ENCLOSURE 6

SHINE MEDICAL TECHNOLOGIES, LLC

SHINE MEDICAL TECHNOLOGIES, LLC OPERATING LICENSE APPLICATION SUPPLEMENT NO. 2

TECHNICAL SPECIFICATIONS
PUBLIC VERSION

111 pages follow

Appendix A to
Facility License No.

Technical Specifications and Bases
Revision No. 2

SHINE Medical Technologies, LLC
Medical Isotope Production Facility
Docket No. 50-608

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1.0 Introduction

1.1 Scope

This document constitutes the technical specifications for the SHINE Medical Isotope Production Facility, as required by 10 CFR 50.36, and supersedes all prior technical specifications. This document includes the “bases” to support the selection and significance of the specifications. The technical specifications employ the applicable features of the guidance provided in NUREG-1537, Part 1, Appendix 14.1, as modified by the Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, and the updated national standard endorsed therein: ANSI/ANS 15.1-2007, The Development of Technical Specifications for Research Reactors.

1.2 Format

The format of this document follows the guidance provided in NUREG-1537 and ANSI/ANS 15.1-2007, with the exception that limiting conditions for operation (LCOs) and surveillance requirements (SRs) are combined into a single section (i.e., Section 3.0) to achieve better clarity and improved human performance.

1.3 Definitions

Channel: A Channel is the combination of sensor, line, amplifier, and output devices that are connected for the purpose of measuring the value of a parameter.

Channel Calibration: A Channel Calibration is an adjustment of the Channel such that its output corresponds with acceptable accuracy to known values of the parameter that the Channel measures. Calibration shall encompass the entire Channel, including equipment actuation, alarm, or trip and shall include a Channel Test.

Channel Check: A Channel Check is a qualitative verification of acceptable performance by observation of Channel behavior or verification of the absence of Channel Check alarms from systems performing an equivalent automatic verification. This verification, where possible, shall include comparison of the Channel with other independent Channels or systems measuring the same variable.

Channel Test: A Channel Test is the introduction of a signal into the Channel for verification that it is Operable.

Confinement: Confinement is an enclosure that is designed to limit the release of effluents between the enclosure and its external environment by use of a sealed low-leakage barrier, and through controlled or defined pathways.

Division: The designation applied to a given system or set of components that enables the establishment and maintenance of physical, electrical, and functional independence from other redundant sets of components.

Facility Secured (Secured): The SHINE Facility is Secured when the following conditions are met:

1. Each Irradiation Unit is in a Safe Shutdown condition.
2. No work is in progress involving special nuclear material, and unirradiated special nuclear material is in a safe storage location.
3. Target solution hydrogen generation rates are below those requiring preventive controls.

Irradiation Unit (IU): An IU is an accelerator-driven subcritical Operating assembly used for the irradiation of an aqueous uranyl sulfate target solution, resulting in the production of molybdenum-99 (Mo-99) and other fission products.

IU Mode: The IU is designed to remain in the subcritical operating region in all Operating Modes. There are five Modes (0-4) of operation for an IU. Each Mode has defined interlocks and permissives in the safety-related and/or nonsafety-related control systems, the target solution vessel (TSV) reactivity protection system (TRPS) and the process integration control system (PICS), respectively. IU Modes of operation are defined in Table 1.3.

Table 1.3 IU Modes of Operation

Mode	Title	Neutron Driver Status	TSV Fill Valves	TSV Dump Valves
0	Solution Removed	Not Operating	Open/Closed	Open/Closed
1	Startup	Not Operating	Open/Closed	Closed
2	Irradiation	Operation Allowed	Closed	Closed
3	Shutdown/ Post-Irradiation	Not Operating	Open/Closed	Open
4	Transfer to RPF	Not Operating	Open/Closed	Open

License: The written authorization, by the responsible authority, for an individual or organization to carry out the duties and responsibilities associated with a personnel position, material, or facility requiring licensing.

Licensed Operator: An individual who is Licensed to manipulate the controls of an IU.

Operable: Operable means a component or system is capable of performing its intended function.

Operating: Operating means a component or system is performing its intended function.

Primary System Boundary (PSB): The PSB means the TSV, TSV dump tank, TSV off-gas system (TOGS), and associated components that enclose target solution and fission product gases during the irradiation process.

Protective Action: Protective Action is the initiation of a signal or the operation of equipment within the safety system in response to a parameter or condition of the facility having reached a specified limit.

Safe Shutdown: An IU is in a Safe Shutdown condition if the following performance criteria are achieved and maintained:

A. Target solution is not present:

No target solution is present in the IU

AND

TSV fill valves are closed.

OR

B. Target solution is present:

Target solution is drained from the TSV

AND

Hydrogen is controlled:

Nitrogen purge system (N2PS) is Operable

OR

Target solution hydrogen generation rates are below those requiring preventive controls.

Safety Systems: Safety Systems, or safety-related control systems, are those systems, including their associated input Channels, that are designed to initiate automatic protection or to provide information for initiation of manual Protective Action.

Senior Licensed Operator: An individual who is Licensed to direct the activities of Licensed Operators. Such an individual is also a Licensed Operator.

SHINE Facility: The area within the site boundary where the Shift Supervisor has direct authority over all activities. The controlled access area fence and the perimeter walls of the main production facility, the material staging building, the storage building, and the resource building are the extent of the SHINE Facility.

Should, **Shall**, and **May**: The word "shall" is used to denote a requirement; the word "should" is used to denote a recommendation; and the word "may" denotes permission, neither a requirement nor a recommendation.

Surveillance Intervals: Allowable surveillance intervals shall not exceed the following:

• Quinquennially (Every five years)	interval not to exceed 72 months
• Biennially (Every two years)	interval not to exceed 30 months
• Annually	interval not to exceed 15 months
• Semi-annually	interval not to exceed 7.5 months
• Quarterly	interval not to exceed 4 months
• Monthly	interval not to exceed 6 weeks
• Weekly	interval not to exceed 10 days
• Daily	interval not to exceed 36 hours

Unscheduled Shutdown: An Unscheduled Shutdown is defined as any unplanned shutdown of an IU caused by actuation of a safety system, operator error, equipment malfunction, or a manual shutdown in response to conditions that could adversely affect safe operation, not including shutdowns that occur during testing or checkout operations.

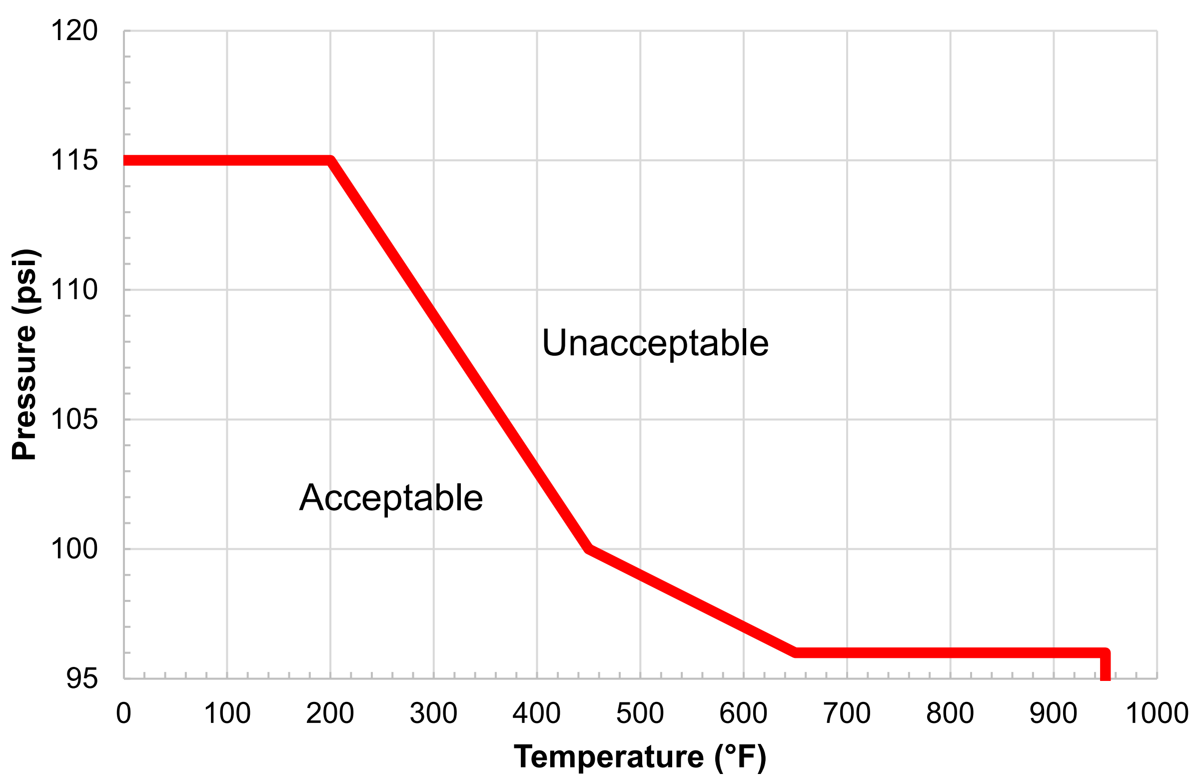
2.0 Safety Limits and Limiting Safety System Settings

2.1 Safety Limits

Objective: To protect physical barriers that guard against the uncontrolled release of radioactivity.

SL 2.1.1	The combination of differential pressure across the low temperature portion of the PSB and the wall temperature averaged through the thickness shall be within the “Acceptable” region defined by Figure 2.1.1. AND Average wall temperature for the low temperature portion of the PSB shall be ≤ 950 degrees Fahrenheit (°F) for differential pressure ≤ 95 pounds per square inch (psi).
Applicability	This safety limit applies at all times to the differential pressure and the wall temperature of the low temperature section of the PSB. The low temperature portion of the PSB includes all PSB components except the hydrogen recombiner housings, the recombiner condensers, the piping between the recombiners and the recombiner condensers, and the piping between the recombiner condensers and the TSV.

Figure 2.1.1 PSB Low Temperature Portion Safety Limit



SL 2.1.2	The differential pressure across the high temperature portion of the PSB shall be ≤ 115 psi and the wall temperature averaged through the thickness shall be ≤ 950°F.
Applicability	This safety limit applies at all times to the differential pressure and the wall temperature of the high temperature portion of the PSB. The high temperature portion of the PSB includes the hydrogen recombiner housings, the recombiner condensers, the piping between the recombiners and the recombiner condensers, and the piping between the recombiner condensers and the TSV.

SL 2.1.3	The pressure within process tanks containing irradiated uranyl sulfate in the radioisotope production facility (RPF) and connected piping up to the first valve shall be ≤ 18 psi gauge (psig).
Applicability	This specification applies at all times to the gauge pressure within the irradiated uranyl sulfate process tanks in the RPF. This specification also applies to piping and piping components, up to the first valve, that share a pressure boundary with the irradiated uranyl sulfate process tanks.

Basis 2.1.1 The PSB consists primarily of American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code (BPVC), Section VIII pressure vessels and ASME B31.3 piping. The principal failure modes for pressure vessels and pipes are excessive pressure and temperature. If pressures are too high within a vessel or pipe, the stresses induced could exceed the allowable conditions of the material of construction, and the vessel or pipe could yield or rupture. A rupture would result in an uncontrolled release of fission product inventory.

High temperatures will decrease the strength of the material, resulting in a reduction of the pressure retaining ability of the vessel or pipe. Excessively high temperatures, concurrent with pressure loading, could result in loss of pressure boundary integrity followed by an uncontrolled release of fission product inventory.

The design pressure of the PSB is 100 psi (689 kPa). Per Section VIII of the ASME BPVC, overpressure protection prevents the pressure from rising more than 16% above the design pressure. To ensure integrity, PSB components are hydrostatically tested at not less than 130% of design pressure.

PSB components, except the hydrogen recombiner housings, the recombiner condensers, the piping between the recombiners and the recombiner condensers, and the piping between the recombiner condensers and the TSV, have a design temperature of 200°F (93.3°C). The safe pressure at temperatures above the design temperature was determined based on the reduction in allowable stress of the material of construction at elevated temperatures. PSB characteristics are described in Final Safety Analysis Report (FSAR) Section 4a2.2.

Basis 2.1.2 The PSB consists primarily of ASME BPVC, Section VIII pressure vessels and ASME B31.3 piping. The principal failure modes for pressure vessels and pipes are excessive pressure and temperature. If pressures are too high within a vessel or pipe, the stresses induced could exceed the allowable conditions of the material of construction, and the vessel or pipe could yield or rupture. A rupture would result in an uncontrolled release of fission product inventory.

High temperatures will decrease the strength of the material, resulting in a reduction of the pressure retaining ability of the vessel or pipe Excessively high temperatures concurrent with pressure loading could result in loss of pressure boundary integrity followed by an uncontrolled release of fission product inventory.

The design pressure of the PSB is 100 psi (689 kPa). Per Section VIII of the ASME BPVC, overpressure protection prevents the pressure from rising more than 16% above the design pressure. To ensure integrity, PSB components are hydrostatically tested at not less than 130% of design pressure.

The portions of the PSB consisting of the hydrogen recombiner housings, the recombiner condensers, the piping between the recombiners and the recombiner condensers, and the piping between the recombiner condensers and the TSV have a design temperature of 650°F (343.3°C). The safe pressure at temperatures above the design temperature was determined based on the reduction in allowable stress of the material of construction at elevated temperature. PSB characteristics are described in FSAR Section 4a2.2.

Basis 2.1.3 The process tanks containing irradiated uranyl sulfate consist of the target solution staging system (TSSS), radioactive liquid waste storage (RLWS) system, radioactive liquid waste immobilization (RLWI) system, and radioactive drain system (RDS) tanks. The process tanks containing irradiated uranyl sulfate are non-code-stamped tanks designed and fabricated following the rules for pressure vessels in ASME BPVC Section VIII. The principal failure modes for pressure vessels and pipes are excessive pressure and temperature.

If pressures are too high within a tank or piping, the stresses induced could exceed the allowable conditions of the material of construction and the tank or piping could yield or rupture. A rupture would result in an uncontrolled release of fission product inventory. A change in geometry of a tank (e.g., plastic deformation) could place the vessel outside of criticality safety analysis inputs and assumptions.

The irradiated uranyl sulfate process tanks are not exposed to high heat sources, such as fission processes or hydrogen recombiners, so a temperature limit is not required to assure pressure boundary integrity.

The design pressure of the irradiated target solution process tanks in the RPF is 15 psi (103 kPa). Per Section VIII of the ASME BPVC, overpressure protection prevents the pressure from rising more than 3 psi (20.7 kPa) above the design pressure. To ensure integrity, the process tanks containing irradiated uranyl sulfate are hydrostatically tested at not less than 130% of design pressure (19.5 psig [134 kPa gauge]).

2.2 Limiting Safety System Settings (LSSS)

Objective: To ensure that automatic Protective Action is initiated before exceeding a safety limit.

Table 2.2 Limiting Safety System Settings

LSSS	Variable	Setpoint	Applicability
LSSS 2.2.1	High wide range neutron flux	≤ 240% power	Modes 1 and 2
LSSS 2.2.2	High time-averaged power range neutron flux	≤ 104% power; averaged over ≤ 45 seconds	Modes 1 and 2
LSSS 2.2.3	High source range neutron flux	≤ 1.5 times the nominal flux at 95% volume of the critical fill height	Mode 1
LSSS 2.2.4	Low TOGS mainstream flow	[ ]PROP/ECI	Modes 1, 2, 3, and 4
LSSS 2.2.5	Low TOGS dump tank flow	[ ]PROP/ECI	Modes 1, 2, 3, and 4
LSSS 2.2.6	High-high dump tank level	≤ 85%	Modes 1, 2, 3, and 4
LSSS 2.2.7	Low primary closed loop cooling system (PCLS) flow	[ ]PROP/ECI; IU Cell Safety Actuation delayed by ≤ 180 seconds	Modes 1 and 2
LSSS 2.2.8	High PCLS temperature	≤ 72.9°F; IU Cell Safety Actuation delayed by ≤ 180 seconds	Modes 1 and 2
LSSS 2.2.9	Low process vessel vent system (PVVS) flow	≥ 7.1 SCFM	Facility not Secured

Basis 2.2.1 The high wide range neutron flux limit is set at a neutron flux equivalent to 240% fission power (i.e., 300 kilowatt (kW)). This limit provides margin to an analytical limit of 390 kW, the power equivalent of [ ]PROP/ECI at the minimum acceptable target solution irradiation volume of [ ]PROP/ECI. TSV power limits are discussed in FSAR Subsections 4a2.6.3 and 7.4.5. This LSSS prevents overheating of the target solution, which could lead to boiling and pressurization of the vessel, protecting the PSB pressure safety limit. This LSSS also prevents uranium precipitation. Uranium precipitation could result in increased reactivity and fission power, leading to boiling and steam production, which could pressurize the PSB, challenging PSB pressure integrity. Increased power may also lead to high radiolysis rates and potential hydrogen deflagration, challenging the PSB pressure integrity. Uncontrolled, precipitation could result in sustained criticality in the TSV with the potential to exceed the temperature limits of the TSV.

Basis 2.2.2 The high time-averaged power range neutron flux limit is set at a neutron flux equivalent to 104% power (i.e., 130 kW). This limit provides margin to an analytical limit of 137.5 kW and ensures that the TSV power does not exceed analyzed conditions related to thermal hydraulic considerations, radiolytic gas generation, or fission product source term. TSV power limits are discussed in FSAR Subsections 4a2.6.3 and 7.4.5. This LSSS prevents overheating of the target solution, which could lead to boiling and pressurization of the vessel, protecting the PSB pressure safety limit. This LSSS also prevents the buildup of hydrogen that could result in a hydrogen deflagration that could exceed the PSB pressure safety limit.

Basis 2.2.3 The high source range neutron flux limit is set to a neutron flux equivalent to 1.5 times the nominal flux at 95% by volume of the critical fill height, as described in FSAR Subsections 4a2.6.2.7 and 7.4.5. This LSSS protects against a sudden increase in reactivity during the fill process, which could cause pressurization of the vessel, and therefore protects the PSB pressure safety limit.

Basis 2.2.4 The low TOGS mainstream flow limit is based on an analytical limit of [ ]PROP/ECI (defined at 68°F [20°C] and 1 atmosphere (atm) [101 kPa]), which has been conservatively calculated to be sufficient to maintain hydrogen concentration within the TSV headspace of less than 4.0% during normal operations. Maintaining a hydrogen concentration below 7.7% prevents a deflagration that could challenge PSB integrity, as described in FSAR Subsections 4a2.8.6 and 7.4.5. This LSSS prevents the buildup of hydrogen that could result in a hydrogen deflagration that could exceed the PSB pressure safety limit.

Basis 2.2.5 The low TOGS dump tank flow limit is based on an analytical limit of [ ]PROP/ECI (defined at 68°F [20°C] and 1 atm [101 kPa]), which has been conservatively calculated to be sufficient to maintain hydrogen concentration within the TSV dump tank of less than 4.0% during normal operations. Maintaining a hydrogen concentration below 7.7% prevents a deflagration that could challenge PSB integrity, as described in FSAR Subsections 4a2.8.6 and 7.4.5. This LSSS prevents the buildup of hydrogen that could result in a hydrogen deflagration that could exceed the PSB pressure safety limit.

Basis 2.2.6 The high-high dump tank level limit is based on an analytical limit of [ ]PROP/ECI, which equates to 87.9% of the [ ]PROP/ECI span of the tank. The TSV dump tank high-high level ensures the TSV dump tank solution height does not obstruct the required TOGS gas flow area, as described in FSAR Subsection 13a2.1.9.2. Maintaining the TSV dump tank solution height below the specified maximum value is also required to provide adequate hydrogen dilution volume in the TSV dump tank headspace for transient conditions. Lack of adequate headspace in the TSV dump tank may lead to a hydrogen deflagration that could challenge the PSB pressure safety limit.

Basis 2.2.7 The low PCLS flow limit is based on an analytical limit of [ ]PROP/ECI, as described in FSAR Subsection 4a2.7.9. PCLS is required to maintain cooling to the TSV during irradiation. The time delay prior to an IU Cell Safety Actuation is based on the acceptability of a complete loss of cooling without neutron driver operation for up to three minutes prior to transferring target solution to the TSV dump tank, as described in FSAR Subsection 4a2.7.3. This LSSS prevents overheating of the target solution, which could lead to boiling and pressurization of the vessel, protecting the PSB pressure safety limit.

Basis 2.2.8 The high PCLS temperature limit is based on an analytical limit of 77°F (25°C), as described in FSAR Subsection 4a2.7.9. PCLS is required to maintain cooling to the TSV during irradiation. The time delay prior to an IU Cell Safety Actuation is based on the acceptability of a complete loss of cooling without neutron driver operation for up to three minutes prior to transferring target solution to the TSV dump tank, as described in FSAR Subsection 4a2.7.3. This LSSS prevents overheating of the target solution, which could lead to boiling and pressurization of the vessel, protecting the PSB pressure safety limit.

Basis 2.2.9 PVVS flow through RPF tanks is required to dilute radiolytic hydrogen generated from irradiated target solution and radioactive liquid waste located in tanks in the RPF. The low PVVS flow limit of 7.1 SCFM is based on an analytical limit of 5.0 SCFM, which is calculated to prevent the concentration of hydrogen in RPF tanks from exceeding 3.0% by volume. Maintaining this hydrogen concentration provides margin to the lower flammability limit of 4.0%. Indication of low PVVS flow results in an RPF Nitrogen Purge Actuation, as described in FSAR Subsection 7.5.5. This LSSS ensures the hydrogen mitigation function is maintained, preventing a deflagration in an RPF tank that could challenge the RPF tank pressure safety limit.

3.0 Limiting Conditions for Operation and Surveillance Requirements

Limiting conditions for operation (LCO) are those administratively established constraints on equipment and operational characteristics that shall be adhered to during operation of the facility. The LCOs are the lowest functional capability or performance level required for safe operation of the facility. Deviations from LCOs may be allowed under specified conditions stated in the LCO.

If an LCO is not met, the equipment or operational characteristics shall immediately be restored, the required action, if specified, shall be completed, or the condition of applicability shall be exited.

LCOs are accompanied by surveillance requirements (SR) that prescribe the frequency and scope of surveillance to demonstrate minimum performance levels established by the associated LCO. Surveillances shall be performed within the specified Surveillance Interval. Maximum allowable intervals defined in Section 1.3 are to provide operational flexibility only and are not used to reduce frequency.

In general, the SRs established herein conform to the guidance of ANSI/ANS 15.1-2007 and the assumptions used in the accident analyses underlying statements in the FSAR.

Surveillance requirements may be deferred when outside the condition of applicability, unless specifically noted in the SR.

Surveillance requirements that establish operability shall be met and within their specified frequency prior to entering the condition of applicability.

3.1 Irradiation Unit Parameters

Objective: To ensure the IU remains within analyzed conditions.

LCO 3.1.1	TOGS shall be Operable. TOGS is considered Operable if: 1. Both Train A and Train B blowers are Operating, 2. Power is supplied to both Train A and Train B recombiner heaters, and 3. Mainstream flow, dump tank flow, oxygen concentration, and condenser demister outlet temperature meet the conditions specified in Table 3.2.5 for both Train A and Train B.
Applicability	According to Table 3.1.1
Action	According to Table 3.1.1
SR 3.1.1	Check that both TOGS trains are Operating prior to entering Mode 1.

Table 3.1.1 TOGS Actions

Applicability (per IU)	**Action (per IU)**
Mode 1 or 2	If TOGS Train B is not Operating, Check that TOGS Train A is Operating AND Place the associated IU in Mode 3. If TOGS Train A or both trains are not Operating, Place the associated IU in Mode 3 AND Actuate the nitrogen purge system.
Mode 3 or 4	If TOGS Train B is not Operating, check that TOGS Train A is Operating. If TOGS Train A or both trains are not Operating, actuate the nitrogen purge system.

LCO 3.1.2	The pressure in the TSV headspace shall be ≥ (-) 4.5 psig and ≤ (+) 0.3 psig.
Applicability	Associated IU in Mode 1 or 2
Action	If TSV headspace pressure is not within limits, place the associated IU in Mode 3.
SR 3.1.2	1. A Channel Check shall be performed on the TOGS pressure instrumentation quarterly. 2. A Channel Calibration shall be performed on the TOGS pressure instrumentation annually.

LCO 3.1.3	Target solution volume in the TSV shall be [ ]PROP/ECI.
Applicability	Associated IU in Mode 2
Action	If the volume of target solution in the TSV is less than the minimum volume, place the associated IU in Mode 3.
SR 3.1.3	1. Verify the minimum target solution volume in the TSV is achieved prior to transition to Mode 2. 2. A Channel Check shall be performed on the TSV level indication quarterly. 3. A Channel Calibration shall be performed on the TSV level indication annually.

LCO 3.1.4	The average temperature of the target solution within the TSV shall be ≤ 176°F
Applicability	Associated IU in Mode 2
Action	If target solution temperature is not below the limit, place the associated IU in Mode 3.
SR 3.1.4	1. A Channel Check shall be performed on the TSV temperature indication quarterly. 2. A Channel Calibration shall be performed on the TSV temperature indication annually.

LCO 3.1.5	Both TSV dump valves shall be Operable. TSV dump valves are considered Operable if: 1. Each valve is capable of fully opening within two seconds of demand. AND 2. Each dump line flow path is capable of draining the TSV from 95% full within 250 seconds of demand.
Applicability	Associated IU in Mode 1 or 2
Action	If one or more TSV dump valve(s) are not Operable, place the associated IU in Mode 3.
SR 3.1.5	1. Verify each TSV dump valve opens in ≤ 2 seconds of demand quarterly. 2. Verify the drain time of each TSV dump line is ≤ 250 seconds when the TSV is ≥ 95% full quarterly.

LCO 3.1.6	Average power density of target solution within the TSV shall be [ ]PROP/ECI
Applicability	Associated IU in Mode 2
Action	If the power density limit is exceeded, place the associated IU in Mode 3.
SR 3.1.6	Verify average power density of the TSV is [ ]PROP/ECI daily.

LCO 3.1.7	Target solution shall be held in the TSV dump tank for ≥ the required minimum hold time specified in Table 3.1.7 if the target solution batch has been irradiated at > 1 effective full power minute during the immediately preceding irradiation cycle.
Applicability	Mode 4
SR 3.1.7	Verify the minimum hold time requirement has been achieved prior to transfer of target solution from the TSV dump tank.

Table 3.1.7 Required Minimum Hold Time

Maximum Historical Irradiation Power	**Required Minimum Hold Time**
> 0 kW but ≤ 10 kW	[ ]PROP/ECI
> 10 kW but ≤ 70 kW	[ ]PROP/ECI
> 70 kW	[ ]PROP/ECI

Basis 3.1.1 LCO

The TOGS serves to maintain hydrogen in the PSB below the lower flammability limit and to maintain iodine concentrations within analyzed limits, as described in FSAR Section 4a2.8. TOGS is designed with two off-gas recirculation trains per IU, that protect against unacceptable deflagrations resulting from TOGS equipment failures.

Hydrogen concentrations in TOGS are normally less than 2.0%. The TOGS blower minimum flowrate is set to maintain hydrogen concentration below the lower flammability limit of 4.0% and ensures a deflagration risk is not present in the TOGS, as described in FSAR Subsection 4a2.8.6. TOGS provides the ability to recombine hydrogen and oxygen through electrically heated recombiners. During irradiation startup, hydrogen is expected to evolve from the target solution more quickly than oxygen; therefore, TOGS also provides the function to inject oxygen during irradiation as required to support the hydrogen recombination function.

While mainstream flow is provided by both TOGS trains, dump tank flow is only provided by TOGS Train A. Iodine removal via the installed zeolite bed is only provided by TOGS Train B. Both TOGS trains are required to be Operating to provide the required functions. The TOGS hydrogen mitigation function is not required when target solution is not present in the IU (Mode 0).

The TOGS is considered Operable when both blowers are Operating, power is supplied to the recombiner heaters, and mainstream flow, dump tank flow, oxygen concentration, and condenser demister outlet temperature meet their specified conditions in Table 3.2.5.

If one or more TOGS train(s) are not Operating in Mode 1 or 2, the associated IU is placed in Mode 3 to stop the irradiation process, although hydrogen generation continues in the TSV dump tank via radiolysis generated by radioactive decay. TOGS Train A is designed to provide hydrogen mitigation of the TSV dump tank (see LCO 3.1.2).

If TOGS Train B is not Operating in Mode 3 or 4, TOGS Train A is verified to be Operating and providing the hydrogen mitigation function.

Additionally, in Mode 1, 2, 3, or 4, if TOGS Train A is not Operating, or both TOGS trains are not Operating, nitrogen purge is required to be actuated regardless of whether TOGS Train B is Operating.

SR

The surveillance requirement ensures both TOGS trains are Operating prior to the introduction of target solution into the TSV (Mode 1).

Basis 3.1.2 LCO

The PSB is normally maintained at slightly negative pressure. The lower TSV headspace pressure limit prevents excessive water uptake into TOGS via increased evaporation. The upper pressure limit corresponds to the initial conditions from a postulated deflagration event, as described in FSAR Subsection 13a2.1.9. The postulated deflagration causes a rapid pressure increase above the initial pressure in the PSB. By maintaining the maximum operating pressure below the LCO limit, the maximum credible deflagration peak pressure remains below the design pressure of the PSB. The limit prevents excessive pressure within the PSB that could result in a PSB leak or rupture. These scenarios are further described in FSAR Section 4a2.8 and Subsection 13a2.1.9. If the pressure is not within allowable limits, the associated IU is placed in Mode 3 to remove target solution from the TSV and to limit hydrogen generation in the IU. Transfer of solution to the TSV dump tank may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the IU Mode through Mode 2 to Mode 3 to perform a normal shutdown.

SR

Pressure excursions within the TSV headspace will result in control room alarms to alert the operator. Channel Check and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required.

Basis 3.1.3 LCO

The minimum TSV liquid volume during irradiation is [ ]PROP/ECI. To meet this limit during Mode 2, approximately [ ]PROP/ECI is required to be added to the TSV in Mode 1 to provide margin for up to 3 L of water anticipated to be held-up in TOGS during irradiation, as described in FSAR Subsection 4a2.6.1.1. The minimum target solution volume is required to maintain the peak target solution temperature below 194°F (90°C) and the average target solution temperature below 176°F (80°C) during irradiation to ensure the solution does not boil (see LCO 3.1.4). The maximum target solution volume is limited by the 1/M startup methodology. The system is filled to a height that is approximately five percent by volume below critical. If a minimum volume of [ ]PROP/ECI of target solution in the TSV has not been achieved when the final fill height is reached, as determined by 1/M calculations, the solution is transferred from the associated IU to the TSV dump tank. TSV solution fill volume requirements are further described in FSAR Subsection 4a2.6.1. During irradiation, the volume of target solution may lower due to leak by past the TSV dump valves and water hold up in the TOGS. If the volume of target solution in the TSV is reduced below the minimum volume of [ ]PROP/ECI, the target solution in the TSV is transferred to the TSV dump tank, in accordance with the specified action.

Transfer of solution to the TSV dump tank may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the IU Mode through Mode 2 to Mode 3 to perform a normal shutdown without irradiating the target solution.

SR

The surveillance requirement ensures the volume of target solution is within limits prior to irradiation and ensures continued operability of the instrumentation when required. Channel Check and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required.

Basis 3.1.4 <u>LCO</u>

The target solution in the TSV must remain within the analyzed temperature range to ensure boiling does not occur in the TSV or in the TSV dump tank after the target solution has been dumped (194.4°F [90.2°C] at 10.2 psi absolute [psia] [70.3 kPa absolute]), as described in FSAR Section 4a2.7 and Subsection 13a2.1.3. Average target solution temperature in the TSV must be ≤ 176°F (80°C) to prevent boiling in the TSV dump tank after the solution is dumped from the TSV to the TSV dump tank as described in FSAR Subsection 4a2.7.6. Temperature in the TSV is measured using nine thermocouples; the average of these readings is the average TSV solution temperature. If the average temperature is not within allowable limits, the associated IU is placed in Mode 3 to stop adding heat via irradiation and to place the solution in a configuration within the TSV dump tank where reactivity is controlled. Transfer of solution to the TSV dump tank may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the IU Mode to Mode 3 to perform a normal shutdown.

<u>SR</u>

The surveillance requirements ensure the continued operability of the instrumentation when required. Channel Check and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required.

Basis 3.1.5 <u>LCO</u>

One TSV dump valve is required to be fully open within two seconds of demand in order to drain solution from the TSV to the TSV dump tank within the time assumed in the accident analysis, as described in FSAR Section 4a2.6. The LCO drain time limit is based on the nominal expected volume of a target solution batch. If the TSV is filled to the minimum volume of [ ]PROP/ECI (see LCO 3.1.3), the maximum drain time for one valve is 183 seconds. Both TSV dump valves are required to be Operable whenever target solution is in the TSV to allow for a single failure of one valve to open. If one or more TSV dump valve(s) are not Operable, target solution is required be removed from the associated TSV. A TSV dump valve that is declared inoperable due to slow opening time or slow drain rate through the dump line flow path is still expected to be able to open, since the valves are cycled frequently and are designed to fail open on a loss of power. It is not considered credible for both valves to remain fully closed on a demand to open. Transfer to Mode 3 may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the associated IU Mode to Mode 3 to perform a normal shutdown.

<u>SR</u>

Quarterly verification of the valve opening time and line drain rate is used to confirm proper valve operation and is consistent with the frequency recommendations from ANSI/ANS 15.1-2007 for operability checks.

Basis 3.1.6 LCO

The transient power density limit is set to [ ]$^{PROP/ECI}$ to limit temperature, pressure, and hydrogen generation in transient events. Transient events are not a concern for uranyl sulfate precipitation because durations are too short to reach steady-state peroxide concentrations. The transient power density limit allows for momentary power spikes caused by the initial start or restart of the neutron driver (within the allowed Driver Dropout timeframe). Reaching the transient power density limit is prevented by the rate of ramp up used during startup and the duration of the allowed Driver Dropout. In addition, the high wide range neutron flux setpoint will initiate an automatic IU Cell Safety Actuation at 240% power, equivalent to approximately [ ]$^{PROP/ECI}$ at the minimum acceptable target solution volume.

SR

The daily verification surveillance requirement ensures that the average power density in the TSV is maintained within limits throughout the irradiation cycle. The neutron flux detectors, used to determine TSV power, are maintained Operable per LCO 3.2.4. The solution volume for the associated batch is ensured to be within limits per LCO 3.1.3. Power excursions will result in control room alarms to alert the operator. The frequency of the daily verification surveillance is based on industry experience.

Basis 3.1.7 LCO

Target solution must be held in the TSV dump tank for a minimum period of time after irradiation has occurred, depending on the maximum historical irradiation power of the target solution batch. The maximum historical irradiation power for a target solution batch is the highest power achieved for that batch in any previous irradiation cycle. The hold time limits the radionuclide inventory of target solution that is transferred to the RPF and ensures the source term does not exceed the initial conditions assumed in the accident analysis or biological shielding dose calculations, as described in FSAR Section 4a2.6.3.2. An aborted batch may be transferred to the RPF without any required hold time if the solution has not been irradiated in the immediately preceding cycle. Target solution is considered to have been irradiated in the immediately preceding cycle if the neutron driver has produced a deuterium beam, directed into a gas target, for greater than 1 effective full power minute after the transition to Mode 2 for that irradiation cycle.

SR

The surveillance requirement ensures the solution is not transferred prior to the minimum decay time required for each irradiation cycle.

3.2 Instrumentation and Control Safety Systems

Objective: To ensure instrumentation and control Safety Systems are able to provide their designed safety functions

LCO 3.2.1	TRPS actuation functions listed in Table 3.2.1 shall be Operable.
Applicability	According to Table 3.2.1
Action	According to Table 3.2.1
SR 3.2.1	Simulated automatic and manual actuation priority logic testing shall be performed every five years. Note – This SR cannot be deferred.

Table 3.2.1 TRPS Actuation Functions

	Function	Minimum Required Divisions	Applicability (per IU)	Action (per IU)
a.	IU Cell Safety Actuation	2	Modes 1, 2, 3, and 4	If one or more Division(s) are not Operable, Place the IU in Mode 3 AND Initiate actions to place the IU in Mode 0.
b.	IU Cell Nitrogen Purge	2	Modes 1, 2, 3, and 4	If one or more Division(s) are not Operable, Place the IU in Mode 3 AND Initiate actions to place the IU in Mode 0.
c.	Driver Dropout	2	Mode 2 with the high voltage power supply (HVPS) breakers closed	If one or more Division(s) are not Operable, open at least one HVPS breaker.

	Function	Minimum Required Divisions	Applicability (per IU)	Action (per IU)
d.	IU Cell TPS Actuation	2	Mode 2	If one or more Division(s) are not Operable, Open at least one HVPS breaker AND Place tritium in the associated train of TPS process equipment in its storage location OR Close at least one redundant IU Cell TPS Actuation valve or damper per flow path.
e.	Fill Stop	1	Mode 1 with the TSV fill valves open	If one or more Division(s) are not Operable, close at least one TSV fill valve.

LCO 3.2.2	Engineered safety features actuation system (ESFAS) actuation functions listed in Table 3.2.2 shall be Operable.
Applicability	According to Table 3.2.2
Action	According to Table 3.2.2
SR 3.2.2	Simulated automatic and manual actuation priority logic testing shall be performed every five years. Note – This SR cannot be deferred.

Table 3.2.2 ESFAS Actuation Functions

	Function	Minimum Required Divisions	Applicability	Action
a.	Radiologically Controlled Area (RCA) Isolation	2	Facility not Secured	If one or more Division(s) are not Operable, place RCA Isolation actuation components in the actuated state.
b.	Supercell Isolation	2 (per hot cell)	Target solution or radioactive process fluids present in the associated hot cell	If one or more Division(s) are not Operable, place Supercell Isolation actuation components in the actuated state for the associated hot cell.
c.	Carbon Delay Bed Isolation	2 (per delay bed group)	Associated carbon delay bed group Operating	If one or more Division(s) for a single carbon delay bed group are not Operable, Close the associated carbon delay bed group isolation valves AND Verify at least 5 carbon delay beds are Operating.
d.	VTS Safety Actuation	2	Solution transfers using VTS in-progress	If one or more Division(s) are not Operable, place VTS Safety Actuation components in the actuated state.

	Function	Minimum Required Divisions	Applicability	Action
e.	Tritium Purification System (TPS) Train Isolation	2 (per train)	Tritium in associated TPS process equipment not in storage	If one or more Division(s) are not Operable, Place tritium in the associated train of TPS process equipment in its storage location OR Close at least one redundant TPS Train Isolation device per TPS glovebox confinement flow path.
f.	TPS Process Vent Actuation	2	Tritium in associated TPS process equipment not in storage	If one or more Division(s) are not Operable, Place tritium in all three trains of TPS process equipment in its storage locations OR Close at least one redundant TPS Process Vent Actuation valve per flow path.
g.	IU Cell Nitrogen Purge	2	Any IU in Mode 1, 2, 3, or 4	If one or more Division(s) are not Operable, open at least one N2PS IU cell header valve.
h.	RPF Nitrogen Purge	2	Facility not Secured	If one or more Division(s) are not Operable, place RPF Nitrogen Purge actuation components in the actuated state.
i.	Molybdenum Extraction and Purification System (MEPS) [ ]PROP/ECI Isolation	2 (per hot cell)	Target solution present in the associated MEPS extraction hot cell	If one or more Division(s) are not Operable, place the associated MEPS [ ]PROP/ECI Isolation actuation components in the actuated state.
j.	Extraction Column Alignment Actuation	2 (per hot cell)	Target solution present in the associated MEPS extraction hot cell	If one or more Division(s) are not Operable, place the Extraction Column Alignment Actuation components in the actuated state.

k.	Iodine and Xenon Purification and Packaging (IXP) Alignment Actuation	2	Target solution present in the IXP hot cell	If one or more Division(s) are not Operable, place the IXP Alignment Actuation components in the actuated state.
l.	Dissolution Tank Isolation	2 (per tank)	Dissolution tank or target solution preparation system (TSPS) glovebox contains uranium	If one or more Division(s) are not Operable, place the Dissolution Tank Isolation actuation components in the actuated state.

LCO 3.2.3	TRPS interlocks listed in Table 3.2.3 shall be Operable.
Applicability	According to Table 3.2.3
SR 3.2.3	Interlocks listed in Table 3.2.3 shall be funtionally tested annually. Note – This SR cannot be deferred.

Table 3.2.3 TRPS Interlocks

	Interlock	Variable	Setpoint	Minimum Required Channels	Applicability (per IU)
a.	Mode 0 to Mode 1 transition	TSV dump valve position indication	Closed	2	Prior to entering Mode 1
b.	Mode 0 to Mode 1 transition	TSV fill valve position indication	Closed	2	Prior to entering Mode 1
c.	Mode 0 to Mode 1 transition	TOGS mainstream flow	[ ]PROP/ECI	2	Prior to entering Mode 1
d.	Mode 1 to Mode 2 transition	TSV fill valve position indication	Closed	2	Prior to entering Mode 2
e.	Mode 2 to Mode 3 transition	HVPS breaker position indication	Open	2	Prior to entering Mode 3
f.	Mode 3 to Mode 4 transition	IU Cell Safety Actuation signal	Cleared	2	Prior to entering Mode 4
g.	Mode 4 to Mode 0 transition	Low-high dump tank level	≤ 3%	2	Prior to entering Mode 0

LCO 3.2.4	Neutron flux detector Channels listed in Table 3.2.4 shall be Operable. Note – Any single required instrumentation Channel may be inoperable while the variable is in the condition of applicability for the purpose of performing a Channel Check or Channel Calibration.
Applicability	According to Table 3.2.4.
Action	According to Table 3.2.4.
SR 3.2.4	1. A Channel Check shall be performed on each Channel of the neutron flux detection system (NFDS) weekly. 2. A Channel Calibration shall be performed on each Channel of the NFDS annually.

Table 3.2.4 TRPS Neutron Flux Instrumentation

	Variable	Setpoint	Minimum Required Channels	Applicability (per IU)	Action
a.	High wide range neutron flux	≤ 240% power	2	Modes 1 and 2	If one or more required Channel(s) are not Operable, place the associated IU in Mode 3.
b.	High time-averaged power range neutron flux	≤ 104% power; averaged over ≤ 45 seconds	2	Modes 1 and 2	If one or more required Channel(s) are not Operable, place the associated IU in Mode 3.
c.	Low power range neutron flux	[ ]PROP/ECI	2	Mode 2 with the HVPS breakers closed	If one or more required Channel(s) are not Operable, open at least one HVPS breaker.
d.	High source range neutron flux	≤ 1.5 times the nominal flux at 95% volume of the critical fill height	2	Mode 1	If one or more required Channel(s) are not Operable, close at least one TSV fill valve.

LCO 3.2.5	TRPS process variable instrument Channels listed in Table 3.2.5 shall be Operable. Note – Any single required instrument Channel may be inoperable while the variable is in the condition of applicability for the purpose of performing a Channel Check, Channel Test, or Channel Calibration.
Applicability	According to Table 3.2.5
Action	1. If one or more required Channel(s) are not Operable, Close at least one TSV fill valve OR Place the associated IU in Mode 3. 2. If one or more required Channel(s) are not Operable, place the associated IU in Mode 3. 3. If one or more required Channel(s) are not Operable, Place the associated IU in Mode 3 OR Verify the associated IU is in Mode 3 or 4 AND Initiate actions to place the associated IU in Mode 0.
SR 3.2.5	1. A Channel Check shall be performed on TRPS process variable instrument Channels quarterly. 2. A Channel Calibration shall be performed on TRPS process variable instrument Channels annually. 3. A Channel Test shall be performed on TRPS process variable instrument Channels quarterly.

Table 3.2.5 TRPS Process Variable Instrumentation

	Variable	Setpoint	Minimum Required Channels	Applicability (per IU)	Action	SR
a.	TSV fill valve position indication	Not Closed	2	Mode 2	1	3
b.	Low PCLS flow	[ ]PROP/ECI; IU Cell Safety Actuation delayed by ≤ 180 seconds	2	Modes 1 and 2	2	1, 2
c.	High PCLS temperature	≤ 72.9°F; IU Cell Safety Actuation delayed by ≤ 180 seconds	2	Modes 1 and 2	2	1, 2
d.	Low PCLS temperature	≥ 63.5°F	2	Modes 1 and 2	2	1, 2
e.	Low-high dump tank level	≤ 3%	2	Modes 1 and 2	2	3
f.	High-high dump tank level	≤ 85%	2	Modes 1, 2, 3, and 4	4	3
g.	Low TOGS mainstream flow	[ ]PROP/ECI	2	Modes 1, 2, 3, and 4	4	1, 2
h.	Low TOGS dump tank flow	[ ]PROP/ECI	2	Modes 1, 2, 3, and 4	4	1, 2
i.	Low TOGS oxygen concentration	≥ 11%	2	Modes 1, 2, 3, and 4	4	1, 2
j.	High TOGS condenser demister outlet temperature	≤ 69.8°F	2	Modes 1, 2, 3, and 4	4	1, 2
k.	ESFAS loss of external power	Loss of Power	2	Modes 1, 2, 3, and 4	4	3

LCO 3.2.6	ESFAS process variable instrument Channels listed in Table 3.2.6 shall be Operable. Note – Any single required instrument Channel may be inoperable while the variable is the condition of applicability for the purpose of performing a Channel Check, Channel Test, or Channel Calibration.
Applicability	According to Table 3.2.6
Action	1. If one or more required Channel(s) are not Operable, place the associated MEPS [ ]PROP/ECI Isolation actuation components in the actuated state. 2. If one or more required Channel(s) for a single carbon delay bed group are not Operable, Close the associated carbon delay bed group isolation valves AND Verify at least 5 carbon delay beds are Operating. 3. If one or more required Channel(s) are not Operable, Open the VTS vacuum pump breakers AND Open the VTS vacuum break valves. 4. If one or more required Channel(s) are not Operable, actuate the nitrogen purge system. 5. If one or more required Channel(s) are not Operable, place the Dissolution Tank Isolation actuation components in the actuated state. 6. If one required Channel is not Operable, restore both Channels to Operable within 72 hours. 7. If both required Channels is not Operable, place all IUs undergoing irradiation in Mode 3. 8. If one or more required Channel(s) are not Operable, place the associated Alignment Actuation components in the actuated state. 9. If one or more required Channel(s) are not Operable, close at least one associated TPS target chamber supply line valve per associated IU.
SR 3.2.6	1. A Channel Check shall be performed on ESFAS process variable instrument Channels quarterly. 2. A Channel Calibration shall be performed on ESFAS process variable instrument Channels annually. 3. A Channel Test shall be performed on ESFAS process variable instrument Channels quarterly.

Table 3.2.6 ESFAS Process Instrumentation

	Variable	Setpoint	Minimum Required Channels	Applicability	Action	SR
a.	High MEPS [ ]PROP/ECI conductivity	≤ 8.8 µmho/cm	2 (per hot cell)	Target solution or radioactive process fluids present in the associated hot cell	1	1, 2
b.	High PVVS carbon delay bed carbon monoxide	≤ 20 ppm	2 (per delay bed group)	Associated carbon delay bed group Operating	2	1, 2
c.	VTS header liquid detection	Active	2	Solution transfers using VTS in-progress	3	3
d.	RDS liquid detection	Active	2	Solution transfers using VTS in-progress	3	3
e.	Low PVVS flow	≥ 7.1 SCFM	2	Facility not Secured	4	3
f.	High dissolution tank level	≤ 98%	2	Dissolution tank or TSPS glovebox contains uranium	5	1, 2
g.	Uninterruptible electrical power supply system (UPSS) loss of external power	Loss of Power; actuation delayed by ≤ 180 seconds	2	Any IU in Mode 1, 2, 3, or 4	6, 7	3
h.	MEPS three-way valve position indication	Supplying	2 (per valve)	Target solution present in the associated hot cell	8	3
i.	IXP three-way valve position indication	Supplying	2 (per valve)	Target solution present in the IXP hot cell	8	3
j.	High TPS target chamber supply pressure	≤ 7.7 psia	2 (per IU)	Tritium in associated TPS process equipment not in storage	9	1, 2
k	High TPS target chamber exhaust pressure	≤ 7.7 psia	2 (per IU)	Tritium in associated TPS process equipment not in storage	9	1, 2

Basis 3.2.1 LCO

The TRPS is required to perform actuation functions, as described in FSAR Section 7.4.

a. IU Cell Safety Actuation is required to automatically transition the associated IU to Mode 3, to isolate PSB flow paths, and to isolate primary Confinement boundary penetrations. The IU Cell Safety Actuation function is required to be Operable when target solution is present in the IU. With one or more Division(s) inoperable, the IU is placed in Mode 3 by automatic or manual transitions. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to initiating transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

b. IU Cell Nitrogen Purge is required to mitigate the loss of hydrogen recombination capability in the associated IU by purging the PSB with nitrogen. This function is required to be Operable when target solution is present in the IU. The ESFAS IU Cell Nitrogen Purge function (see Table 3.2.2, item g.) must also be Operable for the TRPS IU Cell Nitrogen Purge function to be considered Operable. With one or more Division(s) inoperable, the IU is placed in Mode 3 by automatic or manual transitions. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

c. Driver Dropout is required to prevent the associated neutron driver from restarting in conditions where the restart could challenge the power density limit (see LCO 3.1.6) by opening the HVPS breakers to the neutron driver. This function is required to be Operable when the neutron driver is Operating. With one or more Division(s) inoperable, the neutron driver HVPS breakers are required to be opened to prevent restart of the driver.

d. IU Cell TPS Actuation is required to isolate potential release paths between the associated TPS train and the IU cell. TPS train A is associated with IU cells 1 and 2, TPS train B is associated with IU cells 3, 4, and 5, and TPS train C is associated with IU cells 6, 7, and 8. The IU Cell TPS Actuation is initiated by an ESFAS TPS Process Vent Actuation (see Table 3.2.2, item f.), and functions to isolate the TPS target chamber supply isolation valves, TPS deuterium supply isolation valves, TPS target chamber exhaust isolation valves, TPS neutron driver evacuation isolation valves, and the RVZ1 IU cell ventilation dampers, and to initiate a Driver Dropout. With one or more Division(s) inoperable, the neutron driver HVPS breakers are required to be opened and tritium in the associated TPS glovebox is required to be placed in its storage location (i.e., a depleted uranium bed) or at least one redundant valve or damper per flow path into the IU cell is required to be isolated.

e. Fill Stop aids in controlling the rate of fill of the associated target solution vessel and acts to close the TSV fill valves if Fill Stop parameters (see FSAR Subsection 7.4.3.2.4) are not met. After NFDS source range neutron flux has reached or exceeded 40% of the maximum 95% fill flux, if the TSV fill isolation valve is not fully closed, then a [ ]PROP/ECI timer is initiated. If the TSV fill isolation valve is not fully closed before the end of the [ ]PROP/ECI duration, then the TRPS initiates a Fill Stop. If the TSV fill isolation valve is fully closed prior to the end of the [ ]PROP/ECI duration, then the [ ]PROP/ECI timer resets. Additionally, when the TSV fill isolation valve is fully closed, a 5-minute timer is initiated. If the TSV fill isolation valve is not fully closed prior to the duration of the 5-minute timer ending, then the TRPS initiates a Fill Stop. This function is required to be Operable when the TSV is being filled and when the TSV fill valves are open. A Fill Stop results in automatically closing the TSV fill valves, preventing an excess reactivity insertion caused by an uncontrolled fill and subsequent IU Cell Safety Actuation on high source range neutron flux. With the required Division inoperable, the TSV fill valves are required to be closed to prevent addition of target solution to the TSV.

The TRPS contains redundant safety-related components (e.g., power supplies and equipment interface modules) within a single Division, as described in FSAR Section 7.2.2.2. A Division (A, B, or C) of the TRPS will continue to perform its function with one redundant component out of service. Redundant components within a Division of the TRPS may be taken out of service for maintenance without declaring the Division inoperable. Of the safety-related components, only safety function modules do not have redundancy within the Division and therefore cannot be taken out of service without declaring that Division of the function inoperable.

<u>SR</u>

The TRPS platform has end-to-end self-testing that covers each module from sensor input to the output switching logic (except for the discrete circuitry of the actuation and priority logic). The individual self-tests on the different components of the highly integrated protection system (HIPS) platform evaluate whether the entire platform is functioning correctly, as described in FSAR Section 7.2.4. HIPS modules include light emitting diodes (LEDs) that are used to determine the state of the module latches, the operational state of the module, and the presence of any faults. The HIPS platform self-testing features and the associated front panel LEDs allow for the timely identification of certain malfunctions within the HIPS equipment. Only manual actuation and priority logic functions are not covered by the self-testing features and therefore require periodic surveillance. The actuation priority logic test verifies the functionality of the discrete priority logic circuits of the TRPS safety-related control system. The test includes testing of the manual actuation functions of TRPS. Built-in redundancy and notification of failures within the TRPS supports the surveillance frequency.

Basis 3.2.2 <u>LCO</u>

The ESFAS is required to perform actuation functions, as described in FSAR Section 7.5.

a. RCA Isolation functions to isolate potential sources of radiation throughout the facility upon a high radiation signal in either radiological ventilation zone 1 (RVZ1) or radiological ventilation zone 2 (RVZ2) facility exhaust. The function deenergizes RVZ1 exhaust isolation dampers, RVZ2 supply isolation dampers, RVZ2 exhaust isolation dampers, and RVZ3 isolation dampers; opens RVZ1 exhaust, RVZ2 supply, and RVZ2 exhaust blower breakers; performs a Supercell Isolation on all supercell areas; performs a VTS Safety Actuation; and performs a TPS Isolation. The purpose of the RCA Isolation function is to limit the amount of radioactivity that is released to the environment to less than allowable limits in the event of an accidental release. The RCA Isolation function is not required whenever the facility operations are Secured or the radiological ventilation (RV) isolation dampers and actuation devices are already in their safe state (i.e., closed dampers and open breakers). With one or more Division(s) inoperable, the RV isolation dampers are required to be closed to fulfil the RCA Isolation function.

b. Supercell Isolation is required to perform Confinement actions for each hot cell of the supercell upon a high radiation signal from the associated hot cell. The Supercell Isolation functions are required to be Operable when target solution or radioactive process fluids are present in the associated hot cell. Target solution and radioactive process fluids are considered to be no longer present when the radioactive liquids have been drained and the radioactive gases have been flushed with approximately one line volume of air or nitrogen. With one or more Division(s) inoperable, the associated Supercell Isolation devices are required to be in their actuated state (described in items i through iv below).

   i. Supercell Isolation function for the PVVS area closes the inlet and outlet isolation dampers and performs a VTS Safety Actuation.

   ii. Supercell Isolation functions for MEPS extraction areas A, B, and C close the inlet and outlet isolation dampers, perform a MEPS [ ]PROP/ECI Isolation and perform a VTS Safety Actuation.

   iii. Supercell Isolation functions for MEPS purification areas A, B, and C, and packaging areas 1 and 2 close the inlet and outlet isolation dampers.

   iv. Supercell Isolation function for the IXP area closes the inlet and outlet isolation dampers, performs Supercell Isolation functions for MEPS extraction areas B and C (to deenergize MEPS extraction feed pump breakers that may be supplying the IXP area), and performs a VTS Safety Actuation.

c. Carbon Delay Bed Isolation functions to isolate the associated carbon delay bed group upon indication of a fire within that group, detected by elevated carbon monoxide concentration. The Carbon Delay Bed Isolation acts to energize the three-way valves and close the outlet isolation valves. With one or more Division(s) inoperable affecting a single carbon delay bed group, the group is required to be isolated to fulfill the function. Nonsafety-related isolation valves are provided on the inlet and outlet of each carbon delay bed to isolate an individual bed as required for maintenance. At least seven of the eight carbon delay beds are required to be Operating to provide the design noble gas residence time (see LCO 3.5.1). If only five or six carbon delay beds are Operating, the noble gas residence time is reduced. The total curies released from the facility are managed in accordance with LCO 3.7.2.

d. VTS Safety Actuation is required to stop the transfer of target solution or other radioactive solutions upon indication of liquid in the VTS header (potential tank overflow), liquid in the radioactive drain system (RDS) sump tank (potential tank leak), high radiation in the extraction, IXP, or PVVS supercell hot cells, or high radiation in the facility RVZ1 or RVZ2 exhaust (RCA Isolation). The VTS Safety Actuation stops the transfer of fluid by opening the breakers for all three VTS vacuum transfer pumps and opening the VTS vacuum break valves. The VTS Safety Actuation also closes the MEPS areas A, B, and C and IXP area supply isolation valves, since leakage from those systems could also be sources of liquid ingress to the RDS sump tank. With one or more Division(s) inoperable, the VTS vacuum pump breakers and VTS vacuum break valves are required to be opened to stop the transfer of target solution and radioactive liquid wastes within the facility, and MEPS and IXP supercell supply isolation valves (see LCO 3.8.10 items o. through y.) are required to be closed.

e. TPS Train Isolation functions to deenergize and close valves associated with the Confinement boundary of the associated TPS glovebox and dampers associated with the TPS room upon indication of high tritium concentration within a glovebox confinement. TPS Train A is associated with IU cells 1 and 2, TPS Train B is associated with IU cells 3, 4, and 5, and TPS Train C is associated with IU cells 6, 7, and 8. With one or more Division(s) inoperable, tritium in the associated TPS train is required to be placed in its storage location (i.e., a depleted uranium bed) or at least one redundant valve per penetration flow path into the TPS glovebox is required to be isolated.

f. TPS Process Vent Actuation functions to isolate potential release paths to the facility stack from all three trains of TPS process equipment on indication of high tritium in the TPS exhaust to the facility stack. With one or more Division(s) inoperable, tritium in all three TPS gloveboxes is required to be placed in its storage location (i.e., a depleted uranium bed) or at least one redundant TPS Process Vent Actuation valve per flow path is required to be isolated.

g. IU Cell Nitrogen Purge is required to provide N2PS nitrogen sweep gas to one or more IU(s) on a loss of normal hydrogen recombination capability by opening the N2PS IU cell header valves. After a loss of TOGS, the N2PS sweep gas prevents accumulation of hydrogen within the PSB, which could lead to a hydrogen deflagration. With one or more Division(s) inoperable, the N2PS IU cell header valves are required to be opened to complete the function. Opening the header valves does not introduce nitrogen into the IUs, as the individual IU cell isolation valves are controlled by TRPS (see LCO 3.2.1, item b.).

h. RPF Nitrogen Purge is required to mitigate the loss of hydrogen recombination capability in RPF tanks by providing N2PS nitrogen sweep gas to tanks upon an indication of loss of PVVS. After a loss of PVVS, the N2PS sweep gas prevents accumulation of hydrogen within RPF tanks and vessels, which could lead to a hydrogen deflagration. With one or more Division(s) inoperable, the RPF header valves, PVVS carbon guard bed bypass valves, and PVVS blower bypass valves are required to be opened, and the RLWI

PVVS isolation valve and N2PS RVZ2 north and south header valves are required to be closed to actuate nitrogen purge.

i. MEPS [ ]PROP/ECI Isolation functions to close the associated extraction hot cell [ ]PROP/ECI isolation valves and open the extraction feed pump breakers on indication of target solution leakage into the [ ]PROP/ECI, high radiation in the affected extraction cell RVZ1 exhaust duct, or liquid detection in the RDS sump tank (indicative of a potential leak of fluid inside the extraction cell), or in the event of an RCA Isolation. With one or more Division(s) inoperable, the [ ]PROP/ECI isolation valves are required to be closed, and the extraction feed pump breakers are required to be opened, to complete the function.

j. Extraction Column Alignment Actuation functions to deenergize the associated extraction hot cell three-way valves and extraction column eluent valve to prevent inadvertent misdirection of target solution. Misdirected flow could result in uranium precipitation (if target solution is mixed with basic reagents). Misdirection additionally degrades one of the barriers relied on to prevent a criticality (by potentially sending target solution to a non-favorable geometry location), or to prevent target solution from exiting the supercell. With one or more Division(s) inoperable, the three-way valves are placed in the discharging position, and the extraction column eluent valve is closed.

k. IXP Alignment Actuation functions to deenergize the IXP three-way valves and recovery column eluent valve to prevent inadvertent misdirection of target solution. Misdirected flow could result in uranium precipitation (if target solution is mixed with basic reagents). Misdirection additionally degrades one of the barriers relied on to prevent a criticality (by potentially sending target solution to a non-favorable geometry location), or to prevent target solution from exiting the supercell. With one or more Division(s) inoperable, the three-way valves are placed in the discharging position, and the eluate valve is closed.

l. Dissolution Tank Isolation is required to close radioisotope process facility cooling system (RPCS) supply cooling valves and supply and exhaust ventilation dampers on indication of high level in the TSPS dissolution tank to prevent overflow of the tank into the uranium handling glovebox and isolate the glovebox. Overflow of the tank into the glovebox introduces moderator into the glovebox, removing one of the barriers relied on to prevent a criticality when uranium is present in the glovebox. With one or more Division(s) inoperable, the RPCS supply cooling valves and the supply and exhaust ventilation dampers are required to be closed.

The ESFAS contains redundant safety-related components (e.g., power supplies and equipment interface modules) within a single Division, as described in FSAR Section 7.2.2.2. A Division (A, B, or C) of the ESFAS will continue to perform its function with a redundant component out of service. Redundant components within a Division of the ESFAS may be taken out of service for maintenance without declaring the Division inoperable. Of the safety-related components, only safety function modules do not have redundancy within the Division, and therefore cannot be taken out of service without declaring that Division of the function inoperable.

SR

The ESFAS platform has end-to-end self-testing that covers each module from sensor input to the output switching logic (except for the discrete circuitry of the actuation and priority logic). The individual self-tests on the different components of the HIPS platform evaluate whether the entire platform is functioning correctly, as described in FSAR Subsection 7.2.4. HIPS modules include LEDs that are used to determine the state of the module latches, the operational state of the module, and the presence of any faults. The HIPS platform self-testing features and the associated front panel LEDs allow for the timely identification of certain malfunctions within the HIPS equipment. Only manual actuation and priority logic functions are not covered by the self-testing features, and therefore require periodic surveillance. The actuation priority logic test verifies the functionality of the discrete priority logic circuits of the ESFAS safety-related control system. The test includes testing of the manual actuation functions of ESFAS. Built-in redundancy and notification of failures within the ESFAS supports the surveillance frequency.

Basis 3.2.3 LCO

The TRPS interlocks are required to prevent operation of the IU outside of analyzed conditions, as described in FSAR Section 7.4.

a. The TSV dump valves are fully closed prior to entering Mode 1 to prevent immediately actuating an IU Cell Safety Actuation on low-high dump tank level. The interlock is only required to be Operable in order to transition to Mode 1 and may be inoperable in Mode 0 for maintenance when transition to Mode 1 activities are not in progress.

b. The TSV fill valves are fully closed prior to entering Mode 1 to prevent inadvertent addition of target solution before high source range neutron flux signals are required to be Operable. The TSV fill valves may be opened after the IU has been transitioned to Mode 1. The interlock is only required to be Operable in order to transition to Mode 1 and may be inoperable in Mode 0 for maintenance when transition to Mode 1 activities are not in progress. TSV fill valves may be opened in Mode 1 but are subject to Fill Stop time requirements (see LCO 3.2.1, item e.).

c. The TOGS is required to be Operating prior to introducing target solution to the IU. The minimum TOGS mainstream flow setpoint of [ ]$^{PROP/ECI}$ is based on an analytical limit of [ ]$^{PROP/ECI}$, which has been calculated to be sufficient to maintain hydrogen concentration within the TSV at less than 4.0% by volume during normal operation and demonstrates that the TOGS is Operating. The interlock is only required to be Operable in order to transition to Mode 1 and may be inoperable in Mode 0 for maintenance when transition to Mode 1 activities are not in progress.

d. The TSV fill valves are fully closed prior to entering Mode 2 to prevent inadvertent addition of target solution during irradiation. The interlock is only required to be Operable in order to transition to Mode 2. TSV fill valve position indication is used to initiate an IU Cell Safety Actuation after transition to Mode 2.

e. The HVPS breaker is required to be open prior to entering Mode 3 to prevent operation of the neutron driver in that Mode. The interlock is only required to be Operable in order to transition to Mode 3.

f. If an IU Cell Safety Actuation signal has been initiated, this interlock prevents transition of the affected IU to Mode 4 until the initiating conditions and resulting consequences have been identified and dispositioned. The IU Cell Safety Actuation may then be reset and transition to Mode 4 allowed.

g. Target solution is transferred from the TSV dump tank to the RPF during Mode 4. The low-high signal being clear indicates that the TSV dump tank is sufficiently drained to allow transition to Mode 0. An incomplete transfer results in target solution remaining in the TSV dump tank in Mode 0, which is not permissible. The low-high dump tank level signal being clear (below the setpoint of 3%) is indicative of an empty TSV dump tank. Residual target solution below the 3% setpoint is acceptable for transition to Mode 0.

SR

The surveillance requirements ensure the continued operability of the interlock Channels. Annual functional testing is consistent with the recommendations from ANSI/ANS 15.1-2007.

Basis 3.2.4 LCO

The NFDS provides indication of neutron flux and TSV power during IU operations, as described in FSAR Section 7.8 . The NFDS signals provide input to TRPS functions, as described in FSAR Subsection 7.4.5. Three Channels of NFDS are provided for each of the variables in Table 3.2.4, one Channel for each of Divisions A, B, and C. Only two Channels are required to be Operable to provide redundancy to protect against a single failure. When all three Channels are Operable, actuation of the safety function occurs on 2-out-of-3 voting logic. When any single Channel is inoperable, the inoperable Channel is required to be placed in trip, effectively changing the voting logic to 1-out-of-2, preserving the single failure protection.

Any single Channel may be placed in bypass during performance of a required SR, effectively changing the voting logic to 2-out-of-2 (with two other Channels Operable) or 1-out-of-1 (with one other Channel Operable).

a. During irradiation, the NFDS monitors percent power on the wide range Channel up to 250% of 125 kW fission power, the licensed power limit. The high wide range neutron flux limit is set at a neutron flux equivalent to 240% power (i.e., 300 kW). This limit provides margin to an analytical limit of 390 kW, the power equivalent of [ ]PROP/ECI at the minimum acceptable target solution irradiation volume of [ ]PROP/ECI. TSV power limits are discussed in FSAR Subsections 4a2.6.1 and 7.4.5. The high wide range neutron flux setpoint protects against high power density conditions that may lead to target solution precipitation. Exceeding the high wide range neutron flux setpoint results in an IU Cell Safety Actuation. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transition to Mode 3 may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the IU Mode to Mode 3 to perform a normal shutdown.

b. During irradiation, the NFDS monitors percent power on the power range Channel up to 125% of 125 kW (i.e., 156 kW) fission power. The high time-averaged power range neutron flux limit is set at a neutron flux equivalent to 104% power (i.e., 130 kW). This limit provides margin to an analytical limit of 137.5 kW and ensures that the TSV power does not exceed analyzed conditions related to thermal hydraulic considerations, radiolysis gas generation, or fission product source term. TSV power limits are discussed in FSAR Subsections 4a2.6.1 and 7.4.5 . The measured neutron flux is averaged to prevent unnecessary actuations of the Safety Systems during startup of the neutron driver. The averaging time is based on thermal hydraulic considerations, as described in FSAR Subsection 4a2.7.6. The high time-averaged neutron flux setpoint protects against sustained high power that could cause overheating of target solution or excessive hydrogen generation. Exceeding the high time-averaged power range neutron flux setpoint results in an IU Cell Safety Actuation. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transition to Mode 3 may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the IU Mode to Mode 3 to perform a normal shutdown.

c. The low power range neutron flux signal is provided to detect a loss of the neutron driver during irradiation and prevent restart of the driver outside of analyzed conditions. TRPS initiates a loss of neutron driver Driver Dropout on low power range neutron flux by opening the NDAS HVPS breakers with a timed delay. The breakers are then interlocked open until [ ]PROP/ECI

The driver is not permitted to restart if target solution has cooled and [ ]PROP/ECI, as a restart could result in a power excursion that could challenge the power density limit (see LCO 3.1.6). The [ ]PROP/ECI power limit is set such that it is above a flux level expected to be caused by delayed neutrons continuing to be produced after the neutron driver has stopped Operating. The low power range neutron flux signal is required to be Operable in Mode 2, the only Mode where neutron driver operation is allowed. With fewer than two Channels Operable, the neutron driver HVPS breakers are required to be opened to prevent operation of the driver.

d. During the filling process, the NFDS measures the counts per minute, up to 1E+05 cpm. The source range neutron flux detector Channel is required to be Operable to ensure the TSV neutron flux is measured during Mode 1, the only Mode where TSV filling is allowed. Source range neutron flux limit protect against an insertion of excess positive reactivity during the filling process, as discussed in FSAR Subsection 7.4.5. The high source range neutron flux setpoint of 1.5 times the nominal flux at 95% volume of the critical fill height is set to ensure an IU Cell Safety Actuation occurs prior to exceeding a percentage above the normal startup flux as measured by the NFDS, as described in FSAR Subsection 4a2.6.2.7. The setpoint provides margin to an analytical limit of [ ]PROP/ECI times the nominal flux at 95% volume of the critical fill height. This analytical limit provides protection against positive reactivity insertions that could challenge the PSB integrity from an uncontrolled fill at [ ]PROP/ECI, the physical limit of the TSV fill system. Exceeding the high source range neutron flux setpoint results in an IU Cell Safety Actuation. With fewer than two Channels Operable, at least one TSV fill valve is required to be closed to prevent addition of target solution to the TSV.

SR

The surveillance requirements ensure the continued operability of the NFDS. Channel Check and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required. Weekly Channel Checks align with the weekly cycle of IU operations. Performance of these surveillances may require the Channel to be temporarily inoperable (bypassed). The temporary bypass is acceptable based on continuous attendance to the instrumentation by personnel performing the surveillance, the limited time duration of the activity, and industry experience.

Basis 3.2.5 LCO

TRPS process variable instrumentation is required to support the TRPS actuation functions listed in Table 3.2.1 and described in FSAR Section 7.4.

Three TRPS process variable instrumentation Channels are provided for each of the variables in Table 3.2.5, one Channel for each of Divisions A, B, and C, with the exception of TSV fill valve position indication (item a.), and ESFAS loss of external power (item k.) for which only two Channels are provided. Only two Channels of any process variable instrumentation are required to be Operable to provide redundancy to protect against a single failure.

When all three Channels are Operable for a variable provided with three Divisions, actuation of the safety function occurs on 2-out-of-3 voting logic. When any single Channel is inoperable for variables provided with three Divisions, the inoperable Channel is required to be placed in trip, effectively changing the voting logic to 1-out-of-2, preserving the single failure protection.

For variables provided with only two Channels, actuation of the safety function occurs on 1-out-of-2 voting logic.

Any single Channel for any of the TRPS process instrumentation variables may be placed in bypass during performance of a required SR, effectively changing the voting logic to 2-out-of-2 (with two other Channels Operable) or 1-out-of-1 (with one other Channel Operable).

a. The TSV fill valve position indication protects against an inadvertent addition of target solution to the TSV during irradiation. Two position indication Channels are provided per valve. At least one TSV fill valve must be closed in Mode 2; opening both TSV fill valves in Mode 2 results in an IU Cell Safety Actuation. The TSV fill valve position indication also provides an input to the Fill Stop function (see LCO 3.2.1, item e.). The TSV fill valves being opened early, or opened too long, while the IU is in Mode 1 results in a Fill Stop actuation, which automatically closes both TSV fill valves. With fewer than two Channels Operable, at least one TSV fill valve is required to be closed to prevent addition of target solution into the TSV.

b. The low PCLS flow limit of [ ]PROP/ECI is based on an analytical limit of [ ]PROP/ECI, as described in FSAR Subsection 4a2.7.9. PCLS is required to maintain cooling to the TSV during irradiation to prevent boiling of the target solution. The time delay prior to an IU Cell Safety Actuation is based on the acceptability of a complete loss of cooling without neutron driver operation for up to 180 seconds prior to transferring target solution to the TSV dump tank (an IU Cell Safety Actuation). The TRPS initiates a loss of cooling Driver Dropout on low PCLS cooling water flow to open the NDAS HVPS breakers without a timed delay. This shuts down the neutron driver to prevent overheating of the target solution, while allowing the target solution to remain within the TSV. The breakers are then interlocked open until the PCLS flow and temperature are in the allowable range. If PCLS flow and temperature are not in the allowable range within 180 seconds, an IU Cell Safety Actuation is initiated, as described above. With fewer than two Channels Operable, the IU is required to be placed in Mode 3, during which PCLS cooling is not required.

c. The high PCLS temperature limit of 72.9°F (22.7°C) is based on an analytical limit of 77°F (25°C) as described in FSAR Subsection 4a2.7.9. PCLS is required to maintain cooling to the TSV during irradiation to prevent boiling of the target solution. The time delay prior to an IU Cell Safety Actuation is based on the acceptability of a complete loss of cooling for up to 180 seconds prior to transferring target solution to the TSV dump tank (an IU Cell Safety Actuation). This parameter also ensures the temperature of solution during the fill of the TSV during Mode 1 is within analyzed limits, as described in FSAR Subsection 13a2.1.2. The TRPS initiates a loss of cooling Driver Dropout on high PCLS cooling water supply temperature to open the NDAS HVPS breakers without a timed delay. This shuts down the neutron driver to prevent overheating of the target solution, while allowing the target solution to remain within the TSV. The breakers are then interlocked open until the PCLS flow and temperature are in the allowable range. If PCLS flow and temperature are not in the allowable range within 180 seconds, an IU Cell Safety Actuation is initiated, as described above. With fewer than two Channels Operable, the IU is required to be placed in Mode 3, during which PCLS cooling is not required.

d. The low PCLS temperature limit of 63.5°F (17.5°C) is based on an analytical limit of 59°F (15°C). The low temperature signal protects against overcooling of the target solution that could cause an excess positive reactivity insertion, as described in FSAR Subsection 7.4.5. This parameter also ensures the temperature of solution during the fill of the TSV during Mode 1 is within analyzed limits, as described in FSAR Subsection 13a2.1.2. Falling below this setpoint results in an IU Cell Safety Actuation. With fewer than two Channels Operable, the IU is required to be placed in Mode 3, where target solution is drained to the favorable geometry TSV dump tank.

e. The TSV dump tank low-high limit of 3% is based on an analytical limit of [ ]PROP/ECI, which equates to 6.2% of the [ ]PROP/ECI span of the tank. The TSV dump tank low-high level protects against a leak of liquid into the TSV dump tank when the tank is expected to be empty, ensuring there is enough capacity in the TSV dump tank to receive a full TSV solution batch, as described in FSAR Subsections 4a2.2.1.10 and 7.4.5. Exceeding this setpoint results in an IU Cell Safety Actuation and an IU Cell Nitrogen Purge. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Leak indication in Mode 3 is provided by the high-high dump tank level.

f. The TSV dump tank high-high limit of 85% is based on an analytical limit of [ ]PROP/ECI, which equates to 87.9% of the [ ]PROP/ECI span of the tank. The TSV dump tank high-high level ensures the TSV dump tank solution height does not interfere with TOGS operation, as described in FSAR Subsections 13a2.1.9.2 and 7.4.5. Exceeding this setpoint results in an IU Cell Safety Actuation and an IU Cell Nitrogen Purge. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

g. The low TOGS mainstream flow limit of [ ]PROP/ECI is based on an analytical limit of [ ]PROP/ECI, which has been conservatively calculated to be sufficient to maintain hydrogen concentration within the TSV headspace at less than 4.0% by volume during normal operations. Maintaining a hydrogen concentration below 7.7% prevents a deflagration that could challenge the PSB pressure safety limit, as described in FSAR Sections 4a2.8.6 and 7.4.5. Falling below this setpoint results in an IU Cell Safety Actuation and an IU Cell Nitrogen Purge. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

h. The low TOGS dump tank flow limit of [ ]PROP/ECI is based on an analytical limit of [ ]PROP/ECI, which has been conservatively calculated to be sufficient to maintain hydrogen concentration within the TSV dump tank of less than 4.0% during normal operations. Maintaining a hydrogen concentration below 7.7% prevents a deflagration that could challenge the PSB pressure safety limit, as described in FSAR Sections 7.4.5 and 4a2.8.6. Falling below this setpoint results in an IU Cell Safety Actuation and an IU Cell Nitrogen Purge. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

i. The low TOGS oxygen concentration limit of 11% is based on an analytical limit of 10%, which is sufficient to support the hydrogen/oxygen recombination function of the TOGS. Exceeding this setpoint results in an IU Cell Safety Actuation and an IU Cell Nitrogen Purge. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [

]PROP/ECI are required to complete the transfer of target solution to the RPF.

j. The high TOGS condenser demister outlet temperature limit of 69.8°F (21°C) is based on an analytical limit of 77°F (25°C). A high temperature is indicative of a failure of the condenser demister, with the potential for increased water holdup in TOGS. An increased water holdup in TOGS could adversely impact the ability for TOGS to perform its recombination function. In normal operation, TOGS maintains hydrogen concentrations below levels that could result in a hydrogen deflagration in the PSB via hydrogen and oxygen recombination. Exceeding this setpoint results in an IU Cell Safety Actuation and an IU Cell Nitrogen Purge. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

k. The TOGS is required to provide hydrogen mitigation within the IU, as described in FSAR Section 4a2.8. The ESFAS loss of external power signal protects against the expected loss of TOGS blowers and recombiners after the runtime on the UPSS has been exceeded. The ESFAS implements a 180 second timer (see LCO 3.2.6, item g.), which provides margin to the five-minute UPSS runtime, as described in FSAR Subsection 8a2.2.3. Two Channels are provided; one signal is received from each Division of ESFAS. With fewer than two Channels Operable, the IU is required to be placed in Mode 3. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

SR

The surveillance requirements ensure the continued operability of the TRPS process variable instrument Channels. Channel Check, Channel Test, and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required. Performance of these surveillances may require the Channel to be temporarily inoperable (bypassed). The temporary bypass is acceptable based on continuous attendance to the instrumentation by personnel performing the surveillance, the limited time duration of the activity, and industry experience.

Basis 3.2.6 LCO

ESFAS process variable instrumentation is required to be functional to support the protective functions listed in Table 3.2.2 and described in FSAR Section 7.5.

Two ESFAS process variable instrumentation Channels are provided for the variables in Table 3.2.6, one Channel for each of Divisions A and B, with the exception of low PVVS flow (item e.), which is provided three Channels. Two

Channels of any process variable instrumentation are required to be Operable to provide redundancy to protect against a single failure.

For variables provided with only two Channels, actuation of the safety function occurs on 1-out-of-2 voting logic.

For the low PVVS flow signal (item e.), when all three Divisions are Operable, actuation of the safety function occurs on 2-out-of-3 voting logic. When any single Channel is inoperable, the inoperable Channel is required to be placed in trip, effectively changing the voting logic to 1-out-of-2, preserving the single failure protection.

Any single Channel for any of the ESFAS process instrumentation variables may be placed in bypass during performance of a required SR, effectively changing the voting logic to 2-out-of-2 (with two other Channels Operable) or 1-out-of-1 (with one other Channel Operable).

a. The ESFAS monitors conductivity in the MEPS [ ]PROP/ECI to protect against a leakage of high radiation solutions into the MEPS [ ]PROP/ECI, as described in FSAR Section 4b.3 and Subsection 7.5.5. The MEPS [ ]PROP/ECI extend outside of the supercell; radioactive material in the loop would lead to increased radiological doses to workers. Conductivity instrumentation is provided for each extraction hot cell. Conductivity exceeding 8.8 μmho/cm results in a Supercell Isolation for the associated extraction cell. With fewer than two Channels Operable, the MEPS [ ]PROP/ECI isolation valves are required to be closed, and the extraction feed pump breakers are required to be opened, to complete the MEPS [ ]PROP/ECI Isolation function.

b. The ESFAS monitors the carbon monoxide concentration of the gases leaving the PVVS carbon delay beds to protect against a fire in the carbon delay beds, as described in FSAR Subsections 6b.2.2 and 13b.2.6. The setpoint of ≤ 20 ppm provides indication of combustion occurring inside of a carbon delay bed within the delay bed group. Carbon monoxide instrumentation is provided for each carbon delay bed group. Exceeding the carbon monoxide setpoint results in a Carbon Delay Bed Isolation for the affected delay bed group. With fewer than two required Channels Operable affecting a single carbon delay bed group, the group is required to be isolated to fulfill the Carbon Delay Bed Isolation. Nonsafety-related isolation valves are provided on the inlet and outlet of each carbon delay bed to isolate an individual bed as required for maintenance. At least seven of the eight carbon delay beds are required to be Operating to provide the design noble gas residence time. If only five or six carbon delay beds are Operating, the noble gas residence time is reduced. The total curies released from the facility are managed in accordance with LCO 3.7.2.

c. The ESFAS monitors for the presence of liquid in the VTS header to protect against an overflow of liquid out of the VTS lift tanks, as described in FSAR Subsections 6b.3.1.5, 7.5.5, and 9b.2.5.3. Two Divisions of liquid detection are located in the VTS header serving all lift tanks that may contain target solution. The detection of liquid results in a VTS Safety Actuation to stop any in-progress transfers of fluid. The function is required to prevent degrading one of the controls to prevent a criticality, by preventing target solution entering non-favorable geometry locations in the VTS system. With fewer than two required Channels Operable, the VTS vacuum pump breakers and VTS vacuum break valves are required to be opened to stop the transfer of solution within the facility.

d. The ESFAS monitors for the presence of liquid in the RDS to protect against overflow of high radiation liquids into the RDS sump tanks, as described in FSAR Subsections 7.5.5 and 9b.2.5.3. The detection of liquid in the RDS sump tanks results in a VTS Safety Actuation to stop any in-progress transfers of liquid. A filled RDS sump tank prevents that tank from accepting leakage in the event of a leak of target solution into a tank vault, valve pit, pipe trench or in the supercell. The VTS Safety Actuation signal is allowed to be bypassed to restart the VTS and remove solution from the RDS sump tanks as part of the recovery from an instance where liquid has entered the tank. With fewer than two required Channels Operable, the VTS vacuum pump breakers and VTS vacuum break valves are required to be opened to stop the transfer of target solution and radioactive liquid wastes within the facility.

e. PVVS blowers are required to dilute radiolytic hydrogen generated from irradiated target solution and radioactive liquid waste located in tanks in the RPF, as described in FSAR Subsection 6b.2.3. The low PVVS flow limit of 7.1 SCFM is based on an analytical limit of 5.0 SCFM and is indicative of a loss of the PVVS function. Low PVVS flow results in an RPF Nitrogen Purge Actuation, as described in FSAR Subsection 7.5.5. Three Channels of PVVS flow are provided. With fewer than two required Channels Operable, the nitrogen purge system is actuated to provide hydrogen mitigation for RPF tanks.

f. Level in the TSPS dissolution tank is monitored to prevent overflow of the tank and protect against a criticality event in a non-favorable geometry location, as described in FSAR Subsection 6b.3.1.4. Exceeding the setpoint of 98% results in a Dissolution Tank Isolation. With fewer than two required Channels Operable, the Dissolution Tank Isolation components (i.e., RPCS supply cooling valves and the supply and exhaust ventilation dampers) are required to be closed.

g. The ESFAS monitors for a loss of external power to the UPSS to protect against an impending loss of hydrogen mitigation via the TOGS in any IU in Modes 1 through 4, as described in FSAR Section 4a2.8. The ESFAS implements a 180 second timer prior to sending a signal to TRPS to provide margin to the five-minute UPSS runtime for the TOGS blowers and recombiners, as described in FSAR Subsection 8a2.2.3. Two Channels are provided; one signal is received from each Division of the UPSS. This signal results in an IU Cell Nitrogen Purge. With fewer than two required Channels Operable, both Channels are required to be restored to Operable within 72 hours (see LCO 3.6.1). With both required Channels inoperable, all IUs undergoing irradiation are required to be placed in Mode 3 to limit the production of hydrogen via radiolysis in the IUs.

h. Upper and lower MEPS three-way valves are provided for the extraction process in each extraction hot cell. The ESFAS monitors three-way valve position indication in the MEPS extraction column to protect against an incorrect valve configuration leading to misdirection of chemical reagents or target solution, as described in FSAR Subsection 7.5.5. Misdirected flow could result in uranium precipitation (if target solution is mixed with basic reagents). Misdirection additionally degrades one of the barriers relied on to prevent a criticality (by potentially sending target solution to a non-favorable geometry location) or to prevent target solution from exiting the supercell. Both three-way valves in the supplying position results in an Extraction Column Alignment Actuation. With fewer than two required Channels Operable, the three-way valves and the eluate valve are required to be placed in their actuated states (i.e., three-way valves in discharging and the eluate valve closed).

i. Upper and lower IXP three-way valves are provided for the extraction process in the IXP hot cell. The ESFAS monitors three-way valve position indication in the IXP extraction column to protect against an incorrect valve configuration leading to misdirection of chemical reagents or target solution, as described in FSAR Subsection 7.5.5. Misdirected flow could result in uranium precipitation (if target solution is mixed with basic reagents). Misdirection additionally degrades one of the barriers relied on to prevent a criticality (by potentially sending target solution to a non-favorable geometry location), or to prevent target solution from exiting the supercell. Both three-way valves in the supplying position results in an IXP Alignment Actuation. With fewer than two required Channels Operable, the three-way valves and the eluate valve are required to be placed in their actuated states (i.e., three-way valves in discharging and the eluate valve closed).

j. – k The high TPS target chamber supply and exhaust pressure limit of 7.7 psia (53.1 kPa absolute) is based on an analytical limit of 8 psia (55.2 kPa absolute). The supply and exhaust lines are normally maintained at near vacuum. The high pressure signal indicates a loss of vacuum within a neutron driver or TPS system and a potential tritium release inside the IU cell. Exceeding the setpoint results in an TPS Train Isolation. With fewer than two Channels Operable, tritium supply is required to be isolated to the NDAS target chamber by closing at least one TPS target chamber supply line valve per associated IU.

<u>SR</u>

The surveillance requirements ensure the continued operability of the ESFAS process variable instrument Channels. Channel Check, Channel Test, and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required. Performance of these surveillances may require the Channel to be temporarily inoperable (bypassed). The temporary bypass is acceptable based on continuous attendance to the instrumentation by personnel performing the surveillance, the limited time duration of the activity, and industry experience.

3.3 Coolant Systems

Objective: To ensure that target solution heat removal is adequate to maintain the target solution temperature within an acceptable range.

LCO 3.3.1	The light water pool water level shall be ≥ 14 feet, relative to the bottom of the pool.
Applicability	Associated IU in Mode 1, 2, 3, or 4
Action	If the minimum light water pool water level is not achieved, Place the associated IU in Mode 3 AND Initiate actions to place the associated IU in Mode 0.
SR 3.3.1	The light water pool water level shall be verified to be above the minimum specified level prior to entering Mode 1.

Basis 3.3.1 LCO

The light water pool has a nominal height of 15 feet. The light water pool minimum water level of 14 feet is required to provide additional biological shielding in conjunction with the concrete shielding as described in FSAR Subsection 4a2.4.2.3. The minimum water level is required to ensure radiation levels to metal components are within analyzed levels to prevent unacceptable activation of metal components. The water in the light water pool also ensures that the temperature and energy flux incident upon the concrete of the irradiation unit cell biological shield (ICBS) are below one or both of the allowable limits of 1E10 MeV/cm^2-s or 149°F (65°C), as described in FSAR Subsection 4a2.5.3.2. A minimum level of [ ]PROP/ECI is required for decay heat removal, as described in FSAR Subsections 4a2.4.2.2 and 13a2.1.5.

A rapid loss of pool level is not expected, as piping penetrations through the light water pool liner are either above the minimum acceptable water level in the pool, or a specific evaluation is performed to determine the potential for loss of pool water through the penetration. Piping penetrations into the light water pool with the potential for siphoning below the minimum acceptable water level contain anti-siphon devices or other means to prevent inadvertent loss of pool water. Additional discussion is provided in FSAR Subsection 4a2.4.2.1.

With the pool level not within limits, the IU shall be placed in Mode 3 by initiating a manual IU Cell Safety Actuation, or by cycling the IU Mode through Mode 2 to Mode 3 to perform a normal shutdown. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

SR

The surveillance requirement ensures the light water pool water level meets minimum requirements prior to entering the condition of applicability. A rapid loss of pool level during operation is not expected. During operation, loss of pool level would result in control room alarms to alert the operator.

3.4 Confinement

Objective: To prevent radiation exposure to workers or the public in excess of acceptable limits.

LCO 3.4.1	Each primary Confinement boundary or PSB isolation valve or damper listed in Table 3.4.1 shall be Operable. Note – A single isolation valve or damper in a flow path may be inoperable during the performance of required surveillances.
Applicability	Associated IU in Mode 1, 2, 3, or 4
Action	1. If one or more flow path(s) with one or more isolation valve(s) or damper(s) is inoperable, Close at least one valve or damper in the affected flow path OR Place the associated IU in Mode 3 AND Initiate actions to place the associated IU in Mode 0. 2. If one or more flow path(s) with one or more isolation valve(s) or damper(s) is inoperable, Place the associated IU in Mode 3 AND Initiate actions to place the associated IU in Mode 0.
SR 3.4.1	Valves and dampers listed in Table 3.4.1 shall be stroke-tested quarterly.

Table 3.4.1 Isolation Valves and Dampers

	Component	**Number Provided per Flow Path**	**Action**
a.	TSV fill isolation valves	2	1
b.	TSV dump tank drain isolation valve	1	1
c.	VTS lower lift tank target solution valve	1	1
d.	TOGS gas supply isolation valves	2	1
e.	TOGS vacuum tank isolation valves	2	1
f.	N2PS inerting gas supply isolation valves	2	2
g.	TOGS nitrogen vent isolation valves	2	2

	Component	Number Provided per Flow Path	Action
h.	TOGS RPCS return isolation valve	1	2
i.	TOGS RPCS supply isolation valves	2	2
j.	RVZ1e IU cell (PCLS expansion tank) ventilation dampers	2	2
k.	RVZ1r RPCS supply and return isolation valves	1 (per location)	2
l.	PCLS supply isolation valve	1	2
m.	PCLS return isolation valves	2	2
n.	TPS target chamber supply isolation valves	2 (per location)	1
o.	TPS deuterium supply isolation valves	2 (per location)	1
p.	TPS target chamber exhaust isolation valves	2 (per location)	1
q.	TPS neutron driver evacuation isolation valves	2 (per location)	1

LCO 3.4.2	The Confinement check valves listed in Table 3.4.2 shall be Operable.
Applicability	Associated IU in Mode 1, 2, 3, or 4
Action	1. If the check valve is not Operable, close the TOGS RPCS return isolation valve. 2. If the check valve is not Operable, Place the associated IU in Mode 3 AND Initiate actions to place the associated IU in Mode 0. 3. If the check valve is not Operable, Place the associated IU in Mode 3 AND Close the PCLS supply isolation valve. 4. If the check valve is not Operable, close the TPS isolation valve in the affected flow path.
SR 3.4.2	The check valves listed in Table 3.4.2 shall be inspected annually.

Table 3.4.2 Confinement Check Valves

	Component	**Action**
a.	TOGS RPCS return check valve	1
b.	N2PS inerting gas supply check valves (per parallel N2PS inerting gas supply flow path)	2
c.	PCLS supply check valve	3
d.	TPS glovebox pressure control check valve	4
e.	TPS helium supply check valve	4

LCO 3.4.3	Each tritium Confinement boundary valve for each TPS glovebox listed in Table 3.4.3 shall be Operable. Note – A single valve in a flow path may be inoperable during the performance of required surveillances.
Applicability	Tritium in associated TPS process equipment not in storage
Action	If one or more flow path(s) with one or more isolation damper(s) is inoperable, Place tritium in the associated train of TPS process equipment in its storage location OR Close at least one valve in the affected flow path.
SR 3.4.3	1. Valves listed in Table 3.4.3 shall be closure tested quarterly. 2. Each TPS glovebox shall be leak-tested every two years.

Table 3.4.3 TPS Glovebox Confinement Valves

	Component	**Number Provided per TPS Train, per Flow Path**
a.	TPS glovebox pressure control isolation valves	1
b.	TPS impurity treatment system (ITS) isolation valves	2
c.	TPS helium supply valves	1
d.	TPS vacuum isolation valves	2

LCO 3.4.4	Each supercell Confinement damper listed in Table 3.4.4 shall be Operable. Note – A single damper in a flow path may be inoperable during the performance of required surveillances.
Applicability	Supercell process operations in-progress in the associated hot cell
Action	If one or more flow path(s) with one or more isolation damper(s) is inoperable, Close at least one damper in the affected flow path OR Suspend hot cell operations involving the introduction of liquids into the associated hot cell AND Drain target solution and radioactive liquids in process lines from the associated hot cell.
SR 3.4.4	1. Dampers listed in Table 3.4.4 shall be closure tested quarterly. 2. Dampers listed in Table 3.4.4 shall be leak-tested every two years.

Table 3.4.4 Supercell Confinement Dampers

	Component	**Number Provided per Flow Path**
a.	Supercell area 1 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
b.	Supercell area 2 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
c.	Supercell area 3 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
d.	Supercell area 4 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
e.	Supercell area 5 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)

	Component	Number Provided per Flow Path
f.	Supercell area 6 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
g.	Supercell area 7 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
h.	Supercell area 8 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
i.	Supercell area 9 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)
j.	Supercell area 10 1. RVZ2 inlet isolation dampers 2. RVZ1 outlet isolation dampers	2 (per location)

Basis 3.4.1 <u>LCO</u>

Primary Confinement and PSB isolation valves and dampers ensure Confinement of postulated radioactive material releases is provided. A number of process systems penetrate the primary Confinement boundary. Piping systems that penetrate the primary Confinement boundary capable of excessive leakage are equipped with one or more isolation valve(s) that serve as active Confinement or isolation components, except for the N2PS inerting gas supply and TOGS nitrogen vent to PVVS connections, which do not change state on an IU Cell Safety Actuation, and open on an IU Cell Nitrogen Purge to provide hydrogen gas mitigation. Actuation of the valves and dampers is controlled by the TRPS. The primary Confinement boundary is further described in FSAR Subsection 6a2.2.1.1. The PSB is further described in FSAR Section 4a2.2.

a. TSV fill isolation valves isolate the PSB and are provided to prevent the introduction of target solution into the TSV outside of Mode 1 and to control the rate of TSV fill. The valves close on an IU Cell Safety Actuation and a Fill Stop. Two redundant valves, in series, are provided.

b. - c. The TSV dump tank drain isolation valve is provided to prevent inadvertent transfer of irradiated target solution or misdirected flow of liquids into the TSV dump tank. The valve isolates the PSB on an IU Cell Safety Actuation. Redundant isolation valves to the dump tank drain isolation valves are provided by the VTS lower lift tank target solution valves. A single VTS lower lift tank target solution valve is provided for IU cell 1 and for IU cell 8. Piping downstream of the TSV dump tank drain isolation valve for IU cells 2 through 7 contains a branch; therefore, two parallel VTS lower lift tank target solution valves are provided for each of IU cells 2 through 7, one for each parallel branch.

d. - e. TOGS gas supply and vacuum tank isolation valves are provided to isolate the PSB and close on an IU Cell Safety Actuation. Two redundant valves, in series, are provided per flow path.

f. - g. N2PS inerting gas and TOGS nitrogen vent isolation valves provide a flow path for the N2PS to provide hydrogen mitigation for the IU on a loss of TOGS. The valves are opened on an IU Cell Nitrogen Purge. Two redundant valves, in parallel, are provided for each location. The N2PS inerting gas valves are also each equipped with a check valve to protect against reverse flow out of the IU cell.

h. - i. TOGS RPCS supply and return isolation valves provide isolation of the Confinement boundary and prevent flooding of the PSB in the event of a leak into TOGS. The valves are closed on an IU Cell Safety Actuation. Two redundant TOGS RPCS supply isolation valves, in series, are provided, but only one TOGS RPCS return isolation valve is provided. Redundant isolation (to prevent water intrusion into the PSB) is provided by the TOGS RPCS return line check valve (see LCO 3.4.2).

j. RVZ1e IU Cell ventilation dampers are provided in the exhaust flow path of the PCLS expansion tank. These dampers isolate the primary Confinement boundary and are closed on an IU Cell Safety Actuation. Two redundant dampers, in series, are provided.

k. RVZ1r RPCS supply and return isolation valves are provided to isolate the primary Confinement boundary and close on an IU Cell Safety Actuation. One supply and one return valve are provided. Redundant isolation is not required because the RVZ1r cooling coil is not open to the primary Confinement atmosphere.

l. - m. PCLS isolation valves are provided on the cooling water supply and return lines to isolate the primary Confinement boundary and close on an IU Cell Safety Actuation. Redundant PCLS return isolation valves and a single PCLS supply isolation valve is provided for each IU. Redundant isolation for the PCLS supply is provided by the PCLS supply check valve (see LCO 3.4.2). The valves confine a leak of radioactive material into the PCLS to the primary Confinement. The PCLS communicates with the primary Confinement atmosphere (via the PCLS expansion tank vent line).

n. - q. TPS valves are provided to isolate the primary Confinement boundary and close on an IU Cell Safety Actuation or on an IU Cell TPS Actuation. Two redundant valves, in series, are provided for each location.

The valves and dampers are required to be Operable to support the protective functions described in FSAR Section 7.5. With one valve or damper inoperable in a flow path, and if allowable per Table 3.4.1, at least one valve or damper in the affected flow path is isolated; otherwise, the associated IU is placed in Mode 3, and actions to place the IU in Mode 0 are initiated in order to remove target solution from the IU. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ][PROP/ECI] are required to complete the transfer of target solution to the RPF. One valve or damper in a flow path is allowed to be temporarily inoperable for the performance of required surveillances.

SR

The closure testing ensures the continued operability of the valves and dampers. The surveillance frequency is consistent with the recommendations from ANSI/ANS 15.1-2007.

Basis 3.4.2 LCO

Check valves provide isolation functions as described below:

a. The TOGS RPCS return check valve, as described in FSAR Subsection 4a2.8.7, provides redundant isolation with the TOGS RPCS return isolation valve (see LCO 3.4.1, item h.), which allows TOGS to meet single failure criteria following the receipt of an isolation signal from TRPS. With the check valve inoperable, the TOGS RPCS return isolation valve is closed to provide the isolation function.

b. The N2PS inerting gas supply check valves prevent backflow of a potential release in the IU cell into the N2PS header. One check valve is provided per parallel N2PS inerting gas supply flow path. With a check valve inoperable, the IU is required to be placed in Mode 3, and actions to place the IU in Mode 0 are initiated in order to remove target solution from the IU. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ][PROP/ECI] are required to complete the transfer of target solution to the RPF.

c. The PCLS supply check valve, as described in FSAR Subsection 4a2.8.7, provides redundant isolation with the PCLS supply isolation valve (see LCO 3.4.1, item l.), which allows PCLS to meet single failure criteria following the receipt of an isolation signal from TRPS. With the check valve inoperable, the IU is required to be placed in Mode 3 (where PCLS cooling is not required), and the PCLS supply isolation valve is closed to provide the isolation function.

d. - e. The TPS glovebox pressure control check valve and helium supply check valve provide redundant isolation with the TPS glovebox pressure control isolation valves and helium supply valves, respectively (see LCO 3.4.3, items a. and c.). The tritium Confinement boundary is further described in FSAR Subsection 6a2.2.1.2. With the check valve inoperable, the redundant TPS isolation valves are closed to provide the isolation function.

<u>SR</u>

The surveillance requirement ensures the continued operability of the check valves. The surveillance frequency is adequate based on the expected reliability of the passive components.

Basis 3.4.3 <u>LCO</u>

Tritium Confinement boundary isolation valves for the TPS gloveboxes ensure that Confinement of postulated tritium releases is provided for each of the three TPS gloveboxes. The TPS gloveboxes use active isolation valves on the outlet ventilation ports of the glovebox and isolation valves for the tritium process piping. The valves close automatically upon loss of power or receipt of a TPS Train Isolation signal generated by the ESFAS (see LCO 3.2.2, item e.). Redundancy for flow paths with only one isolation valve is provided by check valves (see LCO 3.4.2, items d. and e.). The two TPS glovebox pressure control isolation valves and two TPS helium supply valves are each arranged in parallel configurations; both parallel valves must be closed to provide the isolation function. The tritium Confinement boundary is further described in FSAR Subsection 6a2.2.1.2. The valves are required to be Operable to support the protective functions described in FSAR Section 7.5. With one or more valve(s) inoperable in a flow path, tritium is required to be placed in its storage location (i.e., a depleted uranium bed), otherwise, at least one valve in the affected flow path into the affected TPS glovebox is required to be isolated. One valve in a flow path is allowed to be temporarily inoperable to allow required surveillances to be performed.

SR

The closure testing and leak testing ensures the continued operability of the safety-related valves and dampers and is based on recommendations from ANSI/ANS 15.1-2007.

Basis 3.4.4 LCO

Supercell Confinement isolation dampers ensure Confinement of postulated radioactive material releases is provided. The supercell ventilation exhaust ductwork is fitted with radiation monitoring instrumentation to detect off-normal releases to the supercell Confinement areas (i.e., hot cells). Upon indication of a release exceeding setpoints, a Supercell Isolation is initiated by ESFAS (see LCO 3.2.2, item b.), causing isolation dampers on both the inlet and outlet ducts to close and isolate the affected hot cell from the ventilation system. The supercell dampers are required to be Operable to support the protective functions described in FSAR Section 7.5. With one Division inoperable in a flow path, at least one damper in the affected flow path is required to be isolated; otherwise, hot cell operations involving the introduction of liquids into the cell (e.g., extraction, column washing, elution) are suspended and target solution and radioactive liquids are drained from the associated hot cell. One damper in a flow path is allowed to be temporarily inoperable to allow required surveillances to be performed.

SR

The closure testing and leak testing ensures the continued operability of the dampers and is based on recommendations from ANSI/ANS 15.1-2007.

3.5 Ventilation Systems

Objective: To maintain ventilation systems within required parameters.

LCO 3.5.1	The PVVS shall be Operable. PVVS is considered Operable if: 1. At least 2 PVVS blowers are Operating, with total flow ≥ 7.1 SCFM, 2. At least 1 PVVS inlet header flow path is open, 3. At least 7 carbon delay beds are Operating, and 4. PVVS flow from the individual tanks listed in Table 3.5.1 is above corresponding minimum flowrate. Note – PVVS flow from individual tanks is allowed to drop below the minimum required flowrate during tank sparging or fluid transfer operations.
Applicability	Facility not Secured
Action	If PVVS is not Operable due to conditions 1 or 2, actuate the nitrogen purge system. If PVVS is not Operable due to condition 3, verify at least 5 carbon delay beds are Operating. If PVVS is not Operable due to condition 3, and fewer than 5 carbon delay beds are Operating Verify a flow path exists for PVVS flow through the carbon guard bed or its bypass, and through the delay beds to the facility exhaust AND Place all IUs in Mode 1 in Mode 3 AND Suspend operations to transition any IU in Mode 0 to Mode 1. If PVVS is not Operable due to condition 4, remove target solution or radioactive liquids from the affected tank(s).
SR 3.5.1	1. Verify total flowrate at the exhaust of the PVVS is above the limit daily. 2. Verify flow from individual tanks listed in Table 3.5.1 quarterly.

Table 3.5.1 PVVS Tank Flowrates

	Component	**Number of Tanks**	**Minimum Flowrate Per Tank (SCFM)**
a.	Target solution hold tank	8	1.1E-01
b.	Target solution storage tank	2	1.1E-01
c.	Uranium waste tank	2	1.1E-01

	Component	Number of Tanks	Minimum Flowrate Per Tank (SCFM)
d.	Radioactive liquid waste collection tank	4	2.8E-01
e.	Radioactive liquid waste blending tank	8	2.8E-01
g.	Radioactive drain sump tank	2	1.1E-01

Basis 3.5.1 <u>LCO</u>

The PVVS ensures there is sufficient flow through process vessels to provide hydrogen mitigation and contamination control, as described in FSAR Subsection 9b.6.1. A minimum total PVVS flowrate of 7.1 SCFM, measured at the exhaust of PVVS, is based on an analytical limit of 5.0 SCFM and is calculated to maintain hydrogen concentration ≤ 3% by volume in tanks served by PVVS. The PVVS design flowrate is 16 SCFM, which is selected to achieve a xenon residence time of 40 days, preventing effluents from the facility from exceeding 10 CFR 20 limits. For PVVS to be considered Operable:

1. At least two PVVS blowers must be running providing flow above the minimum total exhaust flowrate. A loss of minimum PVVS flow results in an automatic RPF Nitrogen Purge.
2. Either the north or south inlet header flow path must be open. The N2PS RVZ2 north and south header valves provide the normal inlet flow path to PVVS. Inadvertent isolation of both flow paths valves renders the PVVS inoperable.
3. Seven (of eight) carbon delay beds are required to be Operating to capture iodine and provide the required noble gas residence time. A carbon delay bed is Operating when it contains carbon material and is not isolated.
4. PVVS flow from individual tanks ventilated by the PVVS are within required specification to maintain hydrogen concentration ≤ 3% by volume.

The carbon guard bed(s) function to protect the long-term capacity and efficiency of the carbon delay beds but are not required to be Operating to consider the PVVS Operable. The ESFAS function of Carbon Delay Bed Isolation are controlled under LCO 3.2.2 and are not required to be considered for the operability of the PVVS under this LCO.

With PVVS inoperable due to fewer than the minimum number of PVVS blowers operating, PVVS total flow below the required minimum flowrate, or an insufficient PVVS inlet flow path, nitrogen purge for the RPF is actuated to provide the hydrogen mitigation function.

With PVVS inoperable due to fewer than seven PVVS carbon delay beds Operating, at least five carbon delay beds are verified to be Operating. Nonsafety-related isolation valves are provided on the inlet and outlet of each carbon delay bed to isolate an individual bed as required for maintenance. At least seven of the eight carbon delay beds are required to be Operating to provide the design noble gas residence time. If only five or six carbon delay beds are Operating, the noble gas residence time is reduced. The total curies released from the facility are managed in accordance with LCO 3.7.2.

With PVVS inoperable due to fewer than five PVVS carbon delay beds Operating, the valve alignments for the carbon guard and delay bed three-way valves and isolation valves and the carbon guard bed bypass valves are checked to confirm a flow path exists for the PVVS to the facility exhaust to ensure the sweep gas flow path is sufficient. Operations to start irradiation in any IU are not allowed, as irradiation increases the radionuclide inventory in the facility.

Transition from Mode 1 to Mode 3 may be accomplished by initiating a manual IU Cell Safety Actuation, or by cycling the IU Operating Mode through Mode 2 to Mode 3 to perform a normal shutdown without irradiating the target solution.

Additionally, when fewer than five PVVS carbon delay beds are Operating, operations to transition any IU to Mode 1 (filling) are not allowed, since filling the TSV displaces gas from the TOGS to PVVS, increasing the radionuclide inventory in the PVVS. With fewer than the minimum number of PVVS carbon delay beds Operating, the radionuclide inventory is required to be limited due to the reduced available capacity of the PVVS to capture or delay radionuclides. IUs already in Modes 2, 3, or 4 may continue to be transitioned through the applicable IU Modes to Mode 0 as normal, but no new irradiation cycles are allowed to be started.

With PVVS inoperable due to low PVVS flow to one or more individual tank(s), target solution or radioactive liquids are required to be removed (i.e., drained or vacuum lifted) from the affected tank(s) to eliminate the need for hydrogen sweep gas in that tank.

SR

The verification of flowrates ensures PVVS is Operating within design limits. The daily and quarterly verifications are based on industry experience. Flow excursions will result in control room alarms to alert the operator.

3.6 Emergency Power

Objective: To ensure that safety-related emergency power is available to prevent or mitigate the consequences of design basis accidents.

LCO 3.6.1	Two Divisions of the UPSS shall be Operable.
Applicability	Facility not Secure
Action	If one Division of UPSS is not Operable, restore the Division to Operable within 72 hours. If both Divisions of UPSS are not Operable, Place all IUs undergoing irradiation in Mode 3 AND Open the VTS vacuum pump breakers AND Open at least one VTS vacuum break valve AND Place tritium in all three trains of TPS process equipment in its storage location OR Initiate a TPS Train Isolation for all three gloveboxes.
SR 3.6.1	1. UPSS battery voltage and specific gravity shall be checked semi-annually. 2. UPSS discharge test shall be performed every five years.

LCO 3.6.2	Safety-related breakers listed in Table 3.6.2 shall be Operable.
Applicability	According to Table 3.6.2
Action	If one or more breaker(s) listed in Table 3.6.2 are not Operable, open at least one redundant breaker.
SR 3.6.2	Safety-related breakers listed in Table 3.6.2 shall be cycled annually.

Table 3.6.2 Safety-Related Breakers

	Component	Minimum Required Divisions	Applicability
a.	RVZ1 exhaust blower breakers	2 (per train)	Associated RVZ1 exhaust train operating
b.	RVZ2 exhaust blower breakers	2 (per train)	Associated RVZ2 exhaust train operating
c.	RVZ2 supply blower breakers	2 (per train)	Associated RVZ2 supply train operating
d.	VTS vacuum transfer pump breakers	2 (per pump)	Solution transfers using VTS in-progress
e.	MEPS extraction feed pump breakers	2 (per train)	Target solution present in the associated MEPS extraction hot cell
f.	NDAS HVPS breakers	2	Associated IU in Mode 1, 2, 3, or 4

Basis 3.6.1 LCO

The safety-related uninterruptible electrical power supply system (UPSS) for the facility consists of two redundant Divisions of 125-volt direct current (VDC) batteries, inverters, bypass transformers, distribution panels, and other breakers and distribution equipment necessary to feed safety-related alternating current (AC) and direct current (DC) loads, as described in FSAR Section 8a2.2. The UPSS provides an emergency back-up power supply for safety-related equipment and monitoring which protects against a total or partial loss of normal facility power.

The UPSS minimum Operable Divisions ensures there is adequate backup battery power for postulated accident scenarios, as described in FSAR Subsection 8a2.2.3. A Division of the UPSS is Operable if it is capable of supplying power to its safety-related AC and DC loads from the battery, the breakers integral to the UPSS are capable of protecting the UPSS from an upstream fault, and the battery is sufficiently charged such that it is capable of supplying power for the minimum runtimes specified in FSAR Table 8a2.2-1.

A single overall electrical power system serves the main production facility, including both the irradiation facility and the radioisotope production facility, as well as the site and support buildings, as described in FSAR Section 8a2.1. The normal electrical power supply system receives off-site power from the local utility in two separate feeds for improved reliability.

The standby generator consists of a 480Y/277 VAC, 60 Hertz natural gas-driven generator, as described in FSAR Subsection 8a2.2.6. Although not required by the accident analysis, the SGS is designed to automatically start and begin step loading within one minute of and complete power transfers within five minutes of the LOOP. The SGS is sized to carry the full load of both Divisions of the UPSS. The SGS supplies power to the UPSS buses, re-charges the UPSS batteries, supplies additional loads used for life-safety or facility monitoring, and allows operational flexibility while responding to the LOOP.

One Division of UPSS may be inoperable for 72 hours to perform corrective or preventative maintenance. The 72-hour completion time is based on the availability of off-site power and the standby gas generator system (SGS). This provides a reasonable time to restore the UPSS to Operable status with an acceptably low risk. It also provides sufficient time to prepare and implement an orderly and safe facility shutdown if the UPSS is not restored to Operable status.

With both Divisions of UPSS inoperable, facility processes are required to be shut down to the extent practicable to minimize the risk of an accident coincident with a loss of off-site power. Placing all IUs undergoing irradiation in Mode 3 minimizes the hydrogen production in IUs via radiolysis and may be performed via a manual IU Cell Safety Actuation or by cycling the IU Operating Mode through Mode 2 to Mode 3 to perform a normal shutdown. Opening the VTS vacuum pump breakers and at least one VTS vacuum break valves stops the transfer of radioactive liquids throughout the facility and may be performed via a manual VTS Safety Actuation or by performing the actions individually. Placing tritium in the TPS gloveboxes in its storage location minimizes the risk of a release; otherwise, isolating the TPS gloveboxes via a TPS Train Isolation places the TPS gloveboxes in an isolated condition.

SR

The battery voltage, specific gravity, and discharge surveillance requirements ensure the operability of the UPSS and are consistent with the frequencies stated in ANSI/ANS 15.1-2007.

Basis 3.6.2 LCO

The safety-related breakers are required to be Operable to support the protective functions described in FSAR Sections 7.4 and 7.5. Safety-related breakers are Operable if they are capable of being automatically opened on a receipt of a signal from the safety-related control system. With one or more Division(s) inoperable, at least one redundant breaker is required to be opened to shut down the associated equipment and fulfill the safety function.

a. Two trains of RVZ1 exhaust blowers are provided. Each blower is provided with two Divisions of redundant safety-related breakers. These breakers are opened on an isolation of the RVZ1 RCA exhaust dampers. Continued operation of the blowers can cause damage or excessive leakage of the isolation dampers.

b. Two trains of RVZ2 exhaust blowers are provided. Each blower is provided with two Divisions of redundant safety-related breakers. These breakers are opened on an isolation of the RVZ1 RCA exhaust dampers. Continued operation of the blowers can cause damage or excessive leakage of the isolation dampers.

c. Two trains of RVZ2 supply blowers are provided. Each blower is provided with two Divisions of redundant safety-related breakers. These breakers are opened on an isolation of the RVZ1 RCA exhaust dampers. Continued operation of the blowers can cause damage or excessive leakage of the isolation dampers.

d. Two VTS vacuum transfer pumps are provided. Each vacuum transfer pump is provided with two Divisions of redundant safety-related breakers. These breakers are opened on a VTS Safety Actuation. Opening these breakers prevents the vacuum transfer pump from moving target solution during an accident scenario limiting the amount of radioactive material that is potentially released.

e. Three trains of MEPS extraction cells are located in the supercell. Each extraction cell contains an extraction feed pump, and each extraction pump is provided with two Divisions of redundant safety-related breakers. These breakers are opened on a Supercell Area 2 Isolation and a MEPS [ ]PROP/ECI Isolation. Opening these breakers prevents the extraction feed pump from moving target solution during an accident scenario, limiting the amount of radioactive material that is potentially released.

f. Each neutron driver in an IU is provided with two Divisions of redundant safety-related HVPS breakers. These breakers are opened on a Driver Dropout. Opening the HVPS breakers prevents the neutron driver from producing neutrons in the target chamber. Terminating this neutron source removes a major heat input into the TSV and is an important step in moving the SCAS towards a shutdown condition.

SR

Safety-related breakers are functionally tested annually, to ensure they will be capable of opening on demand. The frequency is based on industry experience.

3.7 Radiation Monitoring Systems and Effluents

Objective: To ensure radiation levels within the facility and radiation released to the environment are within allowable limits.

LCO 3.7.1	Radiation monitoring instruments listed in Table 3.7.1 shall be Operable. Note – Any single required Channel may be inoperable while in the condition of applicability for the purpose of performing a Channel Check or Channel Calibration.
Applicability	According to Table 3.7.1
Action	1. If one or more required Channel(s) are not Operable, close at least one damper in each of the inlet and outlet ventilation for the associated hot cell. 2. If one or more required Channel(s) are not Operable, place RCA Isolation actuation components in the actuated state. 3. If one or more required Channel(s) are not Operable, Place the associated IU in Mode 3 AND Close at least one RVZ1e IU cell ventilation damper for the associated IU cell. 4. If one or more required Channel(s) are not Operable, Place tritium in the associated train(s) of TPS process equipment in its storage location OR Close at least one redundant TPS Train Isolation device per TPS glovebox confinement flow path.
SR 3.7.1	1. A Channel Check shall be performed for radiation monitors monthly. 2. A Channel Calibration shall be performed for radiation monitors annually.

Table 3.7.1 Safety-Related Radiation Monitoring Instruments

	Monitored Location	**Setpoint and Monitored Material**	**Minimum Required Channels**	**Applicability**	**Action**
a.	Supercell exhaust ventilation (PVVS hot cell)	5x background Fission products	2	Facility not Secured	1

	Monitored Location	Setpoint and Monitored Material	Minimum Required Channels	Applicability	Action
b.	Supercell exhaust ventilation (Extraction and IXP hot cells)	5x background Fission products	2 (per hot cell)	Target solution or radioactive process fluids present in the associated hot cell	1
c.	Supercell exhaust ventilation (Purification and packaging hot cells)	5x background Fission products	2 (per hot cell)	Radioisotope products or radioactive process fluids present in the associated hot cell	1
d.	RVZ1 exhaust	5x background Fission products	2	Facility not Secured	2
e.	RVZ2 exhaust	5x background Fission products	2	Facility not Secured	2
f.	RVZ1e IU cell exhaust	5x background Fission products	2	Associated IU in Mode 1, 2, 3, or 4	3
g.	TPS confinement	927 Ci/m^3 Tritium	2	Tritium in associated TPS process equipment not in storage	4
h.	TPS exhaust to facility stack	0.96 Ci/m^3 Tritium	2	Tritium in any TPS process equipment not in storage	4

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	If the monthly curie assessment exceeds 1/12 of the limit, verify the annual curie assessment is within the limit.
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.

Basis 3.7.1 <u>LCO</u>

Safety-related radiation monitors are used to detect elevated levels of radiation that may result in radiation exposure to workers or individual members of the public in excess of allowable limits, as described in FSAR Subsection 7.7.1. At least two Channels of safety-related radiation monitors are provided. Some monitored locations are provided with three Channels, as listed in FSAR Table 7.7-1. Only two Channels are required to be Operable to provide redundancy to protect against a single failure.

For variables provided with three Channels, actuation of the safety function occurs on 2-out-of-3 voting logic when all three Channels are Operable.

When any single Channel is inoperable for variables provided with three Channels, the inoperable Channel is required to be placed in trip, effectively changing the voting logic to 1-out-of-2, preserving the single failure protection.

For variables provided with only two Channels, actuation of the safety function occurs on 1-out-of-2 voting logic.

Any single Channel for any of the radiation monitoring instruments may be placed in bypass during performance of a required SR, effectively changing the voting logic to 2-out-of-2 (with two other Channels Operable) or 1-out-of-1 (with one other Channel Operable).

a. The supercell PVVS hot cell contains equipment for the PVVS and VTS, which contain fission product gases. The radiation monitors provide an actuation signal that isolates the affected hot cell to minimize the spread of radioactive material. Three Channels of radiation monitoring are provided. With fewer than two required Channels Operable, at least one inlet and one outlet damper are closed to provide the isolation function.

b. The supercell extraction and IXP hot cells periodically contain irradiated target solution. The radiation monitors provide an actuation signal that isolates the affected hot cell to minimize the spread of radioactive material. Two Channels of radiation monitoring are provided. With fewer than two required Channels Operable, at least one inlet and one outlet damper are closed to provide the isolation function.

c. The supercell purification and packaging hot cells periodically contain isotope products. The radiation monitors provide an actuation signal that isolates the affected hot cell to minimize the spread of radioactive material. Two Channels of radiation monitoring are provided. With fewer than two required Channels Operable, at least one inlet and one outlet damper are closed to provide the isolation function.

d. The RVZ1 exhaust location is monitored for elevated radiation originating from RVZ1 spaces, including the supercell and the PCLS expansion tanks, which communicate with the IU cell atmosphere. The radiation monitors provide an actuation signal that performs an RCA Isolation to minimize the spread of radioactive material. Three Channels of radiation monitoring are provided. With fewer than two required Channels Operable, RCA isolation dampers (see LCO 3.8.9) are closed to provide the isolation function.

e. The RVZ2 exhaust location is monitored for elevated radiation originating from RVZ2 spaces, which include the general area of the IF and RPF. The radiation monitors provide an actuation signal that performs an RCA Isolation to minimize the spread of radioactive material. Three Channels of radiation monitoring are provided. With fewer than two required Channels Operable, RCA isolation dampers (see LCO 3.8.9) are closed to provide the isolation function.

f. The RVZ1e IU cell exhaust location is monitored for elevated radiation in the PCLS or IU cell atmosphere. The radiation monitors provide an actuation signal that results in an IU Cell Safety Actuation to minimize the spread of radioactive material. Three Channels of radiation monitoring are provided. With fewer than two required Channels Operable, the IU is placed in Mode 3 by automatic or manual transitions. Transfer of target solution out of the IU to achieve Mode 0 requires the target solution to be held in the TSV dump tank for at least the minimum period of time specified in LCO 3.1.7 prior to transfer. Approximately [ ]PROP/ECI are required to complete the transfer of target solution to the RPF.

g. The TPS confinement glovebox atmosphere is monitored for tritium. There is normally a low tritium concentration on the order of less than 1 mCi/m^3 in the TPS glovebox due to process equipment leakage and tritium permeation. The TPS glovebox tritium concentration limit considers instrument uncertainties and is based on an analytical limit of 1000 Ci/m^3. A tritium concentration in excess of this limit is indicative of excessive amounts of tritium leaking from TPS process equipment, as described in FSAR Subsection 13a2.1.12. The radiation monitors provide an actuation signal that isolates the associated glovebox and ventilation of the TPS room to minimize the spread of radioactive material. Two Channels of radiation monitoring are provided. With fewer than two required Channels Operable, tritium is required to be returned to its storage location (i.e., a depleted uranium bed) or at least one redundant TPS Train Isolation device per associated TPS glovebox confinement flow path is closed to provide the isolation function.

h. The TPS exhaust to the facility stack is monitored for tritium. The SEC normally reduces tritium concentrations that enter RVZ1e to less than 10 μCi/m^3. The TPS exhaust to the facility stack tritium concentration limit considers instrument uncertainties and is based on an analytical limit of 1 Ci/m^3. A tritium concentration in excess of this limit is indicative of a malfunction of the TPS or a tritium release, as described in FSAR Subsection 13a2.1.12. The radiation monitors limit the spread of tritium throughout and outside the facility via the ventilation system by providing an actuation signal that isolates the potential release paths to the facility stack from all three TPS gloveboxes via a TPS Process Vent Actuation. Three Channels of radiation monitoring are provided. With fewer than two required Channels Operable, tritium is required to be returned to its storage location (i.e., a depleted uranium bed) or at least one redundant TPS Process Vent Actuation device per TPS exhaust flow path is closed to provide the isolation function.

SR

The surveillance requirements ensure the continued operability of the radiation monitors when required. Channel Check and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required.

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.

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 calibrations ensure the continued operability of the instruments and the accuracy of the measurements. The surveillance requirements are consistent with industry experience.

3.8 Facility-Specific

Objective: To ensure systems are Operating within analyzed limits and prevent excessive radiation exposure to workers and the public.

LCO 3.8.1	The N2PS shall be Operable. The N2PS is considered Operable if: 1. At least 11 nitrogen storage tubes are filled with nitrogen at a minimum pressure of 2,100 psig per tube, and 2. The N2PS is capable of delivering a total of 16 SCFM of sweep gas flow.
Applicability	Facility not Secured
Action	If fewer than 11 nitrogen storage tubes are pressurized to ≥ 2,100 psig, initiate actions to place any operating IUs in Mode 0.
SR 3.8.1	1. Nitrogen pressure in each tube shall be verified to be above the minimum pressure weekly. 2. A Channel Calibration of the pressure sensor for each tube shall be performed annually. 3. A verification of the N2PS capability to deliver the required sweep gas flow shall be performed every five years.

LCO 3.8.2	The concentration of uranium in the target solution in the TSV shall be [ ]PROP/ECI.
Applicability	Target solution in the associated TSV
SR 3.8.2	1. After preparing a new batch of target solution, the target solution uranium concentration shall be verified to be below the uranium concentration limit prior to transferring the batch to a TSV in Mode 1 2. After adding additional target solution to an existing batch, the target solution uranium concentration shall be verified to be below the uranium concentration limit prior to transferring the batch to a TSV in Mode 1

LCO 3.8.3	[ ]PROP/ECI and pH of the target solution shall be within the “Acceptable” region of Figure 3.8.3, defined by the following equation: [ ]PROP/ECI
Applicability	Target solution in the associated TSV
SR 3.8.3	1. After preparing a new batch of target solution, the [ ]PROP/ECI and pH shall be verified to be within the “Acceptable” region of Figure 3.8.3 prior to transferring the batch to a TSV in Mode 1 2. After adding additional target solution to an existing batch, the [ ]PROP/ECI and pH shall be verified to be within the “Acceptable” region of Figure 3.8.3 prior to transferring the batch to a TSV in Mode 1

Figure 3.8.3 Target Solution Catalyst Concentration vs pH

[ ]PROP/ECI

LCO 3.8.4	The concentration of uranium present in the second uranium liquid waste tank and the liquid waste blending tank shall be less than 25 gU/L.
Applicability	At all times
Action	If uranium concentration is above the limit in either the second uranium liquid waste tank or the liquid waste blending tank, Immediately stop transfers of solution to the liquid waste blending tank AND Return solution in the liquid waste blending tank to a favorable geometry location AND Dilute solution in the second uranium liquid waste tank until the uranium concentration is verified to be below the limit.
SR 3.8.4	1. Uranium concentration in the first uranium liquid waste tank shall be measured and verified to be below the limit in accordance with the requirements of the criticality safety program and prior to transfer of liquid to the second uranium liquid waste tank. 2. Uranium concentration in the second uranium liquid waste tank shall be measured and verified to be below the limit in accordance with the requirements of the criticality safety program and prior to transfer of liquid to the liquid waste blending tank. 3. Uranium concentration in the liquid waste blending tank shall be measured and verified to be below the limit in accordance with the requirements of the criticality safety program.

LCO 3.8.5	The NDAS two-key interlocks shall be in the “open” position.
Applicability	Associated IU cell plug not installed or personnel present in the neutron driver service cell (NSC)
SR 3.8.5	1. The function of the NSC driver interlock shall be tested quarterly. Note – This SR cannot be deferred. 2. The function of the IU cell driver interlock shall be tested prior to removal of the IU cell plug, and quarterly thereafter, while the IU cell plug is removed.

LCO 3.8.6	The beam off pressure in the target chamber shall be [ ]$^{PROP/ECI}$.
Applicability	Associated IU in Mode 2
Action	If the target chamber pressure is above the allowable limit, Open the at least one HVPS breaker AND Evacuate tritium from the NDAS target chamber.
SR 3.8.6	Verify the tritium pressure in each NDAS target chamber is below the limit daily.

LCO 3.8.7	Each TPS glovebox shall have a helium atmosphere with dew point ≤ -4°F.
Applicability	Associated TPS glovebox tritium in TPS process equipment not in storage
Action	If the TPS glovebox atmosphere is not within the allowable limit, immediately initiate actions to purge the TPS glovebox with helium.
SR 3.8.7	1. A Channel Check shall be performed on the TPS glovebox dew point monitor quarterly. 2. A Channel Calibration shall be performed on the TPS glovebox dew point monitor annually.

LCO 3.8.8	Each TPS SEC shall be Operable. An SEC is considered to be Operable if: 1. The circulating blower is Operating, 2. At least 1 molecular sieve bed is Operating, and 3. The hydride bed is Operating.
Applicability	Tritium in the associated train of TPS process equipment not in storage.
Action	If an SEC is not Operable, place tritium in the associated train of TPS process equipment in its storage location.
SR 3.8.8	Verify each SEC is Operating daily.

LCO 3.8.9	Each RCA isolation damper listed in Table 3.8.9 shall be Operable. Note – A single Division of required components may be inoperable during the performance of required surveillances.

Applicability	Facility not Secured
Action	If one or more flow path(s) with one or more isolation damper(s) is inoperable, close at least one damper in the affected flow path.
SR 3.8.9	Dampers listed in Table 3.8.9 shall be closure tested quarterly.

Table 3.8.9 RCA Isolation Dampers

	Component	**Number Provided per Flow Path**
a.	RVZ1 RCA exhaust isolation dampers	2
b.	RVZ2 RCA exhaust isolation dampers	2
c.	RVZ2 RCA supply isolation dampers	2
d.	RVZ3 RCA supply isolation dampers 1. Shipping/receiving IF 2. Shipping/receiving RPF 3. Main RCA ingress/egress 4. RPF emergency exit 5. IF emergency exit	2 (per location)
e.	RVZ2 TPS ventilation supply and exhaust dampers	2

LCO 3.8.10	Each safety-related valve or damper listed in Table 3.8.10 shall be Operable. Note – A single Division of required component(s) may be inoperable during the performance of required surveillances.
Applicability	According to Table 3.8.10
Action	1. If one or more Division(s) are not Operable, Open the VTS vacuum pump breakers AND Open at least one VTS vacuum break valve. 2. If one or more Division(s) are not Operable, Open at least one PVVS blower bypass valve AND Close the PVVS blower makeup air supply valve. 3. If one or more Division(s) are not Operable, open at least one carbon guard bed bypass valve. 4. If one or more Division(s) for a single carbon delay bed group are not Operable, Close the associated carbon delay bed group isolation valves AND Verify at least 5 carbon delay beds are Operating. 5. If the required Division is not Operable, Suspend RLWI immobilization feed operations AND Close at least one RLWI PVVS valve. 6. If one or more Division(s) are not Operable, open at least one N2PS IU cell header valve. 7. If one or more Division(s) are not Operable, place RPF Nitrogen Purge Actuation components in their actuated states. 8. If one or more Division(s) in a single flow path are not Operable, isolate the affected flow path by closing at least one N2PS RVZ2 header valve. 9. If one or more Division(s) are not Operable, Immediately suspend dissolution tank operations AND Isolate RPCS supply to and return from the dissolution tanks AND Initiate actions to remove uranium from the TSPS glovebox.

	10. If one or more three-way valve(s) are not Operable, Place at least one three-way valve in the discharging position AND Close the associated eluent valve. 11. If a required valve is not Operable, Close at least one valve in the flow path of the inoperable valve OR Suspend hot cell operations involving the introduction of liquids into the associated hot cell AND Drain target solution and radioactive liquids in process lines from the associated hot cell.
SR 3.8.10	Safety-related valves listed in Table 3.8.10 shall be stroke tested annually.

Table 3.8.10 Automatically-Actuated Safety-Related Valves and Dampers

	Component	**Number Provided per Flow Path**	**Applicability**	**Action**
a.	VTS vacuum break valves	2	VTS Operating	1
b.	PVVS blower bypass valves	2	Facility not Secured	2
c.	PVVS carbon guard bed bypass valves	2	Facility not Secured	3
d.	PVVS carbon delay bed group three-way valves	2 (per delay bed group)	Associated carbon delay bed group Operating	4
e.	PVVS carbon delay bed group outlet isolation valves	2 (per delay bed group)	Associated carbon delay bed group Operating	4
f.	RLWI PVVS isolation valve	1	Facility not Secured	5
g.	N2PS IU cell header valves	2	Facility not Secured	6

	Component	**Number Provided per Flow Path**	**Applicability**	**Action**
h.	N2PS RPF header valves	2	Facility not Secured	7
i.	N2PS RVZ2 header valves 1. North 2. South	2 (per location)	Facility not Secured	8
j.	TSPS RPCS supply cooling valves	2	Dissolution tank or TSPS glovebox contains uranium	9
k	TSPS RPCS return cooling valve	1	Dissolution tank or TSPS glovebox contains uranium	9
l.	RV TSPS dampers 1. Supply 2. Exhaust	1 (per location)	Dissolution tank or TSPS glovebox contains uranium	9
m.	MEPS extraction column three-way valves 1. Upper 2. Lower	1 (per location, per hot cell)	Target solution or radioactive process fluids present in the associated extraction hot cell	10
n.	IXP extraction column three-way valves 1. Upper 2. Lower	1 (per location)	Target solution or radioactive process fluids present in the IXP hot cell	10
o.	MEPS [ ]PROP/ECI isolation valves 1. Inlet 2. Outlet	1 (per location, per hot cell)	Target solution or radioactive process fluids present in the associated extraction hot cell	11
p.	MEPS extraction column wash supply valve	1 (per hot cell)	Target solution or radioactive process fluids present in the associated extraction hot cell	11
q.	MEPS extraction column eluent valve	1 (per hot cell)	Target solution or radioactive process fluids present in the associated extraction hot cell	11
r.	MEPS [ ]PROP/ECI wash supply valve	1 (per hot cell)	Target solution or radioactive process fluids present in the associated extraction hot cell	11
s.	MEPS [ ]PROP/ECI eluent valve	1 (per hot cell)	Target solution or radioactive process fluids present in the associated extraction hot cell	11

	Component	**Number Provided per Flow Path**	**Applicability**	**Action**
t.	IXP recovery column wash supply valve	1	Target solution or radioactive process fluids present in the IXP hot cell	11
u.	IXP recovery column eluent valve	1	Target solution or radioactive process fluids present in the IXP hot cell	11
v.	IXP [ ]PROP/ECI wash supply valve	1	Target solution or radioactive process fluids present in the IXP hot cell	11
w.	IXP [ ]PROP/ECI eluent valve	1	Target solution or radioactive process fluids present in the IXP hot cell	11
x.	IXP facility nitrogen handling system supply valve	1	Target solution or radioactive process fluids present in the IXP hot cell	11
y.	IXP liquid nitrogen supply valve	1	Target solution or radioactive process fluids present in the IXP hot cell	11

LCO 3.8.11	The safety-related check valves listed in Table 3.8.11 shall be Operable.
Applicability	According to Table 3.8.11
Action	1. If the check valve is not Operable, suspend hot cell operations involving the introduction of liquids into any extraction hot cell. 2. If the check valve is not Operable, Close at least one valve in the flow path of the inoperable valve OR Suspend hot cell operations involving the introduction of liquids into the associated hot cell AND Drain target solution and radioactive liquids in process lines from the associated hot cell. 3. If the check valve is not Operable, Suspend RLWI immobilization feed operations AND Close at least one RLWI PVVS valve. 4. If the check valve is not Operable, Immediately suspend dissolution tank operations AND Isolate RPCS supply and return water to the dissolution tanks AND Initiate actions to remove uranium from the TSPS glovebox.
SR 3.8.11	The check valves listed in Table 3.8.11 shall be inspected semi-annually.

Table 3.8.11 Safety-Related Check Valves

	Check Valve	Applicability	Action
a.	MEPS target solution [ ]PROP/ECI check valve (per extraction hot cell)	Target solution or radioactive process fluids present in the associated hot cell	1
b.	MEPS extraction column wash supply check valve (per extraction hot cell)	Target solution or radioactive process fluids present in the associated hot cell	2
c.	MEPS extraction column eluent check valve (per extraction hot cell)	Target solution or radioactive process fluids present in the associated hot cell	2
d.	MEPS [ ]PROP/ECI wash supply check valve (per extraction hot cell)	Target solution or radioactive process fluids present in the associated hot cell	2
e.	MEPS [ ]PROP/ECI eluent check valve (per extraction hot cell)	Target solution or radioactive process fluids present in the associated hot cell	2
f.	IXP recovery column wash supply check valve	Target solution or radioactive process fluids present in the associated hot cell	2
g.	IXP recovery column eluent check valve	Target solution or radioactive process fluids present in the associated hot cell	2
h.	IXP [ ]PROP/ECI wash supply check valve	Target solution or radioactive process fluids present in the associated hot cell	2
i.	IXP [ ]PROP/ECI eluent check valve	Target solution or radioactive process fluids present in the associated hot cell	2
j.	IXP facility nitrogen handling system supply check valve	Target solution or radioactive process fluids present in the associated hot cell	2
k.	IXP liquid nitrogen excess flow check valve	Target solution or radioactive process fluids present in the associated hot cell	2
l.	RLWI PVVS check valve	Facility not Secured	3
m.	TSPS RPCS return check valve	Dissolution tank or TSPS glovebox contains uranium	4

Basis 3.8.1 LCO

There are 12 N2PS nitrogen storage tubes provided, each normally maintained above 2,100 psig. The availability of 11 Operable N2PS nitrogen storage tubes, each pressurized with nitrogen to a minimum pressure of 2,100 psig, ensures there is sufficient nitrogen capacity to provide flow to adequately control hydrogen concentrations in process tanks and IUs during accident scenarios for the required operational time of 72 hours, as described in FSAR Subsection 9b.6.2.

The N2PS nitrogen storage tubes are located in a separate structure from the main production facility. The minimum pressure of 2,100 psig is evaluated to be valid over a temperature range of -40°F to 125°F.

With fewer than 11 nitrogen storage tubes Operable, all IUs currently undergoing irradiation in Mode 2 or filling in Mode 1 are required to placed in Mode 3 to limit the amount of hydrogen generated in the facility via radiolysis. IU Mode 2 operations in any IU cannot be resumed until the minimum supply of nitrogen is restored to at least 11 nitrogen storage tubes.

SR

The pressure verification ensures there is sufficient capacity in the N2PS to perform its required function. The frequency of the pressure verification is based on industry experience. Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required.

The periodic functional test is performed to ensure the N2PS can deliver sweep gas at required flowrates and pressures. The initial verification of the N2PS nitrogen delivery capability is performed during start-up testing; the frequency of periodic verification of nitrogen delivery capability is based on the passive design of the N2PS and the limited number of active components.

Basis 3.8.2 LCO

The reactivity equivalent of fresh [ ]PROP/ECI target solution in conjunction with the Fill Stop function is calculated to maintain k_{eff} below 1.0 in an inadvertent fill scenario, as described in FSAR Subsection 4a2.6.2.7. The limit also ensures that the thermal-hydraulic properties of the target solution are within analyzed conditions to prevent boiling of the target solution and protect the integrity of the PSB, as described in FSAR Subsection 4a2.7.5.5. Target solution batches that do not meet the allowable uranium concentration cannot be transferred into a TSV. As the SR precludes transfer of target solution that does not meet the LCO to the TSV, a separate action statement is not required for this LCO.

SR

Target solution parameters are confirmed after preparation or adjustments are made to batches to ensure parameters are within limits. The uranium concentration of the target solution is not expected to change during irradiation. The adequacy of the frequency of target solution parameter measurements is confirmed during facility start-up testing.

Basis 3.8.3 <u>LCO</u>

Maintaining sufficient [ ][PROP/ECI] and pH level within acceptable bounds prevents uranyl peroxide precipitation from occurring during irradiation, as described in FSAR Subsection 4a2.6.3.5. Target solution batches that do not meet the allowable [ ][PROP/ECI] at the measured pH cannot be transferred into a TSV. As the SR precludes transfer of target solution that does not meet the LCO to the TSV, a separate action statement is not required for this LCO.

<u>SR</u>

Target solution parameters are confirmed after preparation or adjustments are made to batches to ensure parameters are within limits. The [ ][PROP/ECI] and pH of target solution are not expected to change during irradiation. The adequacy of the frequency of target solution parameter measurements is confirmed during facility start-up testing.

Basis 3.8.4 <u>LCO</u>

The first and second uranium liquid waste tanks are designed with favorable geometry. The liquid waste blending tanks are not geometrically favorable. Uranium concentration is required to be below limits evaluated in the nuclear criticality safety program prior to transfer of uranium-bearing solutions to tanks that have not been designed with favorable geometry. The nuclear criticality safety program includes additional requirements for the transfer process to ensure that inadvertent criticality is prevented, as described in FSAR Subsection 6b.3.2.2. If uranium concentration is found to be above the limit of 25 gU/L, all transfer of solution to the liquid waste blending tank is required to be stopped, any solution in the liquid waste blending tank is required to be returned to a favorable geometry location, and the uranium concentration in the second uranium liquid tank is required to be lowered via dilution until it is within limits to prevent a criticality in the RPF.

<u>SR</u>

Uranium concentration is confirmed to be within limits prior to each applicable liquid transfer.

Basis 3.8.5 <u>LCO</u>

A two-key interlock on NDAS operation prevents inadvertent production of neutrons when personnel may be present, to prevent exposing personnel to excessive dose, as described in FSAR Subsection 13a2.1.12.2. A two-key interlock is provided for each IU cell and for the neutron driver service cell (NSC). Personnel are not allowed to enter an IU cell or the NSC if the ability of the associated NDAS to produce a beam has not been disabled.

<u>SR</u>

The interlocks are tested periodically to ensure their operability when required. The IU cells can only be entered via removal of the IU cell plug; therefore, the testing of the IU cell driver interlock is only performed when it is required to be

Operable. The NSC can be entered via a door, therefore, the operation of the interlock is required to be tested at regular periodicity. The quarterly operability test is consistent with the recommendations of ANSI/ANS 15.1-2007.

Basis 3.8.6 LCO

The [ ]PROP/ECI pressure limit ensures that the amount of tritium in an IU cell is below the [ ]PROP/ECI limit, as described in FSAR Subsection 13a2.2.12.1. The pressure limit is derived from the curie limit. The total tritium inventory is used as an input into the dose consequence analysis. Exceeding the pressure, and therefore tritium inventory, would result in increased radiological doses to workers and the public in the event of a release into the IU cell. With pressure in the target chamber above [ ]PROP/ECI, the neutron driver is required to be shut down to minimize the probability of a release, and tritium is required to be removed from the target chamber to return to within the allowable limit.

SR

Verification of the pressure during the irradiation cycle confirms the limit is not exceeded. The frequency of the pressure verification is based on industry experience. Additionally, PICS monitors the pressure in the target chamber, and pressure excursions will result in control room alarms to alert the operator.

Basis 3.8.7 LCO

The dew point in the TPS gloveboxes is monitored as an indication of air-ingress into the glovebox, to ensure flammability risks are minimized and to ensure oxygen does not excessively react with TPS process components, as described in FSAR Subsection 9a2.7.1. Low dew points in the TPS glovebox are indicative of a dry, helium atmosphere, which minimizes flammability risks to TPS process equipment, such as TPS cryopumps, and minimizes air (oxygen) exposure to TPS process equipment that is sensitive to oxygen exposure. If the helium atmosphere is lost, or the dew point temperature is above the allowable limit, the TPS is required to be purged with helium to return the glovebox atmosphere to within allowable parameters.

SR

Channel Check and Channel Calibration frequencies are based on guidance from ANSI/ANS 15.1-2007 and ensure the instrumentation is capable of performing its intended function when required.

Basis 3.8.8 LCO

The TPS SEC system prevents the accumulation of tritium in its associated glovebox, as described in FSAR Subsections 6a2.2.1.2 and 9a2.7.1. Maintaining low tritium levels minimizes leakage of tritium from the glovebox and prevents excessive doses to workers. Part of the tritium storage and separation system is a depleted uranium storage bed that holds tritium when not in use. The depleted uranium storage bed allows tritium to be safely stored during maintenance operations on the TPS. An SEC is Operable when the circulating blower is flowing gas through the series of molecular sieve and hydride beds that capture tritiated water and elemental tritium, respectively. With the SEC not Operable, actions to return tritium to its storage location shall be taken.

SR

The surveillance ensures the continued operability of the system. The frequency of the pressure verification is based on industry experience. Additionally, SEC parameters are monitored via the PICS and control room alarms of SEC blower functionality are provided to alert the operator of a sudden failure.

Basis 3.8.9 LCO

RCA isolation dampers ensure the potential for a release to the environment is limited in the event of a postulated radioactive material release within the facility. The dampers are automatically closed on an RCA Isolation (see LCO 3.2.2, item a.). The dampers are required to be Operable to support the protective functions described in FSAR Section 7.5. The dampers are not required to be Operable when the facility is Secured. With one or more Division(s) inoperable in a flow path, at least one damper in that flow path is required to be closed to fulfil the isolation function.

SR

The closure testing ensures the continued operability of the dampers. The frequency is based on industry experience.

Basis 3.8.10 LCO

The safety-related valves are required to be Operable to support the protective functions described in FSAR Section 7.5.

a. VTS vacuum break valves are used to break vacuum in the VTS, stopping transfer of target solution or radioactive liquids within the facility. The valves are opened by a VTS Safety Actuation signal. With fewer than two divisions Operable, the VTS vacuum pump breakers are opened to shut down the VTS, and at least one VTS vacuum break valve is opened to break vacuum in the system.

b. PVVS blower bypass valves are used to bypass the PVVS blowers during operation of the N2PS to ensure a flow path for N2PS to the safety-related release point is available. The valves are opened on an RPF Nitrogen Purge signal. With fewer than two divisions Operable, at least one PVVS blower bypass valve is opened to ensure the availability of the flow path. With the PVVS blowers Operating, opening these valves could reduce the flowrate of sweep gas to the RPF tanks by providing another source of makeup air. Therefore, the normal PVVS blower makeup air supply is required to be closed when the PVVS blower bypass valves are open to ensure the blowers are capable providing adequate sweep gas flow for RPF tanks.

c. PVVS carbon guard bed bypass valves are used to ensure a flow path exists around the PVVS carbon guard beds to ensure the hydrogen mitigation function of N2PS is maintained. The valves are opened on an RPF Nitrogen

Purge actuation signal to ensure a flow path exists for N2PS. With fewer than the minimum required Divisions Operable, at least one PVVS carbon guard bed bypass valve is opened to ensure the N2PS flow path is maintained.

d. - e. PVVS carbon delay bed three-way and outlet isolation valves are used to isolate a PVVS carbon delay bed group in the event of a fire in a bed within that group. The valves are deenergized to isolate the affected group on a Carbon Delay Bed Isolation signal. With fewer than the minimum required Divisions Operable, the associated carbon delay bed group is required to be isolated, and the remaining carbon delay beds are verified to be Operating.

f. The RLWI PVVS isolation valve is used to isolate the RLWI immobilization feed tank from the PVVS in the event of an RPF Nitrogen Purge actuation to prevent backflow of nitrogen into the RLWI skid. PVVS normally provides ventilation for the RLWI, but this function is not required to prevent unacceptable levels of hydrogen accumulation in the RLWI system and is not connected to N2PS sweep gas supply. Only one RLWI PVVS isolation valve is provided; redundancy is provided via the use of a check valve (see LCO 3.8.11). With the required Division inoperable, operations involving the addition of solution to the RLWI immobilization feed tank are suspended, and at least one valve in the flow path from RLWI to PVVS is closed to provide the function.

g. N2PS IU cell header valves are used to provide nitrogen to the IU cell header; individual IU cell nitrogen purge isolation valves are controlled by TRPS to introduce nitrogen into the IUs. The valves are automatically opened on an IU Cell Nitrogen Purge actuation. With fewer than two Divisions Operable, at least one N2PS IU cell header valve is required to be opened.

h. N2PS RPF header valves are used to provide nitrogen to the RPF tanks containing radioactive solutions. The valves are automatically opened on an RPF Nitrogen Purge actuation. With fewer than two Divisions Operable, the RPF header valves and PVVS blower bypass valves are required to be opened, and the N2PS RVZ2 north and south header valves are required to be closed to actuate nitrogen purge in the RPF.

i. N2PS RVZ2 north and south header valves provide the normal inlet flow path to PVVS. Inadvertent isolation of both flow paths valves renders the PVVS inoperable. The valves are automatically closed on an RPF Nitrogen Purge actuation. With one or more valve(s) inoperable in a single flow path (north or south), the flow path is required to be isolated using at least one N2PS RVZ2 header valve to ensure N2PS will operate if required.

j. - l. TSPS RPCS supply cooling valves, TSPS RPCS return cooling valve, and the RVZ TSPS supply and exhaust dampers prevent overflow of the TSPS dissolution tank into the uranium handling glovebox and isolate the glovebox. The valves and dampers automatically close on a Dissolution Tank Isolation. These components are required by the nuclear criticality safety evaluation for the TSSS. Other controls on the dissolution process identified by the evaluation are implemented by the criticality safety program (see Administrative Control 5.5.7). Only one TSPS RPCS return cooling valve is provided; redundancy is provided via the use of a check valve (see LCO 3.8.11). With fewer than the minimum required Division(s) Operable, operations involving the dissolution of uranium are suspended, the RPCS water supply and return to the tanks is isolated, and actions are initiated to remove uranium from the TSPS glovebox to mitigate the potential criticality hazard. RPCS water may be isolated using local manual valve(s) or automatic isolation valve(s).

m. - n. MEPS and IXP three-way valves are used to direct target solution and other reagent solutions during extraction operations. The valves automatically reposition on an associated Alignment Actuation signal. One upper and one lower three-way valve is provided. The three-way valves must be properly coordinated to prevent a misdirection of target solution towards the chemical addition line or an inadvertent flow of other reagent solutions towards the upper lift tanks. Inadvertent three-way valve misalignments could lead to uranium precipitation. With one or more valve(s) inoperable for a single extraction hot cell, at least one three-way valve is placed in the discharging position, and the extraction column eluate valve is closed. MEPS [ ]PROP/ECI inlet and outlet isolation valves are used to isolate the MEPS [ ]PROP/ECI in the event of a leak of target solution from the extraction column [ ]PROP/ECI. The valves automatically close on a MEPS [ ]PROP/ECI Isolation. One inlet and one outlet valve is provided for each extraction hot cell. With one or more valve(s) inoperable for a single extraction hot cell, the MEPS [ ]PROP/ECI is isolated; otherwise, hot cell operations involving the introduction of liquids into the cell (e.g., extraction, column washing, elution, etc.) are suspended and target solution and radioactive liquids are drained from the associated hot cell. The MEPS [ ]PROP/ECI may be isolated using local manual valves or the automatic isolation valves if they are inoperable but still capable of performing the isolation function when closed.

o. - y. MEPS and IXP wash supply and eluent valves are used to supply reagents and washes to the MEPS extraction, [ ]PROP/ECI, and IXP recovery columns. IXP facility nitrogen handling system supply and liquid nitrogen supply valves provide supply nitrogen and liquid nitrogen to the IXP hot cell to support processes in the cell. These valves automatically close on a VTS Safety Actuation signal. One valve is provided for each supercell penetration; redundancy is provided via the use of check valves (see LCO 3.8.11). With any required valve inoperable, the flow path affected by the inoperable valve is isolated; otherwise, hot cell operations involving the introduction of liquids into the cell (e.g., extraction, column washing, elution, etc.) are suspended and target solution and radioactive liquids are drained from the associated hot cell. The affected flow path may be isolated using local manual valves or automatic isolation valves if they are inoperable but still capable of performing the isolation function when closed.

<u>SR</u>

The surveillance requirements ensure the continued operability of the safety-related valves and dampers. The surveillance frequency is consistent with the recommendations from ANSI/ANS 15.1-2007 and industry experience.

Basis 3.8.11 <u>LCO</u>

Check valves provide isolation functions as described below.

a. The MEPS target solution [ ]PROP/ECI check valve prevents target solution from other extraction cells to inadvertently back flow into the molybdenum eluate tank in the associated hot cell. Since multiple valve misalignment in the other extraction cells would need to occur, redundancy is not required for this function per the accident analysis. With the check valve inoperable, hot cell operations involving the introduction of liquids into the cell are suspended to prevent the inadvertent backflow of solution into the affected cell.

b. - i. MEPS and IXP wash supply and eluent check valves prevent the misdirection of target solution in the event of a three-way valve failure or leakage. A misdirection could result in the target solution migrating outside of the hot cell or target solution exposure to base reagent, which could lead to uranium precipitation. With any required check valve inoperable, the flow path affected by the inoperable valve is isolated; otherwise, hot cell operations involving the introduction of liquids into the cell (e.g., extraction, column washing, elution) are suspended and target solution and radioactive liquids are drained from the associated hot cell. The affected flow path may be isolated using local manual valves or automatic isolation valves (see LCO 3.8.10).

j. The IXP facility nitrogen handling system supply check valve is used to prevent backflow of nitrogen from the IXP hot cell, and provides redundancy to the IXP supply nitrogen isolation valve (see LCO 3.8.10, item y). With the check valve inoperable, nitrogen is required to be isolated to the IXP hot cell.

k. The IXP liquid nitrogen excess flow check valve is described in FSAR Subsection 9b.7.8.2 and limits potential equipment damage due to being exposed to liquid nitrogen in the event of a liquid nitrogen line break. With the check valve inoperable, liquid nitrogen is required to be isolated to the IXP hot cell (see LCO 3.8.10, item x.).

l. The RLWI PVVS check valve is used to prevent backflow of nitrogen into the RLWI skid via PVVS in the event of an RPF Nitrogen Purge actuation. The check valve provides redundancy with the RLWI PVVS isolation valve (see LCO 3.8.10). With the check valve inoperable, operations involving the RLWI immobilization feed tank are suspended, and at least one valve in the flow path from RLWI to PVVS is closed to provide the function.

m. The TSPS RPCS return check valve prevents overflow of the TSPS dissolution tank into the uranium handling glovebox in the event of an RPCS leak. The check valve provides redundancy for the TSPS RPCS return cooling valve (see LCO 3.8.10). With the check valve inoperable, operations involving the dissolution of uranium are suspended, the RPCS water supply and return to the tanks is isolated, and actions are initiated to remove uranium from the TSPS glovebox to mitigate the potential criticality hazard. RPCS water may be isolated using local manual valve(s) or automatic isolation valve(s).

SR

The surveillance requirements ensure the continued operability of the safety-related check valves. The surveillance frequency is adequate based on the expected reliability of the passive components.

4.0 Design Features

4.1 Site and Facility Description

DF 4.1.1	1. The SHINE Facility is owned and operated by SHINE Medical Technologies, LLC and is located at 4021 S. U.S. Highway 51, Janesville, WI, 53546. The SHINE Facility includes the main production facility, N2PS structure, resource building, material staging building, and the storage building. 2. The nearest distance from a potential release point from the main production facility to the site boundary is 756 ft. 3. The site boundary corresponds to the property line around the perimeter of the SHINE site and encompasses approximately 91 acres of land. The owner controlled area is the area within the site boundary. 4. The operations boundary is the area within the site boundary where the Shift Supervisor has direct authority over all activities. The controlled access area fence and the perimeter walls of the main production facility, the material staging building, the storage building, and the resource building constitute the SHINE operations boundary. The operations boundary is the emergency planning zone.

DF 4.1.2	1. The building free volume of the irradiation facility is approximately 13,400 m^3. 2. The building free volume of the radioisotope production facility is approximately 18,000 m^3. 3. The accident dose effluent release height is 0 feet above grade. 4. The normal effluent release height is 67 feet above grade.

DF 4.1.3	1. The PVVS carbon delay bed minimum efficiency for iodine is 99%. 2. The PVVS carbon delay bed delay time is 40 days, based on the travel time of xenon and the depth of the bed. 3. The TOGS zeolite bed minimum efficiency for iodine is 95%. 4. The TOGS recombiner minimum efficiency for hydrogen recombination is 95% for hydrogen concentrations above 3% by volume when heated to operating temperature. 5. The supercell RVZ1 outlet carbon filter minimum efficiency for iodine is 99%.

DF 4.1.4	Supercell ventilation is designed with a maximum flowrate of 40 air exchanges per hour (ACH) for extraction and purification cells.

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

4.2 Coolant Systems

DF 4.2.1	1. Each subcritical assembly system is submerged in an individual light water pool. 2. Each light water pool is provided a seismically qualified stainless steel liner. 3. Piping penetrations into the stainless steel liner are located above the minimum acceptable light water pool water level for decay heat removal, or a specific evaluation is performed to determine the potential for loss of pool water through the penetration. Piping penetrations into the light water pool with the potential for siphoning below the minimum acceptable water level contain anti-siphon devices or other means to prevent inadvertent loss of pool water. 4. Each light water pool is designed to maintain temperatures ≥ 50°F and ≤ 95°F.

4.3 Subcritical Assembly System and Target Solution

DF 4.3.1	Target solution is an aqueous uranyl sulfate solution containing uranium enriched to less than 20 wt. % in U-235.

DF 4.3.2	1. The subcritical assembly system principally consists of the TSV, subcritical assembly support structure (SASS), neutron multiplier and TSV dump tank, and is described in FSAR Section 4a2.2. 2. Redundant overflow tubes are provided for the TSV to protect the TSV headspace to allow for TOGS operation.

DF 4.3.3	The characteristics of the cooling in the subcritical assembly are designed to maintain the relationship between average TSV target solution power density and average TSV target solution temperature within the “Acceptable” region shown in the power density limit curve (Figure 4.3.3). As designed, the PCLS maintains an approximately 50% margin between steady-state power and the power density limit at the corresponding temperature.

Figure 4.3.3 Target Solution Average Power Density vs. Average Temperature

PROP/ECI

4.4 Fissionable Material Storage

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

5.0 Administrative Controls

5.1 Organization

5.1.1 Structure

This section describes the SHINE organizational structure, functional responsibilities, and levels of authority. The levels employed are adapted from the definitions from ANSI/ANS 15.1-2007:

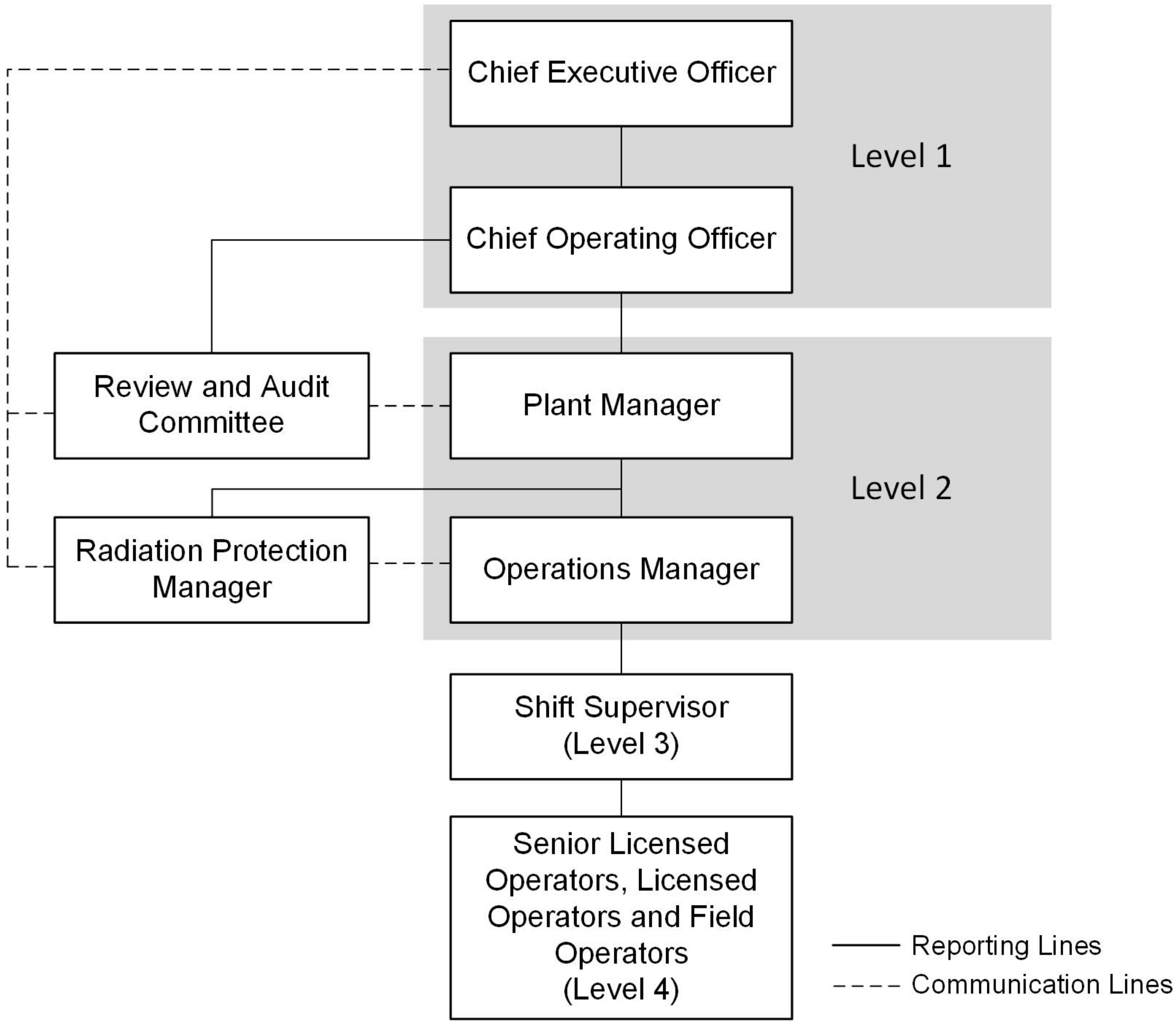
- Level 1: Individuals responsible for the SHINE Facility License;
- Level 2: Individuals responsible for SHINE Facility operation;
- Level 3: Individuals responsible for day-to-day operation or shift;
- Level 4: Operating staff.

Alternates may perform the functions required in the absence of the normal designee.

The management for operation of the SHINE Facility shall consist of the organizational elements described below and shown in Figure 5.1.1:

1. Chief Executive Officer (CEO) - Level 1
2. Chief Operating Officer (COO) - Level 1 Alternate
3. Plant Manager (PM) - Level 2
4. Operations Manager (OM) - Level 2 Alternate
5. Shift Supervisors - Level 3
6. Senior Licensed Operators, Licensed Operators, and Field Operators - Level 4
7. Radiation Protection Manager (RPM)
8. Review and Audit Committee (RAC)

Figure 5.1.1 SHINE Operational Organization Chart



5.1.2 Responsibility

Responsibility for the safe operation of the SHINE Facility shall be with the chain of command established in Figure 5.1.1. Individuals at the various management levels shall be responsible for the policies and operation of the SHINE Facility, for safeguarding the public and facility personnel from undue radiation exposures, and for adhering to all requirements of the License and technical specifications.

1. The CEO is responsible for the overall design, management, and technical leadership of the company and is also responsible for all technical and administrative support activities provided by SHINE. The CEO reports to the Board of Directors with respect to all matters.

2. The COO is responsible for operational aspects of the company including safety, management, and training. The COO is also responsible for matters regarding environment, safety, and health. The COO delegates sufficient responsibility and authority to direct reports that ensures appropriate controls have been

established and for verifying that activities have been correctly performed. The COO has the overall responsibility for any programs that are established to ensure appropriate control of measures pertaining to safety, operability, and maintenance of the facility. The COO encourages managers and employees to identify problems and initiate, recommend, or provide corrective action, and ensures corrective action implementation. The COO reports to the CEO.

3. The PM is responsible for the operation and management of the SHINE Facility. The PM is also responsible for establishing and managing the required training programs to support the organization, and for establishing and maintaining the programs and systems to ensure protection of the company's assets. The PM reports to the COO.

4. The OM is responsible for safe, reliable, and efficient plant operations within the constraints of the operating License and regulatory requirements. This position is also responsible for the development and implementation of appropriate operational controls in accordance with the QAPD. The OM reports to the PM.

5. The Shift Supervisors are responsible for the safe day-to-day operation of the facility. The Shift Supervisors report to the OM.

6. Senior Licensed Operators, Licensed Operators, and Field Operators are responsible for conforming to applicable rules, regulations, and procedures for operation of the facility. Senior Licensed Operators are responsible for safe and efficient operation of a portion of the facility when designated by the Shift Supervisor. Senior Licensed Operators and Licensed Operators are responsible for maintaining Senior Licensed Operator and Licensed Operator status, respectively. Field Operators are non-licensed operations personnel. Senior Licensed Operators, Licensed Operators, and Field Operators report to Shift Supervisors.

7. The RPM fulfills the radiation safety function and is responsible for establishing and implementing the RPP, monitoring worker doses, and the calibration and quality assurance of health physics instrumentation. The RPM reports to the PM.

8. The RAC is responsible for the independent review and audit of the safety aspects of the SHINE Facility operations. The RAC duties, authorities, and responsibilities are described in FSAR Section 12.2.

5.1.3 Facility Staffing Required

1. The minimum staffing when the facility is not Secured shall be:

    a. A Senior Licensed Operator present in the facility,

    b. A second Senior Licensed Operator or Licensed Operator present in the control room, and

    c. An additional designated person present at the facility able to carry out prescribed written instructions.

    Unexpected absence of any of the minimum staffing positions for as long as two hours to accommodate a personal emergency may be acceptable provided immediate action is taken to obtain a replacement.

2. A list of facility personnel by name and telephone number shall be readily available in the control room for use by the operators. The list shall include:

   a. Management personnel,

   b. Radiation safety personnel, and

   c. Other operations personnel.

5.1.4 Selection and Training of Personnel

SHINE establishes and maintains training programs for personnel performing, verifying, or managing facility operation activities to ensure that suitable proficiency is achieved and maintained. The Training Manager (TM) reports to the PM and is responsible for development and implementation of training that ensures satisfactory operational behavior and performance in the areas of nuclear, industrial, and radiological safety. ANSI/ANS 15.4-2016 is used in the selection and training of personnel and compliance is maintained with 10 CFR Part 55. Records of personnel training and qualification are maintained.

In general, personnel have the combination of academic training, job-related experience, health, and skills commensurate with their level of responsibility that provides reasonable assurance that decisions and actions during normal and abnormal conditions are such that the facility is operated in a safe manner.

Additional information is detailed in FSAR Subsection 12.1.4.

5.2 Review and Audit

The COO establishes the RAC and ensures that the appropriate technical expertise is available for review and audit activities. The COO holds approval authority for review and audit activities. Independent audits of the SHINE Facility are conducted periodically.

The RAC will interact with facility management through the dissemination of meeting minutes and meeting reports.

5.2.1 Composition and Qualifications

The RAC shall have the appropriate expertise and experience such that members provide the SHINE management an independent assessment of the operation. The COO shall be the chair of the RAC and shall appoint additional members. The minimum number of the members shall be three. The qualifications for the RAC members shall include a broad spectrum of technical, operational, and managerial expertise. Non-SHINE employees may be appointed as committee members, at the discretion of the COO.

5.2.2 Charter and Rules

The charter for the RAC requires at least one meeting per year, with a quorum being a minimum of 50 percent of committee members where the operating staff does not constitute a majority. Dissemination, review, and approval of minutes shall happen in a timely manner. The RAC charter shall include provisions for the use of subgroups. Committee reports and reviews shall be distributed by memorandum to Level 1 management and other management as designated in the charter. Voting may be conducted at the meeting or by polling members with a majority required for approval.

5.2.3 Review Function

1. At a minimum, the following items shall be reviewed:

    a. Determinations that proposed changes in equipment, systems, tests, or procedures are allowed without prior authorization by the responsible authority (e.g., 10 CFR 50.59 safety reviews);

    b. All new procedures and major revisions thereto having safety significance;

    c. Proposed changes in facility equipment or systems having safety significance;

    d. Proposed changes in technical specifications or License;

    e. Violations of technical specifications or License;

    f. Violations of internal procedures or instructions having safety significance;

    g. Operating abnormalities having safety significance;

    h. Reportable occurrences; and

    i. Audit/Assessment reports

2. A written report or minutes of the findings and recommendations of the RAC shall be submitted to Level 1 and the RAC group members in a timely manner after any review has been completed.

5.2.4 Audit Function

1. The audit function shall include selective (but comprehensive) examination of operating records, logs, and other documents. Discussions with personnel and observation of operations will be used as appropriate. In no case shall the individual immediately responsible for the area perform an audit in that area. SHINE will work to establish relationships with other entities to participate in audits of the facility. The following items shall be audited:

    a. Facility operations for conformance to the technical specifications and applicable License conditions (including organization and responsibilities, training, operations, procedures, logs and records, health physics, technical specification compliance, and surveillances): at least once per calendar year (interval between audits not to exceed 15 months);

    b. The retraining and requalification program for the operating staff: at least once every other calendar year (interval between audits not to exceed 30 months);

    c. The results of action taken to correct those deficiencies that may occur in the production facility equipment, systems, structures, or methods of operations that affect nuclear safety: at least once per calendar year (interval between audits not to exceed 15 months);

    d. The SHINE Facility emergency plan and implementing procedures: at least once every other calendar year (interval between audits not to exceed 30 months);

e. The radiation protection plan: at least once per calendar year (interval between audits not to exceed 15 months);

f. The QAPD: at least once every other calendar year (interval between audits not to exceed 30 months); and

g. The physical security plan: at least once every other calendar year (interval between audits not to exceed 30 months).

2. Deficiencies identified during the audit will be entered into the Corrective Action Program. Deficiencies uncovered that affect nuclear safety shall immediately be reported to Level 1 management. A written report of the findings of the audit shall be submitted to Level 1 management and the review and audit committee members within three months after the audit has been completed.

5.3 Radiation Safety

The RPM shall be responsible for the implementation of the radiation protection program. The requirements of the radiation protection program are established by 10 CFR Part 20. The program shall use the guidelines of ANSI/ANS 15.11-1993, Radiation Protection at Research Reactor Facilities. Furthermore, SHINE is committed to ensuring that radiation exposures are ALARA and in maintaining and effective ALARA Program.

The radiation protection department is independent of facility operations. This independence ensures that the radiation protection department maintains its objectivity and is focused only on implementing sound radiation protection principals necessary to achieve occupational doses and doses to members of the public that are ALARA.

Radiation protection staff maintain the ability to raise safety issues with the review and audit committee or executive management.

5.4 Procedures

1. Procedures for the operation and use of the SHINE Facility provide appropriate direction to ensure that the facility is operated normally within its design basis, and in compliance with technical specifications. These procedures are written, reviewed, approved by appropriate management, as well as controlled and monitored to ensure that the content is technically correct, and the wording and format are clear and concise.

2. The process required to make changes to procedures, including substantive and minor permanent changes, and temporary deviations to accommodate special or unusual circumstances during operation shall be in compliance with ANSI/ANS 15.1-2007.

3. SHINE shall prepare, review, and approve written procedures for the following basic topics:

   a. startup, operation, and shutdown of the IU;

   b. target solution fill, draining, and movement within the SHINE Facility;

   c. maintenance of major components of systems that may have an effect on nuclear safety;

d. surveillance checks, calibrations and inspections required by the technical specifications;

e. personnel radiation protection, consistent with applicable regulatory guidance. The procedures shall include management commitment and programs to maintain exposures and releases as low as reasonably achievable in accordance with applicable guidance;

f. administrative controls for operations and maintenance and for the conduct of irradiations that could affect nuclear safety;

g. implementation of required plans (e.g., emergency, security); and

h. use, receipt, and transfer of byproduct material.

4. The specific procedures within these topic areas are developed in accordance with SHINE QAPD Section 2.5.

5. SHINE shall review and approve written procedures prior to initiating any of the activities listed above. The procedures shall be reviewed by the SHINE review and audit committee and approved by Level 2 management or designated alternates, and such reviews and approvals shall be documented in a timely manner.

6. Substantive changes to procedures related to the activities listed above shall be made effective only after documented review by the SHINE review and audit committee and approval by Level 2 management or designated alternates. Minor modifications to the original procedure that do not change their original intent may be made by Level 3 management or higher, but the modifications must be approved by Level 2 or designated alternates. Temporary deviations from the procedures may be made by a Senior Licensed Operator or higher individual present, in order to accommodate special or unusual circumstances or conditions. Such deviations shall be documented and reported within 24 hours or the next working day to Level 2 management or designated alternates. Review and approval of procedural changes shall be documented in a timely manner, in accordance with the SHINE Document Control procedure.

7. Revisions to the procedures for the operation and use of the SHINE Facility are initiated and tracked through the document control processes. Following preparation, procedure revisions receive a technical review, which will include a screening for 10 CFR 50.59 applicability and are then reviewed and approved as described above.

8. The extent of detail in a procedure is dependent on the complexity of the task; the experience, education, and training of the users; and the potential significance of the consequences of error. The process for making changes and revisions to procedures is documented. A controlled copy of all operations procedures is maintained in the control room. Activities and tasks are performed in accordance with approved implementing procedures.

5.5 Programs

The following programs shall be established, implemented, and maintained.

5.5.1 Nuclear Safety Program

The SHINE nuclear safety program documents and describes the methods used to minimize the probability and consequences of accidents resulting in radiological or chemical release. The program applies a graded approach to the design and management of processes to assure plant safety through risk reduction and satisfaction of SHINE's performance goals. The safety program accomplishes these goals through development and maintenance of the accident analysis, identification of safety-related structures, systems, and components (SSCs) credited for accident mitigation, and establishment of programmatic administrative controls to ensure reliability of the credited SSCs.

5.5.2 Training and Qualification

The SHINE training and qualification programs include initial and requalification training programs for Licensed Operators, which were developed to conform to the requirements of 10 CFR Part 55, as it pertains to non-power facilities, following the guidance contained in ANSI/ANS 15.4-2016, Selection and Training of Personnel for Research Reactors.

5.5.3 Radiation Protection

The SHINE radiation protection program is provided to protect the radiological health and safety of workers and the public. The program meets the requirements of 10 CFR 20, Subpart B, and is consistent with the guidance provided in ANSI/ANS 15.11-2016, Radiation Protection at Research Reactor Facilities, and Regulatory Guide 8.2, Revision 1, Administrative Practices in Radiation Surveys and Monitoring. In addition, SHINE has established this program to maintain occupational radiation exposures and releases to the environment ALARA.

5.5.4 Configuration Management

The SHINE configuration management program provides oversight and control of design information, safety information, and records of modifications that might impact the ability of safety-related SSCs to perform their functions. The configuration management program is applied to all safety-related SSCs. The configuration management program is used to maintain consistency among the design requirements, the physical configuration and the facility documentation, and ensures changes are made in accordance with 10 CFR 50.59, 10 CFR 70.72, and the administrative controls and reviews specified by this program.

Table 5.5.4 lists controls derived from the accident analysis not otherwise included in Sections 3, 4, or 5 of the technical specifications. SHINE maintains these controls under the configuration management program and will not modify the characteristics of the items listed in Table 5.5.4 without prior NRC approval.

Table 5.5.4 Controls

Category	Characteristic
Main Production Facility Structure	The facility structure is designed to protect safety-related SSCs from tornado winds and missile loads, heavy snow and ice loading, and the impact of design basis (small) aircraft, including the effects of fire, as described in FSAR Section 3.4.
	The design of the facility includes provisions for the prevention of adverse effects of flooding from external sources, barriers in the RPCS room prevent flooding from leaving the RPCS room, and the floor of the URSS and TSPS room is elevated to prevent water intrusion in the event of internal flood or use of water for fire suppression in other areas of the facility. The RPF sub-grade vaults and trenches are sealed to resist water intrusion that could compromise the function of the RDS sump.
	The interior design includes shield walls for line of sight trajectory paths from the overhead doors to the interior structure to protect against possible intrusion of tornado missiles.
	The overhead crane in the irradiation facility is designed as single-failure proof to protect against heavy load drops.
	The RPF shielding cover plugs are designed to maintain their structural integrity, to protect equipment located in the vaults, trench, and pits, in the event of a heavy load drop, or a specific evaluation of the potential for and effects of a dropped load is performed.
	The TPS-NDAS Interface lines are protected from damage due to external impacts by 1) the majority of tube lengths are run through subgrade sleeves and are protected by rebar re-enforced concrete, and 2) sections that are above grade in the TPS rooms are protected by mechanical guards.
Irradiation Unit	The PSB piping and structural supports for SCAS and TOGS safety-related equipment are seismically qualified.
	The VTS is designed such that the TSV fill lift tank has a drain path to the target solution hold tank
	The external design pressure of the TSV is greater than the maximum design cooling water pressure of the PCLS.
	The TSV fill line is designed to prevent reverse flow of target solution from the TSV from occurring.
	The PSB contains redundant pressure relief valves and redundant vacuum relief valves to limit pressure transients.

Category	Characteristic
Irradiation Unit (continued)	The fill rate of target solution into the TSV is not more than [ ]PROP/ECI. This rate is set and verified during Startup Testing using a throttle valve that is subsequently locked in place.
	The overflow lines in the TSV are located at a height sufficient to protect the TSV headspace to allow proper operation of the TOGS.
	The TSV dump tank is designed with k_{eff} < 0.95 for the most reactive uranium concentration for the prevention of criticality.
	The TOGS physical design ensures k_{eff} is < 0.95 for the most reactive uranium concentration for the prevention of criticality.
	[ ]PROP/ECI
Coolant Systems	The PCLS expansion tank is provided with a flame arrester at the tank vent inlet to prevent ignition of hydrogen accumulated in the expansion tank from ignition sources in the primary Confinement boundary.
Isotope Production systems	The TSSS process pipes are seismically qualified.
	The MEPS [ ]PROP/ECI is seismically qualified.
	The design of the MEPS upper three-way valve prevents reverse flow from the target solution return header to the eluate tank.
	The MEPS extraction feed pump discharge lines have overpressure protection.
	Vaults, trenches, valve pits, and hot cells where high concentration uranium-bearing solutions may be present are equipped with drains to the favorable geometry RDS sump tanks. The RDS drain in the supercell additionally provides over pressure protection via a relief path to the RDS.
Confinement	Confinement boundaries within the facility are provided to limit the release of effluents from the enclosure to the external environment through controlled or defined pathways.
	The holdup volume in RVZ1e from the PCLS expansion tank, between radiation detectors and isolation devices, provides a time delay for isolation of IU cell gases exiting the confinement boundary.
	The TSPS and URSS gloveboxes provide a low leakage boundary for uranium oxide and metal and are seismically qualified.

Category	Characteristic
Confinement (continued)	The TPS gloveboxes limits the release of tritium in the event of a process leak. The gloveboxes are inerted with helium and are designed with a minimum free volume is specified so that the entire inventory of hydrogen cannot reach the lower flammability limit if released within the glovebox.
Instrumentation	The ESFAS and TRPS safety-related control systems are designed to assume a safe state on a loss of electrical power, as described in FSAR Subsections 7.4.2 and 7.5.2. Divisions A and B of ESFAS and TRPS control cabinets are located on opposite sides of the control room, and are mounted six inches above the floor to remain above maximum credible flood height.
Criticality Safety	Engineered controls are identified in the criticality safety evaluations to prevent criticality in the RPF.

5.5.5 Maintenance of Safety-Related SSCs

The SHINE maintenance program, which includes inspection, testing, and maintenance, ensures that the safety-related SSCs are available and reliable when needed. The maintenance program includes corrective maintenance, preventative maintenance, surveillance and monitoring, and testing. The maintenance program includes the following activities to ensure that safety-related SSCs can perform their functions as required by the accident analysis:

1. Inspection and maintenance of Confinement boundaries;
2. Corrective maintenance and inspections following safety-related system or component actuations or adverse conditions;
3. Overhead crane maintenance and requirements for usage;
4. Safety-related electrical equipment preventive maintenance; and
5. Other inspections and surveillances deemed necessary to ensure the continued functionality of safety-related SSCs.

5.5.6 Fire Protection

The SHINE fire protection program documents and describes the methods used to minimize the probability of and the consequences of fire. The fire protection program ensures, through defense-in-depth, that a fire will not prevent the performance of necessary safety-related functions and that radioactive releases to the environment, in the event of fire, will be minimized. The fire protection program implements the following activities to prevent and mitigate potential fire events in the SHINE Facility:

1. Periodic surveillances;
2. Control of hot work;
3. Control of transient combustibles;
4. Control of physical design characteristics of the facility relied on to prevent or mitigate the effects of fires; and

5. Maintenance of the fire hazards analysis and safe shutdown analysis for the facility.

5.5.7 Nuclear Criticality Safety

The SHINE nuclear criticality safety program ensures that workers, the public, and the environment are protected from the consequences of a nuclear criticality event. The nuclear criticality safety program complies with applicable national consensus standards, as clarified by Regulatory Guide 3.71, Revision 3, Nuclear Criticality Safety Standards for Fuels and Material Facilities, and is described in FSAR Subsection 6b.3.1.

The nuclear criticality safety program evaluates the fissionable material operations in the SHINE RPF and establishes appropriate criticality safety controls which are described in the criticality safety evaluations and the accident analysis. The criticality safety controls are preventative in nature and comply with the preferred hierarchy of controls: passive controls over active controls and engineered controls over administrative controls.

A criticality accident alarm system (CAAS) is provided for the SHINE Facility. The CAAS meets the requirements of 10 CFR 70.24(a) and follows the guidance of ANSI/ANS 8.3-1997. Maintenance and testing of the CAAS is performed in accordance with ANSI/ANS 8.3-1997. The CAAS is further described in FSAR Subsection 6b.3.3.

5.5.8 Chemical Control

The SHINE chemical control program ensures that on-site chemicals are stored and used appropriately to prevent undue risk to workers and the facility. The chemical control program implements the following activities, as required by the accident analysis:

1. Control of chemical quantities permitted in designated areas and processes;
2. Chemical labeling, storage and handling; and
3. Laboratory safe practices.

5.6 Experiments Review and Approval

Experiments, as defined in ANSI/ANS 15.1-2007, are not conducted at the SHINE Facility.

5.7 Required Actions

5.7.1 Safety Limit Violation

In the event of a safety limit violation:

1. The operations leading to the violation shall be shut down immediately and operation of those affected processes shall not be resumed until authorized by the NRC;
2. The safety limit violation shall be promptly reported to Level 2 management or designated alternates;
3. The safety limit violation shall be reported to the NRC; and
4. A safety limit violation report shall be prepared. The report shall describe the following:
    a. Applicable circumstances leading to the violation including, when known, the cause and contributing factors;

b. Effect of the violation upon facility components, systems, or structures and on the health and safety of personnel and the public; and

c. Corrective action to be taken to prevent recurrence.

5. The report shall be reviewed by the RAC, and any follow-up report shall be submitted to the NRC when authorization is sought to resume operation of the affected processes.

5.7.2 Occurrence of Events Requiring a Special Report.

In the event of an occurrence requiring a special report as specified in Section 5.8.2.1, other than a violation of a safety limit:

1. The affected processes or areas of the facility shall be returned to normal conditions or shut down. If it is necessary to shut down processes to correct the occurrence, operation of those affected processes shall not be resumed unless authorized by Level 2 management or designated alternates.
2. The occurrence shall be reported to Level 2 management or designated alternates and to the NRC.
3. The occurrence shall be reviewed by the RAC at its next scheduled meeting.

5.8 Reports

5.8.1 Operating Reports

An annual report covering the operation of the facility during the previous calendar year will be submitted to the NRC Document Control Desk within 30 days of the end of the calendar year providing the following information:

1. A narrative summary of operating experience including the energy produced by each IU or the hours each IU was Operating, or both;
2. The Unscheduled Shutdowns including, where applicable, corrective action taken to preclude recurrence;
3. Tabulation of major preventative and corrective maintenance operations having safety significance;
4. Tabulation of major changes in the facility and procedures, including a summary of the evaluation leading to the conclusions that they are allowed without prior NRC approval;
5. A summary of the nature and amount of radioactive effluents released or discharged to environs beyond SHINE's effective control, as determined at, or before, the point of such release or discharge. The summary will include to the extent practicable an estimate of individual radionuclides present in the effluent. If the estimated average release after dilution or diffusion is less than 25 percent of the concentration allowed or recommended, a statement to this effect is sufficient;
6. A summarized result of environmental surveys performed outside the facility; and
7. A summary of exposures received by facility personnel and visitors where such exposures are greater than 25 percent of that allowed or recommended.

5.8.2 Special Reports

Special reports are used to report unplanned events as well as planned major facility and administrative changes. Special reports will follow the schedule below:

1. There will be a report not later than the following working day by telephone and confirmed in writing by facsimile or similar conveyance to the NRC Operations Center, to be followed by a written report to the NRC Document Control Desk that describes the circumstances of the event within 14 days of any of the following:
    a. Violation of a safety limit;
    b. Release of radioactivity from the site above allowed limits;
    c. Operations with actual Safety System settings for required systems less conservative than the limiting safety system settings specified in Section 2.2;
    d. Operation in violation of limiting conditions for operation established in Section 3, unless prompt remedial action is taken as permitted in Section 3;
    e. A Safety System component malfunction that renders or could render the Safety System incapable of performing its intended safety function. If the malfunction or condition is caused by maintenance, then no report is required;
    f. An unanticipated or uncontrolled change in reactivity greater than one dollar;
    g. Abnormal and significant degradation of the PSB (excluding minor leaks); and
    h. An observed inadequacy in the implementation of administrative or procedural controls such that the inadequacy causes or could have caused the existence or development of an unsafe condition with regard to operations.
2. There will be a written report within 30 days to the NRC Document Control Desk of the following:
    a. Permanent changes in the facility organization involving Level 1 or Level 2 management, and
    b. Significant changes in the transient or accident analysis as described in the FSAR.

5.8.3 Startup Report

SHINE shall conduct startup testing in accordance with the Startup Testing Program, as described in FSAR Section 12.11. Following completion of startup testing, SHINE will submit a Startup Report to the NRC Document Control Desk that identifies the startup tests performed.

The Startup Report shall be submitted within 6 months of the completion of all startup testing activities.

5.9 Records

5.9.1 Lifetime Records

The following records are to be retained for the lifetime of the SHINE Facility:

1. Gaseous and liquid radioactive effluents released to the environs;
2. Offsite environment-monitoring surveys required by the technical specifications;
3. Radiation exposure for all monitored personnel; and
4. Updated drawings of the SHINE Facility.

Applicable annual reports, if they contain all of the required information, may be used as records in this section.

5.9.2 Five Year Records

The following records are to be maintained for a period of at least five years or for the life of the component involved if less than five years:

1. Normal SHINE Facility operation (but not including supporting documents such as checklists, log sheets, etc., which shall be maintained for a period of at least one year);
2. Principal maintenance operations;
3. Reportable occurrences;
4. Surveillance activities required by the technical specifications;
5. Facility radiation and contamination surveys where required by applicable regulations;
6. Radioactive material inventories, receipts, and shipments;
7. Approved changes in operating procedures; and
8. Records of meeting and audit reports of the review and audit group.

5.9.3 Records to be retained for at least one certification cycle

Records of retraining and requalification of operations personnel who are Licensed pursuant to 10 CFR Part 55 shall be maintained at all times while the individual is employed or until License is renewed.