March 9, 2022

2022-SMT-0036
10 CFR 50.30

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

References: (1) SHINE Medical Technologies, LLC letter to the NRC, "SHINE Medical Technologies, LLC Application for an Operating License," dated July 17, 2019 (ML19211C143)
(2) NRC letter to SHINE Medical Technologies, LLC, "SHINE Medical Technologies, LLC – Request for Additional Information Related to the Radiation Monitoring System(s) (EPID No. L-2019-NEW-0004)," dated January 11, 2022 (ML22007A217)

<u>SHINE Technologies, LLC Application for an Operating License</u>
<u>Supplement No. 18 and Response to Request for Additional Information</u>

Pursuant to 10 CFR Part 50.30, SHINE Technologies, LLC (SHINE) submitted an application for an operating license for a medical isotope production facility to be located in Janesville, Wisconsin via Reference 1. Via Reference 2, the NRC staff determined that additional information was required to enable the staff's continued review of the SHINE operating license application.

Enclosure 1 provides the SHINE Final Safety Analysis Report (FSAR) Change Summary, identifying changes to the SHINE FSAR not related to the SHINE responses to the NRC staff's request for additional information.

Enclosure 2 provides the SHINE response to the NRC staff's request for additional information.

If you have any questions, please contact Mr. Jeff Bartelme, Director of Licensing, at 608/210-1735.

I declare under the penalty of perjury that the foregoing is true and correct.
Executed on March 9, 2022.

Very truly yours,

DocuSigned by:
Jim Costedio
F52DB96989224FF...

James Costedio
Vice President of Regulatory Affairs and Quality
SHINE Technologies, LLC
Docket No. 50-608

Enclosures

cc: Project Manager, USNRC
SHINE General Counsel
Supervisor, Radioactive Materials Program, Wisconsin Division of Public Health

ENCLOSURE 1

SHINE TECHNOLOGIES, LLC

SHINE TECHNOLOGIES, LLC APPLICATION FOR AN OPERATING LICENSE SUPPLEMENT NO. 18 AND RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

FINAL SAFETY ANALYSIS REPORT CHANGE SUMMARY

Summary Description of Changes	**FSAR Impacts**
Update to correct inaccuracies in TRPS and ESFAS self-testing descriptions, and to provide clarification on the use of self-testing and technical specifications surveillances in demonstrating operability.	Section 7.4, Section 7.5, Section 7.9

A markup of the Final Safety Analysis Report (FSAR) changes is provided as Attachment 1.

ENCLOSURE 1
ATTACHMENT 1

SHINE TECHNOLOGIES, LLC

SHINE TECHNOLOGIES, LLC APPLICATION FOR AN OPERATING LICENSE SUPPLEMENT NO. 18 AND RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

FINAL SAFETY ANALYSIS REPORT CHANGE SUMMARY

FINAL SAFETY ANALYSIS REPORT MARKUP

The TRPS contains capabilities for inservice testing for those functions that cannot be tested while the IU is out of service (Subsection 7.4.4.4).

Structures, systems, and components that comprise a division are physically separated to retain the capability of performing the required safety functions during a design basis accident (Subsection 7.4.5.2.1).

Redundancy within the TRPS, as described in Subsection 7.4.5.2.2, consists of three divisions of input processing and trip determination and two divisions of actuation logic arranged such that no single failure can prevent a safety actuation when required, and no single failure in a single measurement channel can generate an unnecessary safety actuation (Subsection 7.4.3.4). This was validated by the performance of a single failure analysis of the TRPS, performed in accordance with Institute of Electrical and Electronics Engineers (IEEE) Standard 379-2000 (IEEE, 2000), as described in Subsection 7.4.5.2.2.

A channel of TRPS can be taken out of service by placing the channel in trip or using the maintenance bypass function, as described in Subsection 7.4.4.3. A channel can be taken to trip without an adverse impact on redundancy, as described in Subsection 7.4.4.3.

The maintenance bypass function allows an individual safety function module to be removed from service for up to two hours in accordance with the technical specifications, for the purpose of performing required technical specification surveillance testing (Subsection 7.4.4.3). A time limit of two hours is acceptable based on the small amount of time the channel could be in bypass, the continual attendance by operations or maintenance personnel during the test, the continued operability of the redundant channel(s), and the low likelihood that an accident would occur during the two hour time period. By allowing a single SFM module to be placed in maintenance bypass in accordance with the technical specifications, technical specifications surveillances can be performed to verify the operability of TRPS components during system operation, which supports in-service testability.

Self-test features are provided for components that do not have setpoints or tunable parameters (Subsection 7.4.4.4). The discrete logic of the actuation and priority logic (APL) of the EIM does not have self-test capability but is instead functionally tested (Subsection 7.4.4.4). Calibration, testing, and diagnostics are addressed in Section 8.0 of Topical Report TR-1015-18653, “Design of the Highly Integrated Protection System Platform” (NuScale, 2017). Self-testing capabilities provide indication of component degradation and failure, which allows action to be taken to ensure that no single failure results in the loss of the protection function.

7.4.2.1.4 Protection System Independence

> SHINE Design Criterion 16 – The protection systems are designed to ensure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels, do not result in loss of the protection function or are demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, are used to the extent practical to prevent loss of the protection function.

The TRPS control and logic functions operate inside of the facility control room, where the environment is mild, not exposed to the irradiation process, and is protected from earthquakes, tornadoes, and floods (Subsections 7.4.3.5 and 7.4.3.6). The TRPS structures, systems, and

TRPS Criterion 45 – Mechanisms for deliberate operator intervention in the TRPS status or its functions shall not be capable of preventing the initiation of TRPS.

An enable nonsafety switch (when enabled) allows a facility operator to control the output state of the TRPS with a hardwired binary control signal from the nonsafety-related controls. If the enable nonsafety switch is active, and no automatic safety actuation or manual safety actuation signals are present, the operator is capable of energizing or deenergizing any EIM outputs using the nonsafety-related hardwired control signals (Subsection 7.4.3.3). Additionally, safety-related signals are prioritized over nonsafety-related signals (Subsection 7.4.3.12).

7.4.2.2.11 Equipment Qualification

TRPS Criterion 46 – The effects of electromagnetic interference/radio-frequency interference (EMI/RFI) and power surges (such as high-energy faults and lightning) on the TRPS, including FPGA-based digital portions, shall be adequately addressed.

TRPS rack mounted equipment is installed in a mild operating environment and is designed to meet the environmental conditions described in Subsection 7.4.3.5. Rack mounted TRPS equipment is tested to appropriate standards to show that the effects of EMI/RFI and power surges are adequately addressed. This testing includes emissions testing, susceptibility testing, and surge withstand testing. Appropriate grounding of the TRPS is performed in accordance with Section 5.2.1 of IEEE Standard 1050-2004 (IEEE, 2004b).

7.4.2.2.12 Surveillance

TRPS Criterion 47 – Equipment in the TRPS (from the input circuitry to output actuation circuitry) shall be designed to allow testing, calibration, and inspection to ensure operability. If testing is required or can be performed as an option during operation, the TRPS shall retain the capability to accomplish its safety function while under test.

The TRPS design supports testing, maintenance, and calibration, as described in Subsections 7.4.4.3 and 7.4.4.4. Surveillance testing performed using the maintenance bypass capability during operation is controlled in accordance with the technical specifications to ensure that the TRPS is capable of performing its safety functions when required (Subsection 7.4.4.3). Self-testing features provide for monitoring as described in Subsection 7.4.4.4 to provide indication to the operator if conditions exist that could challenge operability of the equipment.

TRPS Criterion 48 – Testing, calibration, and inspections of the TRPS shall be sufficient to show that, once performed, they confirm that surveillance test and self-test features address failure detection, self-test features, and actions taken upon failure detection.

The TRPS design supports testing, maintenance, and calibration, as described in Subsections 7.4.4.3 and 7.4.4.4. End-to-end testing of the entire TRPS platform can be performed through overlap testing. ~~All~~ TRPS components have self-testing capabilities, except the discrete APL of the EIM, power supplies, and hardwired communications between the TRPS and ESFAS via their respective SBVMs, which ~~is~~are functionally tested. The TRPS continuously provides redundant indication of self-testing results to the PICS to indicate to operators that the TRPS is operating correctly following testing, calibration, or inspections.

one-out-of-two or two-out-of-three coincident voting, a single failure of the same SFM in another division would defeat the safety function. Placing a single SFM in maintenance bypass is allowed by the technical specifications for up to two hours for the purpose of performing required technical specification surveillance testing.

With an SFM's OOS switch in the OOS position and the associated trip/bypass switch in either the trip or bypass position, the input channels associated with the SFM are inoperable.

7.4.4.4 Testing Capability

Testing of the TRPS consists of the inservice self-testing capabilities of the HIPS platform and periodic surveillance testing.

End-to-end testing of the entire HIPS platform is performed through overlap testing. Individual self-tests in the various components of the TRPS ensure that the entire component is functioning correctly. Self-test features are provided for components that do not have setpoints or tunable parameters. All TRPS components, except the discrete APL of the EIM, have self-testing capabilities that ensure the information passed on to the following step in the signal path is correct. Self-testing is used to demonstrate operability of components from the sensor input to the output switching logic (except for the discrete logic of the APL, power supplies, and hardwired communications between the TRPS and ESFAS via their respective SBVMs).

The discrete logic of the APL of the EIM does not have self-test capability but is instead functionally tested. This functional testing consists of periodic simulated automatic and manual actuations to verify the functionality of the APL and the manual actuation pushbuttons. The APL test verifies the operability of the discrete priority logic circuits of the TRPS. The surveillance frequency of the APL test is acceptable based on the built-in redundancy and notification of failures within the TRPS.

The operability of the power supplies within the TRPS cabinets is demonstrated by checking the voltages of the power supplies at a frequency consistent with the guidance provided in American National Standards Institute/American Nuclear Society (ANSI/ANS) 15.1-2007, The Development of Technical Specifications for Research Reactors (ANSI/ANS, 2007).

The operability of hardwired communications between the TRPS and ESFAS via their respective SBVMs is demonstrated via functional testing at a frequency consistent with that of the input devices described below.

Testing of input devices consists of channel checks, channel tests, and channel calibrations. Channel checks are performed while the channel is in service. Channel tests and channel calibrations may be performed while the IU is in a mode where the channel is required to be operable (i.e., inservice) by placing the associated SFM in maintenance bypass (Subsection 7.4.4.3). Channel tests and channel calibrations for inputs provided to an SFM may also be performed when the channel is not required to be operable. Channel tests of inputs provided to an HWM are performed when the channel is not required to be operable, since HWMs are not provided with maintenance bypass capabilities. The channel checks, channel tests, and channel calibrations demonstrate operability of the channel from the field instrument through the SFM, ending at the input to the SBVM or SBM. Channel checks, channel tests, and channel calibrations are performed at frequencies consistent with the guidance provided in ANSI/ANS 15.1-2007 (ANSI/ANS, 2007).

Structures, systems, and components that comprise a division are physically separated to retain the capability of performing the required safety functions during a design basis accident (Subsection 7.4.5.2.1).

Redundancy within the ESFAS, as described in Subsection 7.4.5.2.2, consists of two or three divisions of input processing and trip determination (dependent on the monitored variable) and two divisions of actuation logic arranged such that no single failure can prevent a safety actuation when required (Subsection 7.5.3.3). This was validated by the performance of a single failure analysis of the ESFAS, performed in accordance with IEEE Standard 379-2000 (IEEE, 2000), as described in Subsection 7.4.5.2.2.

A channel of ESFAS can be taken out of service by placing the channel in trip or using the maintenance bypass function, as described in Subsection 7.5.4.4. A channel can be taken to trip without an adverse impact on redundancy, as described in Subsection 7.5.4.4.

The maintenance bypass function allows an individual safety function module to be removed from service in accordance with the technical specifications, for the purpose of performing required technical specification surveillance testing (Subsection 7.5.4.4). A time limit of two hours is acceptable based on the small amount of time the channel could be in bypass, the continual attendance by operations or maintenance personnel during the test, the continued operability of the redundant channel(s), and the low likelihood that an accident would occur during the two hour time period. By allowing a single SFM module to be placed in maintenance bypass in accordance with the technical specifications, technical specifications surveillances can be performed to verify the operability of ESFAS components during system operation, which supports in-service testability.

Self-test features are provided for components that do not have setpoints or tunable parameters (Subsection 7.5.4.5). The discrete logic of the actuation and priority logic (APL) of the EIM does not have self-test capability but is instead functionally tested (Subsection 7.5.4.5). Calibration, testing, and diagnostics are addressed in Section 8.0 of Topical Report TR-1015-18653 (NuScale, 2017). Self-testing capabilities provide indication of component degradation and failure, which allows action to be taken to ensure that no single failure results in the loss of the protection function.

7.5.2.1.4 Protection System Independence

> SHINE Design Criterion 16 – The protection systems are designed to ensure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels, do not result in loss of the protection function or are demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, are used to the extent practical to prevent loss of the protection function.

The ESFAS control and logic functions operate inside of the facility control room where the environment is mild, not exposed to the irradiation process, and is protected from earthquakes, tornadoes, and floods (Subsections 7.5.3.4 and 7.5.3.5). The ESFAS structures, systems, and components that comprise a division are physically separated to retain the capability of performing the required safety functions during a design basis accident. Division independence is maintained throughout, extending from the sensor to the devices actuating the protective function (Subsection 7.4.5.2.1).

An enable nonsafety switch (when enabled) allows a facility operator to control the output state of the ESFAS with a hardwired binary control signal from the nonsafety-related controls. If the enable nonsafety switch is active, and no automatic safety actuation or manual safety actuation signals are present, the operator is capable of energizing or deenergizing any EIM outputs using the nonsafety-related hardwired control signals (Subsection 7.5.3.2). Additionally, safety-related signals are prioritized over nonsafety-related signals (Subsection 7.5.3.11).

7.5.2.2.11 Equipment Qualification

ESFAS Criterion 47 – The effects of electromagnetic interference/radio-frequency interference (EMI/RFI) and power surges, such as high-energy faults and lightning, on the ESFAS, including field programmable gate array (FPGA)-based digital portions, shall be adequately addressed.

ESFAS rack mounted equipment is installed in a mild operating environment and is designed to meet the environmental conditions described in Subsection 7.5.3.4. Rack mounted ESFAS equipment is tested to appropriate standards to show that the effects of EMI/RFI and power surges are adequately addressed. This testing includes emissions testing, susceptibility testing, and surge withstand testing. Appropriate grounding of the ESFAS is performed in accordance with Section 5.2.1 of IEEE Standard 1050-2004 (IEEE, 2004b).

7.5.2.2.12 Surveillance

ESFAS Criterion 48 – Equipment in the ESFAS (from the input circuitry to output actuation circuitry) shall be designed to allow testing, calibration, and inspection to ensure operability. If testing is required or can be performed as an option during operation, the ESFAS shall retain the capability to accomplish its safety function while under test.

The ESFAS design supports testing, maintenance, and calibration to ensure operability as described in Subsections 7.5.4.4 and 7.5.4.5. Surveillance testing performed using the maintenance bypass capability during operation is controlled in accordance with the technical specifications to ensure that the ESFAS is capable of performing its safety functions when required (Subsection 7.5.4.4). Self-testing features provide for monitoring as described in Subsection 7.5.4.5 to provide indication to the operator if conditions exist that could challenge operability of the equipment.

ESFAS Criterion 49 – Testing, calibration, and inspections of the ESFAS shall be sufficient to show that once performed, they confirm that surveillance test and self-test features address failure detection, self-test features, and actions taken upon failure detection.

The ESFAS design supports testing, maintenance, and calibration, as described in Subsections 7.5.4.4 and 7.5.4.5. End-to-end testing of the entire ESFAS platform can be performed through overlap testing. ESFAS components have self-testing capabilities, except the discrete APL of the EIM, power supplies, and hardwired communications between the ESFAS and TRPS via their respective SBVMs, which ~~is~~are functionally tested. The ESFAS continuously provides redundant indication of self-testing results to the PICS to indicate to operators that the ESFAS is operating correctly following testing, calibration, or inspections.

ESFAS Criterion 50 – The design of the ESFAS and the justification for test intervals shall be consistent with the surveillance testing intervals as part of the facility technical specifications.

With an SFM's OOS switch in the OOS position and the associated trip/bypass switch in either the trip or bypass position, the input channels associated with the SFM are inoperable.

7.5.4.5 Testing Capability

Testing of the ESFAS consists of the inservice self-testing capabilities of the HIPS platform and periodic surveillance testing.

End-to-end testing of the entire HIPS platform can be performed through overlap testing. Individual self-tests in the various components of the ESFAS ensure that the entire component is functioning correctly. Self-test features are provided for components that do not have setpoints or tunable parameters. ESFAS components, except the discrete APL of the EIM, have self-testing capabilities that ensure the information passed on to the following step in the signal path is correct. Self-testing is used to demonstrate operability of components from the sensor input to the output switching logic (except for the discrete logic of the APL, power supplies, and hardwired communications between the TRPS and ESFAS via their respective SBVMs).

The discrete logic of the APL of the EIM does not have self-test capability but is instead functionally tested. This functional testing consists of periodic simulated automatic and manual actuations to verify the functionality of the APL and the manual actuation pushbuttons. The APL test verifies the operability of the discrete priority logic circuits of the ESFAS. The surveillance frequency of the APL test is acceptable based on the built-in redundancy and notification of failures within the ESFAS.

The operability of the power supplies within the ESFAS cabinets is demonstrated by checking the voltages of the power supplies at a frequency consistent with the guidance provided in American National Standards Institute/American Nuclear Society (ANSI/ANS) 15.1-2007, The Development of Technical Specifications for Research Reactors (ANSI/ANS, 2007).

The operability of hardwired communications between the TRPS and ESFAS via their respective SBVMs is demonstrated via functional testing at a frequency consistent with that of the input devices described below.

Testing of input devices consists of channel checks, channel tests, and channel calibrations. Channel checks are performed while the channel is in service. Channel tests and channel calibrations may be performed while the associated equipment is in a condition where the channel is required to be operable (i.e., inservice), by placing the associated SFM in maintenance bypass (Subsection 7.5.4.4). Channel tests and channel calibrations may also be performed when the channel is not required to be operable.. The channel checks, channel tests, and channel calibrations demonstrate operability of the channel from the field instrument through the SFM, ending at the input to the SBVM or SBM. Channel checks, channel tests, and channel calibrations are performed at frequencies consistent with the guidance provided in ANSI/ANS 15.1-2007 (ANSI/ANS, 2007).

7.5.4.6 Technical Specifications and Surveillance

Limiting conditions for operation and surveillance requirements are established for ESFAS logic, voting, and actuation divisions and instrumentation monitored by ESFAS as input to safety actuations. Limiting conditions for operation are established for components of the safety-related I&C systems that perform safety functions to ensure that the system will remain available to

7.9 REFERENCES

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ENCLOSURE 2

SHINE TECHNOLOGIES, LLC

SHINE TECHNOLOGIES, LLC APPLICATION FOR AN OPERATING LICENSE SUPPLEMENT NO. 18 AND RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

The U.S. Nuclear Regulatory Commission (NRC) staff determined that additional information was required (Reference 1) to enable the continued review of the SHINE Technologies, LLC (SHINE) operating license application (Reference 2). The following information is provided by SHINE in response to the NRC staff's request.

Chapter 7 – Instrumentation and Control Systems

RAI 7-27

Note 2 of SHINE FSAR Chapter 3, "Design of Structures, Systems, and Components," Table 3.1-1, states that "[t]he generally-applicable design criteria 1-8 from Table 3.1-3 are not specifically listed even though they are generally applicable to most SSCs." However, it is not clear to the NRC staff whether these design criteria are applicable to each radiation monitoring system (i.e., parts of ESFAS, TRPS; and TPS, RAMS, CAMS, and SRMS).

Confirm whether SHINE Design Criteria 1 - 8 are applicable to each radiation monitoring system. Update the SHINE FSAR to describe the relation of the radiation monitoring systems design bases to each applicable SHINE Design Criteria 1-8.

This information is necessary for the NRC staff to understand the relation of the design bases to the principal design criteria of the facility, as required by 10 CFR 50.34.

SHINE Response

SHINE Design Criteria 1, 2, and 4 are applicable to the safety-related process radiation monitors described in Subsection 7.7.1 of the FSAR. SHINE does not rely on these radiation monitors to satisfy SHINE Design Criteria 3 and 5 through 8.

SHINE Design Criteria 1 through 8 are not applicable to the nonsafety-related process radiation monitors described in Subsection 7.7.2 of the FSAR, since these radiation monitors are not used to control personnel or environmental radiological exposures.

SHINE Design Criteria 1 through 8 are not applicable to the radiation area monitoring system (RAMS), the continuous air monitoring system (CAMS), and the stack release monitoring system (SRMS) described in Subsections 7.7.3, 7.7.4 and 7.7.5 of the FSAR, respectively.

SHINE has revised Subsection 7.7.1.2 of the FSAR to describe the relationship of the safety-related process radiation monitor design basis to SHINE Design Criteria 1, 2, and 4. A mark-up of these changes is provided as Attachment 1.

RAI 7-28

NUREG-1537, Part 2, Section 7.7, "Radiation Monitoring Systems," states, in part, that "[t]he applicant should address all equipment, devices, and systems used for monitoring or measuring radiation intensities or radioactivity … [t]his section should detail the operating principles, designs, and functional performance of the I&C aspects of the system [RMS]." Although there may be different types of radiation monitoring systems (as is the case in the SHINE application), the guidance in NUREG-1537, Part 2, Section 7.7, does not provide specific guidance for different types of radiation monitoring systems, rather the guidance in Section 7.7 is understood to be applicable to all radiation monitoring systems.

The acceptance criteria of NUREG-1537, Part 2, Section 7.7 states the following:

- The instrument ranges should be sufficient to cover the expected range of variation of the monitored variable under the full range of normal operation and if assumed in the SAR analysis, accident conditions.

- The sensitivity of each system should be commensurate with the precision and accuracy to which knowledge of the variable is required by analysis or design basis.

In addition, NUREG-1537, Part 2, Section 7.6, "Control Console and Display Instruments," provides guidance for evaluating the control console and display instruments to determine that they include signals from instrument systems monitoring activities, and other system process variables analytically or digitally processed outputs based on monitored variables. The acceptance criteria in NUREG-1537, Part 2, Section 7.3, "Reactor Control Systems," states the following:

- The system should give reliable information about the status and magnitude of process variables necessary for the full range of normal reactor operation.

The radiation monitoring systems described in FSAR Section 7.7 should conform to the acceptance criteria and guidelines so that the controlled variables can be maintained within prescribed ranges for normal operations, anticipated transients, and accident conditions, including the effects of maloperation or failure of the system. Accordingly, the SHINE FSAR should describe the design bases, acceptance criteria, and guidelines used for design of the RMS, as well as analysis of the adequacy of the designs to perform the functions necessary to monitor and control the SHINE facility.

(a) Monitored and displayed variables

NUREG-1537, Part 2, Section 7.7, describes that the systems should be designed to interface with either analog or digital computerized reactor control system or reactor protection system if applicable.

SHINE FSAR Chapter 3, Table 3.1-3, "SHINE Design Criteria," states, in part, the SHINE design criteria as follows:

SHINE Design Criterion 13, “Instrumentation and controls,” instrumentation is provided to monitor variables and systems over the expected range of variation of the monitored variable during normal and transient operation. Also, this criterion requires that the information provided be sufficient to verify that individual safety limits are protected by independent channels. (Note: per FSAR Chapter 3 Tables 3.1-1 and 3.1-2 SHINE Design Criteria 13 applies to TRPS, ESFAS, CAMS, RAMS, and SRMS).

SHINE Design Criterion 38, “Monitoring radioactivity releases,” means are provided for monitoring the primary confinement boundary, hot cell, and glovebox atmospheres to detect potential leakage of gaseous or other airborne radioactive material. Potential effluent discharge paths and the plant environs are monitored for radioactivity that may be released from normal operations, including anticipated transients, and from postulated accidents. (Note: per FSAR Chapter 3 Table 3.1-2 SHINE Design Criteria 38 applies to TRPS, ESFAS, TPS, CAMS, RAMS, and SRMS).

SHINE FSAR Table 7.7-1, “Safety-Related Process Radiation Monitors,” identifies the safety-related process radiation monitors, monitored locations, total available channels, minimum required channels, and operability requirements. In addition, Tables 7.4-1, “TRPS Monitored Variables,” and 7.5-1, “ESFAS Monitored Variables,” identify the radiation variables monitored by the TRPS and ESFAS, respectively. These tables identify range, accuracy, and response time. Further, Section 7.7.1.3.4, “Independence,” describes that safety-related process radiation monitors provide analog communication to the ESFAS and TRPS controls. This section also describes that these radiation monitoring data is provided to non-safety systems through one-way isolated outputs.

SHINE FSAR Section 7.7.1.2.1, “Instrument and Controls,” states, in part, the “Safety-related radiation monitoring channels produce a full-scale reading when subject to radiation fields higher than the full-scale reading; however, they are expected to remain on-scale during accident conditions." Therefore, the NRC staff seeks clarification on the response of the radiation monitoring channels when subject to radiation fields that are higher than the full-scale reading.

1. Identify the means (e.g., radiation monitor and associated control room indications) provided for monitoring each: (1) the primary confinement boundary, (2) hot cell, and (3) glovebox atmospheres (to detect potential leakage of gaseous or other airborne radioactive material).

   Identify the means (e.g., radiation monitor and associated control room indications) provided for monitoring the potential effluent discharge paths and the plant environs for radioactivity that may be released from normal operations, including anticipated transients, and from postulated accidents.

2. Clarify the statement in Section 7.7.1.2.1 regarding response of the radiation monitoring channels is compatible with the digital equipment in the HIPS equipment (i.e., Is the associated HIPS value “full-scale” and valid or invalid?) when subjected to radiation fields higher than the full-scale reading.

The information requested is necessary to support the following finding in Section 7.7 of NUREG-1537, Part 2:

- The systems should be designed to interface with either analog or digital computerized RCS [reactor control system] or RPS [reactor protection system] if applicable.

(b) Tritium measurement and monitored variable

SHINE Design Criterion 38, "Monitoring radioactivity releases," states that:

> Means are provided for monitoring the primary confinement boundary, hot cell, and glovebox atmospheres to detect potential leakage of gaseous or other airborne radioactive material. Potential effluent discharge paths and the plant environs are monitored for radioactivity that may be released from normal operations, including anticipated transients, and from postulated accidents.

SHINE FSAR Section 7.7.1.4.1, "Functionality," describes that the TPS process monitors the tritium concentration within the TPS gloveboxes. SHINE FSAR Table 7.7-1, includes tritium as a monitored material. Based on this information, it is not clear to the NRC staff what instruments or monitors will be used for measuring tritium concentrations within the TPS gloveboxes. Also, it is not clear to the NRC staff whether tritium concentrations within the TPS gloveboxes will be presented to the operator in the control console.

SHINE FSAR Section 7.7.4.1, "System Description," describes that CAMS would be used to measure tritium activity to alert personnel when airborne contamination is above preset limits. Also, SHINE FSAR Section 7.7.5.1, "System Description," describes that the effluent monitoring system includes capabilities to collect and analyze tritium. Based on this information, it is not clear to the NRC staff whether tritium measurements by TPS process monitors, CAMS, and effluent monitors would be transmitted to the Process Integrated Control System. Therefore, it is not clear to the NRC staff what information will be presented to the operator in the control room to monitor the primary confinement boundary, hot cell, and glovebox atmospheres to detect potential leakage of gaseous or other airborne radioactive material.

In RAI 7-20 (a)(2) (ADAMS Accession No. ML21253A234), the NRC staff also requested identification of variables transmitted to the ESFAS, which may overlap with the information being requested in this RAI.

Update the SHINE FSAR to describe the radiation instrument and controls in place to measure tritium concentrations, as well as the information provided to operators in the control room related to tritium concentration for performing manual protective actions in accordance with SHINE Design Criterion 38.

(c) Setpoint Methodology and Calculations

NUREG-1537, Part 2, Section 7.7, describes, in part, that the instrument ranges should be sufficient to cover the expected range of variation of the monitored variable under the full range of normal operation and if assumed in the safety analysis report analysis, accident conditions. This section also describes that the sensitivity of each system should be commensurate with the precision and accuracy to which knowledge of the variable is required by analysis or design basis.

Subparagraph (c)(1)(ii)(A) of 10 CFR 50.36, “Technical specifications,” describes that limiting safety system settings (LSSS) are settings for automatic protective devices related to those variables having significant safety functions. This requires that a LSSS is specified for a variable on which a safety limit has been placed, the setting must be chosen so that automatic protective action will correct the abnormal situation before a safety limit is exceeded.

SHINE FSAR Section 7.7.1.2.1 states, in part, that “Setpoints are selected based on analytical limits and calculated to account for known uncertainties in accordance with the setpoint determination methodology.” In addition, SHINE FSAR Section 7.7.1.4.3, “Setpoints, Calibration and Surveillance,” states, in part, that “Setpoints for safety-related process radiation monitors are selected based on analytical limits and calculated to account for known uncertainties in accordance with the setpoint determination methodology.”

SHINE technical specification (TS) Table 3.7.1-a, “Safety-Related Radiation Monitoring Instruments,” identifies the setpoints for the safety-related radiation monitors. However, the SHINE FSAR does not describe the methodology used to determine these setpoints. The SHINE FSAR Section 7.2.1 states that a setpoint methodology is used for establishing and calibrating setpoints for safety-related I&C functions. This FSAR section generally describes SHINE’s setpoint methodology but lacks specificity in calculating setpoints for various types of instruments used in varying applications. The setpoints for protective function should be based on a documented analysis methodology that identifies assumptions and accounts for instrument uncertainties, such as environmental allowances and measurement computational errors associated with each element of the instrument channel.

1. Identify all **<u>automatic protective actions</u>** that are initiated based on a (radiation monitor related) setpoint other than those of TRPS and ESFAS (which are addressed by the response to RAI 7-20). The following additional questions apply to the non-TRPS/ESFAS setpoints.

2. Revise the SHINE FSAR to describe the setpoint methodology used to establish the setpoints or LSSS from the analytical limits for the variables monitored. The description of the setpoint methodology should include parameters typically consider instrument precision, sensitivity, accuracy, loop uncertainties, and computational errors.

3. Provide a definition of the equipment accuracy identified in SHINE FSAR Table 7.7-1 and that used in the setpoint methodology.

The information requested is necessary to support the following finding in Section 7.4 of NUREG-1537, Part 2:

- The protection channels and protective responses are sufficient to ensure that no safety limit, limiting safety system setting, or related limiting condition of operation discussed and analyzed in the SHINE FSAR will be exceeded. (Also, see RAI 7-20(f) in which the NRC staff requested information on the setpoint methodology used to establish the setpoints or LSSS from the analytical limits for the variables monitored by the TRPS and ESFAS.).

SHINE Response

(a) Monitored and displayed variables

1. The safety-related process radiation monitors that monitor the primary confinement boundary are described in Table 7.7-1 of the FSAR as units 17 through 24.

   The safety-related process radiation monitors that monitor the hot cell (i.e., supercell) are described in Table 7.7-1 of the FSAR as units 1 through 10 and 25 through 27.

   The safety-related process radiation monitors that monitor the tritium purification system (TPS) glovebox atmospheres are described in the SHINE Response to Part (b) of RAI 7-28.

   The safety-related process radiation monitors that monitor the potential effluent discharge paths and the plant environs are described in Table 7.7-1 of the FSAR as units 11, 12, and 16.

   The safety-related process radiation monitors described in Table 7.7-1 of the FSAR provide inputs to the target solution vessel (TSV) reactivity protection system (TRPS) or engineered safety features actuation system (ESFAS). As described in the SHINE Response to Part (a)(1) of RAI 7-20 (Reference 3), variables monitored by the TRPS and ESFAS are provided to operators in the facility control room (FCR) to monitor the operation and status of the irradiation facility (IF) and the radioisotope production facility (RPF).

   The RAMS, CAMS, and SRMS provide defense-in-depth functions and indications as described in the SHINE Response to Part (c) of RAI 7-30.

2. The safety-related process radiation monitors are designed to function during normal operation, anticipated transients, and design basis accidents to a level required to detect accident conditions and provide safety-related inputs to the TRPS and ESFAS to initiate protective actions. If the measured radiation field goes above the full-scale, the analog output from the safety-related process radiation monitor will be equivalent to the full-scale reading. The TRPS or ESFAS will process this signal as a valid, full-scale value.

   SHINE has revised Subsections 7.7.1.2.1 and 7.7.1.3.1 of the FSAR to clarify the descriptions of how the safety-related process radiation monitors provide indication when subjected to radiation fields higher than the full-scale reading. A markup of the FSAR incorporating these changes is provided as Attachment 1.

(b) Tritium measurement and monitored variable

The safety-related process radiation monitors which measure tritium concentration within the TPS gloveboxes are described in Table 7.7-1 of the FSAR as units 13, 14, and 15 for TPS confinement A, B, and C, respectively. Additionally, unit 16 of Table 7.7-1 of the FSAR measures tritium concentration in TPS exhaust. These tritium monitors provide input to ESFAS. As described in the SHINE Response to Part (a)(1) of RAI 7-20 (Reference 3), variables monitored by the ESFAS are provided to operators in the FCR to monitor the operation and status of the IF and the RPF.

In addition to the above-identified safety-related process radiation monitors which measure tritium concentration, Tritium Monitor 12 and Tritium Monitor 13 of the CAMS, as described in

Table 7.7-3 of the FSAR, measure tritium concentration. Information from the nonsafety-related CAMS is provided to operators in the facility control room via the process integrated control system (PICS), as described in the SHINE Response to RAI 7-30(c).

SHINE Design Criterion 38 does not require the performance of manual protective actions to be satisfied. As described in the SHINE Response to Part (a)(1) of RAI 7-20, manual protective actions are not required for the safe operation of the SHINE facility.

As the above information is already provided in the SHINE licensing basis, no additional need to modify the FSAR was identified.

(c) Setpoint Methodology and Calculations

1. There are no automatic protective actions that are initiated based on a radiation monitor related setpoint other than those of the TRPS and the ESFAS.

   The safety-related process radiation monitors identified in Table 7.7-1 of the FSAR each provide an input to the TRPS or the ESFAS based upon the radiation readings detected. There are no setpoints in the safety-related process radiation monitors themselves, and no logic is performed within a monitor to compare a safety-related process radiation monitor reading with a setpoint. Setpoints associated with the safety-related process radiation monitors are contained in the TRPS and the ESFAS. The TRPS and the ESFAS receive inputs from the safety-related process radiation monitors, compare these inputs to the associated setpoints, and generate an actuation signal as necessary. Inputs from safety-related process radiation monitors to the TRPS and ESFAS and the logic used to generate an actuation signal are provided in Figure 7.4-1 and Figure 7.5-1 of the FSAR, respectively.

   The SHINE Response to Part (f) of RAI 7-20 (Reference 3) provides a description of the methodology used to establish setpoints for the TRPS and ESFAS.

2. N/A – There are no automatic protective actions that are initiated based on a radiation monitor related setpoint other than those of the TRPS and the ESFAS.

3. N/A – There are no automatic protective actions that are initiated based on a radiation monitor related setpoint other than those of the TRPS and the ESFAS.

RAI 7-29

NUREG-1537, Part 2, Section 7.7 describes, in part, that information should be provided for the NRC staff to evaluate the signal processing equipment, computer hardware and software that controls sampling, detection, signal processing and logic, power supplies, and actuation systems that accomplish a function for the system.

SHINE FSAR Section 7.7.1.1, “System Description,” states, in part:

> Safety-related process radiation monitors provide input to the safety-related ESFAS or TRPS control systems. These components monitor for either fission products (via beta detection) or tritium. Beta detection radiation monitors are part of the ESFAS or TRPS. The type of safety-related process radiation monitor (fission product or tritium) is selected based on the location and identity of the radioactive material present. The ESFAS and TRPS

process radiation monitors (beta detection) are intended to detect abnormal situations within the facility ventilation systems and provide actuation signals to the ESFAS controls. Safety-related tritium monitors are part of the TPS. The TPS monitors are installed within various portions of the TPS to detect potential tritium releases, provide actuation signals to the ESFAS controls, and provide interlock inputs to the TRPS controls.

SHINE FSAR Sections 7.7.1.3, "Design Bases," and 7.7.1.4, "Operation and Performance," describe design bases and operation and performance of the safety-related process radiation monitors. Based on the information in the SHINE FSAR, the NRC staff does not have a clear description of the radiation monitoring equipment to be installed in the facility (i.e., technology included).

Revise the FSAR to describe whether the safety-related process radiation monitors use analog or digital technology. If the safety-related process radiation monitors use digital technology (per NUREG-1537, Part 2, Section 7.7) describe how the hardware and software for these radiation monitors meet the guidelines of Institute of Electrical and Electronics Engineers (IEEE) Std. 7-4.3.2-1993, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," and Regulatory Guide (RG) 1.152, Revision 1, "Criteria for Digital Computers In Safety Systems of Nuclear Power Plants," and software meets the guidelines of American National Standards Institute/American Nuclear Society (ANSI/ANS)-10.4-1987, "Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry."

The information requested is necessary to support the following finding in Section 7.7 of NUREG-1537, Part 2:

- The designs and operating principles of the instrumentation and control of the radiation detectors and monitors have been described, and have been shown to be applicable to the anticipated sources of radiation.

SHINE Response

Safety-related process radiation monitors that monitor for tritium, described as units 13, 14, 15, and 16 of Table 7.7-1 of the FSAR, use solely analog technology. Safety-related process radiation monitors that monitor for fission products, described as units 1 through 12 and 17 through 27 of Table 7.7-1 of the FSAR, use digital detectors to provide an analog signal to the TRPS or ESFAS. The processing of these analog signals by the TRPS and the ESFAS is described in the SHINE Response to Part (c) of RAI 7-28 and the SHINE Response to RAI 7-31.

In lieu of complying with the nuclear power plant-specific guidance of Regulatory Guide 1.152, "Criteria for the Use of Computers in Safety Systems of Nuclear Power Plants", SHINE complies with applicable portions of Institute of Electrical and Electronics Engineers (IEEE) 7-4.3.2-2003, "Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations" (Reference 4). The safety-related process radiation monitors that use digital detectors comply with Sections 5.3.1, 5.3.2, 5.3.4, 5.3.5, 5.3.6, 5.5.1, 5.5.2, and 5.5.3 of IEEE 7 4.3.2 2003. SHINE has procured the safety-related process radiation monitors from a quality level (QL)-1 vendor that documents compliance with these applicable sections of IEEE 7 4.3.2-2003.

SHINE considers the guidance contained in the above-listed sections of IEEE 7-4.3.2-2003 to be sufficient and more current than that contained in American National Standards Institute

(ANSI)/American Nuclear Society (ANS)-10.4-1987, "Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry" (Reference 5). The most recent version of this standard (i.e., ANSI/ANS-10.4-2008, "Verification and Validation of Non-Safety-Related Scientific and Engineering Computer Programs for the Nuclear Industry" [Reference 6]) would not be applicable to the safety-related process radiation monitors that use digital detectors.

SHINE has revised Subsection 7.7.1.1 of the FSAR to describe the use of analog and digital technology for safety-related process radiation monitors. A markup of the FSAR incorporating these changes is provided as Attachment 1.

RAI 7-30

NUREG-1537, Part 2, Section 7.7 states that, "The systems and equipment should be designed for reliable operation in the environment in which they will function." This section also describes that consideration should be given to the need for single failure protection, seismic and environmental qualification protection, and diversity.

SHINE FSAR Section 7.7.1.4.2, "Reliability, Adequacy, and Timeliness," describes reliability for the safety-related process radiation monitors. SHINE FSAR Section 7.7.1.3, describes the design bases for the safety-related process radiation monitors, including single failure, independence, and redundancy.

(a) Single failure

SHINE FSAR Section 7.7.1.3.3, "Single Failure," describes that safety-related redundant monitors are used for locations requiring radiation monitoring, and for locations where spurious actuation of the process radiation monitor could significantly impact overall facility operation, a third sensing channel was added. Adding redundant monitors increases the reliability of the system. Further, SHINE FSAR Section 7.7.1.3.5, "Redundancy," describes how the system meets the single failure criterion by using redundant safety-related monitors. However, the FSAR does not describe how these monitors are assigned to each division of the ESFAS and TRPS.

1. Update the SHINE FSAR to demonstrate that single failures in the safety-related process radiation monitors do not result in loss of the protection or mitigation function.

2. Update the SHINE FSAR to identify radiation monitors that are only assigned to Division A for TRPS and ESFAS, as appropriate, as well as radiation monitors that include a third sensing division (Division C).

(b) Independence

SHINE FSAR Section 7.7.1.3.4, describes independence of the safety-related process radiation monitors. This section provides information about communication, physical, and electrical independence. SHINE FSAR Section 7.7.1.3.7, "Fire Protection," notes that physical separation is used to achieve separation of redundant sensors. This section also notes that wiring for redundant channels uses physical separation and isolation to provide independence for circuits. However, the information in FSAR Sections 7.7.1.3.4 and 7.7.1.3.7 does not provide sufficient information for the NRC staff to assess how independence is implemented to prevent the failure of the safety-related process radiation monitors and provide reliable operation. The FSAR

should describe how the safety-related process radiation monitors include electrical and communications independence both within the safety-related radiation monitoring channels and between the safety-related process radiation monitors and non-safety-related systems. For communication independence, the FSAR should demonstrate that credible failures such as a logical or software malfunction of the non-safety system would not affect the functions of the safety-related process radiation monitors.

Section 7.7.1.3.4 of the FSAR states that the safety-related process radiation monitors from separate divisions are physically separated from each other and independently powered from the associated UPSS division. However, the information provided is insufficient to evaluate how the safety-related process radiation monitors would be powered and how the system would be powered in case of a loss of power. The FSAR should describe electrical independence are used to maintain the independence of safety-related process radiation monitor circuits and equipment among redundant safety divisions or with non-safety systems so that the safety functions required during and following any analyzed accident can be accomplished.

Update the SHINE FSAR to explain how the safety-related process radiation monitors design implements communication and electrical independence to provide reliable operation.

(c) Defense-in-depth

NUREG-1537, Part 1, Section 7.1.2, “Design Criteria,” describes in part that the SAR should discuss diversity and redundancy of ICSs, and other defense-in-depth features.

Although the SHINE FSAR does not identify any SHINE Design Criterion or criterion for defense-in-depth, SHINE FSAR Section 7.7.1.3.1, “Design Bases Functions,” notes that radiation monitoring systems are provided for defense-in-depth. It is not clear to the NRC staff if other (non-safety-related) monitors are installed in certain areas, and therefore provide defense-in-depth to the safety-related radiation monitoring channels. Also, SHINE FSAR Sections 7.7.3.1 and 7.7.4.1 note that the RAMS and continuous air monitoring system CAMS provide defense-in-depth to alert personnel on the need to evacuate. Based on this information, it is not clear to the NRC staff whether the RAMS and CAMS are providing defense-in-depth to the safety-related radiation monitoring channels.

Confirm if only CAMS and RAMS provide defense-in-depth to safety-related process radiation monitors and provide a list of relevant information that would be transmitted to the operators.

Specifically, the information requested in parts (a) through (c) of RAI 7-30, above, is necessary to support the following evaluation findings in Section 7.7 of NUREG-1537, Part 2:

- The systems and equipment should be designed for reliable operation in the environment in which they will function.

- The systems should be designed not to fail or operate in a mode that would prevent the RPS from performing its safety function, or prevent safe reactor shutdown.

SHINE Response

(a) Single failure

1. Safety-related process radiation monitors were considered as sensors in the single failure analysis of the TRPS and ESFAS described in the SHINE Response to RAI 7-12 (Reference 7). Single failures in safety-related process radiation monitors do not result in a loss of the protection function, as described in the SHINE Response to RAI 7-12. Subsection 7.4.5.2.2 of the FSAR was updated as part of the SHINE Response to RAI 7-12 to enhance the description of the single failure analysis of the TRPS and ESFAS.

2. The assignment of safety-related process radiation monitors to each division of the TRPS and the ESFAS is shown in Figure 7.4-1 and Figure 7.5-1 of the FSAR.

   There are no safety-related process radiation monitors assigned only to Division A of the TRPS or the ESFAS.

   Safety-related process radiation monitors that include a third sensing division (i.e., Division C) are shown in Figures 7.4-1 and 7.5-1 of the FSAR as described above. Additionally, these safety-related process radiation monitors are identified as having three total available channels in Table 7.7-1 of the FSAR.

(b) Independence

The safety-related process radiation monitors are electrically separated by division, as described in Subsection 7.7.1.3.7 of the FSAR, and provide analog signals to a particular division of the TRPS or the ESFAS. As described in Subsection 7.4.5.2.1 of the FSAR, physical separation is maintained between divisions of safety-related process radiation monitors, and divisional independence is maintained from the safety-related process radiation monitor, through the TRPS and ESFAS, to the devices actuating the protective function.

The safety-related process radiation monitors are included in the safety-related instrumentation depicted in Figure 7.1-1 of the FSAR, provide analog signals directly to the TRPS and ESFAS, and do not interface electrically with any nonsafety-related system. Electrical separation is maintained between safety-related and nonsafety-related systems in accordance with Section 5.1.1.2, Table 1 of Section 5.1.3.3, and Table 2 of Section 5.1.4 of IEEE Standard 384-2008, "Standard Criteria for Independence of Class 1E Equipment and Circuits" (Reference 8). Therefore, credible failures of nonsafety related systems would not affect the functions of the safety-related process radiation monitors, demonstrating communications independence.

Electrical independence is maintained in the power supplies to the safety-related process radiation monitors. Safety-related process radiation monitors associated with division A receive power from division A of the uninterruptible electrical power supply system (UPSS). Safety-related process radiation monitors associated with Division B receive power from division B of the UPSS. Safety-related process radiation monitors associated with division C receive auctioneered power from division A and division B of the UPSS. The UPSS provides safety-related power to system loads, including the safety-related process radiation monitors, as described in Subsection 8a2.2.3 of the FSAR.

SHINE has revised Subsection 7.7.1.3.4 and Subsection 7.7.1.3.7 of the FSAR to enhance the description of how safety-related process radiation monitors implement independence. A markup of the FSAR incorporating these changes is provided as Attachment 1.

(c) Defense-in-depth

As stated in Subsection 7.7.1.3.1 of the FSAR, for defense-in-depth, the radiologically controlled area (RCA) exhaust, general area direct radiation levels, and general area airborne particulates are monitored by stack release, radiation area, and continuous area monitors, respectively. The monitors referred to in this sentence are part of the SRMS, the RAMS, and the CAMS. Therefore, the SRMS, RAMS, and CAMS provide defense-in-depth to the safety-related process radiation monitors. Nonsafety-related process monitors described in Subsection 7.7.2 of the FSAR are not used for defense-in-depth to the safety-related radiation monitors.

Information from each RAMS monitor (radiation dose rate) is provided to the operators in the facility control room via the PICS, as described in Subsection 7.7.3 of the FSAR. Table 7.7-2 of the FSAR provides the locations of the RAMS monitors.

Information from each CAMS monitor (airborne radiation levels) is provided to operators in the facility control room via the PICS, as described in Subsection 7.7.4 of the FSAR. Table 7.7-3 of the FSAR provides the locations of the CAMS monitors.

A description of the information the SRMS provides to the operators in the facility control room is provided in the SHINE Response to RAI 7-32.

RAI 7-31

SHINE FSAR Section 7.7.1.3.4, describes that the safety-related process radiation monitors provide analog signals to the TRPS and ESFAS. Further, SHINE FSAR Section 7.7.1.4.1, describes the functionality of the safety-related process radiation monitors, which transmits signals to the TRPS to actuate safety functions and the ESFAS to provide an actuation signal when radiation levels exceed pre-determined limits. SHINE FSAR Figures 7.4-1, “TRPS Logic Diagrams,” and 7.5-1, “ESFAS Logic Diagrams,” in the SHINE FSAR show the logic diagrams for the TRPS and ESFAS, respectively. While these figures show the actuation signal, the logic to process the analog signals and generate the actuation signal is not described.

Update the SHINE FSAR to describe where the logic and processing of the radiation monitor signals are performed, as well as identify what signals are transmitted to the TRPS and ESFAS.

The information requested is necessary to support the following finding in Section 7.7 of NUREG-1537, Part 2:

- The systems should be designed to interface with either analog or digital computerized RCS or RPS if applicable.

SHINE Response

The safety-related process radiation monitors identified in Table 7.7-1 of the FSAR provide analog signals indicating radiation levels to the TRPS and the ESFAS. There are no setpoints in the safety-related process radiation monitors themselves, and no logic is performed within a monitor to compare a safety-related process radiation monitor reading with a setpoint. Setpoints

associated with the safety-related process radiation monitors are contained in the TRPS and the ESFAS. The TRPS and the ESFAS receive inputs from the safety-related process radiation monitors, compare these inputs to the associated setpoints, and generate an actuation signal as necessary. Inputs from safety-related process radiation monitors to the TRPS and the ESFAS and the logic used to generate an actuation signal are provided in Figures 7.4-1 and 7.5-1 of the FSAR. This logic scheme is further described in the SHINE Response to RAI 7-21 (Reference 3).

SHINE has revised Subsection 7.7.1 of the FSAR to clarify the descriptions of the signals transmitted from the safety-related process radiation monitors to the TRPS and ESFAS. A markup of the FSAR incorporating these changes is provided as Attachment 1.

RAI 7-32

The SHINE facility includes a SRMS to monitor effluents in the facility. This system, as described in SHINE FSAR Section 7.7.5, "Effluent Monitoring," includes the carbon delay bed effluent monitor (CDBEM), which monitors for noble gases at the exhaust of the process vessel vent system (PVVS) carbon delay beds to provide information about the health of the PVVS carbon delay beds and to provide the ability to monitor the safety-related exhaust point effluent release pathway when it is in use. SHINE FSAR Section 7.7.5.2.1, "Applicable Design Criteria," states, in part, that "The SRMS units are designed to operate under normal facility conditions and to detect radiation that may be indicative of anticipated transients or design basis accidents." However, the SHINE FSAR does not clearly describe what information will be presented to the operator for normal operation of the facility and if any manual protective actions are required based on detected radiation levels by the SRMS units that may be indicative of anticipated transients or design basis accidents. Also, the SHINE FSAR refers to but does not fully describe or explain what is the "safety-related exhaust point effluent release pathway" and when it is used. SHINE FSAR Section 7.7.5.1, "System Description," notes that the CDBEM does not perform any accident mitigation or personnel protection, and instead it is used to monitor compliance with regulatory limits.

Update the SHINE FSAR to describe information necessary for normal operation of the facility and if any manual protective actions are required based on detected radiation levels by the SRMS units that may be indicative of anticipated transients or design basis accidents.

The information requested is necessary to support the following finding in Section 7.6 of NUREG-1537, Part 2:

- The outputs and display devices showing reactor nuclear status should be readily observable by the operator while positioned at the reactor control and manual protection systems.

SHINE Response

The SRMS is composed of two monitoring units: the stack release monitor (SRM) and the carbon delay bed effluent monitor (CDBEM), as described in Subsection 7.7.5.1 of the FSAR. The SRMS monitors provide defense-in-depth for the safety-related process radiation monitors, as described in the SHINE Response to Part (c) of RAI 7-30. Noble gas activity levels from SRMS monitors will be available to operators in the facility control room. There are no manual protective actions required based on detected radiation levels by the SRMS monitors.

The safety-related exhaust point depicted in Figure 7.7-1 of the FSAR and described in Subsection 7.7.5.4 of the FSAR is associated with the carbon delay beds, which are part of the process vessel vent system (PVVS). Safety functions associated with the PVVS are described in Subsection 9b.6.1.3 of the FSAR. Safety actuations associated with monitored variables in the PVVS are described in Subsections 7.5.3.1.14, 7.5.3.1.15, 7.5.3.1.16, and 7.5.3.1.23 of the FSAR. Although the CDBEM monitors a safety-related point in the PVVS system, the CDBEM is not required to perform a safety function. The CDBEM is used to monitor the health of the carbon delay beds and provide indication of noble gas concentrations to support monitoring for regulatory compliance, as described in Subsection 7.7.5.1 of the FSAR.

SHINE has revised Subsection 7.7.5.4 of the FSAR to enhance the description of the safety-related exhaust point. A markup of the FSAR incorporating these changes is provided as Attachment 1.

RAI 7-33

NUREG-1537, Part 2, Section 7.7, describes, in part, that the systems should be designed not to fail or operate in a mode that would prevent the RPS from performing its safety function, or prevent safe reactor shutdown.

SHINE FSAR Section 7.7.1.3.3, describes how the safety-related process radiation monitors design addresses single failure. This section describes that no single failure of a detector, control division, or power division will prevent the safety-related system from performing its safety function. However, the SHINE FSAR does not describe assessments performed to identify the potential failures and the associated analyses that confirm these failures would not "prevent the RPS from performing its safety function, or prevent safe reactor shutdown" or initiate a condition not considered in the accident analyses.

1. Update the SHINE FSAR to include a summary description of the potential safety-related process radiation monitors failures identified and confirm that they would not affect the operation of the TRPS and ESFAS, as requested by RAI 7-12. (Note: An audit can be used to confirm the description).

2. Update the SHINE FSAR to include a summary description of the fail-safe state of the safety-related radiation process monitors when the system loses electrical power and when other known failures manifest. (Note: An audit can be used to confirm the description).

The information requested is necessary to support the following finding in Section 7.7 of NUREG-1537, Part 2:

- The systems should be designed not to fail or operate in a mode that would prevent the RPS from performing its safety function, or prevent safe reactor shutdown.

SHINE Response

1. For each safety-related process radiation monitor input to the TRPS or the ESFAS, there are either two (to Divisions A and B) or three (to Divisions A, B, and C) redundant and independent radiation monitors which provide an analog input to the respective TRPS or ESFAS division. The input provided to the TRPS or ESFAS is a signal based upon the radiation levels detected. The TRPS or ESFAS compares this signal to a setpoint and

determines if an automatic protective action is required. Automatic protective actions based on two inputs utilize one-out-of-two (1oo2) voting logic whereas those based on three inputs utilize two-out-of-three (2oo3) voting logic. The application of the voting logic takes place internal to the TRPS or ESFAS.

The safety-related process radiation monitors are considered in the single failure analysis described in the SHINE Response to RAI 7-12 (Reference 7). For functions with 1oo2 voting, the protective action is initiated if one of the two channels vote to trip. If one of the two channels fail such that it does not produce a trip, the remaining channel is capable of initiating the required protective action. For functions with 2oo3 voting, the protective action is initiated if two of the three channels vote to trip. If one of the three channels fail such that it does not produce a trip, the remaining two channels are capable of initiating the required protective action.

Potential failure types for inputs from the safety-related process radiation monitors to the TRPS and ESFAS are identified and evaluated in the failure modes and effects analysis (FMEA) described in the SHINE Response to RAI 7-12. The failure types identified for these inputs include the signal Failing Low, Failing High, Short Circuit, Open Circuit, Fail As Is, and a Loose Connection.

For the Failing Low and Failing High failure types, automatic signal limits checking in the Safety Function Module (SFM) detect the fault and generate alarm information which is provided to the PICS for alerting an operator. When this type of fault occurs, the SFM provides the fault information to its associated scheduling and bypass modules (SBM) or scheduling, bypass, and voting modules (SBVM) and the partial trip information for the failed channel is determined by the SBMs or SBVMs based on the state of the associated SFM's Trip/Bypass switch, the position of which is controlled by facility technical specifications during normal operation.

For the Short Circuit and Open Circuit failure types, the result is similar to the Failing Low/Failing High failure types in that the fault is detected by self-testing in the input submodule (ISM) on the SFM, the fault information is then provided to the associated SBMs or SBVMs, and the partial trip information for the failed channel is determined by the SBMs or SBVMs based on the state of the associated SFM's Trip/Bypass switch.

For the Fail As Is failure type, the associated division is not able to determine the need for a protective action when conditions exist. For functions with 2oo3 voting, there are two other divisions available to make a trip determination. For functions with 1oo2 voting, there is one other division available to make a trip determination.

For the Loose Connection failure type, this would have a similar result as the Failing Low, Failing High, or Open Circuit failure types.

Therefore, the FMEA shows that the failure modes applicable to the safety-related process radiation monitors do not affect the operation of the TRPS or ESFAS.

SHINE has revised Subsection 7.7.1.3.3 of the FSAR to enhance the description of single failure for the safety-related process radiation monitors. A markup of the FSAR incorporating these changes is provided as Attachment 1.

2. If the safety-related process radiation detectors lose power, analog outputs to the TRPS or the ESFAS Fail Low and the partial trip information for the failed channel is determined based upon the associated SFM's out-of-service status, as described above. Any other known failures associated with the safety-related process radiation monitor coincident with loss of power to the monitor do not result in a failure different from the six failure types discussed above.

   SHINE has revised Subsection 7.7.1.3.3 of the FSAR to enhance the description of a loss of power for the safety-related process radiation monitors. A markup of the FSAR incorporating these changes is provided as Attachment 1.

RAI 7-34

NUREG-1537, Part 2, Section 7.7, "Radiation Monitoring Systems," describes that the systems and equipment should be designed for reliable operation in the environment in which they will function.

SHINE Design Criterion 13, "Instrumentation and controls," states, in part, that instrumentation is provided to monitor variables and systems over the expected range of variation of the monitored variable during normal and transient operation.

SHINE FSAR Section 7.7.1.3.2, "Operating Conditions," describes the environmental conditions for the different areas within the SHINE facility. However, this FSAR section does not include information for the NRC staff to confirm that the equipment environmental test results envelop the environmental conditions identified in FSAR Tables 7.2-2 through 7.2-5.

In addition, SHINE FSAR Section 7.7.1.3.7, "Fire Protection," describes that the connection from the radiation monitoring components to the ESFAS or TRPS have certifications that demonstrate the ability to inhibit the propagation of flame in the event of a fire. SHINE FSAR Section 7.7.1.3.8, "Natural Phenomena Hazards and Dynamic Effects," describes that process radiation monitors are Seismic Category I, designed in accordance with Section 8 of IEEE Std. 344-2013, "IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations." SHINE FSAR Section 7.7.5.3.3, "Quality," describes that the American National Standards Institute (ANSI) N13.1-1999, "Sampling and Monitoring Release of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities," was applied to the design of the facility effluent monitors. However, the FSAR does not include information of how the radiation monitoring system meets these requirements.

1. Confirm that the radiation monitors equipment has been tested and qualified for the environmental conditions at the installed locations over the lifetime of the facility and/or describe the testing and qualification process.

2. Update the SHINE FSAR to include a summary explanation of how the radiation monitors meet SHINE-specific requirements for seismic, electrical, and other conditions anticipated within the facility.

The information requested is necessary to support the following finding in Section 7.7 of NUREG-1537, Part 2:

- The systems and equipment should be designed for reliable operation in the environment in which they will function.

SHINE Response

The safety-related process radiation monitors are qualified to SHINE-specific requirements by the vendor. A discussion of the environmental, seismic, and electromagnetic interference (EMI)/radio frequency interference (RFI) qualifications testing of the safety-related process radiation monitors are as follows.

Environmental Qualification

Safety-related process radiation monitors are environmentally qualified using guidance provided in Sections 4.1, 5.1, 6.1, and 7 of IEEE Standard 323-2003, “Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations” (Reference 9). The safety-related process radiation monitors are qualified to the environmental parameters provided in Tables 7.2-1, 7.2-3, and 7.2-6 of the FSAR.

Seismic Qualification

The safety-related process radiation monitors are seismically qualified in accordance with Section 8 of IEEE Standard 344-2013, “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations” (Reference 10) using triaxial testing.

EMI/RFI Qualification

EMI/RFI qualification of the safety-related process radiation monitors is performed by testing for emissions, susceptibility, and power surge withstand capability. The safety-related process radiation monitors will be grounded in accordance with Section 5.2.1 of IEEE 1050-2004, “Guide for Instrumentation and Control Equipment Grounding in Generating Stations” (Reference 11).

SHINE has revised Subsections 7.7.1.3 and 7.7.1.4 of the FSAR to enhance the explanation of how the safety-related process radiation monitors are qualified for the seismic, environmental, and electromagnetic conditions anticipated in the facility. A markup of the FSAR incorporating these changes is provided as Attachment 1.

RAI 7-35

NUREG-1537, Part 1, Chapter 7, “Instrumentation and Control Systems,” states:

- In this chapter, the applicant should discuss … the bases of technical specification limiting safety system settings (LSSSs), limiting conditions of operation (LCOs), and surveillance requirements for the I&C systems....

NUREG-1537, Part 2, Section 7.7, “Radiation Monitoring Systems,” describes that the systems and equipment should be readily tested and capable of being accurately calibrated. This section also describes that the bases of TSs, including surveillance tests and intervals, should be

sufficient to ensure that the systems will be operable and will perform their designed functions. Please identify the FSAR section that includes this information. See questions 1 and 4 below.)

Subparagraph (c)(3) of 10 CFR 50.36 states: "Surveillance requirements [(SRs)] are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met." (Identify the FSAR section that describes how the SRs for the radiation monitoring systems ensure the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met. See questions 1 and 4 below.)

SHINE FSAR Section 7.7.5.4.1, "Technical Specifications," states, in part, that "[c]ertain material in this section provides information that is used in the technical specifications," but does not provide additional specificity of how SR frequencies, completion times, and actions in TS Table 3.7.1-a ensure radiation levels within the facility and radiation released to the environment will be within allowable limits when channels are inoperable. Section 7.7.5.4.1 states, in part, that "significant material is also applicable to, and may be referenced by, the bases that are described in the technical specifications." Information in the TS bases should summarize information provided in the FSAR. Information in the TS bases may provide details to partially address the questions below. If so, this information should be incorporated into the FSAR, as appropriate.

SHINE FSAR Section 7.7.1.2.1, "Instrumentation and Controls," describes that the safety-related process radiation monitor setpoints were selected based on analytical limits and the monitors are periodically functionally tested and maintained. Further, SHINE FSAR Section 7.7.1.4.3, "Setpoints, Calibration and Surveillance," notes that these monitors are tested periodically in accordance with SHINE TS to verify operability, and that they are calibrated using commercial radionuclide standards. SHINE TS SR 3.7.1 (Revision 4) defines the frequency for testing the safety-related radiation monitors, and SHINE TS SR 3.7.2 defines the frequency for testing the effluent monitors.

In addition, the TS bases describes that the scope of SHINE TS LCO 3.7.1 begins at the radiation monitoring input devices, includes the associated safety function modules (SFMs), and extends to the inputs to the scheduling, bypass, and voting modules (SBVMs) or scheduling and bypass modules (SBMs). However, SHINE TS LCOs 3.2.1 and 3.2.2 identify the SRs for the SFM, SBVM or SBM for the TRPS and ESFAS, respectively. Based on this information these surveillances may overlap certain components, even though their surveillance frequency is different. The SHINE FSAR does not include sufficient information for the NRC staff to understand how these systems will be tested and maintained to ensure operability.

It is also not clear how the monitored locations in SHINE TS Table 3.7.1-a correlates to all of the 24 safety related process monitors listed in Table 7.7-1. It is also not clear how certain actions for multiple inoperable channels, such as damper closure, to compensate for the systems inability to automatically initiate the associated protective action describe in FSAR Sections 7.7.1.3.1 and 7.7.1.4.1.

1. Per Section 14.1 of the FSAR, "Technical Specifications," SHINE states the TS were developed following the format and content guidance of ANSI/ANS-15.1-2007. Explain the reason for not having checks and calibrations in the TS for CAMS, RAMS, and effluent monitors (described in Table 7.7-2 and 7.7-3 in the FSAR) as established in

Section 4.7 of ANSI/ANS-15.1, 2007, "The Development of Technical Specifications for Research Reactors," provides guidance for radiation monitoring systems and effluents.

2. Describe how the SHINE FSAR Table 7.7-1, "Safety-Related Process Radiation Monitors," corresponds to SHINE TS Table 3.7.1-a, "Safety-Related Radiation Monitoring Instruments." Update the SHINE FSAR and/or TS to ensure consistent labeling for each radiation monitor.

3. Update the SHINE FSAR to describe how the surveillance frequencies were selected, considering how the whole instrument channel would be surveilled to ensure the continued operability of the radiation monitors when required.

4. Update the SHINE FSAR to explain how the scope of SHINE TS LCOs 3.2.1 and 3.2.2 and the scope of SHINE TS LCO 3.7.1 demonstrate operability of the radiation monitors.

The information requested is necessary to support the following finding in Section 7.7 of NUREG-1537, Part 2:

- The bases of technical specifications, including surveillance tests and intervals, should be sufficient to ensure that the systems will be operable and will perform their designed functions.

SHINE Response

1. Section 1.2.1 of ANSI/ANS-15.1-2007, "The Development of Technical Specifications for Research Reactors" (Reference 12) states, "Only those operational parameters and equipment requirements directly related to verifying and preserving that safe envelope shall be listed." As described in Subsections 7.7.3.1, 7.7.4.1, and 7.7.5.1, the CAMS, the RAMS, and the SRMS do not perform a safety function. Therefore, limiting conditions for operation (LCOs) and surveillance requirements (i.e., checks and calibrations) related to these nonsafety-related radiation monitoring systems are not included in the technical specifications. The safety-related process radiation monitors listed in LCO 3.7.1 of the technical specifications satisfy the requirements for monitoring systems provided in Section 3.7.1 of ANSI/ANS-15.1-2007. The CAMS, RAMS, and SRMS provide defense-in-depth for the safety-related process radiation monitors, as described in the SHINE Response to Part (c) of RAI 7-30. Calibration and testing of the RAMS, CAMS, and SRMS is described in Subsections 7.7.3.4, 7.7.4.4, and 7.7.5.4 of the FSAR, respectively.

   SHINE has revised Subsection 7.7.5.4.1 of the FSAR to clarify the non-applicability of the SHINE technical specifications to the SRMS. A markup of the FSAR incorporating these changes is provided as Attachment 1. SHINE has also revised LCO 3.7.2 of the technical specifications to remove the SRMS from the scope of the surveillance requirements and to modify the action to report exceeding the limit. A markup of the technical specifications incorporating these changes is provided as Attachment 2.

2. Table 7.7-1 of the FSAR and Table 3.7.1-a of the technical specifications represent the same safety-related process radiation monitors. While SHINE grouped several safety-related process radiation monitors identified in Table 7.7-1 of the FSAR into a single row in Table 3.7.1-a of the technical specifications, the labeling between these tables is

consistent. The correlation between safety-related process radiation monitors listed in Table 3.7.1-a of the technical specifications and Table 7.7-1 of the FSAR is as follows:

- Row a. in Table 3.7.1-a of the technical specifications corresponds to unit 1 in Table 7.7 1 of the FSAR;
- Row b. in Table 3.7.1-a of the technical specifications corresponds to units 2, 6, 7, and 10 in Table 7.7-1 of the FSAR;
- Row c. in Table 3.7.1-a of the technical specifications corresponds to units 3, 4, 5, 8, and 9 in Table 7.7-1 of the FSAR;
- Row d. in Table 3.7.1-a of the technical specifications corresponds to unit 11 in Table 7.7-1 of the FSAR;
- Row e. in Table 3.7.1-a of the technical specifications corresponds to unit 12 in Table 7.7-1 of the FSAR;
- Row f. in Table 3.7.1-a of the technical specifications corresponds to units 17, 18, 19, 20, 21, 22, 23, and 24 in Table 7.7-1 of the FSAR;
- Row g. in Table 3.7.1-a of the technical specifications corresponds to units 13, 14, and 15 in Table 7.7-1 of the FSAR;
- Row h. in Table 3.7.1-a of the technical specifications corresponds to unit 16 in Table 7.7-1 of the FSAR; and
- Row i. in Table 3.7.1-a of the technical specifications corresponds to units 25, 26, and 27 in Table 7.7-1 of the FSAR.

Table 3.7.1 of the technical specifications provides actions for inoperable channels. Actions 2, 3, 4, 5, and 8 of Table 3.7.1 of the technical specifications provide actions that involve closing dampers. These actions compensate for the inoperability of the associated safety-related process radiation monitor by isolating the ventilation flow path(s) from the area of potential contamination. By placing these dampers in the actuated state, the safety function of the inoperable safety-related process radiation monitor is satisfied.

As the labeling between Table 3.7.1-a of the technical specifications and Table 7.7-1 of the FSAR is consistent, no additional need to modify the licensing basis was identified.

3. The surveillance frequencies for the radiation monitoring instruments included in LCO 3.7.1 of the technical specifications were selected consistent with the guidance provided in ANSI/ANS 15.1-2007. These frequencies are adequate to demonstrate operability of the safety-related process radiation monitors and SFMs. The surveillance frequencies for the TRPS logic and actuation divisions and ESFAS logic and actuation divisions are provided in LCOs 3.2.1 and 3.2.2 of the technical specifications, respectively, and address operability of the channel from the inputs to the SBVMs or SBMs, which come from the SFMs, and extends through the output of the equipment interface modules (EIMs), which go to the actuated components. These frequencies, some of which rely on end-to-end self testing, are described in Subsections 7.4.4.4 and 7.5.4.5 of the FSAR. The frequency of surveillance testing of actuated components is provided in the LCOs for those actuated components and is based upon the guidance of ANSI/ANS 15.1-2007 and industry experience.

   SHINE has revised Subsection 7.7.1.4.3 of the FSAR to include a description of the surveillance frequencies associated with the safety-related process radiation monitors. A markup of the FSAR incorporating these changes is provided as Attachment 1.

4. LCOs 3.2.1 and 3.2.2 of the technical specifications are provided for the TRPS logic and actuation divisions and ESFAS logic and actuation divisions, respectively. End-to-end self testing, as described in Subsections 7.4.4.4 and 7.5.4.5 of the FSAR, demonstrates operability of the channel from the inputs to the SBVMs or SBMs, which come from the SFMs, and extends through the output of the EIMs, which go to the actuated components.

   LCO 3.7.1 of the technical specifications addresses radiation monitoring input devices to the TRPS or ESFAS, and the associated trip determination portions of the TRPS or ESFAS. The scope of the LCO for each channel begins at the radiation monitoring input devices, includes the SFMs and extends to the inputs to the SBVMs or SBMs. The surveillance requirements associated with LCO 3.7.1 of the technical specifications verify the operability of the channel from the safety-related process radiation monitor to the SBVMs or SBMs. These surveillances, combined with the testing described above, demonstrate operability from the safety-related process radiation monitor to the output switching logic.

   Operability from the output of the EIM to the actuated component associated with a safety related process radiation monitor is addressed in the LCOs related to the individual actuated components (i.e., LCOs 3.4.1, 3.4.3, 3.4.4, 3.6.2, 3.8.9, and 3.8.10 of the technical specifications).

   The scope of the LCOs described above demonstrate operability of a safety-related radiation monitor channel from the detector to the actuated component.

   SHINE has revised Subsection 7.7.1.4.3 of the FSAR to include a description of the operability requirements associated with the safety-related process radiation monitors. A markup of the FSAR incorporating these changes is provided as Attachment 1.

References

1. NRC letter to SHINE Medical Technologies, LLC, “SHINE Medical Technologies, LLC – Request for Additional Information Related to the Radiation Monitoring System(s) (EPID No. L 2019-NEW-0004),” dated January 11, 2022 (ML22007A217)

2. SHINE Medical Technologies, LLC letter to the NRC, “SHINE Medical Technologies, LLC Application for an Operating License,” dated July 17, 2019 (ML19211C143)

3. SHINE Technologies, LLC letter to NRC, “Application for an Operating License Supplement No. 13 and Response to Request for Additional Information,” dated November 22, 2021

4. Institute of Electrical and Electronics Engineers, “Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations,” IEEE Standard 7-4.3.2-2003, New York, NY

5. American National Standards Institute/American Nuclear Society, “Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry,” ANSI/ANS-10.4-1987, La Grange Park, IL

6. American National Standards Institute/American Nuclear Society, “Verification and Validation of Non-Safety-Related Scientific and Engineering Computer Programs for the Nuclear Industry,” ANSI/ANS-10.4-2008, La Grange Park, IL

7. SHINE Medical Technologies, LLC letter to NRC, “Application for an Operating License Response to Request for Additional Information,” dated August 27, 2021 (ML21239A049)

8. Institute of Electrical and Electronics Engineers, “Standard Criteria for Independence of Class 1E Equipment and Circuits,” IEEE Standard 384-2008, New York, NY

9. Institute of Electrical and Electronics Engineers, “Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations,” IEEE Standard 323-2003, New York, NY

10. Institute of Electrical and Electronics Engineers, “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations,” IEEE Standard 344-2013, New York, NY

11. Institute of Electrical and Electronics Engineers, “Guide for Instrumentation and Control Equipment Grounding in Generating Stations,” IEEE Standard 1050-2004, New York, NY

12. The Development of Technical Specifications for Research Reactors, ANSI/ANS-15.1-2007, American National Standards Institute/American Nuclear Society, 2007.

ENCLOSURE 2
ATTACHMENT 1

SHINE TECHNOLOGIES, LLC

SHINE TECHNOLOGIES, LLC APPLICATION FOR AN OPERATING LICENSE SUPPLEMENT NO. 18 AND RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

FINAL SAFETY ANALYSIS REPORT CHANGES (MARK-UP)

7.7 RADIATION MONITORING SYSTEMS

This section describes systems and components that perform radiation monitoring functions within the SHINE facility. Radiation monitoring systems and components include:

- safety-related process radiation monitors included as part of the engineered safety features actuation system (ESFAS), target solution vessel (TSV) reactivity protection system (TRPS), and tritium purification system (TPS);
- nonsafety-related process radiation monitors included as part of other facility processes;
- area radiation monitoring consisting of the radiation area monitoring system (RAMS);
- continuous air monitoring consisting of the continuous air monitoring system (CAMS); and
- effluent monitoring consisting of the stack release monitoring system (SRMS).

The objective of the radiation monitoring systems is to:

- provide facility control room personnel with a continuous record and indication of radiation levels at selected locations within processes and within the facility;
- provide local radiation information and alarms for personnel within the facility;
- provide input to safety-related control systems to actuate safety systems; and
- provide the ability to monitor radioactive releases to the environment.

A diagram showing how the facility radiation monitoring systems relate to the overall facility instrumentation and control (I&C) architecture is provided as Figure 7.1-1.

7.7.1 SAFETY-RELATED PROCESS RADIATION MONITORING

7.7.1.1 System Description

Safety-related process radiation monitors provide input to the safety-related ESFAS or TRPS control systems. These components monitor for either fission products or tritium. The type of safety-related process radiation monitor (fission product or tritium) is selected based on the location and identity of radioactive material present. Beta detection radiation monitors monitor for gaseous fission product release and provide input to the ESFAS or TRPS. Gamma-ray radiation monitors monitor for release of fission products through leakage into the molybdenum extraction and purification system (MEPS) hot water loop and provide input to the ESFAS. Safety-related tritium monitors are part of the TPS. The TPS monitors are installed within various portions of the TPS to detect potential tritium releases, provide ~~actuation signals~~inputs to the ESFAS~~ controls~~, and provide interlock inputs to the TRPS~~ controls~~. Information from safety-related process radiation monitors is displayed in the facility control room on the operator workstations (via the process integrated control system [PICS]).

A list of safety-related process radiation monitors is provided in Table 7.7-1.

Safety-related process radiation monitors that monitor for fission products use digital detectors to provide an analog signal to the TRPS or ESFAS. Safety-related process radiation monitors that monitor for tritium use solely analog technology.

Logic diagrams depicting how the safety-related process radiation monitors provide inputs to TRPS and ESFAS are provided in Figure 7.4-1 and Figure 7.5-1, respectively.

7.7.1.2 Design Criteria

The SHINE facility design criteria applicable to the safety-related process radiation monitors are addressed in this section. The generally-applicable SHINE facility design criteria 1, 2, and 4 apply to the safety-related process radiation monitors. The safety-related process radiation monitors are designed, fabricated, and erected to quality standards commensurate to the safety functions to be performed, and are qualified to perform these safety functions during external events and within the environmental conditions associated with normal operation, maintenance, and testing. These elements of the safety-related process radiation monitor design contribute to satisfying SHINE facility design criteria 1, 2, and 4. SHINE facility design criteria 13 and 38 also apply to the safety--related process radiation monitors.

7.7.1.2.1 Instrumentation and Controls

SHINE Design Criterion 13 – Instrumentation is provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated transients, and for postulated accidents as appropriate to ensure adequate safety, including those variables and systems that can affect the fission process, the integrity of the primary system boundary, the primary confinement and its associated systems, and the process confinement boundary and its associated systems. Appropriate controls are provided to maintain these variables and systems within prescribed operating ranges.

Safety-related radiation monitoring channels produce a full-scale reading when subject to radiation fields higher than the full-scale reading; however, they are expected to remain on-scale during accident conditions. The safety-related process radiation monitors that provide actuation signals are designed to function in the range necessaryduring normal operation, anticipated transients, and design basis accidents to a level required to detect accident conditions and provide safety-related inputs to the ESFAS and TRPS control systemsto initiate protective actions (Subsection 7.7.1.3.1). Setpoints are selected based on analytical limits and calculated to account for known uncertainties in accordance with the setpoint determination methodology and the monitors are periodically functionally tested and maintained (Subsection 7.7.1.4.3).

7.7.1.2.2 Monitoring Radioactivity Releases

SHINE Design Criterion 38 – Means are provided for monitoring the primary confinement boundary, hot cell, and glovebox atmospheres to detect potential leakage of gaseous or other airborne radioactive material. Potential effluent discharge paths and the plant environs are monitored for radioactivity that may be released from normal operations, including anticipated transients, and from postulated accidents.

The safety-related process radiation monitors provide radiation monitoring for the primary confinement boundary, hot cell, and glovebox atmospheres, provide radiation monitoring of the MEPS hot water loop, and monitor effluent release paths (Subsection 7.7.1.4.1). The monitors are designed to operate during normal conditions, anticipated transients, and design basis accidents (Subsection 7.7.1.4).

7.7.1.3 Design Bases

7.7.1.3.1 Design Bases Functions

The safety functions of the process radiation monitors are: (1) to detect radioactivity in excess of normal levels and provide an ~~actuation signal~~input to the ESFAS or TRPS ~~controls~~, or (2) to provide input to TRPS for interlocking the operation of the neutron driver. Additional discussion of TRPS and ESFAS functions, interlocks, and bypasses is provided in Section 7.4 and Section 7.5, respectively.

Each location that requires process radiation monitoring as determined by the safety analysis is equipped with safety-related process radiation monitors. The specified minimum number of process radiation monitors (channels) is only required to be operable when the location being monitored contains radioactive material, as specified in Table 7.7-1.

Process radiation monitors are selected for compatibility with the normal and postulated accident environmental and radiological conditions.

A list of safety-related process radiation monitors, specifying the monitored location, number of sensing channels provided, and operability requirements, is provided in Table 7.7-1.

The variables to be monitored and their ranges, accuracies, setpoints, and response times of safety-related process radiation monitors are provided in Table 7.4-1 and Table 7.5-1. Instrument accuracies are appropriate for the associated setpoints. Signal processing time for the ESFAS and TRPS is provided in Subsection 7.4.5.2.3.

~~Safety-related radiation monitoring channels produce a full-scale reading when subject to radiation fields higher than the full-scale reading, however, they are expected to remain on-scale during accident conditions.~~ The safety-related process radiation monitors ~~that provide actuation signals~~ are designed to function ~~in the range necessary~~during normal operation, anticipated transients, and design basis accidents to a level required to detect accident conditions and provide safety-related inputs to the ESFAS and TRPS ~~control systems.~~to initiate protective actions. If the measured radiation field goes above the full-scale, the analog output from the safety-related process radiation monitor will be equivalent to the full-scale reading. The TRPS or ESFAS will process this signal as a valid, full-scale value. For defense-in-depth, the radiologically controlled area (RCA) exhaust, general area direct radiation levels, and general area airborne particulates are monitored by stack release, radiation area, and continuous area monitors, respectively.

7.7.1.3.2 Operating Conditions

During normal operation, the process radiation monitors are designed to operate in the normal environmental conditions (temperature, pressure, relative humidity) identified in Tables 7.2-2 through 7.2-5 for an expected 20-year lifetime of the equipment.

The monitors are designed to operate in the transient conditions identified in Tables 7.2-1 through 7.2-5 until the associated protective function has continued to completion.

7.7.1.3.3 Single Failure

~~At least t~~Two or three redundant and independent safety-related process radiation monitors are provided for each protection function input parameter, each providing input to the associated division of the ~~safety-related control system~~TRPS or ESFAS. Redundancy in monitors ensures that a failure of one monitor will not prevent the ~~control system~~TRPS or ESFAS from performing its safety function.

The Channel A safety-related process radiation monitors receive power from Division A of the uninterruptible power supply system (UPSS), and Channel B safety-related process radiation monitors receive power from UPSS Division B. Channel C safety-related process radiation monitors, when provided, receive auctioneered power from both UPSS Division A and B. For loss of power to a safety-related process radiation monitor, analog outputs to the TRPS or ESFAS fail low, and the partial trip information for the failed channel is determined by the associated safety function module's (SFMs) out-of-service status (Subsections 7.4.4.3 and 7.5.4.4).

Therefore, no single failure of a detector, control division, or power division will prevent the safety-related control system from performing its safety function.

7.7.1.3.4 Independence

Safety-related process radiation monitors provide analog communication to the ESFAS and TRPS~~ controls. Channel communication independence is maintained by implementing separate hardwired connections to the separate ESFAS or TRPS controls divisions~~.

~~Radiation monitoring data provided to nonsafety control systems is through one-way isolated outputs.~~

Physical separation is maintained between divisions of safety-related process radiation monitors, and division independence is maintained from the safety-related process radiation monitors, through the TRPS and ESFAS, to the devices actuating the protective function (Subsection 7.4.5.2.1).

The safety-related process radiation monitors provide analog signals directly to the TRPS and ESFAS and do not interface electrically with any nonsafety-related system. Credible failures of nonsafety-related systems would not affect the functions of the safety-related process radiation monitors, demonstrating communications independence.

Safety-related process radiation monitors from separate divisions are ~~physically separated from each other and~~ independently powered from the associated UPSS division (Subsection 7.7.1.3.3). The UPSS provides safety-related power to system loads, including the safety-related process radiation monitors (Subsection 8a2.2.3).

7.7.1.3.5 Redundancy

Each location that requires engineered safety features to actuate in response to radiation levels, as determined by the safety analysis, is provided with at least two independent safety-related process radiation monitors, designated as Channels A and B. For locations where ~~spurious~~

~~actuation~~failure of a process radiation monitor could significantly impact overall facility operation, a third sensing division (Division C) is provided.

7.7.1.3.6 Human Factors, Display and Recording

Selection and display of process radiation monitor variables are designed with consideration of human factors engineering principles.

See Section 7.6 for additional discussion of information presented to facility operators and recorded for future use.

7.7.1.3.7 Fire Protection

~~Safety-related monitors in different channels are located in separate fire areas when practical.~~ Physical separation is used to achieve separation of redundant sensors. Wiring for redundant channels uses physical separation and isolation to provide independence for circuits. Separation of wiring is achieved using separate wireways and cable trays for each channel. Spatial separation between cable and raceway groups is in accordance with IEEE 384-2008 (IEEE, 2008), Section 5.1.1.2, Section 5.1.3.3 Table 1, and Section 5.1.4 Table 2.

Cable, wire, and electrical connectors utilized to connect radiation monitoring components to the ESFAS or TRPS have certifications that demonstrate the ability to inhibit the propagation of flame in the event of a fire. The certifications use recognized industry standards or guidance.

Noncombustible and heat resistant materials are used where practical in the design.

7.7.1.3.8 Natural Phenomena Hazards and Dynamic Effects

The process radiation monitors are installed in the seismically qualified portion of the main production facility where they are protected from earthquakes, tornadoes, and floods (Subsections 7.4.3.6 and 7.5.3.5). The process radiation monitors are Seismic Category I~~, designed~~ and tested using triaxial testing in accordance with Section 8 of IEEE Standard 344-2013 (IEEE, 2013) (Subsection 7.7.1.3.8). Hurricanes, tsunamis, and seiches are not credible events at the SHINE facility (Subsections 2.4.5.1, 2.4.2.7, and 2.4.5.2).

7.7.1.3.9 Quality

The safety-related process radiation monitors are designed, procured, fabricated, erected, and tested in accordance with the SHINE Quality Program Description (QAPD). Quality records applicable to the design, procurement, fabrication, erection, and testing are maintained.

The following codes and standards are applied to the design of the safety-related process radiation monitors:

- IEEE Standard 323-2003, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (IEEE, 2003b), invoked as guidance to support environmental qualification as described in Subsection 7.7.1.4.
- IEEE 344-2013, Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations (IEEE, 2013), Section 8.

- IEEE 384-2008, IEEE Standard Criteria for Independence of Class1E Equipment and Circuits (IEEE, 2008); invoked for separation of safety-related and nonsafety-related cables and raceways, as described in Subsection 8a2.1.3 and Subsection 8a2.1.5.
- Section 5.2.1 of IEEE Standard 1050-2004, IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations (IEEE, 2004b); invoked as guidance to support electromagnetic compatibility qualification for digital I&C equipment.

7.7.1.4 Operation and Performance

The safety-related process radiation monitors are designed to operate under normal conditions, during anticipated transients, and during design basis accidents such that they will perform their safety function. The safety-related process radiation monitors are qualified to the environmental parameters provided in Tables 7.2-1, 7.2-3, and 7.2-6 by applying the guidance of Sections 4.1, 5.1, 6.1, and 7 of IEEE Standard 323-2003 (IEEE, 2003b).

The safety-related process radiation monitors demonstrate electromagnetic interference (EMI)/radio-frequency interference (RFI) qualification through emissions testing, susceptibility testing, and surge withstand capability testing. The safety-related process radiation monitors are grounded in accordance with Section 5.2.1 of IEEE Standard 1050-2004 (IEEE, 2004b).

7.7.1.4.1 Functionality

TRPS process radiation monitors monitor the ventilation line from the primary closed loop cooling system (PCLS) expansion tanks (i.e., radiological ventilation zone 1 exhaust subsystem [RVZ1e] irradiation unit [IU] cell radiation monitors). These monitors provide an input to the TRPS, where it is compared with a setpoint. An actuation signal is generated, as depicted in Figure 7.4-1, when radiation levels exceed pre-determined limits, indicative of a release of target solution or fission products within the PCLS or the primary confinement atmosphere (with which the tank communicates). The actuation results in an IU Cell Safety Actuation for that unit.

ESFAS process monitors associated with the supercell monitor the ventilation exhaust from each hot cell and provide an input to the ESFAS, where it is compared with a setpoint. An actuation signal is generated, as depicted in Figure 7.5-1, when radiation levels exceed pre-determined limits, indicative of a release of target solution or fission products within that hot cell. The actuation results in isolation of the affected hot cell.

ESFAS process monitors associated with the radiological ventilation zone 1 (RVZ1) and radiological ventilation zone 2 (RVZ2) exhaust ~~are designed to~~ provide an input to the ESFAS, where it is compared to a setpoint. An actuation signal is generated, as depicted in Figure 7.5-1, when radiation levels in the RCA ventilation exhaust systems exceed pre-determined limits, indicative of a failure of a confinement boundary within the facility. The actuation results in isolation of RVZ1, RVZ2, and radiological ventilation zone 3 (RVZ3) ventilation.

The ESFAS process monitors associated with the MEPS hot water loop ~~are designed to~~ provide an input to the ESFAS, where it is compared to a setpoint. An actuation signal is generated, as depicted in Figure 7.5-1, when radiation levels exceed pre-determined limits, indicative of a leak of target solution within the loop. The actuation results in isolation of the affected MEPS hot water loop.

The TPS process monitors associated with tritium confinement are designed to provide an input to the ESFAS, where it is compared to a setpoint. An actuation signal is generated, as depicted in Figure 7.5-1, when tritium concentrations within the TPS gloveboxes exceed predetermined limits, indicative of a failure of TPS process equipment and release of tritium into the TPS glovebox. The actuation results in isolation of the tritium confinement and ventilation associated with the TPS room.

The TPS tritium monitors associated with the TPS exhaust to facility stack are designed to provide an input to the ESFAS, where it is compared to a setpoint. An actuation signal is generated, as depicted in Figure 7.5-1, when tritium concentrations in the TPS exhaust to facility stack exceed predetermined limits, indicative of a release of tritium out of the TPS. The actuation results in isolation of the TPS process vent exhaust lines and ventilation associated with the TPS room.

Additional discussion of safety-related process radiation monitor functionality is provided in Sections 7.4 and 7.5.

7.7.1.4.2 Reliability, Adequacy, and Timeliness

Two safety-related process radiation monitors are provided for each location requiring monitoring. For locations where spurious actuationfailure of the process radiation monitor could significantly impact overall facility operation, a third sensing channel (Channel C) is provided for two-out-of-three voting capability.

Instrument ranges and response times are provided in Tables 7.4-1 and 7.5-1.

7.7.1.4.3 Setpoints, Calibration and Surveillance

Setpoints for safety-related process radiation monitors are selected based on analytical limits and calculated to account for known uncertainties in accordance with the setpoint determination methodology described in Subsection 7.2.1.

Monitors are periodically functionally tested and maintained in accordance with the SHINE technical specifications to verify operability. The surveillance frequencies for the safety-related process radiation monitoring instruments included in the technical specifications were selected consistent with the guidance provided in American National Standards Institute/American Nuclear Society (ANSI/ANS) 15.1-2007, The Development of Technical Specifications for Research Reactors (ANSI/ANS, 2007). The surveillance requirements for the safety-related process radiation monitoring instruments included in the technical specifications verify the operability of the channel from the safety-related process radiation monitor to the inputs to the scheduling, bypass, and voting module (SBVM) or scheduling and bypass module (SBM) located in the TRPS or ESFAS. Testing of the logic and actuation divisions of the TRPS and ESFAS is described in Subsections 7.4.4.4 and 7.5.4.5.

Instrument background count rate is observed to ensure proper functioning of the monitors. Safety-related process radiation monitors located in a low background area are equipped with a check source to be able to verify proper operation.

7.7.5.4 Operation and Performance

The SRMS units are designed to operate under normal facility conditions and to detect radiation that may be indicative of anticipated transients or design basis accidents.

The SRM is used to monitor the main facility stack, which is the normal release path for gaseous effluents from the PVVS and RCA ventilation systems. The SRM includes a mass flow controller to regulate sample flow rate in the isokinetic region relative to stack flow. A vacuum pump is used to draw sampled air through particulate and iodine filter cartridges, which are removed and analyzed periodically. The sampled air is then drawn into a sample chamber, which houses a beta detector used to measure the noble gas radionuclides. The ratemeter for the beta radiation monitor indicates and displays the radiation level inside the sampler from the sampled air. From the sampler, the air is drawn through the flow controller assembly, pump, and exhausted into the return line. Downstream of the particulate and iodine filter, a connection for the tritium detection system is provided. The tritium monitor has its own pump and flow control. The tritium detector is a passive sampler collecting system (i.e., bubble system) to continuously collect and concentrate elemental tritium and tritiated water in small vials. The contents of the vials are assayed using a scintillation counter at regular intervals.

The CDBEM monitors noble gases at the exhaust of the PVVS carbon delay beds using a sampling system. Redundant particulate and iodine filters are installed in-line with the effluent stream, upstream of the safety-related exhaust point, which operates at a much lower flow rate (approximately 16 standard cubic feet per minute) than the main facility stack. The safety-related exhaust point is only used while nitrogen purge is in operation. The PVVS system does not receive gases from process locations expected to contain tritium; therefore, the CDBEM does not include a tritium monitor. Although the CDBEM monitors a safety-related point in the PVVS system, the CDBEM is not required to perform a safety function. The monitoring functions provided by the CDBEM are described in Subsection 7.7.5.1. See Section 9b.6 for additional discussion on the PVVS and nitrogen purge operations.

The initial channel calibration for the SRM and CDBEM noble gas detectors is performed using standards traceable to NIST.

7.7.5.4.1 Technical Specifications

~~Certain material in this section provides information that is used in the~~There are no technical specifications~~. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also~~ applicable to~~, and may be referenced by, the bases that are described in the technical specifications~~ the SRMS.

7.7.6 CONCLUSION

Radiation monitoring within the SHINE facility is performed by multiple radiation monitoring processes. The radiation monitoring supports facility control room operations, provides information and alarms for personnel within the facility, provides input to safety-related control systems to actuate safety systems, and provides the ability to monitor radioactive releases to the environment.

ENCLOSURE 2
ATTACHMENT 2

SHINE TECHNOLOGIES, LLC

SHINE TECHNOLOGIES, LLC APPLICATION FOR AN OPERATING LICENSE SUPPLEMENT NO. 18 AND RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

TECHNICAL SPECIFICATIONS MARK-UPS

	Monitored Location	Setpoint and Monitored Material	Required Channels	Applicability (per IU, TPS train, or monitored location)	Action
i.	MEPS heating loop extraction area A/B/C	≤ 1000 mR/hr Fission products	2 (per hot cell)	Target solution or radioactive process fluids present in the associated hot cell	11, 12

LCO 3.7.2	The annually averaged concentration of radioactive material released in gaseous effluents to unrestricted areas shall be limited to 2800 times the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 1.
Applicability	Facility not Secured
Action	According to Table 3.7.2
SR 3.7.2	1. Total curies released shall be assessed monthly. ~~2. A Channel Calibration of the stack release monitor shall be performed annually.~~ ~~3. A Channel Calibration of the PVVS carbon delay bed effluent monitor shall be performed annually.~~

Table 3.7.2 Gaseous Effluents Actions

	Action	Completion Time
1.	If the ~~monthly~~ curie assessment exceeds ~~1/12th of~~ the established limit, ~~Verify the annual curie assessment is within the limit~~Submit a Special Report as described in Section 5.8.2.	~~24 hours~~As described in Section 5.8.2

Basis 3.7.2 LCO

Release limits on radioactive effluents ensure the facility does not release excessively high levels of radioactive effluents, as described in FSAR Section 11.1. The factor of 2800 times the values listed in 10 CFR 20, Appendix B, Table 2, Column 1 is based on the SHINE site-specific atmospheric dispersion factor (χ/Q) value of 7.1E-5 sec/m^3 for the maximally exposed individual (MEI), which is taken to be the nearest point on the site boundary. The estimated annual dose to the MEI is 3.9 mrem, as discussed in FSAR Subsection 11.1.1.1. The factor of 2800 times values listed in 10 CFR 20, Appendix B, Table 2, Column 1 limits the MEI dose to less than 10 mrem.

~~The stack release monitor provides the ability to monitor the normal effluent release pathway. The carbon delay bed effluent monitor provides information about the health of the PVVS carbon delay beds and provides the ability to monitor the safety-related exhaust point effluent release pathway when it is in use to demonstrate that gaseous effluents from the SHINE Facility are within regulatory limits, as described in FSAR Subsection 7.7.5.~~

If the ~~monthly curie assessment (SR 3.7.2.1) exceeds 1/12th of~~annually averaged concentration of radioactive material released in gaseous effluents exceeds the annual limit, ~~the annual curie assessment shall be verified within the limit within 24 hours. This completion time is adequate to properly review assessment data for errors and, if necessary, to verify annual assessment data. The completion time is acceptable because the likelihood of exceeding annual limits within 24 hours of exceeding 1/12th the annual limit is low~~a Special Report will need to be submitted as described in Section 5.8.2. Additional actions may be taken as necessary to reduce releases of radioactive material to restore or maintain compliance with LCO 3.7.2.

SR

The surveillance requirement ensures that the gaseous effluents from normal operations released to uncontrolled areas are within the allowable limits. ~~The stack release monitor and carbon delay bed effluent monitor Channel Calibrations ensure the continued operability of the instruments and the accuracy of the measurements. A stack release monitor or PVVS carbon delay bed effluent monitor input channel consists of the field instrument through the PICS display. The surveillance requirements are consistent with industry experience.~~By verifying the total curies released on a monthly basis, sufficient time is available to take action, as necessary, to reduce release rates to maintain compliance with LCO 3.7.2.