy of the design basis of the SHINE primary cooling system and satisfy the acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2, which states, in part, that "[t]he primary coolant should provide a chemical environment that limits corrosion of the primary coolant barrier, control and safety rod surfaces, reactor vessels or pools, and other essential components."

In response to RAI 5a2.2-3 (Reference 20),the applicant stated that chemical additives will not be used in the primary coolant systems, the PCLS, or the LWPS. Filters and ion exchange resins will be used to remove contaminants and to maintain water quality parameters. As described in a letter dated October 4, 2013 (Reference 31), SHINE stated that the potentially toxic chemicals used to maintain water quality in the secondary water systems may include non-phosphate buffers (e.g., lithium hydroxide, boric acid, sodium sulfite, sodium lauroyl sarcosinate, or others to be determined during detailed design). The quantities of chemicals needed for the secondary water systems are expected to be small (i.e., less than five pounds), and will be stored in appropriate chemical storage areas, segregated from incompatible chemicals, in accordance with Safety Data Sheets. The chemical storage areas are shown in PSAR Figure 1.3-2, "Production Building Floor Plans Preliminary Arrangement." Toxic chemicals used for other purposes are described in PSAR Section 13b.3.2.2, "Chemical Source Term Analysis." Those chemicals and amounts are provided in PSAR Table 13b.3-1, "Bounding Inventory [pounds] (lbs.) of Significant Process Chemicals."

The staff finds this response satisfies the acceptance criteria of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.2 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 primary cooling system demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 5a2.2, allowing the staff to make the following relevant findings: (1) the primary cooling system and components give reasonable assurance of the maintenance of the system boundary integrity, (2) the sufficiency of the system to remove fission heat from the IUs, (3) the system has been designed to avoid a loss-of-coolant that would lead to system boundary failure, (4) appropriate passive cooling has been incorporated into the design, (5) the chemical quality of the primary coolant will limit corrosion, and (6) systems are present to control hydrogen concentrations.

Therefore, the staff finds that the preliminary design of the SHINE primary coolant system, as described in SHINE PSAR Section 5a2.2 and supplemented by the applicant's responses to RAIs, is sufficient and meets the applicable regulatory requirements and guidance to support

the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis may reasonably be left for later consideration. The staff will confirm that the final design conforms to the design basis during the evaluation of SHINE's FSAR.

5a.4.3 Secondary Cooling System

The staff evaluated the sufficiency of the preliminary design of SHINE's secondary cooling system (RPCS), as described in SHINE PSAR Section 5a2.3, in part, by reviewing the design basis, process functions, probable subjects of technical specifications, RPCS components and interfaces, RPCS cooling functions and operation, cooling control, loss of cooling, component functions and locations; instrument and control; and other uses of the RPCS using the guidance and acceptance criteria from Section 5.3, "Secondary Coolant System," of NUREG-1537, Parts 1 and 2, and 5a2.3, "Secondary Cooling System," of the ISG Augmenting NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.3, the staff verified that all IU conditions requiring heat transfer from the PCLS to the RPCS have been discussed. The staff also notes that the RPCS is a non-safety-related system and is not needed in the event of an accident.

On the basis of its review, the staff finds that the level of detail provided on the RPCS demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 5a2.3, allowing the staff to make the following relevant findings: (1) the design features of the RPCS will allow the transfer of the necessary heat from the primary cooling system, and (2) the location and design specifications of the RPCS ensure that malfunctions will not lead to IU or RPF damage.

Therefore, the staff finds that the preliminary design of the SHINE secondary cooling system, as described in SHINE PSAR Section 5a2.3, is sufficient and meets the applicable regulatory requirements and guidance to support the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis 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.

5a.4.4 Primary Coolant Cleanup

The staff evaluated the sufficiency of the preliminary design of SHINE's primary coolant cleanup system, as described in SHINE PSAR Section 5a2.4, "Primary Coolant Cleanup," in part, by reviewing the design basis, process functions, process flow, system specifications, cleanup loop control and instrumentation, cleanup loop components, and maintenance and coolant testing of SHINE's primary coolant cleanup system using the guidance and acceptance criteria from Section 5.4, "Primary Coolant Cleanup System," of NUREG-1537, Parts 1 and 2, and Section 5a2.4, "Primary Coolant Cleanup System," of the ISG Augmenting NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.4, the staff compared the design bases for the primary coolant water quality with the design bases by which the primary coolant cleanup system will achieve its requirements. The staff notes that primary coolant cleanup system is part of the PCLS and light-water pool system and is not an independent system.

On the basis of its review, the staff finds that the level of detail provided on the RPCS demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 5a2.4, allowing the staff to make the following relevant findings: (1) the design bases and functional descriptions of the primary water cleanup system give reasonable assurance that the required water quality can be achieved, and (2) the system has been designed in accordance with the requirements of 10 CFR Part 20, "Standards for protection against radiation," and as low as reasonably achievable (ALARA) program guidelines.

Therefore, the staff finds that the preliminary design of the SHINE IU primary coolant cleanup, as described in SHINE PSAR Section 5a2.4, is sufficient and meets the applicable regulatory requirements and guidance to support the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis 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.

5a.4.5 Primary Coolant Makeup Water System

The staff evaluated the sufficiency of the preliminary design of SHINE's primary coolant makeup water system (MUPS), as described in SHINE PSAR Section 5a2.5, "Primary Coolant Makeup Water System," in part, by reviewing design basis, process functions, process flow, design specifications, MUPS control and instrumentation, and MUPS components of SHINE's primary coolant makeup water system using the guidance and acceptance criteria from Section 5.5, "Primary Coolant Makeup Water System," of NUREG-1537, Parts 1 and 2, and Section 5a2.5, "Primary Coolant Makeup Water System," of the ISG Augmenting NUREG-1537, Parts 1 and 2.

In accordance with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.5, the staff compared the design bases and functional requirements for replenishing primary coolant, including the quantity and quality of water, the activities or functions that remove primary coolant, and the systems or procedures to accomplish water makeup with the acceptance criteria.

On the basis of its review, the staff finds that the level of detail provided on the MUPS demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 5a2.5, allowing the staff to make the following relevant findings: (1) The design bases, functional descriptions, and procedures for the MUPS give reasonable assurance that the quantity and quality of water required will be provided, (2) the system is designed to prevent overfilling of the primary cooling system, and (3) the system is designed to prevent contamination.

Therefore, the staff finds that the preliminary design of the SHINE MUPS, as described in Section 5a2.5 of the SHINE PSAR, is sufficient and meets the applicable regulatory requirements and guidance to support the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis 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.

5a.4.6 Nitrogen-16 Control

The staff evaluated the sufficiency of the preliminary design of SHINE's N-16 control, as described in SHINE PSAR Section 5a2.6, "Nitrogen-16 Control," using the guidance and acceptance criteria of Section 5a2.6, "Nitrogen-16 Control," of the ISG Augmenting NUREG-1537, Parts 1 and 2. As stated in SHINE PSAR Section 5a2.6, "[t]here is no independent N-16 control system. The radiation dose from N-16 is mitigated by the IU cell walls and shielding around the PCLS/LWPS components in the primary cooling enclosures and the administrative controls defined by the radiation protection program."

In accordance with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section 5a2.6, the staff evaluated the design basis of the systems that control personnel exposures to N-16 to confirm that an independent N-16 control system was not necessary.

On the basis of its review, the staff finds that the level of detail provided on N-16 control (i.e., proposed administrative controls and the preliminary design of the IU cell walls and shielding around the PCLS/LWPS) demonstrates an adequate design basis in support of a preliminary design and satisfies the applicable acceptance criteria of NUREG-1537, Part 2, Section 5a2.6, allowing the staff to make the following relevant findings: (1) the design bases and features of those systems responsible for N-16 control give reasonable assurance that those systems can function as proposed to reduce potential doses to personnel, meet 10 CFR Part 20 requirements, and be consistent with the facility's ALARA program, and (2) an independent N-16 control system is not necessary.

Therefore, the staff finds that the proposed administrative controls and preliminary design of the SHINE IU cell walls and shielding, as described in Section 5a2.6 of the SHINE PSAR, is sufficient for N-16 control and meets the applicable regulatory requirements and guidance to support the issuance of a construction permit in accordance with 10 CFR 50.35. Further technical or design information required to complete the safety analysis 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.

5a.4.7 Auxiliary Systems Using Primary Coolant

The staff evaluated the sufficiency of the preliminary design of SHINE's auxiliary systems using primary coolant, as described in SHINE PSAR Section 5a2.7, "Auxiliary Systems Using Primary Coolant," using the guidance and acceptance criteria of Section 5a2.7, "Auxiliary Systems Using Primary Coolant," of the ISG Augmenting NUREG-1537, Parts 1 and 2. As stated in SHINE PSAR Section 5a2.7, "[t]he SHINE facility IU auxiliary systems do not utilize the primary cooling system for cooling duty. Therefore, this section does not apply to the SHINE facility."

In accordance with the review procedures of the ISG Augmenting NUREG-1537, Part 2, Section, 5a2.7, the staff verified that no auxiliary systems in which potentially damaging temperature increases or excessive radiation exposures were predicted, relied on cooling or shielding using primary coolant.

On the basis of its review, the staff finds that, based on the preliminary design of the SHINE auxiliary systems, there are no auxiliary systems that require or utilize primary coolant for cooling duty. Therefore, this section does not apply to the SHINE facility. The staff will confirm that the final design conforms to this design basis during the evaluation of SHINE's FSAR.

5a.4.8 Probable Subjects of Technical Specifications

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 cooling systems, with special attention given to those items which may significantly influence the final design.

SHINE PSAR Section 5a2.2.4, "Technical Specification Operating Parameters," states that "[t]here are no technical specification parameters identified for the PCLS or the LWPS." Similarly, PSAR Sections 5a2.3.3, "Technical Specification Operating Parameters," and 5a2.4.4, "System Specifications," indicate that there are no technical specification parameters identified for the RPCS, PCLS or the LWPS cleanup. Section 5a2.4.4 further states that "Tables 5a2.2-1 and 5a2.2-2 [provide] for specifications of the primary coolant cleanup system. The specifications in Tables 5a2.2-1 and 5a2.2-2 ensure normal operation of the primary coolant cleanup system without adversely affecting normal operation of other associated systems."

However, the staff notes that SHINE identified potential limiting conditions for operation (LCOs) based on the flow and temperature of the PCLS, as well as the temperature and level of the LWPS in Table 14a2-1, "SHINE Facility Proposed Parameters for Technical Specifications."

Based on the information provided in Sections 5a2.2.4, 5a2.3.3, and 5a2.4.4, as well as Table 14a2-1 of the SHINE PSAR, the staff finds that identification and justification of the proposed LCOs for the PCLS and LWPS is sufficient and meets the applicable regulatory requirements to support 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.

5a.5 Summary and Conclusions

As described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. The summary and conclusions provided below apply to both the IF and RPF.

The staff evaluated descriptions and discussions of SHINE's cooling systems, including probable subjects of technical specifications, as described in SHINE PSAR Section 5a and supplemented by the applicant's responses to RAIs, and finds that the preliminary design of SHINE's cooling systems, 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 and ISG Augmenting NUREG-1537. The staff further notes that the IUs are designed to operate with a minimal heat load during normal operation, which would promptly lessen by at least an order of magnitude following IU shut down. This, coupled with the absence long-lived fission product build-up following shut down, indicates that operation of this facility would pose a minimal risk to the health and safety of the public.

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

(1) SHINE has described the proposed design of the cooling systems, 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 cooling systems may reasonably be left for later consideration in 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.

5b Radioisotope Production Facility Cooling Systems

SER Section 5b, "Radioisotope Production Facility Cooling Systems," provides an evaluation of the preliminary design of SHINE's RPF cooling systems as presented in SHINE PSAR Section 5b, "Radioisotope Production Facility Cooling Systems."

5b.1 Areas of Review

SHINE PSAR Sections 5b and 5a2.3 describe the RPCS, which serves as a secondary cooling system for the IUs and provides cooling to the RPF. Therefore, the areas of review related to the RPCS presented in SER Section 5a.1, "Areas of Review," are applicable to both the SHINE IUs and RPF.

5b.2 Summary of Application

As stated above and described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. Therefore, the summary provided in SER Section 5a.2, "Summary of Application," applies to both the IUs and RPF.

5b.3 Regulatory Basis and Acceptance Criteria

As previously stated and described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. Therefore, the regulatory basis and acceptance criteria provided in SER Section 5a.3, "Regulatory Basis and Acceptance Criteria," apply to both the SHINE IF and RPF.

5b.4 Review Procedures, Technical Evaluation, and Evaluation Findings

As described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. The technical evaluation of this system is provided above in SER Section 5a.4.3, "Secondary Cooling System," and applies to both the SHINE IF and RPF. The staff's review of the RPCS considers the interface of this system between the IF and RPF as part of a comprehensive technical evaluation. Since the RPCS is not considered safety-related, there was no identification of probable subjects of technical specifications for this system.

5b.5 Summary and Conclusions

As described in SHINE PSAR Sections 5b and 5a2.3, the RPCS serves as a secondary cooling system for the IUs and provides cooling to the RPF. The summary and conclusions provided in SER Section 5a.5, "Summary and Conclusions," apply to both the IF and RPF.