CHAPTER 9

AUXILIARY SYSTEMS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ACGIH	American Conference on Governmental Industrial Hygienists
AGS	American Glovebox Society
AHRI	Air-Conditioning Heating and Refrigeration Institute
AHA	acetohydroxamic acid
AHU	air handling unit
AIHA	American Industrial Hygiene Association
ALARA	as low as is reasonable achievable
AMCA	Air Movement and Control Association
ANS	American Nuclear Society
ANSI	American National Standards Institute
API	American Petroleum Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
atm	atmosphere (unit of pressure)
BPVC	Boiler and Pressure Vessel Code
Btu/lb	british thermal unit per pound
CAAS	criticality accident alarm system
CAMS	continuous air monitoring system
CAS	Chemical Abstracts Service
CFR	Code of Federal Regulations

Acronyms and Abbreviations (cont'd)

Acronym/Abbreviation	Definition
Ci	curies (unit of measurement of radioactivity)
CMAA	Crane Manufacturers Association of America
Cs	cesium
DOE	U.S. Department of Energy
DOT	Department of Transportation
DPTE	double door for leaktight transfer
ESF	engineered safety feature
ESFAS	engineered safety features actuation system
F	Fahrenheit
FA	fire area
FCHS	facility chilled water supply and distribution system
FDA	U.S. Food and Drug Administration
FFPS	facility fire detection and suppression system
FHA	fire hazards analysis
FHWS	facility heating water system
FICS	facility integrated control system
FLRS	facility alkaline reagent storage and distribution system
FIGS	facility inert gas system
FM	Factory Mutual
FSAR	Final Safety Analysis Report
ft.	feet
FVZ4	Facility Zone 4 ventilation system

Acronyms and Abbreviations (cont'd)

Acronym/Abbreviation	Definition
g	gram
g U/L	gram of uranium per liter
GTCC	greater than Class C
gpm	gallons per minute
HCFD	hot cell fire detection and suppression system
HEPA	high efficiency particulate air
HMI	human machine interface
hp	horsepower
HVAC	Heating, ventilation, and air conditioning
IBC	International Building Code
IEEE	Institute of Electrical and Electronic Engineers
IESNA	Illuminating Engineering Society of North America
IFC	International Fire Code
IGS	inert gas control
IMC	International Mechanical Code
ISA	Integrated Safety Analysis
IU	irradiation unit
J/g	joules per gram
L	liter
lb U/gal	pound of uranium per gallon
lbs	pounds
LCO	limiting conditions for operation

Acronyms and Abbreviations (cont'd)

Acronym/Abbreviation	Definition
LEU	Low enriched uranium
LFL	lower flammability limit
LOOP	loss of off-site power
LSA	low specific activity
LSC	Life Safety Code
M	molarity (moles per liter)
m	meter
MEPS	molybdenum extraction and purification system
min	minutes
MIPS	molybdenum isotope product packaging system
Mo-99	molybdenum-99
MPFL	maximum possible fire loss
NDAS	neutron driver assembly system
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NGRS	noble gas removal system
NPSS	Normal Electrical Power Supply System
NRC	U.S. Nuclear Regulatory Commission
OIT	operator interface terminals
PAC	process automation controller
PFBS	production facility biological shield system
PFD	process flow diagram

Acronyms and Abbreviations (cont'd)

Acronym/Abbreviation	Definition
PLC	programmable logic controller
PLC/PAC	programmable logic controller/process automation controller
PPE	personal protective equipment
ppm	parts per million
PSAR	Preliminary Safety Analysis Report
Pu	plutonium
PVVS	process vessel vent system
RAM	radiation area monitor
RAMS	radioactive area monitoring system
RCA	radiologically controlled area
RDS	radioactive drain system
RICS	radiological integrated control system
RMHS	radioactive area material handling system
RLWE	radioactive liquid waste evaporation and immobilization system
RLWS	radioactive liquid waste storage
RPCS	radioisotope production facility cooling systems
RDS	radioactive drain system
RMHS	radioactive area material handling system
RLWE	radioactive liquid waste evaporation and immobilization system
RLWS	radioactive liquid waste storage
RPCS	radioisotope production facility cooling systems

Acronyms and Abbreviations (cont'd)

Acronym/Abbreviation	Definition
RV	RCA ventilation System
RVZ1	radiological controlled area ventilation system zone 1
RVZ2	radiological controlled area ventilation system zone 2
RVZ3	radiological controlled area ventilation system zone 3
SCAS	subcritical assembly system
sccm	standard cubic centimeter per minute
SHINE	SHINE Medical Technologies, Inc.
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SNM	special nuclear material
SRWP	solid radioactive waste packaging
SSC	structures, systems and components
Tc	technetium
TCAP	thermal cycling absorption process
TDN	thermal denitration
TELCO	telephone company
TOGS	target solution vessel off gas system
TPCS	TSV process control system
TPS	tritium purification system
TRPS	target solution vessel reactivity protection system
TSPS	target solution preparation system

Acronyms and Abbreviations (cont'd)

Acronym/Abbreviation	Definition
TSV	target solution vessel
U-233	uranium-233
U-235	uranium-235
UHF	ultra high frequency
UL	Underwriters Laboratories
UNCS	uranyl nitrate conversion system
UNP	uranyl nitrate preparation (subsystem of UNCS)
UO_x	uranium oxide
UPS	uninterruptible power supply
UPSS	uninterruptible power supply system
UREX	uranium extraction
vol%	volume percent
WCB	Wisconsin Commercial Building Code
XLPE-FR	cross-linked polyethylene

CHAPTER 9

AUXILIARY SYSTEMS

9a1 HETEROGENOUS REACTOR AUXILIARY SYSTEMS

The SHINE Medical Technologies, Inc. (SHINE) facility is not a reactor-based facility; therefore, this section does not apply to the SHINE facility.

9a2 IRRADIATION FACILITY AUXILIARY SYSTEMS

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

9a2.1.1 RADIOLOGICALLY CONTROLLED AREA VENTILATION SYSTEM

The RCA ventilation system (RV) includes supply air and exhaust subsystems required to condition the air and maintain radiological confinement in the RCA. The supply and exhaust air systems perform safety functions to protect workers and the public from releases of radiological materials and hazardous chemicals.

A ventilation flow diagram is provided in Figure 9a2.1-1 (the legend for process flow diagrams is provided on Figure 1.3-6).

RV consists of the following:

- RCA Ventilation Zone 1 (RVZ1)

  RVZ1, the primary confinement zone, includes those areas where high levels of airborne contamination are anticipated during normal operations. RVZ1 areas draw ambient supply air from adjacent RVZ2 spaces. RVZ1 areas are maintained at negative pressure with respect to their surrounding RVZ2 spaces. RVZ1 area air inlets are equipped with automatic isolation dampers (fail closed), manual isolation dampers, and non-credited high efficiency particulate air (HEPA) filters. These HEPA filters are not assumed to be present in accident analyses, but are present to provide additional protection to workers and equipment.

  The exhaust air from each RVZ1 area filters through local HEPA filters. In addition to the automatic isolation dampers on the air inlet, each RVZ1 area exhaust outlet includes automatic isolation dampers to enable confinement of the RVZ1 area. These automatic dampers are safety-related and isolate the RVZ1 areas upon a signal from the Engineered Safety Features Actuation System (ESFAS) or the Radiological Integrated Control System (RICS), and reduce the exhaust of released airborne material.

  Negative space pressure in RVZ1 is controlled through modulation of local exhaust air flow control valves for each cell.

  The RVZ1 exhaust system is equipped with redundant fans. 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 RVZ1 system exhaust fans draw air through the inlet filters, dampers, and piping, providing the pressure drop needed to maintain pressure negative within the RVZ1 area.

  The speed of the RVZ1 exhaust fans is controlled to maintain a negative pressure set point in the RVZ1 exhaust duct header. RVZ1 exhaust also receives treated output from the Noble Gas Removal System (NGRS) through the Process Vessel Vent System (PVVS). The exhaust from RVZ1 areas collects in the RVZ1 system duct header and then draws through final, testable, HEPA filters and carbon adsorbers prior to discharge into the exhaust stack.

  RVZ1 exhaust discharges to the nominally 56 inch diameter exhaust stack with a radiation monitoring system. The discharge point of the stack is approximately 10 feet above the roof line.

The RVZ1 exhaust heating, ventilation, and air conditioning (HVAC) control components operate through the Facility Integrated Control System (FICS) and are nonsafety-related, except for the isolation dampers noted above, and the automatic isolation dampers located in the RVZ1 exhaust ductwork downstream of the final filters. These isolation dampers are controlled by ESFAS and RICS, which are safety-related. The isolation dampers located in the RVZ1 exhaust ductwork downstream of the final filters perform a safety function and close when required to provide confinement at the RCA boundary.

- RCA Ventilation Zone 2 (RVZ2)

RVZ2, the secondary confinement zone, includes those areas where airborne contamination could be (but is not routinely) generated during normal operations, or as a result of a breach of an RVZ1 confinement area. RVZ2 areas are transient spaces prone to fluctuations in pressure because of changing airflows based on door movements and fume hood activity.

RVZ2 areas are directly supplied air via the RCA supply air handling units (AHUs). The AHUs supply 100 percent outside air to the RVZ2 areas. Each AHU contains filters, pre-heat and cooling coils, and supply fans. The supply system includes three AHUs, each sized for 50 percent of total system capacity. 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. In addition to the outside air supplied directly to RVZ2 areas, RVZ3 air is cascaded into RVZ2 areas through engineered airlock door leakage pathways by a negative pressure differential, maintaining the desired pressure drop between the zones. RVZ2 areas are maintained at negative pressure with respect to RVZ3 areas.

Terminal unit components in the supply duct system include air flow control valves and reheat coils. The terminal reheat coils provide final tempering of supply air to maintain the RVZ2 temperature set point. RVZ2 supply airflow control valves operate in conjunction with exhaust valves to control the negative pressure differential in each zone by maintaining a fixed offset between the total supply and exhaust air flows for each RVZ2 areas.

RCA supply air controls operate through the FICS and are nonsafety-related, except for the automatic isolation dampers (bubble-tight dampers) in the supply duct system at the RCA boundary. These dampers are operated by the safety-related RICS, and perform a safety function, closing when required to provide confinement at the RCA boundary.

RVZ2 areas exhaust through general room exhausts and fume hood enclosures (where present). A portion of the air in RVZ2 areas is also transferred to RVZ1 areas through RVZ12 area air inlets, which contain automatic isolation dampers (fail closed), manual isolation dampers, and non-credited HEPA filters. As described above, the RVZ2 supply and exhaust systems will have airflow control valves, reacting to maintain the design differential pressure and ensuring the zone pressures are negative with respect to atmosphere and RVZ3. Flow control valves in fume hood exhaust ducts (where present) maintain a constant volume through each fume hood. The control valves automatically modulate to compensate for changes in pressure drop due to loading of local filters.

The RVZ2 exhaust system is equipped with redundant fans. 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. Exhaust from RVZ2 areas collects in an RVZ2 exhaust header, and then draws through final, testable, HEPA filters and carbon adsorbers, prior to discharge into the exhaust stack. The RVZ2 exhaust fan speed is controlled to maintain the desired negative pressure in the RVZ2 exhaust header, and local automatic control valves adjust to maintain the negative pressure in the zone.

Along with RVZ1, RVZ2 exhaust discharges to the nominally 56 inch diameter exhaust stack, which contains a stack monitoring system. The discharge point of the stack is approximately 10 feet above the roof line.

The RVZ2 controls operate through the FICS and are nonsafety-related, except for the automatic isolation dampers in the supply duct at the RCA boundary and in the RVZ2 exhaust duct system located downstream of the final filters. These perform a safety function and close when required to provide confinement at the RCA boundary.

- RCA Ventilation Zone 3 (RVZ3)

  RVZ3, the tertiary confinement zone, includes those areas where airborne contamination is not expected during normal facility operations.

  RVZ3 areas have airflow control valves on the supply side delivering air balanced to the design values. Forced air supplied to RVZ3 is then transferred to RVZ2 spaces through engineered airlock door leakage pathways. RVZ3 areas are maintained at an elevated pressure relative to RVZ2 areas, and a negative pressure relative to FVZ4 spaces. No RVZ3 exhaust system is anticipated, as the air from RVZ3 areas is transferred to RVZ2 areas.

9a2.1.1.1 Design Bases

The RV is designed to provide environmental conditions suitable for personnel and equipment. The functions of the system include conditioning the RCA environment for workers and equipment, and confinement of hazardous chemical fumes and airborne radiological materials. The ventilation system includes functions designated as nonsafety-related and safety-related. System safety functions are achieved through maintaining negative pressure gradients between confinement zones and to the outside atmosphere, air-exchange rates, exhaust stream air filtration, and isolation (closure) of ventilation duct systems at designated boundaries.

The RV is designed such that the FICS monitors and controls the RCA ventilation system equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for off-normal conditions and signal alarms as required. The FICS starts, shuts down, and operates the RV in normal operating modes, which prevent positive pressurization of contaminated areas and creates flow patterns that direct air toward areas of increasing contamination potential.

The primary operational design functions of the RCA ventilation system are summarized below:

- Provide ventilation air and condition the RCA environment for workers.
- Provide makeup air and condition the RCA environment for process equipment.
- Confine airborne radiological materials.
- Limit the spread of airborne contamination.
- Maintain dose uptake through ingestion to levels as low as reasonable achievable (ALARA) per 10 CFR 20 – Standards for Protection against Radiation.
- Confine hazardous chemical fumes.

9a2.1.1.2 Safety Design Functions

The safety design functions of the RV are:

- Provide confinement at irradiation unit cell, TOGS shielded cell, noble gas storage cell, and RPF hot cell boundaries.
- Provide confinement at RCA boundary.

9a2.1.2 NON-RADIOLOGICAL AREA VENTILATION SYSTEM

The non-radiological area ventilation system is the facility ventilation Zone 4 (FVZ4) system, which consists of a supply air subsystem and an exhaust air subsystem.

- FVZ4 Supply Air Subsystem

  The supply air subsystem provides conditioned air for workers and equipment in the non-RCA, make-up air for exhaust air systems, and outside air to maintain positive pressure with respect to the RCA.

  The supply AHU draws at least 10 percent of outside air to make up for air exhausted and exfiltrated. The outside air is mixed with the air recirculated from the room and conditioned through the AHU before being supplied to the non-RCA. Each AHU contains filters, pre-heat and cooling coils, and supply fans. The supply system includes two AHUs, each sized for 50 percent of total system capacity. The AHUs normally supply a constant volume of conditioned air to FVZ4 spaces. The supply air system HVAC controls operate through the FICS and are nonsafety-related.

- FVZ4 Exhaust Air Subsystem

  The exhaust subsystem serves the following locations of the non-RCA:

  - Change out lockers.
  - Chemical storage.
  - Men’s and women’s restrooms.
  - Uninterruptible power supply system battery rooms.
  - Control room.

  The exhaust air subsystem controls operate through the FICS and are nonsafety-related.

9a2.1.2.1 Design Bases

The FVZ4 is designed to provide environmental conditions suitable for personnel and equipment, and to maintain positive pressure with respect to the RCA.

The FVZ4 is designed such that the FICS monitors and controls the non-RCA ventilation system equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for off-normal conditions and signal alarms as required.

The primary functions of the FVZ4 are summarized below:

- Provide conditioned air for workers and equipment.
- Provide outside makeup air for ventilation and pressurization.
- Remove hazardous chemical fumes.
- Maintain hydrogen concentration below 2 percent.

9a2.1.2.2 Safety Design Functions

FVZ4 has no safety functions.

9a2.1.3 FACILITY CHILLED WATER SUPPLY AND DISTRIBUTION SYSTEM

The facility chilled water supply and distribution system (FCHS) provides chilled water to the RCA and non-RCA of the SHINE facility.

The FCHS provides chilled water to the cooling coils of the RCA supply AHUs, and to the process cooling heat exchangers of the radioisotope production facility cooling system (RPCS). See Chapter 5 for more information on the RPCS. Also, FCHS provides chilled water to the cooling coils of the FVZ4 AHUs.

The primary components of the FCHS include:

- Air-cooled condensers.
- Chiller evaporators.
- Chilled water pumps, associated piping and valves, and makeup water and water treatment equipment.
- Expansion tank.

The FCHS is a closed loop system serving the RV and FVZ4 cooling coils that are located outside the RCA boundary. The FCHS also supplies water to the heat exchanger in the RPCS, located inside the RCA. The water-to-water heat exchanger provides separation between the RCA and non-RCA chilled water systems to limit the potential for cross-contamination.

Isolation valves on the chilled water supply and return lines to each cooling coil and heat exchanger allow isolation from the water loop for maintenance.

If supplemental ventilation system cooling is required in the RCA, the RPCS serves HVAC cooling coils within the RCA.

The FICS monitors and controls the FCHS equipment status, flow rates, pressures, and temperatures. Instrumentation monitors the system for off-normal conditions and signal alarms as required. The FICS starts, shuts down, and operates the FCHS. Chiller controls are nonsafety-related.

Temperature control valves in the chilled water coil piping for each RCA supply AHU are controlled by a supply air temperature controller with input from a temperature element (sensor) located in the discharge ductwork of each supply AHU. The control valve regulates the chilled water flow to the cooling coil to maintain the setpoint for the supply air discharge temperature.

9a2.1.3.1 Design Basis

The FCHS is designed such that the FICS can monitor and control the equipment, flow rates, pressures, and temperatures. Instrumentation monitors the ventilation systems for abnormal conditions and signal alarms as required.

The primary functions of the FCHS are as follows:

- Remove the heat and condition the air passing through the cooling coils of the RCA supply AHUs. Circulate chilled water through the cooling coils of RCA supply AHUs utilizing water as the working fluid.
- Remove heat from the RPCS. Circulate chilled water through the RPCS heat exchanger using water as the working fluid.
- Remove heat and condition the air passing through the cooling coils of the FVZ4 AHUs. Circulate chilled water through the cooling coils of the FVZ4 AHUs utilizing water as the working fluid.
- Maintain FCHS water quality.

9a2.1.3.2 Safety Design Functions

There are no safety functions identified for the FCHS.

9a2.1.4 FACILITY HEATING WATER SYSTEM

The facility heating water system (FHWS) provides heating water to the RCA and non-RCA of the SHINE facility.

The FHWS provides heating water to the preheat and reheat coils in the RVZ2 and FVZ4 supply systems.

The primary components of the FHWS include:

- Gas boiler.
- Pump, associated piping and valves, and makeup water and water treatment equipment.
- Expansion tank.

The FHWS is designed as a closed loop system where the water is heated by the gas boiler and circulated by the pump to the preheat and reheat coils of the RVZ2 and FVZ4 supply systems where it exchanges heat with the air before returning back to the boiler.

Isolation valves on the hot water supply and return lines to each heating coil and heat exchanger allow isolation from the water loop for maintenance.

The FICS monitors and controls the FHWS equipment status, flow rates, pressures, and temperatures. Instrumentation monitors the system for off-normal conditions and signal alarms as required. The FICS starts, shuts down, and operates the FHWS.

Temperature control valves in the preheat coil piping for each AHU are controlled by a supply air temperature controller with input from a temperature element (sensor) located in the discharge ductwork of each AHU. The control valve regulates the heating water flow to the preheat coil to maintain the setpoint for the supply air discharge temperature. Area thermostats control the reheat coil discharge temperature. Controls are nonsafety-related.

9a2.1.4.1 Design Basis

The design basis for the FHWS is:

- Respond to heating loads during winter in order to satisfy supply air temperature requirements leaving the preheat and reheat coils for the RV and FVZ4.
- Circulate water heated by the gas boiler, then distribute to the preheat and reheat coils by the circulating pump.

9a2.1.4.2 Safety Functions

There are no safety functions identified for the FHWS.

9a2.1.5 TESTING REQUIREMENTS

The design of the HVAC system permits routine testing and inspection without disruption to normal operation. Testing will be performed on an appropriate basis to detect and correct any problems or degradation of the components.

9a2.1.6 MECHANICAL HVAC DESIGN CODES AND STANDARDS

Tables 9a2.1-1, 9a2.1-2, and 9a2.1-3 provide a list of the primary mechanical HVAC design codes, standards, and references. These are to be used as guidance documents for designing the RV, FVZ4, FCHS, and FHWS components.

9a2.1.7 TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the heating, ventilation, and air conditioning systems are provided in Chapter 14.

Table 9a2.1-1 HVAC Design Codes and Standards (Sheet 1 of 3)

Document No.	Title/Description	Version
Air-Conditioning, Heating, and Refrigeration Institute (AHRI), Standard 410	Forced-Circulation Air-Cooling and Air-Heating Coils	2001
Air Movement and Control Association (AMCA), Publication 201	Fans and Systems	2002
AMCA, Publication 203	Field Performance Measurement of Fan Systems	2011
AMCA, Publication 99	Standards Handbook	2010
American Conference on Governmental Industrial Hygienists (ACGIH)	Industrial Ventilation: A Manual of Recommended Practice	2004
American National Standards Institute (ANSI) Z21.13	ANSI Gas Fired Low Pressure Steam & Hot Water Boilers	2010
ANSI/AHRI Standard 430	Performance Rating of Central Station Air Handling Units	2009
ANSI/AHRI Standard 365	Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units	2009
ANSI/AHRI Standard 551/591	Performance Rating of Water-Chilling and Heat Pump Water Heating Packages Using the Vapor Compression Cycle	2011
ANSI/AHRI Standard 850	Performance Rating of Commercial and Industrial Air Filter Equipment	2004
ANSI/American Industrial Hygiene Association (AIHA) Z9.5	Laboratory Ventilation	2003
ANSI/AMCA 204-05	Balance Quality and Vibration Levels for Fans	2012
ANSI/AMCA 210-07	Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating	2007
AMCA 301-06	Methods for Calculating Fan Sound Ratings from Laboratory Test Data	2006
ANSI/AMCA Standard 500-D-12	Laboratory Methods of Testing Dampers for Rating	2012
ANSI/AMCA Standard 500-HL-12	Laboratory Methods of Testing Louvers for Rating	2012
ANSI/AMCA Standard 510-09	Methods of Testing Heavy Duty Dampers for Rating	2009

Table 9a2.1-1 HVAC Design Codes and Standards
(Sheet 2 of 3)

Document No.	Title/Description	Version
ANSI/American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) Standard 15	Safety Standard for Refrigeration Systems	2010
ANSI/ASHRAE Standard 34	Designation and Safety Classification of Refrigerants	2010
ANSI/ASHRAE Standard 52.2	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size	2007
ANSI/ASHRAE Standard 55	Thermal Environmental Conditions for Human Occupancy	2010
ANSI/ASHRAE Standard 62.1	Ventilation for Acceptable Indoor Air Quality	2010
ANSI/ASHRAE/Illuminating Engineering Society of North America (IESNA), Standard 90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition (ANSI Approved; IESNA Co-sponsored)	2010
ANSI N13.1	Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities	1999
ANSI/American Society of Mechanical Engineers (ASME) N509-2002	Nuclear Power Plant Air-Cleaning Units and Components	2008
ANSI/ASME N510	Testing of Nuclear Air Treatment Systems	2007
ASHRAE Standard 111	Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems	2008
ASME AG-1, including Addenda 1a & 1b	Code on Nuclear Air and Gas Treatment	2009, Addenda 1a, Addenda 1-b-2011
ASME B31.5	Refrigeration Piping and Heat Transfer Components	2010
ASME N511	In-Service Testing of Nuclear Air Treatment, Heating, Ventilating, and Air-Conditioning Systems	2007
IMC	International Mechanical Code	2009
National Electrical Manufacturers Association (NEMA) MG-1	Motors and Generators	2011
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems	2012
NFPA 45	Standard on Fire Protection for Laboratories Using Chemicals	2011
NFPA 70	National Electrical Code	2011
NFPA 72	National Fire Alarm and Signaling Code	2013

Table 9a2.1-1 HVAC Design Codes and Standards
(Sheet 3 of 3)

Document No.	Title/Description	Version
NFPA 801	Facilities Handling Radioactive Materials	2008
NFPA 90B	Standard for Installation of Warm Air Heating and Air Conditioning Systems	2012
NFPA 92A	Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences	2009
SMACNA	Seismic Restraint Manual: Guideline for Mechanical Systems, 3rd ed.	2008
SMACNA 1143	HVAC Air Duct Leakage Test Manual	2012
SMACNA 1520	Round Industrial Duct Construction Standards	1999
SMACNA 1922	Rectangular Industrial Duct Construction Standards	2009
SMACNA 1966	HVAC Duct Construction Standards – Metal and Flexible	2005
UL 900	Standard for Air Filter Units - Seventh Edition	2012
UL 1995	Heating and Cooling equipment - Fourth Edition	2011
UL 555	Standard for Fire Dampers - Seventh Edition	2012
UL 555S	Standard for Smoke Dampers - Fourth Edition	2009
Wisconsin Administrative Code	Chapter SPS 345 Mechanical Refrigeration	N/A
Wisconsin Administrative Code	Chapter SPS 363 Energy Conservation	N/A
Wisconsin Administrative Code	Chapter SPS 364 Heating, Ventilating and Air Conditioning	N/A

Table 9a2.1-2 HVAC Damper Design Codes and Standards

Component	Codes and Standards
Safety-Related Dampers	Code on Nuclear Air and Gas Treatment ASME AG-1, including 2009 Addenda 1a and 1b (2011), Section DA, Dampers and Louvers.
Nonsafety-Related Dampers	SMACNA 1966 (Version 2005), HVAC Duct Construction Standards, Metal and Flexible (Use for Low Pressure Duct Sections). SMACNA 1520 (Version 1999), Round Industrial Duct Construction Standards (Use for High Pressure Duct Sections). SMACNA 1922 (Version 2009), Rectangular Industrial Duct Construction Standards (Use for High Pressure Duct Sections). AMCA 500-D-12 (Version 2012), Laboratory Methods for Testing Dampers for Rating.

Table 9a2.1-3 HVAC Ductwork Design Codes

Component	Codes and Standards
Exhaust Ductwork	Code on Nuclear Air and Gas Treatment ASME AG-1, 2009, Addenda 1a, Addenda 1-b-2011, Section SA, Ductwork. SMACNA 1520 (Version 1999), Round Industrial Duct Construction Standards (Use for High Pressure Duct Sections). SMACNA 1922 (Version 2009), Rectangular Industrial Duct Construction Standards (Use for High Pressure Duct Sections). SMACNA 1143 (Version 2012), HVAC Air Duct Leakage Test Standard. NFPA 45 (Version 2011), Standard on Fire Protection for Laboratories Using Chemicals. NFPA 90A (Version 2012), Standard for the Installation of Air Conditioning and Ventilating Systems. NFPA 801 (Version 2008), Facilities Handling Radioactive Materials. AIHA Z9.5 (Version 2003), Laboratory Ventilation. ACGIH Industrial Ventilation: A Manual of Recommended Practice (Version 2004).
Supply Ductwork	SMACNA 1520 (Version 1999), Round Industrial Duct Construction Standards (Use for High Pressure Duct Sections). SMACNA 1922 (Version 2009), Rectangular Industrial Duct Construction Standards (Use for High Pressure Duct Sections). SMACNA 1143 (Version 2012), HVAC Air Duct Leakage Test Standard. NFPA 45 (Version 2011), Standard on Fire Protection for Laboratories Using Chemicals. NFPA 90A (Version 2012), Standard for the Installation of Air Conditioning and Ventilating Systems. NFPA 801 (Version 2008), Facilities Handling Radioactive Materials. AIHA Z9.5 (Version 2003), Laboratory Ventilation. ACGIH Industrial Ventilation: A Manual of Recommended Practice (Version 2004).

9a2.2 HANDLING & STORAGE OF TARGET SOLUTION

9a2.2.1 INTRODUCTION

This section describes the handling and storage of special nuclear material (SNM) and byproducts within the target solution within the irradiation facility (IF), which is shown in Figure 9a2.2-1. The preparation of the target solution is located outside of the IU cell. The piping used for transfer of the target solution to the IU cell includes penetrations of the cell through redundant sets of isolation valves.

Detailed descriptions of the processing and storage of irradiated and unirradiated SNM and byproducts in the RPF are found in Subsections 4b.4.1 and 4b.4.2. Equipment and design features involved in the SNM lifecycle are included in these subsections.

The physical protection of uranium against theft or diversion will be described in the facility physical security plan. The facility physical security plan will be provided with the FSAR.

9a2.2.2 TARGET SOLUTION PREPARATION

Target solution is derived from 19.75 ± 0.2 percent low enriched uranium (LEU) and is prepared in the target solution preparation system (TSPS) by dissolving uranium oxide in sulfuric acid. See Section 9b.2 for a detailed discussion of target solution preparation process steps.

Target solution must meet the chemical property requirements discussed in Subsection 4a2.2.1 before it is transferred from the target solution hold tank (1-TSPS-03T) to the TSV. If the target solution is not within the required chemical specifications, operators make appropriate adjustments while the target solution is being prepared in the TSPS.

The storage and process tanks in the TSPS use double-contingency, criticality-safe controls.

9a2.2.3 IRRADIATION FACILITY TARGET SOLUTION STORAGE AND HANDLING

After target solution has been prepared in the uranyl sulfate preparation tank (1-TSPS-01T), it is pumped to the target solution hold tank (1-TSPS-03T) to await being loaded into the TSV. The reagent addition portion of the preparation tank is located within a glovebox. The hold tank is located within a tank vault. Target solution is pumped from the target solution hold tank (1-TSPS-03T) to the TSV. If a recycled (previously irradiated) target solution batch is used, the recycled target solution is pumped from the recycle target solution tank (1-UNCS-09T) to the target solution hold tank (1-TSPS-03T) instead of using unirradiated target solution prepared in the TSPS.

See Figure 9a2.2-2 for a cross-section of the TSV and subcritical assembly.

After irradiation in the TSV, the target solution is gravity-transferred to the TSV dump tank (1-SCAS-01T) where it is held for decay prior to being pumped to the molybdenum extraction and purification system (MEPS) and then on to the uranyl nitrate conversion system (UNCS) for further processing. SNM and byproducts in the target solution remain in solution until they are separated downstream in the MEPS and UNCS processes. Fissile material in these systems is held in double-contingency, criticality-safe design equipment.

See Section 9b.2 for a detailed discussion of storage and handling for SNM outside of the IF.

9a2.2.4 IRRADIATION FACILITY TARGET SOLUTION HANDLING EQUIPMENT

The following is a list of equipment necessary for loading/unloading the TSV with target solution. The equipment listed is either included in the IU cell or directly feeds/receives target solution from the TSV. See Figure 9a2.2-1 for the flow diagram that shows the irradiation facility target solution handling equipment.

- Target Solution Hold Tank (1-TSPS-03T-A-H)
  - Quantity: 8
  - Nominal Size: [Proprietary Information][Security-Related Information]
  - Normal Operating Pressure: atmospheric (vented)
  - Double-Contingency, Criticality-Safe Design
  - Design/Fabrication Code: ASME BPVC Section VIII Div 1 (ASME, 2012)
  - Location: Outside of IU cell

- Target Solution Feed Pump (1-TSPS-03P-A-H)
  - Quantity: 8
  - Nominal Power: 0.25 horsepower (hp)
  - Design/Fabrication Code: ANSI/HI 3.1-3.5 (ANSI/HI, 2008)
  - Location: Outside of IU cell

- Target Solution Vessel (1-SCAS-01S-A-H)
  - Quantity: 8
  - See Subsection 4a2.2 for a detailed description of the TSV
  - Location: Inside IU cell

- TSV Dump Tank (1-SCAS-01T-A-H)
  - Quantity: 8
  - Nominal Size: [Proprietary Information][Security-Related Information]
  - Normal Operating Pressure: atmospheric
  - Double-Contingency, Criticality-Safe Design
  - Design/Fabrication Code: ASME BPVC Section VIII Div 1 (ASME, 2012)
  - Location: Inside IU cell

- Irradiated Target Solution Pump (1-SCAS-01P-A-H)
  - Quantity: 8
  - Type: Positive Displacement
  - Nominal Power: 0.25 hp
  - Design/Fabrication Code: ANSI/HI 3.1-3.5 (ANSI/HI, 2008)

9a2.2.5 STORAGE OF SNM

Storage of SNM and byproducts in the IF is done in the double-contingency, criticality-safe process/storage tanks. SNM is not otherwise stored in the IF. The IF-related process/storage tanks provide the necessary storage and handling for this area of the facility.

9a2.2.6 CRITICALITY CONTROL

Processing of unirradiated and irradiated SNM and byproducts prevents inadvertent criticality through double-contingency, criticality-safe tanks and other components that handle or store the fissile SNM and byproducts in all conditions. The Nuclear Criticality Safety Program is discussed in 6b.3.

9a2.2.7 BIOLOGICAL SHIELDING

Biological shields are included around the IF-related equipment discussed in this section. The IU cell which houses the neutron driver assembly system (NDAS), light water pool, TSV, and TSV dump tank includes biological shielding. The target solution hold tank is located in a shielded tank vault outside of the IU cell. See Section 4a2.5 for information on the IF biological shield and Section 4b.2 for RPF biological shielding.

9a2.3 FIRE PROTECTION SYSTEMS AND PROGRAMS

9a2.3.1 INTRODUCTION

The fire protection system at the SHINE site is designed to protect the SHINE facility from damage by fire and to provide means to safely shut down the IUs in case of a fire. The fire protection system detects and suppresses fires, and is an integral part of the fire protection program.

The sections that follow include the fire protection system design basis and the associated fire hazards analysis for the SHINE facility. The procedures for operation, testing, and surveillance of the fire protection systems, including relationships between fire protection plans, operating procedures, and the emergency plan will be developed and maintained under the fire protection program.

9a2.3.2 DESIGN BASES

The fire protection program will comply with American National Standards Institute (ANSI)/American Nuclear Society (ANS) Standard for Fire Protection Program Criteria for Research Reactors (ANSI/ANS, 1981). The fire protection system at the SHINE site meets the design criteria of National Fire Protection Association (NFPA) Standard for Standard for Fire Protection for Facilities Handling Radioactive Materials (NFPA, 2008c). Other nationally-recognized codes and standards, listed at the bottom of this subsection, are also used in the design of the fire protection system as applicable in order to achieve reasonable assurance of fire safety. The facility fire protection system (FFPS) is designed to:

- 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 SHINE facility into fire areas separated by fire barriers.
- Separate redundant safe shutdown components and associated electrical divisions to preserve the capability to safely shut down the IUs following a fire.
- Separate redundant trains of safety-related equipment used to mitigate the consequences of a design basis accident (but not required for safe shutdown following a fire) so that a fire within one train will not damage the redundant train.
- Provide confidence that failure or inadvertent operation of the fire protection system cannot prevent SHINE facility safety functions from being performed.
- Preclude the loss of structural support, due to warping or distortion of SHINE facility structural members caused by the heat from a fire, to the extent that such a failure could adversely affect safe shutdown capabilities.
- Provide firefighting personnel access and life safety escape routes for each fire area.
- Minimize exposure to personnel and releases to the environment of radioactivity or hazardous chemicals as a result of a fire.
- The fire protection system is classified as a nonsafety-related, non-seismic system. The fire protection system is not required to remain functional following an accident or the most severe natural phenomena.
- Maintain fire pump design capacity with two 100 percent capacity fire pumps.

The fire protection system is designed to perform the following functions:

- Detect and locate fires and provide operator indication of their location.
- Provide the capability to extinguish fires in any SHINE facility area, to protect SHINE facility personnel and limit fire damage.
- Supply fire suppression water at a flow rate and pressure sufficient to satisfy the demand of any automatic sprinkler system plus 500 gallons per minute (gpm) for fire hoses, for a minimum of 2 hours.

In addition to NFPA 801 (NFPA, 2008c), the design, testing, and surveillance of the fire protection system is based on guidance from the following codes and standards:

- International Fire Code (IFC) (IFC, 2009).
- International Building Code (IBC) (IBC, 2009) as amended by Wisconsin Commercial Building Code (WCB), SPS 360-366 (WCB, 2011).
- Institute of Electrical and Electronic Engineers (IEEE) 1202, Standard for Flame-Propagation Testing of Wire and Cable (IEEE, 2006).
- NFPA 10, Standard for Portable Fire Extinguishers (NFPA, 2010a).
- NFPA 13, Standard for the Installation of Sprinkler Systems (NFPA, 2013a).
- NFPA 14, Standard for the Installation of Standpipe and Hose Systems (NFPA, 2010b).
- NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection (NFPA, 2012a).
- NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection (NFPA, 2013b).
- NFPA 22, Standard for Water Tanks for Private Fire Protection (NFPA, 2008a).
- NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances (NFPA, 2013c).
- NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (NFPA, 2011a).
- NFPA 30, Flammable and Combustible Liquids Code (NFPA, 2012b).
- NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals (NFPA, 2011b).
- NFPA 55, Compressed Gases and Cryogenic Fluids Code (NFPA, 2013d).
- NFPA 70, National Electrical Code (NFPA, 2011c).
- NFPA 72, National Fire Alarm and Signaling Code (NFPA, 2013e).
- NFPA 80, Standard for Fire Doors and Other Opening Protectives (NFPA, 2013f).
- NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating System (NFPA, 2012c).
- NFPA 101, Life Safety Code (NFPA, 2012d).
- NFPA 220, Standard on Types of Building Construction (NFPA, 2012e).
- NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials (NFPA, 2006).
- NFPA 430, Code for the Storage of Liquid and Solid Oxidizers (NFPA, 2004).
- NFPA 484, Standard for Combustible Metals (NFPA, 2012g).
- NFPA 780, Standard for the Installation of Lightning Protection Systems (NFPA, 2011d).
- NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems (NFPA, 2012h).

9a2.3.3 FACILITY FIRE PROTECTION SYSTEM DESCRIPTION

The SHINE facility is subdivided into fire areas that are separated by fire barriers to isolate combustible materials and limit the spread of fire. The fire area boundaries are shown in Figure 9a2.3-1. In each fire area the fire protection system detects fires and provides the capability to extinguish them using fixed automatic and manual suppression systems, manual hose streams, and/or portable firefighting equipment. The FFPS consists of the following:

- Detection systems for early detection and notification of a fire.
- Fixed automatic fire suppression systems.
- Manual fire suppression systems and equipment, including hydrants, standpipes, hose stations, and portable fire extinguishers.
- A fire water supply system including the fire pumps, yard main, and interior distribution piping.
- The descriptions and characteristics of the fire detection and suppression systems in each of the fire areas of the SHINE facility are provided in Subsection 9a2.3.4.

The components of the fire water supply system are shown in Figure 9a2.3-2, Fire Protection Site Layout, and Figure 9a2.3-3, Fire Protection Process Flow Diagram. Fire water is supplied from two separate fresh water storage tanks. There are two 100 percent capacity fire pumps. The lead pump is electric motor-driven and the secondary pump is diesel engine-driven. The fire water tanks are permanently connected to the fire pumps’ suction piping and are arranged so that the pumps can take suction from either or both tanks. Piping between the fire water sources and the fire pumps is in accordance with NFPA 20 (NFPA, 2013b), Standard for the Installation of Stationary Pumps for Fire Protection. A failure in one tank or its piping cannot cause both tanks to drain. Sprinkler and standpipe systems are supplied by connections from the yard main.

Manual valves for sectionalized control of the yard main or for shutoff of the water supply to suppression systems are administratively controlled. Hydrants are provided on the yard main in accordance with NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances (NFPA, 2013c), with at least two hydrants provided within 300 feet (91 meters) of the SHINE facility. The lateral to each hydrant is controlled by an isolation valve.

9a2.3.4 FIRE HAZARDS ANALYSIS

The fire hazards analysis (FHA) contained in this subsection evaluates the potential for occurrence of fires within the SHINE facility, documents the capabilities of the fire protection system, and provides reasonable assurance of the capability to safely shut down the IUs. The FHA is used to assess each fire area (FA) separately to ensure the fire protection program objectives are met.

9a2.3.4.1 Objective

The objective of the FHA is to ensure that fire protection requirements established in NUREG-1537 have been applied to the SHINE facility and are sufficient in:

- Preventing fires, including limiting combustible materials.
- Detecting, controlling, and extinguishing fires to limit consequences.
- Protecting systems required for safe shutdown of the IUs or to prevent an uncontrolled release of radioactive material.

The FHA considers potential in situ and transient fire hazards to accomplish the following objectives:

- Determine the effects of a fire in any location in the SHINE facility on the ability to safely shut down the IUs or to minimize and control the release of radioactivity to the environment,
- Specify measures for fire prevention, fire detection, fire suppression, and fire containment for each fire area containing structures, systems and components (SSC) important to safety in accordance with U.S. Nuclear Regulatory Commission (NRC) guidelines and regulations identified in NUREG-1537.
- Document known deviations and associated approved evaluations, waivers and equivalences.

9a2.3.4.2 Scope

The scope of the FHA consists of the comprehensive assessment of the fire or explosion hazards for the SHINE facility, including a description of the fire protection defense-in-depth features provided to minimize the consequences of such an event.

9a2.3.4.3 Methodology and Acceptance Criteria

9a2.3.4.3.1 Definitions

Authority Having Jurisdiction: The organization, office, or individual responsible for approving equipment materials, an installation, or a procedure (NRC or local Fire Marshal).

Defense-in-Depth: Fire protection for radiological handling facilities uses the concept of defense-in-depth to achieve the required degree of fire and criticality-safety. This concept entails the use of echelons of administrative controls, fire protection systems and features, and safe shutdown capability to achieve the following objectives:

- Prevent fires from starting.
- Detect rapidly, control, and extinguish promptly those fires that do occur.
- Protect SSCs to ensure the IUs can safely shut down.

Fire Area: A portion of the SHINE facility that is separated from other areas by fire barriers.

Fire Barrier: Components of construction (i.e., walls, floors and their supports, including beams, joists, columns, penetration seals or closures, fire doors and fire dampers) that are rated by approving laboratories in hours of resistance to fire and are used to prevent the spread of potential fire.

Fire-Resistive Construction: A construction type in which the structural members are noncombustible and have a fire-resistant rating.

Fire Zone: A self-contained, controlled-environment work enclosure providing a primary fire and radiological barrier from an occupied work area. Operations are performed either remotely or through sealed openings in order to protect the worker and the ambient environment from the hazards of the working material.

Noncombustible Material: Materials having the characteristics listed below:

a) Material which, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.
b) Material having a structural base of noncombustible material, as defined in (a) with a surfacing not over 3.2 millimeter (0.13 inches) thick which has a flame spread rating not higher than 50 when measured in accordance with American Society for Testing and Materials (ASTM) Standard Test Method for Surface Burning Characteristics of Building Materials (ASTM, 2006).
c) There is an exception to this definition that allows the use of combustible interior finishes when listed by a nationally recognized testing laboratory, such as Factory Mutual (FM) or Underwriters Laboratories (UL) Incorporated, for a flame spread, smoke, and fuel contribution of 25 or less in its use configuration.

Mezzanine: An intermediate level or levels between the floor and ceiling of any story that meet IBC (IBC, 2009) floor area and openness requirements.

Non-combustible Construction: A construction type in which the structural elements are entirely of noncombustible or limited-combustible materials. Type IIB noncombustible construction has no fire resistant rating.

9a2.3.4.3.2 General

The FHA provides descriptions of construction, operations, and fire hazards associated with each fire area in the SHINE facility. The following are considered and assessed in the analysis:

- The applicable NRC fire protection requirements and guidance.
- Amounts, types, configurations, and locations of cable insulation and other combustible materials.
- In-situ fire hazards.
- Automatic fire detection and suppression capability and other fire protection features
- Reliance on and qualifications of fire barriers.
- Location and type of manual firefighting equipment and accessibility for manual fire fighting.
- Potential for a toxic, biological, or radiation incident due to a fire.
- Damage potential: maximum possible fire loss (MPFL).
- Protection of SSCs.
- Life safety considerations.

The collected data is used to perform the FHA review for every room or area, on a floor-by-floor basis. The collected data contain the following items:

- Identification of the safety and nonsafety-related systems, and associated cabling within each fire area that could provide support for ensuring a safe shutdown condition.
- Identification of fire areas containing radioactive material that could be released to the site boundary or beyond should a fire occur in that fire area.
- Definition of the fire barriers surrounding a specific room or area which qualify rating the room or area as a separate fire area.

- A specific listing of types, quantities, and characteristics of all combustibles within a fire area that could constitute a fire load.
- Listing of all the fire detection and suppression capabilities provided and their accessibility for each fire area.
- Design provisions for protecting the functional capability of safety systems and associated cabling from the results of inadvertent operation, careless operation, or rupture of the extinguishing systems for each fire area are considered.
- The means of containing and inhibiting the progress of a fire in each fire area; this is defined as the use of a fire-resisting enclosure or barrier, fire seals at wall penetrations, dampers, curbs, or fire doors into the area.

The collected data is used in the FHA to formulate the following:

An analysis of each fire area identifying the design criteria employed in providing fire protection for the equipment within the fire area. Divisional safety equipment is separated by 3-hour rated fire barriers. Fire detection, fire suppression, and fire seal capabilities are also discussed in the analysis.

An analysis defining the consequences of the fire for each fire area; this is stated as loss of function and identifies the divisional backup capability available for safety systems. The loss of function that would not impair the capability of safe shutdown is identified where nonsafety-related systems are involved.

9a2.3.4.3.3 Function and Arrangement

9a2.3.4.3.3.1 General Construction Description

Table 9a2.3-1 provides the IBC and Life Safety Code (LSC), NFPA 101 (NFPA, 2012d), classification summary for the SHINE facility. The IBC is used to classify the use and the construction of the SHINE facility. The LSC is used to classify the SHINE facility occupancy.

9a2.3.4.3.3.2 Fire Area Boundaries

The SHINE facility is divided into twenty-one fire areas. The fire area boundaries are shown in Figure 9a2.3-1. A fire area is defined as that portion of the SHINE facility that is separated from other areas by fire barriers, including components of construction such as beams, joists, columns, penetration seals or closures, fire doors, and fire dampers. Fire barriers that define the boundaries of a fire area have a fire resistance rating of three hours or more. Self-contained fire zones inside fire areas are also shown in Figure 9a2.3-1.

9a2.3.4.3.4 Acceptance Criteria

The following items serve as the acceptance criteria for changes in the configuration of the SHINE facility fire areas and the associated design of fire protection systems and features:

- Automatic water suppression systems are provided in the design for areas in which a transient fire loading is most likely to occur as a result of combustibles introduced by normal maintenance operations. The FHA is based on the introduction of combustibles to any area of the SHINE facility, subject to SHINE’s administrative control.

- The SHINE facility is generally of reinforced concrete construction. The walls, floors, and ceilings have 3-hour fire resistive rating where required by a high combustible loading in the room or where an adjacent room contains equipment or systems from a different safety train. Stair towers which do not communicate between areas of different divisions may have walls and doors with a 2-hour fire rating for personnel protection during egress from the areas. Non-concrete interior walls are constructed of metal studs and gypsum wallboard to the required fire resistive rating.
- Doors, in general, are 3-hour rated, complying with NFPA ratings. There are also doors, not labeled, which provide area separation. Typical of these are the doors for the personnel air lock into the radiological control area (RCA) and the missile/tornado doors at the equipment access entrance to the SHINE facility. The term doors, where used in the analysis, shall mean doors, frames, and hardware.
- Surface finishes are specified to have a flame spread, fuel-contributed and smoke-evolved index of 25 or less (Class A), as determined by ASTM-E84, Standard Test Method for Surface Burning Characteristics of Building Materials (ASTM, 2006), or NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials (NFPA, 2006).
- The use of plastic materials, including electrical cable insulation, has been minimized in the design.
- Suspended ceilings are used in some areas of the SHINE facility. The ceilings, including the lighting fixtures, are of noncombustible construction.
- The electrical cable fire seals are tested to demonstrate a fire rating equal to the rating of the barrier they penetrate. The tests are performed or witnessed by a representative of a qualified, independent testing laboratory. The documented test results for the acceptable fire seals are made a part of the SHINE facility design records.
- Control, power, or instrument cables of redundant systems that are used for bringing the IUs to safe shutdown are separated by 3-hour fire barriers.
- Certain areas of the SHINE facility have trays in stacked array. Where stacking of trays occurs, power cable, which is the most susceptible to internally generated fires, is routed in the uppermost tray to the greatest extent possible to provide maximum isolation from other trays in the stack. The fire loading of electrical cable in trays is based on flame-retardant, cross-linked polyethylene (XLPE-FR) insulation having a calorific value of 3.256 x 10^4 joules per gram (J/g) (1.40 x 10^4 british thermal units per pound [Btu/lb]).

- Electrical cabling specified for the project meets flame-testing requirements IEEE 1202, Standard for Flame Testing of Cables for Use in Cable Tray (IEEE, 2006).

    - The cable trays are estimated at the maximum design fill to contain between 11.91 and 15.63 kilograms (kg) of insulation per running meter of tray (between 8.0 and 10.5 pounds [lbs] of insulation per running foot of tray).
    - The analysis uses an average 13.77 kg of insulation per meter of tray (9.3 lbs of insulation per foot of tray). The combustible loading is based on maximum loading. The loading reduces as cables drop out of (exits) trays and the fire loading decreases.

- Total reliance is not placed on a single fire suppression system. A minimum of two fire suppression means is available to each fire area. The SHINE facility design provides the following types of suppression and utilizes them in suitable combination for the fire hazard considered:

    - Automatic supervised air double interlock preaction systems.
    - Water spray deluge systems.
    - Clean agent suppression systems.
    - Standpipes.
    - Class ABC hand extinguishers.

- Piping penetrations are provided with fire-seals when penetrating fire resistive walls.
- HVAC penetrations are provided with fire dampers equal in rating to the fire barrier penetrated.
- The design provides ventilating systems which minimize the release of radioactive materials through the use of HEPA and charcoal filtration systems.

9a2.3.4.4 Safety Evaluation of Fire Hazards

9a2.3.4.4.1 Life Safety Considerations

9a2.3.4.4.1.1 General

Life safety provisions of the SHINE facility design are in accordance with LSC and IBC. Compliance with the LSC satisfies the exit requirements of the Occupational Safety and Health Standard Title 29 of the Code of Federal Regulations Part 1910 (29 CFR 1910).

Automatic fire detectors are installed where required. In addition, manual pull stations are installed to allow personnel to activate the fire alarm system. Upon actuation of the fire alarm system, audible and visual indicating devices provide notification to personnel to evacuate the SHINE facility.

Interior finishes consist of noncombustible and combustible materials. Exposed interior walls or ceilings (including ceilings formed by the underside of roofs) and any factory-installed facing materials have an UL listed/FM approved surface flame spread rating of 25 or less, and a smoke development rating of 50 or less.

9a2.3.4.4.1.2 Occupancy

The LSC is used to determine the SHINE facility occupancy classification. The occupancy classification for the SHINE facility is provided in Table 9a2.3-1.

9a2.3.4.4.1.3 Means of Egress Features

Emergency exits are available from all areas of the SHINE facility within the IBC allowed maximum travel distance of 250 ft. (76 meters [m]). Common path of travel does not exceed the allowed maximum of 100 ft. (30 m) per the IBC. Dead-end corridors do not exceed the allowed maximum of 50 ft. (15 m) per the IBC.

9a2.3.4.4.1.4 Illumination and Marking of the Means of Egress

The illumination of means of egress is provided in accordance with the LSC and IBC. Emergency lighting and marking of the means of egress are provided in accordance with the LSC and IBC.

9a2.3.4.4.2 Fire Protection Features

This FHA is predicated on the assumption that a fire may occur in any one fire area within the SHINE facility. The nature of the postulated fire depends on the hazards present at any given time within the SHINE facility. The following fire protection features are designed to ensure a fire is successfully controlled or contained until such time as the fire department arrives to provide firefighting efforts.

9a2.3.4.4.2.1 Fire Water Supply System

The fire protection yard main piping arrangement and fire protection water supply system are shown in Figure 9a2.3-2. The fire protection process flow diagram is shown in Figure 9a2.3-3. Automatic fire water suppression systems are provided for the entire SHINE facility except for the following areas:

- Hot cells.
- Gloveboxes.
- Vaulted storage tanks.
- Where water based suppression is ineffective for firefighting.

9a2.3.4.4.2.2 Special Suppression Systems

Clean agent fire suppression systems are provided for fire protection of RPF areas containing flammable gas, if any, such as hot cells, gloveboxes and vaulted storage tanks. These systems are designed in accordance with American Glovebox Society (AGS) Standard of Practice for Glovebox Fire Protection (AGS, 2011), and NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems (NFPA, 2012h).

9a2.3.4.4.2.3 Manual Suppression

Manual fire suppression is conducted by a fully staffed, completely equipped, and adequately trained off-site fire department, capable and committed to respond to fires and related emergencies in a timely and effective manner. Personnel trained in the use of portable fire extinguishers are assumed to voluntarily conduct firefighting efforts on fires in the incipient stage.

Class I standpipes are provided for manual fire suppression capability in the SHINE facility. Class I systems include 2½ inch hose connections. The 2½ inch connection is not provided with a hose and is there for “trained fire-fighter” use only. The Class I standpipes are designed and installed in accordance with NFPA 14, Standard for the Installation of Standpipe and Hose Systems (NFPA, 2010b).

Means for supporting manual fire suppression efforts in the SHINE facility consist of portable multipurpose dry-chemical and clean-agent extinguishers. These extinguishers are selected, installed, inspected, tested, and maintained in accordance with NFPA 10, Standard for Portable Fire Extinguishers (NFPA, 2010a).

9a2.3.4.4.2.4 Fire Detection and Alarm Systems

Fire alarm and detection systems are provided throughout the SHINE facility and are designed, installed, located, inspected, tested, and maintained in accordance with NFPA 72, National Fire Alarm and Signaling Code (NFPA, 2013e).

Fire detection is provided as part of the facility fire detection and suppression system (FFPS) and the hot cell fire detection and suppression system (HCFD). The HCFD provides fire detection and suppression capabilities for the supercells and the hot cells in the RPF. Fire detectors in the HCFD send a signal to isolate the fire-rated dampers in the supercells and the hot cells in the event of a fire in one of these cells. These dampers prevent the spread of fire from the hot cell or supercell. The fire detection in the HCFD is classified as non-safety related, since radiation detectors and associated interlocks with bubble-tight dampers controlled by RICS perform the SR function of reducing potential release of radioactive materials from the hot cell or supercell due to a fire. The suppression subsystem of the HCFD is classified as nonsafety-related.

The fire detection in the rest of the SHINE facility is part of the FFPS. The FFPS is classified as nonsafety-related.

9a2.3.4.4.3 Fire Barriers and Protection of Penetrations

The SHINE facility is generally of reinforced concrete construction. The walls, floors, and ceilings have a 3-hour fire resistive rating where required by a high combustible loading in the room or where adjacent room contains equipment or systems from a different safety train. Stair towers which do not communicate between areas of different divisions may have walls and doors with a 2-hour fire rating for personnel protection during egress from the areas. Non-concrete interior walls are constructed of metal studs and gypsum wallboard to the required fire resistive rating.

The areas within the SHINE facility are subdivided into separate fire areas for the purposes of limiting the spread of fire, protecting personnel, and limiting the consequential damage to the SHINE facility. Determination of fire area boundaries is based on consideration of the following:

- Types, quantities, density, and location of combustible materials.
- Location and configuration of equipment.
- Consequences of inoperable equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.
- Location of major electrical equipment.
- Location of process confinement areas.
- Location of storage areas.
- Separation of office areas from adjacent areas.

Three-hour fire-rated barriers separate the individual fire areas within the SHINE facility. Fire barrier design and construction is in accordance with NRC regulations and NFPA 221, Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls (NFPA, 2012f).

Where fire-rated assemblies are partially or fully penetrated by pipes, ducts, conduits, raceways or other such penetrates, fire barrier penetration material is placed in and around the penetrations to maintain the fire-resistance rating of the assembly. All openings in fire barriers are protected consistent with the designated fire-resistance rating of the barrier. Fire doors and dampers are rated commensurate with the fire barrier in which they are installed and comply with the requirements of NFPA 80, Standard for Fire Doors and Other Opening Protectives (NFPA, 2013f), and NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating System (NFPA, 2012c), respectively.

Certain doors and access hatches throughout the SHINE facility have a multipurpose function such as fire, pressure, radiation, seismic, watertight, and airlocks. Where possible, these doors and hatches are specified to rated and labeled criteria and are then identified as rated doors. When other criteria require the manufacturer to delete the label, the door is identified as equivalent. Where the door is not constructed as a fire door, such as a containment personnel airlock, it is identified by its main function.

9a2.3.4.4.4 Fire Water Collection

Firefighting water expended within the SHINE facility during a fire event is collected, sampled and removed, as necessary. The method of collection will be identified in the FSAR. If HEPA filters require deluge protection, the expended water is collected, sampled, and removed.

9a2.3.4.4.5 Ventilation and Smoke Control

There are no smoke control design requirements associated with the life-safety features of the SHINE facility.

9a2.3.4.4.6 Fire Areas

There are 21 fire areas in the SHINE facility. These fire areas are separated by fire barriers as shown in Figure 9a2.3-1.

9a2.3.4.4.6.1 Radiological Control Area Overview

The RCA is a unique fire area because it separates the radiological area from peripheral support areas of the SHINE facility and contains multiple smaller fire areas (Fire Areas 1 - 5) and fire zones. The RCA is entirely surrounded and separated by a 3-hour fire-rated barrier. The fire areas located within the RCA are broken down further into fire zones.

The RCA consists of multiple areas that include process equipment, vaults, storage, and office space and allows an overhead bridge crane system to transfer material.

Process equipment (i.e., hot cells, gloveboxes, supercells and vault tank units), also defined as fire zones, generate and contain hydrogen gas products that may pose an explosion and fire hazard. Hydrogen gas is classified as a highly flammable gas. A dedicated ventilation system is used to limit concentrations to less than the lower flammability limit (LFL).

9a2.3.4.4.6.2 FA-1 - Tank Farm and Supercell Area

9a2.3.4.4.6.2.1 Description

This area consists of a number of below-grade tanks that contain aqueous mixtures. In addition, this fire area contains several supercell units and hot cells. Specific fire zones include the uranium extraction (UREX) hot cell, pump transfer hot cell, solid waste hot cell, waste evaporation hot cell, thermal denitration (which includes a glovebox), and liquid waste solidification.

9a2.3.4.4.6.2.2 Life Safety Considerations

This fire area is not normally occupied during normal plant operations. The egress route from this area is through the airlock and Fire Area 6, and exit to the exterior. There is no occupant access into the hot cell units; therefore, emergency egress provisions are not required.

9a2.3.4.4.6.2.3 Fire Protection Features

This fire area is protected to provide a defense-in-depth approach to fire protection. This approach results in a fire being quickly detected and suppressed and reduces fire-induced damage.

Suppression

A gaseous fire suppression system is designed and installed within each vault and hot cell.

Detection

An early warning air sampling smoke detection system is designed and installed for each hot cell as well as the thermal denitration glovebox.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.2.4 Potential for Toxic or Radioactive Incident Due to a Fire

Toxic materials are not anticipated within the hot cells. However, radioactive hazards are present within the RCA and pose a radiological threat in the event of a fire.

9a2.3.4.4.6.2.5 Combustible Loading

The area contains small amounts of stored radioactive/contaminated combustible materials such as protective clothing, decontamination supplies, and trash. This material is stored after processing in non-combustible containers, such as vented drums, barrels, and boxes.

Several gallons of hydraulic fluid are contained in the crane gear box which can move throughout the area. Each of the hot cells contains mechanical systems and the associated supporting electrical systems.

In vaults, supercells and hot cells that contain processes that generate and contain hydrogen gas, ventilation systems are used to limit concentrations to less than the LFL in air.

The UREX hot cell contains nominally 5 gallons of odorless kerosene (dodecane).

9a2.3.4.4.6.3 FA-2 - Irradiation Cell Areas

9a2.3.4.4.6.3.1 Description

This fire area primarily contains material associated with the TSV and NDAS, TPS, and multiple pump skids. The IU cell, TOGS cell, and TPS area are subdivided into fire zones that contain a variety of processes and support equipment. Each TPS glovebox is considered a single fire zone. Each of the sixteen IU and TOGS cells is considered an individual fire zone. Each cell is encased in at least 36 inches (91 centimeters) of concrete which is used for radiation shielding.

9a2.3.4.4.6.3.2 Life Safety Considerations

This fire area is not normally occupied during normal plant operations; therefore, emergency egress provisions are not required. The egress route from this area is through the airlock and Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.3.3 Fire Protection Features

Suppression

A non-water based fire suppression system is designed and installed within each hot cell and glovebox as required.

Detection

An early warning air sampling smoke detection system is designed and installed for each IU cell, TOGS cell, hot cell, and glovebox.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.3.4 Potential for Toxic or Radioactive Incident Due to a Fire

Tritium is contained within each of the TPS gloveboxes and IU cells.

9a2.3.4.4.6.3.5 Combustible Loading

In IU cells, TOGS cells, and gloveboxes that generate and/or contain hydrogen gas, ventilation systems are used to limit concentrations to less than the LFL in air. Each of the cells contains mechanical handling and associated supporting electrical systems.

9a2.3.4.4.6.4 FA-3 - Labs

9a2.3.4.4.6.4.1 Description

General office combustibles (e.g., chairs, desks and paper products) are present in the U.S. Food and Drug Administration (FDA) lab, hot lab, decon, tool crib, and health physics rooms.

9a2.3.4.4.6.4.2 Life Safety Considerations

This fire area is normally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 1, the airlock, and Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.4.3 Fire Protection Features

Suppression

A gaseous fire suppression system is designed and installed in the area.

Detection

A fire detection system is provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.4.4 Potential for Toxic or Radioactive Incident Due to a Fire

This area contains small amounts of chemicals and radioactive/contaminated materials.

9a2.3.4.4.6.4.5 Combustible Loading

This area contains small amounts of stored radioactive/contaminated combustible materials such as office equipment, protective clothing, decontamination supplies, and trash. The combustibility of the materials is low and the associated quantity of combustibles is moderate.

9a2.3.4.4.6.5 FA-4 - Noble Gas Storage

9a2.3.4.4.6.5.1 Description

Pressurized gas canisters are stored in this fire area.

9a2.3.4.4.6.5.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 1, the airlock, and Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.5.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

A fire detection system is provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.5.4 Potential for Toxic or Radioactive Incident Due to a Fire

There is a potential for radioactive releases due to a fire in this area.

9a2.3.4.4.6.5.5 Combustible Loading

The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.6 FA-5 - Uranyl Sulfate Storage

9a2.3.4.4.6.6.1 Description

This area serves as a storage and preparation area for uranyl sulfate. There are two gloveboxes present. There is also a fumehood in this area.

9a2.3.4.4.6.6.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 1, the airlock, and Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.6.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

A fire detection system is provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.6.4 Potential for Toxic or Radioactive Incident Due to a Fire

This fire area contains LEU. Hazardous materials are used for processing in the area (nitric acid, sulfuric acid, uranium metal, uranyl nitrate, uranyl sulfate).

9a2.3.4.4.6.6.5 Combustible Loading

The combustibility of the materials is low and the associated quantity of combustibles is low. Combustible metals are stored and handled in accordance with NFPA 484 (NFPA, 2012g), Standard for Combustible Metals.

9a2.3.4.4.6.7 FA-6 - Offices/Corridors/Miscellaneous Area

9a2.3.4.4.6.7.1 Description

This fire area consists of several office and miscellaneous rooms. All corridors outside of the airlock are included in this area. General office supply combustibles (i.e., chairs, desks and paper products) are in offices and storage rooms. This area also contains materials associated with neutron driver test/assembly. Shipping and receiving rooms are in this area. Other miscellaneous rooms include staging rooms, restroom and locker room facilities, janitor supply room, the operations briefing room, and a security station.

9a2.3.4.4.6.7.2 Life Safety Considerations

This fire area is normally occupied during normal SHINE facility operations. The egress route from this area is via multiple exits to the exterior.

9a2.3.4.4.6.7.3 Fire Protection Features

<u>Suppression</u>

Supervised air preaction fire water suppression systems are provided through this entire area.

<u>Detection</u>

A fire detection system is provided for this area.

<u>Passive Protection</u>

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.7.4 Potential for Toxic or Radioactive Incident Due to a Fire

There is a potential for toxic or radioactive materials to be in this area during material transport.

9a2.3.4.4.6.7.5 Combustible Loading

This fire area contains cables in conduit/trays, electrical panels, and other ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.8 FA-7 - Chemical Storage Area

9a2.3.4.4.6.8.1 Description

This fire area is comprised of a total of five rooms. Three chemical storage rooms are in this fire area. In addition, there is a separate acids storage room and a separate alkalines storage room.

9a2.3.4.4.6.8.2 Life Safety Considerations

This fire area is not normally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.8.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided for the three chemical storage rooms in this area. Automatic suppression systems are also provided for the acids storage room and the alkalines storage room.

Detection

A fire detection system is provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas. The acids storage room and the alkalines storage room have fire-rated construction to separate them from other rooms and other fire areas.

9a2.3.4.4.6.8.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no radioactive materials in the area. Toxic and hazardous chemicals are stored in the area. Stored chemicals in the area include: nitric acid, [Proprietary Information] sodium hydroxide (caustic), potassium permanganate, ammonium hydroxide, sodium iodide, silver nitrate, hydrochloric acid, alpha benzoin oxime, hydrogen peroxide, calcium nitrate, dodecane, tributyl phosphate, and acetohydroxamic acid.

9a2.3.4.4.6.8.5 Combustible Loading

Flammable liquids are stored and handled in accordance with NFPA 30 (NFPA, 2012b), with solid and liquid oxidizing agents stored and handled in accordance with NFPA 430 (NFPA, 2004). The quantities and storage of the chemicals are in compliance with IFC (IFC, 2009) and IBC (IBC, 2009).

9a2.3.4.4.6.9 FA-8 - Main Switchgear A

9a2.3.4.4.6.9.1 Description

This fire area contains electrical equipment (e.g., panels, motor control centers), cable trays, and conduits.

9a2.3.4.4.6.9.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.9.3 Fire Protection Features

<u>Suppression</u>

Supervised air preaction fire water suppression systems are provided through this entire area.

<u>Detection</u>

Photoelectric smoke detectors are provided for this area.

<u>Passive Protection</u>

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.9.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.9.5 Combustible Loading

This fire area contains cables in conduit/trays. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.10 FA-9 - Main Switchgear B

9a2.3.4.4.6.10.1 Description

This fire area contains electrical equipment (e.g., panels, motor control centers), cable trays, and conduits.

9a2.3.4.4.6.10.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.10.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.10.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.10.5 Combustible Loading

This fire area contains cables in conduit/trays. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.11 FA-10 - Control and Instrument Air

9a2.3.4.4.6.11.1 Description

Air compressors and control equipment are located in this fire area.

9a2.3.4.4.6.11.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.11.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.11.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.11.5 Combustible Loading

This fire area contains cables in conduit/trays. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.12 FA-11 - Battery A and UPS A

9a2.3.4.4.6.12.1 Description

This fire area contains two train A rooms: battery room and uninterruptible power supply (UPS) room. The batteries are located on steel racks.

9a2.3.4.4.6.12.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.12.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.12.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no combustible toxic or radioactive materials in the area that could be released to the atmosphere. Thus, there is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.12.5 Combustible Loading

This fire area contains cables in conduit/trays and combustibles associated with batteries. The combustibility of the materials is moderate and the associated quantity of combustibles is low.

Ventilation systems are used to limit hydrogen concentrations in the battery room to less than 2 percent by volume in air.

9a2.3.4.4.6.13 FA-12 - FICS and TPCS/RICS Rooms

9a2.3.4.4.6.13.1 Description

This fire area contains two rooms: the FICS room and the target solution vessel (TSV) process control system (TPSC) and the radiological integrated control system (RICS) room.

9a2.3.4.4.6.13.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.13.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.13.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.13.5 Combustible Loading

This fire area contains cables in conduit/trays. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.14 FA-13 - TRPS Room

9a2.3.4.4.6.14.1 Description

This fire area is the TSV reactivity protection system (TRPS) room.

9a2.3.4.4.6.14.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.14.3 Fire Protection Features

Suppression1

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.14.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.14.5 Combustible Loading

This fire area contains cables in conduit/trays. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.15 FA-14 - HMI/TELCO and FFPS/CAAS/RAMS/CAMS Rooms

9a2.3.4.4.6.15.1 Description

This fire area includes the human machine interface/telephone company (HMI/TELCO) room and the facility fire detection and suppression (FFPS) system, criticality accident alarm system (CAAS), radioactive area monitoring system (RAMS) and continuous air monitoring system (CAMS).

9a2.3.4.4.6.15.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.15.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.15.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.15.5 Combustible Loading

This fire area contains cables in conduit/trays. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.16 FA-15 - Control Room

9a2.3.4.4.6.16.1 Description

This fire area consists of three rooms: the facility’s control room, the shift supervisors office, and a bathroom. Computer equipment and general office combustibles (e.g., chairs, desks, and paper products) are in this fire area.

9a2.3.4.4.6.16.2 Life Safety Considerations

This fire area is normally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.16.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.16.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.16.5 Combustible Loading

This fire area contains ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.17 FA-16 - Fire Brigade and Hazmat Room

9a2.3.4.4.6.17.1 Description

Fire brigade and hazmat equipment is stored in this fire area.

9a2.3.4.4.6.17.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.17.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.17.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.17.5 Combustible Loading

This fire area contains ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.18 FA-17 - HVAC Zone 4 (Boiler) Room

9a2.3.4.4.6.18.1 Description

This fire area contains the HVAC boiler and associated equipment.

9a2.3.4.4.6.18.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.18.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.18.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.18.5 Combustible Loading

This fire area contains ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.19 FA-18 - HVAC Zone 4 (Chillers) Room

9a2.3.4.4.6.19.1 Description

This fire area contains the HVAC chillers.

9a2.3.4.4.6.19.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6 and exit to the exterior.

9a2.3.4.4.6.19.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.19.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.19.5 Combustible Loading

This fire area contains ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.20 FA-19 - HVAC Zones 1, 2, and 3 (Supply Air Handler Room)

9a2.3.4.4.6.20.1 Description

This fire area is the supply air handler room for HVAC zones 1, 2, and 3.

9a2.3.4.4.6.20.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is via the mezzanine stairwell, Fire Area 6, and exit to the exterior at grade level.

9a2.3.4.4.6.20.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.20.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no toxic or radioactive materials in the area. There is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.20.5 Combustible Loading

This fire area contains ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.21 FA-20 – RCA HVAC Zones 1, 2, and 3 (Exhaust Filters) and Exhaust Fan & Stack Room

9a2.3.4.4.6.21.1 Description

HEPA filters are provided to support contamination mitigation for the RCA. Fire protection features such as a deluge system are provided to minimize/mitigate the risk of interior and exterior contamination.

9a2.3.4.4.6.21.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is via airlock, Fire Area 19, the mezzanine stairwell, Fire Area 6, and exit to the exterior at grade level.

9a2.3.4.4.6.21.3 Fire Protection Features

Suppression

The exact fire suppression method will be determined when the safety function and housing configuration is determined.

Detection

A fire detection system is provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.21.4 Potential for Toxic or Radioactive Incident Due to a Fire

There is a potential for a radioactive release from this area due to a fire.

9a2.3.4.4.6.21.5 Combustible Loading

This fire area contains HEPA and charcoal filters and other ordinary combustibles. The combustibility of the materials is low and the associated quantity of combustibles is low.

9a2.3.4.4.6.22 FA-21 – Battery B and UPS B Rooms

9a2.3.4.4.6.22.1 Description

This fire area contains two train B rooms: battery room and UPS room. The batteries are located on steel racks.

9a2.3.4.4.6.22.2 Life Safety Considerations

This fire area is occasionally occupied during normal SHINE facility operations. The egress route from this area is through Fire Area 6, and exit to the exterior.

9a2.3.4.4.6.22.3 Fire Protection Features

Suppression

Supervised air preaction fire water suppression systems are provided through this entire area.

Detection

Photoelectric smoke detectors are provided for this area.

Passive Protection

Passive fire protection is provided in the form of fire-rated construction to provide separation between fire areas.

9a2.3.4.4.6.22.4 Potential for Toxic or Radioactive Incident Due to a Fire

There are no combustible toxic or radioactive materials in the area that could be released to the atmosphere. Thus, there is no potential for a toxic or radioactive incident due to a fire.

9a2.3.4.4.6.22.5 Combustible Loading

This fire area contains cables in conduit/trays and combustibles associated with batteries. The combustibility of the materials is moderate and the associated quantity of combustibles is low.

Ventilation systems are used to limit hydrogen concentrations in the battery room to less than 2 percent by volume in air.

9a2.3.5 TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the fire protection system and program are provided in Chapter 14.

Table 9a2.3-1 SHINE Facility IBC and LSC Classifications

Area Code	Facility Description	IBC Use Classification	IBC Construction Classification	LSC Occupancy Classification
1	Medical Isotope Production Facility	F-1 (Special Industrial)	Type I or II (Non-Combustible/ Non-Rated)	Special Purpose Industrial

9a2.4 COMMUNICATIONS SYSTEMS

The communication systems provide communications during normal and emergency conditions between essential areas of the SHINE facility, as well as locations remote to the facility. The systems are designed such that a failure of any system does not impair the ability of the other systems to function. This is accomplished through the use of diverse technologies as described in Subsections 9a2.4.1 (on-site communications) and 9a2.4.2 (off-site communications) below.

A more detailed description of the communication systems, including drawings and specifications of the principal components will be provided in the FSAR.

9a2.4.1 ON-SITE COMMUNICATIONS

9a2.4.1.1 Normal Communication

The facility utilizes a communication system that provides for paging, alarming, and party-line-type voice communications. Stations for this system are located throughout the facility. The system provides communications between any two areas of the facility. The system is designed so that a failure of any one station does not impact the other stations. The stations are modular in design for ease of replacement. In an emergency, this system is used to alert personnel.

9a2.4.1.2 Private Exchange Line

A private exchange system is provided in various areas of the facility. These phones serve as a backup to the normal communications system. The system is tied to the commercial telephone system, which serves as the main off-site communications channel. The system is powered separately from the normal communications system.

9a2.4.1.3 Sound-Powered Phones

Sound-powered phones are installed in strategic areas to supplement the normal communications system. These are hard wired independent of any room or system and are provided with handsets to be plugged in at each strategic area. The phones operate independent of any power source, and so are not affected by loss of power to the facility.

9a2.4.1.4 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 for the facility.

9a2.4.2 OFF-SITE COMMUNICATIONS

9a2.4.2.1 Telephone System

Commercial telephones are provided in normally-manned areas. These phones allow personnel to contact any outside telephone number in the case of an emergency.

9a2.4.2.2 Testing Requirements

The design of the communications systems permits routine testing and inspection without disruption to normal communications. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the communications systems.

9a2.4.3 TECHNICAL SPECIFICATIONS

There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the communication systems.

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

This section applies to the auxiliary systems within the IF that normally interact with byproduct, source, and special nuclear material. Refer to Section 9b.5 for the discussion of possession and use of byproduct, source, and special nuclear material in the radioisotope production facility.

9a2.5.1 BYPRODUCT MATERIAL

Within the SHINE facility, byproduct material is generated by the fission and irradiation of target solution in TSV (see Subsection 11.1.1). In addition, tritium is used in the facility and is classified as byproduct material. Possession and use of byproduct material is authorized and regulated under 10 CFR Part 50 Domestic Licensing of Production and Utilization Facilities, and also regulated under 10 CFR Part 30.

The IF-related auxiliary systems that process byproduct material are the tritium purification system (TPS) and target solution preparation system (TSPS).

9a2.5.1.1 Tritium Purification System

The byproduct material present in the TPS is tritium. The TPS controls the distribution and processing of tritium for the neutron driver. TPS provides tritium at a purity of [Proprietary Information] to the tritium target chamber in the neutron driver assembly system (NDAS), and cleans up impurities in the tritium return stream from the NDAS. Tritium is fed to the tritium target chamber to generate neutrons for nuclear fission of uranium, and remains isolated from the target solution.

Tritium is located throughout the TPS in tanks, piping, and adsorption beds. A raffinate waste stream from the tritium cleanup is sampled before being released to RCA Zone 1 Exhaust.

Tritium processing occurs within the TPS gloveboxes which have a tritium capture system to trap any tritium released to the glovebox atmosphere. The gloveboxes minimize the exposure of workers to tritium. TPS tritium piping external to the glovebox is double-walled with tritium detection. Tritium circulated to the NDAS is at sub-atmospheric pressure. There are redundant TPS process trains in separate gloveboxes.

Refer to Subsection 9a2.7.1 for additional details regarding the TPS.

9a2.5.1.2 Target Solution Preparation System

The target solution hold tanks contain the majority of the byproduct material in the TSPS. These tanks receive irradiated target solution that is recycled from the UNCS. This material contains most of the fission products present in the target solution with the exception of those fission products that are removed in the MEPS.

The target solution hold tanks are criticality-safe by geometry, and are located in shielded tank vaults within the RCA. Access to the tank vault is strictly controlled, to prevent worker exposure to the radiation within the tanks. The tank vaults are equipped with sumps, to detect leakage of byproduct material from the primary fission product barrier (the tank and associated piping).

The tanks are used for staging target solution prior to filling the associated TSV. If necessary, minor chemical adjustments may be made to the target solution in the target solution hold tanks.

9a2.5.2 SOURCE MATERIAL

Source material is defined as natural uranium or thorium or depleted uranium that is not suitable for use as reactor fuel, per 10 CFR 40, Domestic Licensing of Source Material. There is no source material normally present in the auxiliary systems in the IF.

[Proprietary Information]

9a2.5.3 SPECIAL NUCLEAR MATERIAL

Special nuclear material (SNM) is defined as plutonium (Pu), uranium-233 (U-233), or uranium enriched in the isotopes U-233 or uranium-235 (U-235). LEU is irradiated to produce molybdenum-99 by fission within the IF. During this process, a small quantity of Pu is also generated in the target solution [Proprietary Information]. The target solution hold tank contains LEU and a single TSV batch of Pu.

9a2.5.4 TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the possession and use of byproduct, source, and SNM are provided in Chapter 14.

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

The PCLS is a closed loop cooling system that provides cooling to the TSV. Details for the cover gas control in the PCLS cooling water tank (1-PCLS-01T) will be provided in the FSAR.

The LWPS is not a closed-loop system. No cover gas control for the LWPS is utilized. Buildup of radiolysis products in the IU cell is prevented by the RCA ventilation system Zone 1 and the volume of the cell.

9a2.7 OTHER AUXILIARY SYSTEMS

This section describes other auxiliary systems in the IF that are not described in the rest of Section 9a2 or other chapters of the PSAR.

The TPS is the only auxiliary system in the IF.

9a2.7.1 TRITIUM PURIFICATION SYSTEM

9a2.7.1.1 TPS Process Description

This subsection applies to the tritium purification system (TPS). The portion of the system that separates tritium and deuterium is the thermal cycling absorption process (TCAP).

The TPS is responsible for providing high-purity tritium to the neutron driver. The tritium return stream contains significant quantities of deuterium and other impurities. These impurities are removed in a semi-batch process, and the tritium is stored until it is recycled to the NDAS.

9a2.7.1.1.1 System Process Functions

The following is a list of the process functions of the TPS:

a. Provide approximately [Proprietary Information] tritium gas [Proprietary Information] to the NDAS.
b. Receive tritium gas from a bottle periodically.
c. Receive approximately [Proprietary Information] tritium/deuterium gas from the NDAS.
d. Remove water, organic impurities, and deuterium from the tritium.
e. Receive flush gas from the NDAS and remove tritium from the flush gas.
f. Monitor TPS waste streams that are discharged to the exhaust systems.
g. Scrub the glovebox atmosphere for tritium that may escape from the purification processes.

9a2.7.1.2 Safety-Related Functions

Minimize chronic or acute tritium releases.

a. Robust TPS construction and confinement provided by the glovebox and double-walled pipe.
b. TPS confinement system (e.g., relief valves or rupture discs, monitoring instrumentation, isolation valves).
c. TPS cell volume combined with TPS tritium inventory sufficient to maintain less than LFL assuming a TPS tritium leak.

9a2.7.1.2.1 Primary System Interfaces

For a list of system interfaces, refer to Table 9a2.7-1.

9a2.7.1.2.2 Tritium Purification Process Sequence

There are two TPS gloveboxes, which are each sized to supply the entire facility tritium demand. The following are the fundamental steps performed in the gloveboxes to support TCAP. Detailed descriptions of these steps will be provided in the FSAR.

- Target Gas Receiving – Recirculating tritium is transferred to the glovebox by vacuum pumps located in the NDAS and inside the glovebox. The recirculating tritium is stored in storage tanks prior to treatment.

- Impurity Removal – The first purification step is to remove water and other non-hydrogen species. This is accomplished by ambient and cryogenic molecular sieve beds, heated permeators, and getter beds. The cryogenic molecular sieve beds are cooled with liquid nitrogen, and the nitrogen gas is exhausted to the Zone 1 exhaust. The raffinate from the impurity removal feeds into the flush gas evacuation treatment process.

- Storage and Separation – After impurity removal, the gas contains mainly tritium and deuterium. This gas is stored in feed beds prior to separation. From the feed beds, the tritium fills a feed volume tank, and then is fed into TCAP where separation occurs. The product is fed into a product volume tank and then stored on palladium beds. One of the palladium beds is heated to provide tritium to the NDAS. The motive force to supply the NDAS is provided by vapor pressure from heating the palladium beds. The raffinate from TCAP is primarily deuterium with no more than [Proprietary Information] tritium. This raffinate is captured in the TPS exhaust sampling tank.

- Flush Gas Purification – During routine startup of the NDAS, a flush gas is routed to the TPS and treated to remove tritium. This gas will be oxidized on a catalytic reactor, and then dried by passing through an ambient molecular sieve bed. The molecular sieve bed will be regenerated periodically to recover and dispose of the tritium oxide. This raffinate is captured in the TPS exhaust sampling tank. The raffinate from the impurity removal process is also treated in the flush gas evacuation step to minimize the amount of tritium released.

- The raffinates in the TPS exhaust sampling tank (1-TPS_-01T) are sampled for tritium before they are released to the Zone 1 Exhaust. If excessive tritium is present, the gas will be recycled to the flush gas purification process.

See Figure 9a2.7-1 for the TPS process flow diagram (PFD), as well as interfacing systems.

9a2.7.1.2.3 Tritium Stream Properties

See Table 9a2.7-2 for the properties of the tritium supply, return, and raffinate streams. In addition to these streams, the TPS receives flush gas from the NDAS before irradiation of target solution begins. This gas is treated in the flush gas purification step to remove tritium before it is exhausted.

9a2.7.1.2.4 Process Equipment

See Table 9a2.7-3 for a list of major process equipment associated with the TPS.

9a2.7.1.3 TPS Glovebox Description

9a2.7.1.3.1 Glovebox Physical Description

The TPS process equipment is enclosed in two separate gloveboxes, one for Train A and a second for Train B. Both trains are sized to accommodate the entire demand of the eight NDASs in case one train is unavailable.

Each glovebox has an airlock connected to a centrally-located air hood. The airlocks and air hood facilitate the removal and replacement of internal equipment as needed to each glovebox train. Each glovebox has an internal maintenance crane and hoist on the inside ceiling of the glovebox and sliding trays on the floor of the glovebox to allow internal equipment to be removed from its supports, lifted, lowered and placed onto the sliding tray below. The sliding tray is manually pushed using the gloveports in the windows.

Both gloveboxes have gloveport windows mounted on both sides, internal and external electrical receptacles, and top and side mounted lighting fixtures.

The gloveboxes are operated in a nitrogen environment and each uses a blower mounted inside the glovebox to circulate the nitrogen through a water chiller system to provide cooling to the glovebox atmosphere.

The glovebox volume is sized such that a release of stored tritium would not result in exceeding the LFL in the glovebox.

9a2.7.1.3.2 Glovebox Atmosphere Treatment

Tritium is released into the glovebox occasionally, so the glovebox is 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 likely during maintenance activities (e.g. disconnecting beds or pumps for replacement).

The glovebox has a recirculating inert atmosphere with minimal nitrogen makeup. The oxygen content in the glovebox is monitored, and at high levels the operator is notified by alarms. The recirculating loop cleans the atmosphere to minimize the amount of tritium. The glovebox atmosphere exhausts through a HEPA filter and a bubbler into the RVZ1.

The cleanup involves a molecular sieve bed to remove most oxidized tritium, a nickel bed to remove the remaining oxidized tritium, and a zirconium-iron getter bed to capture elemental and gaseous tritium. The zirconium-iron getter bed operates at approximately 662°F (350°C). Since nitrogen reacts with the getter material above 842°F (450°C), the getter bed has high-temperature protection. All beds are regenerable, and are installed with backups in parallel.

9a2.7.1.4 Radiological Protection

The processes associated with the TPS are performed within a glovebox to minimize the exposure of individuals to tritium. The vacuum pumps are oil-less to avoid the spread of tritium contamination. Outside of the glovebox, TPS tritium piping is double-walled with tritium detection monitors and alarms to alert operators of any leaks. Additionally, the tritium outside the glovebox is normally under vacuum. Monitors are located near tritium piping and at glovebox workstations to identify tritium leaks. The TPS is designed to maintain chronic and acute exposures to tritium ALARA. Releases of tritium to the facility or environment are within 10 CFR 20 limits.

Outside the glovebox boundary, TPS tritium piping is double-walled. The annular space is open to the glovebox atmosphere treatment, with monitoring to identify potential leaks. The connections are welded or metal gasket face sealed to ensure high integrity.

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 molecular drag pump is used to aid in returning the tritium gas to the glovebox.

9a2.7.1.5 Hazardous Chemicals

Except tritium, described in Subsection 9a2.7.1.3.2, the current design has not identified any hazardous chemicals in the TPS.

9a2.7.1.6 Instrumentation and Controls

The TPS process equipment within the glovebox is operated through a programmable logic controller/process automation controller (PLC/PAC). The process is performed in semi-batch process steps of treating the contaminated flush gas and purifying the contaminated tritium gas.

Process steps and local interfaces (operator interface terminals [OIT]) are controlled and monitored by the PLC system. See Table 9a2.7-4 for the preliminary control system interface with the TSV process control system (TPCS).

9a2.7.1.7 Technical Specifications

Potential variables, conditions, or other items that will be probable subjects of a technical specification are provided in Chapter 14.

9a2.7.2 OFF-NORMAL AND ACCIDENT SCENARIOS

Part of the evaluation of other auxiliary systems is to determine that the design, functions, and potential malfunctions of the auxiliary system will not cause malfunctions or accidents that could result in uncontrolled release of radioactivity. This evaluation for auxiliary systems in both the IF and the RPF were reviewed as part of the development of the integrated safety analysis (ISA) for potential as a design basis accident (DBA) or initiating event (IE). The bases for the identification of DBAs and their IEs and associated accident scenarios were:

- Hazard and operability study (HAZOPS) as part of the development of the integrated safety analysis (ISA) summary, in accordance with NUREG-1520.
- List of IEs and accidents identified in the Final Interim Staff Guidance Augmenting NUREG-1537, Part 1.
- Experienced hazards analysis team.
- Preliminary design for the processes and facility.

The ISA development process identified process equipment by breaking it down into 56 systems and nearly 400 scenarios for both the IF and RPF. Causes for deviations and their potential outcomes were then identified. Finally, potential protective controls, safety functions, and functional requirements were identified. This led to the identification of the accident scenarios addressed in Chapter 13. For the FSAR a final HAZOPS analysis will be performed. The above noted process considered the other auxiliary systems identified in this chapter.

Table 9a2.7-1 TPS Interfaces

Interfacing System	Interface Description
Neutron Driver Assembly System (NDAS)	TPS interfaces with the NDAS at two locations: the inlet and outlet connections to the NDAS.
Radiological Control Area (RCA) Ventilation Zone 1	TPS interfaces with the RCA Ventilation Zone 1 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.
Radioisotope Process Facility Cooling System (RPCS)	TPS interfaces with the RPCS at two locations: the inlet and outlet connections on the glovebox chiller heat exchanger.
Normal Electrical Power Supply System (NPSS)	TPS interfaces with the NPSS at the following locations: the glovebox electrical penetration(s), 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.
Inert Gas Control (IGS)	TPS interfaces with IGS at one location. Desiccants or other methods of providing dry inerting to the glovebox may be required to avoid excessive loading of the glovebox atmosphere desiccant bed.
Solid Radioactive Waste Packaging (SRWP)	The TPS produces solid radioactive waste that is processed in the SRWP system.
Facility Inert Gas System (FIGS)	The TPS receives liquid nitrogen for cooling components. The interface point is the glovebox wall.
TSV Process Control System (TPCS)	The TPCS receives output signal from the TPS controller(s) and provides some limited input to the TPS controller(s).
Engineered Safety Features Actuation System (ESFAS)	The ESFAS receives input from loss of TPS confinement sensors (radiation and/or pressure), and outputs to the TPS confinement isolation valves.

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

Stream	Supply	Return	Raffinate
Composition			
Tritium	[Proprietary Information]	[Proprietary Information]	[Proprietary Information] max
Deuterium	Balance	Balance	Balance
Nominal Flow	[Proprietary Information]	[Proprietary Information]	10 sccm
Pressure	< 1 atm	< 1 atm	< 1 atm

Table 9a2.7-3 TPS Process Equipment

Component	Description	Code/Standard
Glovebox Atmosphere Recirculation Blower (1-TPS_-02C-A/B)	The blower is used to recirculate the atmosphere so that the glovebox atmosphere treatment equipment may remove any tritium from the glovebox atmosphere. The blower is a positive-displacement type used in a nitrogen environment up to 140°F.	ANSI/API 617
TPS Glovebox Atmosphere Chiller (1-TPS_-02A-A/B)	This water-to-water heat exchanger cools the glovebox cooling water. The glovebox cooling water is used to cool components and/or glovebox atmosphere to maintain the glovebox atmosphere temperature.	Commercial grade
TPS Glovebox Chiller Pump (1-TPS_-01P-A/B)	The positive-displacement pump serves to recirculate the glovebox cooling water.	Commercial grade
TPS Exhaust Sampling Tank (1-TPS_-01T)	The tank is a reservoir to collect TPS effluents before they are released to the RCA Ventilation Zone 1. The tank contents are sampled for acceptance and released, or recycled to the flush gas purification treatment.	ASME BPVC Section VIII
Glovebox Atmosphere Molecular Sieve (1-TPS_-01D-A-D)	The molecular sieve traps water in the glovebox atmosphere.	ASME BPVC Section VIII
Glovebox Atmosphere Nickel Bed (1-TPS_-02D-A-D)	The nickel bed traps water in the glovebox atmosphere.	ASME BPVC Section VIII
Glovebox Atmosphere ZrFe Bed (1-TPS_-03D-A-D)	The zirconium-iron bed traps elemental and gaseous tritium in the glovebox atmosphere.	ASME BPVC Section VIII
TPS Glovebox A/B	The negative-pressure, inert-atmosphere glovebox acts as secondary confinement of the tritium. It is protected from overpressure by a bubbler on the exhaust.	AGS-G001

Table 9a2.7-4 TPS Preliminary Control System Interface[(a)]

Signal Description	Type
TPS Run Status	Output from the TPS PLC.
TPS Fault Status	Output from the TPS PLC.
TPS Mass Flow	Input request from the TPCS. Output from the TPS PLC.
TPS Shutdown Interrupt	Input request from the TPCS. Output from the TPS PLC.
TPS Run Request	Input request from the TPCS at TSV start-up.

a) For TPS trains A and B, the following signals will be relayed between the TPS PLC and TPCS.

9a2.8 IRRADIATION FACILITY AUXILIARY SYSTEMS TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification associated with the IF auxiliary systems are provided in Chapter 14.

9a2.9 REFERENCES

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NFPA, 2008b. NFPA 69, Standard on Explosion Prevention Systems, 2008 Edition.

NFPA, 2008c. NFPA 801, Standard for Fire Protection for Facilities Handling Radioactive Materials, 2008 Edition.

NFPA, 2010a. NFPA 10, Standard for Portable Fire Extinguishers, 2010 Edition.

NFPA, 2010b. NFPA 14, Standard for the Installation of Standpipe and Hose Systems, 2010 Edition.

NFPA, 2011a. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 2011 Edition.

NFPA, 2011b. NFPA 45, Fire Protection for Laboratories Using Chemicals, 2011 Edition.

NFPA, 2011c. NFPA 70, National Electrical Code, 2011 Edition.

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NFPA, 2012a. NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection, 2012 Edition.

NFPA, 2012b. NFPA 30, Flammable and Combustible Liquids Code, 2012 Edition.

NFPA, 2012c. NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating System, 2012 Edition.

NFPA, 2012d. NFPA 101, Life Safety Code, 2012 Edition.

NFPA, 2012e. NFPA 220, Standard on Types of Building Construction, 2012 Edition.

NFPA, 2012f. NFPA 221, Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls, 2012 Edition.

NFPA, 2012g. NFPA 484, Standard for Combustible Metals, 2012 Edition.

NFPA, 2012h. NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems, 2012 Edition.

NFPA, 2013a. NFPA 13, Standard for the Installation of Sprinkler Systems, 2013 Edition.

NFPA, 2013b. NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection, 2013 Edition.

NFPA, 2013c. NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances, 2013 Edition.

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NFPA, 2013e. NFPA 72, National Fire Alarm and Signaling Code, 2013 Edition.

NFPA, 2013f. NFPA 80, Standard for Fire Doors and Other Opening Protectives, 2013 Edition.

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9b RADIOISOTOPE PRODUCTION FACILITY AUXILIARY SYSTEMS

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

The SHINE facility HVAC systems are described in Section 9a2.1.

9b.2 HANDLING & STORAGE OF TARGET SOLUTION

9b.2.1 TARGET SOLUTION LIFECYCLE

The target solution is a uranyl sulfate solution that is prepared by dissolving uranium oxide in sulfuric acid. The target solution is loaded into the TSV where it undergoes irradiation. After irradiation is complete, the irradiated target solution is transferred to the molybdenum extraction and purification system (MEPS) where molybdenum is extracted. The target solution is then either recycled back to the TSV to go through irradiation and MEPS processing again, or is sent to the UNCS to be converted into uranyl nitrate and subsequently into uranium oxide in order to repeat the overall process.

The chemical properties of the target solution can be found in Subsection 4a2.2.1, which includes uranium content, density, and solubility.

Detailed descriptions of the processing of irradiated and unirradiated SNM and byproducts are found in Subsections 4b.4.1 and 4b.4.2. Equipment and design features involved in the SNM lifecycle are included in these chapters. This section focuses on the storage and handling of SNM and byproducts during the lifecycle of the target solution in the facility (preparation to shipment off-site).

Refer to Figures 9a2.2-1 and 9b.2-1 for the flow diagrams of the process equipment discussed in this section.

9b.2.2 DISSOLUTION OF URANIUM METAL

Newly introduced unirradiated SNM is in the form of uranium metal. Uranium metal is dissolved in 12 M nitric acid in the uranium metal dissolution tank (1-TSPS-02T) to form a uranyl nitrate solution. The uranyl nitrate solution is then transferred to the recycle uranyl nitrate hold tank (1-UNCS-06T) and then transferred to the thermal denitration (TDN) process to be processed into uranium oxide. Addition of uranium metal makes up for uranium losses throughout the processes within the RCA. The dissolution process also allows the facility to be loaded or charged with uranium during facility startup.

The uranium metal dissolution tank (1-TSPS-02T) dissolves up to [Security-Related Information] of uranium metal in [Security-Related Information] of 12 M nitric acid in a single batch. The uranium metal dissolution tank (1-TSPS-02T) is maintained between 167 to 185°F (75 to 85°C) during dissolution without an agitation mechanism. To accommodate various amounts of uranium metal to be dissolved, [Security-Related Information] of nitric acid is used per [Security-Related Information] of uranium metal.

The uranium oxide produced from the dissolution and thermal denitration of unirradiated uranium metal is stored in uranium oxide storage cans in criticality-safe configuration within the uranium oxide storage rack. Uranium oxide is stored until needed by the facility for the production of target solution.

9b.2.3 TARGET SOLUTION PREPARATION

Target solution (uranyl sulfate) is prepared in the target solution preparation tank (1-TSPS-01T) by dissolving uranium oxide in approximately 0.8 M sulfuric acid with the tank maintained at approximately 158°F (70°C) and agitated until the uranium oxide is fully dissolved. The range of uranyl sulfate concentration is [Proprietary Information][Security-Related Information], and the desired concentration is prepared with an accuracy better than 1 percent. The pH of the target solution is between [Proprietary Information]. The volume range of the target solution is [Proprietary Information][Security-Related Information] per TSV batch. See Subsection 4a2.2.1 for a list of the target solution chemical properties.

The mass of uranium oxide used to prepare target solution is measured in the target solution preparation hood and transferred to target solution preparation tank (1-TSPS-01T) by emptying the required number of uranium oxide storage cans into the tank. Operators adjust the amount of sulfuric acid to be added based on the amount of uranium oxide loaded into the target solution preparation tank (1-TSPS-01T).

9b.2.4 SHIPMENT AND RECEIPT OF SNM

Unirradiated SNM is received in the form of uranium metal in solid form from a Department of Energy (DOE) supplier. The shipments consist of LEU metal enriched to 19.75 ± 0.2 weight percent U-235, with a maximum of 19.95 weight percent U-235. Shipment of uranium metal is received on pallets containing transport containers and is transferred to the uranium metal receipt area within the RCA. Uranium metal is stored in a criticality-safe geometry. The uranium metal receipt area has the capacity to store transport containers. The transport containers containing three convenience containers with up to [Security-Related Information] of uranium metal each (up to [Security-Related Information] total) are individually removed from the transport container and placed in the receipt ventilation hood. Within the receipt ventilation hood the convenience container is opened, the contents are verified. Up to [Security-Related Information] of uranium metal is then repackaged into the uranium metal storage can. The uranium metal storage can is designed to be criticality-safe in this configuration. The uranium metal storage can is then transferred to the uranium metal storage rack prior to further processing. See Figure 9b.2-2 for the assembly view of the uranium metal/oxide storage rack.

Shipments of uranium oxide are received in containers and are transferred to the RCA. These containers are individually placed in the receipt ventilation hood. Within the receipt ventilation hood, the container is opened, the contents are verified. Up to [Security-Related Information] of uranium oxide is then repackaged into the uranium oxide storage can. The uranium oxide storage can is then transferred to the criticality-safe uranium oxide storage rack prior to further processing. Uranium oxide is also received as a product from TDN. This uranium oxide is packaged in uranium oxide storage cans and stored in the uranium oxide storage rack prior to further processing. See Figure 9b.2-2 for the assembly view of the uranium metal/oxide storage rack.

Refer to Chapter 4b.4.2 for additional shipment and receipt information.

9b.2.5 TARGET SOLUTION PREPARATION HANDLING EQUIPMENT

The flow diagrams that include the equipment discussed in this subsection are Figures 9a2.2-1 and 9b.2-1.

After target solution has been prepared in the target solution preparation tank (1-TSPS-01T), it is pumped to the target solution hold tank (1-TSPS-03T) to wait for loading into the TSV. Target solution is pumped from the target solution hold tank (1-TSPS-03T) to the TSV before irradiation operations begin. If a recycled (previously irradiated) target solution batch is used, the recycled target solution is pumped from the recycle target solution tank (1-UNCS-09T) to the target solution hold tank (1-TSPS-03T) instead of using unirradiated target solution prepared in the TSPS.

After irradiation in the TSV, the target solution is gravity-transferred to the TSV dump tank (1-SCAS-01T) where it waits to be pumped to MEPS and then on to UNCS for further processing. SNM and byproducts in the target solution remain in solution until they are separated downstream in the MEPS and UNCS processes. Fissile SNM is held in criticality-safe geometry equipment. See Section 4b.3 and 4b.4.1 for a detailed description of MEPS and UNCS SNM processing.

The following is a list of equipment necessary for preparing target solution in the RPF. See Figure 9a2.2-1 for the flow diagram that shows the TSV-related equipment and Figure 9b.2-1 for the TSPS-related equipment.

- Uranyl Sulfate Preparation Tank (1-TSPS-01T-A/B)
    - Quantity: 2
    - Nominal Size: [Proprietary Information][Security-Related Information]
    - Normal Operating Pressure: atmospheric (vented)
    - Double-Contingency, Criticality-Safe Geometry
    - Design/Fabrication Code: ASME BPVC Section VIII Div 1 (ASME, 2011)
- Uranyl Sulfate Pump (1-TSPS-01P-A/B)
    - Quantity: 2
    - Type: Positive Displacement
    - Nominal Power: 0.25 hp
    - Design/Fabrication Code: To be determined at final design
- Uranium Metal Dissolution Tank (1-TSPS-02T-A/B)
    - Quantity: 2
    - Nominal Size: [Security-Related Information]
    - Normal Operating Pressure: atmospheric (vented)
    - Double-Contingency, Criticality-Safe Geometry
    - Design/Fabrication Code: ASME BPVC Section VIII Div 1 (ASME, 2011)
- Dissolution Solution Pump (1-TSPS-02P-A/B)
    - Quantity: 2
    - Type: Positive Displacement
    - Nominal Power: 0.25 hp
    - Design/Fabrication Code: To be determined at final design

- Uranium Receipt Ventilation Hood
    - Quantity: 1
    - Design/Fabrication Code:
    - AGS-G001-2007 (AGS, 2007)

9b.2.6 STORAGE OF SNM

Uranium metal is stored in the uranium metal storage rack within the uranium metal receipt area. The uranium metal storage rack holds up to [Proprietary Information][Security-Related Information] uranium storage cans in a criticality-safe configuration.

Uranium oxide is stored in the uranium oxide storage rack within the uranium oxide storage area. The uranium oxide storage rack holds up to [Proprietary Information][Security-Related Information] uranium oxide storage cans in a criticality-safe configuration. Refer to Subsection 4b.4.2 for additional SNM storage information.

Areas and vessels that contain SNM are appropriately shielded to limit exposure to facility personnel. Refer to Section 4b.2 for more information on the RPF biological shield.

9b.2.7 CRITICALITY CONTROL

Inadvertent criticality during processing of fissile materials is prevented by double-contingency, criticality-safe design of cans, racks, tanks, and other components that handle or store the fissile material. The Nuclear Criticality Safety Program is discussed in 6b.3.

9b.3 FIRE PROTECTION SYSTEMS AND PROGRAMS

The facility fire protection system and program for the SHINE facility are common to the IF and the RPF and are discussed in Section 9a2.3.

9b.4 COMMUNICATION SYSTEMS

The communication systems for the SHINE facility are common to the IF and RPF. See Section 9a2.4 for the description of the SHINE facility communication systems.

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

This section covers the possession and use of byproduct, source, and special nuclear material in auxiliary systems inside the RPF. The possession and use of byproduct, source, and special nuclear material within the IF is found in Section 9a2.5.

9b.5.1 BYPRODUCT MATERIAL

Within the SHINE facility, byproduct material is generated by the fission and irradiation of target solution in the TSV. Byproduct material is regulated under 10 CFR Part 30.

The auxiliary systems that process byproduct material in the RPF are:

- Target Solution Preparation System (TSPS).
- Radioactive Drain System (RDS).
- Aqueous Radioactive Liquid Waste Storage System (RLWS).
- Radioactive Liquid Waste Immobilization System (RLWE).
- Process Vessel Vent System (PVVS).
- Molybdenum Isotope Product Packaging System (MIPS).
- Solid Radioactive Waste Packaging (SRWP).
- Noble Gas Removal System (NGRS).

9b.5.1.1 Target Solution Preparation System

The recycled uranium, which has been through the UNCS system, contains trace quantities of byproduct material, chiefly technetium and neptunium. This is present in the uranium oxide storage racks and the uranyl sulfate preparation tanks. The radionuclides are not present in quantities that cause a dose hazard to facility workers or the public. Local area monitors confirm the absence of hazardous radiation fields, and alert operators if allowable fields are exceeded. The uranium oxide storage racks are located in the uranyl sulfate storage room. The uranyl sulfate preparation tanks are located in the uranyl sulfate preparation area. Both of these are inside the RCA. The uranyl sulfate preparation tanks are accessible via a glovebox.

9b.5.1.2 Radioactive Drain System

This system is further described in Subsection 9b.7.6. The RDS is a network of sumps and pipes that converge at the criticality safe sump catch tank, located at the lowest point of the facility. The RDS receives byproduct material in the event of a leak of a tank or pipe containing byproduct material, or the overflow of a tank containing byproduct material. These are events that are not anticipated to occur frequently. They only result from a mechanical or control system failure.

The RDS piping and equipment is located within shielded tank vaults, hot cells, and pipe trenches in order to reduce worker radiation exposure. The RDS exists to contain radioactive liquids in the event of a leak, spill, or overflow, and to route the liquid to a controlled location such that the material can be returned to the process.

The quantity, and chemical and radiological composition of byproduct material in the RDS depends on the location in the process that the leak, spill, or overflow occurs. The highest concentration of radionuclides is present in the target solution at the end of irradiation in the TSV.

The byproduct material is collected in the criticality-safe sump catch tank and pumped to the uranyl nitrate conversion tank for use in the process.

The RDS sump catch tank is equipped with radiation monitoring and level instrumentation to detect the presence of material in the system.

9b.5.1.3 Aqueous Radioactive Liquid Waste Storage

This system is further described in Subsection 9b.7.4. The RLWS provides receipt, mixing, and buffer storage for aqueous radioactive wastes generated by processing operations within the RCA. The primary feed to the RLWS is raffinate from the UREX section of the UNCS system. This contains the majority of byproduct material within the facility; specifically, the fission products generated in the TSV. Each of the two RLWS storage tanks can hold a maximum of 21 TSV batches of UREX raffinate.

The two RLWS liquid waste storage tanks are located in shielded tank vaults to reduce worker exposure to radiation. The tanks normally contain byproduct material, and have a relatively high radiation field. The tank vaults contain radiation monitoring instrumentation, which detect elevated levels of radiation and alert operators. The liquid waste in the RLWS is fed to the RLWE for treatment prior to disposal.

9b.5.1.4 Radioactive Liquid Waste Evaporation and Immobilization System

This system is further described in Subsection 9b.7.3. The RLWE concentrates and immobilizes aqueous radioactive wastes generated by processing operations within the RCA. As such, it processes, for disposal, the majority of the byproduct material within the facility. The RLWE system is located in hot cells, with normal operations being conducted remotely. The hot cells are shielded to reduce worker exposure to radiation.

Within the RLWE, the radioactive waste is first concentrated by evaporation. The evaporator is a submerged-tube, forced-recirculation design. This is the configuration most frequently used for radioactive waste evaporation. The waste is evaporated to the extent possible while enabling it to be immobilized and disposed of as Class C waste. The condensed overheads stream may contain trace quantities of byproduct material. The level of byproduct material present is verified before the overheads are recycled for use within the process.

The evaporator bottoms product, containing most of the byproduct material, is pumped to the immobilization system. It is pumped into 55 gal. (208.2 L) drums, which have been pre-loaded with grouting materials (Portland cement, blast furnace slag, and calcium hydroxide or other components as required to meet the receiving facilities' waste acceptance criteria). The filled drum is then sealed with a lid and mixed via mechanical means. This mixes the liquid waste and grouting solids. The drum is then moved to the curing area in the hot cell, to allow the cement to cure and form a monolithic solid waste form, suitable for final disposal.

The drums containing cured, grouted waste are moved to the waste staging and shipping building, outside of the production facility building. From here they are exported to a radioactive waste disposal site.

The RLWE hot cells are equipped with radiation detection instrumentation to monitor radiation fields within the cells. If elevated levels are detected, the operators are alerted. The design of the hot cells also includes liquid sumps with level instrumentation, radiation area monitors (RAMs), and CAMs. These detect leaks or spills of byproduct material within the hot cells and alert the operators.

9b.5.1.5 Process Vessel Vent System

This system is further described in Subsection 9b.6.1. The PVVS is not anticipated to contain significant quantities of byproduct materials. The PVVS receives vent gases from the majority of the process tanks, plus the vent gas from the noble gas removal system (NGRS). The gas from the NGRS has been stored for decay for at least 40 days, so the majority of byproduct material, specifically short-lived isotopes of noble gases, has decayed to stable isotopes.

The vents from process tanks are not anticipated to contain substantial quantities of byproduct material. The only process step that employs gas sparging for mixing and mass transfer is thermal denitration. The byproduct material present in this step is insignificant. Some process tanks include pumped recirculation loops for mixing, so there is some entrainment of liquids in the tank vent. This includes byproduct materials that are present in liquid contained in the tank.

The PVVS is located within an area in the RCA that is not occupied during normal operations. This area includes the necessary shielding to reduce worker exposure to radiation. The PVVS area is equipped with RAMs, CAMs, and leak detection equipment.

The PVVS process includes an acid gas scrubber that uses a caustic solution (sodium hydroxide) to remove acid gases from process tank vent streams. The acids are primarily sulfuric acid and nitric acid, one or both of which are present in the majority of process tanks. In addition to neutralizing and removing the acid gases, the scrubber also removes the majority of the byproduct material from the gas stream by mass transfer. The byproduct material then leaves the PVVS in the spent scrubber solution. This is transferred to the RLWS system and then evaporated and immobilized in the RLWE system.

9b.5.1.6 Molybdenum Isotope Packaging System

This system is further described in Subsection 9b.7.1. The MIPS loads the molybdenum-99 (Mo-99) into the final product packaging, for shipment. The primary byproduct material in the MIPS is Mo-99. The Mo-99 product contains trace quantities of other byproduct radionuclides. These concentrations of contaminants are measured by sampling and analysis to ensure they are below the maximum allowable concentrations.

The MIPS is located inside a shielded hot cell, with all operations performed remotely, using manipulators. This reduces the dose to the worker from the byproduct material. When the Mo-99 product has been loaded into its product bottle, the bottle is loaded into a shielded shipping container before the material leaves the MIPS hot cell. The cell design includes radiation detection instrumentation to monitor radiation fields. If elevated levels are detected, the operators are alerted.

9b.5.1.7 Solid Radioactive Waste Packaging

This system is further described in Subsection 9b.7.5. The SRWP system packages solid waste generated by processing and mechanical handling operations within the RCA. The SRWP receives and handles solid waste that is contaminated with byproduct material. The majority of SRWP operations are performed in hot cells. The operations are performed remotely, using manipulators. The hot cells are shielded to reduce worker radiation exposure. The hot cell design includes radiation detection instrumentation to monitor radiation fields. If elevated levels are detected, the operators are alerted.

Some SRWP operations are performed in normally occupied areas. One example of this is spent NDAS disassembly and packaging.

The specific byproduct material that is present in the SRWP depends on the source of the solid waste being packaged. The highest levels of radionuclides that are anticipated to be present on solid waste are associated with equipment that is used to process, or has been in contact with, irradiated target solution. This may be scrap equipment, such as pumps, or spent processing equipment that is generated by routine operations, such as spent [Proprietary Information] adsorption columns from the MEPS system.

9b.5.1.8 Noble Gas Removal System

This system is further described in Subsection 9b.6.2. The NGRS monitors, stores, and releases radioactive isotopes of iodine and noble gases (primarily xenon and krypton) that are received from the TSV off-gas system (TOGS) after an irradiation cycle. The gases are byproduct material resulting form the fissioning of the target solution in the TSV. These gases are circulated in a closed loop in TOGS and the subcritical assembly system (SCAS) during the irradiation cycle, and are purged to NGRS following shutdown of the neutron driver and a hold time for decay in the TOGS and SCAS.

The NGRS collects this byproduct material from the eight irradiation units, compresses the gas into noble gas decay tanks to allow for further decay, and after verification of acceptable radioactivity levels, releases the gases to PVVS.

The NGRS compressors and tanks are located in the noble gas shielded cell, which is not occupied during normal operations. The noble gas shielded cell provides the necessary shielding to reduce worker exposure to radiation.

9b.5.2 SOURCE MATERIAL

Source material is defined as natural uranium or thorium or depleted uranium that is not suitable for use as reactor fuel, per 10 CFR 40. There is none of this material normally present in the RPF auxiliary systems.

[Proprietary Information]

9b.5.3 SPECIAL NUCLEAR MATERIAL

SNM is defined as Pu, U-233, or uranium enriched in the isotopes U-233 or U-235. Within the SHINE facility, LEU is irradiated to produce Mo-99 by fission. During this process, a small quantity of Pu is also generated. This is less than [Proprietary Information][Security-Related Information] total Pu per TSV batch. The auxiliary systems in the RPF that are anticipated to contain more than trace quantities of SNM are:

- Target Solution Preparation System (TSPS).
- Radioactive Drain System (RDS).
- Aqueous Radioactive Liquid Waste Storage System (RLWS).
- Radioactive Liquid Waste Immobilization System (RLWE).
- Solid Radioactive Waste Packaging (SRWP).

9b.5.3.1 Target Solution Preparation System

The following process equipment in the TSPS contains LEU:

- The uranium metal dissolution tank.
- The target solution hold tank.
- The uranium metal storage rack.
- The uranium oxide storage racks.
- The uranyl sulfate preparation tank.

Equipment containing the SNM is criticality-safe by geometry. The target solution hold tank is located in a shielded tank vault. This is required because of the concentration of fission products in the recycled target solution rather than the presence of SNM.

The UO_3 storage racks are located in the uranyl sulfate storage room. The uranyl sulfate preparation tanks are located in the uranyl sulfate preparation area. Both of these are inside the RCA. The uranyl sulfate preparation tanks are located inside a fume hood.

9b.5.3.2 Radioactive Drain System

The RDS is a network of sumps and pipes that converge at the criticality-safe sump catch tank, located at the lowest point of the facility. The RDS receives SNM in the event of a leak of a tank or pipe containing SNM, or the overflow of a tank containing SNM. These are events that are not anticipated to occur frequently, and would represent a mechanical or control system failure.

The RDS piping and equipment is located within shielded tank vaults, hot cells, and pipe trenches, in order to reduce worker radiation exposure. Due to the potential for LEU to be present in the RDS, the system is criticality safe by geometry throughout. The RDS contains radioactive liquids in the event of a leak, spill, or overflow, and routes the liquid to a controlled location such that the material can be returned to the process. This also applies to SNM, which can be returned to the process from the RDS in the event of a leak, spill, or overflow.

The quantity and composition of SNM in the RDS depends on the location in the process that the leak, spill, or overflow occurred. The [Security-Related Information]. At this point, the LEU concentration is [Security-Related Information]. Within the target solution, the maximum concentration of SNM is [Proprietary Information][Security-Related Information].

The SNM is collected in the criticality-safe sump catch tank.

9b.5.3.3 Aqueous Radioactive Liquid Waste Storage

The RLWS provides receipt, mixing, and buffer storage for aqueous radioactive wastes generated by processing operations within the RCA. The primary feed to the RLWS is raffinate from the UREX section of the UNCS.

There is an insignificant quantity of LEU in the RLWS. The UREX raffinate is analyzed to verify LEU levels are within limits prior to transfer from the UNCS to the RLWS. The RWLS contents will be administratively controlled to ensure criticality-safety. The Pu generated in the TSV does pass through the RLWS. The maximum inventory of Pu in each of the liquid waste storage tanks in the RLWS is less than [Security-Related Information].

The two RLWS liquid waste storage tanks are located in shielded tank vaults to reduce worker exposure to radiation. This is required due to the presence of fission products rather than SNM.

9b.5.3.4 Radioactive Liquid Waste Evaporation and Immobilization

The RLWE concentrates and immobilizes aqueous radioactive wastes generated by processing operations within the RCA. There is not a significant quantity of LEU in the RLWE. There are no criticality controls required or implemented in the RLWE. There is a small quantity of Pu within the RLWE. The maximum inventory of Pu in the RLWE is less than [Security-Related Information]. The RLWE system is located in hot cells, with normal operations being conducted remotely. The hot cells are shielded to reduce worker exposure to radiation. This is due to the presence of fission products rather than SNM.

Within the RLWE, the radioactive waste is first concentrated by evaporation. The waste is evaporated to the extent possible while enabling it to be immobilized and disposed of as Class C waste. The condensed overheads from the evaporator are ostensibly free of SNM. This is verified before the overheads are recycled for use within the process.

The evaporator bottoms product, containing essentially all of the SNM, is pumped to the immobilization system. Here it is converted into a monolithic solid waste form suitable for final disposal.

The RLWE hot cells are equipped with RAMs and CAMs to monitor radiation fields within the cells. If elevated levels are detected, the operators are alerted. The design of the hot cells also includes liquid sumps with level instrumentation. These detect leaks or spills within the hot cells and alert the operators.

9b.5.3.5 Solid Radioactive Waste Packaging

The SRWP system packages solid waste generated by processing and mechanical handling operations within the RCA. The SRWP receives and handles solid waste that may be contaminated with SNM. The majority of SRWP operations are performed in hot cells, which are not normally occupied. The operations are performed remotely, using manipulators. The hot cells are shielded to reduce worker radiation exposure. This is due to the presence of fission products, rather than SNM. The hot cell design includes CAMs and RAMS to monitor radiation fields. If elevated levels are detected, the operators are alerted.

Some SRWP operations are performed in normally occupied areas. One example of this is spent NDAS disassembly and packaging.

The specific SNM that is present in the SRWP depends on the source of the solid waste being packaged. This may be scrap equipment, such as pumps, or spent processing equipment that is generated by routine operations, such as spent [Proprietary Information] adsorption columns from the MEPS system.

There is no processing of SNM in the SRWP. The presence of SNM is incidental to the operation of the system and the intent is to retain the SNM on the solid waste being packaged for disposal.

9b.5.4 TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the possession and use of byproduct, source, and SNM are provided in Chapter 14.

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

There are no primary coolant systems in the RPF. This section will discuss systems that handle radioactive gases from process vessels.

9b.6.1 PROCESS VESSEL VENT SYSTEM

9b.6.1.1 Process Description

9b.6.1.1.1 Process Functions

The PVVS collects and treats the off-gases from process vessels in the SHINE facility. The PVVS collects off-gases from each vented vessel containing a significant quantity of radioactive material in the RPF, and receives noble gases from the NGRS after a period of decay. The PVVS consists of an acid gas scrubber loop and a blower to vent treated gases out of the RCA.

The process functions for the PVVS are the following:

- Receive off-gas from the process systems within the RPF.
- Treat off-gas to remove excess acids.
- Transfer treated off-gas to the RVZ1 exhaust system.
- Maintain process vessels at a negative pressure for confinement.
- Prevent detonations or deflagrations in process vessels from potential hydrogen accumulation.

9b.6.1.1.2 Safety Functions

PVVS preliminary safety functions and classifications:

- Prevent detonation or deflagration of radiolytic hydrogen gas by maintaining the hydrogen concentration below the LFL. Classification: SR.
- Capture noble gases from process vessel vents. Classification: SR

9b.6.1.1.3 Primary System Interfaces

Vented process vessels within the RPF that contain significant quantities of radioactive material are connected to the PVVS, which exhausts the off-gas from the tank ullage. For a list of system interfaces, refer to Table 9b.6-1. The stream numbers referred to in the interface descriptions can be found in Figure 9b.6-1.

9b.6.1.1.4 Process Sequence

The PVVS receives off-gas from vented process vessels in the RPF. The majority of process vessels contain sulfuric acid or nitric acid solutions, and the off-gas is assumed to entrain some of these acids. A blower maintains the tank ullage at a slight negative pressure and draws all the off-gas through an acid-gas scrubber. The scrubber is a packed column with countercurrent flow: the off-gas in up-flow and a 1 M sodium hydroxide caustic scrub solution in gravity down-flow. The caustic scrub solution neutralizes the acids present in the off-gas, and is recycled through the scrubber until it is spent and requires replacing. A heat exchanger, cooled with process chilled water, removes the acid-base heat of reaction, heat introduced by the pump, and the excess heat from any high-temperature off-gases.

Off-gas is provided to the PVVS intermittently in varying quantities depending on what processes are occurring in the RCA at any given moment. The caustic scrub solution flow rate is set to process the maximum quantity of off-gas that may enter the scrubber at any one time. The caustic scrub solution is periodically purged from the acid-gas scrubber loop when it no longer neutralizes the acid off-gas, as measured by a pH meter located in the acid-gas scrubber loop.

Radioactive particles potentially entrained in the process off-gas are either absorbed in caustic scrub solution in the acid-gas scrubber, or are vented out of the PVVS. Treated off-gas is vented to the RVZ1 where, following HEPA and charcoal filtration, the gas is exhausted out the facility stack. Spent caustic scrub solution is pumped to the RLWS system for waste treatment. Fresh caustic scrub solution is supplied by the facility alkaline reagent storage and distribution system (FLRS), located outside the RCA.

See Figure 9b.6-1 for the PFD of the PVVS. Refer to Table 9b.6-2 for a description of the process equipment.

9b.6.1.1.5 Hydrogen Mitigation

Hydrogen may be generated by radiolysis in the target solution or uranyl nitrate solution contained in various process vessels downstream of the IU. The hydrogen may cause detonations or deflagrations if the concentration reaches the lower flammability limit (LFL) of 4 volume percent. PVVS is a SR system to prevent hydrogen detonation or deflagration in the process vessels.

PVVS maintains low hydrogen concentrations in the ullage of process tanks by diluting the evolved gases. Vents located above the overflow lines of tanks provide an inlet for air to sweep the tank ullage and dilute any hydrogen that is present. The required sweep rate for each process tank will be determined in detailed design based on hydrogen generation rate calculations and, if necessary, hydrogen monitors will be installed.

In the case of loss of off-site power (LOOP), the PVVS blower is connected to a UPS. There are redundant blowers connected to separate UPS systems. A differential pressure switch across the blower indicates whether or not the blower is operating properly. The PVVS blower continues to operate even if the RVZ1 exhaust system is no longer functioning.

The current design of the UPSS provides for a two hour duration of Class 1E power following LOOP. The effects of post-shutdown hydrogen generation have not been fully determined. Final hydrogen generation rates and associated mission time for the emergency power system will be determined as part of final design. Design studies are on-going to establish design features that could be used for maintaining stable long-term post-accident conditions assuming that the off-site power is not available. These potential design features include:

- Passive hydrogen recombiners
- On-site safety-related emergency diesel generators
- Robust piping systems
- Deflagration flame arrestors

- Other potential design features identified during the detailed design

The emergency power system will operate for the required mission time as delineated in the final analysis which will be provided in the FSAR.

9b.6.1.1.6 Noble Gas Capture

The systems and processes in the RPF have the potential to release noble gas radioisotopes from the target solution or uranyl nitrate solution, especially xenon and krypton. The final design will ensure that 10 CFR 20 limits are met.

9b.6.1.1.7 Instrumentation and Control

The PVVS includes differential pressure instrumentation to ensure normal operation of the blower. The PVVS instrumentation is tested periodically.

Pressure instrumentation in PVVS monitors the differential pressure across the blower and switches to the redundant blower if one fails to operate properly. The normal operating range of the PVVS blower pressure will be determined in detailed design.

See the detailed alarm description in Subsection 7b.4.1.2.6.

9b.6.1.2 Radiological Protection and Criticality Control

There is no significant amount of SNM present in the PVVS. As such, the vessels and equipment in the PVVS are not designed for criticality safety. PVVS processes are normally remotely controlled. Occasional manual maintenance operations are required. Shielding of PVVS ensures that exposure of individuals to radiation is within the regulatory limits of 10 CFR 20.1201 and 10 CFR 20.1301. Radiation monitors and alarms are used to monitor the potential release of radiological materials.

9b.6.1.3 Technical Specifications

Potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the process vessel vent system are provided in Chapter 14.

9b.6.2 NOBLE GAS REMOVAL SYSTEM

9b.6.2.1 Process Description

The NGRS receives the cover gas from the eight independent TOGS. This gas is primarily air, with small gram quantities of krypton, xenon, and iodine. The gases are compressed up to 100 psig (680 kPa), then stored in one of five noble gas decay tanks for at least 40 days. This enables the noble gases to largely decay. The stored gases can then be vented to the RCA ventilation Zone 1 (RVZ1).

There is no significant quantity of SNM within the NGRS system. Therefore, no criticality controls or safeguards are required.

9b.6.2.1.1 Process Functions

The NGRS monitors, stores, and releases the radioactive isotopes of iodine and noble gases (primarily krypton and xenon) that are received from the TSV off-gas system (TOGS) following an irradiation cycle. Radioactive gases are generated and released from the target solution in the TSV during irradiation. The NGRS collects the off-gas from the TSV after irradiation is complete, and holds the gases in order to allow the short-lived noble gas radioisotopes to decay prior to release of the off-gas to the PVVS. The radiation level in the decayed gases is verified with radiation monitors prior to release.

The process functions for the NGRS are the following:

- Store TSV off-gas to allow for noble gas radioactive decay.
- Release decayed off-gas to PVVS.
- Monitor off-gas releases to ensure radioactivity levels are below regulatory limits for discharge to the environment.

9b.6.2.1.2 Safety Functions

NGRS preliminary safety functions and classifications:

- Prevent the release of radioactive material to the environment beyond the applicable regulatory limits. Classification: SR.
- Limit the exposure of the worker, public, and environment to radioactive material. Classification: SR.
- Contain and store noble gases (primarily xenon and krypton) generated in the TSV for at least 40 days. Classification: SR.

9b.6.2.1.3 Primary System Interfaces

Refer to Table 9b.6-3 for a list of system interfaces. The stream numbers referred to in the interface descriptions can be found in Figure 9b.6-2.

9b.6.2.1.4 Process Sequence

The NGRS consists of two gas compressors, five noble gas decay tanks, a condensate knock-out tank, associated piping components, and monitoring instrumentation. After a TSV completes an irradiation cycle, a mixture of gases is present in the TOGS loop, mainly air sweep gas with small amounts of radioactive gaseous isotopes including iodine, krypton, and xenon. Hydrogen is also present, and the TOGS catalytic recombiner maintains the hydrogen concentration below the LFL. Refer to Subsection 4a2.8 for more detail regarding the TOGS.

The TOGS transfers the TSV off-gas to the NGRS, where a compressor stores the off-gas in decay tanks. Prior to transfer to the NGRS, hydrogen sensors in the TOGS ensure hydrogen concentration is below the acceptable limit. The NGRS uses five noble gas decay tanks to provide temporary storage of TSV off-gas containing radioactive noble gases. The tanks allow for the decay of short-lived noble gas radioisotopes, including xenon-133, which is an isotope of concern for nuclear non-proliferation monitoring. The tanks are sized to store the TSV off-gas for approximately 40 days post-irradiation to allow the noble gas radioisotopes to decay to within applicable regulatory limits for discharge to the environment. The decay tanks are rated pressure vessels, with an approximate working volume of [Proprietary Information][Security-Related Information]. The off-gas in the decay tanks is compressed to approximately [Proprietary Information][Security-Related Information]. The decay tanks are filled and emptied sequentially to allow for continued operation of the IUs. The NGRS is designed to provide redundancy and storage capacity to process anticipated TSV off-gas volumes due to equipment downtime and maintenance activities. The NGRS design is in compliance with ANSI/ANS-55.4 (ANSI/ANS, 1993).

Upon completion of 40 days of decay, the off-gas is processed through a condensate knock-out tank, analyzed for radioactivity, and released to the PVVS. In the PVVS, the off-gas is mixed with other exhaust gases, treated further, and released to the environment via the facility stack. Refer to Subsection 9b.6.1 for more detail regarding the PVVS. The condensate is mainly water from the off-gas, and is routed to the RLWS system for further processing. Refer to Subsection 9b.7.4 for more detail regarding the RLWS system. If the off-gas has not sufficiently decayed, it is recycled back to the NGRS compressor and stored again in a noble gas decay tank.

See Figure 9b.6-2 for the PFD of the NGRS. Refer to Table 9b.6-4 for a description of the process equipment.

9b.6.2.1.5 Instrumentation and Control

NGRS includes pressure and radioactivity instrumentation on the noble gas decay tanks. These instruments monitor the tanks to ensure no gas is leaking as evidenced by a pressure drop, and determine the level of radioactive decay. Radioactivity monitors are also located downstream of the condensate knock-out tank. If the off-gas is released from a decay tank and does not meet regulatory limits, it is recycled back to the compressor to be stored in a decay tank again.

9b.6.2.2 Safety-Related Effects

9b.6.2.2.1 Radiological Protection and Criticality Control

There is no significant amount of SNM present in the NGRS. As such, criticality-safety requirements are not required for vessels or equipment in the NGRS.

The NGRS is located in a shielded cell, which limits the exposure of individuals to radiation within the regulatory limits of 10 CFR 20.

The processes are remotely controlled, manually controlled, or performed with telemanipulators, with minimal automated sequences. Radiation monitors and alarms are used to monitor release of radiological materials, monitor high background gamma dose levels, and to detect criticality events.

Gases and liquids that contain potentially-radiological material are transferred through shielded pipe chases to limit the exposure of individuals to radiation.

9b.6.2.3 Technical Specifications

Potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the noble gas removal system are provided in Chapter 14.

Table 9b.6-1 PVVS Interfaces

Interfacing System	Interface Description
Target Solution Preparation System (TSPS)	The PVVS interfaces with the TSPS at three locations: the vent lines from the uranyl sulfate preparation tank (1-TSPS-01T), the uranium metal dissolution tank (1-TSPS-02T), and the target solution hold tank (1-TSPS-03T).
Molybdenum-99 Extraction and Purification System (MEPS)	The PVVS interfaces with the MEPS at one location: the vent line from the Mo eluate hold tank (1-MEPS-02T).
Uranyl Nitrate Preparation (UNP) subsystem of the UNCS	The PVVS interfaces with the UNP subsystem at three locations: the vent lines from the uranyl nitrate conversion tank (1-UNCS-01T), the UREX feed tank (1-UNCS-02T), and the recycle target solution tank (1-UNCS-09T).
Uranium Extraction (UREX) subsystem of the UNCS	The PVVS interfaces with the UREX subsystem at three locations: the vent lines from the solvent hold tank (1-UNCS-04T), the raffinate hold tank (1-UNCS-05T), and the recycle uranyl nitrate (UN) hold tank (1-UNCS-06T).
Thermal Denitration (TDN) subsystem of the UNCS	The PVVS interfaces with the TDN subsystem at one location: the vent line from the thermal denitrator (1-UNCS-08T), downstream of the thermal denitrator overheads cooler (1-UNCS-04A).
Noble Gas Removal System (NGRS)	The PVVS interfaces with the NGRS at one location: the discharge line from the noble gas condensate knockout tank (1-NGRS-02T), downstream of the radiation monitor and recycle loop back to the noble gas compressor (1-NGRS-01C).
Radioactive Liquid Waste Evaporation and Immobilization (RLWE)	The PVVS interfaces with the RLWE at two locations: the vent lines from the liquid waste condensate collection tank (1-RLWE-01T) and the liquid radioactive waste collection tank (1-RLWE-02T).
RCA Ventilation Zone 1	The PVVS interfaces with the RVZ1 at one location: the discharge line from the process vent gas blower (1-PVVS-01C).
Radioactive Liquid Waste Storage (RLWS)	The PVVS interfaces with the RLWS at two locations: the bottoms discharge from the PVVS acid-gas scrubber loop (stream 0926) and the vessel vent from the liquid waste storage tank (1-RLWS-01T-A/B).
Facility Alkaline Reagent Storage and Distribution System (FLRS)	The PVVS interfaces with the FLRS at one location: the supply line providing caustic to the acid-gas scrubber loop (stream 0924).
Radioisotope Process Facility Cooling System (RPCS)	The PVVS interfaces with the RPCS at two locations: the process chilled water supply and the process chilled water return. Process chilled water is supplied to the acid gas scrubber cooler (1-PVVS-01A).
Normal Electrical Power Supply System (NPSS)	The PVVS interfaces with the NPSS. The NPSS is distributed to operate the process vent gas blower (1-PVVS-01C), acid gas scrubber pump (1-PVVS-01P), and ancillary equipment.
Uninterruptible Power Supply System (UPSS)	The PVVS interfaces with the UPSS at one location: the process vent gas blower (1-PVVS-01C) is on UPS power.
Radiological Integrated Control System (RICS)	The RICS controls the PVVS.

Table 9b.6-2 PVVS Process Equipment

Component	Description	Code/Standard
1-PVVS-01D	Acid Gas Scrubber. Packed column contacts off-gas with caustic scrub solution to neutralize acids, knock out entrained particulate, and remove any excess heat.	ASME BPVC Section VIII
1-PVVS-01A	Acid Gas Scrubber Cooler. Heat exchanger transfers heat from caustic scrub solution in acid-gas scrubber loop to the RPCS. Plate and frame type.	ASME BPVC Section VIII
1-PVVS-01C	Process Vent Gas Blower. Draws off-gas from process vessels and through the acid-gas scrubber, then exhausts off-gas to RCA Ventilation Zone 1. Redundant blowers connected to UPSS.	ASME AG-1, Section BA – Fans and Blowers
1-PVVS-01P	Acid Gas Scrubber Pump. Circulates caustic scrubber solution through the acid-gas scrubber loop, and transfers spent caustic scrubber solution to RLWS.	ANSI/HI 3.1-3.5
Piping Components	PVVS piping, valves, in-line components.	ASME B31.3

Table 9b.6-3 NGRS Interfaces

Interfacing System	Interface Description
TSV Off-Gas System (TOGS)	The NGRS interfaces with the TOGS at one location: the isolation valve on stream 0428 between the TSV off-gas blower (1-TOGS-01C) and the noble gas compressor (1-NGRS-01C).
Process Vessel Vent System (PVVS)	The NGRS interfaces with the PVVS at one location: the discharge line from the noble gas condensate knockout tank (1-NGRS-01T), downstream of the radiation monitor and recycle loop back to the noble gas compressor (1-NGRS-01C).
Radioactive Liquid Waste Storage (RLWS)	The NGRS interfaces with the RLWS at one location: the condensate drain line (stream 0432) from the noble gas condensate knock-out tank (1-NGRS-01T).
Radioactive Drain System (RDS)	The NGRS interfaces with the RDS at one location: the drain line penetrations for the NGRS hot cell. The drain lines are sloped to the criticality-safe sump catch tank.
Radiological Integrated Control System (RICS)	The RICS controls the NGRS.
Normal Electrical Power Supply System (NPSS)	The NGRS interfaces with the NPSS. The NPSS is distributed to operate the noble gas compressor (1-NGRS-01C) and ancillary equipment/instrumentation.

Table 9b.6-4 NGRS Process Equipment

Component	Description	Code/Standard
1-NGRS-01C-A/B	Noble Gas Compressor. Compresses off-gas into decay tanks for storage. Backup compressor maintained on standby. Water seal or metal diaphragm compressor to eliminate gas leakage.	API Standard 617
1-NGRS-01V-A-E	Noble Gas Decay Tank. Pressure vessel that stores compressed off-gas to allow decay of noble gas radioisotopes. Multiple tanks allow for filling, discharge, and storage simultaneously.	ASME BPVC Section VIII
1-NGRS-01T	Noble Gas Condensate Knock-Out Tank. Remove moisture from gas stream released from decay tanks.	ASME BPVC Section VIII
Piping Components	NGRS piping, valves, in-line components.	ASME B31.3

9b.7 OTHER AUXILIARY SYSTEMS

This section describes auxiliary systems in the RPF not captured in other chapters of the PSAR.

9b.7.1 MOLYBDENUM ISOTOPE PRODUCT PACKAGING SYSTEM

The molybdenum isotope product packaging system (MIPS) receives the Mo-99 product collection bottle from the MEPS. Once in the MIPS area of the supercell, the product goes through an assay and quality control procedure. The final Mo-99 product is then transferred to the Mo-99 product shipping container. The lot number and expiration date on the Mo-99 final product shipping container is recorded and the final product shipping container is transferred into the shipping casks for delivery.

The MIPS is located in each of three supercells dedicated to the extraction, purification, and packaging of the Mo-99 product. The supercell provides the appropriate shielding to limit personnel radiation exposure. The radiological integrated control system (RICS) provides the process monitoring and control of the MIPS (see Section 7b.2.3). Figures 9b.7-1 and 9b.7-2 show the physical layout of the MIPS equipment within the supercell.

9b.7.1.1 Molybdenum-99 Receipt

The Mo-99 product collection bottle is received from the MEPS through the shielded pass-through between the two systems. The Mo-99 product collection bottle contains purified Mo-99 solution.

The Mo-99 packaging area of the supercells has the capability of holding up to [Proprietary Information] TSVs worth of Mo-99 product.

9b.7.1.2 Molybdenum-99 Assay

After receipt of the Mo-99 product from MEPS, a product sample is sent through the quality control process to ensure the product meets customer specifications.

9b.7.1.3 Molybdenum-99 Packaging

Once the quality control process is complete, the Mo-99 product is removed from the Mo-99 product collection bottle and placed in an inner Mo-99 product shipping container. The inner shipping containers meet customer requirements.

The inner shipping containers are expected to be labeled with lot number, date, and bar code for recording, identification, and tracking purposes.

9b.7.1.4 Molybdenum-99 Transfer

The Mo-99 inner product shipping containers are transferred to approved shipping containers for delivery.

9b.7.1.5 Process Functions

- Receive Mo-99 from MEPS.
- Perform Mo-99 assay.
- Package Mo-99 for shipment.

9b.7.1.6 Safety Functions

This system is nonsafety-related.

9b.7.1.7 Criticality Control Features

There is no SNM within the system.

9b.7.1.8 Shielding and Radiological Protection

The MIPS are located in shielded hot cells. This limits the radiation exposure of individuals to within the regulatory limits of 10 CFR 20. Refer to Chapter 11 for the radiation exposure goals, and Section 4b.2 for further detail of shielding requirements. Internal local shielding will be added for protection of internal equipment as necessary.

9b.7.1.9 Technical Specifications

There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the MIPS.

9b.7.2 RCA MATERIAL HANDLING

The RCA material handling system (RMHS) includes overhead cranes, fork trucks, hand trucks, carts, and master-slave manipulators that are used to move or manipulate radioactive material within the RCA. The RICS provides the process monitoring and control of the RMHS (See Section 7b.1). The equipment and locations of the equipment are discussed further in the sections below.

9b.7.2.1 RCA Overhead Cranes

The three overhead cranes in the RCA provide the necessary crane coverage to support operational and maintenance activities within the RCA. Crane locations and coverage are shown on Figure 9b.7-3. The overhead cranes meet the requirements of ASME B30.2 and CMAA 70.

Overhead Crane OC-0001 has a 75-ton capacity and provides crane coverage over the IU cells and the TPS.

Overhead Crane OC-0002 has a 40-ton capacity and provides crane coverage over the tank farm and UREX hot cell (HC-0003), SRWP hot cell (HC-0004), RLWE evaporation hot cell (HC-0008) and RLWE immobilization hot cell (HC-0009) (see Figure 9b.7-4).

Overhead Crane OC-0003 has a 40-ton capacity and provides crane coverage over the receipt area and supercells (HC-0001 and HC-0002).

9b.7.2.2 RCA Forklift

A forklift is used in the RCA for manipulation of shielded waste casks, shipping containers, and other material handling needs.

9b.7.2.3 In-Cell Overhead Hoists

There are in-cell overhead hoists in each of the hot cells and the supercell areas listed below:

- Supercell molybdenum extraction area of MEPS.
- Supercell molybdenum purification area of MEPS.
- Supercell molybdenum packaging area of MIPS.
- UREX hot cell.
- RLWE evaporation hot cell.
- RLWE immobilization hot cell.
- SRWP hot cell.

The in-cell overhead hoists are controlled remotely from outside the cells. The hoists are used to handle remotely operated tooling to replace failed equipment, as well as transport equipment between points in the cell. The in-cell overhead hoists meet the requirements of ASME B30.2. The hoists perform only nonsafety-related functions.

9b.7.2.4 Hot Cell Master-Slave Manipulators

The hot cells and supercells are fitted with master-slave manipulators on the front of the cells. The location and quantity of the master-slave manipulators is given in Table 9b.7-1. The master-slave manipulators are used for process and maintenance activities. The master-slave manipulators are in accordance with the guidance provided by ASTM C1554-2011.

9b.7.2.5 DPTE Transfer Carts

The hot cells and supercells are fitted with double doors for leaktight transfer (DPTE) systems. The DPTE systems are used for waste, material, and equipment transfer into and out of the cells. The DPTE system requires a transfer cart for docking and transport of the DPTE drums. Each of the following cells and cell areas utilize a DPTE transfer system and require a DPTE transfer cart:

- Supercell molybdenum extraction area of MEPS.
- Supercell molybdenum purification area of MEPS.
- Supercell molybdenum packaging area of MIPS.
- UREX hot cell.
- RLWE evaporation hot cell.
- RLWE immobilization hot cell.
- SRWP hot cell.

9b.7.2.6 Uranium Metal/Oxide Material Transfer Cart

The TSPS and TDN systems require a uranium metal/oxide material transfer cart. The transfer cart is used to transfer canned uranium metal from the uranium metal storage rack to the uranium metal dissolution tank and to transfer canned uranium oxide from the thermal denitrator to the uranium oxide storage rack. The uranium metal/oxide material transfer cart is designed to be criticality-safe.

9b.7.2.7 Safety Functions

The RMHS prevents inadvertent criticality through inherently safe design of equipment.

9b.7.2.8 Criticality Control Features

SNM handled by the RMHS meet the criticality safety limits of the material being handled.

9b.7.3 RADIOACTIVE LIQUID WASTE EVAPORATION AND IMMOBILIZATION SYSTEM

9b.7.3.1 RLWE Process Description

This section applies to the RLWE. The primary purpose of the RLWE is to reduce the volume of radioactive liquid wastes generated by facility operations and convert them to a form suitable for shipping and disposal.

9b.7.3.1.1 System Process Functions

The process functions of the RLWE system are:

- Receive radioactive liquid waste from the RLWS system.
- Reduce the volume of the liquid waste to the extent allowable to meet final waste criteria.
- Convert the liquid waste to a form suitable for shipping and disposal as radioactive waste.

9b.7.3.1.2 Primary System Interfaces

For a list of system interfaces, refer to Table 9b.7-2.

The RLWE system receives aqueous radioactive liquid waste from the RLWS tanks (1-RLWS-01T-A/B). The radioactive liquid waste is derived from operations within the RCA. These are primarily routine process wastes, but also include liquid wastes generated by non-routine operations such as equipment flushes, cell wash-down, and maintenance activities.

The RLWE includes two primary operations:

- Liquid waste evaporation.
- Liquid waste immobilization.

See Figure 9b.7-5 for the PFD of the radioactive liquid waste evaporation subsystem and Figure 9b.7-6 for the PFD of the radioactive liquid waste immobilization subsystem.

The liquid waste evaporation step reduces the liquid waste volume to the extent allowable to meet final waste criteria. It is anticipated that plutonium concentration will be the limiting factor in the evaporation step, in order to ensure the immobilized waste is Class C or less. There may be instances where another material or isotope becomes the limiting factor for volume reduction. The evaporator system includes monitoring and sampling capabilities to identify such occurrences and adjust operations accordingly.

The evaporator is a submerged-tube, forced-circulation design. This is the most widely-used design for radioactive liquid waste evaporation. The high recirculation rate and submerged tubes in this design prevent boiling within the heater. This reduces corrosion and fouling within the heater tubes compared to designs in which the boiling occurs within the heater tubes. The high tube-side velocities further limit fouling. The submerged-tube, forced-recirculation design also provides a high degree of operational flexibility, as it is able to accommodate wide variability of feed rates and compositions.

The evaporator feed is supplied by the liquid waste evaporator feed pump (1-RLWE-01P-A/B). The feed is added to the liquid waste evaporator tank (1-RLWE-01D). This tank functions as the reservoir of aqueous waste for the evaporator and the vapor-liquid separator for the overheads and bottoms product. This tank is operated at nominally atmospheric pressure. For the anticipated evaporator feed composition, the temperature in this tank is approximately 220°F (104.4°C). This varies by a few degrees depending on the radioactive liquid waste feed composition.

Liquid from the liquid waste evaporator tank (1-RLWE-01D) is pumped around the evaporator loop by the liquid waste evaporator recirculation pump (1-RLWE-02P-A/B). The pump-around rate of the evaporator loop is relatively high compared to the feed rate and bottoms product draw rate. The liquid is heated by 4-6°F (1.9-2.8°C) in the liquid waste evaporator heater (1-RLWE-01A). This is an electrical heater, with the current to the heater controlled by pressure in the vapor space of the liquid waste evaporator tank (1-RLWE-01D). The low temperature rise and the hydrostatic head of liquid above the heater tubes suppress boiling in the heater tubes. The super-saturated liquid from the heater recirculates back to the liquid waste evaporator tank (1-RLWE-01D), where it flashes to equilibrium. The vapor rises in the liquid waste evaporator tank (1-RLWE-01D), passing through a demister, which removes entrained moisture droplets, then out to the liquid waste condenser (1-RLWE-02A). The liquid in the recirculation loop return falls to the bottom of the liquid waste evaporator tank (1-RLWE-01D).

The overhead vapor from liquid waste evaporator tank (1-RLWE-01D) is condensed in the liquid waste condenser (1-RLWE-02A). This condenser is cooled by process chilled water from the RPF cooling system (RPCS). This water is supplied at approximately 60°F (15.6°C) and returned to the RPCS at approximately 75°F (23.9°C). The condenser sub-cools the overheads vapor to approximately 100°F (37.8°C). The condensate drains to one of two liquid waste condensate collection tanks (1-RLWE-01T-A/B). These tanks are operated in an online/offline configuration. One tank is in filling mode, while the other is being sampled and emptied. The condensate is sampled in the offline tank to ensure the radioactive contamination is below the level required for recycle and reuse within the facility. If the condensate does not meet the requirements for water recycle, it is pumped to the liquid waste collection tank (1-RLWS-01T-A/B) for re-processing through the evaporator.

The bottoms product from the evaporator is drawn off between the liquid waste evaporator recirculation pump (1-RLWE-02P-A/B) and the liquid waste evaporator heater (1-RLWE-01A). The bottoms product is cooled to approximately 100°F (37.8°C) in the liquid waste evaporator product cooler (1-RLWE-03A). The cooled bottom product is routed to one of two liquid radioactive waste collection tanks (1-RLWE-02T-A/B). These tanks are operated in an online/offline configuration. One tank is in filling mode, while the other is being sampled and emptied.

The evaporator bottoms product in the liquid radioactive waste collection tank (1-RLWE-02T-A/B) is pumped by the liquid waste pump (1-RLWE-04P A/B) to the immobilization system.

The immobilization system mixes the bottoms product from the evaporator with a cement formula to produce a monolithic solid waste form that is suitable for shipping and disposal as radioactive waste.

The waste is immobilized in standard 55 gal. drums. The solid grouting reagents are added to the drums in a filling station that is located outside the liquid waste solidification hot cell. This facilitates maintenance of this equipment in a clean environment. The solidification reagents typically are:

- Ordinary Portland cement – to create the cementitious final product.
- Blast furnace slag – to improve concrete durability.
- Calcium hydroxide – to raise the pH of the liquid waste to 7.0-7.5.

The solidification reagents are added to the drum from dedicated hoppers: one hopper for each reagent. They are metered into the drum using rotary valves. Each reagent is added separately, such the quantity of each reagent is measured on the weigh scale (1-RLWE-01Z). Once a drum has been loaded with solidification reagents, it is moved into the liquid waste solidification hot cell. Here the evaporator bottoms product is pumped into the drum by the liquid waste pump (1-RLWE-04P-A/B). This is a positive displacement pump that allows close control of the liquid volume. The liquid is pumped through a line that is connected to the drum lid, to eliminate splashing of the waste and reduce contamination of the hot cell.

Once the liquid has been added to the drum, it is sealed. The sealed drum is then mixed using a drum mixer. This rotates the drum through 360 degrees, ensuring thorough mixing of the grout components with the liquid waste.

After mixing, the drum is moved from the mixer to a curing area. Once cured, the drum is ready for testing and transport to the waste staging and shipping building.

9b.7.3.1.3 Process Equipment

See Table 9b.7-3 for a list of major process equipment associated with the RLWE.

9b.7.3.2 Safety-Related Effects

The RLWE processes material with a significant concentration of radioactive byproduct materials. In order to limit the exposure of individuals to radiation, the RLWE vaults are shielded.

Radiation monitors and criticality alarms are used to monitor releases of radiological materials and detect potential criticality events.

9b.7.3.2.1 Safety Functions

The safety design functions of the RLWE are:

- Maintaining piping, valve, and component integrity to ensure radiological material is contained.
- Instrumentation to prevent tank overfills.
- Level trips to ensure no spillage.

9b.7.3.2.2 Criticality Control Features

The RLWE does not contain appreciable quantities of fissile material. The primary feed to the RLWE is raffinate from the UREX system. The absence of appreciable quantities of fissile materials from this process stream is verified in the raffinate hold tank before the raffinate is transferred to the liquid waste storage tank. The UREX raffinate contains the plutonium produced in the irradiation cycle. This does not present a criticality hazard for the facility. None of the other process streams fed to the RLWE contain appreciable quantities of fissile material.

As an additional precaution, the RLWE hot cells are monitored by the CAAS.

9b.7.3.2.3 Shielding and Radiological Protection

The RLWE processes are performed in shielded hot cells, which limit the exposure of radiation to individuals within the regulatory limits of 10 CFR 20. Refer to Chapter 11 for the radiation exposure guidelines, and Subsection 4b.2.5 for further detail of shielding requirements.

Radiation monitors and alarms are used to monitor gamma dose levels and detect the release of radiological materials within the hot cell.

Piping that contains radioactive and potentially radioactive materials is routed through shielded pipe chases to limit the exposure of radiation to individuals.

9b.7.3.3 Technical Specifications

There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with RLWE.

9b.7.4 AQUEOUS RADIOACTIVE LIQUID WASTE STORAGE SYSTEM

The primary purpose of the RLWS is to provide buffer storage of the liquid wastes generated by facility operations.

9b.7.4.1 System Description

The RLWS is designed to provide buffer storage for liquid radioactive wastes generated from processing operations. Buffer storage decouples radioisotope production operations from liquid waste treatment operations.

9b.7.4.1.1 System Process Functions

The process functions of the RLWS system are:

- Receive radioactive liquid waste from the following systems:
    - Uranyl nitrate conversion system (UNCS).
    - Mo extraction and purification system (MEPS).
    - Process vessel vent system (PVVS).
    - Noble gas removal system (NGRS)
    - Receive radioactive liquid waste from non-routine operations.
- Store the received liquid wastes to allow for smoothing of feed rate and composition of feed to the RLWE.
- Provide additional time for radioactive decay of isotopes in the liquid waste.
- Allow sampling of the stored liquid waste.

9b.7.4.2 Safety-Related Effects

The RLWS contains significant quantities of radioactive materials. To limit the exposure of individuals to radiation, the RLWS vaults are shielded. Radiation monitors and alarms are used to monitor releases of radiological materials and detect criticality events.

9b.7.4.2.1 Safety Functions

The safety design functions of the RLWS are:

- Maintaining piping, valve, and component integrity to ensure radiological material is contained.
- Instrumentation to prevent tank overfills.
- Level trips to ensure no spillage.

9b.7.4.2.2 Primary System Interfaces

For a list of system interfaces, refer to Table 9b.7-4.

9b.7.4.2.3 Processing Sequence

The RLWS system receives liquid radioactive waste from a variety of sources within the RCA. The liquid waste is primarily routine effluents from within the process, but also includes liquid wastes generated by non-routine operations such as equipment flushes, cell wash-downs, and maintenance activities.

See Figure 9b.7-5 for the PFD that shows the radioactive liquid waste storage system.

The RLWS is comprised of two liquid waste storage tanks (1-RLWS-01T-A/B). These tanks are configured in parallel, with one tank being in filling, sampling, and radioactive decay mode, while the other is in evaporator feed mode. The tanks are located in individual tank vaults.

Each tank has a working volume of approximately [Security-Related Information]. This provides around 40 days of buffer storage capacity of liquid wastes produced by normal facility operations. The liquid waste generation varies in frequency, composition, and flowrate. The liquid waste storage tanks provide smoothing of these variations. This allows the evaporator in the RLWE system to be operated at near steady state conditions while it processes the contents of each liquid waste storage tank.

Each tank has liquid recycle capability to enable the tanks to be mixed prior to sampling. The recycle is via the liquid waste evaporator feed pump (1-RLWE-01-A/B). The tank sampling is located on the liquid recycle line. The waste in the tanks is sampled to verify the chemical and radiological composition prior to feeding to the liquid waste evaporator in the RLWE system.

9b.7.4.2.4 Process Equipment

See Table 9b.7-5 for a list of major process equipment associated with the RLWS.

9b.7.4.3 Operational Analysis and Safety Function

9b.7.4.3.1 Criticality Control Features

The RLWS does not contain appreciable quantities of fissile material (see Subsection 9b.5.3.3). The primary feed to the RLWS is raffinate from the UREX system. The absence of appreciable quantities of fissile materials from this process stream is verified in the raffinate hold tank before the raffinate is transferred to the liquid waste storage tank. The UREX raffinate contains the plutonium produced in the irradiation cycle. This does not present a criticality hazard for the facility. The other process streams fed to the RLWS also do not contain appreciable quantities of fissile material.

As an additional precaution, the RLWS tank vaults are monitored by the CAAS.

9b.7.4.3.2 Shielding and Radiological Protection

The RLWS tanks are located in shielded tank vaults. This limits the radiation exposure of individuals to within the regulatory limits of 10 CFR 20. Refer to Chapter 11 for the radiation exposure goals, and Section 4b.2 for further detail of shielding requirements.

Radiation monitors and alarms are used to monitor gamma dose levels and detect the release of radiological materials within the tank vaults. Piping that contains radioactive and potentially radioactive materials is routed through shielded pipe chases to limit the exposure of radiation to individuals.

9b.7.4.4 Instrumentation and Control

The primary control for the RLWS is the tank and valve configuration to control which tank is filling and which tank is emptying. This control is accomplished by valving on the liquid inlet and outlet lines from each tank. The tank in fill mode has the inlet valve open and the outlet valve closed. The tank in emptying mode has the inlet valve closed and the outlet valve open.

The two liquid waste storage tanks (1-RLWS-01T-A/B) also include:

- Level measurement – including low and high level alarms, plus low-low and high-high level trips. The low level alarm alerts the operator and allows an intervention to prevent the tank emptying and running the liquid waste evaporator feed pump (1-RLWE-01P-A/B) dry. The low-low level trip automatically stops the online liquid waste evaporator feed pump (1-RLWE-01P-A/B) to prevent damage from running dry. The high level alarm alerts the operator and allows an intervention to prevent the tank overfilling. The high-high level trip automatically stops pumps that feed the liquid waste storage tanks.

- Pressure measurement – including a high pressure alarm, which alerts the operator to a rise in the tank pressure.

9b.7.4.5 Technical Specifications

There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with RLWS.

9b.7.5 SOLID RADIOACTIVE WASTE PACKAGING SYSTEM

The SRWP provides a means to collect, process, store, package, and prepare for off-site shipment, solid radioactive waste material produced by the normal operation of the facility. The single SRWP described herein services the wastes from systems throughout the IF and RPF.

9b.7.5.1 System Process Functions

The SRWP is designed to provide for the collection, processing, packaging, and storage of solid wastes resulting from normal plant operations without limiting the normal operation or availability of the facility.

9b.7.5.2 Safety-Related Effects

9b.7.5.2.1 Safety Functions

This system is nonsafety-related.

9b.7.5.3 System Design Inputs

9b.7.5.3.1 NDAS Waste Stream

The NDAS creates a waste stream that consists of activated vacuum hardware, target chambers, and the upper portion of the neutron driver.

9b.7.5.3.2 Solid Radioactive Waste Handling Hot Cell Waste Stream

The inputs to the solid radioactive waste handling hot cell are summarized in Figure 9b.7-7. These include spent Mo extraction columns, [Proprietary Information], scrap radioisotope purification process glassware, spent light water pool deionizer units, spent PCLS cooling water deionizer units, spent Tc removal columns, [Proprietary Information], and scrap contaminated equipment.

9b.7.5.3.3 Miscellaneous Dry Waste Stream

Miscellaneous dry waste in the form of rags, paper, and contaminated PPE is collected in specific locations within the facility based on operational and health physics approaches.

9b.7.5.4 System Storage and Packaging Requirements

9b.7.5.4.1 Neutron Driver

The neutron driver drift tubes and target chambers are placed into a DOT IP-1 cargo container (SC-0001) for storage after removal from the light water pool. They accumulate until the cargo container is either full or the container reaches its maximum gross weight capacity of 67,200 lb. The upper portion of the neutron drivers are placed into decay storage. They are then placed into a DOT IP-1 cargo container for disposal. Refer to Table 9b.7-7 for waste classification, quantities, and final destination of the neutron driver waste.

9b.7.5.4.2 Solid Radioactive Waste Handling Hot Cell

Both the spent Mo extraction columns [Proprietary Information] are stored within the supercell Mo extraction area for a duration of no less than 2 weeks after use. After the initial decay period, the spent columns are transferred to the storage vault for an additional six months of decay time. The spent columns are then transferred to the solid radioactive waste handling hot cell for consolidation and packaging into an approved LSA container. Refer to Table 9b.7-7 for waste classification, quantities, and final destination of the Mo extraction [Proprietary Information].

The scrap radioisotope purification process glassware is removed from the supercell purification area and transferred to the solid radioactive waste handling hot cell. The glassware is deposited into a drum that has had an absorbent added and crushed, until the drum is full and then removed for shipping. Refer to Table 9b.7-7 for waste classification, quantities, and final destination of the radioisotope purification process glassware waste.

The [Proprietary Information] are transferred to the solid radioactive waste handling hot cell. [Proprietary Information]. Refer to Table 9b.7-7 for waste classification, quantities, and final destination of the [Proprietary Information].

Scrap contaminated equipment is transferred to the solid radioactive waste handling hot cell, as necessary. The contaminated equipment is then packaged in a specifically designed LSA container.

9b.7.5.4.3 Miscellaneous Dry Waste

The miscellaneous dry waste is consolidated, packaged, and sent to the waste staging and shipping building. Refer to Table 9b.7-7 for waste classification, quantities, and final destination of the dry waste.

9b.7.5.5 Equipment Description

See Table 9b.7-6 for a list of major equipment associated with the solid radioactive waste packaging system.

9b.7.5.6 System Shipping Procedures

Solid radioactive waste is shipped on a regular basis by a DOT licensed carrier.

9b.7.5.7 Criticality Control Features

No criticality-safe control features are necessary in the solid radioactive waste packaging system as transuranic or fissile material is not present in significant quantities in these waste streams.

As an additional precaution, the SRWP is monitored by the CAAS.

9b.7.5.8 Instrumentation and Control

The RICS provides the process monitoring and control of the SRWP (See Subsection 7b.1).

9b.7.5.9 Technical Specifications

There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the SRWP.

9b.7.6 RADIOACTIVE DRAIN SYSTEM

9b.7.6.1 RDS Process Description

The RDS receives radioactive liquids from various systems. Its primary purpose is to collect spills and leaks of radioactive liquids from processing areas.

9b.7.6.1.1 System Process Functions

The following is a list of the process functions of the RDS system:

- Receive and hold radioactive liquids from leaks and tank overflows in the processing areas.
- Detect and alarm when radioactive liquids are received.
- Perform pH adjustment.
- Route collected liquids to the UNCS.

9b.7.6.2 Safety-Related Effects

There is a potential for radioactive material to be present in the RDS after an overflow or leak, so the RDS is located in shielded pipe chases to limit the exposure of individuals to radiation.

Radiation monitors and alarms are used to monitor release of radiological materials and monitor high background gamma dose levels. CAAS provides monitoring for potential criticality events.

9b.7.6.2.1 Safety Functions

The safety design functions of the RDS are:

- Contain loss of inventory from process vessels and components.
- Provide sumps and drains that lead from the pipe trenches, tank vaults, hot cells, and process enclosures with a geometry that prevents an inadvertent criticality.

9b.7.6.2.2 Primary System Interfaces

For a list of system interfaces, refer to Table 9b.7-8.

9b.7.6.2.3 RDS Collection

Tank vaults, hot cells, process enclosures and the pipe trenches have drain lines to collect pipe and tank leaks, as well as wash-down sprays. The floors are sloped towards the drains. Small wells near the drain provide leak detection. Additionally, tank overflow lines are hard-piped to drain lines. Refer to the schedule on Figure 9b.7-8 for a list of drain locations.

9b.7.6.2.4 Processing Sequence

The RDS drain lines are sloped to the criticality-safe sump catch tank (1-RDS-01T), which is sized to contain a potential leak from the largest tank with radioactive liquids (UN recycle hold tank). Once the liquid is received in the criticality-safe sump catch tank, it can be sampled and characterized, if needed. The liquid may be treated with caustic or nitric acid, depending on the pH. Finally, the liquid is transferred to the UNCS to allow the uranium to be recovered.

See Figure 9b.7-8 for the PFD related to the RDS.

9b.7.6.2.5 Process Equipment

See Table 9b.7-9 for a list of major process equipment associated with the RDS.

9b.7.6.2.6 Criticality Control Features

The RDS prevents inadvertent criticality through inherently-safe geometrical design of sumps, tanks, drain lines, and in-line components that may handle fissile material.

9b.7.6.2.7 Shielding and Radiological Protection

Piping that contains potentially-radiological material is routed through shielded pipe chases to limit the exposure of radiation to personnel. The criticality-safe sump catch tank is shielded by a tank vault, which is a part of the process facility biological shield system (PFBS).

Refer to Chapter 11 for the radiation exposure goals, and Section 4b.2 for further detail of shielding requirements.

Radiation monitors and alarms are used to monitor for release of radiological materials, and monitor high background gamma dose levels.

9b.7.7 MATERIAL HANDLING

The material handling system (MHS) provides equipment for the safe manipulation and transportation of material or equipment within the facility, external to the RCA (for material handling inside the RCA, see the RMHS system). The MHS includes overhead cranes, hoists, fork trucks, hand trucks, and carts, as necessary, that are used to move or manipulate material, including chemicals, or equipment, within the facility. The MHS system is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the MHS system.

9b.7.8 FACILITY POTABLE WATER SYSTEM

The facility potable water system (FPWS) provides a potable water supply for the SHINE facility. The FPWS is fed by a connection to the City of Janesville water supply, and includes a meter house, backflow prevention valves, and distribution piping and valves as necessary, to the locations within the facility that use potable water. The FPWS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FPWS system.

9b.7.9 FACILITY INSTRUMENT AIR SYSTEM

The facility instrument air system (FIAS) serves the RCA and areas outside the RCA of the SHINE facility to provide clean, filtered, compressed, dry air to the facility’s various pneumatic-controlled components. This system includes compressors, pre-filters, dryers, receivers, and after filters. The FIAS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FIAS system.

9b.7.10 FACILITY COMPRESSED AIR SYSTEM

The facility compressed air system (FCAS) serves the RCA and non-RCA of the SHINE facility to provide clean, filtered, compressed air for maintenance and miscellaneous use. This system includes compressors, filters, and receivers. The FCAS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FCAS system.

9b.7.11 FACILITY BREATHING AIR SYSTEM

The facility breathing air system (FBAS) serves the RCA and non-RCA of the SHINE facility and provides clean, filtered air suitable for breathing hoods or masks. The system includes multiple compressors, receiver, control panel, and air purification equipment. The FBAS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FBAS system.

9b.7.12 FACILITY INERT GAS SYSTEM

The facility inert gas system (FIGS) provides a clean source of nitrogen gas for the purpose of inerting. The FIGS consists of a bulk storage tank containing cold, compressed liquid nitrogen, a vaporizer, distribution piping, and controls. The FIGS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FIGS system.

9b.7.13 FACILITY ROOF DRAINS SYSTEM

The facility roof drains system (FRDS) removes rainfall precipitation from the flat roof of the main production building. Water is directed to exterior perimeter downspouts, discharge to the ground surface, and then overland flow to the site perimeter drainage ditch. The downspouts are connected directly to the catch basins inlets and the perimeter ditch via underground piping. Downspout discharges are directed away from the buildings via surface flow and sloped lawn areas. The FRDS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FRDS system.

9b.7.14 FACILITY SANITARY DRAINS SYSTEM

The facility sanitary drains system (FSDS) removes normal domestic sanitary waste water from sinks, bathrooms, and cleaning maintenance closets via an interior gravity piping network, to an exterior lateral connected to the City of Janesville sewer system. If required due to elevation differences, the exterior gravity lateral will be replaced with a sanitary lift-pumping station that discharges to the City sewer. The FSDS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FSDS system.

9b.7.15 FACILITY ACID REAGENT STORAGE AND DISTRIBUTION SYSTEM

The facility acid reagent storage and distribution system (FARS) serves the RCA and areas outside the RCA of the SHINE facility to provide clean, filtered acid for use in the process. The system contains a storage tank, filters, metering pumps, and distribution piping. The FARS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FARS system.

9b.7.16 FACILITY ALKALINE REAGENT STORAGE AND DISTRIBUTION SYSTEM

The facility alkaline reagent storage and distribution system (FLRS) serves the RCA and areas outside the RCA of the SHINE facility to provide clean, filtered alkaline for use in the process. The system contains a storage tank, filters, metering pumps, and distribution piping. The FLRS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FLRS system.

9b.7.17 FACILITY SALT REAGENT STORAGE AND DISTRIBUTION SYSTEM

The facility salt reagent storage and distribution system (FSRS) serves the RCA and areas outside the RCA of the SHINE facility to provide clean, filtered salts for use in the process. The system contains a storage tank, filters, metering pumps, and distribution piping. The FSRS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FSRS system.

9b.7.18 FACILITY ORGANIC REAGENT STORAGE AND DISTRIBUTION SYSTEM

The facility organic reagent storage and distribution system (FORS) serves the RCA and areas outside the RCA of the SHINE facility to provide clean, filtered organics for use in the process. The system contains a storage tank, filters, metering pumps, and distribution piping. The FORS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the FORS system.

9b.7.19 ORGANIC LIQUID WASTE STORAGE AND EXPORT

The organic waste storage and export system (OLWS) is used to collect, store, and dispose of organic liquid wastes generated at various points in the RCA and areas outside the RCA of the SHINE facility during the Mo-99 production process. The system contains an organic liquid waste storage tank with level instrumentation and alarms, a transfer pump and piping, and valves, as necessary. The OLWS is not safety-related. A more detailed system description will be provided in the FSAR. There are no potential variables, conditions, or other items that will be probable subjects of a technical specification associated with the OLWS system.

9b.7.20 OFF-NORMAL AND ACCIDENT SCENARIOS

Part of the evaluation of other auxiliary systems is to determine that the design, functions, and potential malfunctions of the auxiliary system will not cause malfunctions or accidents that could result in uncontrolled release of radioactivity. This evaluation for auxiliary systems in both the IF and the RPF were reviewed as part of the development of the integrated safety analysis (ISA) for potential as a design basis accident (DBA) or initiating event (IE). The bases for the identification of DBAs and their IEs and associated accident scenarios were:

- Hazard and operability study (HAZOPS) as part of the development of the integrated safety analysis (ISA) summary, in accordance with NUREG-1520.
- List of IEs and accidents identified in the Final Interim Staff Guidance Augmenting NUREG-1537, Part 1.
- Experienced hazards analysis team.
- Preliminary design for the processes and facility.

The ISA development process identified process equipment by breaking it down into 56 systems and nearly 400 scenarios for both the IF and RPF. Causes for deviations and their potential outcomes were then identified. Finally, potential protective controls, safety functions, and functional requirements were identified. This led to the identification of the accident scenarios addressed in Chapter 13. For the FSAR a final HAZOPS analysis will be performed.

Table 9b.7-1 Master-Slave Manipulators

Master-Slave Manipulator Location	Quantity
Supercell Molybdenum Extraction Area of MEPS (each supercell)	2
Supercell Molybdenum Purification Area of MEPS (each supercell)	2
Supercell Molybdenum Packaging Area of MIPS (each supercell)	2
UREX Hot Cell	2
RLWE Evaporation Hot Cell	2
RLWE Immobilization Hot Cell	2
SRWP Hot Cell	2

Table 9b.7-2 RLWE System Interfaces

Interfacing System	Interface Description
Process Vessel Vent System (PVVS)	Tanks in the RLWE vent to the PVVS.
Radioactive Drain System (RDS)	Several of the process tanks in the RLWE overflow to the RDS.
Aqueous Radioactive Liquid Waste Storage (RLWS)	The RLWE receives radioactive liquid waste from the RLWS system.
Radiological Integrated Control System (RICS)	The RLWE is controlled by the RICS.
Normal Electrical Power Supply System (NPSS)	The RLWE is powered by the NPSS.
Radioisotope Process Facility Cooling System (RPCS)	The RLWE uses chilled water from the RPCS to cool process streams.

Table 9b.7-3 RLWE Process Equipment

Component	Description	Code/Standard
Liquid waste evaporator feed pump (1-RLWE-01P-A/B)	Centrifugal pump that transfers aqueous liquid radioactive waste to the evaporator. Nominal flowrate is 0.4 gpm.	ASME, 2011
Liquid waste evaporator tank (1-RLWE-01D)	Evaporator recirculation tank, with dual functions of providing liquid hold-up and vapor-liquid separation. The liquid hold-up is the limiting sizing criteria. The tank design includes a demister at the top to remove moisture droplets.	ASME, 2011
Liquid waste evaporator recirculation pump (1-RLWE-02P-A/B)	Centrifugal pump that recirculates liquid radioactive waste through the heater to the liquid waste evaporator tank. Nominal flowrate is 35 gpm.	ANSI/HI, 2008
Liquid waste evaporator heater (1-RLWE-01A)	Electrical heater to provide heat input for evaporation. Nominal capacity is 87,248 Btu/hr (25.6 kW).	
Liquid waste condenser (1-RLWE-02A)	Evaporator overheads condenser, cooled by RPCS chilled water. Nominal heat duty is 71,871 Btu/hr (20.9 kW).	
Liquid waste condensate collection tank (1-RLWE-01T-A/B)	Dual collection tanks for evaporator condensate. Working capacity is 70 gal.	ASME, 2011
Liquid waste condensate pump (1-RLWE-03P-A/B)	Centrifugal pump that transfers condensate from the liquid waste condensate collection tank. Nominal flowrate is 10 gpm.	ANSI/HI, 2008
Liquid waste evaporator product cooler (1-RLWE-03A)	Evaporator bottoms product cooler, cooled by RPCS chilled water. Nominal heat duty is 14,128 Btu/hr (4.1 kW).	
Liquid waste collection tank (1-RLWE-02T-A/B)	Dual collection tanks for evaporator bottoms product. Working capacity is [Security-Related Information].	ASME, 2011
Liquid waste pump (1-RLWE-04P-A/B)	Positive displacement pumps that meters evaporator bottoms product from the liquid waste collection tank to the immobilization system drum filling station. Nominal flowrate is 5 gpm.	ANSI/HI, 2008
Cement hopper (1-RLWE-03T)	Storage hopper for cement. Nominal capacity is 4981 lb.	
Blast furnace slag hopper (1-RLWE-04T)	Storage hopper for blast furnace slag. Nominal capacity is 3179 lb.	
Calcium hydroxide hopper (1-RLWE-05T)	Storage hopper for calcium hydroxide. Nominal capacity is 1591 lb.	
Waste drum solids weigh scale (1-RLWE-01Z)	Weigh scale for measuring solidification materials additions to drums.	
Waste drum liquids weigh scale (1-RLWE-02Z)	Weigh scale for measuring liquid waste addition to drums.	
Waste drum mixer (1-RLWE-03Z)	Rotating drum mixer for mixing liquid waste and solidification materials.	

Table 9b.7-4 RLWS System Interfaces

Interfacing System	Interface Description
Process Vessel Vent System (PVVS)	The process tanks in the RLWS vent to the PVVS. The interface is at the tank exhaust. The RLWS receives acid gas scrubber blowdown from the PVVS.
Mo Extraction and Purification System (MEPS)	The RLWS receives liquid waste from the following sources within the MEPS: • Spent Mo extraction column washes • [Proprietary Information] • Rotary evaporator condensate • Spent purification process liquids
Radioactive Drain System (RDS)	The process tanks in the RLWS overflow to the RDS.
Radioactive Liquid Waste Evaporation and Immobilization (RLWE)	The RLWS transfers radioactive liquid waste to the RLWE system.
Noble Gas Removal System (NGRS)	The NGRS condensate is routed to the RLWS system.
Radiological Integrated Control System (RICS)	The RLWS is controlled by the RICS.
Normal Electrical Power Supply System (NPSS)	The RLWS is powered by the NPSS.
Uranyl Nitrate Conversion System (UNCS)	The RLWS receives raffinate from the UREX system in the UNCS.

Table 9b.7-5 RLWS Process Equipment

Component	Description	Code/Standard
Liquid waste storage tank (1-RLWS-01T-A/B)	These tanks provide buffer storage of the radioactive liquid waste generated by facility operations.	ASME BPVC Section VIII

Table 9b.7-6 Solid Radioactive Waste Packaging System Equipment List

Equipment	Description	Waste Stream
DOT IP-1 Cargo Container (SC-0001)	67,200 lb. gross weight capacity shipping container. The container is nominally 240 in. L x 96 in. W x 102 in. H, and has a 1,162 cu. ft. internal volume.	Neutron Driver
DPTE Drum Transfer System	A DPTE drum transfer system is used for the introduction of waste being received from the supercell area.	Solid Radioactive Waste Handling Hot Cell
Shielded Cask	Shielded storage casks are used to store the waste in order to protect the environment and personnel from irradiated solid waste.	Solid Radioactive Waste Handling Hot Cell
Telemanipulators	Telemanipulators are used when remote handling is required for handling of solid waste.	Solid Radioactive Waste Handling Hot Cell
Packaging Drum Transfer System	A drum transfer system is used to repackage solid waste into an acceptable storage container.	Solid Radioactive Waste Handling Hot Cell
Overhead Hoist	An overhead hoist is used to assist in remote handling of solid waste within a hot cell environment.	Solid Radioactive Waste Handling Hot Cell

Table 9b.7-7 Estimated Type and Quantity of Radioactive Wastes Associated with the SHINE Facility (Sheet 1 of 3)

Description	Matrix	Class as Generated	Contents	Volume	Volume as shipped (ft^3)	55-gallon drum equivalent as shipped	Shipment Type	Number of Shipments/yr	Destination
Neutron Generator	Solid	A	Activated metal parts	4338 ft^3/yr	4338	590	LSA	3	ES
Extraction Columns	Solid	A	Stainless resin columns						
Class A Trash	Solid	A	PPE, Mo-99 purification glassware, filters, etc						
Spent Solvent	Liquid	A	n-dodecane, tributyl phosphate	22 gallons/ yr	--	0.4	LSA	1	DSSI
Tc/I columns	Resin	C	Resin	16	23	3.1	Type B	0.3	WCS
Zeolite Beds	Solid	GTCC	Silver coated beds	0.4 ft^3/yr	0.4	0.05	Type B	1	WCS
[Proprietary Information]	[Proprietary Information]	GTCC	Resin	16	23	3.1	Type B	0.3	WCS
[Proprietary Information]	[Proprietary Information]	B	[Proprietary Information]	295 gallons/yr	79	11	Type B	1	WCS

Table 9b.7-7 Estimated Type and Quantity of Radioactive Wastes Associated with the SHINE Facility
(Sheet 2 of 3)

Description	Matrix	Class as Generated	Contents	Volume	Volume as shipped (ft^3)	55-gallon drum equivalent as shipped	Shipment Type	Number of Shipments/yr	Destination
Spent Washes	Liquid[(a)]	A	[Proprietary Information]	59,708 gallons/yr	9738	1324	LSA	18	ES
Rotovap Condensate	Liquid[(a)]	A	[Proprietary Information]						
UREX Raffinate	Liquid[(a)]	B	[Proprietary Information]						
Decontamination Waste	Liquid[(a)]	A	Decon fluid unknown						
Spent Eluate Solution	Liquid[(a)]	A	[Proprietary Information]						
NO_x Scrubber Solution	Liquid[(a)]	A	[Proprietary Information]						

Table 9b.7-7 Estimated Type and Quantity of Radioactive Wastes Associated with the SHINE Facility

(Sheet 3 of 3)

a) This liquid waste discharged from the various processes at the SHINE facility is either solidified and then shipped to a waste depository or reused.

Table 9b.7-8 RDS Interfaces

Interfacing System	Interface Description
Process Vessel Vent System (PVVS)	The RDS vents to the PVVS which enables the criticality-safe sump catch tank to be vented to a system that treats radioactive gases.
Target Solution Preparation System (TSPS)	The RDS receives spills from the sumps in the TSPS area.
Molybdenum Extraction and Purification System (MEPS)	The RDS receives spills from the sumps in the MEPS hot cells (supercells).
Uranyl Nitrate Conversion System (UNCS)	The RDS receives spills from the sumps in the tank vaults, sumps in the UREX hot cell, and sumps in the TDN area. Additionally, the liquids collected in the RDS are routed to the UNCS in order to recover any uranium.
Radiological Integrated Control System (RICS)	The RDS is controlled by the RICS.
Normal Electrical Power Supply System (NPSS)	The RDS is powered by the NPSS.
Radioactive Liquid Waste Evaporation and Immobilization (RLWE)	The RDS receives spills from the RLWE hot cell (not shown on PFD).
Aqueous Radioactive Liquid Waste Storage	The RDS receives spills from the sumps in the RLWS tank vaults (not shown on PFD).

Table 9b.7-9 RDS Process Equipment

Component	Description	Code/Standard
Radioactive Drain Pump	The positive-displacement pump serves to recirculate the collected liquids if pH balancing is required. It also serves to transfer collected liquids to the UNCS.	ANSI/HI 3.1-3.5
Criticality-Safe Sump Catch Tank	This catch tank is the reservoir for collecting fissile radioactive liquids from leaks or spills from the facility. It is criticality-safe by design. The tank is vented to the PVVS in order to maintain atmospheric pressure and treat radioactive gases. It is sized to collect the entire contents of the single-largest tank containing radioactive liquids.	ASME BPVC Section VIII

9b.8 RADIOISOTOPE PRODUCTION FACILITY AUXILIARY SYSTEMS TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification associated with the RPF Auxiliary Systems are provided in Chapter 14.

9b.9 REFERENCES

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