CHAPTER 9

AUXILIARY SYSTEMS

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
AGS	American Glovebox Society
AHU	air handling unit
ALARA	as low as is reasonably achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ATIS	accelerator TPS interface system
atm	atmosphere (unit of pressure)
BPVC	Boiler and Pressure Vessel Code
CAAS	criticality accident alarm system
CHO	Chemical Hygiene Officer
Ci	curies (unit of measurement of radioactivity)
CMAA	Crane Manufacturers Association of America
Cs	cesium
DAW	dry active waste
DU	depleted uranium

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
ESC	emergency support center
ESFAS	engineered safety features actuation system
FCHS	facility chilled water system
FCRS	facility chemical reagent system
FCU	fan coil unit
FDCS	facility data and communication system
FDWS	facility demineralized water system
FFPS	facility fire detection and suppression system
FHA	fire hazards analysis
FHWS	facility heating water system
FNHS	facility nitrogen handling system
FPP	Fire Protection Program
FPWS	facility potable water system
FSDS	facility sanitary drain system
FSTR	facility structure

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
FVZ4	facility ventilation zone 4
FVZ4e	FVZ4 exhaust subsystem
FVZ4r	FVZ4 room cooling recirculation subsystem
FVZ4s	FVZ4 supply and transfer air subsystem
g	gram
GBSS	glovebox stripper system
gU/l	gram of uranium per liter
HDPE	high-density polyethylene
HEPA	high efficiency particulate air
HMI	human machine interface
HPLC	high-performance liquid chromatogrpahy
HVAC	heating, ventilation, and air conditioning
I-131	iodine-131
ICBS	irradiation cell biological shield
ICP-MS	inductively coupled plasma mass spectroscopy
ICP-OES	inductively coupled plasma optical emission spectroscopy

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
IF	irradiation facility
IRS	impurity removal system
IT	information technology
IU	irradiation unit
IXP	iodine and xenon purification and packaging
L	liter
LABS	quality control and analytical testing laboratories
LEU	low enriched uranium
LFL	lower flammability limit
LWPS	light water pool system
MEPS	molybdenum extraction and purification system
MHS	material handling system
MIPS	molybdenum isotope product packaging system
Mo-99	molybdenum-99
N2PS	nitrogen purge system
NDAS	neutron driver assembly system

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
NFPA	National Fire Protection Association
NPSS	Normal Electrical Power Supply System
NSC	NDAS service cell
OSHA	Occupational Safety and Health Administration
PA	public announcement
PCLS	primary closed loop cooling system
PCP	process control program
PESS	process evacuation separation system
PFBS	production facility biological shield
PICS	process integrated control system
PSB	primary system boundary
Pu	plutonium
PVVS	process vessel vent system
QC	quality control
RCA	radiologically controlled area
RDS	radioactive drain system

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
RLWI	radioactive liquid waste immobilization system
RLWS	radioactive liquid waste storage
RPCS	radioisotope production facility cooling system
RPF	radioisotope production facility
RV	radiological ventilation
RVZ1	radiological ventilation zone 1
RVZ1e	RVZ1 exhaust subsystem
RVZ1r	RVZ1 recirculating subsystem
RVZ2	radiological ventilation zone 2
RVZ2e	RVZ2 exhaust subsystem
RVZ2r	RVZ2 recirculating subsystem
RVZ2s	RVZ2 supply subsystem
RVZ3	radiological ventilation zone 3
SASS	subcritical assembly support structure
SCAS	subcritical assembly system
sccm	standard cubic centimeter per minute

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
SF6	sulfur hexafluoride
SGS	standby generator system
SNM	special nuclear material
SPS	Wisconsin Department of Safety and Professional Services
SRMS	stack release monitoring system
SRWP	solid radioactive waste packaging
SSC	structures, systems, and components
SSS	storage and separation system
TCAP	thermal cycling absorption process
TGRS	target gas receiving system
TOGS	TSV off-gas system
TPS	tritium purification system
TRPS	TSV reactivity protection system
TSPS	target solution preparation system
TSSS	target solution staging system
TSV	target solution vessel

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
UHF	ultra high frequency
UPS	uninterruptible power supply
UPSS	uninterruptible electrical power supply system
URSS	uranium receipt and storage system
VAV	variable air volume
VFD	variable frequency drive
VoIP	voice over internet protocol
VTS	vacuum transfer system

9a2 IRRADIATION FACILITY AUXILIARY SYSTEMS

9a2.1 HEATING, VENTILATION, AND AIR CONDITIONING SYSTEMS

9a2.1.1 RADIOLOGICALLY CONTROLLED AREA VENTILATION SYSTEM

The radiological ventilation (RV) systems include supply air, recirculating, and exhaust subsystems required to condition the air and provide the confinement and isolation needed to mitigate design basis accidents. The SHINE facility utilizes three ventilation systems in the radiologically controlled area (RCA) to maintain the temperature and humidity of the RCA and to progress air from areas of least potential for contamination to areas with the most potential for contamination:

- Radiological ventilation zone 1 (RVZ1)
  - RVZ1 recirculating subsystem (RVZ1r)
  - RVZ1 exhaust subsystem (RVZ1e)
- Radiological ventilation zone 2 (RVZ2)
  - RVZ2 exhaust subsystem (RVZ2e)
  - RVZ2 supply subsystem (RVZ2s)
  - RVZ2 recirculating subsystem (RVZ2r)
- Radiological ventilation zone 3 (RVZ3)

Figure 9a2.1-1 provides the ventilation zone designations within the SHINE facility.

Chapter 6 provides a detailed description of the SHINE confinement strategy for limiting the potential for release of radioactive materials to occupied spaces and the environment.

9a2.1.1.1 Design Bases

The design bases of the RV systems include:

- Provide confinement at ventilation zone 1 confinement boundaries. See Chapter 6 for a description of the specific portions of the RVZ1 system credited as being a confinement boundary.
- Provide isolation at the RCA boundary. See Section 7.5 for a description of the specific portions of the RVZ1, RVZ2, and RVZ3 systems that provide the isolation functions.
- Confine airborne radiological materials in an accident scenario.
- Provide ventilation air and condition the RCA environment for workers.
- Provide makeup air and condition the RCA environment for process equipment.
- Filter exhaust streams prior to them being exhausted out of the RCA.
- Maintain occupational exposure to radiation as low as reasonably achievable (ALARA) and to ensure compliance with the requirements of 10 CFR 20.
- Exhaust hazardous chemical fumes.

Nonsafety-related portions of the RV systems are constructed to the requirements of Chapters SPS 362, SPS 363 and SPS 364 of the Wisconsin Administrative Code. Nonsafety-related piping is designed, installed, tested and inspected in accordance with American Society of Mechanical Engineers (ASME) B31.9, Building Services Piping (ASME, 2017).

Details of the inspection and testing requirements of safety-related RV systems are provided in Subsection 9a2.1.1.5.

9a2.1.1.2 System Description

Radiological Ventilation Zone 1

RVZ1 is divided into two subsystems: RVZ1r and RVZ1e. A flow diagram of RVZ1r is provided in Figure 9a2.1-2. A flow diagram of RVZ1e is provided in Figure 9a2.1-3.

RVZ1r provides cooling for systems within the IU cell and the target solution vessel (TSV) off-gas system (TOGS) cell. RVZ1r recirculates, filters, and cools air within the irradiation unit (IU) cell and the TOGS cell. The system includes two fan coil units and associated ductwork and dampers per each set of IU/TOGS cells. Each set of RVZ1r units is located within the confinement boundary for the IU/TOGS cells that it serves. RVZ1r provides sampling, ventilation, and cleanup connections for the primary confinement.

RVZ1e exhausts air from the areas with a high potential for contamination in the facility. The air is filtered and directed out of the SHINE facility through the exhaust stack. The subsystem includes fans, filters, ductwork, dampers, and high efficiency filter banks. It also includes the necessary transfer ductwork to allow makeup from the RCA general area into the exhausted areas.

RVZ1e is designed to maintain ventilation zone 1 areas at a lower pressure than ventilation zone 2 areas. The design inhibits backflow with the use of backflow dampers at the discharge of the RVZ1e and RVZ2e exhaust fans in order to minimize the spread of contamination. RVZ1e ductwork provides sampling locations for radiation detectors, fire detection equipment, stack release monitoring, and an exhaust stack connection point for RVZ2e and the process vessel vent system (PVVS).

The RVZ1 serves the following areas:

- IU cells
- TOGS cells
- Glovebox stripper system (GBSS) process equipment
- Primary closed loop cooling system (PCLS) expansion tank
- Uranium receipt and storage system (URSS) glovebox
- Radioactive liquid waste immobilization (RLWI) shielded enclosure
- Supercell
- Target solution preparation system (TSPS) glovebox
- Target solution dissolution tanks
- Target solution preparation tank
- HVAC enclosures

Radiological Ventilation Zone 2

RVZ2 includes three subsystems: RVZ2e, RVZ2s, and RVZ2r. A flow diagram of RVZ2e is provided in Figure 9a2.1-4. A flow diagram of RVZ2s air handling units (AHUs) is provided in Figure 9a2.1-5. A flow diagram of RVZ2s distribution and RVZ2r is provided in Figure 9a2.1-6.

RVZ2e exhausts air from the general areas of the RCA. The subsystem includes fans, filters, ductwork, dampers, and high efficiency filter banks. It also includes the necessary transfer ductwork to allow makeup from the RCA general area into the exhausted rooms. The transfer ductwork is located in the following spaces:

- from the irradiation facility (IF) general area to the tritium purification system (TPS) room;
- from each of the cooling rooms to the IF general area;
- from the storage to the preparation room;
- from the transfer aisle to the storage room;
- from the analytical lab to the quality control (QC) lab;
- from the QC lab to the workspace;
- from RCA labyrinth to the workspace; and
- from the workspace to the transfer aisle.

RVZ2 provides ventilation and humidity control for ventilation zone 2 rooms within the RCA. RVZ2e provides an exhaust path for the QC lab and analytical laboratory fume hoods within the RCA and maintains the QC lab and analytical labs at positive pressure with respect to the ventilation zone 2 general area. The system is designed to maintain the RCA at a lower pressure than areas outside of the RCA. The RVZ2e design inhibits backflow within ductwork that could spread contamination. RVZ2e ductwork provides sampling locations for engineered safety features actuation system (ESFAS) radiation detectors and fire detection equipment.

RVZ2s supplies conditioned outside air into the RCA to provide ventilation and to make up for RVZ1e and RVZ2e exhaust volumes. The system includes AHUs, filters, ductwork, and dampers. RVZ2s provides cooling, heating, humidification for all systems within ventilation zone 2 as well as maintains the QC lab and analytical labs at positive pressure with respect to the ventilation zone 2 general area.

RVZ2r recirculates, filters, and conditions air within the RCA. The system includes AHUs, filters, ductwork, and dampers. The RVZ2r units are located within the RCA. RVZ2r provides additional cooling for systems within ventilation zone 2. RVZ2r is also used to cool air being supplied to the supercell, which reduces the flow rate required to cool the equipment within the supercell. The filters and bubble-tight dampers on the inlet side of the supercell are part of RVZ1e.

Areas served by RVZ2 include:

- GBSS hood
- QC lab hood
- Analytical lab hood
- RCA exhaust filter room
- Access control area
- Don/doff rooms
- Decontamination room
- Labyrinths
- Analytical lab
- QC lab
- Workspace
- Transfer aisle
- Radioisotope process facility cooling system (RPCS) room
- Storage rooms

- Preparation room
- Tool crib
- Vestibule
- Primary cooling rooms
- IF general area
- Neutron driver assembly system (NDAS) service cell
- TPS room
- Supercell

Radiological Ventilation Zone 3

Under normal operating conditions, RVZ3 transfers air from ventilation zone 4 to ventilation zone 3 then from ventilation zone 3 to ventilation zone 2 via engineered pathways. RVZ3 receives air from RVZ2s in the IF exit labyrinth. A flow diagram of RVZ3 is provided in Figure 9a2.1-7. Under accident conditions, bubble tight dampers close, isolating ventilation zone 2. The design of RVZ3 inhibits backflow within ductwork that could spread contamination.

9a2.1.1.3 System Operation

RVZ1e areas draw ambient supply air from adjacent ventilation zone 2 spaces, except for the supercell. During normal operation, areas ventilated by RVZ1e are maintained at negative pressure with respect to their surrounding ventilation zone 2 spaces. The supercell is supplied air directly from RVZ2r. The air supplied to the supercell is exhausted by RVZ1e.

RVZ1e contains redundant fans that are capable of continuous operation. During normal operation, one fan is operating while the other fan is on standby. If the operating fan fails, the standby fan will start automatically.

The exhaust from RVZ1e areas collects in the RVZ1e system duct header and then is drawn through the final filter banks on the mezzanine. These filter banks contain high efficiency particulate air (HEPA) filters and carbon adsorbers upstream of the building isolation dampers. These filters and adsorbers are equipped with differential pressure monitoring equipment and are periodically monitored by operations personnel. The building isolation dampers are safety-related automatic isolation dampers controlled by ESFAS. These dampers are located at the RCA boundary, upstream of the exhaust fans and exhaust stack.

Negative pressure is maintained in the ductwork to control contamination and maintain pressure gradients. System operation between RVZ1e, RVZ2e, and RVZ2s is coordinated such that the overall airflow and pressure gradients are maintained. The pressure gradients create flow patterns that direct air towards areas of increasing contamination potential. This is maintained by the variable frequency drives (VFDs) on the exhaust fans. Minimum airflow will be maintained during normal system operation.

During upset conditions, affected sections of the RVZ1e, RVZ2s, and RVZ2e ventilation systems are isolated as required for the specific event or indication. Bubble tight dampers close, based on detection of increased radiation. RVZ1e flow paths that exhaust confinements for fission products contain non-credited HEPA filters and credited, redundant bubble-tight dampers as near to the confinement boundary as practical.

Upon loss of power, loss of signal, or ESFAS initiation of confinement, dampers seal the affected confinement areas within 30 seconds.

The RVZ1r fan coil units (FCUs) are capable of continuous operations. The RVZ1r recirculates, and cools air within the IU cell and TOGS cell. The IU cell and TOGS cell are established as low leakage boundaries.

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

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

RVZ2s AHUs are capable of continuous operation. Ventilation zone 2 and portions of ventilation zone 3 areas are directly supplied air via the RVZ2s AHUs. The AHUs supply conditioned, 100 percent outside air. Each AHU contains filters, pre-heat and cooling coils, and supply fans. The supply system includes redundant AHUs. If a single AHU fails, the standby AHU will start automatically. The AHUs normally supply a constant volume of conditioned air to RVZ2 and RVZ3 areas.

The RVZ2s supply duct contains safety-related automatic isolation dampers controlled by ESFAS. These dampers are located at the RCA boundary.

RVZ2r AHUs are capable of continuous operation. The RVZ2r AHUs further condition the air in the RCA general area to comfort levels.

The RVZ1e and RVZ2e subsystems combine downstream of each subsystem's respective filter banks, RCA isolation bubble-tight dampers, and exhaust fans, as shown in Figure 9a2.1-8. The PVVS delay bed discharge is also combined with the RVZ1e and RVZ2e flow downstream of the exhaust fans and upstream of the stack release monitor. The discharge of the stack is approximately 10 feet above the roofline of the facility and will maintain a minimum discharge velocity of 3,000 fpm.

9a2.1.1.4 Instrumentation and Control

The RV systems are designed such that the process integrated control system (PICS) monitors the system equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for off-normal conditions and signal alarms as required. The PICS starts, shuts down, and operates the RV system in normal operating modes. Coordinated controls maintain negative pressurization to create flow patterns that direct air toward areas of increasing contamination potential.

PICS monitors the differential pressures across all the filters in the RVZ1e and RVZ2e filter banks and produces an alarm if the differential pressure of any filter is above its established limit.

9a2.1.1.5 Inspection and Testing

The ventilation systems are balanced upon installation. Control systems are tested to assure that control elements are calibrated and properly adjusted. Safety-related isolation dampers are inspected and tested as required by, and in accordance with, Section DA of ASME AG-1, Code on Nuclear Air and Gas Treatment (ASME, 1999). Safety-related ductwork will be inspected and tested as required by, and in accordance with, Section SA of ASME AG-1 (ASME, 1999).

9a2.1.1.6 Nuclear Criticality Safety

Subsection 6b.3.2.7 provides a discussion related to the nuclear criticality safety requirements for the URSS glovebox ventilation. Subsection 6b.3.2.4 provides discussion related to the nuclear criticality safety requirements for the TSPS glovebox ventilation.

9a2.1.1.7 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also applicable to, and may be used for, the bases that are described in the technical specifications.

9a2.1.2 NON-RADIOLOGICAL AREA VENTILATION SYSTEM

The non-radiological area ventilation system is the facility ventilation zone 4 (FVZ4) system.

Ventilation zone 4 consists of areas which are located within the SHINE facility, but outside of the RCA. The FVZ4 system is completely independent of the RV systems described in Subsection 9a2.1.1. The FVZ4 system supply AHUs draw at least 10 percent outside air to make up for air exhausted and exfiltrated. The outside air is mixed with recirculated air and conditioned through the AHUs before being supplied to FVZ4 areas. FVZ4 exhaust streams exhaust directly to the outside of the SHINE facility. No radiation detectors are provided in the FVZ4 exhaust, as contamination is not expected to be present in the FVZ4 system.

9a2.1.2.1 Design Bases

The design bases for the FVZ4 system include:

- Provide environmental conditions suitable for personnel and equipment, and to maintain positive pressure with respect to the RCA.
- Provide outside makeup air for ventilation and pressurization for spaces outside of the RCA.
- Remove hazardous chemical fumes from spaces outside of the RCA.
- Maintain hydrogen concentration below 2 percent in the UPS battery rooms.

FVZ4 is constructed to the requirements of Chapters SPS 362, SPS 363 and SPS 364 of the Wisconsin Administrative Code.

9a2.1.2.2 System Description

The FVZ4 system is nonsafety-related. The FVZ4 system is a variable air volume (VAV) type heating, ventilation and air conditioning (HVAC) system that supplies conditioned air into ventilation zone 4 areas. The FVZ4 system supplies outside air as required and exhausts air to maintain indoor design conditions in ventilation zone 4 areas. The FVZ4 provides transfer air into exhausted ventilation zone 4 rooms and into the RVZ3 system airlocks. The FVZ4 system is comprised of the following three subsystems:

- FVZ4 supply and transfer air subsystem (FVZ4s)
- FVZ4 exhaust subsystem (FVZ4e)
- FVZ4 room cooling recirculation subsystem (FVZ4r)

9a2.1.2.3 System Operation

FVZ4 Supply and Transfer Air Subsystem (FVZ4s)

The supply air subsystem provides conditioned air for workers and equipment in the non-RCA portion of the facility, makeup air for exhaust air systems, and outside air to maintain positive pressure with respect to the RCA. The distribution of the FVZ4s is provided in Figure 9a2.1-9.

The supply AHU draws outside air to make up for air exhausted and exfiltrated. The outside air is mixed with the return air recirculated from the spaces served by FVZ4s and conditioned through the AHU before being supplied to the non-RCA areas of the facility. Each AHU contains filters, heating and cooling coils, and supply fans. The FVZ4s subsystem includes two AHUs, each sized for 100 percent of total system capacity. One FVZ4s subsystem AHU operates at a time with the other unit on standby. The AHUs normally supply a variable volume of conditioned air to ventilation zone 4 areas, with a minimum flow determined by ventilation requirements

Dampers are provided to isolate the FVZ4s subsystem to each battery room and each uninterruptible power supply (UPS) room, independently, on an initiation signal from each location’s fire suppression system.

A flow diagram of the return air associated with the FVZ4s subsystem is provided in Figure 9a2.1-10. A diagram of the FVZ4s subsystem AHUs is provided in Figure 9a2.1-11.

FVZ4 Exhaust Subsystem (FVZ4e)

FVZ4e serves the following locations of the non-RCA area of the facility:

- Janitor closets
- Chemical storage
- Restrooms
- Battery rooms
- Control room

The FVZ4e subsystem exhausts the battery rooms and UPS rooms within ventilation zone 4 to maintain the hydrogen concentration below 2 percent and the temperature under 120°F. Upon a loss of power, the battery rooms will be exhausted by dedicated fans powered by the standby generator system (SGS).

Dampers are provided to isolate the FVZ4 exhaust air subsystem to each battery room and each UPS room, independently, on an initiation signal from each location's fire suppression system.

The distribution of the FVZ4e subsystem is provided in Figure 9a2.1-12.

FVZ4 Room Cooling Recirculation Subsystem (FVZ4r)

The FVZ4r subsystem recirculates and cools air within the human machine interface (HMI)/ telecommunication room and the process/server room. The system is made up of two split systems that cool the server space. The FVZ4r subsystem provides equipment status to the PICS.

9a2.1.2.4 Radiation Protection and Criticality Safety

There are no radiation contamination hazards or criticality safety hazards associated with the FVZ4 system.

9a2.1.2.5 Instrumentation and Control

The supply air subsystem HVAC controls operate through the PICS. The FVZ4 system is designed such that the PICS monitors and controls the non-RCA recirculation air subsystem ventilation equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for off-normal conditions and signal alarms as required.

The PICS performs the following functions relative to FVZ4:

- starts, shuts down, and operates FVZ4 in normal operating modes;
- monitors the return and supply temperature from the AHUs; and
- monitors the pressure differential across the filters.

9a2.1.2.6 Inspection and Testing

The FVZ4 system is balanced upon installation. HVAC control systems are tested to assure that control elements are calibrated, adjusted, and in proper working condition.

9a2.1.2.7 Technical Specifications

There are no technical specification parameters associated with the FVZ4.

9a2.1.3 FACILITY CHILLED WATER SYSTEM

The facility chilled water system (FCHS) is a closed-loop, forced circulation system which provides chilled water to the cooling coils of the RVZ2s subsystem AHUs, which are located outside of the RCA. FCHS also provides chilled water to the cooling coils of the FVZ4 AHUs. The FCHS rejects heat to the atmosphere.

9a2.1.3.1 Design Bases

The design bases of the FCHS include:

- Circulate chilled water through the cooling coils of RVZ2s subsystem AHUs.
- Circulate chilled water through the cooling coils of the FVZ4 AHUs.

The FCHS is constructed to the requirements in Chapters SPS 361 and SPS 363 of the Wisconsin Administrative Code.

9a2.1.3.2 System Description

The FCHS is nonsafety-related. Primary components of the FCHS include:

- Air-cooled chillers;
- Chilled water pumps, associated piping and valves, and makeup water and water treatment equipment; and
- An expansion tank.

9a2.1.3.3 System Operation

The system is powered by the normal electrical power supply system (NPSS) under normal operating conditions.

The system is a variable closed-loop cooling system using VFDs on each centrifugal pump to supply a single pump header. Each chiller supply line maintains a modulating flow control valve capable of fully-open or fully-closed valve position. Each RVZ2s subsystem and FVZ4 AHU cooling fluid supply line maintains a modulating flow control valve capable of fully-open or fully-closed valve position. System flow, temperature, and differential pressures are utilized by an FCHS controller to signal valves, pumps, and chillers to come online, vary speed, or secure as necessary to meet system setpoints during normal system operation.

PICS monitors the RVZ2s and FVZ4 airstream delivery temperatures. An FCHS controller monitors flow control valve position and delivers a signal to individual valves to adjust cooling water flow rates in response to signals sent to the load instrumentation. A flow control valve is maintained on the system bypass line and is controlled by input signals from FCHS controller inputs made by chiller supply, RVZ2s, and FVZ4 modulating flow control valves.

Each pump’s VFD status is monitored by local chiller equipment for fault status and motor amps. When the FCHS controller registers that a pump is not running, and a stop command has not been issued from the control panel, an alarm is generated at the control panel and the standby pump is automatically started.

Local chiller equipment monitors differential pressures across each chiller and the chillers’ running status. Upon communication of a fault alarm, an FCHS controller isolates that chillers’ modulating flow control valve and issues a start command to the back-up chiller. System pumps respond accordingly to the loading of the chillers via a local controller. Chiller fault alarms on multiple chillers initiates an automatic shutdown of the system through an FCHS controller.

The system maintains alarms monitored by PICS and displays them at operator workstations for system volumes out of range.

9a2.1.3.4 Radiation Protection

There are no radiation contamination hazards associated with the FCHS.

9a2.1.3.5 Instrumentation and Controls

Instrumentation monitors the system for off-normal conditions and signal alarms as required. FCHS controls are nonsafety-related.

The FCHS provides the necessary output signal to the PICS for the monitoring of heating water temperatures, pressures, and flow rates.

9a2.1.3.6 Inspection and Testing

The FCHS testing requirements for water piping, pipe supports, and valves are in accordance with ASME B31.9, Building Services Piping (ASME, 2017). Hydrostatic tests are performed in accordance with Section 937.3 of ASME B31.9 (ASME, 2017). Visual welding inspections are performed on piping and piping supports in accordance with ASME B31.9 (ASME, 2017).

9a2.1.3.7 Technical Specifications

There are no technical specification parameters associated with the FCHS.

9a2.1.4 FACILITY HEATING WATER SYSTEM

The facility heating water system (FHWS) is a hydronic hot water heating system configured in a variable primary flow piping arrangement.

9a2.1.4.1 Design Bases

The design bases of the FHWS include:

- Supply heated water to the RVZ2s subsystem and the FVZ4 system as well as other heating coils outside of the RCA.
- Maintain system operation in the event of a single pump or single boiler failure.

The FHWS is constructed to the requirements of Chapters SPS 341 and SPS 365 of the Wisconsin Administrative Code. Natural gas piping and natural gas piping installations comply with National Fire Protection Association (NFPA) 54, National Fuel Gas Code (NFPA, 2018), as required by Chapter SPS 365 of the Wisconsin Administrative Code.

9a2.1.4.2 System Description

The FHWS is nonsafety-related.

The FHWS consists of equipment required to deliver heating hot water to RVZ2 and FVZ4 AHUs in non-RCA portions of the SHINE facility. The boilers, pumps, air separator and expansion tank are in the resource outbuilding. Three boilers and three pumps are provided to maintain the system flow rate and supply temperature. When one pump or boiler is down for maintenance, two 50 percent capacity pumps and boilers are capable of meeting system demands. Two pumps each are provided on the FVZ4s subsystem and the RVZ2s subsystem to maintain freeze protection. When one pump is down for maintenance the other can ensure freeze protection.

The primary components of the FHWS include:

- three 50 percent natural gas-fired boilers;
- three 50 percent centrifugal hot water pumps;
- eight 100 percent centrifugal hot water circulating pumps for heating coil freeze protection;
- an air separator; and
- an expansion tank.

9a2.1.4.3 System Operation

A single set of pumps provides flow through both the boilers and the heating coils. The flow through the system is varied by modulating the pump speed based upon maintaining the temperature differential across the boilers. A bypass valve (supply to return) is installed at the end of the coil loop piping to maintain the minimum flow required to operate the pumps.

Each boiler is a natural gas-fired, fully modulating condensing type with high mass and high volume to allow large variations in flow through the boiler with no minimum return water temperature requirement and low water pressure drop.

9a2.1.4.4 Radiation Protection and Criticality Safety

There are no radiation contamination hazards or nuclear criticality safety hazards associated with the FHWS.

9a2.1.4.5 Instrumentation and Control

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

9a2.1.4.6 Inspection and Testing

FHWS piping is designed, installed, tested and inspected in accordance with ASME B31.9, Building Services Piping (ASME, 2017).

The FHWS testing requirements for water piping, pipe supports, and valves are in accordance with ASME B31.9 (ASME, 2017). Hydrostatic tests are performed in accordance with Section 937.3 of ASME B31.9 (ASME, 2017). Visual welding inspections are performed on piping and piping supports in accordance with ASME B31.9 (ASME, 2017).

9a2.1.4.7 Technical Specifications

There are no technical specification parameters associated with the FHWS.

Figure 9a2.1-1 – Ventilation System Zone Designations Within the SHINE Facility

Figure 9a2.1-2 – Radiological Ventilation Zone 1 Recirculating Cooling Subsystem (RVZ1r) Flow Diagram

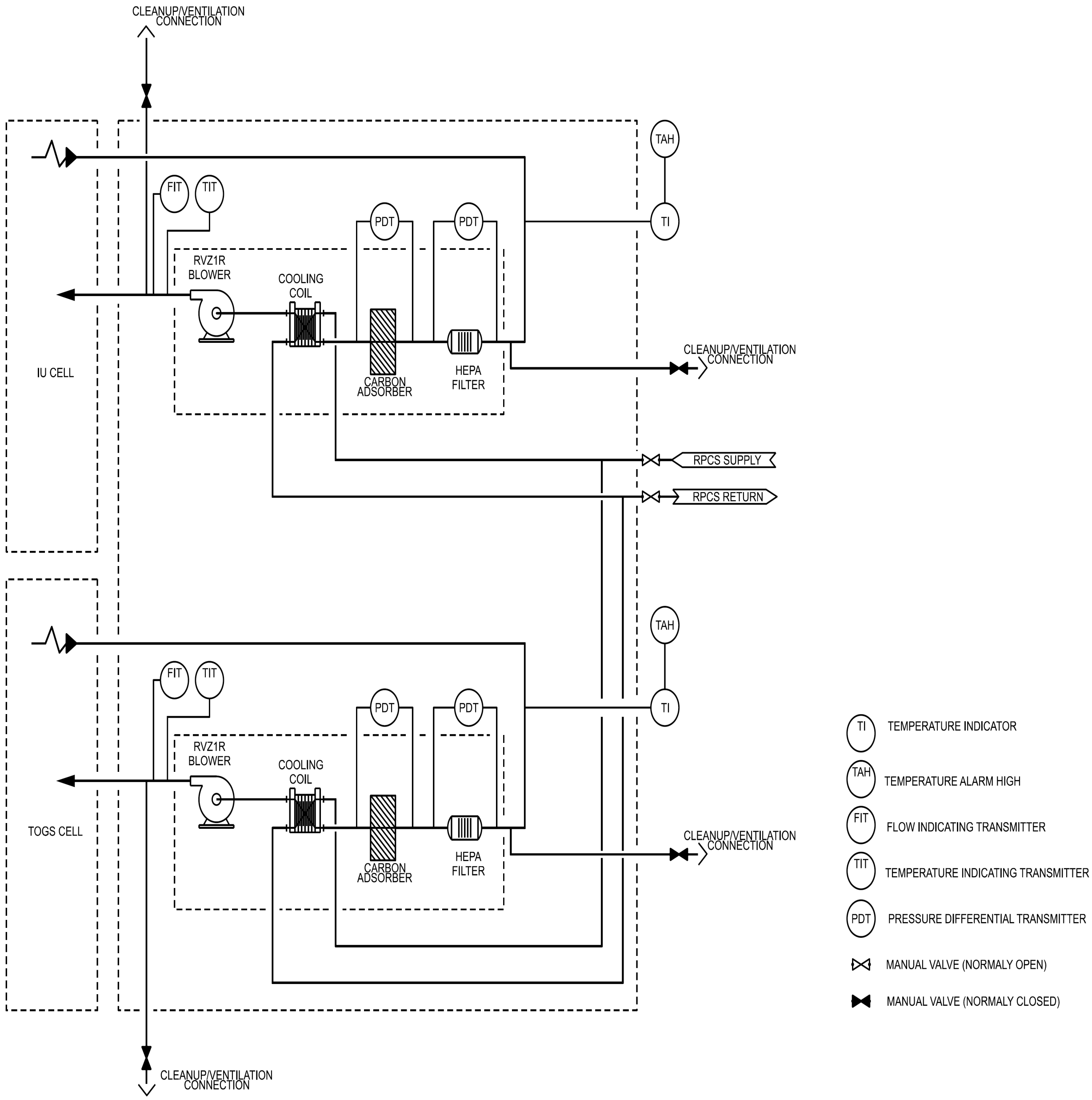


Figure 9a2.1-3 – Radiological Ventilation Zone 1 Exhaust Subsystem (RVZ1e) Flow Diagram

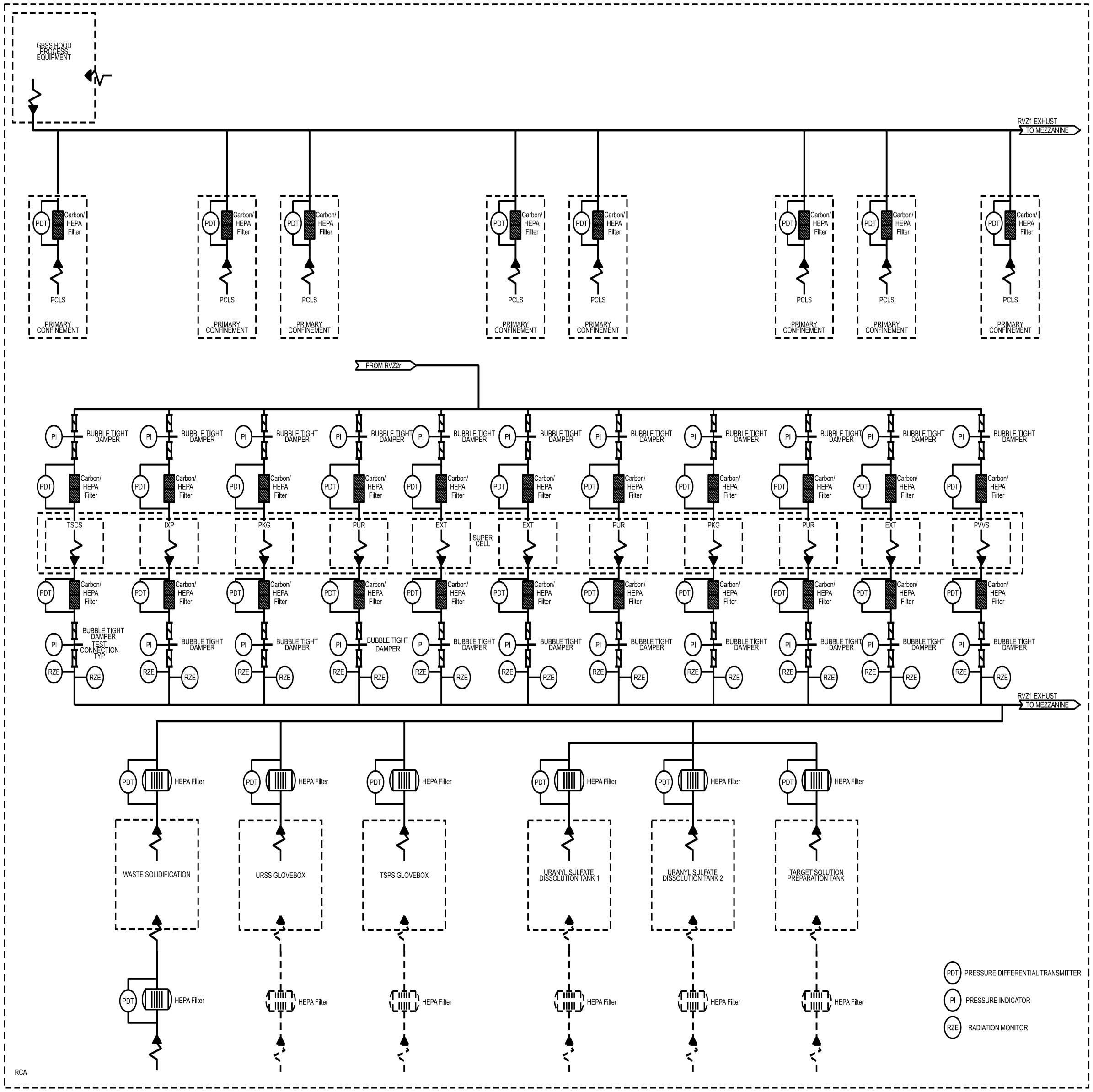


Figure 9a2.1-4 – Radiological Ventilation Zone 2 Exhaust Subsystem (RVZ2e) Flow Diagram

Figure 9a2.1-5 – Radiological Ventilation Zone 2 Supply Subsystem (RVZ2s) Air Handling Units (AHUs)

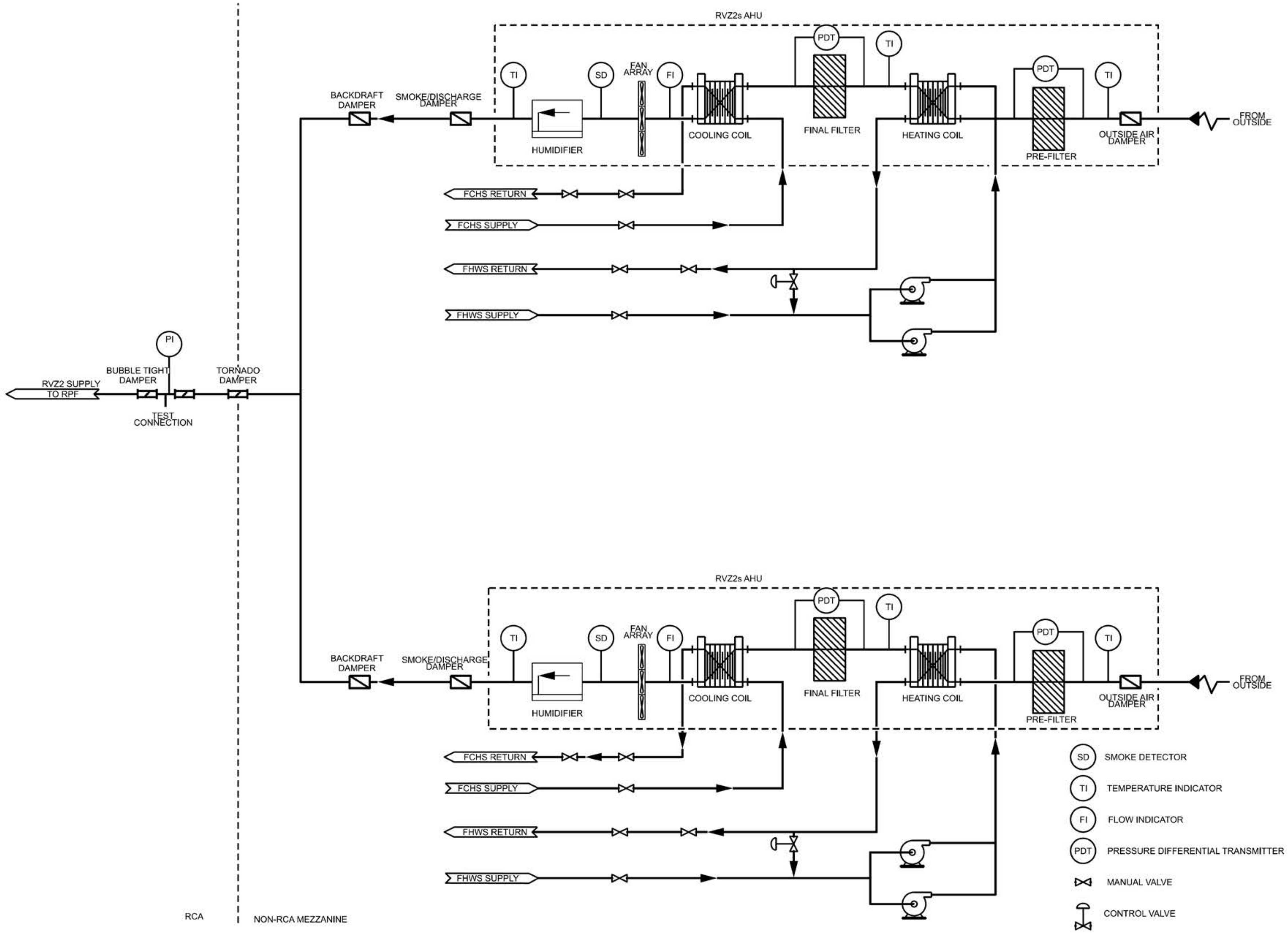


Figure 9a2.1-6 – Radiological Ventilation Zone 2 Supply Subsystem (RVZ2s) and Radiological Ventilation Zone 2 Recirculating Cooling Subsystem (RVZ2r) Flow Diagram

Figure 9a2.1-7 – Radiological Ventilation Zone 3 (RVZ3) Flow Diagram

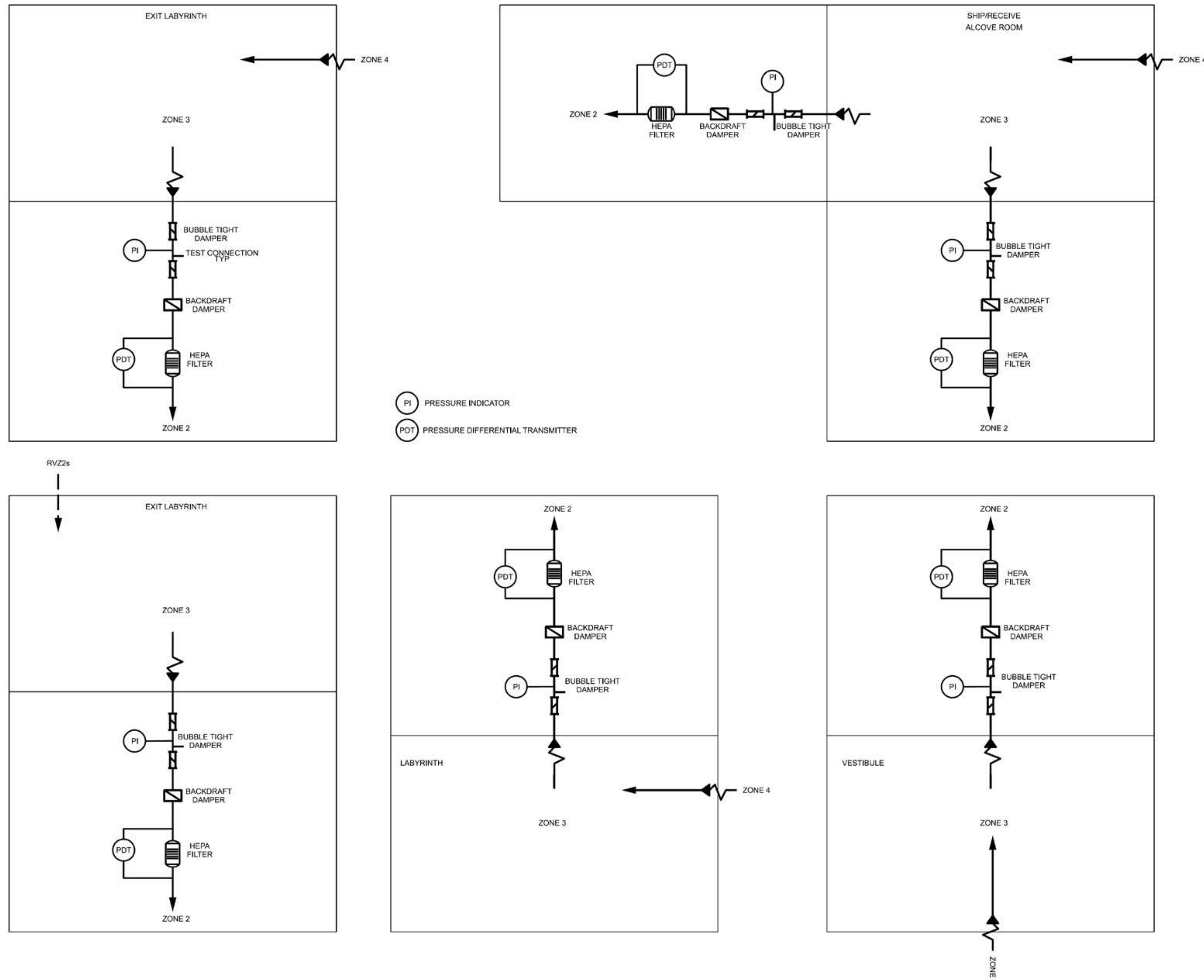


Figure 9a2.1-8 – Radiological Ventilation Zone 1 Exhaust Subsystem (RVZ1e) and Radiological Ventilation Zone 2 Exhaust Subsystem (RVZ2e) Mezzanine

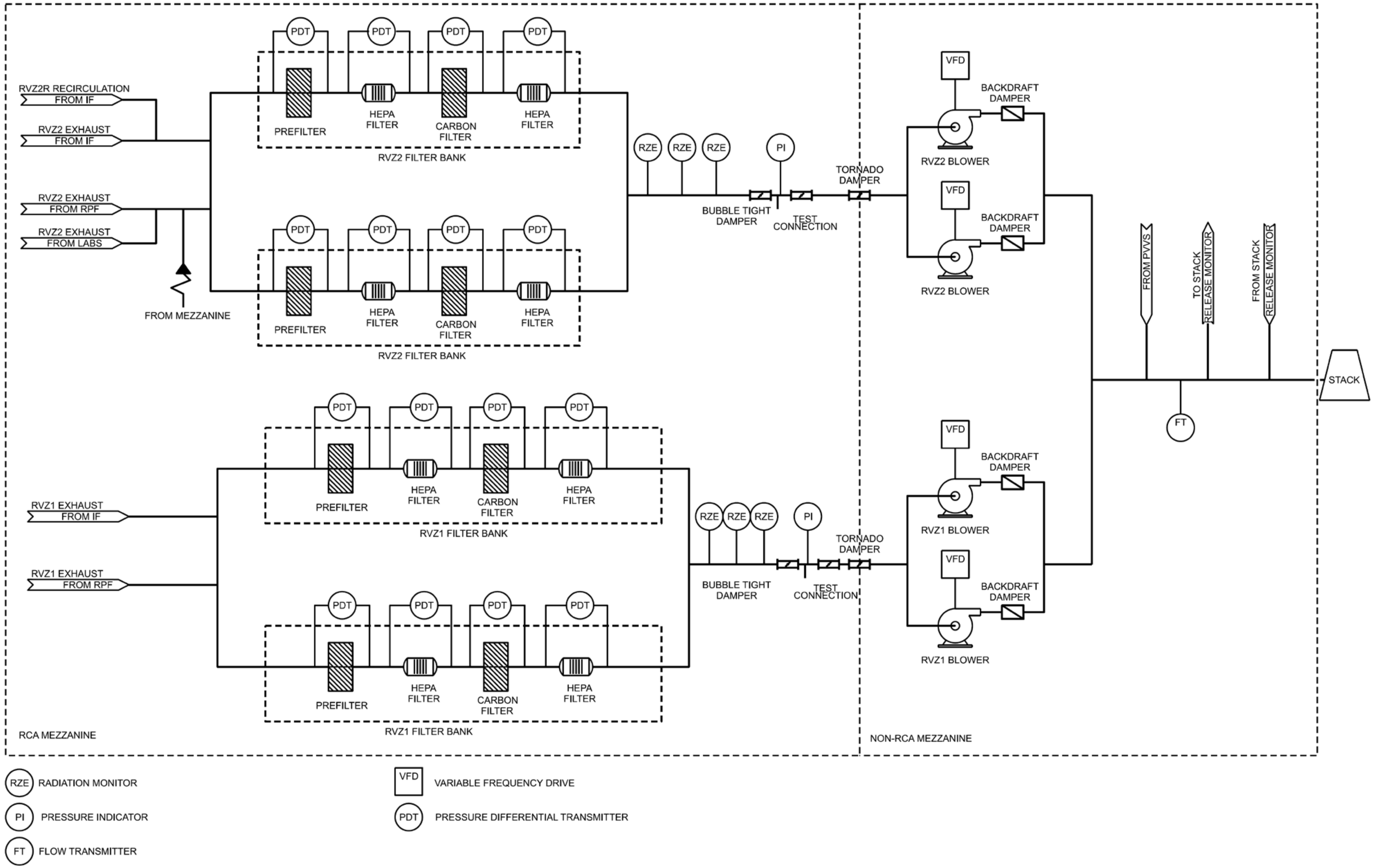


Figure 9a2.1-9 – Facility Ventilation Zone 4 Supply and Transfer Air Subsystem (FVZ4s) Distribution

Figure 9a2.1-10 – Facility Ventilation Zone 4 Supply and Transfer Air Subsystem (FVZ4s) Return Air Flow Diagram

Figure 9a2.1-11 – Facility Ventilation Zone 4 (FVZ4) Air Handling Units (AHUs) (Typical)

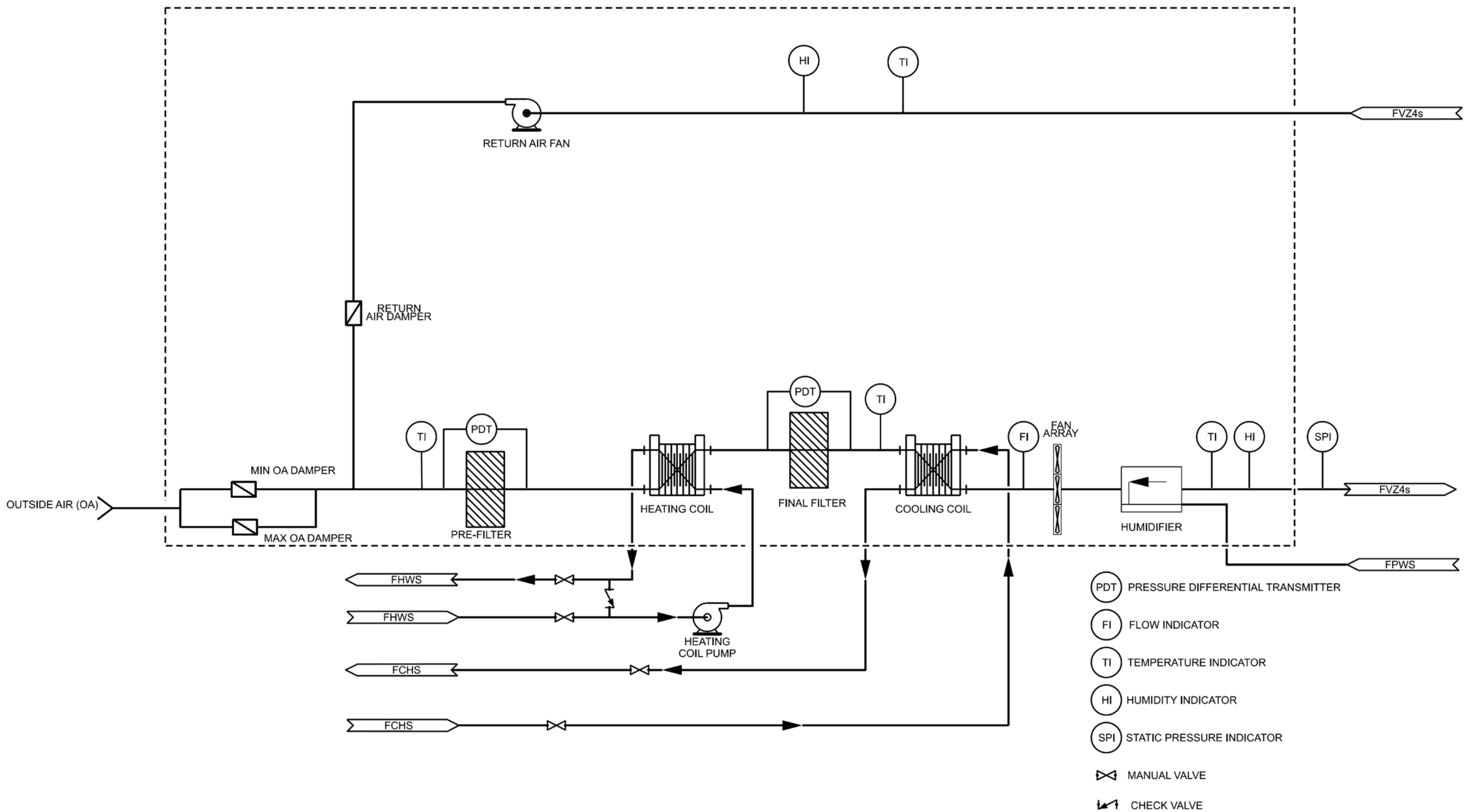


Figure 9a2.1-12 – Facility Ventilation Zone 4 Exhaust Subsystem (FVZ4) Distribution Flow Diagram

9a2.2 HANDLING AND STORAGE OF TARGET SOLUTION

9a2.2.1 INTRODUCTION

This section describes the handling and storage of target solution within the irradiation facility (IF). The chemical properties of the target solution are described in Section 4a2.2, including uranium concentration, density, and pH.

Detailed descriptions of the processes involving irradiated and unirradiated special nuclear material (SNM), including the byproduct material produced as a result of the irradiation of SNM, are provided in Section 4b.4. Equipment, application of administrative controls, and design features related to the target solution lifecycle are also discussed in Section 4b.4. A detailed description of the target solution lifecycle is provided in Section 9b.2.

Physical protection of the target solution from theft or diversion is ensured via the implementation of the Physical Security Plan, described in Section 12.8. The primary closed loop cooling system (PCLS) removes heat from the target solution vessel (TSV), neutron multiplier, and components of the subcritical assembly system (SCAS) during irradiation of the target solution, as described in Section 5a2.2. Radiological considerations during normal operations related to the handling and storage of target solution are described in Section 11.1. An analysis of accident scenarios involving the mishandling or malfunction of target solution within the IF is provided in Subsection 13a2.1.4.

9a2.2.2 IRRADIATION FACILITY TARGET SOLUTION STORAGE AND HANDLING

After target solution is prepared and qualified in the target solution preparation system (TSPS), it is transferred to the target solution hold tank prior to transfer into the TSV. Target solution is transferred from the target solution hold tank to the TSV via the TSV fill lift tank.

The target solution hold tank is at an elevation below that of the TSV to prevent an accidental gravity-driven transfer of target solution to the TSV. The vacuum transfer system (VTS) is used to transfer the target solution to the TSV in a controlled manner, both with respect to fill rate and fill volume. A description of the incremental process used to fill the TSV is provided in Section 4a2.6.1. Target solution batches that have been previously irradiated are returned to the target solution hold tank from processes in the hot cells or from the target solution storage tank.

9a2.2.3 IRRADIATION FACILITY TARGET SOLUTION HANDLING EQUIPMENT

The following is a list of major equipment that interacts with target solution in the IF.

- Target Solution Vessel
  - Quantity: 8
  - Location: Inside irradiation unit (IU) cell
- TSV Dump Tank
  - Quantity: 8
  - Location: Inside IU cell

9a2.2.4 STORAGE OF TARGET SOLUTION

Storage of target solution in the IF is limited to storage in the TSV dump tanks following irradiation in the TSV.

9a2.2.5 CRITICALITY CONTROL FEATURES

Protection against inadvertent criticality in the TSV dump tank is discussed in Subsection 4a2.6.3. Protection against inadvertent criticality in the TOGS is discussed in Subsection 4a2.8.5. Reactivity control for the SCAS is discussed in Section 4a2.6.

9a2.2.6 BIOLOGICAL SHIELDING

The irradiation cell biological shield (ICBS) ensures that the projected radiation dose rates and accumulated doses in occupied areas within the IF do not exceed the limits of 10 CFR 20. Furthermore, the dose reduction by the ICBS supports the radiation exposure goals defined in the as low as reasonably achievable (ALARA) Program, as described in Section 11.1.

Section 4a2.5 provides a detailed description of the ICBS.

9a2.2.7 TECHNICAL SPECIFICATIONS

Controls on target solution during handling and storage, including testing and surveillance, are described in the technical specifications.

9a2.3 FIRE PROTECTION SYSTEMS AND PROGRAMS

9a2.3.1 FIRE PROTECTION PLAN AND PROGRAM

The Fire Protection Plan describes the overall facility Fire Protection Program (FPP). The FPP describes the fire protection organization and responsibilities, design and programmatic approach, and means to limit the probability and consequences of fire at the SHINE facility. The Fire Protection Plan establishes the requirements to be satisfied by the facility fire protection program. This plan establishes a program that represents an integrated effort involving components, procedures, analyses, and personnel used in defining and carrying out activities of fire protection. It includes system and facility design, fire prevention, fire detection, annunciation, confinement, suppression, administrative controls, inspection and maintenance, training, quality assurance, and testing. The established fire protection program elements, systems, structures, and components are subject to the SHINE Quality Assurance Program, as described in the Quality Assurance Program Description. The elements of the FPP work together to satisfy the requirements of applicable regulatory requirements presented in 10 CFR 50.48(a). The FPP is comprised of the following lower tier documents which are developed and maintained as part of the overall FPP.

- Fire Hazards Analysis (FHA);
- Safe Shutdown Analysis;
- Pre-Fire Plans; and
- Administrative controls (e.g., implementing procedures, drawings, calculations, analyses, specifications).

Development of the FPP is informed by the guidance provided in National Fire Protection Association (NFPA) 801, Standard for Fire Protection for Facilities Handling Radioactive Materials (NFPA, 2014). The structure and content of the FPP are based on the precepts of 10 CFR 50.48(a) and NFPA 801. The FPP ensures, through the application of the defense-in-depth concept, 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.

9a2.3.2 DESIGN BASES

The concept of defense-in-depth is fundamental to the FPP. Fire protection defense-in-depth for the SHINE facility is defined as follows:

- Prevent fires from starting, including limiting combustible materials;
- Detect, control, and extinguish those fires that do occur to limit consequences; and
- Provide protection for structures, systems, and components (SSCs) important to safety so that a continuing fire will not prevent the safe shutdown of the irradiation units or cause an uncontrolled release of radioactive material to the environment.

The FPP is developed and implemented to accomplish these criteria.

9a2.3.3 FIRE HAZARD ANALYSIS

The foundation of the facility fire protection design is the FHA. The FHA establishes and describes individual facility fire areas, which are unique areas separated by fire-rated construction or administrative controls to prevent the spread of fire between adjacent fire areas.

The FHA is performed to determine the hazard posed by operations and contents resident to the fire area of concern. This analysis identifies the level of fire protection needed to provide the desired confinement/control of postulated fires. The analysis demonstrates the adequacy of protection provided, and, if necessary, the need for additional protection.

The primary objectives of the FHA are:

- Establish or identify fire area boundaries,
- Identify fire hazards within the analyzed area,
- Determine worst case fire effects on safe shutdown capability of the irradiation units (IUs) and the potential for uncontrolled release of radioactive materials, and
- Evaluate the adequacy of fire protective features provided.

The FHA is maintained in accordance with the FPP for identified fire areas and facility changes.

9a2.3.4 SAFE SHUTDOWN ANALYSIS

The FPP includes performance of a safe shutdown analysis to demonstrate a means of safe shutdown of the SHINE IUs to ensure they can be placed and maintained in a safe and stable condition following a severe fire in any facility fire area. The analysis also considers the effect of severe fires on safety-related equipment required to prevent uncontrolled releases of radioactive material. A deterministic evaluation is conducted on a fire area by fire area basis to ascertain potential damage and assess the effectiveness of the provided protection.

The fire safe shutdown analysis identifies the means by which safe shutdown of the IUs is accomplished and uncontrolled release of radioactive material is prevented for a fire in each facility fire area. Conduct of the safe shutdown analysis is discussed in detail in implementing procedures and reports. Analysis of safe shutdown and prevention of uncontrolled release of radioactive material for the facility is generally conducted through conduct of the following types of analyses:

- Development of performance goals and analysis methodology
- Selection of credited equipment and systems
- Performance of cable selection and circuit analysis
- Performance of functional analysis
- Development of necessary safe shutdown implementing procedures

9a2.3.5 ADMINISTRATIVE CONTROLS

Administrative controls and procedures are established by the FPP to ensure satisfaction of the program goals and maintenance of a fire safe workplace. These procedures ensure policies and procedures are in place to minimize the possibility of fire and to provide equipment and systems necessary to mitigate the effects of fires that do occur. Each of the fire-related procedures is designed to strengthen the defense-in-depth approach to fire protection.

9a2.3.6 REGULATORY AND CODE REQUIREMENTS

SHINE fire protection systems are designed to comply with the applicable portions of the nationally recognized codes and standards identified below. Adherence to these codes and standards ensures that the facility fire protection features and systems are available to perform their functions when required. The SHINE facility is designed to meet the following fire protection objectives:

- Prevent fire initiation by controlling, separating, and limiting the quantities of combustibles and sources of ignition.
- Isolate combustible materials and limit the spread of fire by subdividing the facility into fire areas separated by fire-rated barriers.
- Separate redundant safety-related components and associated electrical divisions to ensure the capability to achieve and maintain safe shutdown and prevent uncontrolled releases of radioactive material as a result of fire.
- Provide confidence that failure or inadvertent operation of firefighting systems does not significantly impair the safety capability of credited SSCs.
- Provide incipient firefighting capability and access for professional firefighters.
- Minimize exposure to personnel and releases to the environment of radioactivity or hazardous chemicals as a result of a fire.

The facility fire protection features and systems are classified as nonsafety-related and generally non-seismic. Facility fire protection features and systems are not required to remain functional following a design basis accident or the most severe natural phenomena.

The design, installation, testing, and surveillance of the facility fire protection features and systems are based on applicable guidance from nationally recognized codes and standards. The codes and standards used and the code-of-record is as defined in the FPP and applicable design documentation.

9a2.3.7 FACILITY FIRE PROTECTION SYSTEM DESCRIPTION

The facility is subdivided into fire areas that are separated by fire-rated barriers to limit the spread of fire. The fire area boundaries are described and illustrated in the FHA. In each fire area, the facility fire detection and alarm system provides for the detection and alarm of fire conditions. Facility fire suppression systems and manual firefighting capability provide for the suppression of fires. These systems consist of the following:

- Detection systems for early detection and notification of fire;
- Fixed automatic fire suppression systems;
- Manual fire suppression systems and equipment, including hydrants, standpipes, hose stations, and portable fire extinguishers; and
- A fire water supply system including the fire pump, yard main, and interior distribution piping.

The facility FPP and lower tier documentation provide a complete description of the facility fire protection features and systems.

9a2.3.8 RADIOLOGICAL FIRE HAZARDS

Fissionable materials in the form of low-enriched uranium metal and uranium oxide are brought into the facility and used to produce target solution. Target solution is an aqueous uranyl sulfate solution which is irradiated to produce molybdenum-99 (Mo-99) and other medical isotopes. Following irradiation, the target solution is transferred through piping and tanks for chemical processing in the radioisotope production facility (RPF) to extract Mo-99, other radioisotopes, and impurities allowing for reuse of the solution in the irradiation process. These processes present a possibility of radiological release from processes, with fire presenting an energetic source that can drive release. Radiological release due to fire is typically associated with combustion of radiologically contaminated ordinary combustible materials or fire damage to confinement systems that could allow release of collocated radiological materials.

Uranium oxide and uranium metal are received and stored in the uranium receipt and storage system (URSS) room. Storage of the uranium metal and uranium oxide is in metal storage canisters. Canisters are stored on metal storage racks to ensure a safe configuration of the stored materials. Uranium metal is received in sufficiently massive configurations that it is not pyrophoric.

The TSPS and URSS rooms are protected with automatic fire detection and provided with appropriate portable fire extinguishers for incipient stage fire suppression. Combustible loading in these rooms is maintained low to prevent fire. Fire response using water-based extinguishants is prohibited; elevated floors of the URSS and TSPS fire area are provided to prevent flooding of these rooms.

Irradiation is performed in the irradiation facility (IF). Chemical processing, to extract medical isotopes from the target solution, is performed in the RPF. The irradiation and chemical processing of radiological materials is discussed in detail in Chapter 4.

Once target solution is introduced to the irradiation process, it is contained in pipes and tanks. These pipes and tanks are located in the IU cells, hot cells, tank vaults, and pipe trenches throughout the IF and RPF. The IU cells, hot cells, tank vaults, and pipe trench structures are constructed of massive steel and concrete barriers to provide radiation shielding. The monolithic construction of these structures provides significant fire separation from the general areas of the IF and RPF. This construction provides protection to the pipes and tanks containing radiological materials. Combustible loading in the spaces within the IU cells, hot cells, tank vaults, and pipe trenches is maintained very low. Combustible materials in these spaces are limited to cable and equipment. Combustible loading in the IF and RPF general areas is maintained low to present a minimal potential for fire. The IF and RPF general areas are equipped with automatic fire detection and provided with portable fire extinguishers to provide incipient fire suppression capability.

Filters contained in the facility ventilation systems that may contain fission products are replaced on a regular basis. Filters are contained in non-combustible ductwork. Areas of the radiologically controlled area (RCA) containing filters are protected with automatic fire detection and portable fire extinguishers. Combustible loading is maintained low in these areas.

The carbon guard beds located in the process vessel vent system (PVVS) are equipped with temperature detection. The guard beds are isolated upon indication of an unacceptable increase in temperature. The carbon delay beds are monitored with in-bed temperature detection and carbon monoxide detectors at each outlet. The carbon delay beds are equipped with a nitrogen purge line that is used to extinguish hot spots if detected.

Three facility systems are provided to mitigate hydrogen generation due to radiolysis. These systems are the TSV off-gas system (TOGS), PVVS, and nitrogen purge system (N2PS).

TOGS is the subcritical assembly system (SCAS) gas management system. The TOGS sweeps radiolysis and fission product gases from the TSV during irradiation and from the TSV dump tank during cool down. The TOGS is located in the TOGS cell of each IU. During target solution irradiation, iodine and noble gases are formed by fission and decay, and hydrogen and oxygen are formed by radiolysis. The hydrogen concentration in the TSV headspace is normally maintained below lower flammability limit (LFL) by using air as a sweep gas. The TOGS system is described in detail in Section 4a2.8.

The PVVS provides ventilation for the tanks in the RPF. The system dilutes radiolytic hydrogen generated in RPF tanks and captures or delays radiological off-gas prior to release out the stack. Blowers at the discharge of the system develop a slight vacuum to pull air across the headspace of each tank. The flow rates across each tank are balanced such that radiolytic hydrogen generated in each tank is diluted below the hydrogen LFL. The PVVS is described in detail in Section 9b.6.

The N2PS provides back-up sweep gas flow in the form of stored, pressurized nitrogen gas. Upon a loss of power, or the loss sweep gas flow in an IU as determined by the TSV reactivity protection system (TRPS), solenoid valves on the N2PS discharge manifold will fail open releasing nitrogen to the IU cell supply header. Upon a loss of sweep gas flow in an IU, nitrogen gas supply solenoid isolation valves for that cell will be deenergized to the open position, releasing nitrogen gas to the TSV dump tank in that cell. A flow switch will give indication that nitrogen sweep gas is flowing to the IU cell distribution system. The flow rates into each TSV dump tank are balanced such that the radiolytic hydrogen generated in each tank is diluted to acceptable concentrations. The sweep gas flows through the TSV dump tank, the TSV, and TOGS equipment and piping and is discharged into the PVVS.

Upon a loss of power or loss of sweep gas flow through PVVS as determined by the engineered safety features actuation system (ESFAS), normal radiological ventilation zone 2 (RVZ2) flow is isolated and nitrogen purge gas is directed to the RPF distribution header. A flow switch provides indication that nitrogen sweep gas is flowing to the RPF distribution system. The flow rates across each tank are balanced such that the radiolytic hydrogen generated in each tank is diluted below the LFL. The nitrogen gas flows through the existing PVVS piping and into the PVVS.

9a2.3.9 TECHNICAL SPECIFICATIONS

The FPP is included in the Administrative Controls section of the Technical Specifications. Including the FPP in the Administrative Controls section of the Technical Specifications ensures that the FPP elements are available and reliable by requiring that testing, surveillance, and maintenance activities are conducted as required.

9a2.4 COMMUNICATION SYSTEMS

The facility data and communication system (FDCS) provides the ability to communicate during normal and emergency conditions between the different areas of the main production facility and facility support buildings, as well as locations remote to the SHINE site. Employing the FDCS, SHINE facility operations staff maintain the ability to contact other facility staff as well as announce the existence of an emergency to all areas of the site. The FDCS is designed using multiple diverse subsystems such that a failure of any system does not impair the ability of the other systems to function. The nonsafety-related FDCS supports implementation of SHINE Design Criteria 8, “Emergency Capability,” as described in Table 3.1-3.

The FDCS consists of five subsystems:

- Facility voice over internet protocol (VoIP) telephone system
- Facility overhead public announcement (PA) system
- Facility sound-powered telephone system
- Facility radio system (on-site and off-site communications)
- Facility information technology (IT) subsystem

9a2.4.1 TELEPHONES

The facility uses a commercial telephone communication system that provides for on-site two-way communication, paging and public address, and party-line-type voice communications. Stations for this system are located throughout the main production facility and outbuildings. In an emergency, this system is available to alert on-site personnel.

The telephone system allows personnel to contact or receive calls from any outside telephone number. In an emergency, this system is used to contact off-site SHINE and emergency support organization personnel, as described in the SHINE Emergency Plan. Designated emergency cell phones are also maintained in the facility control room, emergency support center (ESC) and backup ESC.

As part of the telephone communication system, certain phones are designated as private exchange phones. Communication between these phones takes priority over any activity from outside of the private exchange. The private exchange system allows for incoming and outgoing calls. The telephone communication system contains redundant servers and a battery backup as a means of improving the reliability of the phone system, public address, and private exchange communication paths. The system is also provided standby power from the standby generator system (SGS), as described in Section 8a2.2.

9a2.4.2 PUBLIC ADDRESS SYSTEM

The PA system uses the telephone communication system to initiate public address announcements. The system also includes dedicated base transmitting units, which are designed to continue to function in the event of a failure of the phone system. Announcements can be made site-wide or to specific predefined zones. The public address system is audible in the following areas:

- Occupiable areas of the main production facility radiologically controlled area (RCA)
- Normally occupied areas of the main production facility and support buildings

- Hallways and corridors of the main production facility and support buildings
- Outdoor areas on the SHINE campus within the controlled access area fence

The PA system provides speakers and power distribution for volume levels meeting the audibility requirements of National Fire Protection Association (NFPA) 72, National Fire Alarm and Signaling Code, Chapter 24 (NFPA, 2016).

The PA system includes a prioritization of phone lines such that announcements from the control room override any other use of the PA system. The public address system uses the same redundant servers and battery backup as the telephone communication system.

9a2.4.3 SOUND-POWERED PHONES

Sound-powered phones supplement the telephone system for on-site communications. The system uses portable sound-powered telephones that can plug into local terminal jacks. The sound powered telephones are located in areas where critical operations and response activities are anticipated to occur. The sound-powered telephones utilize the user’s voice to create the necessary power for reliable and uninterrupted communications in the event of an emergency. The phones operate independent of any power source and are not affected by loss of power to the facility.

9a2.4.4 RADIO SYSTEM

Hand-held portable radios operating on ultra high frequency (UHF) bands are provided. These radios are powered by replaceable, rechargeable battery packs and once charged are independent of facility power until recharging is needed. Base station radios for communication with the portable radios are provided in select locations.

The radio system contains equipment necessary to communicate with designated off-site emergency support organizations. The system allows for communication with the two primary emergency support organizations (the Janesville Fire Department and the Janesville Police Department) using P25 transmission protocols. Standby power for the facility radio system is provided by the SGS.

9a2.4.5 INFORMATION TECHNOLOGY

The information technology system provides corporate network services and connectivity to the internet for the SHINE facility. The IT system supports nonsafety-related personnel information technology needs. The IT system acts as the historian for the process integrated control system (PICS), receiving information from the PICS via data diode such that no inputs can be provided to the PICS from off-site sources. The IT system can also be used to transmit information received from PICS to off-site locations if required.

9a2.4.6 TESTING REQUIREMENTS

The design of the communications systems permits routine testing and inspection without disruption to normal communications. Testing is performed in accordance with the SHINE Emergency Plan in order to ensure communications systems operability.

9a2.4.7 PHYSICAL SECURITY

The use of the FDCS for security purposes is addressed in the SHINE Physical Security Plan.

9a2.4.8 TECHNICAL SPECIFICATIONS

There are no technical specifications associated with the communication systems.

9a2.5 POSSESSION AND USE OF BYPRODUCT, SOURCE, AND SPECIAL NUCLEAR MATERIAL

This section applies to the possession and use of byproduct, source, and special nuclear material (SNM) within the irradiation facility (IF). Refer to Section 9b.5 for the discussion of possession and use of byproduct, source, and special nuclear material in the radioisotope production facility (RPF).

The IF is designated as a radiologically controlled area as shown in Figure 1.3-1. Radiation protection program controls and procedures, including the as low as reasonably achievable (ALARA) program, applicable to the IF are described in Section 11.1. Radioactive waste management is discussed in Section 11.2. A discussion of the Security Plan is provided in Section 12.8. Discussion of the Emergency Plan is included in Section 12.7. Fire protection details applicable to the IF are described in Section 9a2.3. Technical Specifications include limits that apply to the possession, management, and use of byproduct, source, and SNM.

9a2.5.1 BYPRODUCT MATERIAL

The SHINE facility is designed to generate byproduct materials (e.g., molybdenum-99) for use as medical isotopes. Byproduct materials within the IF include fission and activation products generated during irradiation unit (IU) operations, as well as tritium which is used within the neutron driver assembly system (NDAS) to create deuterium-tritium fusion reactions as described in Section 4a2.1.

The tritium purification system (TPS) controls the distribution and processing of tritium for the NDAS as described in Section 9a2.7. The quantity of tritium within the facility is described in Table 11.1-5. The types and quantities of fission and activation byproduct materials, as well as the systems where these byproduct materials are located, are discussed in Section 11.1.

Additionally, up to eight (alpha, neutron) neutron sources (e.g., Am-241/Be) with combined strength up to [ ]SRI are used, one in each IU, for IU start-up operations, as described in Section 4a2.2.

9a2.5.2 SOURCE MATERIAL

Source materials in the IF include the depleted uranium (DU) within TPS and the natural uranium neutron multiplier within the subcritical assembly. The DU within TPS is used as storage beds for tritium gas as described in Section 9a2.7. The use of source material within the neutron multiplier is described in Section 4a2.2. SHINE uses up to 330 lbs (150 kg) of DU and 51,000 lbs. (23,000 kg) of natural uranium for these purposes.

9a2.5.3 SPECIAL NUCLEAR MATERIAL

Special nuclear material (SNM) in the IF includes low enriched uranium (LEU) within the target solution vessel (TSV). LEU is irradiated to produce molybdenum-99 by fission within the IF. During this process, plutonium is generated in the target solution and the neutron multiplier. Up to [ ]PROP/ECI of LEU are used in the IF to support facility operations. The total LEU inventory for the SHINE facility is discussed in Section 9b.5.

SNM is also used for neutron flux detection and measurement. Up to eight (alpha, neutron) neutron sources (e.g., Pu-238/Be) with combined strength up to [ ]SRI are used, one in each IU, for IU start-up operations, as described in Section 4a2.2. Additionally, up to 0.55 lbs. (250 g) of uranium-235 are used within neutron flux detectors.

9a2.6 COVER GAS CONTROL IN CLOSED PRIMARY COOLANT SYSTEMS

The primary closed loop cooling system (PCLS) is the closed loop cooling system that provides cooling to the target solution vessel (TSV). Buildup of radiolysis products in the PCLS is controlled by the ventilation of the PCLS expansion tank by radiological ventilation zone 1 (RVZ1). Cover gas control for the PCLS is further described in Section 5a2.2.

9a2.7 OTHER AUXILIARY SYSTEMS

This section describes auxiliary systems in the irradiation facility (IF) that are not described elsewhere.

9a2.7.1 TRITIUM PURIFICATION SYSTEM

The tritium purification system (TPS) is a tritium-deuterium isotope separation system designed to receive mixed tritium-deuterium gas from operating neutron driver assembly system (NDAS) units and provide high purity tritium and deuterium streams to each operating NDAS unit. The TPS components are located in the IF in the TPS room [ ]SRI. Major subsystems of the TPS are identified below and are classified by their function and location within the IF. The TPS services up to eight NDAS units operating simultaneously.

9a2.7.1.1 Tritium Purification System Subsystems

9a2.7.1.1.1 Isotope Separation System

The main isotope separation section of the TPS receives mixed tritium-deuterium gas from operating NDAS units, removes trace impurities from the gas stream, performs isotope separation of the mixed gas stream, and provides purified streams of tritium and deuterium back to the operating NDAS units to drive the tritium-deuterium fusion reaction in the NDAS target chamber. The TPS isotope separation system also flushes and evacuates process lines before entering a maintenance period and after maintenance is complete.

9a2.7.1.1.2 Accelerator TPS Interface System

The accelerator TPS interface system (ATIS) provides the interface between each NDAS unit and the supply and return gas lines of TPS. There are eight instances of ATIS, one for each IU. The ATIS controls delivery of high purity tritium and deuterium gas to the NDAS and returns mixed tritium-deuterium gas to the isotope separation process. The ATIS also includes interfaces with the NDAS to allow for NDAS evacuation before maintenance and exhausting of NDAS secondary enclosures. Each instance of ATIS operates independently depending on the status of the NDAS unit it serves.

9a2.7.1.1.3 ATIS Header

The ATIS header consists of multiple transfer lines and supports between the main TPS process equipment and each ATIS. The transfer lines consist of the supply and return lines for deuterium and tritium as well as lines for process evacuation and ATIS glovebox purge gas. Transfer lines that contain tritium are jacketed to prevent leaks in the lines from introducing tritium directly to the IF environment. Monitoring capability is provided for the ATIS header to detect potential tritium leaks.

9a2.7.1.1.4 TPS Glovebox

The TPS glovebox is a confinement glovebox that encloses the isotope separation process equipment. The TPS glovebox is maintained at negative pressure relative to the TPS room and has a nitrogen atmosphere. The glovebox atmosphere is continuously cleaned by the glovebox stripper system to maintain low levels of tritium contamination and oxygen. A detailed physical description of the TPS glovebox is provided in Subsection 9a2.7.1.4.

9a2.7.1.1.5 ATIS Gloveboxes

There are eight ATIS gloveboxes that provide confinement to process equipment for each ATIS. The gloveboxes are located [ ]SRI. The ATIS gloveboxes are maintained at negative pressure relative to the IF and have a nitrogen atmosphere.

9a2.7.1.1.6 Glovebox Stripper System

The glovebox stripper system (GBSS) strips tritium from the nitrogen atmosphere of the TPS and ATIS gloveboxes as well as the waste streams from TPS process lines when the lines are evacuated for maintenance. The GBSS removes tritium in glovebox environments from both chronic sources (leakage and permeation) and accidental releases. The GBSS also maintains low levels of oxygen in the glovebox atmospheres. The GBSS process equipment exhausts to the radiological ventilation zone 1 exhaust (RVZ1e).

9a2.7.1.1.7 Glovebox Stripper System Hood

The GBSS hood is a fume hood that contains the GBSS process equipment. The fume hood draws in zone 2 air from the TPS room and exhausts it to radiological ventilation zone 2 exhaust (RVZ2e) where it combines with the ventilation for the TPS room.

9a2.7.1.1.8 Tritium Purification System Room

The TPS room houses the TPS glovebox, GBSS hood, portions of the ATIS header, and supporting control and process equipment.

9a2.7.1.2 Design Bases

The TPS maintains the integrity of the TPS confinement boundary by preventing leakage to the IF from the TPS glovebox, GBSS process equipment, ATIS header, and ATIS gloveboxes, which could result in potential off-site exposures to individual members of the public or occupational dose exposures to individual workers in excess of prescribed dose criteria, which are described in Section 11.1. TPS isolation functions are actuated by the engineered safety features actuation system (ESFAS) as described in Section 7.5.

The TPS prevents leakage from primary confinement boundary through isolation of interface process lines between ATIS process equipment and NDAS during and after a design basis seismic event which could result in potential off-site exposures to individual members of the public or occupational dose exposures to individual workers in excess of SHINE's dose criteria, which are addressed in Section 11.1. Primary confinement isolation functions are actuated by the target solution vessel (TSV) reactivity protection system (TRPS), as described in Section 7.4.

SHINE design criteria applicable to the TPS are described in Section 3.1.

9a2.7.1.3 Tritium Purification Process Sequence

The TPS isotope separation process begins with the target gas receiving system (TGRS), which consists of vacuum pumps that draw in mixed tritium-deuterium return gas from NDAS units. Gas from TGRS is cleaned in the impurity removal system (IRS) before isotope separation.

The IRS provides impurity removal through an activated carbon or molecular sieve bed. The impurity removal bed captures chemical impurities to protect more sensitive TPS equipment downstream. The IRS also contains a gas chromatograph to monitor the process stream to confirm functionality of the impurity removal bed and identify if breakthrough on the bed has occurred and if the bed needs to be replaced.

After impurity removal, deuterium and tritium isotopes are separated through the thermal cycling adsorption process (TCAP), which is part of the storage and separation system (SSS). TCAP separates deuterium and tritium through the thermal cycling of a palladium-based column and a molecular sieve column. By thermally cycling the TCAP columns, pure tritium gas is collected at one end of the palladium-based column and pure deuterium is collected at one end of the molecular sieve column. Tritium is then drawn from the end of the palladium-based column and deuterium is drawn from the molecular sieve column.

TCAP is a batch process. To receive and deliver a continuous supply of gas to and from operating NDAS units, an arrangement of feed, product, and raffinate volumes are used together with the separation columns. Feed volumes are used to supply mixed tritium and deuterium gas to the TCAP separation columns, which separates the two isotopes and fills the product and raffinate volumes. The product and raffinate volumes are used to supply the tritium and deuterium header lines, respectively, which are used to supply source and target gas to each operating NDAS. Additional SSS components include a uranium storage bed to hold tritium when not in use and an interface location where fresh tritium may be supplied from a gas cylinder or uranium storage bed. The uranium storage bed allows tritium to be safely stored during maintenance operations on the TPS. A supply volume provides the ability to add measured amounts of tritium to the TPS from either the storage bed or external source.

Operating NDAS units deliver and receive gas from the isotope separation process through the ATIS. Each ATIS is connected to the ATIS header that allows for gas transfer from the main TPS process equipment to an NDAS unit. Tritium and deuterium supplies are provided to the NDAS through mass flow controllers that determine the flow of deuterium into the NDAS ion source and flow of tritium into the NDAS target chamber. The return gas from the NDAS is returned to TGRS through a booster pump to provide proper flow through the ATIS header. The ATIS header tritium lines have jacketed tubing to ensure potential leaks in process lines between the gloveboxes do not result in tritium releases to the facility or environment. Potential leaks in process lines enter the jacket space instead of being released to the facility environment and are detected by tritium monitoring equipment. The NDAS may also be evacuated down to vacuum through the TPS which maintains the ability to remove trace tritium before the waste stream enters the facility ventilation.

The isotope separation equipment is confined inside the TPS glovebox. The TPS glovebox provides a secondary confinement boundary along with isolation valves to ensure excessive tritium releases to the facility and environment do not occur. The TPS glovebox also provides confinement in the event of a breach in the TPS process equipment. Each instance of ATIS process equipment is confined in an ATIS glovebox.

In addition to the process equipment for isotope separation, TPS contains multiple supporting systems. To deliver new tritium gas or store process tritium before entering maintenance, the SSS contains tritium supply and storage vessels, such as uranium tritide beds. The SSS will supply new tritium gas to TGRS so that fresh tritium gas passes through the IRS before reaching TCAP. The process evacuation separation system (PESS) consists of the support equipment necessary to evacuate the main process lines before maintenance or component replacement. PESS evacuates process lines to the stripper system to capture any residual tritium before maintenance to reduce loss of tritium inventory and reduce tritium release outside of TPS.

The GBSS removes hydrogen isotopes and moisture in the TPS and ATIS glovebox nitrogen purge gas before the purge gas enters the facility ventilation system and exhausts to the environment through the facility stack. The GBSS uses a combination of catalytic recombiner and molecular sieve beds to convert tritium to tritiated water and capture the tritiated water before the process stream reaches the facility ventilation. The molecular sieve beds are periodically replaced to ensure sufficient water capture capacity is available. The GBSS samples the process streams from the tritium cleanup process before it enters the facility ventilation system. The GBSS recirculates a portion of TPS glovebox atmosphere and treats the ATIS gloveboxes as a single pass-through before ultimately exhausting to the stack. When process lines are evacuated before maintenance, the streams are directed through GBSS to minimize tritium releases to the environment. The GBSS is contained in a fume hood near the TPS glovebox.

Table 9a2.7-1 provides a description of TPS interfaces. Table 9a2.7-2 provides the nominal properties of the tritium supply, return, and raffinate streams. Table 9a2.7-3 provides a listing of process equipment associated with the TPS.

Figure 9a2.7-1 provides a TPS process flow diagram.

9a2.7.1.4 TPS Glovebox Description

The TPS process equipment is enclosed in a central glovebox and eight smaller interface gloveboxes, one for each IU cell. The central glovebox is sized to accommodate the entire demand of the eight NDAS units. The glovebox has a stainless steel shell with gloveports and windows on both sides for operator access to equipment. The glovebox has feedthrough connections to allow process tubing, electrical power, and instrumentation lines to pass through the glovebox to the TPS process equipment. The glovebox has an antechamber to facilitate the removal and replacement of internal equipment as needed. External lighting fixtures provide light to the glovebox interior.

The glovebox volume is sized such that a release of stored tritium and deuterium would not result in exceeding the lower flammability limit (LFL) in the glovebox.

There is a small interface glovebox [ ]SRI. The interface gloveboxes contain the necessary equipment to regulate flows of tritium and deuterium to each NDAS and return the mixed tritium and deuterium gas to the central glovebox for isotope separation.

9a2.7.1.5 Glovebox Atmosphere Treatment

Small amounts of tritium are released into the glovebox during normal operation, so the glovebox has a cleanup system designed to treat the atmosphere to minimize the tritium concentration. The glovebox atmosphere normally has a very low tritium concentration. The most significant releases of tritium to the glovebox atmosphere are expected to occur during maintenance activities (e.g., disconnecting beds or pumps for replacement).

The glovebox has a recirculating inert atmosphere with minimal nitrogen makeup. The oxygen and tritium content in the glovebox is monitored, and at high concentrations the operator is notified by alarms. The recirculating loop cleans the atmosphere to minimize the amount of tritium in the glovebox atmosphere. The glovebox atmosphere exhausts through the GBSS into RVZ1e.

The cleanup involves a catalytic recombiner and molecular sieve bed to remove most oxidized tritium. The molecular sieve beds are replaced as required over the course of operations.

9a2.7.1.6 Radiological Protection

The processes associated with the TPS are performed within gloveboxes to minimize the exposure of individuals to tritium. Outside of the gloveboxes, TPS tritium tubing is double-walled with tritium detection monitors and alarms to alert operators of potential leaks. Additionally, the tritium outside the glovebox is normally under partial vacuum. Monitors are located near tritium tubing and at glovebox workstations to identify tritium leaks. The TPS is designed to maintain occupational exposures to tritium to within as low as reasonably achievable (ALARA) program goals. Releases of tritium to the facility or environment are within 10 CFR 20 limits.

Process lines that penetrate the central glovebox confinement boundary have isolation valves that close on high tritium alarm in the glovebox. In the event of a tritium release, the glovebox may be isolated from the rest of the TPS process and IF through actuation of the isolation valves. Isolation valves are also located on process lines at the interface between the TPS and NDAS units that can be closed to support confinement of an IU cell.

Outside the glovebox boundary, TPS tritium tubing is jacketed. The annular space is monitored to identify potential leaks. TPS process equipment and tubing is designed and fabricated with low leakage rate requirements to ensure low tritium leakage to the glovebox atmosphere or IF.

Tritium is supplied to the NDAS at sub-atmospheric pressure. The tritium within the NDAS is circulated to and from the target chamber by vacuum pumps. A pump is used to aid in returning the mixed tritium and deuterium gas to the glovebox.

Evaluation of accidents involving releases of tritium from the TPS is discussed in Subsection 13a2.1.12.

9a2.7.1.7 Instrumentation and Controls

The process integrated control system (PICS) provides normal monitoring and control of process variables and control components not important to the safe operation of the TPS. Section 7.3 provides a detailed description of the PICS.

The TRPS monitors TPS variables important to the safety functions of the irradiation process during each operating mode of the IU to perform an IU Cell Safety Actuation. Section 7.4 provides a detailed description of the TRPS.

The ESFAS monitors variables important to the safety functions for confinement of tritium within the IF to perform isolation of the TPS. Section 7.5 provides a detailed description of the ESFAS.

9a2.7.1.8 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also applicable to, and may be used for the bases that are described in the technical specifications.

9a2.7.2 NEUTRON DRIVER ASSEMBLY SYSTEM SERVICE CELL

The NDAS service cell (NSC) is a dedicated work area provided to support the staging, commissioning, maintenance, and disposal of a single NDAS unit. The NSC provides additional space for maintenance activities that are difficult or impossible to perform when an NDAS is installed in an IU cell.

9a2.7.2.1 Design Bases

The NSC accommodates commissioning, maintenance, and disposal activities for the operational lifetime of each NDAS.

9a2.7.2.2 System Description

The NSC is a roofless room formed by a shared wall with the [ ]SRI on the north, an exterior building wall on the east, a wall facing the laydown area on the south, and a wall on the west. The NSC contains a service pit to allow installation of a dedicated target for NDAS beam testing. Outside of the NSC, there is sufficient space (either in the laydown area outside the NSC or on the roof of the TPS room) for placement of a control station, high voltage power supply, cooling and electrical cabinets, and NDAS-related consumables and tooling to support NDAS testing. Figure 4a2.5-1 provides a plan and section view of the NSC. A list of system interfaces associated with the NSC is provided in Table 9a2.7-4.

Commissioning, maintenance, and disposal activities associated with the NDAS and performed in the NSC are summarized below.

- Commissioning
  An NDAS may be tested in the NSC prior to installation in an IU cell. The NDAS sub-assemblies will be staged, mounted to the supporting pads in the NSC, and assembled with the support of the facility crane. The assembled NDAS is connected to service utilities such as electrical, control, cooling water, and supply gases inside and outside the NSC. The commissioning activities to be carried out in the NSC may include establishing vacuum, helium leak rate testing, filling the pressure vessel with sulfur hexafluoride (SF_6) gas, and beam performance testing.
- Maintenance
  If portions of an NDAS require maintenance or replacement, it may be moved from an IU cell to the NSC. The NDAS is lifted by the IF bridge crane and transferred to the NSC where work can be performed.
- Disposal
  The NSC may also be used to disassemble an NDAS into smaller parts that can fit more easily into containers before sending to an appropriate waste repository.

9a2.7.2.3 Radiological Protection

Gamma radiation monitoring of the NSC is provided to allow for safe operation and interlocking of activities in the NSC. The NSC has a directed airflow system to manage residual tritium contamination of NDAS components. This airflow system maintains the capability to interface with the facility heating, ventilation, and air conditioning (HVAC) through RVZ2e. A passive tritium sample collector at the interface to RVZ2e provides a record of tritium content entering RVZ2e from the NSC. The NSC provides a real-time tritium monitor at the interface to the RVZ2e to measure real-time tritium content in exhaust gas from NDAS testing sent to RVZ2e.

The NSC shield walls are made from approximately 24-inch (61 centimeter) thick concrete walls with reinforcing carbon steel bars. Additional local shielding, such as water or polycarbonate blocks, may also be installed during testing in the NSC. Implementation of local shielding in the pit, and around an installed NDAS as necessary, provides radiation shielding during NDAS testing. This local shielding functions in conjunction with the shielding provided by the NSC shield walls and door to maintain occupational exposures to neutron and gamma radiation to within ALARA program goals. Table 11.1-4 provides radiation areas at the SHINE facility, and includes dose rates to the IF general area during accelerator testing in the NSC. Calculated dose rates during accelerator operation in the NSC are approximately 8 mrem/hr outside the NSC walls. The annual average neutron flux to the NSC surrounding soil is expected to be less than 100 n/cm^2-s.

9a2.7.2.4 Instrumentation and Controls

The NSC provides instrumentation and controls to perform testing of an NDAS to verify proper operation before returning to service. Interlocks for safe testing of the NDAS, such as preventing operation of the NDAS while the service cell door is open are provided. A radiation interlock button located inside the NSC prevents or shuts down operation of the NDAS when actuated by personnel in the NSC.

9a2.7.2.5 Technical Specifications

There are no technical specifications associated with the NSC.

Table 9a2.7-1 – Tritium Purification System Interfaces

Interfacing System	Interface Description
Neutron driver assembly system (NDAS)	Tritium purification system (TPS) interfaces with the NDAS through process tubing connections that allow delivery of tritium and deuterium gas along with return of mixed tritium and deuterium exhaust gas or NDAS evacuation.
Process integrated control system (PICS)	PICS provides normal monitoring and control of all process variables and control components not important to the safe operation of the TPS.
Target solution vessel (TSV) reactivity protection system (TRPS)	The TRPS provides monitoring and indication of the TPS variables important to the safe operation of individual irradiation unit (IU) cells and provides control of all TPS isolation valves into the primary confinement boundary in the event of a design basis event.
Engineered safety features actuation system (ESFAS)	The ESFAS provides monitoring and indication of the TPS variables important to the safe operation of the TPS glovebox and glovebox stripper system. The ESFAS also provides control of all TPS isolation valves out of the TPS and the glovebox stripper system in the event of a design basis event. The ESFAS controls the position of the safety-related actuation components of the TPS.
Facility nitrogen handling system (FNHS)	Gaseous nitrogen is supplied to the TPS gloveboxes to establish and maintain the inert environment below atmospheric pressure. Liquid nitrogen is supplied to TPS process equipment to operate impurity removal and TCAP equipment. Nitrogen is also used to actuate air-operated valves throughout the TPS process.
Radiological ventilation zone 1 (RVZ1)	TPS interfaces with RVZ1 at two locations: the point of connection from the glovebox exhaust to the zone 1 header duct, and the point of connection from the TPS exhaust sampling tank.
Radiological ventilation zone 2 (RVZ2)	TPS interfaces with RVZ2 at the exhaust point of the liquid nitrogen cooling lines (in the form of nitrogen gas) and the overall ventilation of the TPS room.
Normal electrical power supply system (NPSS)	TPS interfaces with the NPSS at the following locations: the glovebox electrical penetrations and connections to equipment located external to the glovebox. Electrical power is distributed within the glovebox to operate the various pumps and heaters in the TPS, and other ancillary equipment.
Uninterruptible electrical power supply system (UPSS)	TPS interfaces with the UPSS at the connections to safety-related equipment and instrumentation that require safety-related backup power. Some nonsafety-related portions of the GBSS are also on the UPSS.

Table 9a2.7-2 – Nominal Tritium Supply/Return Properties

Parameter	Tritium Supply	Deuterium Supply	Mixed Tritium-Deuterium Return
Tritium Concentration	[ ]PROP/ECI	[ ]PROP/ECI	[ ]PROP/ECI
Deuterium Concentration	Balance	Balance	Balance
Flow Rate	[ ]PROP/ECI	[ ]PROP/ECI	[ ]PROP/ECI
Pressure	< 1 atm	40 psig	< 1 atm

Table 9a2.7-3 – Tritium Purification System Process Equipment

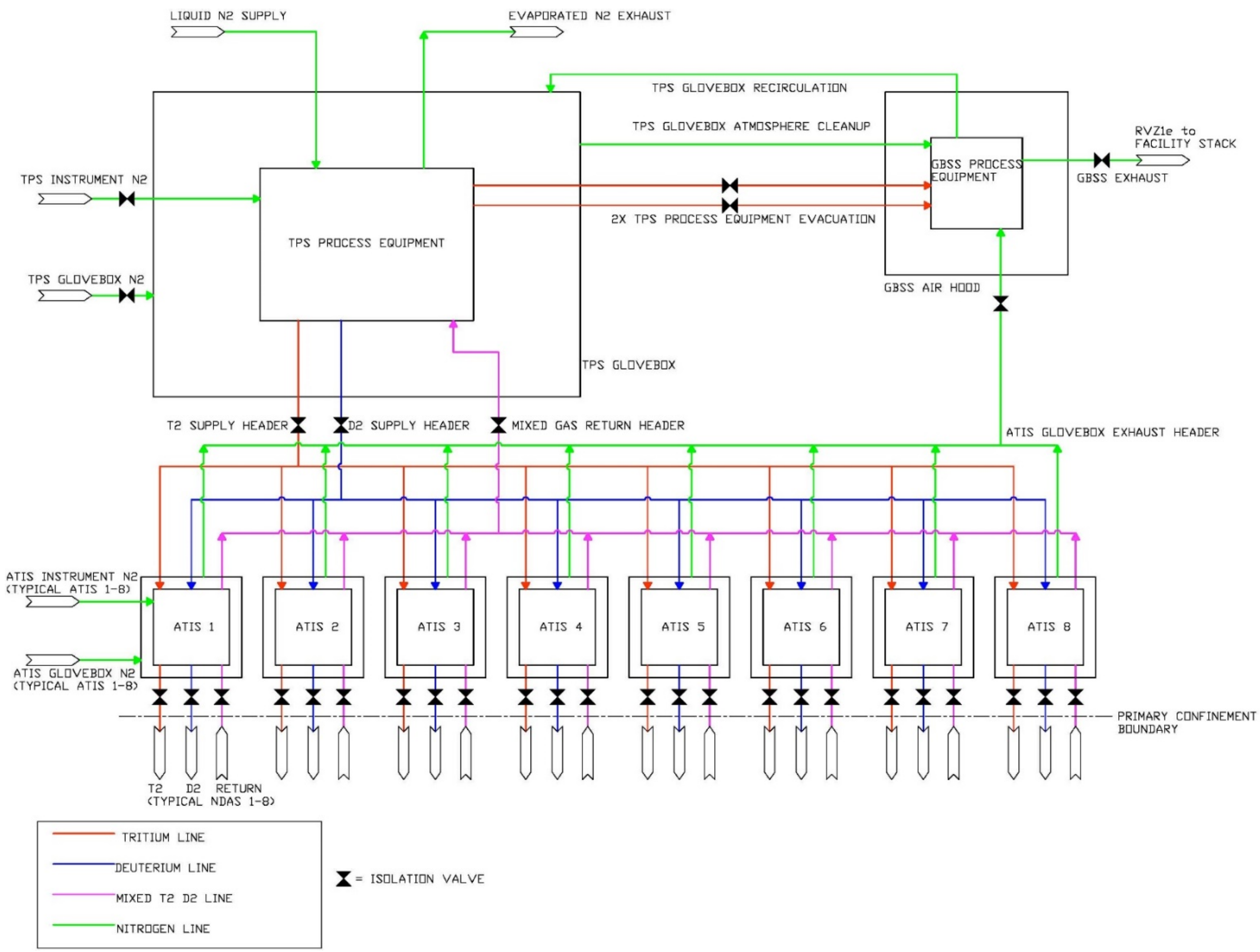
Component	Description	Design/Fabrication Code or Standard
Tritium purification system (TPS) glovebox	The TPS glovebox provides a secondary confinement barrier that prevents tritium leakage from isotope separation process equipment from releasing to the facility	AGS-G001-2007 is considered as guidance for the design of the glovebox. (AGS, 2007)
Accelerator TPS (ATIS) gloveboxes	The ATIS gloveboxes provide a secondary confinement barrier for interface equipment located [ ][SRI] that minimizes tritium leakage from TPS/neutron driver assembly system (NDAS) interface process equipment from releasing to the facility	AGS-G001-2007 is considered as guidance for the design of the glovebox. (AGS, 2007)
Impurity removal bed	The impurity removal bed captures trace impurities from the TPS process to prevent impurities from reaching the isotope separation columns	Note (a)
Thermal cycling adsorption process (TCAP) columns	The TCAP columns are a palladium-based column and a molecular sieve column that are thermally cycled to isotopically separate tritium and deuterium	Note (a)
TPS tritium cleanup catalytic recombiners	The TPS tritium cleanup catalytic recombiners oxidize trace tritium from the glovebox atmosphere so that it may be captured on the cleanup system molecular sieve beds	Note (a)
TPS tritium cleanup molecular sieve bed	The TPS molecular sieve beds capture tritiated water to reduce tritium released to the facility ventilation	Note (a)
TPS isolation valves	TPS isolation valves are located on process lines to provide confinement in conjunction with the TPS glovebox and IU cells in the event a radiological release is detected in the IU cell or central TPS glovebox	Note (a)

(a) Commercially available equipment designed to standards satisfying system operation.

Table 9a2.7-4 – NDAS Service Cell Interfaces

Interfacing System	Interface Description
Neutron driver assembly system (NDAS)	The NDAS service cell (NSC) supports the NDAS maintenance and testing needs.
Normal electrical power supply system (NPSS)	The NPSS provides power to NSC equipment to support testing of an NDAS.
Radioisotope process facility cooling system (RPCS)	The RPCS provides cooling water to the NDAS cooling cabinet associated with the NSC to support testing of an NDAS.
Radiological ventilation zone 2 (RVZ2)	The NSC is open to RVZ2 air and exhausts to RVZ2 exhaust (RVZ2e). RVZ2 will receive heat rejected by NSC equipment.

Figure 9a2.7-1 – TPS Process Flow Diagram



9a2.8 REFERENCES

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9b RADIOISOTOPE PRODUCTION FACILITY AUXILIARY SYSTEMS

9b.1 HEATING, VENTILATION, AND AIR CONDITIONING SYSTEMS

The heating, ventilation, and air conditioning (HVAC) systems for the SHINE facility are common to the irradiation facility (IF) and the radioisotope production facility (RPF). The SHINE facility HVAC systems are described in Section 9a2.1.

9b.2 HANDLING AND STORAGE OF TARGET SOLUTION

9b.2.1 TARGET SOLUTION LIFECYCLE

This section addresses the lifecycle of the target solution from the time that it enters the jurisdiction of the SHINE facility until it is released from such jurisdiction.

Target solution is a low-enriched, uranyl sulfate solution that is prepared by converting solid uranium oxide into the uranyl sulfate solution using the target solution preparation system (TSPS). Low enriched uranium (LEU) is received by the uranium receipt and storage system (URSS) as either uranium metal or uranium oxide. If metal is received, the URSS converts the metal to uranium oxide, as described in Subsection 4b.4.2. After preparation, the target solution is held in the target solution preparation tank until it is transferred to the target solution staging system (TSSS) and loaded into the target solution vessel (TSV) from the TSSS for an irradiation cycle. After irradiation is complete, the irradiated target solution is transferred to the molybdenum extraction and purification system (MEPS) where molybdenum is separated from the target. Following processing in MEPS, the target solution may be delivered to the TSSS for storage or another irradiation cycle, to the radioactive liquid waste storage (RLWS) system for disposal, or to the iodine and xenon purification and packaging (IXP) system for separation of iodine and xenon isotopes as products. At the end of its lifecycle as target solution, the uranyl sulfate solution is transferred to the RLWS. In the RLWS, the uranyl sulfate solution is blended with other waste streams and held in storage until it is ready to be solidified by the radioactive liquid waste immobilization (RLWI) system. Solidified wastes are transferred to the material staging building for preparation for shipment off-site.

The chemical properties of the target solution are described in Subsection 4a2.2.1.

Detailed descriptions of the processes involving irradiated and unirradiated special nuclear material (SNM) are provided in Subsection 4b.4.1 and Subsection 4b.4.2, respectively. Equipment, application of administrative controls, and the design features involved in the SNM lifecycle are included in this section.

Section 12.8 provides a discussion of the physical security of the SNM. Section 4b.2 provides a discussion of the shielding requirements associated with irradiated target solution. Section 5a2.2 provides a description of the primary closed loop cooling system (PCLS), which is used to remove heat from the TSV and neutron multiplier during irradiation of the target solution. Chapter 13 provides the accident analysis accident analysis of the SHINE facility, including those scenarios related to the storage and handling of target solution. Detailed discussions of radiological considerations related to the handling and storage of target solution are provided in Section 11.1.

9b.2.2 RECEIPT AND STORAGE OF UNIRRADIATED SNM

The URSS receives, handles, and stores unirradiated uranium. The URSS facilitates the sampling of received SNM and converts uranium metal to uranium oxide prior to its use in TSPS. Uranium is stored in canisters placed on racks designed for criticality safety. Subsection 6b.3.2 provides information on criticality safety controls for receipt and storage of uranium.

A detailed description of the URSS is provided in Subsection 4b.4.2.1.

9b.2.3 TARGET SOLUTION PREPARATION

The TSPS converts uranium oxide into a uranyl sulfate solution for use as a target solution batch or as makeup solution. Uranium is transferred from the URSS and imported into the TSPS glovebox for dispensation into the dissolution tanks. After conversion to uranyl sulfate in the dissolution tank, the uranium solution is pumped to the target solution preparation tank for storage until it is needed for an irradiation cycle or as makeup solution.

A detailed description of the TSPS is provided in Subsection 4b.4.2.2.

9b.2.4 TARGET SOLUTION STAGING SYSTEM

Target solution batches prepared for irradiation are transferred from the TSPS to the TSSS. The TSSS consists of target solution hold tanks and target solution storage tanks. Target solution hold tanks stage the target solution for transfer into the primary system boundary (PSB). Target solution storage tanks provide additional storage capacity for the facility. Tanks in the TSSS can receive target solution discharged from processes in the hot cells. The target solution may be sampled from each tank.

A detailed description of the TSSS is provided in Subsection 4b.4.1.1.

9b.2.5 VACUUM TRANSFER SYSTEM

The vacuum transfer system (VTS) provides the transport of radioactive liquids, including target solution, throughout the radioisotope production facility (RPF). The VTS operates by applying vacuum to an intermediary lift tank or directly to a destination tank. The VTS also provides vacuum service to RPF systems.

9b.2.5.1 Design Bases

The VTS is designed to:

- Prevent inadvertent criticality in accordance with the criticality safety evaluation.
- Relieve the system to atmospheric pressure upon actuation of the engineered safety features actuation system (ESFAS) to terminate transfers of target solution.

9b.2.5.2 System Description

The VTS consists of vacuum pumps, a knockout pot, vacuum lift tanks, and associated piping components and instrumentation. Process piping and pipe components are designed to meet the requirements of ASME B31.3, Process Piping (ASME, 2013).

VTS transfers liquid by one of the two following distinct methods:

- The first method moves liquid in batches via small volume tanks. These tanks are collectively named lift tanks. In the VTS, a vacuum is drawn on the knockout pot by a set of vacuum pumps, which discharge to the process vessel vent system (PVVS) for off-gas treatment. Solution transfers occur by aligning a vacuum lift tank with the knockout pot. Vacuum is applied to the lift tank, and solution flows from the source tank. Once the vacuum lift tank level setpoint is reached, the lift tank is isolated from the knockout pot and the lift tank is vented to atmosphere. Once pressure is equalized, the solution may be drained, pumped from the lift tank, or transferred to a second stage of lift tanks for additional elevation gain. Liquid transfers using vacuum lift tanks in the RPF are identified in Table 9b.2-1.

- The second method facilitates solution transfers without using a vacuum lift tank. Vacuum from the knockout pot is applied directly to the selected destination tank, and valves in the pathway between the source tank and destination tank are aligned to allow flow. This method is typical for transfers in the RLWS system, the RLWI system, and between laboratory scale processes that are part of the isotope separation process. Direct liquid transfers between tanks facilitated by VTS are identified in Table 9b.2-2.

The VTS provides an interface for sampling of solution in the target solution hold tanks, target solution storage tanks, RLWS system tanks, and the radioactive drain system (RDS).

The VTS is the only system used to transport SNM between the RPF and IF. A description of the process used to fill the TSV is provided in Subsection 4a2.6.1. The VTS is one of the systems used to transport solutions of SNM or byproduct material in the RPF. The other systems used to transport solutions containing SNM or byproduct material in the RPF are TSPS, MEPS, IXP, and the RLWI system, which use pumps to provide the motive force to transport the solutions.

Table 9b.2-3 identifies the systems which interface with the VTS.

Figure 9b.2-1 provides a process flow diagram of the VTS.

9b.2.5.3 Instrumentation and Controls

Temperature of solution in the source tank is monitored prior to a transfer to ensure that the transfer does not induce the solution to flash in the pipe. Level of each vacuum lift tank is also monitored to allow the process integrated control system (PICS) to control each transfer. Automatic flow shut-off valves and liquid detection instruments are provided in the VTS to prevent solution from entering the knockout pot. On detection of liquid by these instruments, ESFAS actuates valves that act as vacuum breakers on the knockout pot and trips the breakers on the vacuum pumps, terminating solution transfers. The knockout pot drains to favorable geometry tanks in the RLWS system in the event of high-level alarm. ESFAS also trips the vacuum breaking valves and pump on detection of high radiation in radiological ventilation zone 1 (RVZ1) or on level detection in the RDS. A detailed description of the ESFAS is provided in Section 7.5.

9b.2.5.4 Safety Analysis

The VTS is a safety-related system. The VTS structural framework and pipe supports are designed to withstand design basis seismic events. The VTS is classified as Seismic Category I. The design of the VTS includes provisions that ensure that a failure of the system will not adversely affect the functional performance of safety-related systems or components.

Chapter 13 provides additional discussion of potential accident scenarios involving the VTS.

9b.2.5.5 Criticality Control Features

Criticality safety controls for the VTS are described in Subsection 6b.3.2.5.

9b.2.5.6 Shielding and Radiological Protection

VTS equipment is located in the hot cells and shielded in below-grade vaults. Piping that may contain radiological materials is routed through shielded pipe chases to limit the exposure of individuals to radiation.

Section 11.1 provides a description of the radiation protection program, and Section 4b.2 provides a detailed description of the production facility biological shield (PFBS).

9b.2.5.7 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also applicable to, and may be used for the bases that are described in the technical specifications.

9b.2.6 RADIOACTIVE LIQUID WASTE STORAGE

Liquid wastes from the isotope production processes may contain SNM. These liquids are drained from the hot cells to the first favorable geometry uranium waste tank in the RLWS system. Once the liquid waste is verified to be below administrative limits, it is transferred to the second uranium waste tank where it is sampled again prior to sending to the liquid waste blending tanks for additional storage time. Target solution batches are disposed of through the RLWS system. Once a batch is designated for disposal, it is transferred to the RLWS system to be blended with other wastes.

A detailed description of the RLWS system is provided in Subsection 9b.7.4.

9b.2.7 RADIOACTIVE LIQUID WASTE IMMOBILIZATION

Liquid wastes in the RLWS system are solidified by the RLWI system. Liquid wastes in the RLWS system may contain SNM. Solutions are transferred to the RLWI system by the VTS from the RLWS system. In the RLWI system, solution may be [ ]PROP/ECI to remove isotopes that impact waste classification (e.g., Sr-90, Cs-137). Liquids are solidified in drums pre-filled with immobilization agents. The cured waste drums are handled by the solid radioactive waste packaging (SRWP) system upon removal from the RLWI system.

A detailed description of the RLWI system is provided in Subsection 9b.7.3.

9b.2.8 SOLID WASTE PACKAGING AND SHIPMENT

The solid radioactive waste packaging (SRWP) system collects, segregates, and stages solids wastes for shipment. A detailed description of the SRWP system is provided in Subsection 9b.7.5.

Solidified drums from the RLWI system are transported to the material staging building prior to shipment off site. These wastes may contain SNM.

Isotope separation columns may also contain adsorbed SNM. The columns are loaded into drums and placed in bore holes for storage within the RPF. After storage, the drums are transported to the material staging building prior to shipment off site.

9b.2.9 CRITICALITY CONTROL

Inadvertent criticality is prevented in RPF systems involved in the processing of fissile materials through the application of the nuclear criticality safety program, described in Section 6b.3.

Table 9b.2-1 – Liquid Transfers Using Vacuum Lift Method

Lift	Description
Target solution vessel (TSV) dump tank to molybdenum extraction and purification system (MEPS)	Target solution is transferred from the TSV dump tank to the MEPS using two stages of lift tanks. Extraction lower lift tanks and extraction upper lift tanks. Extraction lower lift tanks are located in hold tank valve pits and extraction upper lift tanks are located in the extraction hot cells.
Target solution hold tank to TSV	Target solution is transferred from the target solution hold tank to the TSV via the TSV fill lift tank. A dedicated TSV fill lift tank is provided for each irradiation unit (IU) cell. Excess target solution in the lift tank when the TSV fill has been completed is drained back to the target solution hold tank.
Between target solution staging system (TSSS) tanks	Target solution may be transferred between TSSS tanks using the target solution storage lift tank. The target solution storage lift tank is located in one of the extraction hot cells.
TSSS tanks to first uranium liquid waste tank	Target solution may be transferred from a TSSS tank to the first uranium liquid waste tank using the liquid waste lift tank. The liquid waste lift tank is located in one of the extraction hot cells.
First uranium liquid waste tank to target solution storage tank	Solution may be transferred from the first uranium liquid waste tank to a target solution storage tank using the liquid waste lift tank. The liquid waste lift tank is located in one of the extraction hot cells.
Between uranium liquid waste tanks	Liquid waste is transferred between the uranium liquid waste tanks using the liquid waste lift tank. The liquid waste lift tank is located in one of the extraction hot cells.
Radioactive drain system (RDS) sump tank to first uranium liquid waste tank	Liquid in the RDS sump tank may be transferred to a target solution storage tank using a two-stage lift through the RDS lower lift tank and the liquid waste lift tank. The RDS lower lift tank is located in one of the RDS sump tank vaults and the liquid waste lift tank is located in one of the extraction hot cells.
RDS sump tank to target solution storage tank	Liquid in the RDS sump tank may also be transferred to a target solution storage tank using a two-stage lift through the RDS lower lift tank and liquid waste lift tank. The RDS lower lift tank is located in one of the RDS tank vaults and the liquid waste lift tank is located in one of the extraction hot cells.

Table 9b.2-2 – Direct Transfer of Liquid via Application of Vacuum to Destination Tank

Lift	Description
Second uranium liquid waste tank to liquid waste blending tanks	Liquid waste from the second uranium liquid waste tank is transferred to one of the liquid waste blending tanks by applying vacuum to the destination blending tank.
Between liquid waste collection tanks	Liquid waste is transferred between the liquid waste collection tanks by applying vacuum to the destination collection tank.
Liquid waste collection tanks to liquid waste blending tanks	Liquid waste from the liquid waste collection tanks is transferred to the liquid blending tanks by applying vacuum to the destination blending tank.
Between liquid waste blending tanks	Liquid waste is transferred between the liquid waste blending tanks by applying vacuum to the destination blending tank.
Liquid waste blending tanks to immobilization feed tank	Liquid waste is transferred directly from a liquid waste blending tank to the immobilization feed tank by applying vacuum to the immobilization feed tank.
Other vacuum service provided by VTS	The VTS is used to provide vacuum service to the molybdenum extraction and purification system (MEPS) and the target solution vessel (TSV) off-gas system (TOGS) as needed. The VTS is also used to provide sampling capability to the target solution staging system (TSSS) and the radioactive liquid waste storage (RLWS) system via the target storage lift tank, liquid waste lift tank, and dedicated sampling lines.

Table 9b.2-3 – Vacuum Transfer System Interfaces
(Sheet 1 of 2)

Interfacing System	Interface Description
Molybdenum extraction and purification system (MEPS)	The VTS transfers target solution to MEPS for molybdenum extraction and provides vacuum service for the rotary evaporator and purification equipment. MEPS reduces load of evolved vapors within the system to VTS to reduce corrosion.
Process vessel vent system (PVVS)	The VTS discharges gases from the vacuum pumps to the PVVS. The PVVS provides ventilation to VTS vacuum lift tanks when they are not lifting.
Normal electrical power supply system (NPSS)	Electrical power is provided to the vacuum pumps and ancillary equipment by NPSS.
Radioactive liquid waste storage (RLWS) system	The VTS interfaces with the RLWS in several locations. Solutions are transferred between the tanks using both a vacuum lift tank and by direct connections to VTS.
Target solution staging system (TSSS)	The VTS transfers solutions from the target solution hold tanks to the target solution vessel (TSV). Solutions are also transferred between the TSSS tanks and from TSSS to the RLWS by VTS.
Radioactive liquid waste immobilization (RLWI) system	Vacuum service is provided to the RLWI feed tank to transfer solution from the RLWS.
Radioactive drain system (RDS)	The VTS is used to remove solution from the RDS sump tanks and transfers it to either RLWS or TSSS.
TSV off-gas system (TOGS)	The VTS provides a source of vacuum to the TOGS.
Facility chemical reagent system (FCRS)	FCRS pumps solutions into vacuum lift tanks in the hot cell to introduce reagents to the RPF processes.
Nitrogen purge system (N2PS)	The N2PS injects sweep gas into the vacuum lift tanks to mitigate hydrogen accumulation during a PVVS failure.
Engineered safety features actuation system (ESFAS)	The ESFAS actuates vacuum relief functions of the VTS on detection of high level to prevent an inadvertent criticality or on high radiation to minimize source inventory at risk in the spill location.
Process integrated control system (PICS)	PICS allows operators to monitor VTS parameters and control process functions.
Iodine and xenon purification and packaging (IXP)	The VTS provides vacuum service to IXP for liquid transfers between components within the IXP.
Production facility biological shield (PFBS)	The VTS components with radiological inventories are within a hot cell or shielded, below-grade vaults to minimize worker doses.

Table 9b.2-3 – Vacuum Transfer System Interfaces
(Sheet 2 of 2)

Interfacing System	Interface Description
Subcritical assembly system (SCAS)	The TSV fill lift tank provides target solution to the TSV via gravity drain. The VTS provides transfer of target solution from the TSV dump tank to the MEPS. The VTS drains excess target solution in the TSV fill lift tank, not transferred to the TSV during filling, back to the target solution hold tank.
Molybdenum isotope packaging system (MIPS)	The VTS provides vacuum service to the MIPS for shipping package leak detection.

Figure 9b.2-1 – Vacuum Transfer System Process Flow Diagram (Sheet 1 of 6)

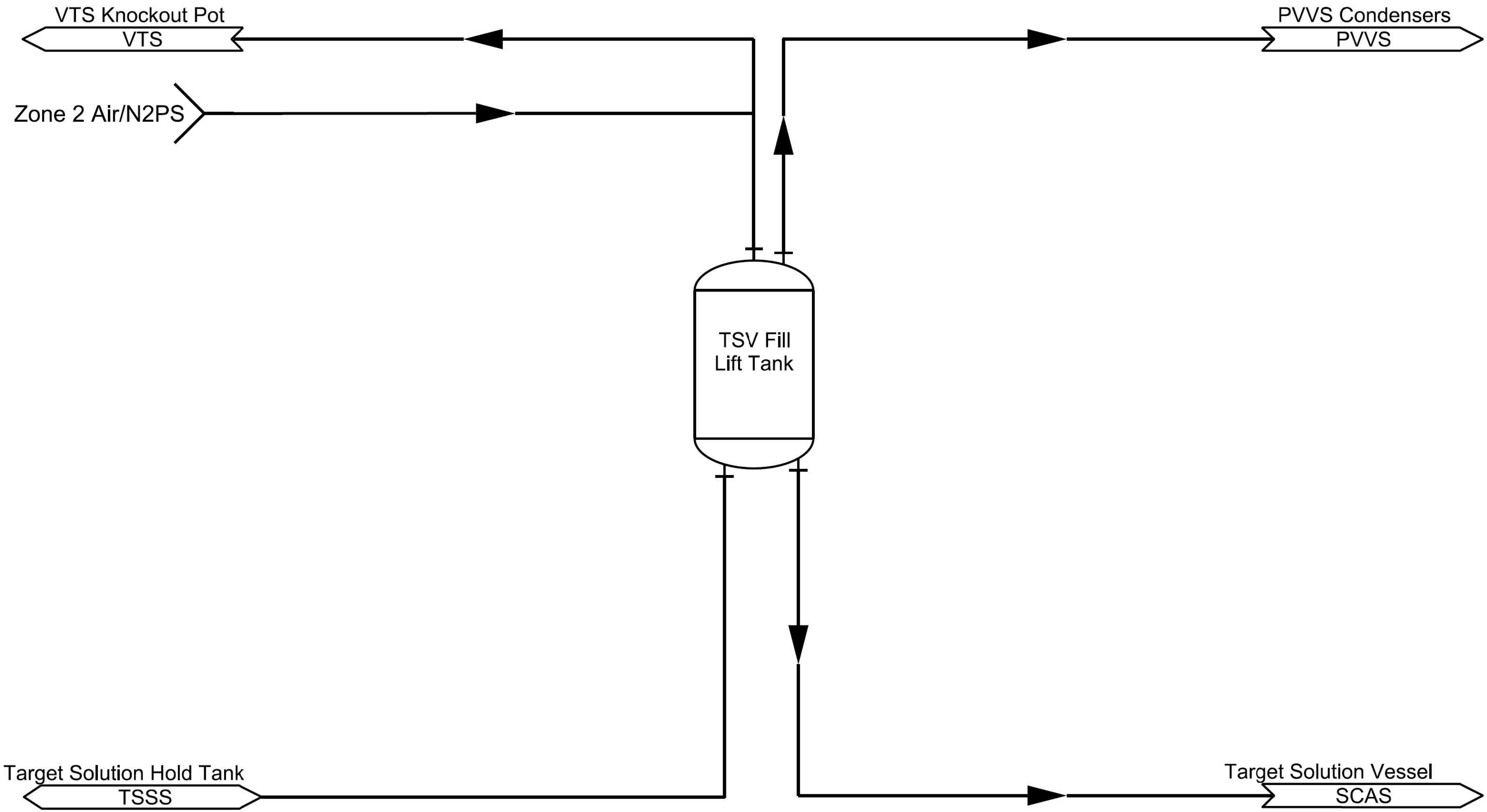


Figure 9b.2-1 – Vacuum Transfer System Process Flow Diagram (Sheet 2 of 6)

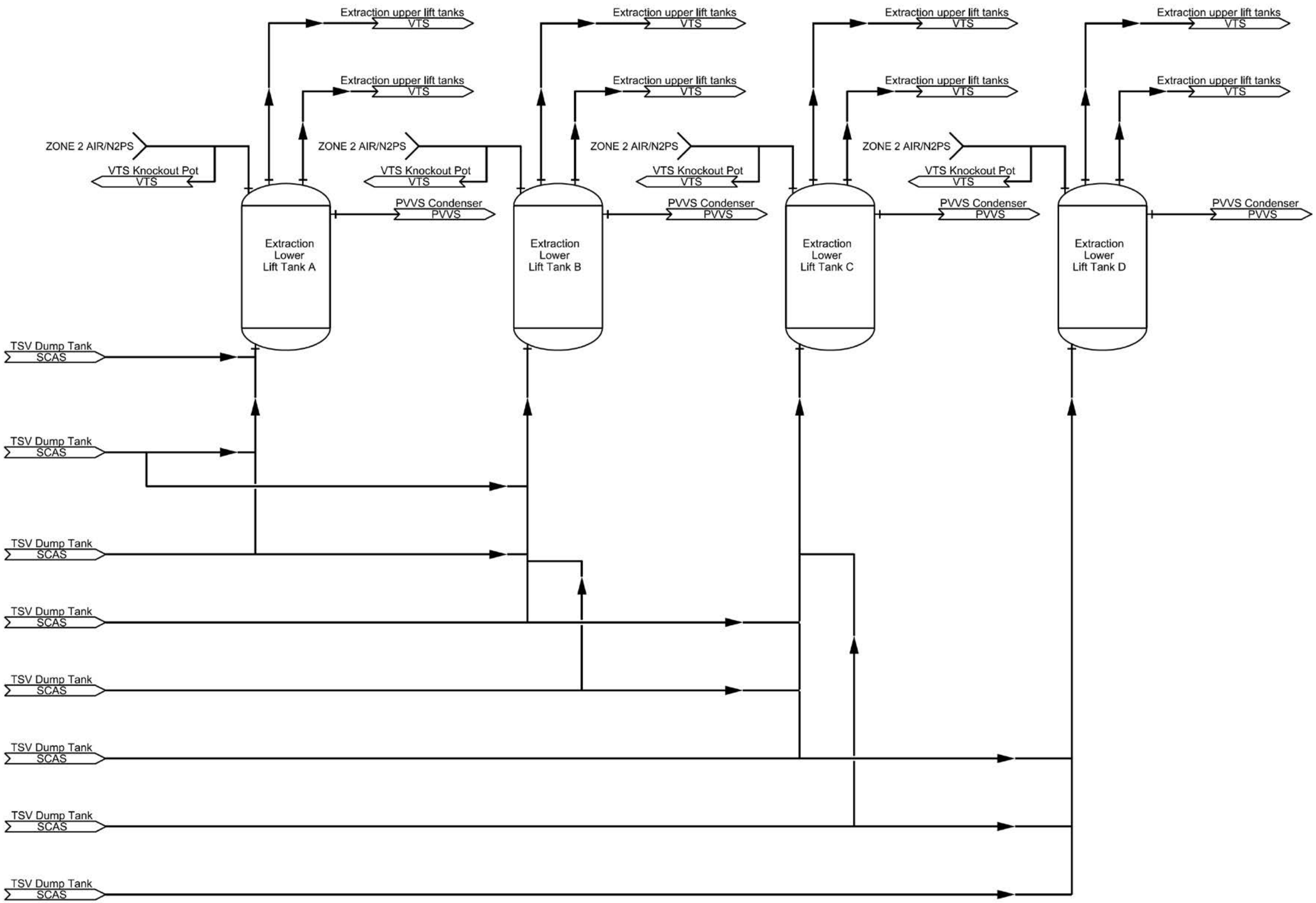


Figure 9b.2-1 – Vacuum Transfer System Process Flow Diagram (Sheet 3 of 6)

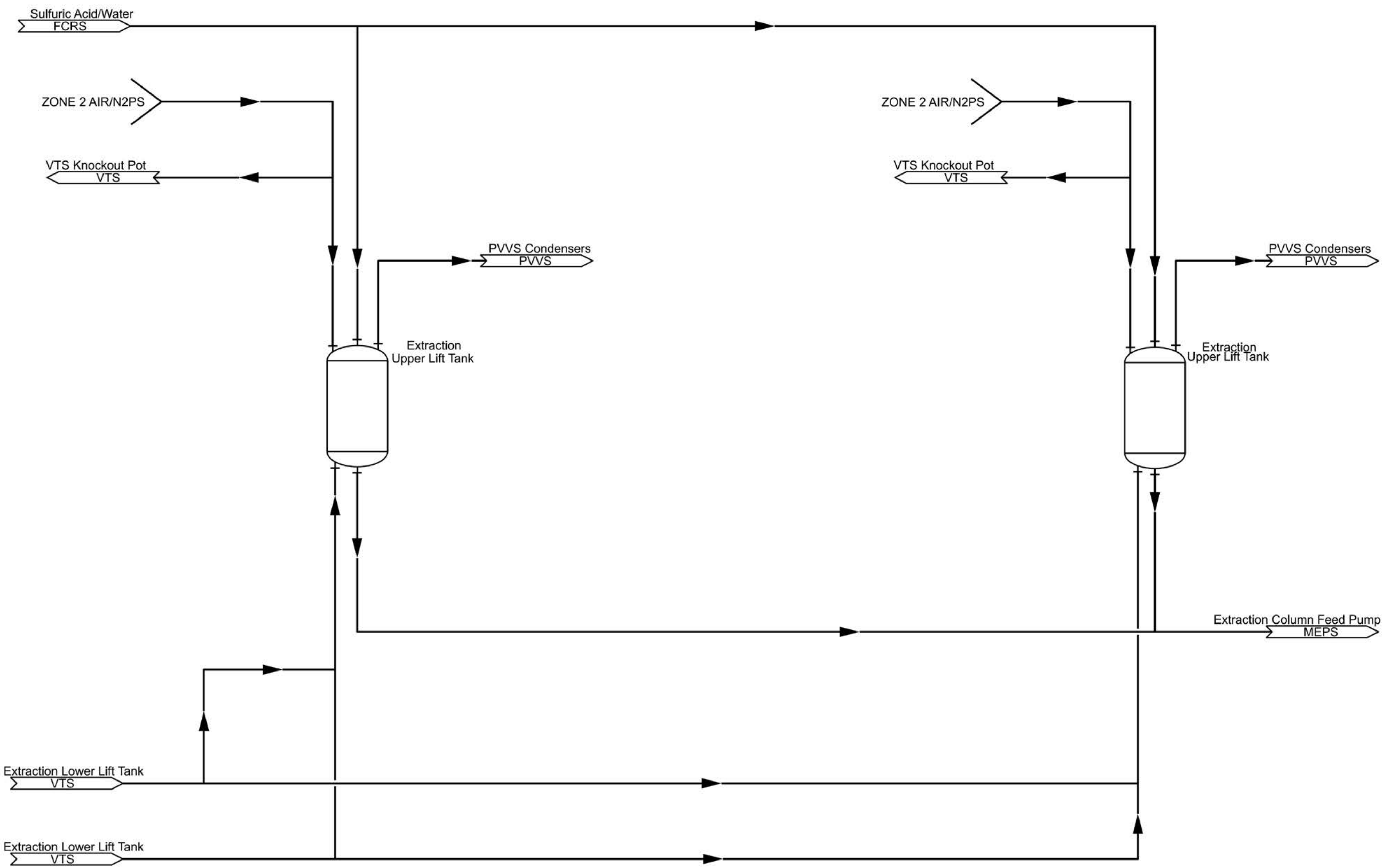


Figure 9b.2-1 – Vacuum Transfer System Process Flow Diagram
(Sheet 4 of 6)

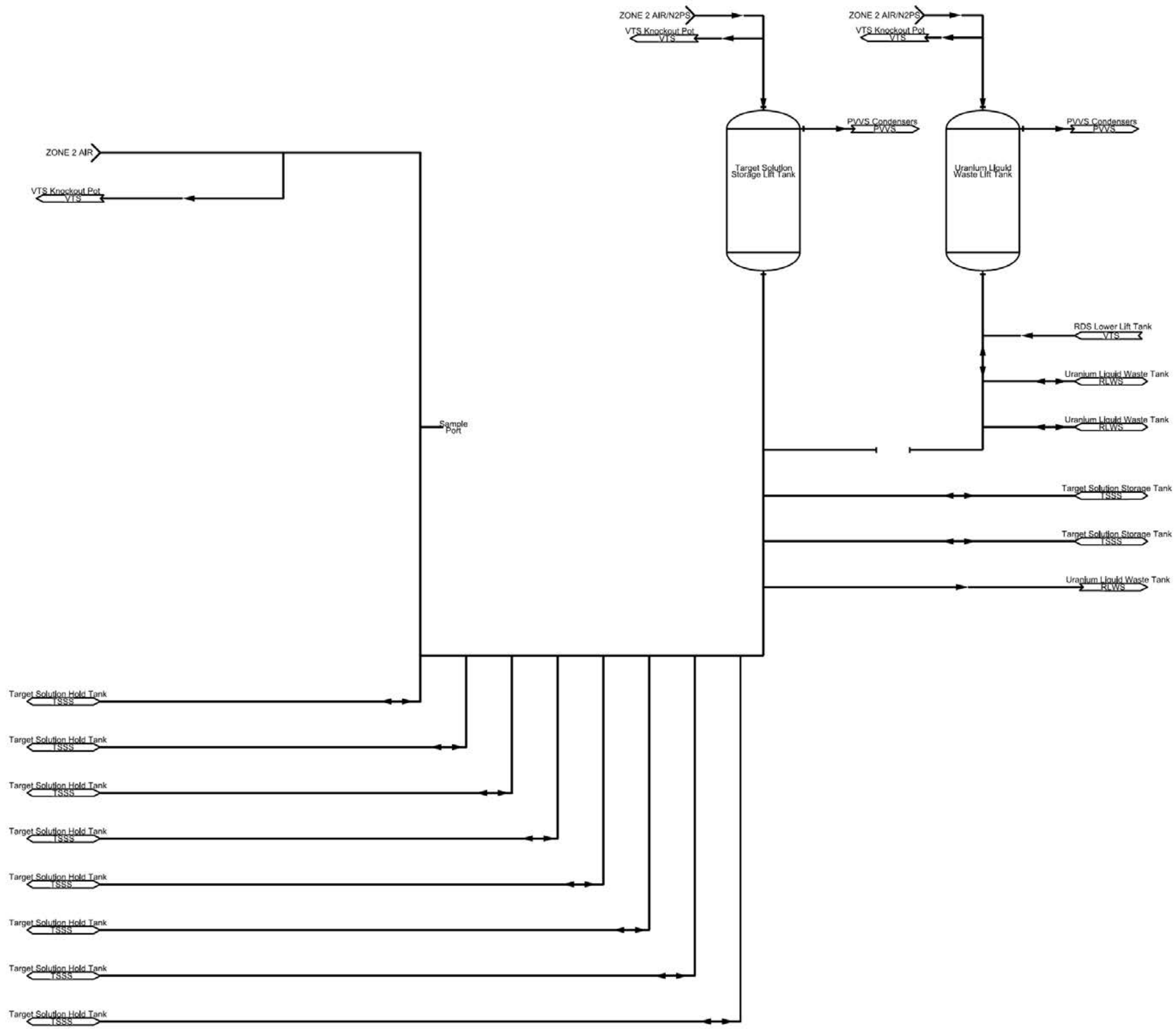


Figure 9b.2-1 – Vacuum Transfer System Process Flow Diagram
(Sheet 5 of 6)

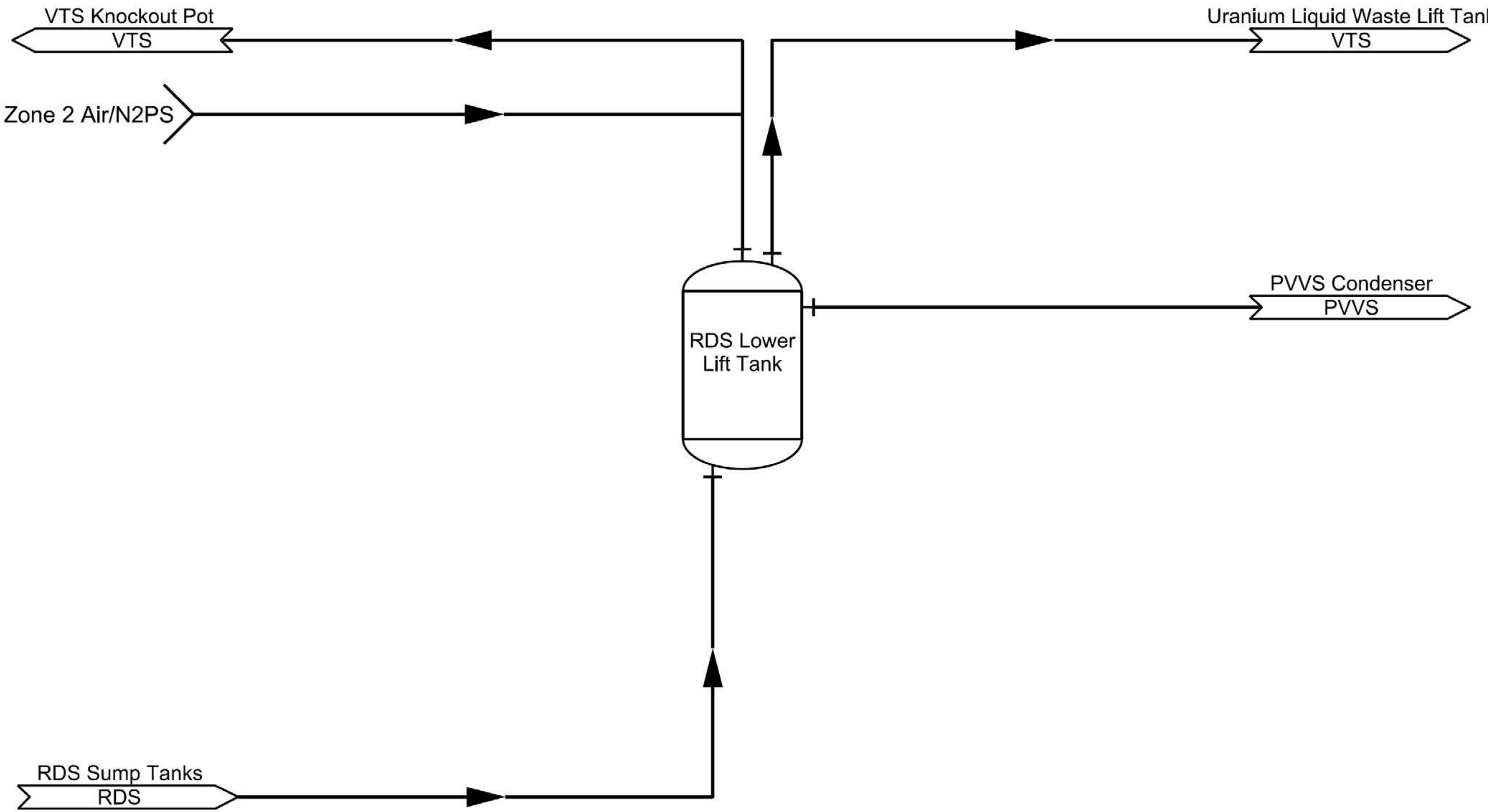
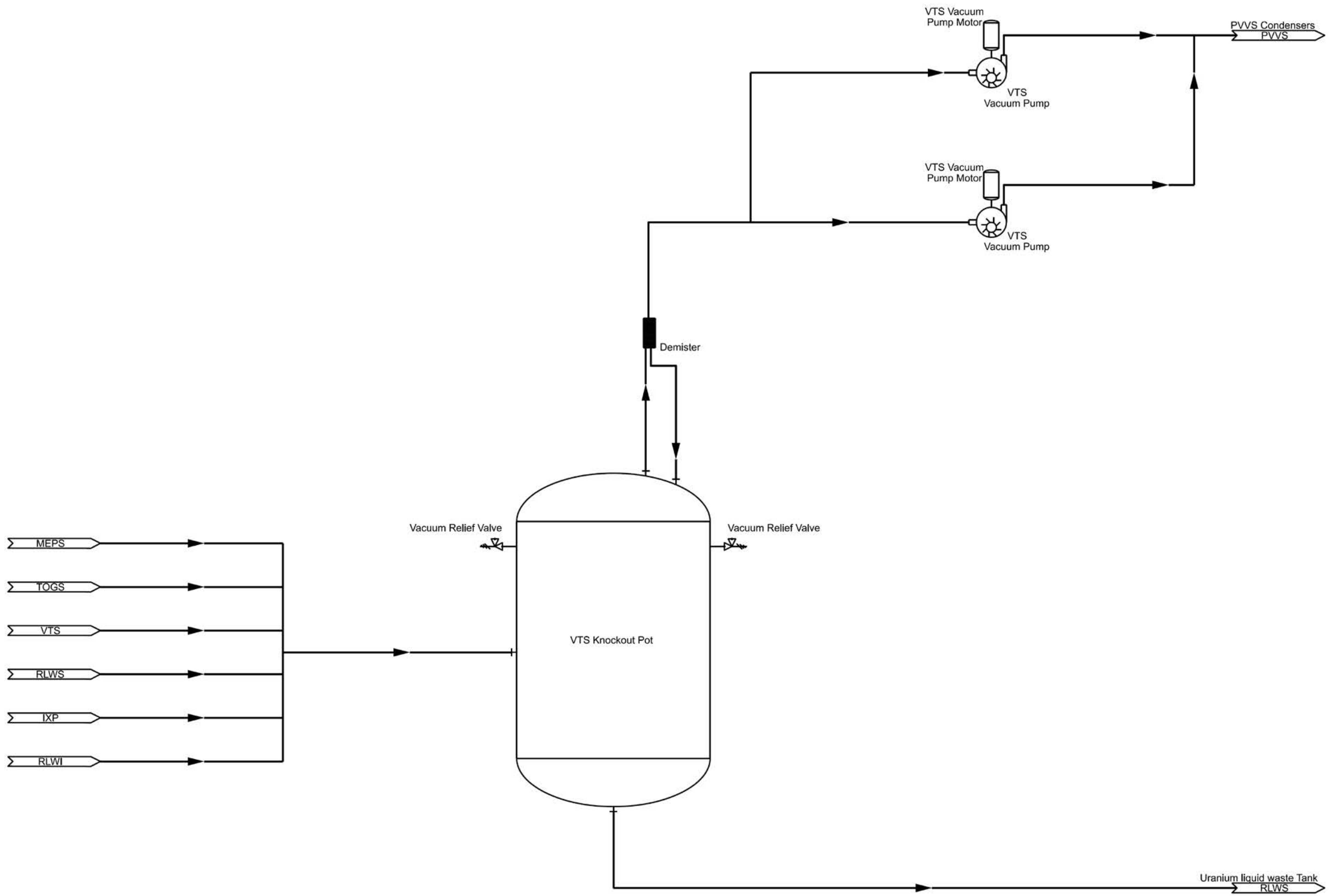


Figure 9b.2-1 – Vacuum Transfer System Process Flow Diagram (Sheet 6 of 6)



9b.3 FIRE PROTECTION SYSTEMS AND PROGRAMS

The fire protection system and program for the SHINE facility are common to the irradiation facility (IF) and radioisotope processing facility (RPF). The SHINE fire protection system and program are described in Section 9a2.3.

9b.4 COMMUNICATION SYSTEMS

The communication systems for the SHINE facility are common to the irradiation facility (IF) and radioisotope production facility (RPF). The SHINE facility communication systems are described in Section 9a2.4.

9b.5 POSSESSION AND USE OF BYPRODUCT, SOURCE, AND SPECIAL NUCLEAR MATERIAL

This section applies to the possession and use of byproduct, source, and special nuclear material (SNM) in the radioisotope production facility (RPF). The possession and use of byproduct, source, and SNM within the irradiation facility (IF) is described in Section 9a2.5.

The RPF is designated as a radiologically controlled area (RCA) as shown in Figure 1.3-1. Radiation Protection Program controls and procedures, including the as low as reasonably achievable (ALARA) Program, applicable to the RPF, are described in Section 11.1. Radioactive waste management is discussed in Section 11.2. A discussion of the Security Plan is provided in Section 12.8. Details of the Emergency Plan are described in Section 12.7. Fire protection details applicable to the RPF are described in Section 9a2.3. Technical Specifications include limits that apply to the possession, management, and use of byproduct, source, and SNM.

The SHINE facility design and procedures ensure that personnel exposures to radiation, including ingestion or inhalation, do not exceed limiting values in 10 CFR 20 and are consistent with the ALARA Program, as described in Section 11.1.

9b.5.1 BYPRODUCT MATERIAL

The SHINE facility is designed to generate byproduct materials (e.g., molybdenum-99) for use as medical isotopes. Byproduct materials within the RPF include fission and activation products generated during irradiation unit (IU) operations. Target solution, containing byproduct and SNM, is transferred from the IF to the RPF for processing. Specific byproduct materials are separated (e.g., molybdenum, iodine) from the irradiated target solution as described in Subsection 4b.3.1.

The systems in which byproduct material may be present in the RPF include:

- The radioactive drain system (RDS), as described in Subsection 9b.7.6. The RDS contains radioactive liquids which contain byproduct materials collected in the event of a leak, spill, or overflow, and routes these liquids to a controlled location.
- The radioactive liquid waste storage (RLWS) system, as described in Subsection 9b.7.4. The RLWS system provides receipt, mixing, and storage for aqueous radioactive wastes containing byproduct materials generated by processing operations within the RCA.
- The radioactive liquid waste immobilization (RLWI) system, as described in Subsection 9b.7.3. The RLWI immobilizes liquid radioactive wastes which contain byproduct materials generated by processing operations within the RCA.
- The process vessel vent system (PVVS), as described in Subsection 9b.6.1. The PVVS collects and treats off-gases containing byproduct materials from each RPF tank containing irradiated solutions, VTS vacuum pump discharge, and from the target solution vessel (TSV) off-gas system (TOGS).
- The molybdenum isotope product packaging system (MIPS), as described in Subsection 9b.7.1. The MIPS receives finished products (e.g., molybdenum-99, iodine-131, xenon-133) in their product bottles and places them in the applicable shipping container.
- The solid radioactive waste packaging (SRWP) system, as described in Subsection 9b.7.5. The SRWP system packages solid waste containing byproduct materials for shipment and disposal.

- The quality control and analytical testing laboratories (LABS), as described in Subsection 9b.5.4. The LABS analyze samples containing byproduct materials taken from various locations throughout the SHINE process.
- The target solution staging system (TSSS), as described in Subsection 4b.1.3.5. The TSSS is a set of tanks and piping used to provide staging and storage of irradiated target solution containing byproduct materials.
- The vacuum transfer system (VTS) as described in Subsection 9b.2.5. The VTS provides transfer of radioactive liquids containing byproduct materials throughout the RPF and also provides vacuum service to the MIPS and the TOGS.
- The molybdenum extraction and purification system (MEPS) as described in Subsection 4b.3.1. The MEPS extracts molybdenum from irradiated target solution and prepares a concentrated form of molybdenum.
- The iodine and xenon purification and packaging (IXP) system as described in Subsection 4b.3.1. The IXP extracts iodine from an acidic solution following target solution irradiation.

The types and quantities of byproduct materials within the SHINE facility are discussed in Section 11.1.

9b.5.1.1 Byproduct Materials Extraction and Purification

Extraction and purification of byproduct materials occur in the MEPS and IXP. The MEPS and the IXP are described in Subsection 4b.3.1. The primary byproduct material separated in the MEPS is molybdenum-99. The primary byproduct materials separated in the IXP are iodine-131 and xenon-133. A batch of molybdenum-99 is up to [ ]PROP/ECI and up to 8 batches of molybdenum-99 may be produced a week. A batch of iodine-131 is up to [ ]PROP/ECI and up to 8 batches of iodine-131 may be produced a week. A batch of xenon-133 is up to [ ]PROP/ECI and up to 8 batches of xenon-133 may be produced a week.

9b.5.2 SOURCE MATERIAL

Source material is not normally possessed or used within the RPF. There is a potential for radioactive waste containing source material to be processed within the RPF. This may include IF components such as tritium storage beds (i.e., depleted uranium) or neutron multipliers. The types and quantities of source material within these components are described in Section 9a2.5. Radioactive waste management is discussed in Section 11.2.

9b.5.3 SPECIAL NUCLEAR MATERIAL

SNM in the RPF includes low enriched uranium (LEU) as well as plutonium generated in irradiated target solution located in systems throughout the RPF. The systems in which SNM may be present in the RPF are:

- The target solution preparation system (TSPS), as described in Subsection 4b.4.2. The TSPS is used to prepare LEU uranyl sulfate solution.
- The RDS, as described in Subsection 9b.7.6. The RDS contains liquids containing SNM collected in the event of a leak, spill, or overflow, and routes these liquids to a controlled location.

- The RLWS system, as described in Subsection 9b.7.4. The RLWS system provides receipt, mixing and storage for liquid radioactive wastes containing SNM generated by processing operations in the RCA.
- The RLWI system, as described in Subsection 9b.7.3. The RLWI system immobilizes liquid radioactive wastes containing SNM.
- The SRWP system, as described in Subsection 9b.7.5. The SRWP system packages solid waste containing SNM.
- The TSSS, as described in Subsection 4b.4.1.1. The TSSS is a set of tanks and piping used to provide staging and storage of LEU uranyl sulfate target solution.
- Uranium receipt and storage system (URSS), as described in Subsection 4b.4.2. The URSS provides for receipt and storage of LEU metal and LEU oxide and converts LEU metal to LEU oxide.
- The LABS, as described in Subsection 9b.5.4. The LABS analyze samples containing SNM taken from various locations throughout the SHINE process.
- The VTS, as described in Subsection 9b.2.5. The VTS provides transfer of radioactive liquids containing SNM throughout the RPF.
- The MEPS, as described in Subsection 4b.1.3.2. The MEPS extracts molybdenum from irradiated target solution. SNM is only present in significant quantities in MEPS while extraction of molybdenum is taking place.
- The IXP system, as described in Subsection 4b.1.3. The IXP system extracts iodine from an acidic solution following target solution irradiation. SNM is only present in significant quantities in IXP while extraction of iodine is taking place.

Up to 6600 lbs. (3000 kg) of LEU, representing the total inventory of LEU for the SHINE facility, is used in the RPF to support facility operations.

9b.5.4 QUALITY CONTROL AND ANALYTICAL TESTING LABORATORIES

The quality control and analytical testing laboratories (LABS) consist of the wet laboratory and the instrument laboratory. The LABS are located in the RPF.

9b.5.4.1 Design Basis

The LABS design basis is to provide analytical laboratory support relative to the production of molybdenum-99, iodine-131, xenon-133, qualification and production of target solution, and analysis of other process samples, as necessary. Analysis is used to determine: (1) enrichment, purity, and conversion of uranium; (2) identification, activity, concentration, and purity of molybdenum-99, iodine-131, and xenon-133 products; (3) process stream chemical and radionuclide analyses; and (4) chemical and radionuclide analysis for waste characterization and disposition.

9b.5.4.2 System Description

The LABS analyze samples taken from various locations throughout the SHINE process. The system processes samples using two adjacent laboratories designated the wet lab and the instrument lab which are further described below. The wet lab is used for sample preparation, and the instrument lab is used for sample analysis. The purpose of separating these two labs is to decrease the likelihood for cross-contamination and to protect the analytical instrumentation from exposure to environments that may impact calibration and accuracy.

Process and product samples are taken at the appropriate process locations. If necessary, samples are transported to the wet laboratory for preparation. When in the appropriate form for instrument laboratory analysis, samples are taken into the instrument laboratory and analyzed.

Table 9b.5-1 identifies the systems that interface with the LABS.

9b.5.4.2.1 Wet Laboratory

If necessary, samples are first prepared and manipulated in the wet laboratory where they are put in the appropriate chemical and radiochemical matrices for further analysis in the instrument lab. While in the wet laboratory, samples may undergo general radiochemical and chemical processing such as heating, cooling, concentration, dilution, separation, filtration, and precipitation. Basic analyses such as pH and density determination are performed in the wet laboratory.

9b.5.4.2.2 Instrument Laboratory

Detailed sample analysis takes place in the instrument laboratory. Examples of such analyses include isotopic identification, isotopic quantification, radionuclide identification, radionuclide quantification, elemental identification, elemental quantification, pH, and density determination.

9b.5.4.3 Operational Analysis and Safety Functions

The LABS perform no safety function.

The LABS maintain positive pressure relative to the normally occupied areas of the RPF. The LABS are maintained at an ambient temperature and humidity commensurate with equipment requirements, and are designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, and testing.

Personnel contamination monitors, dosimetry, and training pertaining to good radiochemical and health physics practices are incorporated into the LABS design. The wet laboratory and the instrument laboratory have the ability to shield samples, standards, and waste using moveable lead bricks or other custom shielding. The design of the LABS satisfies the applicable requirements of the Radiation Protection Program.

The LABS contain less than a combined 250 g of uranium at any given time in order to ensure criticality safety.

Analytical instruments in the LABS are appropriately qualified using installation, operational, and performance qualifications. Equipment calibrations are performed using standards traceable to certified standards, if existing. Records of calibrations are maintained. The current calibration status of equipment is known and verifiable. Instruments that do not meet calibration criteria are not used.

The LABS satisfy applicable requirements in the Chemical Hygiene Plan. A Chemical Hygiene Officer (CHO) oversees the effective implementation of the Chemical Hygiene Plan, in coordination with the Radiation Protection Manager. In addition to supervision and oversight of operations, SHINE will have a training program which emphasizes safety. The Chemical Hygiene Plan directs the use of protective equipment as appropriate.

An emergency safety shower as well as eyewash stations are provided in the wet laboratory and instrument laboratory. Each lab maintains a spill kit.

The wet laboratory and the instrument laboratory each have oxygen level sensors to detect decreased oxygen levels due to release of simple asphyxiant gas.

Table 9b.5-1 – Quality Control and Analytical Testing Laboratories System Interfaces (Sheet 1 of 2)

System	Interface Description
Vacuum transfer system (VTS)	The LABS provide sample analysis for samples collected using VTS.
Irradiation cell biological shield (ICBS)	The LABS provide sample analysis for ICBS.
Light water pool system (LWPS)	The LABS provide sample analysis for LWPS.
Primary closed loop cooling system (PCLS)	The LABS provide sample analysis for PCLS.
Subcritical assembly system (SCAS)	The LABS provide sample analysis for SCAS.
Target solution vessel (TSV) off-gas system (TOGS)	The LABS provide sample analysis for TOGS.
Radioactive liquid waste storage (RLWS) system	The LABS provide sample analysis for RLWS.
Radiological ventilation zone 2 (RVZ2)	- Provides an exhaust for the radiochemical fume hoods within the wet laboratory and the instrument laboratory. - Provides an exhaust for the product fume hood within the wet laboratory. - Provides an exhaust for the ICP-MS in the instrument laboratory. - Provides an exhaust for the ICP-OES in the instrument laboratory. - Maintains a positive pressure in the LABS compared to the normally occupied areas of the radiologically controlled area (RCA). - Maintains a temperature range and maximum rate of temperature change commensurate with equipment requirements in the LABS. - The LABS have the capability to analyze RVZ2r condensate for radionuclide concentration.
Normal electrical power supply system (NPSS)	NPSS provides the instrument and wet labs with electrical power commensurate with the requirements of the equipment in the LABS.

Table 9b.5-1 – Quality Control and Analytical Testing Laboratories System Interfaces (Sheet 2 of 2)

System	Interface Description
Facility demineralized water system (FDWS)	- The FDWS provides deionized water to the LABS for sample preparation. - The FDWS provides deionized water to each of the laboratory deionized water point of use locations. - The FDWS provides water to each emergency eyewash and shower located in the LABS.
Solid radioactive waste processing (SRWP) system	The SRWP system collects, transports, and packages for shipment solid radioactive waste from the LABS including, but not limited to, laboratory glassware, personal protective equipment, and immobilized liquid waste.
Process integrated control system (PICS)	The PICS monitors exhaust air flow rate from each fume hood and actuates a local alarm upon low flow conditions.
Stack release monitoring system (SRMS)	The LABS provide sample analysis for the SRMS.
Continuous air monitoring system	The LABS provide sample analysis for the CAMS.

9b.6 COVER GAS CONTROL IN THE RADIOISOTOPE PRODUCTION FACILITY

This section discusses radiolytic gas management systems located in the radioisotope production facility (RPF) that manage radioactive gases associated with SHINE facility processes.

9b.6.1 PROCESS VESSEL VENT SYSTEM

The process vessel vent system (PVVS) collects and treats the off-gases from processes in the SHINE facility. The PVVS collects off-gases from each RPF tank containing irradiated solutions, from the vacuum transfer system (VTS) vacuum pump discharge, and periodically from the target solution vessel (TSV) off-gas system (TOGS). The PVVS consists of acid adsorbers, carbon filters, high-efficiency particulate air (HEPA) filters, condensers, reheaters, carbon beds, and blowers which are employed to vent treated gases out of the radiologically controlled area (RCA). A description of system interfaces is provided in Table 9b.6-1.

9b.6.1.1 Design Bases

The design bases of the PVVS include:

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

9b.6.1.2 System Description

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

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

Condensate is collected in the PVVS condensate tank within the PVVS hot cell, located within the supercell. Condensate may be returned to the target solution staging system (TSSS) tanks as makeup water or to the radioactive liquid waste storage (RLWS) system for waste processing. An in-line heater, the PVVS reheater, downstream of the condenser heats the off-gas back to ambient temperature to reduce the relative humidity. The off-gas then flows through acid adsorber beds, HEPA filters, and the guard beds to neutralize entrained acid droplets or gases, filter particulates, and capture iodine. The gas flows from the hot cell to a below-grade, shielded vault, passing through a series of delay beds packed with carbon to delay the release of fission product noble gases such as xenon and krypton. A final set of HEPA filters removes any entrained carbon fines upstream of the blowers, and the treated gases are discharged to the facility stack.

In the event PVVS loses the capability to provide flow, the nitrogen purge system (N2PS) actuates nitrogen flow to the RPF tanks to mitigate hydrogen generation. Upon actuation of the N2PS, the isolation valves at the PVVS intake interface with ventilation zone 2 actuate closed to prevent nitrogen backflow. During the nitrogen purge, the PVVS equipment and piping continues to provide the flow path for the off-gas through the RPF. Safety-related bypasses are provided around filtration equipment in the hot cell that could contribute to a blocked pathway and an alternate, safety-related exhaust point to the roof is actuated open. The branch to the alternate release point is upstream of the PVVS blowers.

Fire protection is provided for the guard beds and delay beds. Temperature instrumentation and carbon monoxide detection are used to monitor for oxidation. The beds may be isolated or purged with nitrogen to smother the reaction. Additionally, operators can attempt to increase the system flow rate to increase convective cooling. The engineered safety features actuation system (ESFAS) automatically isolates an affected bed on high temperature in the carbon guard beds or high carbon monoxide in the carbon delay beds.

Principal components of the PVVS are identified in Table 9b.6-2.

A process flow diagram of the PVVS is provided in Figure 9b.6-1.

9b.6.1.3 Operational Analysis and Safety Function

The PVVS provides confinement of fission products to prevent release of radioactive material. The PVVS maintains hydrogen concentrations below the lower flammability limit (LFL) to preclude a hydrogen deflagration or detonation, as discussed in Subsection 9b.6.1.3.1. The PVVS passively reduces the concentration of radionuclides in the gaseous effluent to the facility stack, including during postulated transients, as discussed in Subsection 9b.6.1.3.2.

In addition to the above:

- Safety-related components in the PVVS remain functional during normal conditions, and during and following design basis events.
- Valves in PVVS fail to their designated safe position on loss of power.
- Redundant isolation capabilities are provided at confinement boundaries.

- Redundant isolation is provided for safety-related actuations.
- An open flow path through PVVS remains available during normal conditions, and during and following design basis events.
- PVVS components installed over, attached to, or adjacent to safety-related equipment are designed so as not to fail in such a way that is detrimental to the operation of safety-related equipment.

9b.6.1.3.1 Hydrogen Mitigation

Hydrogen is generated by radiolysis in the target solution and the byproduct solutions contained in the process tanks of the RPF, excluding the target solution preparation system (TSPS). Build-up of the hydrogen could result in a detonation or deflagration if the concentration exceeds the LFL. PVVS ventilates the RPF tanks to prevent build-up of hydrogen above LFL.

In the event of failure of the PVVS discharge blowers, the PVVS filtration equipment continues to process the sweep gas provided from N2PS through the tanks throughout the RPF. The quantity of sweep gas supplied is sufficient to maintain hydrogen concentration below the LFL. Under normal operation, the required quantity of sweep gas is induced into the process tanks by the suction from the PVVS blowers. In the event of failure of the PVVS blowers, the N2PS will provide the sweep gas flow, thereby maintaining the sweep gas component of the total PVVS flow.

9b.6.1.3.2 Iodine and Noble Gas Abatement

The systems and processes in the RPF release radioactive isotopes of iodine and noble gases from the target solution and from byproduct solutions. Gases discharged by TOGS from the primary system boundary, which contain noble gases and iodine, are also processed by the PVVS. The off-gas may also contain radioactive particulates such as cesium. HEPA filters are used to remove entrained particulates from the air flow. Carbon filters are used to capture iodine and carbon beds are employed to delay the release of xenon and krypton isotopes. The design ensures that 10 CFR 20 limits are met.

9b.6.1.4 Instrumentation and Control

Safety-related PVVS instrumentation has redundant channels and provides output to ESFAS. Nonsafety-related PVVS instrumentation provides output signals to the process integrated control system (PICS).

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

Redundant gas analyzers monitor the hydrogen concentration upstream of the guard beds. The gas analyzers are used to monitor the operation of the delay beds and to monitor carbon monoxide concentrations in the bed effluent.

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

Pressure instrumentation is provided to monitor performance of the HEPA filters.

9b.6.1.5 Radiological Protection and Criticality Control

PVVS processes are performed within the production facility biological shield (PFBS) hot cells and below-grade vaults, which supports compliance with the as low as reasonably achievable (ALARA) objectives and 10 CFR 20 dose limits. Section 11.1 provides a description of the radiation protection program, and Section 4b.2 provides a detailed description of the PFBS.

There are no credible mechanisms by which to create a criticality hazard in the PVVS. As described in Subsection 6b.3.1.6, there are no identified criticality safety controls for the PVVS.

9b.6.1.6 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also applicable to, and may be used for the bases that are described in the technical specifications.

9b.6.2 NITROGEN PURGE SYSTEM

The N2PS provides a backup supply of sweep gas to each irradiation unit (IU) and to all tanks normally ventilated by the PVVS during a loss of normal power or loss of normal sweep gas flow. The off-gas resulting from the nitrogen purge is treated by passive PVVS filtration equipment prior to being discharged to the stack, as discussed in Subsection 9b.6.1.2. The nitrogen supply pressure is regulated to overcome the pressure drop through pipe fittings, PVVS filtration components, and the facility stack. The N2PS is safety-related and Seismic Category I. A description of system interfaces is provided in Table 9b.6-3.

9b.6.2.1 Design Bases

The design bases of the N2PS include:

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

9b.6.2.2 System Description

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

A process flow diagram of the N2PS is provided in Figure 9b.6-2.

Purge of an IU

Upon loss of normal power as determined by the engineered safety features actuation system (ESFAS) and after a delay or upon loss of normal sweep gas flow in the IU as determined by the TSV reactivity protection system (TRPS), solenoid valves on the nitrogen discharge manifold actuate open, releasing nitrogen into the IU cell supply header. Upon loss of sweep gas flow in any IU cell, nitrogen solenoid isolation valves for the given cell actuate open releasing nitrogen purge gas into the TSV dump tank, and valves in the TOGS actuate open to allow the nitrogen purge gas to flow to the PVVS. The nitrogen purge gas flows through the TSV dump tank, TSV, and TOGS equipment before discharging into PVVS. A flow switch provides indication that nitrogen is flowing to the IU cell. A detailed discussion of the IU Cell Nitrogen Purge is provided in Section 7.4.

Purge of RPF Equipment

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

Processes that are ventilated by PVVS during normal conditions are also ventilated by N2PS during deviations from normal operation. In the RPF, the N2PS ventilates tanks in the TSSS, RLWS system, radioactive liquid waste immobilization (RLWI) system, radioactive drain system (RDS), molybdenum extraction and purification system (MEPS), iodine and xenon purification and packaging (IXP) system, and VTS. A detailed discussion of the RPF Nitrogen Purge is provided in Section 7.5.

9b.6.2.3 Operational Analysis and Safety Function

In the event of a loss of normal power, loss of sweep gas flow through PVVS, or loss of sweep gas flow through any TOGS, the N2PS controls the buildup of hydrogen which is released into the primary system boundary and tanks or other volumes which contain fission products to ensure that the system and confinement boundaries are maintained.

The N2PS provides back-up sweep gas in the form of stored pressurized nitrogen gas. Downstream pressure is controlled with self-regulating pressure reducing valves with overpressure protection provided by pressure relief valves. Tanks containing irradiated target solution in the RPF are supplied with a self-regulating pressure reducing valve with overpressure protection provided by a pressure relief valve. TSV dump tanks are supplied with a self-regulating pressure reducing valve. N2PS piping, valves, and in-line components are designed to ASME B31.3, Process Piping (ASME, 2013).

The high-pressure nitrogen gas storage is contained in integrally forged pressure vessels (i.e., high-pressure nitrogen gas tubes) designed to meet the requirements of ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Rules for Construction of Pressure Vessels (ASME, 2010). The tubes and associated piping, manual isolation valves, high point vents, low point drains, self-regulating pressure reducing valves, relief valves, check valves, and pressure instrumentation for the supply system are located in the N2PS structure, an above-grade reinforced concrete structure adjacent to the main production facility. The N2PS structure and equipment are designed to remain functional during and following a seismic event. Additionally, the N2PS structure is designed to withstand the impact of tornado missiles.

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

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

9b.6.2.4 Instrumentation and Control

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

The N2PS includes flow switches on the piping to the IU cells and RPF tanks to provide indication of normal operation when the purge is actuated. The flow switch status is provided to PICS.

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

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

TRPS actuates the N2PS purge of the affected IU on loss of normal power to an IU cell after a delay or on loss of flow in TOGS.

ESFAS actuates the N2PS purge of the RPF tanks on loss of normal power to the PVVS or on loss of flow in PVVS.

9b.6.2.5 Radiological Protection and Criticality Control

The N2PS contains no special nuclear material or any other radioactive material. Therefore, the N2PS does not require shielding nor is criticality safety considered in the design.

9b.6.2.6 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also applicable to, and may be used for the bases that are described in the technical specifications.

Table 9b.6-1 – Process Vessel Vent System Interfaces
(Sheet 1 of 2)

Interfacing System	Interface Description
Engineered safety features actuation system (ESFAS)	The ESFAS monitors the operation of the process vessel vent system (PVVS) and actuates the nitrogen purge system (N2PS) on failure of the PVVS blowers.
Iodine and xenon purification and packaging (IXP) system	The PVVS ventilates tanks in the IXP.
Molybdenum extraction and purification system (MEPS)	The PVVS ventilates the molybdenum eluate hold tank and MEPS condensate tank.
Nitrogen purge system (N2PS)	The N2PS provides sweep gas flow through the PVVS piping and filtration equipment on loss of normal power or normal flow in PVVS.
Normal electrical power supply system (NPSS)	The NPSS is distributed to the PVVS blowers, the PVVS reheater, and ancillary equipment.
Process integrated control system (PICS)	The PICS controls the PVVS and monitors PVVS instrument signals.
Production facility biological shield (PFBS)	The PFBS provides shielding to workers from the PVVS. PVVS equipment is located in a hot cell and in a below-grade vault.
Radioactive drain system (RDS)	The PVVS ventilates the RDS tanks.
Radioactive liquid waste storage (RLWS) system	The PVVS ventilates the RLWS tanks. The PVVS drains condensate water to the RLWS for disposal.
Radioactive liquid waste immobilization (RLWI) system	The PVVS ventilates the immobilization feed tank.
Radioisotope process facility cooling system (RPCS)	The RPCS provides cooling capacity to the PVVS for the off-gas condensers.
Radiological ventilation zone 1 (RVZ1)	The PVVS blowers discharge into a header shared by RVZ1 to the facility stack. Some PVVS components are located in a hot cell, which is ventilated by RVZ1.
Radiological ventilation zone 2 (RVZ2)	The PVVS intake removes air from RVZ2 for use as sweep gas across the RPF tanks.
Stack release monitoring system (SRMS)	The SRMS monitors the discharge from the PVVS delay beds to the stack.
Standby generator system (SGS)	The SGS provides nonsafety-related backup power to PVVS components.
Target solution staging system (TSSS)	The PVVS ventilates the TSSS tanks to mitigate hydrogen generation. The PVVS may also transfer condensate water to the TSSS for reuse in the irradiation cycle.

Table 9b.6-1 – Process Vessel Vent System Interfaces
(Sheet 2 of 2)

Interfacing System	Interface Description
Target solution vessel (TSV) off-gas system (TOGS)	The PVVS accepts sweep gas from the TOGS gas analyzers, purges from the TOGS boundary, and discharge from the TOGS pressure relief valves.
Vacuum transfer system (VTS)	The PVVS accepts the discharge of the VTS vacuum pumps. The PVVS also ventilates the vacuum lift tanks when they are not lifting to mitigate hydrogen generation.

Table 9b.6-2 – Process Vessel Vent System Process Equipment

Component	Description
Acid adsorbers	Filter cartridge packed adsorbent to neutralize potential acids in the off-gas
Guard beds	Filter cartridge packed with activated carbon to adsorb iodine species from the off-gas
Delay beds	Vessels packed with activated carbon to delay the release of noble gases in the off-gas (e.g., xenon and krypton) to the stack
HEPA filters	Filters to remove particulates and carbon fines from the off-gas
PVVS condensers	Heat exchanger to reduce dew point of the off-gas upstream of the carbon beds
PVVS reheaters	Electric heater to reduce relative humidity of the off-gas upstream of the carbon beds
PVVS blowers	Draws off-gas from process vessels and exhausts off-gas to facility stack
Condensate tank	Collects the condensate from the PVVS condensers
PVVS condensate pump	Positive displacement pumps to transfer condensate back into the process or to the waste system
Piping components	PVVS piping, valves, in-line components

Table 9b.6-3 – Nitrogen Purge System Interfaces

Interfacing System	Interface Description
Engineered safety features actuation system (ESFAS)	ESFAS actuates the N2PS on loss of normal power or loss of normal flow in the process vessel vent system (PVVS). Outputs of instruments in N2PS are provided to ESFAS.
Process integrated control system (PICS)	PICS monitors outputs of nonsafety-related instruments in N2PS.
PVVS	N2PS uses the normal PVVS piping for sweep gas to the radioisotope production facility (RPF) tanks and through PVVS filtration equipment.
Radiological ventilation zone 2 (RVZ2)	The N2PS discharges pressurized nitrogen into PVVS distribution piping. The normal intake of this distribution pipe is taken from RVZ2.
Subcritical assembly system (SCAS)	N2PS provides sweep gas to the target solution vessel (TSV) dump tank, TSV, and TSV off-gas system (TOGS) on loss of normal power or loss of normal TOGS flow.
Target solution vessel (TSV) reactivity protection system (TRPS)	TRPS actuates the N2PS on loss of normal power or loss of normal flow in TOGS. Outputs of instruments in N2PS are provided to TRPS.
Uninterruptible electrical power supply system (UPSS)	Emergency safety-related power is provided to N2PS equipment by UPSS.

Figure 9b.6-1 – PVVS Process Flow Diagram

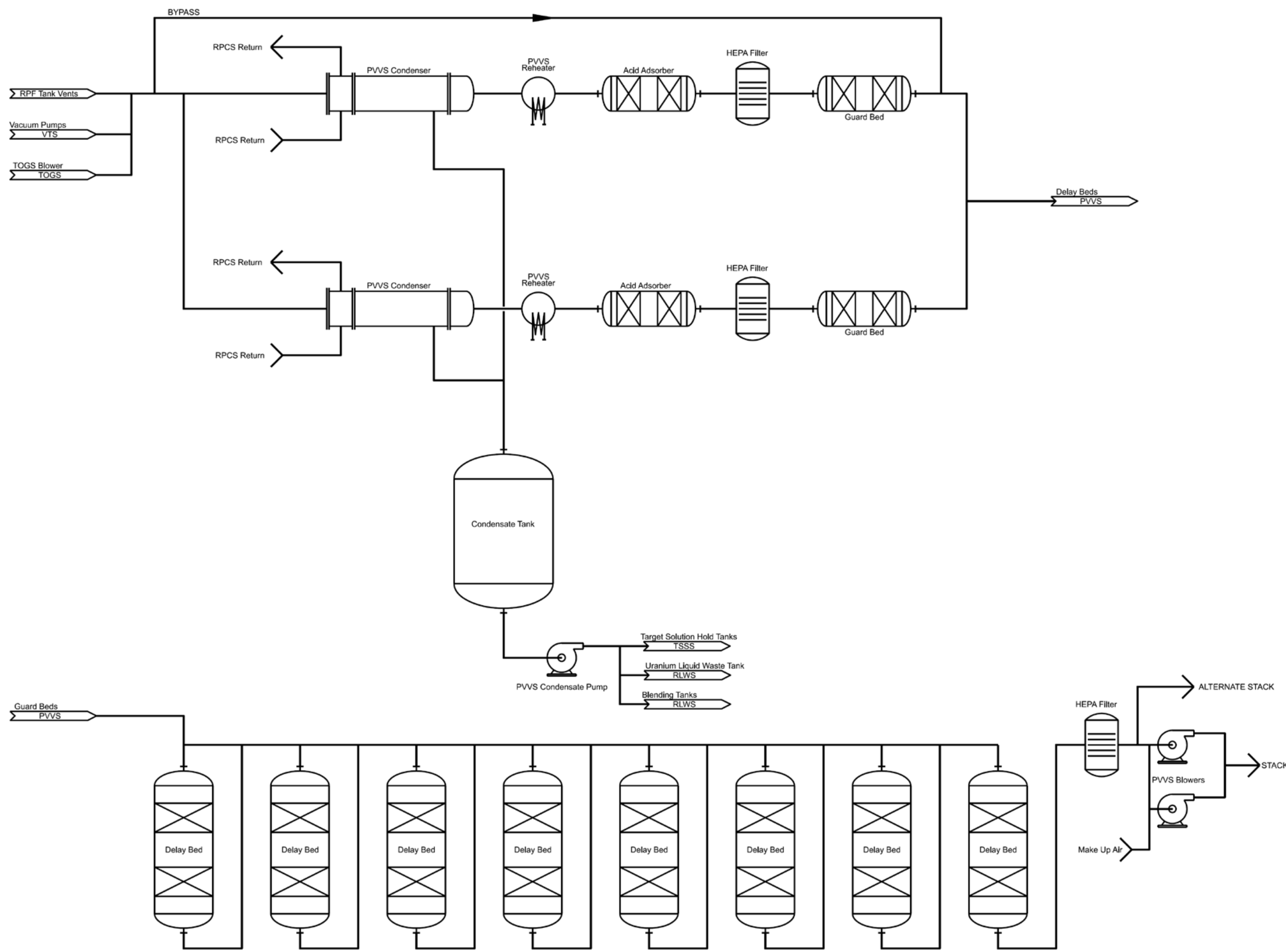
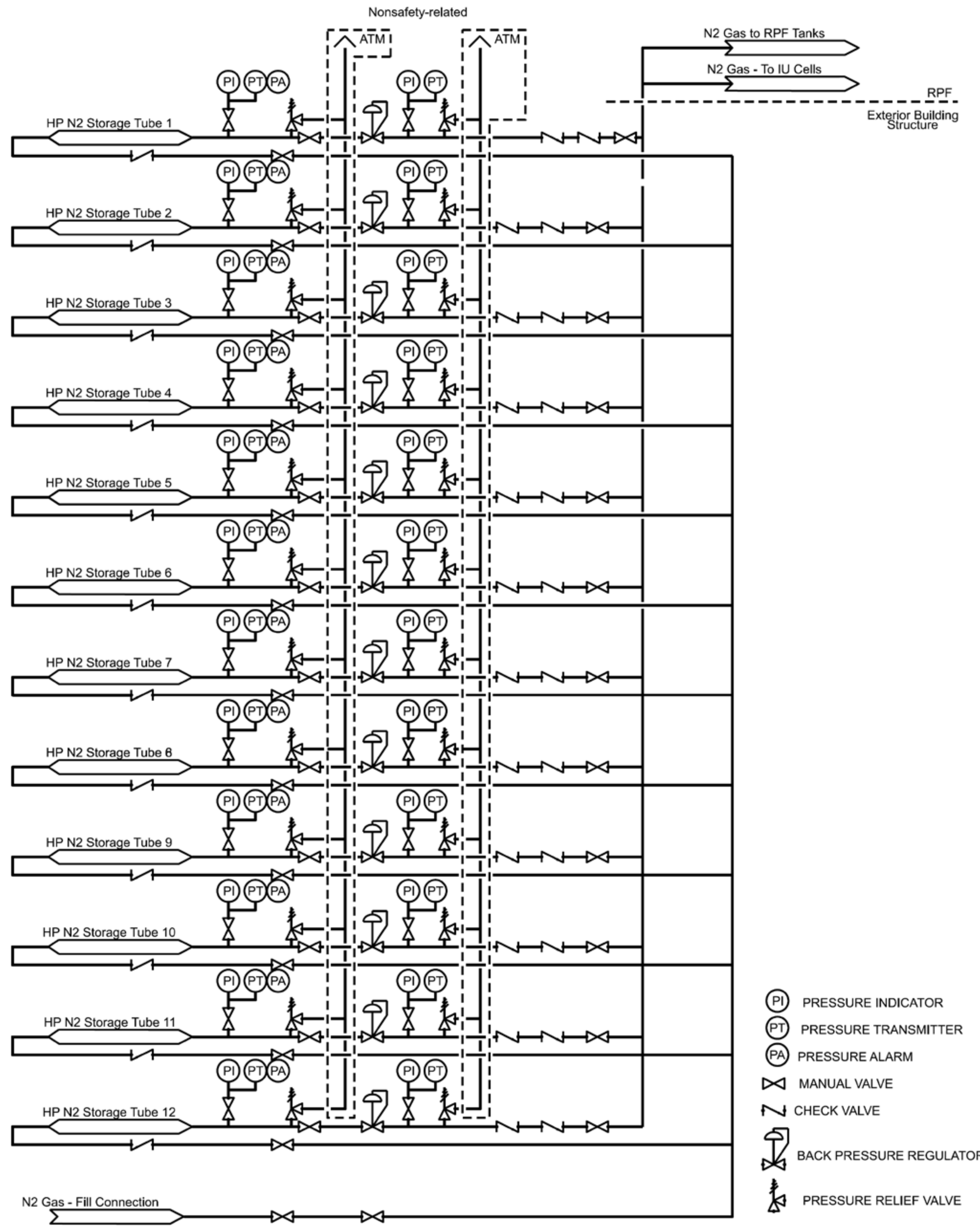


Figure 9b.6-2 – N2PS Process Flow Diagram



9b.7 OTHER AUXILIARY SYSTEMS

9b.7.1 MOLYBDENUM ISOTOPE PRODUCT PACKAGING SYSTEM

9b.7.1.1 Design Bases

The design bases of the molybdenum isotope product packaging system (MIPS) include:

- Receive the product collection bottle from either the molybdenum process lines or the iodine and xenon process line; and
- Package product collection bottle for shipment.

9b.7.1.2 System Description

The MIPS prepares the molybdenum-99 (Mo-99) product bottle, iodine product bottle, or xenon product bottle for shipment. The package is labeled and placed in the appropriate shipping container. The MIPS provides a quarantine area for products undergoing quality control testing prior to shipment, as discussed in Subsection 9b.7.1.3.

Equipment within the MIPS includes:

- Molybdenum product bottle
- Molybdenum secondary container
- Molybdenum shipping cask
- Iodine product bottle
- Iodine secondary container
- Iodine shipping cask
- Xenon product bottle
- Xenon secondary container
- Xenon shipping cask
- Leak test equipment
- Label printers

After the finished radioisotopes are purified and sampled in the purification hot cell and the iodine and xenon purification and packaging (IXP) hot cell, the product bottles are transferred to one of the two packaging hot cells within the supercell. One of the packaging hot cells serves two molybdenum extraction and purification system (MEPS) process lines, and the other packaging hot cell serves a MEPS process line and the IXP process line. Figure 4b.2-4 shows a general depiction of the supercell.

9b.7.1.3 Operational Analysis and Safety Function

Labels are applied to the product bottle, secondary container, and shipping container. The labels contain the appropriate information for shipment. The product bottles are secured within a secondary container and then into a shielded cask that is part of the shipping package. The lid of the shielded cask is applied to the container, and the package is leak tested. If leakage acceptance criteria are met, the shielded cask can be secured into the overpack and the shipping container may be released.

Product bottles may be quarantined in the hot cell prior to their placement in a shipping container while awaiting results of product testing performed as part of quality control to confirm the product being shipped meets specification. Shipping containers may also be quarantined after the product bottle has been secured for the same reason.

The SHINE product bottle for Mo-99 is a stainless-steel bottle with a stainless-steel screw cap container/closure system or high-density polyethylene (HDPE) with a plastic screw cap. The product volume ranges from [ ]PROP, depending on the customer. The product form will be an aqueous solution of sodium molybdate with an activity of up to [ ]PROP at time of dispatch. The product bottles would then be placed in approved shipping containers and transported to the customers in accordance with regulatory requirements.

The iodine product is expected to be packaged in solution vials less than one liter in size, containing the iodine in a solution of sodium hydroxide, which will then be packaged in an approved shipping container. The xenon product is expected to be packaged in gas cylinders with an internal volume of less than one liter. These product cylinders would then be placed in approved shipping containers and transported to customers.

The MIPS is located in shielded hot cells in the supercell. Shielding on the packaging hot cells limits the radiation exposure of individuals to within the regulatory limits described in 10 CFR 20. Section 11.1 provides a description of the radiation protection program, and Section 4b.2 provides a detailed description of the production facility biological shield (PFBS).

There is no special nuclear material (SNM) present within the MIPS system boundary. There are no nuclear criticality safety requirements associated with the MIPS.

The MIPS is nonsafety-related.

9b.7.1.4 Instrumentation and Control

The process integrated control system (PICS) accepts outputs from MIPS instruments. Section 7.3 provides a detailed discussion of the PICS.

9b.7.1.5 Technical Specifications

There are no technical specifications applicable to the MIPS.

9b.7.2 MATERIAL HANDLING SYSTEM

9b.7.2.1 Design Bases

The material handling system (MHS) includes overhead cranes and hoists that are used to move or manipulate radioactive material within the radiologically controlled area (RCA).

<u>Irradiation Facility Overhead Crane</u>

The irradiation facility (IF) crane is designed to meet the applicable requirements of American Society of Mechanical Engineers (ASME) B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist) (ASME, 2011a); Crane

Manufacturer's Association of America (CMAA) 70, Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes (CMAA, 2004); and ASME NOG-1, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder) (AMSE, 2015).

The IF overhead crane is designed to the following criteria:

- Meet seismic requirements and prevent failures of the crane that could damage safety-related equipment such that the equipment would be prevented from performing its safety function.
- Meet the single-failure-proof design criteria and construction of ASME NOG-1, Type I cranes and be designed to perform as a Service Level B – Light Service crane as described in CMAA 70.
- Secure its load in place upon a loss of power and any fault condition. The hoisting machinery and wire rope reeving system, in addition to other affected components, is designed to withstand the most severe potential overload, including two-blocking and load hang-up.

Radioisotope Production Facility Overhead Crane

The radioisotope production facility (RPF) overhead crane is designed to meet the applicable requirements of ASME B30.2 (ASME, 2011a), CMAA 70 (CMAA, 2004), and ASME NOG-1 (ASME, 2015).

The RPF overhead crane is designed to the following criteria:

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

9b.7.2.2 System Description

Irradiation Facility Overhead Crane

The IF overhead crane is a 40-ton, double girder, bridge style crane designed for the handling of shield cover plugs and equipment such as neutron drivers and process skids inside the IF. The IF overhead crane is designed to span the width of the IF and travel the length of the IF.

The use of a single-failure-proof crane with rigging and procedures that implement the requirements of NUREG-0612, Control of Heavy Loads at Nuclear Power Plants (USNRC, 1980) assures that the potential for a heavy load drop is extremely small, and therefore, analysis of the potential effects of heavy load drops are not required.

The IF overhead crane is designed and constructed such that it will remain in place and support the critical load during and after an aircraft impact but is not required to be operational after this event. Single failure-proof features are included such that any credible failure of a single component will not result in the loss of capability to stop and hold the critical load.

Radioisotope Production Facility Overhead Crane

The RPF overhead crane is a 15-ton, double girder, bridge style crane designed for the handling of shield cover plugs and equipment in the RPF. The RPF overhead crane is designed to span the width of the RPF and travel the length of the RPF.

The RPF overhead crane employs the use of mechanical stops, electrical-interlocks, and predetermined safe load paths to minimize the movement of loads in proximity to redundant or dual safe shutdown equipment. These safeguards ensures that off-normal load events from loads containing radioactive materials or safety-related SSCs that are beneath, or directly adjacent to a potential travel load path of the RPF overhead crane, could not result in the complete loss of a safe shutdown function or the release of radioactivity in excess of 10 CFR 20 limits.

The RPF overhead crane is designed and constructed following the seismic requirements for an ASME NOG-1, Type II crane so that it will remain in place with or without a load during a design basis earthquake. The crane is not required to support the critical load nor remain operational during and after such an event.

9b.7.2.3 Operational Analysis and Safety Function

The IF overhead crane removes irradiation unit (IU) cell plugs, the target solution vessel (TSV) off-gas system (TOGS) cell plugs, primary cooling room plugs, and neutron driver transport to and from IU cells and the neutron driver assembly system (NDAS) service cell. The IF overhead crane is used for lifting, repositioning, and landing operations associated with major components of the subcritical assembly system (SCAS), the primary closed loop cooling system (PCLS), the TOGS, and the tritium purification system (TPS) as well as various planned maintenance activities throughout the IF.

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

The IF and RPF overhead cranes are inspected, tested, and maintained in accordance with ASME B30.2 (ASME, 2011a). The inspection requirements reduce the probability of a load drop that could result in a release of radioactive materials or damage to essential safe shutdown equipment that could cause unacceptable radiation exposures. Inspection and testing of special lifting devices are performed in accordance with American National Standards Institute (ANSI) N14.6, Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More (ANSI, 1993). Inspection and testing of lifting devices not specially designed are in accordance with ASME B30.9, Slings (ASME, 2018).

With respect to the SHINE facility, a heavy load is defined as a load that, if dropped, may cause radiological consequences that challenge 10 CFR 20 limits. For cranes operating in the vicinity of safety-related SSCs, SHINE has applied guidance from Section 5.1.1 of NUREG-0612 (USNRC, 1980) relative to the crane design as follows:

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

The IF and RPF overhead cranes are nonsafety-related.

9b.7.2.4 Instrumentation and Control

The IF and RPF overhead crane control systems provide for separate operation of the hoist, bridge, and trolley motions. Overhead crane control switches for the main hoists, bridges, and trolleys are radio controlled with backup pendant controllers. Both IF and RPF overhead crane systems allow all motions to be controlled from the radio transmitter as well as a backup pendant pushbutton station. The controls for both the IF and RPF overhead cranes are interlocked so only one station (radio or pendant) can be operated at a time. The IF and RPF overhead crane controls are such that the release of the controller or loss of power automatically stops the crane's motion and sets the brakes.

9b.7.2.5 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications.

9b.7.3 RADIOACTIVE LIQUID WASTE IMMOBILIZATION SYSTEM

9b.7.3.1 Design Bases

The design bases of the radioactive liquid waste immobilization (RLWI) system include:

- Receive blended liquid waste from the radioactive liquid waste storage (RLWS) system for immobilization.
- Perform selective removal of classification-driving isotopes, as needed, from blended liquid waste [ ]PROP/ECI.
- Perform solidification of blended liquid waste.

- Reduce radiation exposure during operation in accordance with applicable guideline exposures set forth in 10 CFR 20.

The RLWI system piping is designed and constructed in accordance with ASME B31.3, Process Piping (ASME, 2013). Nonsafety-related components within the RLWI system are designed to standards satisfying system operation.

9b.7.3.2 System Description

The RLWI system solidifies blended liquid waste to a form suitable for shipping and disposal. The RLWI system removes selected isotopes, as needed, from the blended liquid waste and then immobilizes the wastes for ultimate disposal. The headspace cover gas in the immobilization feed tank is swept by the PVVS or nitrogen from the nitrogen purge system (N2PS) to maintain radiolytically generated hydrogen gas below the lower flammability limit.

The blended liquid waste sources and radionuclide and uranium concentrations are described in Subsection 9b.7.4.

The immobilization feed tank is filled from the liquid waste blending tanks on a batch basis by vacuum suction applied to the immobilization feed tank from the vacuum transfer system (VTS). Positive displacement pumps transfer the contents of the immobilization feed tank [ ]PROP/ECI, and meter the tank contents to a disposable waste drum.

The waste drums are prefilled with measured amounts of dry, powdered solidification agent in accordance with the process control program (PCP). The prefilled drum is transferred into an enclosure for contamination control. The radiological ventilation zone 1 exhaust subsystem (RVZ1e) equipment processes air from the enclosure through a high efficiency particulate air (HEPA) and carbon filter before discharging to the facility stack. Transfer of the prefilled waste drum inside the enclosure is by remote handling equipment and positioners.

The liquid waste drum is filled with blended liquid waste and mixed. Subsequent to fill and mixing, the fill and vent ports are disengaged. The drum is then remotely transferred to a curing station where the mixed contents of the waste drum hardens prior to removal from the enclosure. The cured drum is remotely transferred into a shielded cask and transported to the material staging building for further radiological decay, as needed, prior to shipment to a licensed disposal facility.

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

Table 9b.7-1 identifies the systems which interface with the RLWI system. Figure 9b.7-1 provides a process flow diagram of the RLWI system.

9b.7.3.3 Operational Analysis and Safety Function

Liquid waste solidification is performed in accordance with a PCP. The RLWI system is sized to process approximately double the routine liquid waste generation rate from the RPF.

The maximum level in the immobilization feed tank is limited to a predetermined level below the cover gas supply and vent piping. The system is provided with the ability to drain unprocessed liquid waste back to the RLWS, if necessary, for corrective maintenance access to the RLWI equipment.

The RLWI system valves and dampers fail in the safe position on loss of power.

Table 11.2-5 provides the waste methodology for consolidated liquids.

The RLWI system is designed to limit exposure to individuals by ensuring compliance with the applicable requirements of 10 CFR 20. The immobilization feed tank, liquid waste drum fill pumps, and valves are located in a shielded enclosure. Selective isotope removal and waste drum filling and mixing are also performed within the shielded enclosure. Piping that contains radioactive and potentially radioactive materials is routed through shielded pipe chases to limit the exposure of individuals to radiation.

Section 11.1 provides a description of the radiation protection program, and Section 4b.2 provides a detailed description of the PFBS.

Piping and components connected to, installed over, or installed adjacent to safety-related SSCs are designed to meet seismic requirements because its failure could damage safety-related equipment such that the equipment would be prevented from performing its safety function.

The safety function of the RLWI system is to prevent inadvertent criticality through design of equipment in accordance with the criticality safety evaluation. A description of provisions for criticality control in the RLWI system is provided in Subsection 6b.3.2.9.

9b.7.3.4 Instrumentation and Controls

Valve position indicators and temperature, flow, level, and pressure instrumentation provide remote indication of the operating state of the RLWI. Output of valve position indicators and other instrumentation is provided to the remotely-located PICS.

9b.7.3.5 Technical Specifications

There are no technical specifications associated with RLWI.

9b.7.4 RADIOACTIVE LIQUID WASTE STORAGE SYSTEM

9b.7.4.1 Design Bases

The design bases of the RLWS system include:

- Collect liquid radioactive wastes from the MEPS, IXP, VTS, PVVS and non-routine operations such as decontamination flushes.
- Blend collected liquid radioactive wastes for feed to the RLWI system.
- Provide holdup time for radioactive decay of isotopes in the liquid waste.
- Allow remote sampling of the stored liquid waste.
- Control radioactive liquid waste solution pH to preclude precipitation of uranium and potential criticality.

9b.7.4.2 System Description

The RLWS system collects, stores, blends, conditions, and meters liquid wastes for processing by the RLWI for solidification. Included in the blended liquid wastes is PVVS condensate which can also be recycled through the target solution staging system (TSSS) to minimize waste generation. The RLWS system can also transfer liquid via a normally removed pipe spool to a target solution storage tank for sampling and verification against target solution parameters. The headspace in each RLWS system tank is swept with air by the PVVS or by N2PS to remove the potential accumulation of radiolytically generated hydrogen gas.

Laboratory waste is preconditioned and manually processed separately from the RLWS system.

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

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

Uranium liquid waste tanks are geometrically favorable annular tanks similar in design to those used in TSSS. These tanks include two redundant overflow lines which drain to the radioactive drain system (RDS) in the event of an overfill. The uranium liquid waste tanks are connected in series to ensure high concentration uranium-bearing waste (greater than 25 gU/l) is not inadvertently transferred to the non-geometrically favorable liquid waste blending tanks.

The uranium liquid waste tanks are configured to operate in series, with the first tank receiving wastes from the following sources:

- Mo-99 extraction column washes
- Iodine-131 (I-131) recovery column washes
- Spent target solution
- Solution in radioactive drain sump tanks
- Solution in VTS knockout pot
- Decontamination liquid waste
- PVVS condensate tank
- Solution from the second uranium liquid waste tank via gravity drain from the uranium liquid waste lift tank

The remaining liquid wastes are collected in four liquid waste collection tanks designed and sized to maximize storage capacity. The liquid waste collection tanks are configured to receive wastes from the following sources:

- [ ]$^{PROP/ECI}$ effluent and washes
- MEPS condensate and purification waste
- [ ]$^{PROP/ECI}$ washes

Process liquid wastes determined by sampling to be less than 25 gU/l are consolidated into the eight liquid waste blending tanks. The liquid waste blending tanks are configured to receive wastes from the following sources:

- Second uranium liquid waste tank
- PVVS condensate tank
- Liquid waste collection tanks

Uranium liquid waste is combined with the radioactive liquid waste and/or PVVS condensate in the liquid waste blending tanks for homogeneous radionuclide and uranium concentrations in the RLWI system feed.

The tanks are sized to maximize decay time thereby minimizing dose rates from the immobilized waste product. Each uranium liquid waste tank has a minimum nominal capacity of [ ]PROP/ECI, and each of the liquid waste collection tanks and liquid waste blending tanks has a minimum nominal capacity of 600 gallons.

The RLWS system piping is designed and constructed in accordance with ASME B31.3, Process Piping (ASME, 2013).

Table 11.2-6 provides the chemical composition and radiological properties of liquid waste streams.

Table 9b.7-2 identifies the systems which interface with the RLWS system. Figure 9b.7-2, Figure 9b.7-3, and Figure 9b.7-4 provide process flow diagrams of the RLWS system.

9b.7.4.3 Operational Analysis and Safety Function

Solenoid valves isolating radioactive liquid flow paths fail to the normally isolated positions. Solenoid valves isolating the sweep gas flow path fail to the normally aligned flow from air to the PVVS vent header. Operators align the RLWS tank inlets and outlets based on procedures using information from the position indicators and instrumentation.

The RLWS system tanks, valves, and piping are located in shielded tank vaults, valve pits, and pipe trenches within the RPF. Section 11.1 provides a description of the radiation protection program, and Section 4b.2 provides a detailed description of the PFBS.

Sampling of RLWS system tank contents for pH verifies that waste solution acidity is maintained or is adjusted as necessary. Sampling of waste tanks is performed by vacuum lift to a hot cell, where samples are remotely obtained.

Following a period of decay to reduce dose rates, waste is transferred from the liquid waste blending tanks to the RLWI system immobilization feed tank. Subsection 9b.7.3 provides a detailed discussion of the RLWI system.

RLWS system piping connected to, installed over, or installed adjacent to safety-related equipment is designed to meet seismic requirements because its failure could damage safety-related equipment such that the equipment would be prevented from performing its safety function.

The safety function of the RLWS system is to prevent inadvertent criticality through design of equipment in accordance with the criticality safety evaluation. A description of provisions for criticality control in the RLWS system is provided in Subsection 6b.3.2.2.

9b.7.4.4 Instrumentation and Control

Valve position indicators and temperature, level, and uranium concentration instrumentation provide remote indication of operating state of the RLWS tanks. Output of valve position indicators and other instrumentation is provided to the remotely-located PICS.

9b.7.4.5 Technical Specifications

Certain material in this section provides information that is used in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. In addition, significant material is also applicable to, and may be referenced by, the bases that are described in the technical specifications.

9b.7.5 SOLID RADIOACTIVE WASTE PACKAGING SYSTEM

9b.7.5.1 Design Bases

The design bases function of the solid radioactive waste packaging (SRWP) system is to collect, segregate, and stage for shipment, solid radioactive wastes from the IF and RPF in accordance with the radioactive waste management program.

9b.7.5.2 System Description

The SRWP system consists of equipment designed and specified to collect and package solid radioactive waste from systems throughout the IF and RPF without limiting the normal operation or availability of the facilities. Solid waste may include dry active waste (DAW), spent ion exchange resin, and filters and filtration media. The SRWP system also inventories materials entering and exiting the facility structure storage bore holes as the supercell imports and exports them.

Table 11.2-1 includes a summary of the estimated annual waste stream and Table 11.1-10 includes a description of radioactive sources. Tables 11.2-2 through 11.2-4 present the waste methodology associated with the disposal of neutron drivers, spent columns, and process glassware, respectively.

Table 9b.7-3 identifies the systems which interface with the SWRP system.

9b.7.5.3 Operational Analysis and Safety Function

Solid radioactive waste is collected in segregated containers. Containers may be sorted for potentially non-contaminated waste. Contaminated waste is sealed, labeled, and transported to the material staging building for characterization, documentation, and staging for shipment. Solid wastes potentially having high levels of radioactivity are collected and transported to the material staging building in shielded casks.

Used, activated NDAS units are disassembled prior to transport to the material staging building or storage in storage bore holes. Disassembly minimizes the waste volume shipped for ultimate disposal.

Separation columns used in the processes contained within the supercell are stored on supercell storage racks for a minimum of 14 days following their use. Following decay on storage racks, columns are transferred to column waste drums imported by the supercell. The column waste drums are exported and transferred to the drum storage bore holes. Following extended decay, column waste drums are removed from the bore holes by the supercell.

Depending on weight, solid waste may need to be transferred to the material staging building using forklifts or other lifting devices. Once in the material staging building, solid wastes may be held for decay. Waste is characterized and staged for shipment in the material staging building.

Waste is handled and shipped off site in accordance with the radioactive waste management program, described in Section 11.2.

SRWP system operations are performed in accordance with the requirements of the radiation protection program, described in Section 11.1.

No nuclear criticality safety requirements are identified for the SRWP system. Nuclear criticality safety is controlled in upstream interfacing systems, where appropriate.

The SRWP system is nonsafety-related.

9b.7.5.4 Instrumentation and Control

No instrumentation or controls have been identified for the SRWP system.

9b.7.5.5 Technical Specifications

There are no technical specification parameters associated with the SRWP system.

9b.7.6 RADIOACTIVE DRAIN SYSTEM

9b.7.6.1 Design Bases

The design bases of the RDS include:

- Collect liquids leaked from tanks, piping, or other components which require favorable geometry for collection and storage.
- Collect liquids resulting from the overflow of the target solution storage tanks, target solution hold tanks, and uranium liquid waste tanks.
- Provide overpressure protection for the extraction cells and IXP cells of the supercell, as the RDS forms an open pathway through the RDS tanks to the PVVS.
- Allows a representative sample of the contents of the RDS sump tanks to be obtained.
- Provide a minimum collection volume equal to the maximum liquid volume of one annular tank.

9b.7.6.2 System Description

The RDS consists of drip pans with drain lines, tank overflow lines, collection tanks and instrumentation to alert operators of system status. The RDS includes drip pans located beneath the extraction and IXP hot cells, favorable geometry tanks, and piping for systems that normally contain high concentration (> 25 gU/l) fissile solution. The RDS also collects overflow from target solution and uranium waste tanks. The RDS consists of two favorable geometry tanks (annular tanks) that collect leakage from postulated sources. The leakage and overflow are connected by piping that is substantially located within the basemat of the RPF as well as in the RPF pipe trench. Gravity provides the motive force between the various drip pans and the RDS tanks. No valves are installed between the potential collection source and the collection tanks.

Table 9b.7-4 identifies the systems which interface with the RDS.

Figure 9b.7-5 provides a process flow diagram for the RDS.

9b.7.6.3 Operational Analysis and Safety Function

The RDS includes two sump tanks, each sized to accept the largest volume of liquid containing SNM that is postulated to leak from a favorable geometry tank. The largest volume of liquid containing SNM postulated to leak into the RDS system is the volume of the largest favorable geometry tank, assuming the tank is filled to the overflow line. The inclusion of two RDS tanks provides operational margin.

The RDS sump tanks are connected to the target solution storage tanks, target solution hold tanks, and uranium liquid waste tanks. Additionally, the sump tanks are connected to drip pans in vaults containing annular tanks, drip pans in valve pits servicing annular tanks, drip pans in the main pipe trench, and drip pans in the extraction and IXP hot cells. Redundant overflows to a common RDS header are provided for each annular tank. The RDS is not used in any normal operating conditions. Instrumentation is provided to alert operators of the presence of liquid in the various drip pans and of liquid level in the RDS sump tanks. If liquid is detected in the drip pans or sump tanks, contingency actions may be performed by using systems other than the RDS. Contents of the RDS tanks are sampled and transferred by the VTS to the appropriate location. Characterization of the sample is performed by the quality control and analytical testing laboratories (LABS).

The RDS needs to remain open for drainage of fissile-containing liquids (for criticality safety), while also not compromising the integrity of the confinement barrier. Fluids are contained within appropriate process piping and vessels, and the system is vented to the PVVS.

Piping that contains potentially-radiological material is routed through shielded pipe chases to limit the exposure of radiation to personnel. The RDS tanks are shielded by a tank vault, which is a part of the PFBS. The PFBS shielding requirements are described in Section 4b.2.

RDS operations are performed in accordance with the requirements of the radiation protection program, described in Section 11.1.

The RDS prevents inadvertent criticality through inherently-safe geometrical design of sump, tanks, drain lines, and in-line components that may handle fissile material. A description of provisions for criticality control in the RDS is provided in Subsection 6b.3.2.8.

The RDS is a Seismic Category I, safety-related system.

9b.7.6.4 Instrumentation and Control

The RDS is designed as a passive system, and as such does not use any controls.

The RDS provides liquid detection signals to the engineered safety features actuation system (ESFAS), as described in Subsection 7.5.5.

Nonsafety-related monitoring and control is provided by PICS, as described in Subsection 7.3.3.

9b.7.6.5 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications.

9b.7.7 FACILITY POTABLE WATER SYSTEM

9b.7.7.1 Design Bases

The design bases function of the facility potable water system (FPWS) is to provide the SHINE facility with potable water. The FPWS piping and system components are designed to the applicable requirements of the Wisconsin Administrative Code, Safety and Professional Services, and the applicable City of Janesville Ordinances.

9b.7.7.2 System Description

The FPWS provides a potable water supply to the SHINE facility and is connected to the City of Janesville water supply. The boundaries of the FPWS include the components from the City of Janesville water main to the fixtures in each of the buildings on the SHINE facility. The fixtures are part of the facility sanitary drain system (FSDS), described in Subsection 9b.7.9. The FPWS ends at the backflow prevention device interfacing with both the facility demineralized water system (FDWS) and facility heating water system (FHWS). The FPWS does not supply water to the facility fire detection and suppression system (FFPS) or any firefighting equipment.

9b.7.7.3 Operational Analysis and Safety Function

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

Shielding and radiological protection is not required for the FPWS and the FPWS contains no SNM.

The FPWS is nonsafety-related.

9b.7.7.4 Instrumentation and Control

The FPWS hot water supply is equipped with automatic temperature controls capable of adjustments.

9b.7.7.5 Technical Specifications

There are no technical specification parameters associated with the FPWS.

9b.7.8 FACILITY NITROGEN HANDLING SYSTEM

9b.7.8.1 Design Bases

The facility nitrogen handling system (FNHS) is designed to supply liquid and compressed gaseous nitrogen to systems inside the RCA. The FNHS gaseous piping is designed, constructed, and tested in accordance with the ASME B31.9, Building Services Piping (ASME, 2011b). The FNHS liquid nitrogen piping is designed, constructed, and tested in accordance with ASME B31.3, Process Piping (ASME, 2013). The FNHS vaporizers, receivers, and bulk liquid nitrogen tanks are designed, constructed, and tested to the ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels (ASME, 2010). The balance of the equipment included in the FNHS is commercially available and is designed to standards satisfying the system operation.

The design basis of the FNHS includes:

- Provide nitrogen gas at the pressures and flow rates to operate sampling equipment in the RLWS system, the RDS, the TSSS, the MEPS, and the target solution preparation system (TSPS).
- Provide nitrogen gas for sparging and mixing of tanks in the RLWS, the TSSS, the MEPS, the RDS, and the IXP system.
- Provide liquid and gaseous nitrogen to the TPS. Gaseous nitrogen is used by the TPS to inert glovebox environments and operate pneumatic equipment. Liquid nitrogen is supplied to the TPS impurity removal system and the thermal cycling absorption process (TCAP) isotope separation columns.
- Provide liquid nitrogen in dewars to the IXP system and the instrument laboratory for equipment cooling.
- Provide nitrogen gas to the TOGS for pressure regulation.
- Provide nitrogen gas to the PCLS and the FFPS for pneumatic control mechanisms.

The FNHS is not relied upon to prevent accidents that could cause undue risk to the health and safety of the workers and the public or to control or mitigate the consequences of such accidents.

9b.7.8.2 System Description

Bulk liquid nitrogen is stored in tanks outside the main production facility and is supplied to vaporizer units. The vaporizer units vaporize the liquid nitrogen to provide a clean gaseous nitrogen supply that is piped into the main production facility. A liquid nitrogen supply line upstream of the vaporizers supplies liquid nitrogen from the bulk storage tank into the main production facility via vacuum jacketed cryogenic piping.

The FNHS supplies liquid nitrogen to an adjustable pressure phase separator inside the main production facility that has the capability to store and deliver high quality liquid nitrogen to the TPS. Liquid nitrogen is supplied to a fill station inside the main production facility. The fill station is installed to fill portable dewars for the disbursement of liquid nitrogen in small quantities as needed by facility processes. Liquid nitrogen dewars supplying the IXP are equipped with an excess flow check valve for the protection of supercell and downstream equipment. Off-gassing from the FNHS phase separator and fill station are ventilated through a connection to the radiological ventilation zone 2 exhaust subsystem (RVZ2e) inside the IF.

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

A FNHS remote receiver tank is maintained on the FNHS ring header to supply abrupt demands and provide consistent nitrogen gas flow and pressure to all serviced areas in the RCA. The FNHS ring header supplies nitrogen gas to sampling equipment, tank sparging and mixing equipment, and level indication equipment. The FNHS ring header supplies nitrogen gas to each FNHS cooling room receiver tank where it is used by TOGS.

Table 9b.7-5 identifies the systems which interface with the FNHS. Figure 9b.7-6 provides a process flow diagram for the FNHS.

9b.7.8.3 Operational Analysis and Safety Function

The FNHS bulk liquid nitrogen storage tanks are continuously pressurized by the naturally occurring liquid to gas phase change inside the tank with the presence of liquid nitrogen. The FNHS bulk liquid nitrogen storage tank head space pressure is regulated to provide flow to the vaporizer. A pressure relief system with a vent path to the atmosphere is maintained on each bulk liquid storage tank to prevent overpressurization of the vessel.

Liquid nitrogen is directed from the pressurized bulk storage tank to vaporizers where it is heated and vaporized to nitrogen gas. The gaseous nitrogen supply is regulated through a control manifold designed to control the pressure and prevent possible liquid carryover to the FNHS end users. The FNHS bulk liquid nitrogen storage tank and vaporizers supply nitrogen gas to the main FNHS receiver tank, the facility nitrogen gas ring header, and the FNHS remote receiver tank located inside the RCA. The control manifold ensures that adequate pressure is maintained within the production facility. Overpressure protection is provided on the FNHS gaseous facility supply line.

The FNHS cooling room receiver tanks are filled from the facility nitrogen gas ring header by opening a normally closed manual valve allowing flow to the tank corresponding to the actuated valve. Once pressure has equalized the valve is closed and the tank is placed in service.

Redundant isolation upstream of the cooling room remote receiver tanks ensures that a direct path from the atmosphere inside confinement boundaries to outside those areas are not created. The manual isolation provided is maintained normally closed and administrative controls ensure that the valve is only opened to service the TOGS when the associated IU and TOGS are not in service. The isolation prevents backflow from the TOGS into normally occupied IF spaces.

Shielding and radiological protection is not required for the FNHS. The FNHS contains no SNM.

The FNHS is nonsafety-related.

9b.7.8.4 Instrumentation and Control

The FNHS is comprised of a packaged skid control system that includes system instrumentation. The packaged control system interfaces with the PICS to deliver FNHS data to plant operators. The FNHS is designed with low temperature shutdown equipment to protect downstream components from cryogenic temperatures.

9b.7.8.5 Technical Specifications

There are no technical specification parameters associated with the FNHS.

9b.7.9 FACILITY SANITARY DRAIN SYSTEM

9b.7.9.1 Design Bases

The facility sanitary drain system (FSDS) collects domestic sanitary waste and wastewater, discharging it to a city sewer main.

The FSDS building sewer drain piping and system equipment outside the RCA are designed to the applicable requirements of the Wisconsin Administrative Code, Safety and Professional Services, and the applicable City of Janesville Ordinances.

9b.7.9.2 System Description

The FSDS removes domestic sanitary waste and wastewater from the areas of the main production facility (not inside the RCA), the storage building, and the resource building; and discharges sanitary waste and wastewater to the City of Janesville public sewer main.

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

9b.7.9.3 Operational Analysis and Safety Function

The piping in the FSDS building sewer is sloped per the Wisconsin Administrative Code to ensure directed flow to the City of Janesville public sewer main. Building drains that are subject to backflow are protected with a backwater valve or sump and pumping equipment to comply with applicable requirements of the Wisconsin Administrative Code.

Shielding and radiological protection is not required for the FSDS. Sanitary waste sources contain no SNM.

The FSDS is nonsafety-related.

9b.7.9.4 Instrumentation and Control

The FSDS has no instrumentation or control equipment.

9b.7.9.5 Technical Specifications

There are no technical specification parameters associated with the FSDS.

9b.7.10 FACILITY CHEMICAL REAGENT SYSTEM

9b.7.10.1 Design Bases

The facility chemical reagent system (FCRS) provides storage and equipment for non-radioactive chemical reagents used in the SHINE processes.

The design basis of the FCRS includes:

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

9b.7.10.2 System Description

Bulk chemical storage is provided in the storage building. Chemical storage is also provided in the chemical storage and preparation room in the main production facility, which is located outside the RCA. Storage of compressed oxygen gas, used as a reagent, is provided by the FCRS. Compressed oxygen is supplied to the TOGS to facilitate the recombination of radiolytic hydrogen. Other chemical reagents are used for batch production, solution adjustment, and process flushing.

Chemical reagents are placed into volume-limited FCRS containers for transfer to process tie-in location tanks and into single-use laboratory scale containers (e.g., flasks, syringes, pipets) for import into hot cells inside the RCA.

Reagents transported in portable containers are transferred into the tanks and pumped on demand directly into the respective process tie-in locations for:

- TSPS uranyl sulfate solution preparation and adjustment;
- MEPS extraction, purification, and flushing;
- IXP system iodine extraction, purification, and flushing;
- RLWS system pH adjustment;
- RLWI system flushing;
- VTS flushing and adjustment of target solution in the TSSS;
- PVVS condensate pH adjustment and flush; and
- PSB flushing.

Reagents in laboratory containers are manually introduced into the MEPS purification hot cells through hot cell pass-throughs. Hot cell master-slave manipulators are used to add chemicals to the laboratory scale purification processes performed in the hot cells.

Compressed oxygen cylinders are stored inside the IF to service the TOGS. Compressed oxygen is routed through dry particulate filters, regulated, and distributed to the TOGS.

Table 9b.7-6 identifies the systems which interface with the FCRS.

9b.7.10.3 Operational Analysis and Safety Function

Bulk liquid and solid chemicals and chemical reagents are received, stored, maintained, and used in accordance with the chemical hygiene plan and are stored per their applicable safety data sheets.

The FDWS provides demineralized water to both the storage building and the chemical storage and preparation room for chemical reagent preparation. Individual acid, base, and organic waste containers are provided for disposal of chemicals.

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

Mixing of acids and bases could cause a highly exothermic reaction. As such, bulk quantities of acids are stored separately from the bases and hydrogen peroxide in segregated storage spaces within the storage building. Small volumes of chemicals to be used in laboratory settings and in processes are stored and labeled in accordance with their applicable safety data sheets. Table 13b.3-1 provides a list of chemicals within the SHINE facility.

The storage and delivery of oxygen gas inside the RCA complies with fire hazard analysis (FHA), as described in Section 9a2.3, and applicable Occupational Safety and Health Administration (OSHA) requirements.

FCRS operations are performed in accordance with the requirements of the radiation protection program, described in Section 11.1.

The FCRS contains no SNM; however, the addition of basic chemical reagents to interfacing systems may result in uranium precipitation. Therefore, chemical additions to process tanks are evaluated under the nuclear criticality safety program, as described in Section 6b.3.

9b.7.10.4 Instrumentation and Control

Process parameters for systems interfacing with the FCRS are monitored by the PICS, as described in Section 7.3.

9b.7.10.5 Technical Specifications

Certain material in this subsection provides information that is used in the technical specifications.

Table 9b.7-1 – Radioactive Liquid Waste Immobilization System Interfaces (Sheet 1 of 2)

Interfacing System	Interface Description
Nitrogen purge system (N2PS)	N2PS supplies sweep gas to RLWI tank headspace cover gas upon a loss of power or loss of normal sweep gas flow to remove potential accumulation of radiolytically generated hydrogen gas.
Process vessel vent system (PVVS)	The PVVS supplies sweep gas to the immobilization feed tank headspace to remove potential accumulation of radiolytically generated hydrogen gas. The immobilization feed tank cover gas and waste drum vent both discharge via a common header to the PVVS vent header.
Radioactive liquid waste storage (RLWS) system	Immobilization feed tank receives radioactive liquid waste from the RLWS system.
Vacuum transfer system (VTS)	Suction from VTS provides the motive force for waste liquid transfer from the blending tanks to the immobilization feed tank.
Radiological ventilation zone 1 (RVZ1)	The RLWI shielded enclosure is ventilated by RVZ1. Ventilation of the solidification skid enclosure and glovebox removes residual decay heat in the immobilization feed tank and the heat of hydration from the solidification process in the glovebox.
Radiological ventilation zone 2 (RVZ2)	The RVZ2 is the source of air supply to the shielded enclosure through RVZ2 filtration equipment. The RVZ2 is the source of air for the vacuum break between the VTS suction header and the drum fill head vacuum test tank.
Facility nitrogen handling system (FNHS)	The FNHS provides instrument-grade pressurized nitrogen to immobilization feed tank level instrumentation.
Process integrated control system (PICS)	The components of the RLWI system are controlled and monitored by the PICS.
Normal electrical power supply system (NPSS)	The components of the RLWI system are powered by the NPSS.

Table 9b.7-1 – Radioactive Liquid Waste Immobilization System Interfaces (Sheet 2 of 2)

Interfacing System	Interface Description
Facility chemical reagent system (FCRS)	The FCRS pumps dilute sulfuric acid solution from a limited capacity tank to support flushing of the immobilization feed tank, liquid waste drum fill pumps, and the RLWI system piping and valves.
Material handling system (MHS)	The MHS transports the solidified waste drum from the shielded enclosure to the material staging building and imports empty waste drums into the shielded enclosure.

Table 9b.7-2 – Radioactive Liquid Waste Storage System Interfaces (Sheet 1 of 2)

Interfacing System	Interface Description
Nitrogen purge system (N2PS)	The N2PS supplies sweep gas to the RLWS system tanks to remove potential accumulation of radiolytically generated hydrogen gas upon loss of normal power or loss of normal sweep gas flow.
Process vessel vent system (PVVS)	The RLWS system provides a location to receive wastes from the PVVS condensate tanks. The PVVS provides zone 2 air as sweep gas to the RLWS system tanks to remove potential accumulation of radiolytically generated hydrogen gas.
Molybdenum extraction and purification system (MEPS)	The RLWS system provides a location to receive wastes from the MEPS. The MEPS provides flushing capabilities to the uranium liquid waste tanks and liquid waste collection tanks.
Iodine and xenon purification and packaging (IXP) system	The RLWS system provides a location to receive wastes from the IXP system. Influents from the IXP system to the RLWS system are normally isolated unless actively processing solution through the IXP system.
Radioactive drain system (RDS)	The RDS provides capacity to collect solution from the uranium liquid waste tanks that results from off-normal overflow.
Facility chemical reagent system (FCRS)	The FCRS supplies acid for pH adjustment in RLWS system tanks. This acid supply is through the supercell via a MEPS flow path.
Vacuum transfer system (VTS)	The RLWS system provides a location to receive wastes from the VTS knockout pot. Suction from the VTS provides the motive force for waste liquid transfers within the RLWS system.
Quality control and analytical testing laboratories (LABS)	The LABS maintain the capability to handle and measure constituents in diluted samples obtained from the uranium liquid waste, liquid waste collection, and liquid waste blending tanks via remote sampler assemblies.
Production facility biological shield (PFBS)	The PFBS provides a barrier to protect personnel, members of the public, and components and equipment by reducing radiation exposure from the RLWS system.
Radioactive liquid waste immobilization (RLWI) system	The RLWS system transfers blended liquid waste to the RLWI system for solidification. The RLWI system immobilization feed tank level instrumentation provides for metering of liquid waste transfers from the RLWS system blended liquid waste tanks.

Table 9b.7-2 – Radioactive Liquid Waste Storage System Interfaces (Sheet 2 of 2)

Interfacing System	Interface Description
Facility nitrogen handling system (FNHS)	The FNHS provides instrument grade pressurized nitrogen to RLWS system tank level instrumentation and uranium liquid waste tank spargers.
Process integrated control system (PICS)	The PICS receives and monitors control signals sent from nonsafety-related RLWS system instrumentation, initiates actuation, and provides interlocks.
Normal electrical power supply system (NPSS)	The NPSS provides normal electrical power to the equipment and instrumentation in the RLWS.

Table 9b.7-3 – Solid Radioactive Waste Packaging System Interfaces (Sheet 1 of 2)

Interfacing System	Interface Description
Radioactive liquid waste immobilization (RLWI) system	The SRWP system collects and provides for the packaging and shipment of potentially contaminated solid wastes generated by the RLWI system excluding the immobilized liquid waste and [ ]PROP/ECI drums. Solid waste may include the high efficiency particulate air (HEPA) filters and failed equipment and components.
Process vessel vent system (PVVS)	The SRWP system collects and provides for the packaging and shipment of PVVS solid wastes. Wastes may include spent HEPA filters, acid adsorbers, carbon guard beds, and failed equipment.
Uranium receipt and storage system (URSS)	The SRWP system collects and provides for the packaging and shipment of potentially contaminated solid waste generated from the URSS. Wastes may include shipping package components, HEPA filters, glovebox gloves, materials and components used for uranium handling within the glovebox and spent cleaning materials used for decontaminating surfaces.
Primary closed loop cooling system (PCLS)	The SRWP system packages and ships spent PCLS deionizers and spent PCLS cooling water filters for disposal.
Light water pool system (LWPS)	The SRWP system packages and ships spent LWPS deionizers and spent LWPS filters for disposal.
Target solution preparation system (TSPS)	The SRWP collects and provides for packaging and shipment of spent uranyl sulfate dissolution tank filters, TSPS glovebox air inlet and outlet HEPA filters, and uranyl sulfate dissolution tank demisters.
Target solution vessel (TSV) off-gas system (TOGS)	The SRWP system collects and provides for the packaging and shipment of spent TOGS skid components. This includes the TOGS zeolite beds, recombiner beds, and demisters.
Neutron driver assembly system (NDAS)	The SRWP system collects and provides for packaging and shipment of portions of the NDAS.
Radiological ventilation zone 1 (RVZ1) and radiological ventilation zone 2 (RVZ2)	The SRWP system collects and provides for packaging and shipment of solid waste generated by the radiologically controlled area ventilation systems. Waste may include HEPA filter and carbon filters.
Production facility biological shield (PFBS)	The supercell includes features to package spent columns into drums and transfer to the drum storage bore holes. The supercell includes features to export column waste drums from the drum storage bore holes.

Table 9b.7-3 – Solid Radioactive Waste Packaging System Interfaces (Sheet 2 of 2)

Interfacing System	Interface Description
Normal electrical power supply system (NPSS)	NPSS supplies connections for portable electrically powered tools at various locations through the radioisotope production facility (RPF) and material staging building to support potential requirements for disassembly and packaging of contaminated equipment as solid radioactive waste.

Table 9b.7-4 – Radioactive Drain System Interfaces

Interfacing System	Interface Description
Process vessel vent system (PVVS)	PVVS provides the RDS sump tanks with ventilation to mitigate hydrogen accumulation in the tank headspace.
Nitrogen purge system (N2PS)	The N2PS provides a source of sweep gas to mitigate hydrogen accumulation in RDS sump tanks in the event of a failure of PVVS to provide the sweep gas.
Facility nitrogen handling system (FNHS)	The FNHS provides compressed gas to the RDS sump tanks for solution agitation.
Target solution staging system (TSSS)	The RDS provides capacity to collect solution from the target solution hold tanks and the target solution storage tanks that results from overflow of these tanks.
Radioactive liquid waste storage (RLWS) system	The RDS provides capacity to collect solution from the uranium liquid waste tanks that results from overflow of these tanks.
Vacuum transfer system (VTS)	The VTS provides liquid transfer out of the RDS tanks.
Engineered safety features actuation system (ESFAS)	ESFAS monitors tank level sensors and mitigates potential sources of leaks.
Process integrated control system (PICS)	The RDS system provide measurement signals to the PICS of sump tank levels as well as tank temperature.
Normal electrical power supply system (NPSS)	The RDS is powered by the NPSS.
Uninterruptible power supply system (UPSS)	The UPSS supplies electrical power to leak detection equipment that is part of the RDS in the event that normal electrical power is lost.
Process facility biological shield (PFBS)	The PFBS provides shielding from sources of radiation in RDS to ensure that accumulated doses in occupied areas do not exceed defined limits. The RDS collects solution from drip pans located in the supercell, valve pits, tank vaults, and trenches that have the potential to contain liquid that requires favorable geometry.
Quality control and analytical testing laboratories (LABS)	LABS measure properties of solution from the RDS.

Table 9b.7-5 – Facility Nitrogen Handling System Interfaces

Interfacing System	Interface Description
Quality control and testing analytical laboratories (LABS)	The FNHS provides liquid nitrogen to dewars to supply the needs of the instrument laboratory.
Facility fire detection and suppression system (FFPS)	The FNHS provides nitrogen gas to pneumatic actuators for the pre-action fire system.
Iodine and xenon purification and packaging (IXP) system	The FNHS provides a nitrogen gas supply line for product bottle sparging. The FNHS portable dewars, containing liquid nitrogen, interface with the IXP cryotraps to cool system components.
Molybdenum extraction and purification system (MEPS)	The FNHS provides nitrogen gas to sampling equipment maintained by the MEPS.
Primary closed loop cooling system (PCLS)	The FNHS maintains nitrogen gas supply to PCLS nitrogen operated valves in each of the cooling rooms.
Radioactive drain system (RDS)	The FNHS provides nitrogen gas to sampling equipment maintained by the RDS. The FNHS provides nitrogen gas to facilitate sparging and mixing operations in the RDS sump tanks. The FNHS provides a nitrogen gas supply for liquid level detectors in the RDS sump tanks.
Radioactive liquid waste storage (RLWS) system	The FNHS provides nitrogen gas to sampling equipment maintained by the RLWS. The FNHS provides nitrogen gas to facilitate sparging and mixing operations in the uranium liquid waste tanks. The FNHS provides a nitrogen gas supply for liquid level detectors in the liquid waste blending tanks, uranium liquid waste tanks, and liquid waste collection tanks.
Tritium purification system (TPS)	The FNHS provides liquid nitrogen directly piped to the TPS. The FNHS provides nitrogen gas to inert glovebox atmospheres and for the operation of pneumatic equipment.
Target solution vessel (TSV) off-gas system (TOGS)	The FNHS maintains nitrogen gas supply to each of the TOGS skids though a penetration made in each cooling room.
Target solution preparation system (TSPS)	The FNHS provides nitrogen gas to sampling equipment maintained by the TSPS
Target solution staging system (TSSS)	The FNHS provides nitrogen gas to sampling equipment maintained by the TSSS. The FNHS provides nitrogen gas to facilitate sparging and mixing operations in the target solution hold tanks and target solution storage tanks. The FNHS provides a nitrogen gas supply for liquid level detectors in the target solution hold tanks and target solution storage tanks.

Table 9b.7-6 – Facility Chemical Reagent System Interfaces
(Sheet 1 of 2)

Interfacing System	Interface Description
Molybdenum extraction and purification system (MEPS)	The FCRS provides pumped MEPS extraction and purification reagents.
Iodine and xenon purification and packaging (IXP) system	The FCRS provides pumped IXP purification and recovery reagents.
Radioactive liquid waste storage (RLWS) system	The FCRS provides pumped chemical adjustment reagents via VTS through MEPS for waste solution adjustment in the RLWS tanks
Radioactive liquid waste immobilization (RLWI) system	The FCRS provides pumped reagents for RLWI flushing and for acid makeup to liquid waste solidification drum on interruption of flow from immobilization feed tank.
Target solution staging system (TSSS)	The FCRS provides pumped chemical adjustment reagents via VTS pumped chemical adjustment and flush reagents for target solution composition adjustment in the TSSS tanks.
Process vessel vent system (PVVS)	The FCRS provides acidification reagents to the PVVS for condensate adjustment as necessary and provides flushing reagents to the PVVS.
Target solution preparation system (TSPS)	The FCRS provides reagents to the TSPS for uranyl sulfate preparation and adjustments and provides reagents for flushing the TSPS.
Facility ventilation zone 4 (FVZ4)	FVZ4 provides dedicated fume hood exhaust to the environment for the FCRS chemical preparation fume hoods.
Vacuum transfer system (VTS)	The FCRS provides process tie-in points to the VTS for the introduction of MEPS pumped extraction reagents. The FCRS provides process tie-in points to VTS for the introduction of pumped chemical adjustment and flush reagents for target solution composition adjustment in the TSSS tanks. The FCRS provides process tie-in points to VTS for the introduction of pumped chemical adjustment reagents through MEPS for waste solution adjustment in the RLWS tanks.
Facility demineralized water system (FDWS)	Demineralized water from the FDWS is supplied to FCRS for process system flushing. The FDWS supplies the FCRS sinks with deionized water.
Facility potable water system (FPWS)	The FPWS supplies water to the eye wash stations and chemical showers within the working areas of the chemical storage and preparation room and storage building where reagent preparation is performed.

Table 9b.7-6 – Facility Chemical Reagent System Interfaces (Sheet 2 of 2)

Interfacing System	Interface Description
Facility sanitary drain system (FSDS)	The FSDS provides drainage or catchments for emergency chemical showers, eye wash stations, and FCRS sinks.
Target solution vessel (TSV) off-gas system (TOGS)	The FCRS provides compressed oxygen to TOGS.

Figure 9b.7-1 – RLWI System Process Flow Diagram

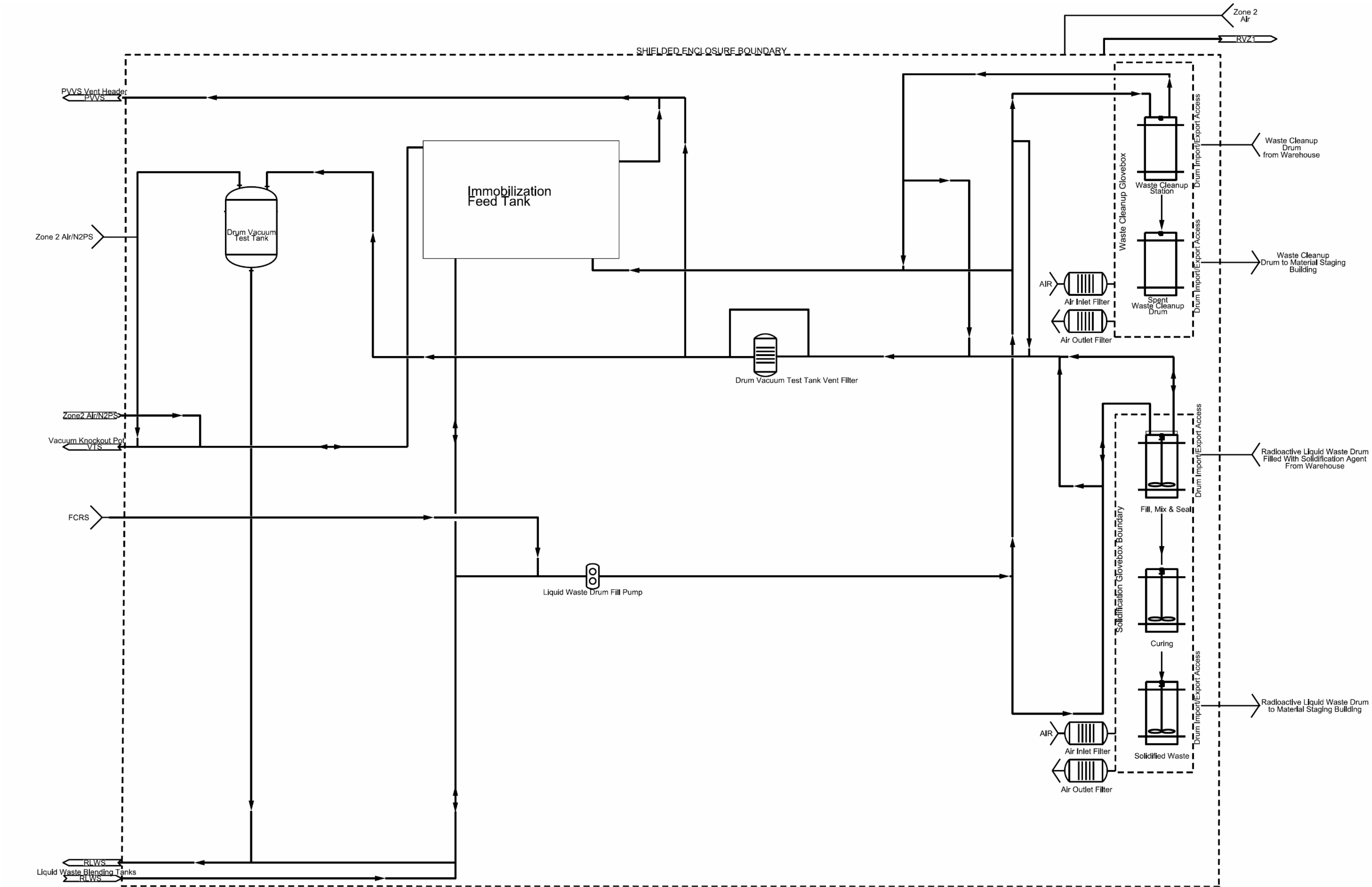


Figure 9b.7-2 – RLWS Uranium Liquid Waste Tanks Process Flow Diagram

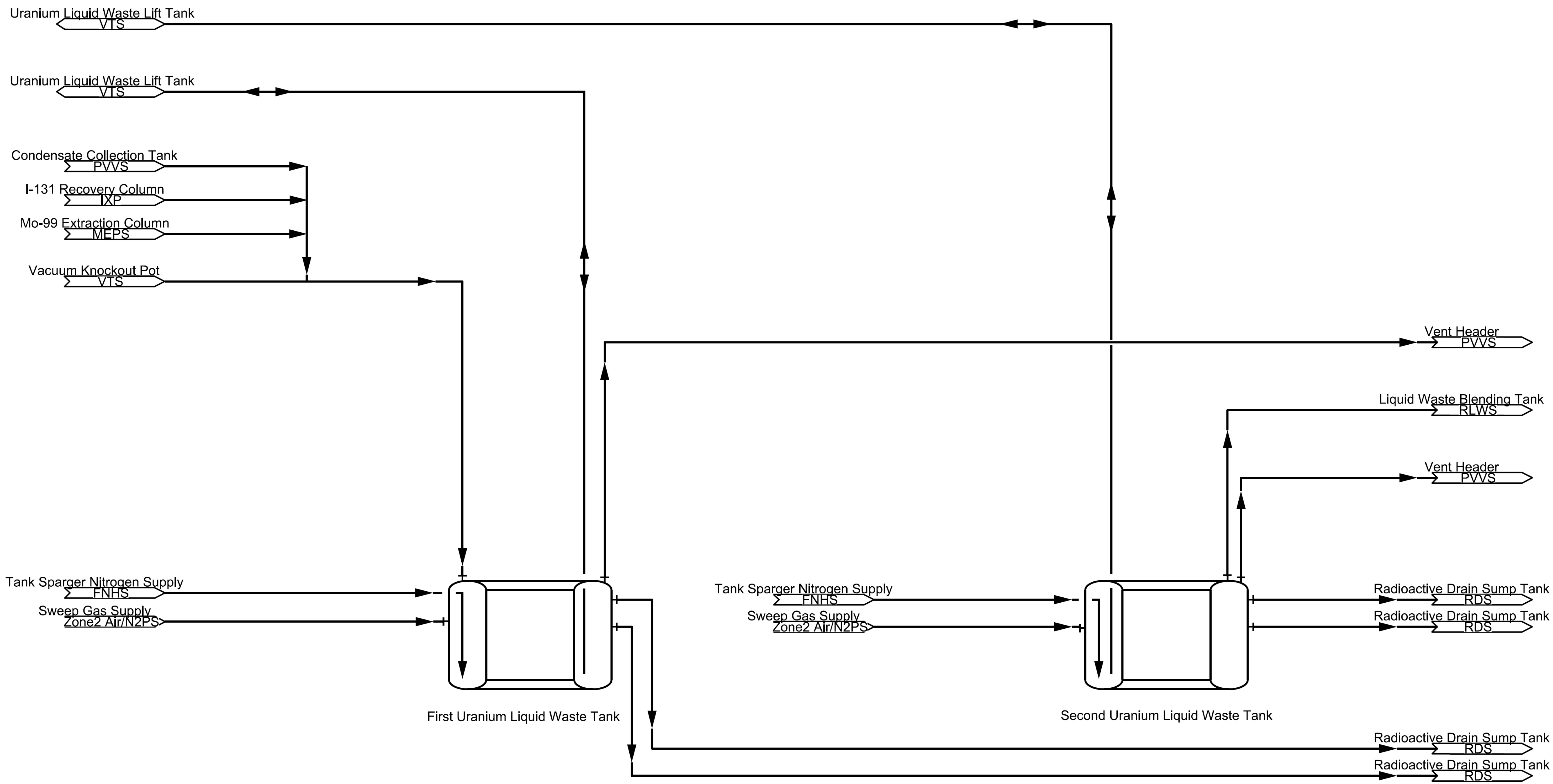


Figure 9b.7-3 – RLWS Liquid Waste Collection Tanks Process Flow Diagram

Figure 9b.7-4 – RLWS Liquid Waste Blending Tanks Process Flow Diagram

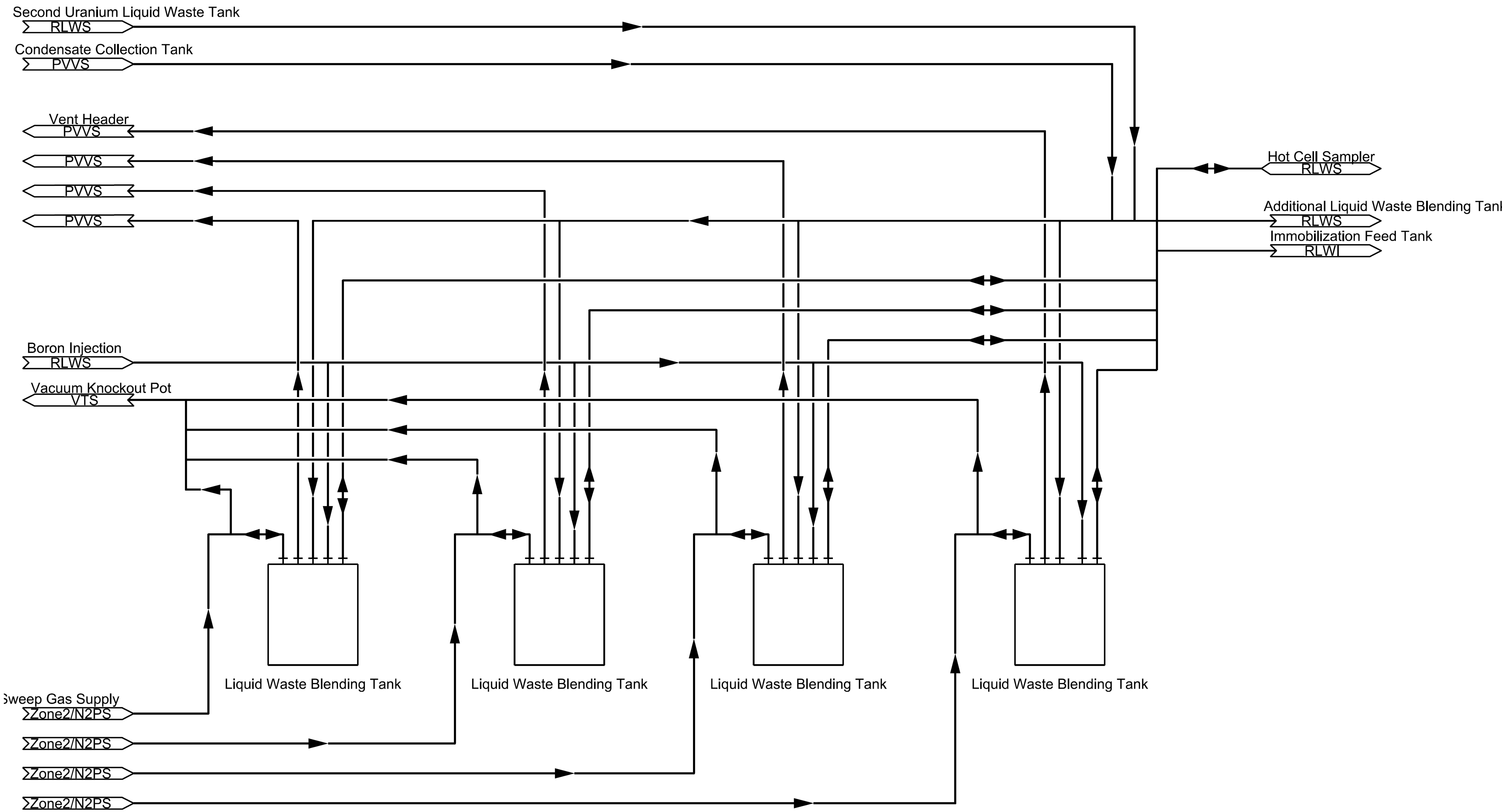


Figure 9b.7-5 – RDS Process Flow Diagram

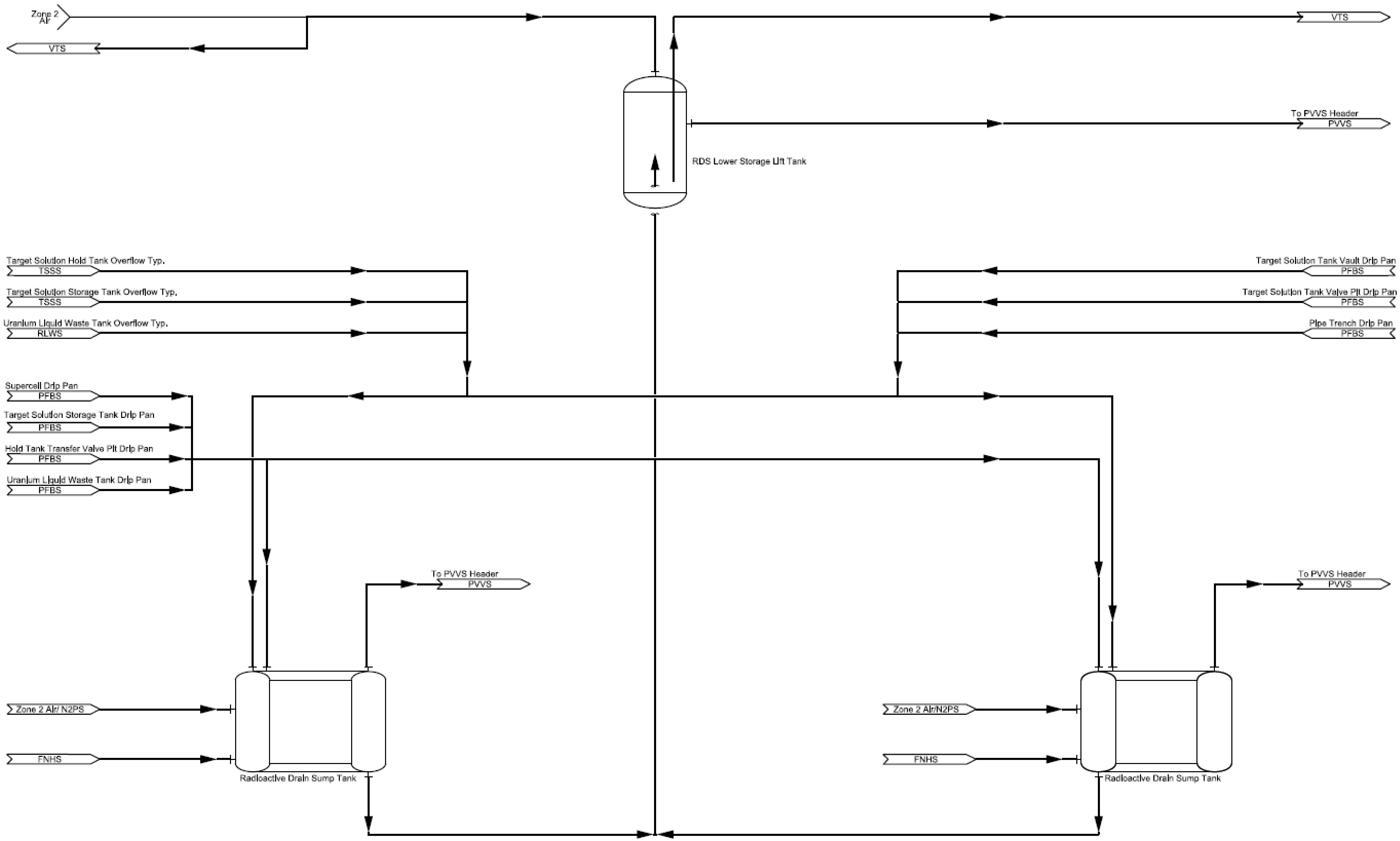
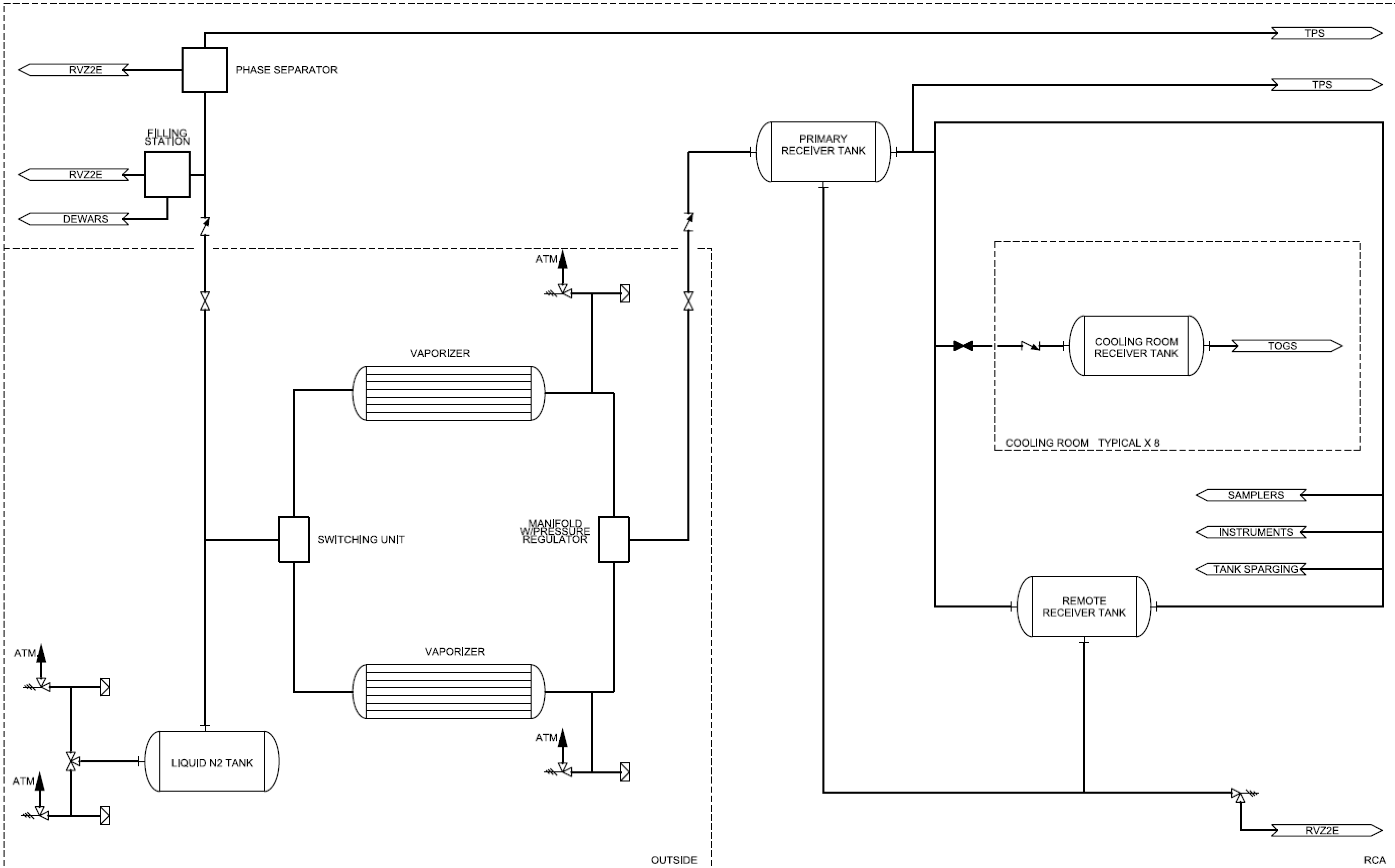


Figure 9b.7-6 – FNHS Process Flow Diagram



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