9.0 AUXILIARY SYSTEMS

The final design description of the auxiliary systems in the SHINE FSAR focuses on those structures, systems, and components (SSCs) and associated equipment that constitute the auxiliary safety systems and includes the overall design bases, system classifications, functional requirements, and system architecture. The auxiliary systems are designed for the operation of the SHINE Medical Technologies, LLC (SHINE, the applicant), irradiation facility (IF) and radioisotope production facility (RPF).

This chapter of the SHINE operating license application safety evaluation report (SER) describes the review and evaluation by the U.S. Nuclear Regulatory Commission (NRC, the Commission) staff of the final design of the SHINE auxiliary systems as presented in Chapter 9, “Auxiliary Systems,” of the SHINE Final Safety Analysis Report (FSAR) and supplemented by the applicant’s responses to staff requests for additional information (RAIs).

9a Irradiation Facility Auxiliary Systems

SER Section 9a, “Irradiation Facility Auxiliary Systems,” provides an evaluation of the final design of SHINE’s IF auxiliary systems as presented in SHINE FSAR Section 9a2, “Irradiation Facility Auxiliary Systems.”

9a.1 Areas of Review

The NRC staff reviewed SHINE FSAR Section 9a2 against applicable regulatory requirements using appropriate regulatory guidance and acceptance criteria to assess the sufficiency of the final design and performance of SHINE’s IF auxiliary systems. The final design of SHINE’s IF auxiliary systems’ control systems was evaluated to ensure that the design bases and functions of the systems and components are presented in sufficient detail to allow a clear understanding of the facility and that the facility can be operated for its intended purpose and within regulatory limits for ensuring the health and safety of the operating staff and the public. Drawings and diagrams were evaluated to ensure that they present a clear and general understanding of the physical facility features and of the processes involved. In addition, the staff evaluated the sufficiency of SHINE’s proposed technical specifications (TSs) for the facility.

Areas of review for this section included a summary description of the IF auxiliary systems’ control systems, as well as a detailed description of the IF confinement and radiologically controlled area (RCA) isolation. Within these review areas, the NRC staff assessed, in part, the design bases and functional descriptions of the required mitigative features of the auxiliary systems; drawings, schematic drawings, and tables of important design and operating parameters and specifications for the auxiliary systems; description of control and safety instrumentation, including locations and functions of sensors, readout devices, monitors, and isolation components, as applicable; and the required limitations on the release of confined effluents to the environment.

9a.2 Summary of Application

SHINE FSAR Section 9a2 includes a summary of the auxiliary systems in the IF, including the design bases, a system description, operational analysis and safety function, instrumentation and control, and relevant TSs. The IF auxiliary systems include the heating, ventilation, and air conditioning systems, handling and storage of target solution, fire protection systems and

programs, communication systems, possession and use of byproduct, source, and special nuclear material, cover gas control in closed primary coolant systems, and other auxiliary systems.

9a.3 Regulatory Requirements and Guidance and Acceptance Criteria

The NRC staff reviewed SHINE FSAR Section 9a2 against the applicable regulatory requirements, using appropriate regulatory guidance and acceptance criteria, to assess the sufficiency of the bases and the information provided by SHINE for the issuance of an operating license.

9a.3.1 Applicable Regulatory Requirements

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

10 CFR 50.34, "Contents of applications; technical information," paragraph (b), "Final safety analysis report."

10 CFR 50.36, "Technical Specifications."

10 CFR 50.40, "Common Standards."

10 CFR 50.57, "Issuance of operating license."

10 CFR Part 20, "Standards for Protection Against Radiation."

9a.3.2 Applicable Regulatory Guidance and Acceptance Criteria

In determining the regulatory guidance and acceptance criteria to apply, the NRC staff used its technical judgment, as the available guidance and acceptance criteria were typically developed for nuclear reactors. Given the similarities between the SHINE facility and non-power research reactors, the staff determined to use the following regulatory guidance and acceptance criteria:

NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996.

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.

"Final Interim Staff Guidance 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.

"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.

As stated in the interim staff guidance (ISG) augmenting NUREG-1537, the NRC staff determined that certain guidance originally developed for heterogeneous non-power research and test reactors is applicable to aqueous homogenous facilities and production facilities. SHINE used this guidance to inform the design of its facility and to prepare its FSAR. The staff's use of reactor-based guidance in its evaluation of the SHINE FSAR is consistent with the ISG augmenting NUREG-1537.

As appropriate, the NRC staff used 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, etc.) in the review of the SHINE FSAR. The additional guidance was used 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 FSAR. Additional guidance documents used to evaluate the SHINE FSAR are provided as references in Appendix B, "References," of this SER.

In addition, the following SHINE design criteria, located in SHINE FSAR Chapter 3, "Design of Structures, Systems, and Components," are applicable to various IF auxiliary systems:

Criterion 29 - Confinement design
Criterion 30 - Confinement design basis
Criterion 31 - Fracture prevention of confinement boundary
Criterion 32 - Provisions for confinement testing and inspection
Criterion 33 - Piping systems penetrating confinement
Criterion 34 - Confinement isolation
Criterion 35 - Control of releases of radioactive materials to the environment
Criterion 36 - Target solution storage and handling and radioactivity control
Criterion 37 - Criticality control
Criterion 38 - Monitoring radioactivity releases
Criterion 39 - Hydrogen mitigation

9a.4 Review Procedures, Technical Evaluation, and Evaluation Findings

The NRC staff performed a review of the technical information presented in SHINE FSAR Section 9a2, as supplemented, to assess the sufficiency of the final design and performance of SHINE's auxiliary systems in the IF for the issuance of an operating license. The sufficiency of the final design and performance of SHINE's IF auxiliary systems is determined by ensuring that it meets applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 9a.3, "Regulatory Requirements and Guidance and Acceptance Criteria," of this SER. The findings of the staff review are described in SER Section 9a.5, "Review Findings."

9a.4.1 Heating, Ventilation, and Air Conditioning Systems

The NRC staff evaluated the sufficiency of SHINE's heating, ventilation, and air conditioning (HVAC) systems, as described in SHINE FSAR Section 9a2.1, "Heating, Ventilation, and Air Conditioning Systems," using the guidance and acceptance criteria from Section 9.1, "Heating, Ventilation, and Air Conditioning Systems," of NUREG-1537, Part 2.

9a.4.1.1 Radiologically Controlled Area Ventilation System

SHINE FSAR Section 9a2.1.1, “Radiologically Controlled Area Ventilation System,” states that the radiological ventilation (RV) systems include supply air, recirculating, and exhaust subsystems to condition the air and provide confinement and isolation. There are three ventilation systems in the radiologically controlled area (RCA): Radiological Ventilation Zone 1 (RVZ1), RVZ2, and RVZ3. The FSAR also states the design basis of the RV systems as follows:

- Provide confinement at ventilation zone 1 confinement boundaries.
- Provide isolation at the RCA boundary.
- Confine airborne radiological materials in an accident scenario.
- Provide ventilation and makeup air and condition the RCA environment for workers and process equipment.
- Filter exhaust streams prior to them being exhausted out of the RCA.
- Maintain occupational exposure to radiation as low as is reasonably achievable (ALARA) and to ensure compliance with the requirements of 10 CFR Part 20.
- Exhaust hazardous chemical fumes.

Radiological Ventilation Zone 1

SHINE FSAR Section 9a.2.1.1.2, “System Description,” states that RVZ1 consists of two subsystems, the RVZ1 recirculating subsystem (RVZ1r) and the RVZ1 exhaust subsystem (RVZ1e). SHINE FSAR Figures 9a2.1-2 and 9a2.1-3 provide flow diagrams for these subsystems.

RVZ1r consists of two recirculation cooling units for each set of irradiation unit (IU) and target solution off-gas system (TOGS) cells, one providing cooling for the systems within the IU cell and one providing cooling for the TOGS cell. The two units are located in a common cooling room for each IU unit, thus there are a total of 16 recirculation units for the eight (8) IU units. Each RVZ1r unit consists of a high efficiency particulate air (HEPA) filter, carbon adsorbers, and cooling coil, aided by a blower and dampers to recirculate the air from the cell served by the unit. The cooling water of the cooling coils is provided by the nonsafety-related RPF cooling system (RPCS), which in turn is cooled by the nonsafety-related process chilled water system (PCHS). Condensate collected from the drip pan serving the IU cell is routed to the light water pool. In a letter dated March 23, 2021 (ADAMS Accession No. ML21095A229), SHINE stated that condensate from the cooling coil serving the TOGS cell is not expected because the TOGS cell cooling coil removes sensible heat only; however, the cooling coil is provided with a drip pan and drip pan heating elements in the event that small amounts of condensate were to form.

RVZ1e areas draw ambient supply air from adjacent ventilation zone 2 spaces, except for the supercell. The supercell is supplied air directly from RVZ2r. The air supplied to the supercell is exhausted by RVZ1e. During normal operation, areas ventilated by RVZ1e are maintained at negative pressure with respect to their surrounding ventilation zone 2 spaces. RVZ1e contains redundant fans, with one fan operating while the other fan is on standby. If the operating fan fails, the standby fan will start automatically.

The exhaust from both RVZ1e is drawn through a single filter bank consisting of HEPA filters and carbon adsorbers, connected to redundant exhaust fans. Figure 9a2.1-8, “Radiological Ventilation Zone 1 Exhaust Subsystem (RVZ1e) and Radiological Ventilation Zone 2 Exhaust Subsystem (RVZ2e) Mezzanine,” shows an isolable line to bypass the filter bank. The filter bank is located in the RCA mezzanine and the exhaust fans are located in the non-RCA

mezzanine. Safety-related, automatic, bubble tight isolation dampers controlled by the engineered safety features actuation system (ESFAS) are located at the RCA boundary. Downstream of the dampers, also at the RCA boundary, is a tornado damper to protect the RCA from tornadoes. The filters and adsorbers are equipped with differential pressure monitoring equipment and are periodically monitored by operations personnel. The exhaust fans discharge to an exhaust stack that is shared with the process vessel vent system (PVVS). The NRC staff finds that the downstream safety-related, automatic isolation dampers controlled by ESFAS provide reasonable assurance that that the proposed systems are adequate to control the release of airborne radioactive effluents during the full range of facility operations.

In the letter dated March 23, 2021, SHINE stated that the occupational dose requirements of 10 CFR Part 20 will be met during normal operations and maintenance by following the radiation protection practices and the radiation protection program described in SHINE FSAR Section 11.1. The NRC staff evaluated SHINE's radiation protection program in Chapter 11, "Radiation Protection Program and Waste Management," of this SER.

Radiological Ventilation Zone (RVZ) 2

SHINE FSAR Section 9a2.1.1.2 states that RVZ2 consists of three subsystems: the RVZ2 supply subsystem (RVZ2s), RVZ2r, and RVZ2e, as depicted in flow diagrams in SHINE FSAR Figures 9a2.1-5, 9a2.1-6, and 9a2.1-4, respectively.

RVZ2s supplies conditioned outside air into the RCA to provide ventilation and cooling, and to make up for the air quantities exhausted by RVZ1e and RVZ2e subsystems. The system includes two air handling units (AHUs) containing filters, cooling and heating coils, a humidifier, and dampers. RVZ2s provides cooling, heating, and humidification for all areas within ventilation zone 2 and maintains the quality control lab and analytical labs at positive pressure with respect to the ventilation zone 2 general area. The AHUs are located in the non-RCA mezzanine with a tornado damper at the RCA boundary, including two redundant bubble tight dampers downstream of the tornado damper located within Zone 2 of the RCA.

RVZ2r recirculates, filters, and conditions air within the RCA. The system includes several AHUs, filters, ductwork, and dampers. The RVZ2r units are located within the RCA. RVZ2r units provide additional cooling for systems within ventilation zone 2. RVZ2r is also used to cool air supplied to the supercell, which reduces the flow rate required to cool the equipment within the supercell. In the letter dated March 23, 2021, SHINE stated that condensate is not generated by RVZ2r units because the RVZ2r units function to remove sensible heat only, at temperatures above the dew point. SHINE also stated that the RVZ2s AHUs condition outside air by removing moisture prior to supply into the RCA.

The RVZ2e train contains HEPA filters and carbon adsorbers to remove airborne contaminants from the ventilation air stream. Figure 9a2.1-8 also shows an isolable line to bypass the filter bank in RVZ2e. The filter bank is located in the RCA mezzanine and the exhaust fans are located in the non-RCA mezzanine. Safety-related, automatic, bubble tight isolation dampers controlled by ESFAS are located at the RCA boundary. Downstream of the dampers, also at the RCA boundary, is a tornado damper to protect the RCA from tornadoes. The filters and adsorbers are equipped with differential pressure monitoring equipment and are periodically monitored by operations personnel. The exhaust fans discharge to an exhaust stack that is shared with the PVVS. The NRC staff finds that the downstream safety-related, automatic isolation dampers controlled by ESFAS provide reasonable assurance that that the proposed

systems are adequate to control the release of airborne radioactive effluents during the full range of reactor operations.

Radiological Ventilation Zone (RVZ) 3

SHINE FSAR Section 9a.2.1.1.2 states that during normal operations, RVZ3 transfers air from ventilation zone 4 to ventilation zone 3 then from ventilation zone 3 to ventilation zone 2 via engineered pathways as depicted in SHINE FSAR Figure 9a2.1-7. Under accident conditions, bubble tight dampers in the pathways close, isolating ventilation zone 2 from ventilation zone 3. The design of RVZ3 includes a backdraft damper in the engineered pathways, which inhibits backflow within ductwork that could spread contamination to outside of ventilation zone 2. Transfer ductwork from ventilation zone 3 to ventilation zone 2 is provided for several areas of ingress/egress to and from the RCA, including emergency exits to the IF and RPF general areas.

In the letter dated March 23, 2021, SHINE stated that the design of the engineered pathways, which includes backflow prevention by backdraft dampers in the pathways from RVZ3 to RVZ2 and from RVZ4 to RVZ 3, prevents the transfer of contaminated air from RVZ2 to ventilation zone 4 during entry and exit through RVZ3. SHINE further stated that non-RCA areas are included in the surveys required by 10 CFR 20.1501 in the event of an inadvertent release of radioactive airborne material into non-RCA areas from a ventilation system or component failure.

RVZ1, RVZ2, and RVZ3 System Operation

SHINE FSAR Section 9a2.1.1.3, “System Operation,” states that system operation between RVZ1e, RVZ2e, and RVZ2s is coordinated such that the overall airflow and pressure gradients are maintained. The pressure gradients create flow patterns that direct air towards areas of increasing contamination potential, maintained by the variable frequency drives on the exhaust fans. Minimum airflow will be maintained during normal system operation.

The building isolation dampers are safety-related automatic isolation dampers controlled by ESFAS. These dampers are located at the RCA boundary, upstream of the exhaust fans and exhaust stack. During upset conditions, affected sections of the RVZ1e, RVZ2s, and RVZ2e ventilation systems are isolated as required for the specific event or indication. Bubble tight dampers close, based on the detection of radiation at a predetermined level that is more than normal background radiation levels. Upon loss of power, loss of signal, or ESFAS initiation of confinement, dampers seal the affected confinement areas within 30 seconds. The NRC staff evaluated SHINE’s instrumentation and control system, including ESFAS, in Chapter 7, “Instrumentation and Control Systems,” of this SER.

RVZ2e exhausts the various normally occupiable rooms within the RCA, filters the air via HEPA filter banks, and discharges to the facility stack. Exhaust headers are maintained at a negative pressure by the variable frequency drives on the exhaust fans. Negative pressure is maintained in the ductwork to control contamination and maintain pressure gradients. The exhaust from RVZ2 areas collects in the RVZ2 system duct header and then is drawn through final HEPA filters and carbon adsorbers prior to discharge to the exhaust stack.

During normal operation, ventilation zone 2 areas are maintained at negative pressure with respect to RVZ3 airlocks. The speed of the RVZ2e exhaust fans is controlled to maintain a negative pressure setpoint in the RVZ2e exhaust header.

Ventilation zone 2 areas are directly supplied air by the RVZ2s AHUs. The AHUs supply conditioned, 100 percent outside air. Each AHU contains filters, pre-heat and cooling coils, and supply fans. The AHUs normally supply a constant volume of conditioned air to RVZ2 areas. The RVZ2 supply duct contains safety-related automatic isolation dampers located at the RCA boundary and controlled by ESFAS.

SHINE FSAR Section 9a2.1.1.4, "Instrumentation and Control," states that the process integrated control system (PICS) monitors the radiological ventilation system equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for off-normal conditions and signals alarms as required. The PICS starts, shuts down, and operates the radiological ventilation system in normal operating modes. Coordinated controls maintain negative pressurization to create flow patterns that direct air toward areas of increasing contamination potential.

SHINE FSAR Section 9a2.1.1.5, "Inspection and Testing," states that the ventilation systems (RVZ1, RVZ2, and RVZ3) are balanced upon installation. Control systems are tested to ensure that control elements are calibrated and properly adjusted. Safety-related isolation dampers are inspected and tested as required by, and in accordance with, Section DA of American Society of Mechanical Engineers (ASME) AG-1, "Code on Nuclear Air and Gas Treatment." Safety-related ductwork will be inspected and tested as required by, and in accordance with, Section SA of ASME AG-1.

Design Criteria

As stated in SHINE FSAR Section 3.1, "Design Criteria," the nuclear safety classification of safety-related SSCs at SHINE are those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to the health and safety of workers and the public; and to control or mitigate the consequences of such accidents. SHINE FSAR Table 3.1-1, "Safety-Related Structures, Systems, and Components," identifies the SSCs at SHINE that are classified as safety-related. The list includes the ventilation system features and all of its supporting structures and systems. SHINE FSAR Table 3.1-3, "SHINE Design Criteria," provides the generically applicable design criteria for the SHINE facility. The NRC staff focused on the design criteria applicable to the ventilation system features, namely criterion 29, 32, 35, and 39. For instance, many criteria shown in FSAR Table 3.1-1 applicable to confinements are addressed in Chapter 6, "Engineered Safety Features," of this SER. The applicable criteria are listed in Section 9a.3.2 of this SER.

For criterion 29, the NRC staff finds that SHINE appropriately identified passive RCA boundaries and active components for the establishment of the fourth class of confinement boundaries (i.e., RCA ventilation isolations). The staff finds that the ventilation system RCA boundaries for the RCA ventilation zones are addressed in sufficient detail in SHINE FSAR Section 9a2.1 and SHINE FSAR Figures 9a2.1-5, 9a2.1-7, and 9a2.1-8.

For criterion 32, the NRC staff finds that periodic inspection, surveillance, and testing are satisfied by the proposed TSs.

For criterion 35, the NRC staff finds that the facility is equipped with isolation provisions in the ventilation system at the RCA boundary and that they are subject to the TSs.

For criterion 39, the NRC staff finds that the applicant has described systems to control the buildup of hydrogen that is released into the primary system boundary and ensure that the integrity of the system is maintained during normal operating conditions.

Based on the above, the NRC staff finds that the applicant provided final analysis and evaluation of the design and performance of SSCs as it relates to confinement and satisfies 10 CFR 50.34(b)(4).

Conclusion

Based on its review, the NRC staff finds that the level of detail provided on the Radiologically Controlled Area Ventilation System for SHINE demonstrates an adequate description for its design and concludes that SHINE's operating license application sufficiently defines systems operation in accordance with 10 CFR 50.34(b)(2).

The NRC staff evaluated the descriptions and discussions of SHINE's Radiologically Controlled Area Ventilation System, including proposed TSs, as described in SHINE FSAR Section 9a2.1, and finds that the final design of SHINE's Radiologically Controlled Area Ventilation System, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9a.4.1.2 Non-radiological Area Ventilation System

SHINE FSAR Section 9a2.1.2, "Non-Radiological Area Ventilation System," states that facility ventilation zone 4 (FVZ4) consists of areas that are located within the main production facility, but outside of the RCA, and is completely independent of the RVZ systems described in SHINE FSAR Section 9a.2.1.1. The FVZ4 system is nonsafety-related. FVZ4 exhausts directly to the outside of the main production facility with no radiation detectors present in the exhaust path, as contamination is not expected to be present in the FVZ4 system.

The design bases for the FVZ4 system are to provide environmental conditions suitable for personnel and equipment, maintain positive pressure with respect to the RCA, provide outside makeup air for ventilation, exhaust, and pressurization, maintain hydrogen concentration within acceptable limits (< 2%) in the uninterruptible power supply (UPS) battery rooms, and remove hazardous chemical fumes from applicable spaces. The FVZ4 also provides transfer air into the RVZ3 system airlocks. The FVZ4 system consists of three subsystems: the FVZ4 supply and transfer air subsystem (FVZ4s), the FVZ4 exhaust subsystem (FVZ4e), and the FVZ4 room cooling recirculation subsystem (FVZ4r).

FVZ4s provides conditioned air for workers and equipment in the non-RCA portion of the facility, makeup air from outside to compensate for exhaust air systems in RVZ4, and to maintain positive pressure with respect to the RCA. The supply air distribution diagram of FVZ4s is provided in SHINE FSAR Figure 9a2.1.9. The flow diagram of the return air associated with the FVZ4s is provided in SHINE FSAR Figure 9a2.1-10. The flow diagram of FZV4s subsystem AHUs is provided in SHINE FSAR Figure 9a2.1-11.

The FVZ4s consists of two 100% capacity AHUs and a single return air fan, with each AHU equipped with filters, heating and cooling coils, and supply fans. The AHUs are capable of providing a variable volume of conditioned air to FVZ4 areas, with a minimum flow determined by ventilation requirements. The FVZ4s supplies air to and the FVZ4e exhausts air from each

battery and UPS room, each room can be independently isolated by dampers on an initiation signal from each location's fire suppression system.

FVZ4e maintains hydrogen concentration below 2% in each battery and UPS room. Dedicated fans powered by the standby generator system are provided to exhaust the battery and UPS rooms during loss of power. The FVZ4e flow diagram is provided in SHINE FSAR Figure 9a2.1-12.

FVZ4r recirculates and cools air within the electrical/telecommunication rooms. The subsystem is made up of two split systems that cool the server space. The FVZ4r subsystem provides equipment status to PICS. The supply air subsystem HVAC controls operate through the PICS. The FVZ4 system is designed such that the PICS monitors and controls the recirculation air subsystem ventilation equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for off-normal conditions and signals alarms as required. In addition, PICS can perform start, shutdown, and operational functions of FVZ4 during normal operating modes, monitor supply and return air temperatures from the AHUs, and monitor pressure differential across the filters.

The FVZ4 system will be balanced and the HVAC control systems tested to ensure that control elements are calibrated, adjusted, and in proper working condition.

The NRC staff evaluated the descriptions and discussions of SHINE's Non-Radiological Area Ventilation System, as described in SHINE FSAR Section 9a2.1, and finds that the final design of SHINE's Non-Radiological Area Ventilation System, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9a.4.1.3 Facility Chilled Water System

SHINE FSAR Section 9a2.1.3, "Facility Chilled Water System," states that the facility chilled water system (FCHS) is a closed-loop, forced circulation system which provides chilled water (CW) to the cooling coils of the RVZ2s subsystem AHUs. The FCHS also provides chilled water to the cooling coils of the FVZ4 AHUs. The FCHS rejects heat to the atmosphere via air-cooled chillers. The FVZ4 AHUs, RVZ2s AHUs, chillers, and chilled water pumps are located external to the RCA.

The FCHS is nonsafety-related. Primary components of the FCHS include air-cooled chillers, CW pumps, system piping and valves, makeup water and water treatment equipment, and an expansion tank. The chilled water pumps are equipped with variable frequency drives and the chilled water supply lines to RVZ2s and FVZ4 contain a modulating flow control valve capable of a fully-open or fully-closed valve position. AHU system flow, temperature, and differential pressure are utilized by an FCHS controller to signal valves, pumps, and chillers to come online, vary speed, or secure as necessary to meet system setpoints during normal system operation.

PICS monitors the RVZ2s and FVZ4 airstream delivery temperatures. An FCHS controller monitors flow control valve position and delivers a signal to individual valves to adjust cooling water flow rates in response to signals sent to the load instrumentation. A flow control valve is maintained on the system bypass line and is controlled by input signals from FCHS controller inputs made by chiller supply, RVZ2s, and FVZ4 modulating flow control valves. When the FCHS controller registers that a pump is not running, and a stop command has not been issued

from the control panel, an alarm is generated at the control panel and the standby pump is automatically started.

Local chiller equipment monitors differential pressure across each chiller and the chillers' running status. Upon communication of a fault alarm, an FCHS controller isolates that chiller's modulating flow control valve and issues a start command to the back-up chiller. System pumps respond accordingly to the loading of the chillers via a local controller.

The system maintains alarms monitored by PICS and displays them at operator workstations for system volumes out of range. All FCHS controls are nonsafety-related.

The FCHS testing requirements for water piping, pipe supports, and valves are in accordance with ASME B31.9, "Building Services Piping.". Hydrostatic tests are performed in accordance with Section 937.3 of ASME B31.9. Visual welding inspections are performed on piping and piping supports in accordance with ASME B31.9.

The NRC staff evaluated the descriptions and discussions of SHINE's FCHS, as described in SHINE FSAR Section 9a2.1, and finds that the final design of SHINE's FCHS, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9a.4.1.4 Facility Heating Water System

SHINE FSAR Section 9a2.1.4, "Facility Heating Water System," states that the design bases of the facility heating water system (FHWS) are to supply heated water to the RVZ2s and the FVZ4 system, as well as other heating coils outside of the RCA, and be able to maintain system operation in the event of a single pump or single boiler failure. The FHWS is nonsafety-related.

The FHWS consists of equipment required to deliver heating hot water to the RVZ2 and FVZ4 AHUs in non-RCA portions of the main production facility. The primary components of the FHWS are three 50 percent natural gas-fired boilers, three 50 percent centrifugal hot water pumps, eight 100 percent centrifugal pumps for heating coil freeze protection, an air separator, and an expansion tank. Two pumps each are provided on the FVZ4s and the RVZ2s to maintain freeze protection. If one pump is down for maintenance, the other can ensure freeze protection.

The flow through the system is varied by modulating the pump speed based upon maintaining the temperature differential across the boilers. A bypass valve is installed at the end of the coil loop piping to maintain the minimum flow required to operate the pumps.

The FHWS provides the necessary output signal to PICS for the monitoring of heating water temperatures, pressures, and flow rates. Low water cutoff controls and flow sensing controls are provided, which automatically stop the combustion operation of the boiler when the water level drops below the lowest acceptable water level or when water circulation stops.

FHWS piping design, installation, inspection, and testing are in accordance with ASME B31.9. Hydrostatic tests are performed in accordance with Section 937.3 of ASME B31.9. Visual welding inspections are performed on piping and piping supports in accordance with ASME B31.9.

The NRC staff evaluated the descriptions and discussions of SHINE's FHWS, as described in SHINE FSAR Section 9a2.1, and finds that the final design of SHINE's FHWS, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9a.4.2 Handling and Storage of Target Solution

The NRC staff evaluated the sufficiency of SHINE's handling and storage of the target solution, as described in SHINE FSAR Section 9a2.2, "Handling and Storage of Target Solution," using the guidance and acceptance criteria from Section 9.2, "Handling and Storage of Reactor Fuel," of NUREG-1537, Part 2.

SHINE FSAR Section 9a2.2.2, "Irradiation Facility Target Solution Storage and Handling," states that target solution is transferred from the target solution hold tank to the target solution vessel (TSV) via the TSV fill lift tank by using the vacuum transfer system. The target solution in the TSV fill lift tank gravity drains into the TSV. Upon completion of filling the TSV, any remaining target solution in the TSV lift tank is drained back into the target solution hold tank. After filling the TSV with target solution, the TSV is isolated from the TSV fill lift tank and the target solution hold tank by closing two fill valves in series. SHINE FSAR Section 9a2.2.3, "Irradiation Facility Target Solution Handling Equipment," states that the major equipment that interacts with the target solution in IF are 8 TSVs and 8 connected TSV dump tanks. Both the TSV and TSV dump tanks are located within the IU cell. SHINE FSAR Section 9a2.2.6, "Biological Shielding," states that the irradiation cell biological shield ensures that projected radiation dose rates and accumulated doses in occupied areas within the IF do not exceed the limits of 10 CFR Part 20 and supports SHINE's radiation exposure goal described in SHINE's ALARA program. The IF biological shield is evaluated in Section 4a.4.5 of this SER. Reactivity control mechanisms for the TSV are evaluated in Section 4a4.2.2 of this SER. SHINE's ALARA program is evaluated in Section 11.4.1.3 and the nuclear criticality program is evaluated in Section 6b.4.5 of this SER.

The NRC staff finds that methods for handling, moving, and storing target solution in the IF provide reasonable assurance that potential personnel doses from irradiated target solution will not exceed regulatory limits in 10 CFR Part 20 and supports SHINE's ALARA program.

9a.4.3 Fire Protection Systems and Programs

The NRC staff evaluated the sufficiency of SHINE's fire protection systems and programs, as described in SHINE FSAR Section 9a2.3, "Fire Protection Systems and Programs," using the guidance and acceptance criteria from Section 9.3, "Fire Protection Systems and Programs," of NUREG-1537, Part 2.

9a.4.4 Communication Systems

The NRC staff evaluated the sufficiency of SHINE's communication systems, as described in SHINE FSAR Section 9a2.4, "Communication Systems," using the guidance and acceptance criteria from Section 9.4, "Communication Systems" of NUREG-1537, Part 2.

SHINE FSAR Section 9a2.4 describes the facility data and communication system (FDCS) that provides the ability to communicate during both normal and emergency conditions between different areas of the production facility and the main facility, support buildings, and remote locations to the SHINE site. SHINE Emergency Plan, Section 9.1, "Control Room," states that the control room is provided with communications equipment to communicate within and outside

the SHINE facility, which includes commercial telephones, sound-powered phones, base station radios, and the ability to broadcast information on the public address system. FSAR Section 9b.4, “Communication Systems,” states that the communication systems for the SHINE facility are common to both the IF and the RPF.

SHINE FSAR Section 9a2.4.1, “Telephones,” describes the general design of the telephone communication system. The FSAR states that the SHINE facility uses a commercial telephone communication system that provides for onsite two-way communication, paging and public address, and party-line-type voice communications for the main facility and outbuildings. The system is provided power from the standby generator system (SGS), as described in SHINE FSAR Section 8a2.2 should a loss of offsite power occur.

SHINE FSAR Section 9a2.4.3, “Sound-Powered Phones,” describes the general design and operation of the sound-powered phone system. The FSAR states that the sound-powered phones supplement the commercial telephone communication system. These phones plug into local terminal jacks where critical operations and response activities are anticipated to occur within the site. Because the sound-powered phones operate independent of any electrical power source, the system provides uninterrupted communications in the event of a loss of power to the facility. The NRC staff finds that the sound-powered phones provide two-way communications between different locations throughout the facility. SHINE Emergency Plan, Section 9.8.3, “Sound Powered Phones,” states that a sound-powered phone is located in the control room.

Based on the information in SHINE FSAR Sections 9a2.4.1 and 9a2.4.3, the NRC staff finds that both the telephone communication system and the sound-powered phone system are designed to provide two-way communications between the control room and other locations to support safe operation of the facility.

SHINE FSAR Section 9a2.4.2, “Public Address System,” describes the general design and operation of the public address (PA) system. The FSAR states that the PA system, using the commercial telephone communication system, is designed to make announcements site-wide or to specified predefined areas. Specifically, the PA system is designed to be audible in occupiable areas in the RCA, normally occupied areas of the facility and support buildings, hallways and corridors of the facility and support buildings, and outdoor areas within the controlled access area fence. The PA system includes a prioritization such that announcements from the control room override any other use of the PA system. The PA system has a battery backup to ensure system reliability during any loss of power.

Based on the information in SHINE FSAR Section 9a2.4.2, the NRC staff finds that the PA system is designed to announce emergency information to the entire facility and support buildings.

SHINE FSAR Section 9a2.4.4, “Radio System,” describes the general design and operation of the hand-held portable radios. The FSAR states that hand-held portable radios, powered by rechargeable battery packs, are provided to communicate with off-site emergency support organizations. This system allows for communication with the Janesville Fire and Police Departments using P25 transmission protocols. In the case of loss of offsite electrical power, backup power is provided by the SGS, as described in FSAR Section 8a2.2. SHINE Emergency Plan, Section 9.8.4, “Radio,” states that the handheld portable radios are located in the control room and available for use by facility emergency organization personnel as an additional onsite backup communication device. Additionally, SHINE Emergency Plan, Section

9.8.5, “Mobile Telephones,” states that a mobile telephone is stored in the control room and serves as a back-up onsite and offsite communication system.

The design of the telephone system, as described in SHINE FSAR Section 9a2.4.1, provides facility personnel the ability to contact or receive calls from any outside telephone number to ensure that offsite personnel can be contacted for assistance in case of an emergency. Further, designated emergency cell phones located in the control room, emergency support center (ESC), and backup ESC can be used to contact offsite personnel in case of an emergency.

Based on the information in the FSAR, Sections 9a2.4.4 and 9a2.4.1, the NRC staff finds that the facility communication systems are designed to contact both onsite and offsite emergency personnel for assistance.

SHINE FSAR Section 9a2.4.8 states that there are no TSs associated with the communication systems. The NRC staff reviewed NUREG-1537, Part 1, Appendix 14.1, “Format and Content of Technical Specifications for Non-Power Reactors,” and ANSI/ANS 15.1-2007, “The Development of Technical Specifications for Research Reactors,” for guidance on the inclusion of the communication systems in TSs. The staff didn’t identify any specific guidance for including a communication system in TSs. Further, the staff reviewed the TSs of several non-power reactors to identify whether communication systems were included within the facilities’ TSs. The staff didn’t identify any TS requirements for a communication system. Based on the staff’s review of similar facilities’ TSs and the guidance in NURE-1537, Part 1, and ANSI/ANS 15.1-2007, the staff finds that no TSs are necessary for the communication systems. Therefore, the staff finds that the lack of a TS requiring SHINE’s communication systems is acceptable.

The NRC staff finds that the design of the SHINE communications systems provides effective two-way communication between locations essential for safe operation of the facility, allows for a facility-wide announcement of an emergency, and has provisions for contacting offsite personnel for assistance in case of an emergency. Therefore, the staff finds that the SHINE communications systems, as described in SHINE FSAR Section 9a2.4, meet the guidance in NUREG-1537, Part 2, Section 9.4, and are acceptable.

9a.4.5 Possession and Use of Byproduct, Source, and Special Nuclear Material

The NRC staff evaluated the sufficiency of SHINE’s program for possession and use of byproduct, source, and special nuclear material in the IF, as described in SHINE FSAR Section 9a2.5, “Possession and Use of Byproduct, Source, and Special Nuclear Material,” using the guidance and acceptance criteria from Section 9.5, “Possession and Use of Byproduct, Source, and Special Nuclear Material,” of NUREG-1537, Part 2.

SHINE FSAR Section 9a2.5 states that the IF is designated as an RCA and that radiation protection program controls and procedures, including the ALARA program, apply to the IF as described in SHINE FSAR Section 11.1. SHINE FSAR Figure 1.3-1, “Main Production Facility Building General Arrangement,” identifies the areas and rooms that constitute the IF and the RPF.

SHINE FSAR Section 9a2.5.1, “Byproduct Material,” states that the SHINE facility is designed to generate byproduct material, such as molybdenum-99 (Mo-99) for use as medical isotopes, fission and activation products, and tritium within the neutron driver assembly. Additionally, the FSAR states that up to eight neutron sources are used, one in each IU, for start-up operations.

SHINE FSAR Section 9a2.5.2, "Source Material," states that the IF includes depleted uranium within the tritium purification system and natural uranium within the neutron multiplier. By letter dated April 29, 2021 (ADAMS Accession No. ML21119A165), as supplemented on August 20, 2021 and December 2, 2021 (ADAMS Accession Nos. ML21242A028 and ML21336A193), SHINE requested to amend its construction permit for the SHINE facility to allow the receipt and possession of certain radioactive materials during the construction of the facility. On December 2, 2021 (ADAMS Accession No. ML21320A224), the NRC issued Amendment No. 2 to the construction permit to authorize SHINE to receive and possess sealed neutron sources. Further, the amendment authorized SHINE to receive and possess natural uranium in the form of neutron multipliers and depleted uranium in the form of tritium storage beds.

SHINE FSAR Section 9a2.5.3, "Special Nuclear Material," states that the IF includes low enriched uranium (LEU) within the TSV. The LEU is irradiated to Mo-99 by fission within the IF. Further, the FSAR states that plutonium is generated in the target solution and the neutron multiplier. The FSAR also states the total amount of LEU used in the IF to support facility operation. By letter dated October 15, 2021 (ADAMS Accession No. ML21288A543), SHINE notified the NRC of the submission date for a planned request to license certain byproduct, source, and special nuclear material to support initial facility operations as April 2022.

Based on the above information, the NRC staff finds that SHINE has radiation protection controls, procedures, and an ALARA program to help ensure that potential radiation exposures to workers are within the limits of 10 CFR Part 20. The staff finds that the authorized spaces for the use of material have been sufficiently described. Further, the staff finds that the use of controls and procedures provides reasonable assurance that an uncontrolled release of radioactive material to the unrestricted environment will not occur. The staff notes that SHINE will submit a separate request for a license to use and possess certain byproduct, source, and special nuclear material to support initial faciality operations.

9a.4.6 Cover Gas Control in Closed Primary Coolant Systems

The NRC staff evaluated the sufficiency of SHINE's description of cover gas control in the primary coolant systems, as presented in SHINE FSAR Section 9a2.6, "Cover Gas Control in Closed Primary Coolant Systems," using the guidance and acceptance criteria from Section 9.6, "Cover Gas Control in Closed Primary Coolant Systems," of NUREG-1537, Part 2.

SHINE FSAR Section 9a2.6 states that the Primary Closed Loop Cooling System (PCLS) is the closed loop cooling system that provides cooling to the TSV. Buildup of radiolysis products in the PCLS is controlled by the ventilation of the PCLS expansion tank by RVZ1. Cover gas control for the PCLS is described in SHINE FSAR Section 5a2.2 and depicted in SHINE FSAR Figure 5a2.2-1A.

The PCLS cooling water leaves the subcritical assembly system (SCAS) and enters the PCLS air separator, which allows entrained radiolytic gas to separate from the cooling water. In addition to hydrogen and oxygen, the headspace contains air, water vapor, and small amounts of Nitrogen-16 and Argon-41. An interface between the RVZ1e and the expansion tank allows radiolytic gases to be purged to RVZ1e, preventing the buildup of hydrogen gas. Ambient air from within the primary confinement boundary is drawn through a flame arrestor and filter for sweeping of the expansion tank headspace. SHINE FSAR Section 5a2.2.7 states that radiolysis of the primary cooling water and the light water pool results in the generation of hydrogen and oxygen gases. The RVZ1 draws air from the primary confinement and through the PCLS expansion tank and SHINE provided figures to support that the nominal flow rate

provided by RVZ1e is significantly greater than the combined quantity of hydrogen gas calculated from the primary cooling water and light water pool.

Deuterium source gas is also exhausted to the facility ventilation. In the letter dated March 23, 2021, SHINE discussed the potential for a combustible deuterium-air mixture. SHINE stated that during normal ventilation system conditions, the formation of flammable mixtures of deuterium source gas and other sources of hydrogen is prevented by the forced RVZ1e ventilation, which maintains hydrogen concentration in the IU cell atmosphere and RVZ1e exhaust stream below 1 percent hydrogen by volume. SHINE also stated that ignition of deuterium source gas and hydrogen in the PCLS expansion tank and RVZ1e ductwork is prevented by the PCLS flame arrestor.

The NRC staff evaluated the descriptions and discussions of SHINE's cover gas control, as described, and finds that the final design of SHINE's cover gas control, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9a.4.7 Other Auxiliary Systems

The NRC staff evaluated the sufficiency of SHINE's other auxiliary systems in the IF, as described in SHINE FSAR Section 9a2.7, "Other Auxiliary Systems," using the guidance and acceptance criteria from Section 9.7, "Other Auxiliary Systems," of NUREG-1537, Part 2.

9a.4.7.1 Tritium Purification System

SHINE FSAR Section 9a2.7.1, "Tritium Purification System," states that the function of the tritium purification system (TPS) is to separate the deuterium-tritium gas mixture from the neutron driver assembly system (NDAS) into pure deuterium and tritium gas streams and remove other impurities from the gas. The TPS supplies purified deuterium and tritium gas streams to the NDAS to achieve the desired target mixture fractions. There are three trains of the TPS, and all components of the system are located in the TPS room. Each train independently serves a fixed set of IUs. The TPS limits the amount of tritium in waste streams that are exhausted to the facility ventilation system. The TPS also provides storage for tritium in depleted uranium as a metal hydride. There are external supplies of deuterium, helium, and liquid nitrogen for use in the TPS. Only deuterium from the external tank supply is used for the NDAS ion source. The liquid nitrogen is used to cool the cryopumps that are part of the isotope separation system. The system has redundant valves that can isolate the system if a tritium leak is detected. The processes associated with the TPS are performed within gloveboxes to minimize tritium exposure to the workers.

SHINE FSAR Section 9a2.7.1.1, "Tritium Purification System Subsystems," describes the subsystems of the TPS. The subsystems of the TPS are the isotope separation system (ISS), the TPS-NDAS interface lines, the TPS gloveboxes, the secondary enclosure cleanup subsystem (SEC), the vacuum impurity treatment subsystems (VAC/ITS), the NDAS secondary enclosure cleanup (NDAS SEC), and the TPS room. The ISS receives the gas mixture from the NDAS units, removes impurities from the gas, and separates the tritium from the deuterium so that it can supply high purity tritium to each NDAS. The ISS also flushes and evacuates process lines before and after maintenance activities. The TPS-NDAS interface lines are used to transfer the tritium to the NDAS. The lines run through subgrade penetrations and the lines are protected from impact in the run between the subgrade penetrations and the TPS gloveboxes. There is also monitoring of the lines to detect tritium leaks. The lines can be

isolated to minimize releases during design basis accidents. The TPS gloveboxes are confinement gloveboxes that enclose the isotope separation equipment. The gloveboxes have gloveports and windows to support operator access to the equipment in the gloveboxes. The gloveboxes are maintained at a negative pressure relative to the TPS room and have a recirculating helium atmosphere. An external helium tank provides any makeup helium that is necessary. The gloveboxes and associated redundant isolation valves minimize the release of tritium to the facility and the environment. The secondary enclosure cleanup system maintains low levels of tritium and oxygen in the glovebox atmosphere. The operator is notified of high tritium concentration in the glovebox by an alarm. There are three gloveboxes to service the three TPS trains (one per train). Each train independently serves a subset of the NDAS units. The volumes of the gloveboxes are large enough that a release of the tritium and deuterium in the glovebox would not cause it to exceed the lower flammability limit.

The SEC removes tritium and oxygen from the recirculating helium TPS glovebox atmosphere. The SEC minimizes the amount of tritium in the glovebox atmosphere. It can remove both elemental tritium and tritiated water. The SEC removes tritium from the glovebox atmosphere before it is exhausted to RVZ1e. There are alarms to notify the operator of high tritium levels in the glovebox. The VAC/ITS evacuates the TPS process lines and removes tritium from process waste streams to support operations and maintenance. The waste streams are monitored for tritium before being exhausted to the facility ventilation system. When the NDAS is evacuated for maintenance, it is treated by the VAC/ITS system before exhausting it to the ventilation system. The NDAS SEC removes tritium resulting from leakage and permeation to the NDAS secondary enclosures during operation of the NDAS. The TPS room houses the equipment that is part of the TPS including the TPS gloveboxes, the VAC/ITS equipment, the NDAS secondary enclosure cleanup equipment, TPS fume hoods, SEC equipment, and supporting control and process equipment. The TPS fume hoods and the overall ventilation of the TPS room exhaust to RVZ2.

SHINE FSAR Section 9a2.7.1.7, “Instrumentation and Controls,” states that PICS provides normal process control and monitoring of components not important to the safe operation of the TPS. The TPS exhaust and the TPS confinements are monitored by ESFAS for high tritium concentration. The ESFAS initiates a TPS Process Vent Actuation if the TPS exhaust exceeds 1 Ci per cubic meter. The ESFAS initiates a TPS Train Isolation if the tritium concentration in a train confinement exceeds 1000 Ci per cubic meter. The ESFAS also initiates a TPS Train Isolation if the TPS target chamber supply or exhaust pressure in an IU cell connected to the train exceeds 8 psia because this indicates a breach of the low-pressure tritium boundary.

SHINE FSAR Section 3.1, “Design Criteria,” Table 3.1-1, “Safety Related Structures, Systems, and Components,” identifies the TPS as safety-related and includes the applicable design criteria. SHINE FSAR Table 3.1-3, “SHINE Design Criteria,” describes the applicable design criteria. The NRC staff finds that the TPS meets the applicable design criteria of 29-36 and 38. The staff finds that the TPS is designed to detect and minimize leakage from the TPS confinement boundary during normal operations and design basis accidents through a combination of multiple barriers, cleanup systems, and isolations initiated by the ESFAS. The staff also finds that the TPS prevents leakage from the primary confinement boundary in the IUs by isolating the interface process lines from the NDAS during and after a design basis seismic event through the TSV reactivity protection system (TRPS). The staff evaluated SHINE’s instrumentation and control system and design basis accidents in Chapter 7 and Chapter 13, “Accident Analysis,” of this SER, respectively.

9a4.7.2 Neutron Driver Assembly System Service Cell

SHINE FSAR Section 9a2.7.2, “Neutron Driver Assembly System Service Cell,” states that the NDAS Service Cell (NCS) is a dedicated work area provided to support the staging, commissioning, maintenance, and disposal of a single NDAS unit. The FSAR further describes the NCS as a roofless room with four walls. Within the NCS area, a directed airflow system is used for the reduction of residual tritium contamination of NDAS components. The airflow system interfaces with the facility’s Zone 2 exhaust system. The NCS shield walls consist of 24-inch-thick concrete walls with reinforced carbon steel rebar. Local shielding can be added to the NCS area to help reduce occupation exposure to workers within the area. SHINE FSAR Section 9a2.7.2.3, “Radiological Protection,” states that the calculated dose rates during accelerator operation in the NCS are estimated to be 8 millirem per hour outside the NCS walls. The NCS is designed with an interlock to prevent operation of the NDAS while the service door is open. The NCS is also designed with a radiation interlock button inside the NCS that prevents or stops operation of the NDAS when actuated. FSAR Figure 4a2.5-1, “Irradiation Facility Biological Shielding,” provides a general layout of the NCS. The NCS is a non-safety-related system.

Based on the above information, the NRC staff finds that the design of the NCS will minimize the possibility of tritium contamination and keep radiation exposures to workers consistent with ALARA principles with the use of permanent shielding (i.e., NCS concrete walls), local shielding, and interlocks. The staff evaluated SHINE’s ALARA program and radiation protection program in Chapter 11, “Radiation Protection Program and Waste Management,” of this SER.

9a.4.8 Proposed Technical Specifications

In accordance with 10 CFR 50.36(a)(1), the NRC staff evaluated the sufficiency of the applicant’s proposed TSs for the SHINE auxiliary systems in the IF as described in SHINE FSAR Chapter 9.

The proposed TS 3.8, “Facility-Specific,” Limiting Condition for Operation (LCO) 3.8.7 and Surveillance Requirement (SR) 3.8.7, states the following:

LCO 3.8.7	Each TPS glovebox shall have a helium atmosphere with dew point ≤ -4°F. Note – This LCO is applied to each TPS train independently; actions are only applicable to the TPS train(s) that fail to meet the LCO during the associated condition(s) of applicability.
Applicability	Associated TPS glovebox tritium in TPS process equipment not in storage
Action	According to Table 3.8.7
SR 3.8.7	1. A Channel Check shall be performed on the TPS glovebox dew point monitor quarterly. 2. A Channel Calibration shall be performed on the TPS glovebox dew point monitor annually.

The proposed Table 3.8.7, “TPS Glovebox Atmosphere Actions,” states the following:

	Action (per TPS glovebox)	Completion Time
1.	If the TPS glovebox atmosphere is not within the allowable limit, Initiate actions to purge the TPS glovebox with helium	6 hours

LCO 3.8.7 specifies the helium atmosphere dew point temperature limit for the TPS gloveboxes and the actions to be taken if it is not below the limit. The NRC staff finds that the limit would minimize the flammability risk and minimize oxygen exposure to TPS process equipment. The staff finds that if the temperature is above the allowable limit, purging the glovebox with helium will return the glovebox atmosphere to within allowable parameters. The staff also finds that the completion time of 6 hours would minimize the risk of a fire. Therefore, the staff finds the LCO acceptable.

SR 3.8.7 requires a channel check to be performed on the TPS glovebox dew point monitor quarterly. The NRC staff finds that this frequency is in accordance with guidance in ANSI/ANS 15.1-2007. SR 3.8.7 also requires a channel calibration to be performed on the TPS glovebox dew point monitor annually. The staff finds that this frequency is also in accordance with guidance in ANIS/ANS 15.1-2007. Therefore, the staff finds the SR acceptable.

The proposed TS 3.8, LCO 3.8.8 and SR 3.8.8, states the following:

LCO 3.8.8	Each TPS SEC shall be Operable. An SEC is considered to be Operable if: 3. The circulating blower is Operating, 4. At least 1 molecular sieve bed is Operating, and 5. The hydride bed is Operating. Note – This LCO is applied to each TPS train independently; actions are only applicable to the TPS train(s) that fail to meet the LCO during the associated condition(s) of applicability.
Applicability	Tritium in the associated train of TPS process equipment not in storage.
Action	According to Table 3.8.8
SR 3.8.8	Verify each SEC is Operating daily.

The proposed Table 3.8.8, "TPS SEC Actions," states the following:

	Action (per TPS glovebox)	Completion Time
1.	If an SEC is inoperable, Place tritium in the associated train of TPS process equipment in its storage location.	12 hours

LCO 3.8.8 specifies that each TPS SEC should be operable, provides the conditions for the TPS SECs to be considered operable, and provides the actions to be taken if they are not operable. The NRC staff finds that requiring the TPS SEC to be operable would prevent the accumulation of tritium in its associated glovebox which minimizes the leakage of tritium and prevents excessive dosage to workers. The staff finds that if an SEC is inoperable, the completion time of 12 hours would allow for minor repairs and adequate time to store the tritium in its storage location. Therefore, the staff finds the LCO acceptable.

SR 3.8.8 requires the verification of each SEC to be operable daily. The NRC staff finds that this frequency would ensure continued operability of the system. Therefore, the staff finds the SR acceptable.

The proposed TS 3.8, LCO 3.8.9 and SR 3.8.9, states the following:

LCO 3.8.9	Each RCA isolation damper listed in Table 3.8.9-a shall be Operable. A damper is considered Operable if: 1. The damper is capable of closing on demand from ESFAS Note – A single Division of required components may be inoperable for up to 2 hours during the performance of required surveillances.
Applicability	Facility not Secured
Action	According to Table 3.8.9
SR 3.8.9	Dampers listed in Table 3.8.9-a shall be closure tested quarterly.

The proposed Table 3.8.9, "RCA Isolation Damper Actions," states the following:

	Action	Completion Time
1.	If one or more flow path(s) with one isolation damper is inoperable, Close at least one damper in the affected flow path.	72 hours
2.	If one or more flow path(s) with two isolation dampers are inoperable, Close at least one damper in the affected flow path.	12 hours

The proposed Table 3.8.9-a, "RCA Isolation Dampers," states the following:

	Component	Number Provided per Flow Path
a.	RVZ1 RCA exhaust isolation dampers	2
b.	RVZ2 RCA exhaust isolation dampers	2
c.	RVZ2 RCA supply isolation dampers	2

d.	RVZ3 RCA transfer isolation dampers 1. Shipping/receiving IF 2. Shipping/receiving RPF 3. RPF emergency exit 4. IF emergency exit 5. Mezzanine emergency exit	2 (per location)
e.	RVZ2 TPS room supply and exhaust isolation dampers	2 (per location)
f.	RVZ2 main RCA ingress/egress supply isolation dampers	2
g.	RVZ2 main RCA ingress/egress exhaust isolation dampers	2

LCO 3.8.9 specifies that each RCA isolation damper listed in Table 3.8.9-a, "RCA Isolation Dampers," shall be operable when the facility is not secured and provides actions to be taken if they are inoperable. The NRC staff finds that this condition would ensure that the RCA is automatically isolated to prevent the inadvertent release of radioactive material. The staff also finds that if the valves listed in Table 3.8.9-a are inoperable, the flow path is isolated by closing at least one valve. The staff finds that the completion time allows for investigation and the performance of minor repairs and is based on the continued availability of the redundant actuation valve or redundant check valve in the flow path. Therefore, the staff finds the LCO acceptable.

SR 3.8.9 requires that the dampers listed in Table 3.8.9-a shall be closure tested quarterly. Section 4.4.2, "Confinement," of ANSI/ANS 15.1-2007 states that a functional test should be performed quarterly. The NRC staff finds that this SR frequency is in accordance with the guidance in ANSI/ANS 15.1-2007; therefore, the staff finds the SR acceptable.

9a.5 Review Findings

The NRC staff reviewed the descriptions and discussions of the SHINE IF auxiliary systems, as described in SHINE FSAR Section 9a2, as supplemented, against the applicable regulatory requirements and using appropriate regulatory guidance and acceptance criteria.

Based on its review of the information in the FSAR and independent confirmatory review, the NRC staff determined that:

(1) SHINE described the IF auxiliary systems and identified the major features or components incorporated therein for the protection of the health and safety of the public.

(2) The processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other TSs provide reasonable assurance that the applicant will comply with the regulations in 10 CFR Part 50 and 10 CFR Part 20 and that the health and safety of the public will be protected.

(3) The issuance of an operating license for the facility would not be inimical to the common defense and security or to the health and safety of the public.

Based on the above determinations, the NRC staff finds that the descriptions and discussions of SHINE's IF auxiliary systems are sufficient and meet the applicable regulatory requirements and guidance and acceptance criteria for the issuance of an operating license.

9b Radioisotope Production Facility Auxiliary Systems

SER Section 9b, "Radioisotope Production Facility Auxiliary Systems," provides an evaluation of the final design of SHINE's RPF auxiliary systems as presented in SHINE FSAR Section 9b, "Radioisotope Production Facility Auxiliary Systems."

9b.1 Areas of Review

The NRC staff reviewed SHINE FSAR Section 9b against applicable regulatory requirements, using appropriate regulatory guidance and acceptance criteria, to assess the sufficiency of the final design and performance of SHINE's RPF auxiliary systems. As part of this review, the staff evaluated descriptions and discussions of SHINE's auxiliary systems, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations. The final design of SHINE's RPF auxiliary systems' control systems were evaluated to ensure that the design bases and functions of the systems and components are presented in sufficient detail to allow a clear understanding of the facility and that the facility can be operated for its intended purpose and within regulatory limits for ensuring the health and safety of the operating staff and the public. Drawings and diagrams were evaluated to ensure that they present a clear and general understanding of the physical facility features and of the processes involved. In addition, the staff evaluated the sufficiency of SHINE's proposed TSs for the facility.

Areas of review for this section included a summary description of the RPF auxiliary systems' control systems, as well as a detailed description of the RPF confinement and RCA isolation. Within these review areas, the NRC staff assessed, in part, the design bases and functional descriptions of the required mitigative features of the auxiliary systems; drawings, schematic drawings, and tables of important design and operating parameters and specifications for the auxiliary systems; description of control and safety instrumentation, including locations and functions of sensors, readout devices, monitors, and isolation components, as applicable; and the required limitations on the release of confined effluents to the environment.

9b.2 Summary of Application

SHINE FSAR Section 9b includes a description of the auxiliary systems in the RPF, including the design bases, a system description, operational analysis and safety function, instrumentation and control, and relevant TSs. The RPF auxiliary systems include the heating, ventilation, and air conditioning systems, handling and storage of target solution, fire protection systems and programs, communication systems, possession and use of byproduct, source, and special nuclear material, cover gas control in the radioisotope production facility, and other auxiliary systems.

9b.3 Regulatory Requirements and Guidance and Acceptance Criteria

The NRC staff reviewed SHINE FSAR Section 9b against the applicable regulatory requirements, using appropriate regulatory guidance and acceptance criteria, to assess the sufficiency of the bases and the information provided by SHINE for the issuance of an operating license.

9b.3.1 Applicable Regulatory Requirements

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

> 10 CFR 50.34, "Contents of applications; technical information," paragraph (b), "Final safety analysis report."
>
> 10 CFR 50.36, "Technical Specifications."
>
> 10 CFR 50.40, "Common Standards."
>
> 10 CFR 50.57, "Issuance of operating license."
>
> 10 CFR Part 20, "Standards for Protection Against Radiation."

9b.3.2 Applicable Regulatory Guidance and Acceptance Criteria

In determining the regulatory guidance and acceptance criteria to apply, the NRC staff used its technical judgment, as the available guidance and acceptance criteria were typically developed for nuclear reactors. Given the similarities between the SHINE facility and non-power research reactors, the staff determined to use the following regulatory guidance and acceptance criteria:

> NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996.
>
> 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.
>
> "Final Interim Staff Guidance 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.
>
> "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.

As stated in the ISG augmenting NUREG-1537, the NRC staff determined that certain guidance originally developed for heterogeneous non-power research and test reactors is applicable to aqueous homogenous facilities and production facilities. SHINE used this guidance to inform the design of its facility and to prepare its FSAR. The staff's use of reactor-based guidance in its evaluation of the SHINE FSAR is consistent with the ISG augmenting NUREG-1537.

As appropriate, the NRC staff used additional guidance (e.g., NRC regulatory guides, IEEE standards, ANSI/ANS standards, etc.) in the review of the SHINE FSAR. The additional guidance was used 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

FSAR. Additional guidance documents used to evaluate the SHINE FSAR are provided as references in Appendix B, "References," of this SER.

In addition, the following SHINE design criteria, located in SHINE FSAR Chapter 3, "Design of Structures, Systems, and Components," are applicable to various RPF auxiliary systems:

Criterion 29 - Confinement design
Criterion 30 - Confinement design basis
Criterion 31 - Fracture prevention of confinement boundary
Criterion 32 - Provisions for confinement testing and inspection
Criterion 33 - Piping systems penetrating confinement
Criterion 34 - Confinement isolation
Criterion 35 - Control of releases of radioactive materials to the environment
Criterion 36 - Target solution storage and handling and radioactivity control
Criterion 37 - Criticality control
Criterion 38 - Monitoring radioactivity releases
Criterion 39 - Hydrogen mitigation

9b.4 Review Procedures, Technical Evaluation, and Evaluation Findings

The NRC staff performed a review of the technical information presented in SHINE FSAR Section 9b, as supplemented, to assess the sufficiency of the final design and performance of SHINE's auxiliary systems in the RPF for the issuance of an operating license. The sufficiency of the final design and performance of SHINE's RPF auxiliary systems is determined by ensuring that it meets applicable regulatory requirements, guidance, and acceptance criteria, as discussed in Section 9b.3, "Regulatory Requirements and Guidance and Acceptance Criteria," of this SER. The findings of the staff review are described in SER Section 9b.5, "Review Findings."

9b.4.1 Heating, Ventilation, and Air Conditioning Systems

The review and evaluation described in SER Section 9a.4.1, "Heating, Ventilation, and Air Conditioning Systems," is applicable to both the SHINE IF and RPF.

9b.4.2 Handling and Storage of Target Solution

The NRC staff evaluated the sufficiency of SHINE's handling and storage of the target solution, as described in SHINE FSAR Section 9b.2, using the guidance and acceptance criteria from Section 9.2, "Handling and Storage of Reactor Fuel," of NUREG-1537, Part 2.

SHINE FSAR Section 9b2.1, "Target Solution Lifecycle," describes the different RPF systems that contain target solution during and after it is preprepared. These systems include the uranium receipt and storage system, target solution preparation system, target solution staging system (TSSS), molybdenum extraction and purification system (MEPS), radioactive liquid waste storage system (RLWS), radioactive liquid waste immobilization system (RLWI) and iodine and xenon purification and packing (IXP) system.

SHINE FSAR Section 9b.2.5, "Vacuum Transfer System," describes the method of transporting radioactive liquids, including target solution, throughout the RPF. The design bases of the vacuum transfer system (VTS) are to prevent inadvertent criticality in accordance with the criticality safety evaluation and to relieve the VTS to atmospheric pressure upon actuation of

ESFAS to terminate transfers of target solution. The ESFAS is evaluated in Chapter 7 of this SER. The VTS operates by applying a vacuum to a lift tank or directly to a destination tank. The VTS is designed with two separate headers based on the liquid, which contains fissile or non-fissile material, being transferred. The NRC staff finds that the use of two separate headers ensures that fissile material is maintained separate from non-fissile liquids preventing cross contamination.

The VTS is located in the hot cells and in below-grade vaults to minimize radiation exposure to workers. Automatic flow isolation valves and liquid level instruments in the VTS prevent solution from entering the knockout pots. If liquid is detected in the knockout pots, the ESFAS system actuates to break the vacuum in the system and turn off the vacuum pumps. The ESFAS is evaluated in Chapter 7 of this SER. All solution in the knockout pots drains to the favorable geometry tanks in the RLWS. The VTS is classified as seismic Category I. Criticality safety controls are evaluated in Section 6b of this SER. Accident scenarios involving the VTS are evaluated in Chapter 13 of this SER.

By locating the VTS the hot cells and in below-grade vaults, the NRC staff finds there is reasonable assurance that potential personnel doses from radiological materials will not exceed regulatory limits and supports SHINE's ALARA program. By the use of favorable geometry tanks and ESFAS to terminate solution transfers, the NRC staff also finds that the VTS design, as described in SHINE FSAR Section 9b2.5, provides reasonable assurance that the final design will conform to the design basis, and meets all applicable regulatory requirements and acceptance criteria in NUREG-1537.

The NRC staff finds that methods for handling, moving, and storing target solution in the RPF provide reasonable assurance that potential personnel doses will not exceed regulatory limits in 10 CFR Part 20 and support SHINE's ALARA program.

9b.4.3 Fire Protection Systems and Programs

The review and evaluation described in SER Section 9a.4.3, "Fire Protection Systems and Programs," is applicable to both the SHINE IF and RPF.

9b.4.4 Communication Systems

The review and evaluation described in SER Section 9a.4.4, "Communication Systems," is applicable to both the SHINE IF and RPF.

9b.4.5 Possession and Use of Byproduct, Source, and Special Nuclear Material

The NRC staff evaluated the sufficiency of SHINE's program for possession and use of byproduct, source, and special nuclear material in the RPF, as described in SHINE FSAR Section 9b.5, using the guidance and acceptance criteria from Section 9.5, "Possession and Use of Byproduct, Source, and Special Nuclear Material," of NUREG-1537, Part 2.

As discussed in SHINE FSAR Section 9b.5, the RPF is designated as an RCA and SHINE Radiation Protection Program controls and procedures, including the ALARA Program, apply to the RPF. SHINE FSAR Section 9b.5.1, "Byproduct Material," describes the various RPF systems that may contain byproduct material. Shine identifies that a batch of Mo-99 can be up to 5000 curies and up to 8 batches of Mo-99 may be produced in a week. The maximum amount of Iodine-131 (I-131) and Xenon-133 (Xe-133) shipped in a week is 2000 curies per

isotope. Source material is not normally processed in the RPF, however, SHINE describes in Section 9b.5.2, “Source Material,” that there is a potential for source material to be processed as waste within the RPF in the form of IF components, such as the tritium beds or neutron multipliers that contain source material. The NRC staff evaluated SHINE’s waste management in Section 11.4.2, “Radioactive Waste Management,” of this SER. As described in SHINE FSAR Section 9b.5.3, “Special Nuclear Material,” the RPF includes LEU in the form of target solution (i.e., uranyl sulfate solution). The SHINE FSAR describes the systems within the RPF that may contain SNM. SHINE FSAR Section 9b.5.3, states that the total inventory of LEU in the RPF used to support facility operations is up to 6600 pounds (lbs) of LEU. SHINE FSAR Section 9b5.4, “Quality Control and Analytical Testing Laboratories,” describes the use of two labs to provide analytical laboratory support for the production of Mo-99, I-131, and Xe-133. The wet lab is used for sample preparations and the instrument lab is used for detailed sample analysis. SHINE FSAR Section 9b.5.4.3, “Operational Analysis and Safety Functions,” states that the labs perform no safety functions.

Based on the information above, the NRC staff finds that SHINE would have radiation protection controls and procedures and an ALARA program to ensure that potential radiation exposures to workers are within the limits of 10 CFR Part 20. The staff finds that the authorized spaces for the use of material have been described. Further, the staff finds that the use of controls and procedures provides reasonable assurance that an uncontrolled release of radioactive material to the unrestricted environment will not occur.

9b.4.6 Cover Gas Control in the Radioisotope Production Facility

The NRC staff evaluated the sufficiency of SHINE’s description of the radiolytic gas management systems located in the RPF, as presented in SHINE FSAR Section 9a2.6, “Cover Gas Control in Closed Primary Coolant Systems,” using the guidance and acceptance criteria from Section 9.6, “Cover Gas Control in Closed Primary Coolant Systems,” of NUREG-1537, Part 2.

9b4.6.1 Process Vessel Vent System

SHINE FSAR Section 9b.6.1.1 provides the design basis of the PVVS as:

- Mitigate radiolytic hydrogen generation in the headspace of RPF tanks and vessels;
- Capture radioiodine from the off-gas stream;
- Delay the release of radioactive noble gases in gaseous effluents to the environment;
- Filter radioactive particulates from the gaseous effluents;
- Maintain RPF tanks and vessels at a negative pressure;
- Accept VTS vacuum pump discharge;
- Accept TOGS pressure relief discharge;
- Accept purges of TOGS, resulting from either a loss of TOGS capability to mitigate radiolytic hydrogen generation or maintenance requirements;
- Accept any sweep gases from TOGS used to purge gas analyzer instrumentation;
- Condition collected off-gas to improve reliability and performance of filtration equipment; and
- Discharge off-gases to the facility stack.

The PVVS provides radiolytic hydrogen mitigation capability for the RPF by ventilating the process tanks and vessels and accepting flow gases discharged from VTS and TOGS. Flows

from VTS and TOGS include vacuum pump discharge, sweep gas from gas analyzer instruments, nitrogen purges, and pressure relief. PVVS blowers upstream of the facility stack induce flow through the ventilation system. Flow rate requirements for PVVS are constant for nominal ventilation in the RPF but increase when tanks are sparged for mixing, when VTS is operating, or during TOGS transients such as a purge during fill or maintenance, or pressure relief. PVVS equipment is designed for the maximum off-gas flow rate that could require processing at any one time.

SHINE FSAR Table 9b.6.2 identifies the principal components of the PVVS. SHINE FSAR figure 9b.6.1 provides a flow diagram for the PVVS.

The off-gases are processed to remove or delay iodine, noble gases, and radioactive particulates prior to the gas being discharged to the facility stack. The PVVS blower placement ensures the system is maintained at a negative pressure relative to ventilation zone 2. Intakes within ventilation zone 2 are the nominal air source for PVVS. Air flows from the intake, across the tank headspace, to the PVVS headers and the combined quantity is passed thorough conditioning and filtration equipment. Gases pass through condensers, cooled with chilled water from the RPCS to remove excess heat and reduce absolute humidity of the off-gas.

Condensate can either be collected in the PVVS condensate tank within the PVVS hot cell, located within the supercell, or can be returned to the target solution staging system (TSSS) tanks as makeup water or to the RLWS system for waste processing. An in-line heater, the PVVS reheater, downstream of the condenser heats the off-gas back to ambient temperature to reduce the relative humidity. Gases discharged by TOGS from the primary system boundary, which contain noble gases and iodine, are also processed by the PVVS. The off-gas may also contain radioactive particulates such as cesium. HEPA filters are used to remove entrained particulates from the air flow. Carbon filters are used to capture iodine and carbon beds are employed to delay the release of xenon and krypton isotopes. The design ensures that 10 CFR Part 20 limits are met. The off-gas then flows through acid adsorber beds, HEPA filters, and the guard beds to neutralize entrained acid droplets or gases, filter particulates, and capture iodine. The gas flows from the hot cell to a below-grade, shielded vault, passing through a series of delay beds packed with carbon to delay the release of fission product noble gases. The eight delay beds are organized into three groups as shown in Figure 9b.6-1. Group 1 includes Delay Beds 1 and 2. Group 2 includes Delay Beds 3, 4, and 5. Group 3 includes Delay Beds 6, 7, and 8.

The ESFAS automatically isolates affected delay bed groups when carbon monoxide concentrations in the effluent gas exceed 50 ppm. The arrangement facilitates bypassing any combination of beds to facilitate maintenance. A final set of HEPA filters removes any entrained carbon fines upstream of the blowers, and the treated gases are discharged to the facility stack.

PVVS processes are performed within the production facility biological shield (PFBS) hot cells and below-grade vaults, thus complying with the ALARA objectives and 10 CFR Part 20 dose limits.

Instrumentation and Control

Safety-related PVVS instrumentation has redundant channels and provides output to ESFAS. Nonsafety-related PVVS instrumentation provides output signals to PICS.

Temperature instrumentation is used to monitor the performance of the condensers, heaters, and acid adsorbers as well as the guard beds and delay beds.

Carbon monoxide gas analyzers are used to monitor the operation of the delay beds and to monitor carbon monoxide concentrations in the bed effluent.

Flow instrumentation is used to monitor the flow rate of air from ventilation zone 2 into the RPF tanks and vessels ventilated by PVVS. The PICS alerts operators on low flow. Flow instrumentation is used to monitor the flow rate of air from the RPF tanks and vessels to the condensers. The system is designed to maintain this flow rate above the minimum required to maintain hydrogen levels below the LFL.

The NRC staff evaluated SHINE's instrumentation and control system, including ESFAS and PICS, in Chapter 7 of this SER.

Design Criteria

As stated in SHINE FSAR Section 3.1, the nuclear safety classification of safety-related SSCs at SHINE are those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public; and to control or mitigate the consequences of such accidents. SHINE FSAR Table 3.1-1 identifies the SSCs at SHINE that are classified as safety-related. The list includes PVVS. SHINE FSAR Table 3.1-3 provides the generically applicable design criteria to the SHINE facility. However, the NRC staff focused on the design criteria directly applicable to the PVVS, namely criterion 35 and 39. The applicable criteria to this section of the SER are described in section 9b.3.2 of this SER.

For criterion 35, the NRC staff finds that the PVVS includes means to suitably control the release of radioactive materials due to the condensers and filtration equipment (carbon adsorbers, HEPA filters, and delay beds) included in the design of the systems. The NRC staff also finds that the delay beds provide holdup capacity of the system affluents.

For criterion 39, the NRC staff finds that PVVS is designed to control the buildup of hydrogen that is released into the primary system boundary and tanks. PVVS is also capable of controlling buildup of hydrogen during normal operating conditions.

Based on the above, the NRC staff finds that the licensee has provided final analysis and evaluation of the design and performance of structures, systems, and components as it relates to cover gas control in process vessel vent system and satisfies 50.34(b)(4).

Conclusion

Based on its review, the NRC staff finds that the level of detail provided on the PVVS demonstrates an adequate description of its design and concludes that SHINE's operating license application sufficiently defines systems operation in accordance with 10 CFR 50.34(b)(2).

The NRC staff evaluated the descriptions and discussions of SHINE's PVVS, including proposed TS, as described in SHINE FSAR Section 9b.6.1, "Process Vessel Vent System," and finds that the final design of the PVVS, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9b.4.6.2 Nitrogen Purge System

SHINE FSAR Section 9b.6.2.1, “Design Bases,” states the design basis of the N2PS as:

- Ensure safe shutdown by preventing detonations or deflagrations from potential hydrogen accumulation in the IUs and RPF processes during deviations from normal conditions; and
- Remain functional during and following design basis events.

The N2PS provides a backup supply of sweep gas to each IU and to all tanks normally ventilated by the PVVS during a loss of normal power or loss of normal sweep gas flow. Upon PVVS flow dropping below a preset minimum amount, the ESFAS automatically initiates RPF nitrogen purge to mitigate hydrogen generation in RPF tanks. The RPF header valves from N2PS actuate open and PVVS header valves actuate closed. In addition, the PVVS isolation valve at the RLWI interface actuates closed to prevent nitrogen backflow. The off-gas resulting from the nitrogen purge is treated by passive PVVS filtration equipment (e.g. delay beds) prior to being discharged to the stack, as discussed in FSAR Subsection 9b.6.1.2, “System Description.” Active PVVS components such as the condensers, RPCS supply to the condensers, and heaters are bypassed. The nitrogen supply pressure is regulated to overcome the pressure drop through pipe fittings, PVVS filtration components, and the facility stack. Thus, the N2PS is safety-related and Seismic Category I.

N2PS system interfaces are described in SHINE FSAR Table 9b.6-3. The N2PS process flow diagram is provided in SHINE FSAR Figure 9b.6-2.

Nitrogen supply is from pressurized nitrogen stored gas. As described above, during the nitrogen purge, the PVVS equipment and piping continues to provide the flow path for the off-gas through the RPF, except that safety-related bypasses are provided around filtration equipment in the hot cell that could contribute to a blocked pathway and an alternate, safety-related exhaust point to the roof is opened. The branch to the alternate release point is upstream of the PVVS blowers.

N2PS provides back-up sweep gas flow. Downstream pressure is controlled with self-regulating pressure reducing valves with overpressure protection from pressure relief valves. On actuation of the N2PS, nitrogen flows through the IF and RPF equipment to ensure the hydrogen concentration is below the lower flammability limit (LFL). The nitrogen purge flows through the normal PVVS path and the delay beds. After exiting the delay beds in PVVS, the nitrogen purge is diverted to a safety-related alternate vent path in case of a downstream blockage. Valves configured to fail open allow the diversion to the alternate vent path. After actuation of the N2PS, the pressurized storage tubes can be refilled by truck deliveries.

<u>Purge of and IU or RPF equipment</u>

Upon loss of normal power as determined by ESFAS and after a delay or upon loss of normal sweep gas flow in the IU as determined by TRPS, solenoid valves on the nitrogen discharge manifold actuate open, releasing nitrogen into the IU cell supply header. Upon loss of sweep gas flow in any IU cell, nitrogen solenoid isolation valves for the given cell actuate open releasing nitrogen purge gas into the TSV dump tank, and valves in the TOGS actuate open to allow the nitrogen purge gas to flow to the PVVS. The nitrogen purge gas flows through the

TSV dump tank, TSV, and TOGS equipment before discharging into PVVS. A flow switch provides indication that nitrogen is flowing to the IU cell.

Upon loss of normal power or loss of normal sweep gas flow through PVVS, as determined by the ESFAS, solenoid valves on the ventilation zone 2 air supply to PVVS fail close and isolate the sweep gas air flow to the RPF tanks. At the same time, solenoid valves on the nitrogen discharge manifold actuate open, releasing nitrogen into the RPF distribution piping. The nitrogen flows through the RPF equipment in parallel before discharging into PVVS. A flow switch provides indication that nitrogen is flowing to the RPF distribution piping.

Processes that receive ventilation air from the PVVS during normal conditions are also ventilated by N2PS during deviations from normal operation. In the RPF, the N2PS ventilates tanks in the TSSS, RLWS system, radioactive drain system (RDS), MEPS, IXP system, and VTS.

Tanks containing irradiated target solution in the RPF are supplied with a self-regulating pressure reducing valve with overpressure protection provided by a pressure relief valve. TSV dump tanks are supplied with a self-regulating pressure reducing valve. N2PS piping, valves, and in-line components are designed to ASME B31.3, “Process Piping.”

The high-pressure nitrogen gas storage is contained in integrally forged pressure vessels (i.e., high-pressure nitrogen gas tubes) designed to meet the requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels. The high-pressure nitrogen gas tubes and associated piping, manual isolation valves, high point vents, low point drains, self-regulating pressure reducing valves, relief valves, check valves, and pressure instrumentation for the supply system are housed in the N2PS structure, an above-grade reinforced concrete structure adjacent to the main production facility. The N2PS structure and equipment are designed to remain functional during and following a seismic event. In addition, the N2PS structure is designed to withstand the impact of tornado missiles.

The tubes are manifolded so they will act in unison and have a common remote fill connection to allow refill by tanker truck delivery. One redundant high-pressure nitrogen gas tube provides service in the event of the loss of a tube or failure of the associated valves upstream of the common manifold. Each high-pressure nitrogen gas tube and the downstream piping and equipment is protected from overpressure by relief valves discharging to atmosphere above the roof of the structure, through a nonsafety-related vent path.

The N2PS is sized to provide three days of sweep gas flow to tanks containing irradiated target solution in the RPF during a loss of normal power or a loss of sweep gas flow. The N2PS also provides three days of sweep gas flow to each TSV dump tank.

<u>Instrumentation and Control</u>

The N2PS includes pressure instrumentation to monitor the function of the self-regulating pressure reducing valves. The nitrogen tube pressure, tube discharge pressures, pressure to the IU cells, and pressure to the RPF tanks are monitored. The pressure instrument output is provided to PICS.

The N2PS includes flow switches to provide indication of normal operation when the purge is actuated. The flow switch status is provided to PICS.

N2PS solenoid valves include valve position indication. The position status for each valve is provided to TRPS if it serves the IU cells or to ESFAS if it serves the RPF tanks.

Oxygen sensors are provided in locations near N2PS equipment. The oxygen instruments alert operators locally of an asphyxiation hazard in the event of a nitrogen leak.

TRPS actuates the N2PS purge of the affected IU on loss of normal power to an IU cell after a delay or on loss of flow in TOGS. A detailed discussion of the IU cell nitrogen purge is provided in SHINE FSAR Section 7.4, “Target Solution Vessel Reactivity Protection System.”

ESFAS actuates the N2PS purge of the RPF tanks on loss of normal power to the PVVS or on loss of flow in PVVS. A detailed discussion of the RPF Nitrogen Purge is provided in SHINE FSAR Section 7.5, “Engineered Safety Features Actuation system.”

The NRC staff evaluated SHINE’s instrumentation and control system, including TRPS, ESFAS and PICS, in Chapter 7 of this SER.

Design Criteria

As stated in SHINE FSAR Section 3.1, the nuclear safety classification of safety-related SSCs at SHINE are those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public; and to control or mitigate the consequences of such accidents. SHINE FSAR Table 3.1-1 identifies the SSCs at SHINE that are classified as safety-related. The list includes N2PS. SHINE FSAR Table 3.1-3 provides the generically applicable design criteria to the SHINE facility. However, the NRC staff focused on the design criteria directly applicable to N2PS, namely criterion 39. The applicable criteria to this section of the SER are described in section 9b.3.2 of this SER.

For criterion 39, the NRC staff finds that N2PS systems are designed to control the buildup of hydrogen that is released into the primary system boundary and tanks. The NRC staff also finds that N2PS is designed to controlling buildup of hydrogen when PVVS is not available.

Based on the foregoing, the NRC staff concludes that the licensee has provided final analysis and evaluation of the design and performance of structures, systems, and components as it relates to cover gas control in process vessel vent system and satisfied 50.34(b)(4).

Conclusion

Based on its review, the NRC staff finds that the level of detail provided on the N2PS demonstrates an adequate description of its design and concludes that SHINE’s operating license application sufficiently defines systems operation in accordance with 10 CFR 50.34(b)(2).

The NRC staff evaluated the descriptions and discussions of SHINE’s N2PS, including proposed TS, as described in SHINE FSAR Section 9b.6.2, “Nitrogen Purge System,” and finds that the final design of the N2PS, including the principal design criteria, design bases, and information relative to the subject systems, meets all applicable regulatory requirements and acceptance criteria.

9b.4.7 Other Auxiliary Systems

The NRC staff evaluated the sufficiency of SHINE's other auxiliary systems in the RPF, as described in SHINE FSAR Section 9b.7, "Other Auxiliary Systems," by reviewing the following systems, using the guidance and acceptance criteria from Section 9.7, "Other Auxiliary Systems," of NUREG-1537, Part 2.

9b.4.7.1 Molybdenum Isotope Product Packaging System

SHINE FSAR Section 9a.7.1.2, "System Description," states, in part, the molybdenum isotope product packaging system (MIPS) prepares the Mo-99, iodine, or xenon product bottles for shipment. The FSAR further describes the MIPS as providing a quarantine area for products undergoing quality control testing prior to shipment. The equipment with the MIPS includes product bottles, secondary containers, shipping casks, leak test equipment and label printers. The Mo-99 product volume depends on the specific customer. MIPS is a non-safety related system and is located in a shielded hot cell within the supercell. SHINE FSAR Section 9b.7.1.3, "Operational Analysis and Safety Function," states that shielding on the packaging hot cells limits the radiation exposure of individuals to within the regulatory limits described in 10 CFR Part 20. The shielding of the packaging hot cell is evaluated in SHINE FSAR Section 4b.4.2, "Radioisotope Production Facility Biological Shielding," and the radiation protection program is evaluated in Chapter 11 of this SER. Based on the information above, the NRC staff finds that the design of the MIPS will help reduce occupational doses by shielding workers from radiation produced by byproduct material. Further, the NRC staff finds that the implementation of a radiation protection program will provide reasonable assurance that radiation dose from MIPS to workers is minimized.

9b.4.7.2 Material Handling System

The material handling system (MHS) is defined in SHINE FSAR Section 9b.7.2 and includes overhead cranes and hoists that are used to move or manipulate radioactive material within the RCA. The MHS design is evaluated for loads associated with two overhead bridge cranes, one servicing the IF area and one servicing the RPF area.

The IF overhead crane (40-ton capacity) removes IU cell plugs, TOGS cell plugs, primary cooling room plugs, and neutron driver transport to and from IU cells and the NDAS service cell. The IF overhead crane is used for lifting, repositioning, and landing operations associated with major components of the subcritical assembly system (SCAS), PCLS, TOGS, and TPS as well as various planned maintenance activities throughout the IF.

The applicant described that the IF overhead crane would be designed and constructed such that it would remain in place and support the critical load during and after an aircraft impact, but it would not necessarily be operational after this event. The applicant also stated that single failure-proof features would be included in the IF crane such that any credible failure of a single component would not result in the loss of capability to stop and hold the critical load.

The RPF overhead crane (15-ton capacity) is utilized for lifts including the removal of tank vault, valve pit, and pipe trench plugs, removal of carbon delay bed vault plugs, supercell slave manipulator replacements, and the removal of column waste drums and post cooldown shielding and packaging. The RPF overhead crane is also used for various planned maintenance activities. In addition, the crane performs lifting of empty tanks in the RPF, immobilized waste drums and the associated shielding and packaging hardware, and other major components within the RPF.

The applicant stated that the RPF overhead crane would employ the use of mechanical stops, electrical-interlocks, and predetermined safe load paths to minimize the movement of loads in proximity to redundant or dual safe shutdown equipment. The applicant also stated that the RPF overhead crane would be designed and constructed following the seismic requirements for an ASME NOG-1, "Rules for Construction of Overhead and Gantry Cranes," Type II crane so that it will remain in place with or without a load during a design basis earthquake, but it would not necessarily be operational after this event.

The IF and RPF overhead cranes are non-safety-related. As defined in SHINE FSAR Table 3.4-1, the MHS cranes are designed to Seismic Category II. SHINE FSAR Section 3.4.3.1 defines Seismic Category II SSCs as SSCs co-located with a Seismic Category I SSC and must maintain structural integrity in the event of a safe shutdown earthquake to prevent unacceptable interactions with a Seismic Category I SSC but are not required to remain functional. SHINE FSAR Section 9b.7.2 indicates the Seismic II cranes are designed to remain in place on the runway girder, with or without a load, during and after a seismic event. With respect to the SHINE facility, a heavy load is defined as a load that, if dropped, may cause radiological consequences that challenge 10 CFR Part 20 limits.

Material Handling System Operations

To reduce the probability and mitigate the consequences of an accidental load drop, the licensee describes a heavy load handling program consistent with the NRC general programmatic guidelines for design, operation, testing, maintenance, and inspection of heavy load material handling systems. With respect to the MHS, the applicant defined a heavy load as a load that, if dropped, may cause radiological consequences that challenge 10 CFR Part 20 limits. The applicant stated that guidance from Section 5.1.1 of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Activity A-36," would be applied to heavy load handling as follows:

(1) Safe load paths will be defined for the movement of heavy loads; deviations from the defined load paths will require written procedures approved by site safety personnel.
(2) Procedures will be developed to cover load handling operations for heavy loads. Procedures will include the identification of required equipment, inspections, and acceptance criteria required before movement of loads; the steps and proper sequence to be followed in handling the load; the defined safe load path and other special precautions.
(3) Crane operators will be trained, qualified, and conduct themselves in accordance with Chapter 2-3 of ASME B30.2.
(4) Special lifting devices used in the vicinity of safety-related SSCs will satisfy the guidelines of ANSI N14.6.
(5) Lifting devices that are not specially designed will be installed and used in accordance with the guidelines of ASME B30.9.
(6) Tests and inspections will be performed prior to use where it is not practical to meet the frequencies of ASME B30.2 for periodic inspection and testing, or where frequency of crane use is less than the specified inspection and test frequency.
(7) The crane will be designed to meet applicable criteria and guidelines of ASME B30.2 and CMAA 70.

SHINE FSAR Section 9b.7.2.3, "Operational Analysis and Safety Function," provides a discussion on operational analysis and safety function. This section specifies the IF and RPF overhead cranes are inspected, tested, and maintained in accordance with ASME B30.2,

"Overhead and Gantry Cranes." The inspection requirements reduce the probability of a load drop that could result in a release of radioactive materials or damage to essential safe shutdown equipment that could cause unacceptable radiation exposures. Inspection and testing of special lifting devices are performed in accordance with N14.6, "Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More." Inspection and testing of lifting devices not specially designed are in accordance with ASME B30.9, "Slings."

IF Overhead Crane:

SHINE FSAR Section 9b.7.2.1, "Design Bases," states that the IF overhead crane is designed to the following criteria:

- Meet seismic requirements and prevent failures of the crane that could damage safety-related equipment such that the equipment would be prevented from performing its safety function. SHINE FSAR Table 3.4-1 defines MHS as Seismic Category II.
- Meet the single failure proof design criteria and construction of ASME NOG-1, Type I cranes and be designed to perform as a Service Level B – Light Service crane as described in CMAA 70.
- Secure its load in place upon a loss of power and any fault condition. The hoisting machinery and wire rope reeving system, in addition to other affected components, is designed to withstand the most severe potential overload, including two-blocking, and load hang-up.
- Remain in place on the runway girder, with or without a load, during and after a seismic event.

RPF Overhead Crane:

SHINE FSAR Section 9b.7.2.1, states that the RPF overhead crane is designed to the following criteria:

- Meet seismic requirements and prevent failures of the crane that could damage safety-related equipment such that the equipment would be prevented from preforming its safety function.
- Meet the design criteria and construction of ASME NOG-1, Type II cranes, and be designed to perform as a Service Level B – Light Service crane as described in CMAA 70.
- Remain in place with or without a load during and after a seismic event.

Conclusion

The NRC staff evaluated the descriptions and discussions of SHINE's MHS, as described in SHINE FSAR Section 9b.7.2, and finds that the final design of SHINE's MHS, including the design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria. Specifically, the descriptions of the MHS satisfy the requirements of 10 CFR 50.34(b) related to descriptions of radioactive material handling system design, maintenance, operations, and testing. There are design basis accidents related to the MHS; the NRC staff evaluated SHINE's design basis accidents in Chapter 13 of this SER.

9b.4.7.3 Radioactive Liquid Waste Immobilization System

SHINE FSAR Section 9b.7.3 states that the RLWI system solidifies blended liquid waste to a form suitable for shipping and disposal. The RLWI system removes selected isotopes, as needed, from the blended liquid waste and then immobilizes the wastes for ultimate disposal. The headspace cover gas in the immobilization feed tank is swept by the PVVS. Liquid wastes in the RLWS system may contain SNM. Solutions are transferred to the RLWI system by the VTS from the RLWS system. Liquids are solidified in drums pre-filled with immobilization agents.

SHINE FSAR Section 4b.1.3.8 provides a general process description. Wastes may be recirculated in the RLWI system through a set of adsorption columns to remove isotopes that impact dose. Solution in the RLWI system is pumped into a waste drum pre-filled with solidification agents, and the drum is mixed and allowed to cure. The solidified waste drum is transported from the RPF to the material staging building. The SNM within the RLWI system is from process wastes where target solution was present and from spent target solution. The maximum inventory of SNM in the system is 10 kg within the RLWI process vessels and piping. SHINE FSAR Figure 9b.7-1 provides a flow diagram of the RLWI system.

The RLWI system is safety-related and seismic category I. As defined in SHINE FSAR Section 3.1, safety-related SSCs at SHINE are those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public; and to control or mitigate the consequences of such accidents. The safety function of the RLWI system is to prevent inadvertent criticality through design of equipment in accordance with the criticality safety controls. A description of provisions for criticality control in the RLWI system is provided in SHINE FSAR Section 6b.3.2.9. NRC staff evaluated SHINE's nuclear criticality safety in Chapter 6 of this SER.

The flow through the RLWI system consists of the receipt of liquid waste from the RLWS Liquid Waste Blending Tank to solidified waste loaded in waste solidification drums. Waste with a uranium concentration capable of meeting the waste acceptance and storage requirements enters the system from the RLWS Liquid Waste Blending Tanks to the immobilization feed tank. Upon receipt of liquid waste from RLWS, the RLWI system and process is performed within a shielded enclosure located in the RPF. When the waste is ready to be immobilized, it is pumped from the immobilization feed tank by the liquid waste drum fill pump and into a radioactive liquid waste drum pre-loaded with solidification agents. The empty waste drums are prefilled with measured amounts of dry, powdered solidification agent in accordance with the process control program (PCP). The prefilled drum is then transferred outside the RLWI system to a separate enclosure for contamination control.

The RLWI system is also capable of removing selected isotopes, as needed, from the blended liquid waste and immobilizing the wastes for ultimate disposal. Selective isotope removal and mixing are performed within the shielded enclosure. The RLWI shieled enclosure is ventilated by RVZ1e. The RVZ1e equipment processes air from the enclosure through a HEPA and carbon filter before discharging to the facility stack. Transfer of the prefilled waste drum inside the enclosure is by remote handling equipment and positioners. For combustion control, the immobilization feed tank cover gas and waste drum vent both discharge via a common header to the PVVS vent header.

Remote sampling for waste characterization is performed in the RLWS prior to solidification activities within the RLWI. Radiation measurements are performed on the solidified waste drum prior to shipment in the material staging building to verify it meets shipping dose rate

requirements. The RLWS system transfers blended liquid waste to the RLWI system, as described in SHINE FSAR Section 9b.7.4, "Radioactive Liquid Waste Storage System." The RLWI system immobilization feed tank level instrumentation provides for metering of liquid waste transfers from the RLWS system blended liquid waste tanks.

The RLWI system is contained within a shielded enclosure within the RPF. The RLWI shielded enclosure provides dose reduction and supports compliance with the ALARA objectives and dose limit required by 10 CFR Part 20.   The liquid process wastes enter the RLWI shielded enclosure through the process piping trench, they are solidified in the cell, and the solidified waste drums exit through the RLWI drum access door. New drums enter the RLWI shielded enclosure through the same drum access door, and personnel can enter and leave the shielding via the personnel access door. Contaminated process equipment is removed via the drum access door or shield plugs. Selective isotope removal and waste drum filling and mixing are also performed within the shielded enclosure. Piping that contains radioactive and potentially radioactive materials is routed through shielded pipe chases to limit the exposure of individuals to radiation.

Design Criteria

SHINE FSAR Table 3.1-1, "Safety- Related Structures, Systems, and Components", identifies the SSCs at SHINE that are classified as safety-related. The list includes the RLWS. SHINE FSAR Table 3.1-3, "SHINE Design Criteria," provides the generically applicable design criteria to the SHINE facility. The NRC staff focused on the design criteria applicable to RLWS, namely criterion 35, 36, and 37. The criteria are described in section 9b.3.2 of this SER.

For criterion 35, the NRC staff finds that the RLWI is equipped to control the release of radioactive materials in liquid effluents and to handle radioactive solid wastes produced during normal operation, including anticipated transients.

For criterion 36, the NRC staff finds that the facility handling of the liquid waste, solid waste and other systems that contain radioactivity are designed with adequate safety under normal and postulated accident conditions. The staff also finds that the RLWI system is contained within suitable shielding with adequate controls for safe handling of radioactive waste.

For criterion 37, the NRC staff finds that the facility description of provisions for criticality control in the RLWI system is provided in Section 6b.3.2.9 of the FSAR and NRC staff evaluated SHINE's nuclear criticality safety in Chapter 6, "Engineered Safety Features," of this SER.

Conclusion

The NRC staff evaluated the descriptions and discussions of SHINE's RLWI system, as described in SHINE FSAR Section 9b.7.3, and finds that the final design of SHINE's RLWI system, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria. There are design basis accidents related to the RLWI; the NRC staff evaluated SHINE's design basis accidents in Chapter 13 of this SER.

9b.4.7.4 Radioactive Liquid Waste Storage System

SHINE FSAR Section 9b.7.4 states that the RLWS system collects, stores, blends, conditions, and stages liquid wastes upstream of the RLWI system for solidification. The RLWS is a set of

below grade tanks used to provide storage for radioactive liquid wastes prior to immobilization. Liquid wastes from processes that may contain greater than trace amounts of uranium, including spent target solution, are placed in favorable geometry tanks until the solutions are verified to have a uranium concentration below the single-parameter administrative limit as described in SHINE FSAR Section 6b.3. Liquid wastes from other processes are collected separately. Liquid wastes are blended prior to immobilization.

Liquid waste collected, blended, and stored by the RLWS system includes:

- Uranium liquid waste, with uranium concentrations potentially exceeding 25 grams of uranium per liter (gU/l). This waste is located in the uranium liquid waste tanks.
- Blended liquid waste, with low uranium concentrations (< 25 gU/l). Blended waste may originate from uranium liquid waste, radioactive liquid waste, or any combination of the two.
- Radioactive liquid waste, with negligible uranium concentration with respect to criticality safety (< 1 gU/l). This waste is stored in the liquid waste collection tanks.

The RLWS system is safety-related and seismic category I. As defined in SHINE FSAR Section 3.1, safety-related SSCs at SHINE are those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public; and to control or mitigate the consequences of such accidents. The safety function of the RLWS system is to prevent inadvertent criticality through design of equipment in accordance with the criticality safety evaluation. A description of provisions for criticality control in the RLWS system is provided in SHINE FSAR Section 6b.3.2.2

Following isotope extraction, the target solution is directed to one of the target solution hold tanks, the target solution storage tanks, or the RLWS system. The RLWS contains a first and second uranium liquid waste tanks, four radioactive liquid waste tanks, and eight liquid waste blending tanks. The uranium liquid waste tanks are of geometrically favorable design and contained in individual below grade vaults. The first and second uranium liquid waste tanks are connected in series to preclude inadvertent direct transfers to the non-favorable-geometry liquid waste blending tanks. The liquid waste blending tanks are large volume, non-favorable-geometry tanks which store low concentration wastes. These blending tanks receive low concentration wastes from the second uranium liquid waste tank and negligible concentration waste from the upstream radioactive liquid waste tank. The radioactive liquid waste tanks are large volume, non-favorable-geometry tanks which receive and store negligible concentration wastes from the PVVS, MEPS, and IXP.

The normal RLWS process for receiving high concentration wastes proceeds as follows. First, the high concentration wastes are moved from an upstream system into the first uranium liquid waste tank. When the waste is desired to be transferred to the waste immobilization system, it is first down-blended if needed with PVVS condensate or water to less than 25 gU/L. The first uranium liquid tank is sampled prior to the authorization of any transfers to verify less than 25 gU/L is met. Then, the waste is transferred to the second uranium liquid waste tank and re-sampled. If the sampling conditions are met, the low concentration waste is then transferred by vacuum to the liquid waste blending tank. Blended waste may originate from uranium liquid waste, radioactive liquid waste, or any combination of the two. The liquid waste blending tank may be further down-blended with negligible concentration wastes from the radioactive liquid waste tanks to meet downstream waste disposal specifications in the RLWI system. Liquid waste is transferred between RLWS tanks by use of the VTS.

Valve position indicators and temperature and level instrumentation provide remote indication of operating state of the RLWS tank is provided to PICS.

The RLWS system tanks, valves, and piping are located in shielded tank vaults, valve pits, and pipe trenches within the RPF. The waste tanks of the RLWS are located below ground. The below grade portions of the PFBS are the process tank vaults, pipe trench, valve pits, drum storage bore holes, and carbon delay bed vault. Each of the below grade PFBS volumes can be accessed through concrete shield plugs which are either grouted or sealed by other means.

Design Criteria

SHINE FSAR Table 3.1-1 identifies the SSCs at SHINE that are classified as safety-related. The list includes the RLWS. SHINE FSAR Table 3.1-3 provides the generically applicable design criteria to the SHINE facility. The NRC staff focused on the design criteria applicable to RLWS.

For Criteria 29–34, the NRC staff finds the confinement is adequately addressed, as the RLWS system and tanks are located entirely within the RPF confinement. The RLWS does not contain any piping or tanks that penetrate the RPF confinement boundary.

For criterion 35, the NRC staff finds that the RLWS is equipped to control the release of radioactive materials and to handle radioactive liquid wastes produced during normal operation, including anticipated transients.

For criterion 36, the NRC staff finds that the RLWS has provided adequate shielding, sampling, and other protective measures to allow safe handling of liquid waste.

For criterion 37, the NRC staff finds that the facility description of provisions for criticality control in the RLWI system is provided in Section 6b.3.2.2 of the FSAR and NRC staff evaluated SHINE's nuclear criticality safety in Chapter 6, Engineered Safety Features," of this SER.

For Criteria 39, the NRC staff finds that the design has provisions to control the buildup of hydrogen that is released into the primary system boundary and tanks or other volumes as the headspace in each RLWS tank is swept with air by the PVVS or by the N2PS to remove the potential accumulation of radiolytically generated hydrogen gas.

Conclusion

The NRC staff evaluated the descriptions and discussions of SHINE's RLWS system, as described in SHINE FSAR Section 9b.7.4, and finds that the final design of SHINE's RLWS system, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9b.4.7.5 Solid Radioactive Waste Packaging System

SHINE FSAR Section 9b7.5 states that the design bases function of the solid radioactive waste packaging (SRWP) system is to collect, segregate, and stage for shipment solid radioactive wastes. The solid waste may include dry active waste, spent ion exchange resin, and filters and filtration media. The SRWP system also inventories materials entering and exiting the facility structure storage bore holes. The SRWP is a nonsafety-related system.

The solid radioactive waste is collected in segregated containers and the containers may be sorted for non-contaminated waste. Contaminated waste is sealed, labeled, and transported to the material staging building. Solid wastes potentially having high levels of radioactivity are collected and transported to the material staging building in shielded casks. Used NDAS units are disassembled to transport to the material staging building or for storage in storage bore holes. Used separation columns are stored on storage racks for a minimum of 14 days following their use, and the columns are then transferred to column waste drums. The column waste drums are exported and transferred to the drum storage bore holes. The column waste drums are removed following extended decay. There are no technical specifications or instrumentation and controls identified for the SRWP system.

The NRC staff finds that waste is handled and shipped in accordance with SHINE's radioactive waste management program. The staff also finds that SRWP system operations are performed in accordance with the requirements of the radiation protection program. The staff finds that the implemented programs provide reasonable assurance that the SRWP should not cause uncontrolled release of radioactivity. The NRC staff evaluated SHINE's radioactive waste management program and the radiation protection program in Chapter 11 of this SER.

The NRC staff evaluated the descriptions and discussions of SHINE's SRWP system, as described in SHINE FSAR Section 9b.7.5, and finds that the final design of SHINE's SRWP system, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria.

9b.4.7.6 Radioactive Drain System

SHINE FSAR Section 9b.7.6 states that the Radioactive Drain System (RDA) is normally empty, prevents the accumulation of radioactive solution, and provides liquid detection sensor to detect fluid in-leakage to protect confinement boundary. The RDS is confined within the RCA without any penetration to a non-RCA, consisting of drip pans with drain lines, tank overflow lines, collection tanks and instrumentation to alert operators of system status. The RDS includes drip pans located beneath the extraction and IXP hot cells, favorable geometry tanks, and piping for systems that normally contain high concentration fissile solution. The RDS contains two favorable geometry tanks that collect leakage from postulated sources. The leakage and overflow from system tanks are connected by piping that is substantially located within the basemat of the RPF as well as in the RPF pipe trench.

The RDS is safety-related and seismic category I. As defined in SHINE FSAR Section 3.1, safety-related SSCs at SHINE are those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to health and safety of workers and the public; and to control or mitigate the consequences of such accidents.

The RDS operates by gravity drain, where overflows and leakage flow through installed piping directly to the RDS hold tanks. The hold tank contents can be mixed, sampled, and withdrawn through the VTS to the TSSS or RLWS as appropriate. Gravity provides the motive force between the various drip pans and the RDS tanks. No valves are installed between the potential collection source and the collection tanks. SHINE FSAR Figure 6b.3-7 provides a flow diagram of the RDS interfaces draining into the RDS tanks. The RDS collects solution from drip pans located in the supercell, valve pits, tank vaults, and trenches that have the potential to contain liquid that requires favorable geometry.

Each of the RDS sump tanks is sized to accept the largest volume of liquid containing SNM that is postulated to leak from a favorable geometry tank. SHINE defines this volume as liquid containing SNM postulated to leak into the RDS system, assuming the tank is filled to the overflow line. In accordance with Criterion 39, the design must have provisions to control the buildup of hydrogen that is released into the primary system boundary and tanks or other volumes. The NRC staff finds that PVVS provides the RDS sump tanks with ventilation to mitigate hydrogen accumulation in the tank headspace. Additionally, the N2PS provides a source of sweep gas to mitigate hydrogen accumulation in RDS sump tanks in the event of a failure of PVVS to provide the sweep gas.

The facility nitrogen handling system (FNHS) provides a nitrogen gas supply for liquid detectors for the RDS sump tanks. The FNHS provides compressed gas to the RDS sump tanks for solution agitation.

As indicated in the FSAR, contents of the RDS tanks are sampled, and transferred by the VTS to the appropriate location. Piping that contains potentially radiological material is routed through shielded pipe chases to limit the exposure of radiation to personnel. The RDS tanks are shielded by a tank vault, which is a part of the PFBS. The PFBS provides shielding from sources of radiation in RDS to ensure that accumulated doses in occupied areas do not exceed defined limits. Fluids collected in the RDS can be returned to production or transferred to the RLWS for disposal. In accordance with Criterion 36, the NRC staff finds that the target solution storage and handling, radioactive waste, and other systems within the RDS containing radioactivity have the capability to permit appropriate periodic inspection, suitable shielding for radiation protection, and appropriate confinement and filtering systems.

The RDS does not contain fissile material under normal process conditions and leakage or overflow of target solution to the RDS is considered an abnormal condition. The RDS hold tanks and piping are favorable geometry for the most reactive concentration of target solution. In accordance with Criterion 37, a detailed description of the criticality safety program is provided in Section 6b.3 of the SHINE FSAR. NRC staff evaluated SHINE's nuclear criticality safety in Chapter 6 of this SER.

PICS directly monitors and provides alarms for RDS sump tank temperature and level. The RDS liquid detection switch signal is received by the ESFAS as a discrete input from a liquid detection switch. When one or more RDS liquid detection switch signal channels are active, then a VTS Safety Actuation is initiated. The NRC staff evaluated SHINE's instrumentation and control system, including ESFAS and PICS, in Chapter 7 of this SER.

The NRC staff evaluated the descriptions and discussions of SHINE's RDS, as described in SHINE FSAR Section 9b.7.6, and finds that the final design of SHINE's RDS, including the principal design criteria, design bases, and information relative to the subject system, meets all applicable regulatory requirements and acceptance criteria. The staff also finds that target solution storage and handling within the RDS provides adequate radioactivity confinement, critically control, and hydrogen mitigation features and is, therefore, acceptable.

9b.4.7.7 Facility Potable Water System

SHINE FSAR Section 9b.7.7 states that the facility potable water system (FPWS) provides a potable water supply to the SHINE facility and is connected to the City of Janesville water supply. The boundaries of the FPWS include the components from the City of Janesville water

main to the fixtures in each of the buildings on the SHINE facility. The fixtures themselves are part of the facility sanitary drain system (FSDS).

Potable water is distributed throughout the SHINE facility through a subgrade piping network. The FPWS site main connects to SHINE facility building mains, which include the main production facility (outside the RCA), the storage building, and the resource building. The FPWS protects the public water system from backflow of contaminants through the water service connection into the public water system through the installation of backflow prevention devices.

The FPWS supplies inventory to both the facility demineralized water system (FDWS) and FHWS with a backflow prevention device at system interfaces. The FPWS supplies water to the eye wash stations and chemical showers within the non-RCA working areas of the chemical storage and preparation room, and storage building where reagent preparation is performed which are located outside the RCA.

The FPWS is not a safety-related system because it performs no function to prevent or mitigate postulated accidents, and potable water contains no radioactive material or SNM. Shielding and radiological protection is not required for the FPWS. For instrumentation, the FPWS hot water supply is equipped with automatic temperature controls capable of adjustments.

The NRC staff finds that potable water interfaces only with systems outside the RCA and contains backflow preventors to prevent inadvertent contamination with interfacing systems. Therefore, the staff finds that the applicant adequately described the design and function of the FPWS to comply with the requirements of 10 CFR 50.34 and that the system has reasonable protections against radioactive contamination such that the requirements of 10 CFR Part 20 are satisfied.

9b.4.7.8 Facility Nitrogen Handling System

SHINE FSAR Section 9b.7.8 states that the FNHS is designed to supply both liquid nitrogen and compressed gaseous nitrogen to interfacing systems inside and outside the RCA. Outside the main production facility, bulk liquid nitrogen is stored in tanks and is supplied to vaporizer units. The FNHS vaporizer units vaporize the liquid nitrogen to provide a clean gaseous nitrogen supply that is piped into the main production facility. A liquid nitrogen supply line upstream of the vaporizers supplies liquid nitrogen from the bulk storage tank into the main production facility via vacuum jacketed cryogenic piping.

Inside the RCA, a portion of the nitrogen supply gas is piped to a main receiver storage tank which feeds the FNHS ring header. The remainder of the nitrogen supply gas is piped to the TPS room serving the TPS.

Systems that use the FNHS nitrogen supply to support their functions are identified in SHINE FSAR Table 9b.7-5. Although the FNHS interfaces with these systems, FNHS is non-safety and not relied upon to prevent or mitigate accidents.

The FNHS bulk liquid nitrogen storage tank and vaporizers supply nitrogen gas to the main FNHS receiver tank, the facility nitrogen gas ring header, and the FNHS remote receiver tank located inside the RCA. The FNHS ring header inside the RCA supplies nitrogen gas to sampling equipment, tank sparging and mixing equipment, and level indication equipment. The FNHS ring header also supplies nitrogen gas to each FNHS cooling room receiver tank where it

is used by TOGS. The FNHS provides liquid and gaseous nitrogen to the TPS as shown in SHINE FSAR Figure 9b.7-6. Gaseous nitrogen is used by the TPS to operate pneumatic equipment.

Liquid nitrogen is supplied from an outside bulk liquid nitrogen storage tank to the filling station and TPS within the RCA through a valved penetration. The FNHS supplies liquid nitrogen to an adjustable pressure phase separator inside the main production facility that has the capability to store and deliver high quality liquid nitrogen to the TPS. Liquid nitrogen is also supplied to a fill station inside the main production facility. The fill station is installed to fill portable dewars for the disbursement of liquid nitrogen in small quantities as needed by facility processes. A separate remote receiver tank is maintained on the FNHS ring header to supply abrupt demands and provide consistent nitrogen gas flow and pressure to all serviced areas in the RCA.

The FNHS bulk liquid nitrogen storage tanks outside RCA are continuously pressurized by the naturally occurring liquid to gas phase change inside the tank with overpressure venting to the atmosphere. Liquid nitrogen is directed to either vaporizers or sent to phase separator for supply to TPS. The supply nitrogen gas from the vaporizer is routed through a manifold with a pressure regulator to the primary receiver tank, facility nitrogen gas ring header, and remote receiver tank located inside the RCA. The nitrogen gas is regulated through a control manifold designed to control the pressure and prevent possible liquid carryover to the FNHS end users. The control manifold ensures that adequate pressure is maintained within the main production facility.

Overpressure protection is provided for the FNHS with venting both inside and outside RCA. The components outside consist of FNHS bulk liquid nitrogen storage tank, vaporizer and manifold. A pressure relief system with a vent path to the atmosphere is maintained on each bulk liquid storage tank to prevent over-pressurization of the vessel. SHINE FSAR Figure 9b.7-6 shows a pressure relief and a control manifold downstream of vaporizers prior to entering RCA for overpressure protection and to ensure that adequate pressure is maintained within the main production facility. Inside the RCA, nitrogen supply gas received from the manifold is piped to a primary receiver storage tank which feeds a remote receiver tank on the ring header inside RCA. Primary and remote receiving tanks contain overpressure devices venting to the RVZ2e within the RCA. Through a second RCA penetration, the FNHS supplies liquid nitrogen to an adjustable pressure phase separator with capability to store and deliver high quality liquid nitrogen to the filling station and TPS. Off-gassing from this phase separator is vented through a connection to the RVZ2e.

The NRC staff finds that acceptable design provisions have been made to safely supply nitrogen to the supported systems and prevent over-pressurization of the FNHS by use of pressure relief components. Additionally, the FNHS contains pressure monitoring within PICS isolation provisions at RCA penetrations. Therefore, the staff finds that the applicant adequately described the design and function of the FNHS to comply with the requirements of 10 CFR 50.34 and that the system has reasonable protections against radioactive contamination such that the requirements of 10 CFR Part 20 are satisfied.

9b.4.7.9 Facility Sanitary Drain System

SHINE FSAR Section 9b.7.9 states that the FSDS removes domestic sanitary waste and wastewater from the areas of the main production facility (outside the RCA), the storage building, and the resource building; and discharges sanitary waste and wastewater to the City of

Janesville public sewer main. The FSDS building sewer removes sanitary waste via a gravity drainage system. The subsystem includes distribution piping, pipe fittings, isolation valves, backwater valves, vents, traps, cleanouts, manholes, and fixtures.

The FSDS is not a safety-related system because it performs no function to prevent or mitigate postulated accidents, and sanitary waste sources contain no radioactive material or SNM. Shielding and radiological protection is not required for the FSDS. The FSDS has no instrumentation or control equipment.

Building drains that are subject to backflow are protected with a backwater valve or sump and pumping equipment to comply with applicable requirements of the Wisconsin Administrative Code.

The NRC staff finds that the FSDS service drains are outside the RCA and not connected to contaminated systems. As such, the risk of contamination is extremely low. Therefore, the staff finds that the applicant adequately described the design and function of the FSDS to comply with the requirements of 10 CFR 50.34 and that the system has reasonable protections against radioactive contamination such that the requirements of 10 CFR Part 20 are satisfied.

9b.4.7.10 Facility Chemical Reagent System

SHINE FSAR Section 9b.7.10 states that the facility chemical reagent system (FCRS) provides storage and equipment for non-radioactive chemical reagents used in the SHINE processes and the design basis of the FCRS includes:

- Provide intermediate storage for chemical reagents and bulk chemicals used to prepare chemical reagents.
- Provide for preparation of chemical reagents from bulk chemicals.
- Transfer reagents from their intermediate storage locations to process at tie-in locations.
- Deliver reagents into the SHINE process.
- Provide compressed oxygen to the TOGS.

Systems that use the FCRS reagents to support their functions are identified in SHINE FSAR Table 9b.7-6. Although the FCRS interfaces with systems identified as safety-related, the FCRS is nonsafety-related.

Bulk chemical storage is provided in the storage building outside RCA. Chemical storage is also provided in the chemical storage and preparation room in the main production facility, which is also located outside the RCA. Chemical reagents are placed into volume-limited FCRS containers for transfer to process tie-in location tanks and into single-use laboratory scale containers (e.g., flasks, syringes, pipets) for import into hot cells inside the RCA.

SHINE FSAR Section 9b.7.10.2, “System Description,” and Table 9b.7-6 provides a list of systems that use reagents transported in portable containers, transferred into the tanks, and pumped on demand directly into the respective process tie-in locations. These systems primarily use FCRS during the SHINE processes of extraction, purification, flushing, and pH adjustment.

Storage of compressed oxygen gas, used as a reagent, is provided by the FCRS. Compressed oxygen is supplied to the TOGS to facilitate the recombination of radiolytic hydrogen.

Compressed oxygen cylinders are stored inside the IF to service the TOGS. The oxygen is routed through dry particulate filters, regulated, and distributed to the TOGS. The FSAR states the storage and delivery of oxygen gas inside the RCA complies with fire hazard analysis (FHA), as described in Section 9a2.3 of SHINE FSAR. The PICS provides monitoring and alarms for pressure in oxygen receivers for end users. Other chemical reagents are used for batch production, solution adjustment, and process flushing.

Reagents from FCRS process delivery tanks are pumped directly into the respective process tie-in points at controlled flow rates and temperatures in accordance with the process requirements. Administrative and engineered controls, including accurate identification of reagents inside process delivery tanks and containers, and color-coded and size specific connections, ensure that reagents are not inadvertently supplied at incorrect process tie-in points. The FCRS process delivery tanks are volume limited, thereby setting maximum volume of reagents that can be supplied to respective production-related processes.

FCRS provides pumped MEPS extraction and purification reagents. Reagents in laboratory containers are manually introduced into the MEPS purification hot cells through hot cell pass-throughs. Hot cell manipulators are used to add chemicals to the laboratory scale purification processes performed in the hot cells. As discussed in SHINE FSAR Section 6b.3.2, a three-way valve design prevents flow of target solution toward the FCRS reagent vessels. An isolation valve is installed between the FCRS and upper vacuum lift tanks that is administratively closed during target solution processing, and a check-valve also exists to prevent inadvertent flow of target solution to the reagent vessels.

Prevention of target solution backflow into the FCRS provides protection against criticality accidents. A check valve is installed to prevent the flow of solution upstream to FCRS. Additionally, an isolation valve located between the check valve and the FCRS is administratively closed during processing of target solution. The FCRS contains no SNM; however, the addition of basic chemical reagents to interfacing systems may result in uranium precipitation. Chemical additions to process tanks in interfacing systems are evaluated under the nuclear criticality safety program, as described in Section 6b.3, "Nuclear Criticality Safety," of the SHINE FSAR. NRC staff evaluated SHINE's nuclear criticality safety in Chapter 6 of this SER.

The NRC staff finds that acceptable design provisions have been made to prevent the inadvertent contamination of the systems with radioactive material or SNM during storage and handling of chemical reagents. Therefore, the staff finds that the FPWS is adequately described, including its design and function, to comply with the requirements of 10 CFR 50.34 and that the system has reasonable protections against radioactive contamination such that the requirements of 10 CFR Part 20 are satisfied.

9b.4.8 Proposed Technical Specifications

In accordance with 10 CFR 50.36(a)(1), the NRC staff evaluated the sufficiency of the applicant's proposed TSs for the SHINE facility.

The proposed TS 2.2, Table 2.2, "Limiting Safety System Settings (LSSS)," states the following:

LSSS 2.2.9	Low process vessel vent system (PVVS) flow	≥ 7.1 SCFM	Facility not Secured

LSSS 2.2.9 provides a setpoint to ensure that the PVVS flow rate is at least 7.1 standard cubic feet per minute (SCFM) if the facility is not secured. The NRC staff finds that this flow limit is bounded by the analytical limit for the PVVS flow limit. The staff finds that the analytical limit ensures that the concentration of hydrogen does not reach the lower flammability limit and prevents a deflagration. Therefore, the staff finds the LSSS acceptable.

The proposed TS 3.5, "Ventilation Systems," LCO 3.5.1 and SR 3.5.1, states the following:

LCO 3.5.1	The PVVS shall be Operable. PVVS is considered Operable if: 1. At least 2 PVVS blowers are Operating, with total flow ≥ 7.1 SCFM, 2. At least 1 PVVS inlet header flow path is open, 3. At least 7 carbon delay beds are Operating, and 4. PVVS flow from the individual tanks containing target solution or radioactive liquids listed in Table 3.5.1-a is above corresponding minimum flowrate. Note – PVVS flow from individual tanks is allowed to drop below the minimum required flowrate during tank sparging or fluid transfer operations.
Applicability	Facility not Secured
Action	According to Table 3.5.1
SR 3.5.1	1. Verify total flowrate at the exhaust of the PVVS is above the limit daily. 2. Verify flow from individual tanks listed in Table 3.5.1-a quarterly.

The proposed Table 3.5.1, "PVVS Actions," states the following:

	Action	**Completion Time**
1.	If fewer than 2 PVVS blowers are Operating, OR If PVVS total flow is < 7.1 SCFM, OR If no PVVS inlet header flow path is open, Actuate the RPF Nitrogen Purge.	1 hour
2.	If fewer than 7 carbon delay beds are Operating, Restore at least 7 carbon delay beds to Operating.	60 days

3.	If PVVS fewer than 5 carbon delay beds are Operating, OR Action and completion time of Condition 2 not met, Suspend operations to transition any IU in Mode 0 to Mode 1 AND Place all Mode 1 IUs in Mode 3 AND Verify a flow path exists for PVVS flow through the carbon guard bed or its bypass, and through the Operating delay beds to the facility exhaust.	 1 hour 6 hours 1 hour
4.	If PVVS flow from the individual tanks listed in Table 3.5.1-a is ≤ the corresponding minimum flowrate, Remove target solution or radioactive liquids from affected tank(s).	 12 hours

The proposed Table 3.5.1-a, "PVVS Tank Flowrates," states the following:

	Component	Number of Tanks	Minimum Flowrate Per Tank (SCFM)
a.	Target solution hold tank	8	1.1E-01
b.	Target solution storage tank	2	1.1E-01
c.	Uranium waste tank	2	1.1E-01
d.	Radioactive liquid waste collection tank	4	2.8E-01
e.	Radioactive liquid waste blending tank	8	2.8E-01
f.	Radioactive drain sump tank	2	1.1E-01

LCO 3.5.1 requires the PVVS to be operable, provides the conditions for the PVVS to be considered operable, and provides the actions to be taken if it is not operable. The NRC staff finds that the requirements to be considered operable would ensure that the PVVS is able to perform its safety function. The staff finds that Action 1 and its completion time would ensure that hydrogen mitigation for the RPF is maintained. The staff finds that Action 2 would ensure that the limits in 10 CFR Part 20 are not exceeded, and that the completion time is acceptable due to the limited duration. The staff also finds that the completion time would allow for investigation and the repair of a carbon delay bed. The staff finds that Action 3 would prevent the increase of the facility's radionuclide inventory and ensure that the sweep gas flow path is sufficient. The staff finds that the completion times are acceptable due to the availability of the ESFAS automatic safety function to initiate an RPF nitrogen purge on low PVVS flow (e.g., a blocked flow path) and the availability of at least one carbon delay bed or carbon guard bed to continue to provide limited hold up of radionuclides prior to release. The staff finds that Action 4 would eliminate the need for sweep gas in the affected tank. The staff finds that this completion time provides adequate time to repair a minor problem or remove radioactive liquids from

affected tanks. The staff finds that there is a low rate of hydrogen generation in these tanks during the completion time. Therefore, the NRC staff finds the LCO acceptable.

SR 3.5.1 requires the daily verification of the total flowrate at the PVVS exhaust and the quarterly verification of flow from the tanks listed in Table 3.5.1-a. The NRC staff finds that the frequency of the verifications would ensure that the PVVS is operating within design limits. Therefore, the staff finds the SR acceptable.

The proposed TS 3.8, "Facility Specific," LCO 3.8.1 and SR 3.8.1, states the following:

LCO 3.8.1	The N2PS shall be Operable. The N2PS is considered Operable if: 1. At least 11 nitrogen storage tubes are filled with nitrogen at a minimum pressure of 2,100 psig per tube, and 2. The N2PS is capable of delivering a total of 16 SCFM of sweep gas flow.
Applicability	Facility not Secured
Action	According to Table 3.8.1
SR 3.8.1	1. Nitrogen pressure in each tube shall be verified to be above the minimum pressure weekly. 2. A Channel Calibration of the pressure sensor for each tube shall be performed annually. 3. A verification of the N2PS capability to deliver the required sweep gas flow shall be performed every five years.

The proposed Table 3.8.1, "Nitrogen Purge System Actions," states the following:

	Action	Completion Time
1.	If fewer than 11 nitrogen storage tubes are pressurized to ≥ 2,100 psig, OR If N2PS is unable to deliver a total of 16 SCFM of sweep gas flow,	
	Place all IUs undergoing irradiation in Mode 3	12 hours
	AND	
	Restore N2PS to Operable.	72 hours

LCO 3.8.1 requires the N2PS to be operable, provides the conditions for N2PS to be considered operable, and provides the actions to be taken if it is not. The NRC staff finds that 11 out of 12 N2PS storage tubes pressurized to a minimum pressure would ensure there is sufficient nitrogen capacity to adequately control hydrogen concentrations in process tanks and IUs during accident scenarios for the required 72 hours. The NRC staff finds that placing all IUs undergoing irradiation in Mode 3 if the N2PS is not operable would limit the amount of hydrogen

generated. The NRC staff finds that the completion time of 12 hours would allow time to restore the N2PS to operable or to transition the operating IUs to Mode 3 in a controlled manner, there is also a low likelihood of an event requiring an N2PS activation during this time. The NRC staff finds that restoring N2PS to operable within 72 hours would allow for more extensive maintenance of the N2PS to be performed. Therefore, the NRC staff find the LCO acceptable.

SR 3.8.1 requires the nitrogen pressure to be verified weekly, a channel calibration of each pressure sensor annually, and the N2PS sweep gas flow to be verified every five years. The NRC staff finds that verification of the nitrogen pressure weekly would ensure the N2PS can perform its required function. The staff finds that the frequency of channel calibrations of the pressure sensors is in accordance with guidance in ANIS/ANS 15.1-2007. The NRC staff finds that the sweep gas flow verification every five years is acceptable based on the passive design of the N2PS. Therefore, the NRC staff finds the SR acceptable.

The proposed LCO 3.8.10 and SR 3.8.10 state the following:

LCO 3.8.10	Each safety-related valve listed in Table 3.8.10-a shall be Operable. A valve is considered Operable if: 1. The valve is capable of opening or closing on demand from ESFAS. Note – A single Division of required component(s) may be inoperable for up to 2 hours during the performance of required surveillances.
Applicability	According to Table 3.8.10-a
Action	According to Table 3.8.10
SR 3.8.10	Safety-related valves listed in Table 3.8.10-a shall be stroke tested annually.

The proposed Table 3.8.10, “Safety-Related Valves Actions,” provides the actions to be taken and the completion time for each action if the LCO is not met.

The proposed Table 3.8.10-a, “Automatically-Actuated Safety-Related Valves,” provides a list of the safety-related valves that shall be operable according to LCO 3.8.10, the number of valves provided per flow path, the applicability for each valve, and the applicable actions for each valve.

LCO 3.8.10 requires the safety-related valves listed in Table 3.8.11-a to be operable and the actions to be taken if not. The NRC staff finds that the operability of the safety-related valves would ensure the valves are able to provide the applicable isolation functions. The NRC staff finds that the actions taken if a safety-related valve is not operable would ensure any hazards caused by the inoperable valves are minimized. The NRC staff finds that the completion times provide reasonable time to investigate and repair minor problems. The NRC staff also finds that the likelihood of a release within the completions times is low. Therefore, the NRC staff finds the LCO acceptable.

SR 3.8.10 requires the safety-related valves to be stroke tested annually. The NRC staff finds that the frequency is based on industry experience. Therefore, the NRC staff finds the SR acceptable.

The proposed LCO 3.8.11 and SR 3.8.11 state the following:

LCO 3.8.11	The safety-related check valves listed in Table 3.8.11-a shall be Operable.
Applicability	According to Table 3.8.11-a
Action	According to Table 3.8.11
SR 3.8.11	The check valves listed in Table 3.8.11-a shall be inspected semi-annually.

The proposed Table 3.8.11, "Safety-Related Check Valve Actions," provides the actions to be taken and the completion time for each action if the LCO is not met.

The proposed Table 3.8.11-a, "Safety-Related Check Valves," provides a list of the safety-related check valves that shall be operable according to LCO 3.8.11, the applicability for each check valve, and the applicable actions for each check valve.

LCO 3.8.11 requires the safety-related check valves listed in Table 3.8.11-a to be operable and the actions to be taken if not. The NRC staff finds that the operability of the safety-related check valves would ensure the valves are able to provide the applicable isolation functions. The NRC staff finds that the actions taken if a safety-related check valve is not operable would ensure any hazards caused by the inoperable check valves are minimized. The NRC staff finds that the completion times provide reasonable time to investigate and repair minor problems and to isolate the affected flow path and remove the material. Therefore, the NRC staff finds the LCO acceptable.

SR 3.8.11 requires the check valves to be inspected semi-annually. The NRC staff finds the frequency to be consistent with the expected reliability of the components. Therefore, the NRC staff finds the SR acceptable.

The proposed TS 4.1, "Site and Facility Description," Design Feature (DF) 4.1.5 states the following:

DF 4.1.5	The design of the N2PS contains the following characteristics to protect its equipment from the effects of external events: 1. Reinforced concrete structure for the compressed gas supply tanks and piping to protect against severe weather and tornado generated missiles. 2. Nitrogen gas purge exhaust height designed to be above the design snow accumulation depth. 3. N2PS and SSCs in interfacing systems that could significantly impact its operation are seismically designed to ensure N2PS operability during and after a seismic event.

DF 4.1.5 states design characteristics of the N2PS to protect its equipment from the effects of external events. SHINE FSAR Section 12a2.1.6.2 discusses external event scenarios that include the N2PS and the design of the system. The NRC staff finds that the reinforced

concrete structure would protect against severe weather and tornado generated missiles. The NRC staff finds that the nitrogen gas purge exhaust heigh is designed to be above the potential snow drift height to ensure operability. The NRC staff also finds that N2PS is Seismic Category 1 and is designed to perform its safety function after a safe shutdown earthquake. Therefore, the staff finds the DF acceptable.

The proposed TS 4.4, “Fissionable Material Storage,” DF 4.4.1 states the following:

DF 4.4.1	The margin of subcriticality for uranyl sulfate systems in the RPF shall be greater than or equal to 0.06.

DF 4.4.1 states that the margin of subcriticality for uranyl sulfate systems in the RPF shall be greater than or equal to 0.06. SHINE FSAR Section 4a2.6.2.6.1 discusses the calculations and uncertainties of the effective neutron multiplication factor. The NRC staff finds that the margin would ensure subcriticality is adequately maintained. Therefore, the NRC staff finds the DF acceptable.

9b.5 Review Findings

The NRC staff reviewed the descriptions and discussions of the SHINE RPF auxiliary systems, as described in SHINE FSAR Section 9b, as supplemented, against the applicable regulatory requirements and using appropriate regulatory guidance and acceptance criteria.

Based on its review of the information in the FSAR and independent confirmatory review, the NRC staff determined that:

(1) SHINE described the RPF auxiliary systems and identified the major features or components incorporated therein for the protection of the health and safety of the public.

(2) The processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other TSs provide reasonable assurance that the applicant will comply with the regulations in 10 CFR Part 50 and 10 CFR Part 20 and that the health and safety of the public will be protected.

(3) The issuance of an operating license for the facility would not be inimical to the common defense and security or to the health and safety of the public.

Based on the above determinations, the NRC staff finds that the descriptions and discussions of SHINE’s RPF auxiliary systems are sufficient and meet the applicable regulatory requirements and guidance and acceptance criteria for the issuance of an operating license.