Spallation Neutron Source Accelerator Safety Envelope

102030103-ES0016-R07.1

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INTRODUCTION

This document constitutes the Accelerator Safety Envelope (ASE) for the entire Spallation Neutron Source (SNS) facility. The bases for the ASE requirements are found in Chapter 5 of the *Final Safety Assessment Document for Proton Facilities* (FSAD-PF) [1] and Chapter 5 of the *Final Safety Assessment Document for Neutron Facilities* (FSAD-NF) [2]. This document also includes changes to Appendix 1, Sections 10 and 11 as described in the *USI Evaluation for Increased Helium Gas Holdup in the Mercury Process Loop During Gas Injection Commissioning Testing with Beam* [3]. This document supersedes all previous revisions of the SNS ASE.

DEFINITIONS

a. **Certification**: verification that a system is operable and calibrated as required in accordance with written approved SNS procedures.

b. **Compensatory Measures**: alternate actions that may be invoked to allow for safe operations when a system is required to be operable but is not fully capable of performing its intended safety function.

c. **Credited Engineered Control**: engineered control determined through safety analysis to be essential for safe operations directly related to the protection of personnel or the environment.

d. **Passive Credited Engineered Control**: a safety feature that accomplishes its credited safety function by its inherent physical characteristics and does not require frequent surveillance or operator intervention for reliable functioning. A passive control typically does not require human interaction or electronic feedback when called upon to perform the safety function.

e. **Active Credited Engineered Control**: a credited engineered control that is not passive.

f. **Credited Administrative Control**: administrative control determined through safety analysis to be essential for safe operations directly related to the protection of personnel or the environment.

g. **Critical Device**: designated devices used by the Personnel Protection System (PPS) to stop beam production or prevent beam transport as described in the FSAD-PF [1].

h. **Mercury Circulation Loop**: portion of mercury process system on the process side of the storage tank transfer valve; does not include the mercury storage tank.

i. **Operable**: a structure, component, or system capable of performing its intended safety function.

j. **Segment**: a defined set of areas (linac, High Energy Beam Transport (HEBT), ring, Ring to Beam Transport (RTBT), and Target) where the PPS provides protection from prompt radiation hazards as described in the FSAD-PF [1].

k. **Shall, Should, and May**: the word “shall” denotes a requirement, the word “should” denotes a recommendation, and the word “may” denotes permission.

SECTION 1: LIMITATIONS TO OPERATING PARAMETERS

This section identifies the measurable limitations on critical operating parameters that, in conjunction with the specifically identified hazard control considerations established by the facility design and construction, ensure that accelerator operations do not exceed the bounding conditions evaluated in the FSADs.

Control of Beam Power

1.1 When beam is directed to the Target, beam power **shall not exceed the nominal 2 MW limit** by more than 10%, averaged over any 1-minute period.

1.2 When beam is directed to the Ring Injection Dump (RID), beam power **shall not exceed the nominal 150 kW limit** by more than 50 kW, averaged over any 1-hour period. Beam power shall not exceed 200 kW for more than 1 minute.

1.3 When beam is **not** directed to either the Target or the RID, beam power shall not exceed the nominal 7.5 kW by more than 10%, averaged over any 1-minute period.

SECTION 2: SHIELDING

2.1 Permanent shielding shall be designed to be consistent with 2 MW beam operation.

2.2 Incomplete beamlines (i.e., those that have **not** successfully completed an Instrument Readiness Review (IRR)) shall have their primary shutter locked in the closed position (or have their concrete shield plug replacements secured) and tagged as a Radiation Safety Hold to prevent movement during beam operation to the target.

2.3 Installed beamlines (i.e., those that have successfully completed an IRR for the applicable operational configuration) shall be allowed to open their primary shutter during beam operation to the target.

SECTION 3: CREDITED ENGINEERED CONTROL

All active and passive credited engineered controls (CEC) are configuration controlled. Active CECs are certified by approved SNS procedures and/or applicable ORNL Fire Department instructions.

CECs that perform an active safety function include:

1. Target Protection System
2. Personnel Protection System
3. Oxygen Deficiency Hazard Systems
4. Emergency Ventilation System
5. Service Bay Differential Pressure Monitoring System
6. Transfer Bay Access Control System
7. Fire Suppression System Inside the Service Bay
8. Target Building Fire Suppression System Outside the Service Bay

CECs with passive safety functions are listed below and further discussed in Appendix 1:

1. Cryogenic Moderator System Hydrogen Boundary
2. Cryogenic Moderator System Vacuum Boundary
3. Service Bay and Core Vessel 2-Hour Equivalent Fire Barrier
4. Confinement Function of Core Vessel and Neutron Beam Windows
5. Service Bay and Monolith Confinement of Mercury
6. Primary Confinement Exhaust System
7. High Bay Floor Design
8. Mercury Heat Exchanger Double-Wall Design
9. Mercury Pump Tank Exhaust Line Loop Seal
10. Mercury Pump Tank Rupture Disk and Discharge Path
11. Mercury Pump Tank Exhaust Line Loop Seal and Orifice
12. High Bay Crane Design
13. Central Helium Liquification Compressor Room Passive Ventilation Features
14. Cryogenic Moderator System Catalytic Converter Retention Elements

Each of these CECs has requirements specified in the following sections for:

- Safety function requirements for operability
- Compensatory measures
- Requirements for periodic surveillance to ensure the CEC remains operable

3.1 Target Protection System (TPS)

The TPS prohibits beam on target based on high mercury temperature or low mercury flow to ensure the mercury temperature remains below the mercury boiling point (357 ºC). The TPS also prevents beam on target when the target cart is not fully inserted.

3.1.1 Operability

The TPS shall be operable whenever beam in excess of 5.6 kWh in any 24-hour period is directed onto the target or when the target cart is retracted.

3.1.2 Compensatory Measures

If the TPS is not operable while the target cart is not fully inserted, beam on target shall be prohibited and controlled in accordance with the appropriate lock out of critical devices.

3.1.3 Surveillance

The TPS system shall undergo annual certification (not to exceed 15 months) as specified by approved SNS procedures.

3.2 Personnel Protection System (PPS)

The PPS safety functions are (1) prevent beam operation in a segment unless its associated exclusion areas are cleared of personnel (beam containment), (2) shut off beam if personnel enter an exclusion area associated with a segment where beam is permitted (access violation), (3) shut off beam if radiation levels set by the Radiation Safety Officer (RSO) are reached at PPS interlocked area radiation monitor locations, (4) prohibit beam to the target when the target cart is out of the "cart-inserted" position, and (5) shut off beam to prevent beam directed to the target from exceeding the beam power limit defined in Section 1.1 of the ASE principal document via the Beam Power Limiting System (BPLS) portion of the PPS.

3.2.1 Operability

Those functions of the PPS required to support the applicable operational configuration shall be operable during operations with beam.

The BPLS portion of the PPS shall be operable during beam operations to the target whenever more than 23 cryomodules are in service in the superconducting linac system.

3.2.2 Compensatory Measures

3.2.2.1 Operations with beam to segments with an inoperable PPS shall be prohibited and controlled in accordance with the appropriate lock out of PPS critical devices.

3.2.2.2 Beam to target may be allowed with the PPS target cart position interlock bypassed provided the following restrictions are in place:

- The TPS shall be operable.
- The RSO and SNS Operations Manager (or designees) visually verify that the target cart is fully inserted into the target cart tunnel.

- The cart hydraulic drive unit is locked out and tagged as a Radiation Safety Hold such that it cannot be energized.

3.2.2.3 If the BPLS portion of the PPS is required but inoperable, operations with beam to target may be permitted at a nominal beam power of 1.8 MW or less using approved SNS procedures that develop and document parameter constraints to ensure beam power to the target does not exceed 2 MW as described below:

- The SNS Operations Manager (or designee) shall provide authorization prior to any operations with beam to target while the BPLS is inoperable to develop parameter constraints. During these operations, the repetition rate of the accelerator shall be limited to 1 Hz.

- Once the parameter constraints are documented and implemented, the SNS Operations Manager (or designee) shall approve commencement of 60 Hz operations under the documented parameter constraints.

- The documented parameter constraints shall be maintained in the Central Control Room (CCR) and adherence to the parameter constraints shall be verified by the Control Room Shift Supervisor (CRSS) every shift.

3.2.3 Surveillance

The PPS shall undergo annual certification (not to exceed 15 months) as specified by approved SNS procedures.

3.3 Oxygen Deficiency Hazard (ODH) System

The Linac ODH System monitors oxygen levels in the linac and HEBT tunnel and provides audible and visual alarms inside the tunnel and visual alarms at entrances to warn workers to evacuate or not enter upon detection of low oxygen levels. The Linac ODH System sends a signal to start the credited Emergency Ventilation System (EVS, see Section 3.4 of the ASE principal document) upon detection of low oxygen levels in the linac tunnel.

The Central Helium Liquification (CHL) ODH System monitors oxygen levels in the CHL Cold Box Room and provides audible and visual alarms inside the area and visual alarms at entrances to warn workers to evacuate or not enter upon detection of low oxygen levels.

3.3.1 Operability

The Linac ODH System is required to be operable when cryogenic helium is present in the superconducting linac system. If the Linac ODH System becomes inoperable when cryogenic helium is present in the superconducting linac system:

- Personnel shall be evacuated from and excluded from entering the linac and HEBT tunnel.

- Since the Linac ODH System cannot initiate the EVS, action is required as described in Section 3.4 of the ASE principal document for an inoperable EVS.

The CHL ODH System is required to be operable when cryogenic helium or nitrogen is present in the CHL system. If the CHL ODH System becomes inoperable when cryogenic helium or nitrogen is present in the CHL system:

- Personnel shall be evacuated from and excluded from entering the CHL Cold Box Room.

3.3.2 Compensatory Measures

Entry into the linac and HEBT tunnel or CHL Cold Box Room when the associated ODH system is inoperable is permitted in accordance with approved procedures that require (1) a safety watch and portable ODH monitoring for each person or (2) use of a breathing apparatus.

3.3.3 Surveillance

The Linac ODH System and CHL ODH System shall undergo annual certification (not to exceed 15 months) as specified by approved SNS procedure.

3.4 Emergency Ventilation System (EVS)

The EVS prevents an oxygen deficiency hazard from propagating outside of the linac and HEBT tunnel by ventilating the linac tunnel upon receipt of a signal from the Linac ODH System.

3.4.1 Operability

The EVS is required to be operable when cryogenic helium is present in the superconducting linac system. If the EVS becomes inoperable when cryogenic helium is present in the superconducting linac system:

- Personnel shall be evacuated from and excluded from entering the ring and RTBT tunnel and the Front End Building (including the mezzanine).

3.4.2 Compensatory Measures

3.4.2.1 Entry into the ring and RTBT tunnel and the Front End Building (including the mezzanine) when the EVS is inoperable is permitted in accordance with approved procedures that require (1) a safety watch and portable ODH monitoring for each person or (2) use of a breathing apparatus.

3.4.2.2 If the Linac ODH System is capable of providing notification of an ODH alarm to the CCR upon detection of low oxygen levels in the linac tunnel, then entry into the ring and RTBT tunnel and the Front End Building (including the mezzanine) when the EVS is inoperable is permitted using approved SNS procedures that ensure:

- The CCR is continuously staffed with procedures in place that direct evacuation of the ring and RTBT tunnel and the Front End Building (including the mezzanine) upon receipt of the linac ODH alarm.

3.4.2.3 If the EVS is capable of ventilating the linac tunnel upon manual initiation from the CCR, then entry into the ring and RTBT tunnel and the Front End Building (including the mezzanine) when the EVS is inoperable (e.g., when the Linac

ODH System is inoperable) is permitted using approved SNS procedures that ensure:

- The CCR is continuously staffed with procedures in place to initiate the EVS upon receipt of notification of a potential ODH condition, and
- A safety watch (1) continuously occupies the linac and HEBT tunnel in accordance with the provisions of Section 3.3.2 of the ASE principal document, and (2) is assigned the responsibility of promptly notifying the CCR to manually start the EVS in the event of a cryogenic helium release in the tunnel in accordance with approved SNS procedures.

3.4.3 Surveillance

The EVS system shall undergo annual certification (not to exceed 15 months) as specified by approved SNS procedure.

3.5 Service Bay Differential Pressure Monitoring System (SBDPMS)

The SBDPMS provides audible and visual alarms in areas adjacent to the service bay if confinement exhaust is not maintaining sufficient negative pressure or system flow to ensure confinement of service bay atmosphere, supporting evacuation of personnel.

3.5.1 Operability

In order to protect personnel in areas adjacent to the service bay, the SBDPMS shall be operable if any of the following conditions exist:

3.5.1.1 Mercury is loaded in the mercury circulation loop.

3.5.1.2 Airborne mercury concentrations inside the service bay exceed the OSHA ceiling of 0.1 mg/m^3 [4].

3.5.1.3 One or more service bay T-beams are removed.

3.5.2 Compensatory Measures

In the event that the SBDPMS is not operable:

3.5.2.1 Personnel access to areas adjacent to the service bay may be allowed by approved SNS procedures that ensure personnel evacuation upon loss of Primary Confinement Exhaust System (PCES) ventilation. The SNS procedures shall also ensure personnel safety upon subsequent re-entry.

3.5.2.2 The transfer bay personnel door may be opened and personnel allowed to enter only when the following conditions are met:

- The RSO and SNS Operations Manager (or designees) visually verify that both the upper and lower intrabay doors are in the closed position.
- Prior to fully opening the transfer bay personnel door, the airborne mercury concentration in the transfer bay and surrounding areas shall be measured.

- The SNS Operations Manager (or designee) shall review the airborne mercury concentration measurements and shall ensure that appropriate controls are in place to protect the worker prior to authorizing entry.

- Mercury airborne concentrations in the transfer bay and surrounding areas shall be monitored when personnel are in the transfer bay.

3.5.2.3 In the event that the SBDPMS becomes inoperable while the transfer bay personnel door is open, response shall be performed in accordance with approved SNS procedures.

3.5.3 Surveillance

The system shall undergo annual certification (not to exceed 15 months) as specified by approved SNS procedure.

3.6 Transfer Bay Access Control (TBAC) System

The safety function of the TBAC is to (1) prevent opening of the transfer bay personnel door unless both intrabay doors are closed, and (2) sound an alarm if the intrabay doors are opened while the transfer bay personnel door is open.

3.6.1 Operability

The TBAC system shall be operable unless the transfer bay personnel door is locked in the closed position and tagged with a radiation safety hold.

3.6.2 Compensatory Measures

3.6.2.1 Entry into the transfer bay with the intrabay doors closed and the TBAC system inoperable must adhere to the following restrictions:

- The intrabay doors shall be visually verified to be in the closed position and the electrical breakers that supply power for opening the intrabay doors are locked out and tagged as a Radiation Safety Hold to prevent opening.

- Entry is conducted in accordance with an approved Radiological Work Permit (RWP).

3.6.2.2 Entry into the transfer bay and other areas of the service bay with the TBAC System inoperable or key bypassed and the intrabay doors open must adhere to the following restrictions:

- Beam on target shall be prohibited and controlled in accordance with the appropriate lock out of critical devices.

- Entry is conducted in accordance with SNS procedures approved by the RSO and SNS Operations Manager (or designees) that require radiation surveys to be conducted in accordance with an RWP. Entry shall be approved by the RSO and SNS Operations Manager (or designees).

3.6.2.3 If the TBAC becomes inoperable while the transfer bay personnel door is open, response shall be performed in accordance with approved SNS procedures.

3.6.3 **Surveillance**
The TBAC system shall undergo annual certification (not to exceed 15 months) as specified by approved SNS procedure.

3.7 Fire Suppression System (FSS) Inside the Service Bay

To ensure that the FSS inside the service bay (i.e., water mist system) is operable and capable of minimizing the risk associated with a fire potentially vaporizing process mercury.

3.7.1 Operability

The FSS in the process and maintenance bay portions of the service bay shall be operable unless:

- The process mercury is drained to the storage tank, or
- The steel shielding designed to cover the mercury circulation loop is fully installed.

3.7.2 Compensatory Measures

3.7.2.1 Planned impairments associated with scheduled inspection, testing, and maintenance activities are performed in accordance with ORNL Fire Department instructions.

3.7.2.2 Temporary impairment and bypasses of the system are allowed by approved SNS procedures for instances including but not limited to:

- When personnel enter the service bay.
- When activities are being conducted that have a high probability of actuating a false alarm (e.g., welding, cutting).

3.7.3 Surveillance

The system shall undergo annual inspection, testing, and maintenance every 12 months (not to exceed 15 months).

3.8 Target Building Fire Suppression System (FSS) Outside the Service Bay

To automatically initiate sprinkler flow to control a fire that develops in areas directly adjacent to the service bay and in the high bay, instrument hall, or target building basement area, and to prevent challenges to the structural integrity of the target building.

3.8.1 Operability

The FSS outside the service bay shall be operable as required by the ORNL Standards Based Management System (SBMS) Fire Protection, Prevention, and Control subject area and approved SNS procedures.

3.8.2 Compensatory Measures

3.8.2.1 Planned impairments associated with scheduled inspection, testing, and maintenance activities are performed in accordance with ORNL Fire Department instructions.

3.8.2.2 Temporary impairment of the FSS outside the service bay is allowed when interim compensatory measures are conducted in accordance with approved SNS procedures.

3.8.3 Surveillance

The system shall undergo annual (not to exceed 15 months) inspection, testing, and maintenance in accordance with the ORNL SBMS Fire Protection, Prevention, and Control subject area.

SECTION 4: CREDITED ADMINISTRATIVE CONTROLS

This section identifies the credited administrative controls (CAC) listed in the FSAD-NF [2] to mitigate hazards associated with target building activities. The CACs are promulgated through SNS programs and approved procedures.

1. The **Radiological Protection Program** provides a means of controlling the radiological exposure received by facility workers by controlling the planning, approval, monitoring, and execution of radiological work.

2. The **Chemical Safety Program** provides protection against inadvertent exposure to mercury or mercury vapor during initial facility startup.

3. The **Combustible Materials Control Program** inside and outside of the service bay.

4. The **Ignition Control Program** outside of the Service Bay and Core Vessel 2-Hour Equivalent Fire Barrier.

5. The **Hoisting and Rigging Program**:
   - Restricts crane lifts in the high bay.
   - Restricts external crane lifts over the target building.
   - Addresses certification and preventative maintenance for the Service Bay Crane and Gantry Crane Robotic Arm.

6. **Procedures and training** are required and are in place for the following:
   - To ensure proper response to a SBDPMS alarm including evacuation of areas adjacent to the service bay.
   - To control mercury inventory on the PCES charcoal adsorbers.

7. **Emergency response procedures and training** are required and are in place for the following:
   - To close the transfer bay personnel door upon evacuation from a service bay fire.
   - To ensure evacuation of personnel in response to an external crane load drop on the target building.
   - To ensure evacuation of personnel in response to a service bay fire during maintenance activities when the target service bay, transfer bay, and high bay are open to common air flow.

SECTION 5: MODIFICATIONS AND VIOLATIONS OF THE ASE

5.1 The following are the basic requirements for control of modifications to the ASE and general actions to be taken upon discovery of a violation of the ASE:

- Modifications to the ASE shall be approved by the Department of Energy (DOE) prior to implementation.
- Any activity violating ASE limits or requirements must be terminated immediately and put in a safe and stable condition.
- Any activity that was shut down by DOE must not recommence until DOE approves the activity.
- Exception to the requirements of the ASE is provided for lifesaving activities when the required actions of the ASE would unnecessarily delay medical services or increase the risk of death or serious bodily harm to personnel from a real and present danger.

SECTION 6: STAFFING

6.1 The staffing requirement for all machine operations with particle beam is a minimum of one qualified CRSS and one qualified Control Room Accelerator Specialist (CRAS). During such operations, one of the two must remain in the CCR at all times. If one operations staff member is incapacitated, the remaining operations staff member may continue beam operations as long as staffing requirements are restored within four hours.

6.2 At least one qualified Operations Shift Technician (OST) shall be onsite during beam on target operations and at times when mercury is loaded in the mercury circulation loop or hydrogen is loaded in the CMS. Under extenuating circumstances (e.g., inclement weather, sudden illness) the OST post may be vacated for a period not to exceed six hours with the approval of target operations line management and notification of the CRSS.

SECTION 7: REFERENCES

1. *Spallation Neutron Source Final Safety Assessment Document for Proton Facilities*, 102030103-ES0018, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

2. *Spallation Neutron Source Final Safety Assessment Document for Neutron Facilities*, 102030102-ES0016, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. *USI Evaluation for Increased Helium Gas Holdup in the Mercury Process Loop During Gas Commissioning Testing with Beam*, 102030102-ES0138-R00, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

4. Code of Federal Regulations, Title 29, *OSHA*, Part 1910.100, *Toxic and Hazardous Substances*, Table Z-2.

APPENDIX 1: PASSIVE CREDITED ENGINEERED CONTROLS

1. **Cryogenic Moderator System (CMS) Hydrogen Boundary**
The safety function of the CMS hydrogen boundary is to prevent hydrogen leakage into the core vessel due to breaches of the system.

1.1. **Operability**
The CMS hydrogen rupture disks and vent path are required to be operable unless hydrogen is purged from the CMS.

1.2. **Compensatory Measures**
None.

1.3. **Surveillance**
The integrity and configuration of the vent paths from the rupture disks to atmosphere shall be visually verified at least annually (not to exceed 15 months) in accordance with approved SNS procedures. This check will include the piping and exhaust ("Top Hat") cover. A rupture disk shall be replaced if:

- Pressure to the disk rises to the deformation pressure (note: not applicable to reverse buckling rupture disks),
- The disk safety head has been removed from the system, or
- It has not been replaced in five years.

2. **Cryogenic Moderator System (CMS) Vacuum Boundary**
The CMS vacuum boundary (vessel and piping) shall provide a robust barrier as a second level of protection to the hydrogen barriers that prevent hydrogen from escaping into the core vessel.

2.1. **Operability**
The CMS vacuum rupture disks and vent paths are required to be operable unless hydrogen is purged from the CMS.

2.2. **Compensatory Measures**
None.

2.3. **Surveillance**
The integrity and configuration of the vent paths from the rupture disk to atmosphere shall be visually verified at least annually (not to exceed 15 months) in accordance with approved SNS procedures. This check will include the piping and exhaust ("Top Hat") cover. A rupture disk shall be replaced if:

- Pressure to the disk rises to the deformation pressure (note: not applicable to reverse buckling rupture disks),
- The disk safety head has been removed from the system, or
- It has not been replaced in five years.

3. **Service Bay and Core Vessel 2-Hour Equivalent Fire Barrier**
Isolation Function: provide a physical barrier between the service bay and core vessel and combustibles located outside of the service bay and core vessel. The barrier shall be designed to prevent migration of either combustibles or mercury across the barrier.
Fire Barrier Function: prevents a fire outside of the service bay and core vessel from propagating into the service bay and core vessel for a two-hour equivalent fire.

3.1. **Operability**
Designed and built as a concrete and steel structure with steel shielding surrounding the core vessel.

3.2. **Compensatory Measures**

3.2.1. If mercury is not loaded into the mercury circulation loop, then the monolith and service bay T-beams may be removed.

- Prior to the removal of service bay T-beams, approved SNS procedures shall be in place to ensure safety of personnel in the high bay during the period when the T-beams are removed, including provision for evacuation of personnel in the case of a fire inside the service bay (see Section 4.7 of the ASE principal document).

3.2.2. Mercury may be loaded into the mercury circulation loop with the monolith T-beams removed provided the following compensatory measures are taken:

- Bulk shielding remains in place (does not include shutters and shutter drive units).
- A dedicated OST will be stationed to operate the mercury circulation loop and will have written instructions to drain the loop in the event of a fire.
- Lift restrictions supporting Section 7 of the ASE appendix are followed.

3.3. **Surveillance**
Configuration controlled through approved SNS procedures.

4. **Confinement Function of Core Vessel and Neutron Beam Windows**
The core vessel and neutron beam windows shall (1) retain liquid mercury in a confined location and (2) mitigate mercury vapor release inside the target building in the event of a mercury spill inside the core vessel. The core vessel rupture disk ensures that the core vessel will relieve excess pressure.

4.1. **Operability**
The core vessel rupture disk and vent path are required to be operable when mercury is in the mercury circulation loop. If the core vessel rupture disk is not intact, then the mercury shall be drained from the mercury circulation loop.

4.2. **Compensatory Measures**
None.

4.3. **Surveillance**
The integrity and configuration of the vent paths from the rupture disk to atmosphere shall be visually verified at least annually (not to exceed 15 months) in accordance with approved SNS procedures. This check will include the piping and exhaust ("Top Hat") covers. A rupture disk shall be replaced if:

- Pressure to the disk rises to the deformation pressure (note: not applicable to reverse buckling rupture disks),
- The disk safety head has been removed from the system, or
- It has not been replaced in five years.

5. **Service Bay and Monolith Confinement of Mercury**
Provide confinement of liquid mercury and mitigate an airborne mercury release by retaining the liquid mercury in a confined location in the service bay or monolith.

5.1. **Operability**
The service bay was designed and built with a stainless-steel liner and a sloped floor. The monolith support pedestal has a sloped steel liner designed to direct spilled mercury to a stainless-steel lined pit which can contain the maximum credible spill within a two-hour fire wall boundary. Penetrations are adequately above floor level.

5.2. **Compensatory Measures**
None.

5.3. **Surveillance**
Configuration controlled through approved SNS procedures.

6. **Primary Confinement Exhaust System (PCES)**
The PCES ductwork protects workers inside the target building from exposure to mercury vapor by preventing or minimizing leakage of confinement exhaust from the service bay into occupiable areas. Design features of the PCES also support the Service Bay and Core Vessel 2-Hour Equivalent Fire Barrier by preventing transmission of hot gases into or out of the service bay via the PCES intake ducting.

6.1. **Operability**
The backdraft dampers shall be operable when mercury is loaded in the mercury circulation loop.

6.2. **Compensatory Measures**
If the leak-tight integrity of the PCES ductwork is compromised:

6.2.1. The mercury shall be drained from the mercury circulation loop.

6.2.2. Personnel occupancy in the area of the compromised ducting shall be monitored and controlled in accordance with approved SNS procedures.

6.2.3. Appropriate measures shall be implemented to account for effects on SBDPMS (per Section 3.5 of the ASE principal document).

6.3. **Surveillance**
Annual verification (not to exceed 15 months) as specified in approved SNS procedures is to be performed to assure that the backdraft dampers close freely upon loss of airflow.

7. **High Bay Floor Design**
Prevent a dropped load from contacting the interior of the service bay or core vessel by ensuring that the high bay floor can withstand a load drop for all allowable crane lifts.

7.1. **Operability**
Administrative limits on crane lifts in the high bay shall be in force whenever mercury is loaded into the mercury circulation loop.

7.2. **Compensatory Measures**

- T-beams may be removed from the high bay floor in accordance with Section 3.2 of the ASE appendix.
- If the monolith T-beams are removed with mercury loaded in the mercury circulation loop, lifts that will pass over the core vessel must be approved by the SNS Operations Manager.

7.3. **Surveillance**
Configuration controlled through approved SNS procedures.

8. **Mercury Heat Exchanger Double-Wall Design**
Prevent target mercury release into cooling water which could lead to escape from the service bay.

8.1. **Operability**
The double-walled barrier shall be intact when mercury is loaded in the mercury circulation loop.

8.2. **Compensatory Measures**
None.

8.3. **Surveillance**
The integrity of both barriers shall be verified to be intact prior to each fill of the mercury circulation loop.

9. **Mercury Pump Tank Exhaust Line Loop Seal**
Prevent liquid mercury from escaping the service bay via the mercury off-gas treatment system (MOTS) in the event of a mercury pump tank overfill during routine mercury circulation loop filling operations.

9.1. **Operability**
The top of the mercury pump tank loop seal, as installed in the service bay, must be sufficiently high to prevent the inert gas pressure in the mercury storage tank from forcing liquid mercury over the top of the loop seal.

9.2. **Compensatory Measures**
If the mercury pump tank loop seal does not satisfy the operability requirement in Section 9.1 of the ASE appendix, the mercury storage tank shall be vented to atmospheric pressure.

9.3. **Surveillance**
Configuration controlled through approved SNS procedures.

10. **Mercury Pump Tank Rupture Disk and Discharge Path**
The Mercury Pump Tank Rupture Disk and Discharge Path works in conjunction with the Mercury Pump Tank Exhaust Line Loop Seal and Orifice to prevent liquid mercury from leaking outside of the service bay via the MOTS during any credible mercury level transient.

10.1. **Operability**
The following requirements apply at any time the mercury storage tank is pressurized above atmospheric pressure or target gas injection is in operation:

10.1.1. The Mercury Pump Tank Rupture Disk shall be sized to rupture at a pressure less than that developed by a column of liquid mercury that reaches the top elevation of the Mercury Pump Tank Exhaust Line Loop Seal.

10.1.2. The Mercury Pump Tank Rupture Disk and Discharge Path must be able to discharge mercury from the pump tank at a rate that ensures the Mercury Pump Tank Exhaust Line Loop Seal and Orifice are capable of preventing liquid mercury from leaking outside the service bay via the MOTS during any credible mercury level transient.

10.2. **Compensatory Measures**

10.2.1. If the Mercury Pump Tank Rupture Disk and Discharge Path do not satisfy the operability requirements in Section 10.1 of the ASE appendix, then the mercury storage tank shall be vented to atmospheric pressure and target gas injection operation shall be secured.

10.2.2. If the rupture disk is not intact, then the mercury shall be drained from the loop.

10.3. **Surveillance**

10.3.1. The integrity and configuration of the Mercury Pump Tank Rupture Disk and Discharge Path shall be visually verified at least annually (not to exceed 15 months) in accordance with approved SNS procedures to ensure the discharge path configuration is consistent with design requirements.

10.3.2. Configuration controlled through approved SNS procedures.

10.3.3. A rupture disk shall be replaced if:

- Pressure to the disk rises to the deformation pressure (note: not applicable to reverse buckling rupture disks),
- The disk safety head has been removed from the system, or
- It has not been replaced in five years.

11. **Mercury Pump Tank Exhaust Line Loop Seal and Orifice**
The Mercury Pump Tank Exhaust Line Loop Seal and Orifice works in conjunction with the Mercury Pump Tank Rupture Disk and Discharge Path to prevent liquid mercury from leaking outside of the service bay via the MOTS during any credible mercury level transient.

11.1. **Operability**
The following requirements apply at any time the mercury storage tank is pressurized above atmospheric pressure or target gas injection is in operation:

11.1.1. The top of the Mercury Pump Tank Exhaust Line Loop Seal, as installed in the service bay to meet the requirements of Section 9 of the ASE appendix, also ensures that the rupture disk actuates before a column of liquid mercury could reach the top elevation of the Mercury Pump Tank Exhaust Line Loop Seal.

11.1.2. The Mercury Pump Tank Exhaust Line Loop Seal and Orifice must be designed and built to provide sufficient flow resistance to ensure that the mercury discharge rate of the Mercury Pump Tank Rupture Disk and Discharge Path is sufficient to prevent liquid mercury from leaking outside of the service bay via the MOTS during any credible mercury level transient.

11.2. **Compensatory Measures**
If the Mercury Pump Tank Exhaust Line Loop Seal and Orifice does not satisfy the operability requirements specified in Section 11.1 of the ASE appendix, then the mercury storage tank shall be vented to atmospheric pressure and target gas injection operation shall be secured.

11.3. **Surveillance**
Configuration controlled through approved SNS procedures.

12. **High Bay Crane Design**
The design of the high bay crane prevents failures that could result in a dropped load.

12.1. **Operability**
The High Bay Crane was designed per ASME NOG-1. If the High Bay Crane does not meet the requirements of ASME NOG-1, then it shall not be used to lift loads over the service bay or monolith.

12.2. **Compensatory Measures**
None.

12.3. **Surveillance**
Configuration controlled in accordance with ORNL SBMS Perform Hoisting and Rigging procedure.

13. **Central Helium Liquification (CHL) Compressor Room Passive Ventilation Features**
The CHL Compressor Room open side-wall air inlet vents and roof-level vents passively provide a sufficient source of outdoor air for natural convection flow to protect workers from a potential leak from the helium compressors or associated piping.

13.1. **Operability**
The passive ventilation features must be operable when helium is loaded in the compressor system, otherwise personnel access shall be excluded from the CHL Compressor Room.

13.2. **Compensatory Measures**
Entry into the CHL Compressor Room when the passive ventilation features are inoperable is permitted in accordance with approved procedures that require (1) a safety watch and portable ODH monitoring for each person or (2) use of a breathing apparatus.

13.3. **Surveillance**
Configuration controlled through approved SNS procedures.

14. **Cryogenic Moderator System (CMS) Catalytic Converter Retention Elements**
The CMS Catalytic Converter Retention Elements confine the catalyst media to its designed canister and prevent transport into the CMS loop.

14.1. **Operability**
The CMS Catalytic Converter Retention Elements must be operable whenever catalyst media is loaded into the associated catalyst module.

14.2. **Compensatory Measures**
None.

14.3. **Surveillance**
Configuration controlled through approved SNS procedures.