CHAPTER 8

ELECTRICAL POWER SYSTEMS

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
AC	alternating current
BT	bus train
CAAS	criticality accident alarm system
CAMS	continuous air monitoring system
DC	direct current
EMI	electromagnetic interference
ESFAS	engineered safety features actuation system
FDCS	facility data and communications system
FFPS	facility fire detection and suppression
FVZ4	facility ventilation zone 4
HCFD	hot cell fire detection and suppression system
HVAC	heating, ventilation, and air conditioning
Hz	hertz
IEEE	Institute of Electrical and Electronics Engineers
IU	irradiation unit
kV	kilovolt

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
LOOP	loss of off-site power
MEPS	molybdenum extraction and purification system
N2PS	nitrogen purge system
NDAS	neutron driver assembly system
NFPA	National Fire Protection Association
NFDS	neutron flux detection system
NPSS	normal electrical power supply system
PICS	process integrated control system
PVVS	process vessel vent system
RAMS	radiation area monitoring system
RFI	radio frequency interference
RLWI	radioactive liquid waste immobilization
RLWS	radioactive liquid waste storage
RPF	radioisotope production facility
RVZ1	radiological ventilation zone 1
RVZ1e	radiological ventilation zone 1 exhaust subsystem

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
RVZ2	radiological ventilation zone 2
RVZ2e	radiological ventilation zone 2 exhaust subsystem
RVZ2s	radiological ventilation zone 2 supply subsystem
SEC	secondary enclosure cleanup
SGS	standby generator system
SRM	stack release monitor
SRMS	stack release monitor system
TPS	tritium purification system
TOGS	TSV off-gas system
TRPS	TSV reactivity protection system
TSV	target solution vessel
UP	utility power
UPSS	uninterruptible electrical power supply system
V	volts
VAC	volts – alternating current

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Definition**
VDC	volts – direct current
VTS	vacuum transfer system

8a2 IRRADIATION FACILITY ELECTRICAL POWER SYSTEMS

8a2.1 NORMAL ELECTRICAL POWER SUPPLY SYSTEM

A single overall electrical power system serves the main production facility, including both the irradiation facility and the radioisotope production facility, as well as the site and support buildings. The normal electrical power supply system (NPSS) for the SHINE facility consists of the normal power service entrances from the electric utility and a distribution system providing three utilization voltages, 480Y/277, 400Y/230, and 208Y/120 volts alternating current (VAC), 3-phase, 60 hertz. Grounding and lightning protection is provided.

The NPSS receives off-site power service from the local utility, Alliant Energy, at 480Y/277 VAC through five separate transformer feeds. Portions of the NPSS that comprise the emergency electrical power system can also receive power from the standby generator system (SGS). The NPSS is used for normal operation and normal shutdown of the facility.

The NPSS is sized for safe operation of the facility. The largest loads on the NPSS are the process chilled water system (PCHS), neutron driver assembly system (NDAS), and the facility chilled water system (FCHS); however, those loads are not required for safe shutdown of the facility. Refer to Section 8a2.2 for a tabulation of emergency electrical load requirements.

A simplified diagram of the overall electrical power system is provided in Figure 8a2.1-1.

8a2.1.1 DESIGN BASIS

The design of the NPSS is based on Criterion 27, Electrical power systems, and Criterion 28, Inspection and testing of electric power systems, of the SHINE design criteria. The SHINE design criteria are described in Section 3.1.

The design of the NPSS provides sufficient, reliable power to facility and site electrical equipment as required for operation of the SHINE facility and to comply with applicable codes and standards. The NPSS is designed such that it:

- Does not prevent the ability of safety-related SSCs to perform their safety functions;
- Provides for the separation or isolation of safety-related circuits from nonsafety-related circuits, including the avoidance of electromagnetic interference with safety-related instrumentation and control functions;
- Fails to a safe configuration upon a loss of off-site power (LOOP);
- Provides the normal source of power supply to the safety-related electrical buses;
- Provides the safety-related function of removing power from select components when demanded by the safety-related engineered safety features actuation system (ESFAS) or target solution vessel (TSV) reactivity protection system (TRPS); and
- Is able to be inspected, tested, and maintained to meet the above design bases.

The following codes and standards are used in the design of the NPSS:

- National Fire Protection Association (NFPA) 70-2017, National Electrical Code (NFPA, 2017), as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code, Electrical)

- Institute of Electrical and Electronics Engineers (IEEE) 384-2008, Standard Criteria for Independence of Class 1E Equipment and Circuits (IEEE, 2008), invoked for isolation and separation of nonsafety-related circuits from safety-related circuits, as described in Subsections 8a2.1.3 and 8a2.1.5.
- IEEE Standard 323-2003, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (IEEE, 2003), invoked for environmental qualification of safety-related equipment as described in Subsection 8a2.1.3.
- IEEE Standard C.37.13-2015, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures (IEEE, 2015a); invoked for ensuring reliability of safety-related breakers, as described in Subsection 8a2.1.3.

8a2.1.2 OFF-SITE POWER SUPPLY DESCRIPTION

The SHINE facility is connected to two single power circuits from the off-site transmission electric network. The power circuits are shared with other utility customers. The two power circuits feed five local outdoor 12.47 kilovolt (kV) - 480Y/277 VAC 3-phase transformers. The 12.47 kV feeders originate from the Alliant Energy Tripp Road substation, about 2.8 circuit miles from the SHINE facility, and the Alliant Energy Venture substation, about 2.3 circuit miles from the SHINE facility.

Two transformers are each connected to one of the SHINE facility's two main 480 VAC switchgear buses. Figure 8a2.1-1 depicts the off-site connections to the SHINE facility.

8a2.1.3 NORMAL ELECTRICAL POWER SUPPLY SYSTEM DESCRIPTION

The NPSS operates as five separate branches, each receiving utility power at 480Y/277 VAC. The branches automatically physically disconnect from the utility by opening the associated utility power (UP) supply breaker (UP BKR 1, UP BKR 2, UP BKR 3, or UP BKR 4) on a loss of phase, phase reversal, or sustained overvoltage or undervoltage as detected by protection relays for each utility transformer. This function is not required for safe shutdown, as described in Subsection 8a2.1.6. UP BRK 5, which provides isolation for the resource building, provides overcurrent and surge protection. UP BKR 5 disconnecting from the utility is not required for safe shutdown since it does not impact safety-related equipment in the main production facility.

The two branches, serving loads in the main production facility and the nitrogen purge system (N2PS) structure, can be cross-connected by manually opening one of the UP breakers and manually closing both bus tie (BT) breakers (BT BKR 1 and BT BKR 2) in the event of the loss of a single utility 480Y/277 VAC feed. This cross-connection would be administratively controlled to ensure the remaining utility feed is not overloaded.

The distribution system serving the main production facility and the N2PS structure consists of two line-ups of 480 volts (V) switchgear, two emergency 480 V buses (that are supported by the standby generator), and isolation and cross-tie breakers. The two switchgear line-ups each feed an individual emergency bus and the single SGS switchgear. The two emergency 480 V buses are nonsafety-related, but each provides power to a safety-related uninterruptible electrical power supply system (UPSS) division via division-specific battery chargers and bypass transformers. The SGS and the UPSS are further described in Section 8a2.2.

The distribution system serving the material staging building, storage building, and facility chillers consists of two 480 V switchgear with isolation and bus tie breakers (BT BKR 3 and BT BKR 4).

A single distribution system serves the resource building. There are no safety-related loads powered from these distribution systems.

Surge protection is provided at each electrical service entrance to limit voltage spikes and electrical noise. The electrical services are monitored for voltage, frequency, and loss of phase. When an electrical service exceeds prescribed limits, the facility is disconnected from the utility to prevent damage.

Loss of phase protection is provided by use of a negative sequence relay. The NPSS monitors each phase and disconnects from utility power on a loss of any one of the three incoming phases. Refer to Section 8a2.2 for further discussion of facility response to transient events.

The NPSS complies with NFPA 70 (NFPA, 2017), as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code, Electrical); with Sections 6.1.2.1, 6.1.2.2, and 6.1.2.3 of IEEE 384 (IEEE, 2008) for isolation; with Section 5.1.1.2, Table 1 of Section 5.1.3.3, and Table 2 of Section 5.1.4 of IEEE 384 (IEEE, 2008) for physical separation between nonsafety-related circuits and safety-related circuits; and with IEEE C.37.13 (IEEE, 2015a) to ensure reliability of safety-related breakers.

Compliance with NFPA 70 (NFPA, 2017) ensures sufficient reliability to minimize the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electric power system. Compliance with NFPA 70 (NFPA, 2017) also ensures adequate accessibility to NPSS components to permit periodic inspection and testing.

Compliance with IEEE C.37.13 (IEEE, 2015a) guidance for ratings, functional components, temperature limitations, classification of insulating materials, and testing procedures ensures that safety-related breakers in the NPSS have a high degree of reliability, the capacity, and the capability to perform their safety functions.

The NPSS contains the following safety-related equipment:

- Two safety-related breakers are provided for each instance of the NDAS to provide the redundant ability to disconnect power.
- Two safety-related breakers per vacuum pump to provide the redundant ability to disconnect power from each vacuum pump in the vacuum transfer system (VTS).
- Two safety-related breakers per extraction feed pump to provide the redundant ability to disconnect power from each (of three) extraction feed pumps in the molybdenum extraction and purification system (MEPS).
- Two safety-related breakers providing the redundant ability to disconnect power from the radiological ventilation zone 1 (RVZ1) exhaust fans, radiological ventilation zone 2 (RVZ2) exhaust fans and RVZ2 supply air handling units.

The safety functions performed by the specified breakers are related to preventing actions that could initiate or increase the consequences of an accident. The equipment tied to these breakers does not perform an active safety function. Redundant breakers are provided to ensure that the safety function can still be performed in the event of a single active failure.

Safety-related NPSS equipment is located in a mild environment, is not subject to harsh environmental conditions during normal operation or transient conditions, and has no significant aging mechanisms. This equipment is designed and qualified by applying the guidance of

Sections 4.1, 5.1, 6.1, and 7 of IEEE 323 (IEEE, 2003), and is qualified to the environmental parameters provided in Tables 7.2-2 and 7.2-3.

8a2.1.4 GROUNDING AND LIGHTNING PROTECTION

Equipment ground conductors, driven electrodes, buried conductors, and ground bars provide a conductive connection between facility SSCs and earth. These components, when taken together, provide intentional low impedance conductive paths for facility SSCs as required to ensure personnel safety, equipment protection, proper component function, electrical noise reduction and signal integrity.

The facility grounding system complies with NFPA 70 (NFPA, 2017). The facility grounding equipment provides no safety-related function.

Lightning protection equipment provides low impedance paths to ground that minimize the effects of potential lightning strikes on personnel, equipment, and the facility structure. It provides no safety-related function.

8a2.1.5 RACEWAY AND CABLE ROUTING

There are four separation groups for cables and raceways for the SHINE facility: Group A, Group B, Group C, and Group N. Spatial separation between groups is in accordance with Section 5.1.1.2, Table 1 of Section 5.1.3.3, and Table 2 of Section 5.1.4 of IEEE 384 (IEEE, 2008).

- Separation Group A contains safety-related power circuits from UPSS Division A and safety-related control circuits from TRPS, NFDS, and ESFAS Division A.
- Separation Group B contains safety-related power circuits from UPSS Division B and safety-related control circuits from TRPS, NFDS, and ESFAS Division B.
- Separation Group C contains safety-related control circuits from TRPS and ESFAS Division C. For additional information on the Division C circuits see Section 7.4.
- Group N contains the facility nonsafety-related cables, including NPSS and SGS power circuits and process integrated control system (PICS) control circuits.

Nonsafety-related circuits are electrically isolated from safety-related circuits by isolation devices in accordance with Sections 6.1.2.1, 6.1.2.2, and 6.1.2.3 of IEEE 384 (IEEE, 2008). See Chapter 7 for additional discussion of safety-related control systems.

8a2.1.6 LOSS OF OFF-SITE POWER

A LOOP is defined as zero voltage/power supplied by the utility, loss of a phase, phase reversal, sustained overvoltage or sustained undervoltage. When there is loss of phase, phase reversal, sustained overvoltage or sustained undervoltage, the facility automatically disconnects from the utility. For the plant equipment, all the scenarios result in zero voltage/power supplied by the utility.

IUs in Mode 0 (Solution Removed) are unaffected by the LOOP - the neutron driver is not operating and target solution is not present in the IU.

TSV filling operations for IUs in Mode 1 (Filling) will be stopped via the loss of power to the VTS, which causes the VTS vacuum pumps to shut down and the VTS vacuum breaker valve to open. Neutron flux monitoring and safety-related protection systems will remain operational, powered via the UPSS (see Section 8a2.2). If the SGS is available, the SGS will auto start to provide backup power to the TSV off-gas system (TOGS), allowing the TOGS to continue to operate and mitigate hydrogen generated by radiolysis from decay radiation in the target solution. If the SGS is not available, the TOGS will continue to operate for five minutes, powered by the UPSS. Three minutes after loss of external power to the UPSS, before the TOGS blowers are unloaded from the UPSS, TRPS will initiate an IU Cell Nitrogen Purge, and the N2PS will inject nitrogen into the TSV dump tank to provide hydrogen control in the IU. The PCLS pumps are not powered by the UPSS or SGS; therefore, PCLS flow to the TSV will be lost. Loss of PCLS flow starts a three minute timer. If PCLS flow is not restored within the three minute duration, TRPS will initiate an IU Cell Safety Actuation, resulting in the TSV dump valves opening and the target solution draining from the TSV to the TSV dump tank. Once in the TSV dump tank, the decay heat is passively removed from the target solution via natural convection to the light water pool. See Section 7.4 for additional information about the TRPS. See Section 4a2.4 for additional discussion of the light water pool.

Each operating neutron driver for an IU in Mode 2 (Irradiation) will shut down due to loss of power to the driver. Shutdown of the neutron driver will result in lowered neutron flux within the IU. This causes a Driver Dropout actuation on low neutron flux which results in opening the driver high voltage power supply breakers. Similar to the effect of a LOOP during Mode 1 operation, the target solution will be drained from the TSV to the TSV dump tank after a three minute delay via an IU Cell Safety Actuation occurs unless off-site power is restored. Also similar to Mode 1, an IU Cell Nitrogen Purge will occur after three minutes if the NPSS or SGS is not available to power the TOGS.

IUs in Mode 3 (Post-Irradiation) will be provided hydrogen mitigation by TOGS, which is powered by the UPSS for five minutes if the SGS is unavailable. TRPS initiates an IU Cell Nitrogen Purge after three minutes if power from the NPSS or SGS is not restored. If the SGS is available, these units are unaffected by a LOOP because active cooling is not provided in Mode 3.

Finally, with the exception of target solution transfer operations, which will be stopped via the loss of VTS, IUs in Mode 4 (Transfer to RPF) are affected by the LOOP identically to IUs in Mode 3.

Additionally, a LOOP will result in the following conditions for the facility:

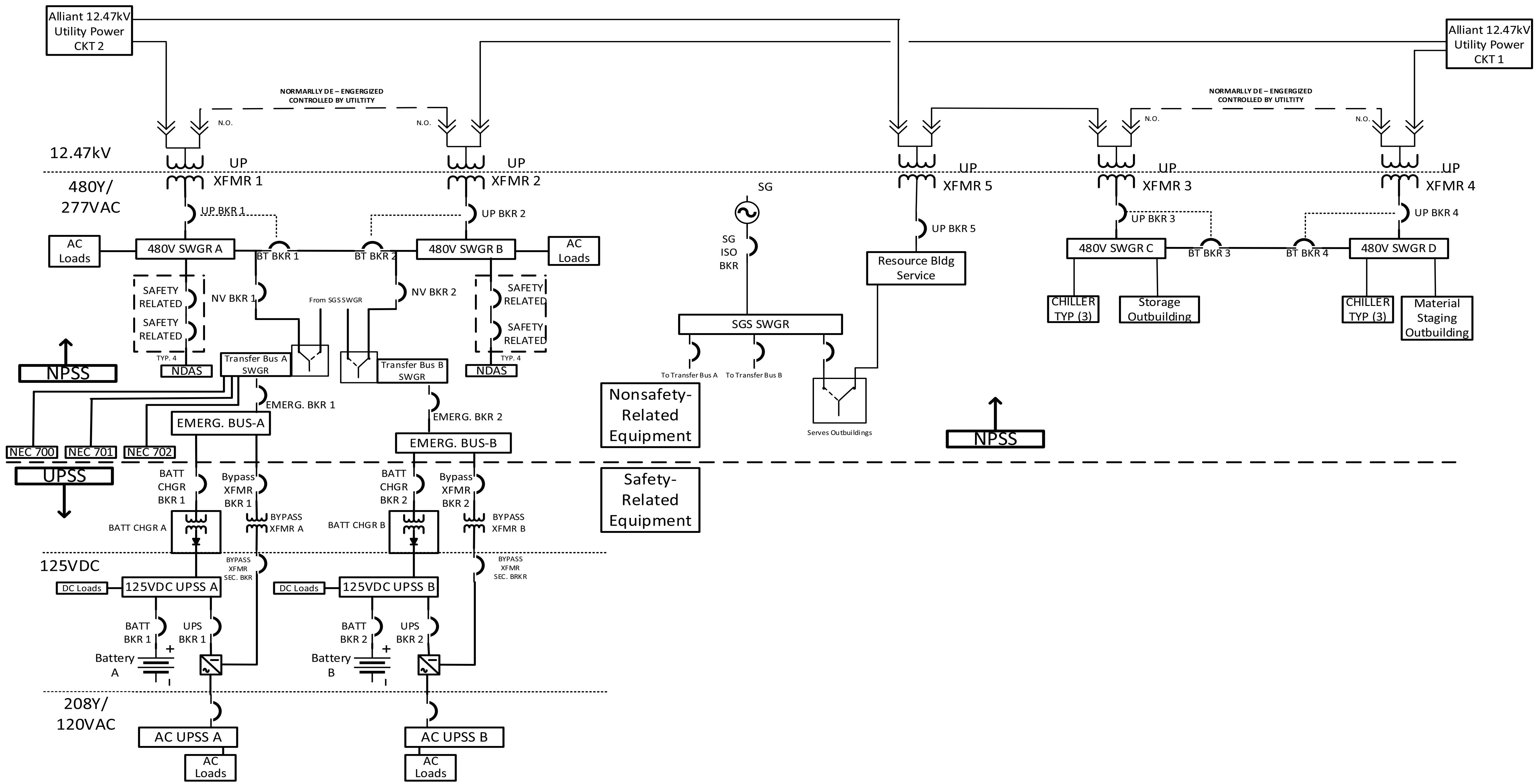
- If the SGS does not start, the process vessel vent system (PVVS) blowers shut down immediately and the TOGS blowers shut down after a five minute delay. N2PS valves open on loss of PVVS to allow the introduction of nitrogen sweep gas into process tanks in the RPF containing radioactive liquid to dilute hydrogen gas generated by radiolysis. N2PS valves open after a three minute delay to allow the introduction of nitrogen sweep gas into TSV dump tanks in the IF, preventing the accumulation of hydrogen beyond allowable limits.
- Heating, ventilation, and air conditioning (HVAC) systems shut down and ventilation dampers with a confinement function fail closed to ensure the confinement function is provided, and preventing uncontrolled releases of radioactive material.

- Other systems throughout the facility, including tritium purification system (TPS), VTS, and all three cooling water systems shut down and isolation valves with a confinement function fail closed.
- Controlled releases of radioactive material continue using N2PS sweep gas through the carbon delay beds, which is monitored by the carbon delay bed effluent monitor. The carbon delay bed effluent monitor is powered by the UPSS with backup power from the SGS.
- The radioactive liquid waste storage (RLWS) and the radioactive liquid waste immobilization (RLWI) systems fail safe upon a LOOP.

8a2.1.7 TECHNICAL SPECIFICATIONS

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

Figure 8a2.1-1 – Electrical Distribution System (Simplified)



8a2.2 EMERGENCY ELECTRICAL POWER SYSTEMS

The emergency electrical power systems for the SHINE facility consist of the safety-related uninterruptible electrical power supply system (UPSS), the nonsafety-related standby generator system (SGS), and nonsafety-related local power supplies and unit batteries. The UPSS provides reliable power for the safety-related equipment required to prevent or mitigate the consequences of design basis events. The UPSS consists of a 125-volt direct current (VDC) battery subsystem, inverters, bypass transformers, distribution panels, and other distribution equipment necessary to feed safety-related alternating current (AC) and direct current (DC) loads and select nonsafety-related AC and DC loads.

The SGS consists of a single natural gas-driven generator, associated breakers, transfer switches, and distribution equipment. The SGS provides an alternate source of power for UPSS loads. Additionally, emergency power is provided by the SGS for facility physical security control systems and information and communications systems. Unit batteries provide power for egress and exit lights, switchgear control (station control batteries), and nonsafety-related local uninterruptible power supplies which provide back-up power for communications, data systems, and nonsafety-related control systems. The SGS provides an alternate source of power for the unit batteries and their associated loads.

Nonsafety-related local power supplies for the process integrated control system (PICS) and the facility data and communications systems (FDCS) are described in Sections 7.6 and 9a2.4, respectively.

8a2.2.1 UNINTERRUPTIBLE ELECTRICAL POWER SUPPLY SYSTEM DESIGN BASIS

The design of the UPSS is based on Criterion 27, Electrical power systems, and Criterion 28, Inspection and testing of electric power systems, of the SHINE design criteria. The SHINE design criteria are described in Section 3.1.

The purpose of the UPSS is to provide a safety-related source of power to equipment required to ensure and maintain safe facility shutdown and prevent or mitigate the consequences of design basis events.

The UPSS:

- Provides power at a sufficient capacity and capability to allow safety-related SSCs to perform their safety functions;
- Is designed, fabricated, erected, tested, operated, and maintained to quality standards commensurate with the importance of the safety functions to be performed;
- Is designed to withstand the effects of design basis natural phenomena without loss of capability to perform its safety functions;
- Is located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions;
- Has sufficient independence, redundancy, and testability to perform its safety functions assuming a single failure;
- Incorporates provisions to minimize the probability of failure as a result of or coincident with the loss of power from the transmission network; and
- Permits appropriate periodic inspection and testing to assess the continuity of the system and the condition of components.

8a2.2.2 UNINTERRUPTIBLE ELECTRICAL POWER SUPPLY SYSTEM CODES AND STANDARDS

The UPSS is designed in accordance with the following codes and standards:

- National Fire Protection Association (NFPA) 70-2017, National Electrical Code (NFPA, 2017), as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code, Electrical)
- IEEE Standard 344 - 2013, IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations (IEEE, 2013); invoked to meet seismic requirements, as described in Subsection 8a2.2.3
- IEEE Standard 384 - 2008, Standard Criteria for Independence of Class 1E Equipment & Circuits (IEEE, 2008); invoked for separation and isolation of safety-related and nonsafety-related cables and raceways and for associated equipment, as described in Subsection 8a2.2.3
- IEEE Standard 450-2010, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications (IEEE, 2010a); invoked as guidance for the inspection of batteries, as described in Subsection 8a2.2.3
- IEEE Standard 484-2002, Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications (IEEE, 2002); invoked as guidance for the installation of batteries, as described in Subsection 8a2.2.3
- IEEE Standard 485 - 2010, Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications (IEEE, 2010b); invoked for battery sizing of UPSS loads, as described in Subsection 8a2.2.3
- IEEE Standard 323-2003, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (IEEE, 2003); invoked for environmental qualification of safety-related equipment as described in Subsection 8a2.2.3
- IEEE Standard 946-2004, Recommended Practice for the Design of DC Auxiliary Systems for Generating Stations (IEEE, 2004); invoked as guidance for the design of the DC components, as described in Subsection 8a2.2.3
- IEEE Standard C.37.20-2015, Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear (IEEE, 2015b); invoked as guidance for the design of UPSS switchgear, as described in Subsection 8a2.2.3

While the UPSS is not classified as a Class 1E system, portions of Class 1E-related standards, as described in this section, are applied to the design of the UPSS in order to satisfy applicable SHINE design criteria.

8a2.2.3 UNINTERRUPTIBLE ELECTRICAL POWER SUPPLY SYSTEM DESCRIPTION

The safety-related UPSS provides a reliable source of power to the redundant divisions of AC and DC components on the safety-related power buses. Each division of the UPSS consists of a 125 VDC battery subsystem, 125 VDC to 208Y/120 volts alternating current (VAC) inverter, rectifier (battery charger), bypass transformer, static switch and a manual bypass switch, 208Y/120 VAC and 125 VDC distribution panels, and a nonsafety-related 208Y/120 VAC bus system isolated from the safety-related portion of the system by breakers or isolating fuses which meet Section 6.1.2 requirements of IEEE 384 (IEEE, 2008) for isolation devices, ensuring that a failure of nonsafety-related loads does not impact safety-related loads.

Distribution wiring from each division of the UPSS is isolated and separated from the other division per Sections 6.1.2.1, 6.1.2.2, and 6.1.2.3 of IEEE 384 (IEEE, 2008) for isolation and with Section 5.1.1.2, Table 1 of Section 5.1.3.3, and Table 2 of Section 5.1.4 of IEEE 384 (IEEE, 2008) for physical separation.

A simplified diagram of the UPSS is provided in Figure 8a2.2-1.

Each division of UPSS is normally powered by an emergency 480 VAC NPSS bus via a division-specific battery charger. The emergency 480 VAC NPSS buses can also be powered by the SGS, providing an alternate source of power to the UPSS. The SGS is described in Subsection 8a2.2.4.

The UPSS is isolated from the NPSS and SGS by isolating breakers feeding the battery chargers and the bypass transformers. These devices are identified as breakers BATT CHGR BRK 1, BATT CHGR BKR 2, BYPASS XFMR BKR 1 and BYPASS XRMR BKR 2 in Figure 8a2.2-1. The breakers monitor incoming power for voltage, phase, and frequency, and will trip when monitored variables are out of limits.

Each battery charger supplies power to the safety-related 125 VDC bus for its division. The loads on each DC bus consist of the following:

- Engineered safety features actuation system (ESFAS)
- Target solution vessel (TSV) reactivity protection system (TRPS)
- TSV off-gas system (TOGS) recombiner heaters
- Nitrogen purge system (N2PS) solenoid valves
- TSV dump valves

Each 125 VDC bus supplies power to an associated 208Y/120 VAC bus via an inverter. The two 208Y/120 VAC buses can also each receive power directly from the associated emergency 480 VAC NPSS bus through a bypass transformer. The safety-related loads on each AC bus consist of the following:

- ESFAS radiation monitors
- TRPS radiation monitors
- TPS tritium monitors
- Neutron driver assembly system (NDAS) high voltage power supply breaker undervoltage hold circuits
- Vacuum transfer system (VTS) vacuum pump breaker undervoltage hold trip circuits
- Molybdenum extraction and purification system (MEPS) undervoltage hold trip circuits
- Radiological ventilation zone 1 (RVZ1) exhaust subsystem (RVZ1e) exhaust fans, Radiological ventilation zone 2 (RVZ2) exhaust subsystem (RVZ2e) exhaust fans, and RVZ2 supply subsystem (RVZ2s) air handling units undervoltage hold trip circuits
- TOGS blowers
- Neutron flux detection system (NFDS) power cabinets and detectors for the associated division

Separate distribution panels connected to the 208Y/120 VAC bus, isolated from the safety-related portion of the bus by isolation overcurrent devices, provide power to nonsafety-related loads important for providing alerts to facility personnel and for monitoring the status of the facility.

These loads consist of:

- Main facility stack release monitor (SRM)
- Process vessel vent system (PVVS) carbon delay bed effluent monitor
- TPS secondary enclosure cleanup (SEC) blowers
- Criticality accident alarm system (CAAS)

Additional details about the UPSS loads are provided in Table 8a2.2-1.

Upon a loss of NPSS power and unavailability of SGS power, the AC and DC UPSS buses are powered by the safety-related battery bank for each division. Each UPSS division is located in a separate fire area in the safety-related, seismic portion of the main production facility. The UPSS is required to perform its safety function before, during, and after a seismic event, and is qualified by one of the testing methods described in Sections 8 and 9.3 of IEEE 344 (IEEE, 2013).

Compliance with NFPA 70-2017 (NFPA, 2017) ensures adequate accessibility to UPSS components to permit periodic inspection and testing.

DC components within the UPSS include the safety-related batteries, battery chargers, and DC switchgear. These DC components are designed in accordance with Sections 5.2, 6.2, 6.5, 7.1, 7.3, Table 2 of 7.4, 7.6, and 7.9 of IEEE 946 (IEEE, 2004). Compliance with these portions of IEEE 946 (IEEE, 2004) ensures DC components have sufficient testability and minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

The battery sizing for the UPSS loads is shown in Table 8a2.2-2, using the sizing guidance provided in Sections 6.1.1, 6.2.1, 6.2.2, 6.2.3, 6.2.4, 6.3.2 and 6.3.3 of IEEE 485 (IEEE, 2010b). Compliance with these sections of IEEE 485 ensures that the battery capacity and capability are sufficient to support UPSS loads. Batteries are vented lead-acid. Transfer of loads from the NPSS to the UPSS is automatic and requires no control power.

UPSS batteries are installed in accordance with Sections 5 and 6 of IEEE 484 (IEEE, 2002). Compliance with these sections of IEEE 484 (IEEE, 2002) ensures the batteries are properly installed and tested, and minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

Battery maintenance will be performed in accordance with Section 5 of IEEE 450 (IEEE, 2010a). Compliance with Section 5 of IEEE 450 (IEEE, 2010a) ensures the batteries are inspected regularly, and any identified issues are corrected, which minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system.

UPSS switchgear is designed in accordance with IEEE C.37.20.1 (IEEE, 2015b). Compliance with IEEE C.37.20.1 (IEEE, 2015b) ensures that the UPSS has a high degree of reliability, which minimizes the probability of losing electric power from the UPSS as a result of or coincident with the loss of power from the off-site electrical power system. UPSS switchgear is designed with the ability to install a temporary load bank to perform required testing.

The required reserve for loads is listed in Table 8a2.2-2. 15 percent of the total is reserved to accommodate variations of power during equipment procurement and an additional 10 percent is initially reserved for future needs that may be identified during the lifetime of the facility.

The run time requirements in Table 8a2.2-1 are based on:

1) Equipment required to prevent hydrogen deflagration is powered for five minutes,
2) Equipment used to minimize transient effects on the facility due to short duration power loss is powered for five minutes,
3) Equipment used to provide alerts for facility personnel and monitor the status of the facility during immediate recovery efforts is powered for two hours, or
4) Defense-in-depth power for nonsafety-related equipment used to monitor and reduce the tritium source term in the tritium confinement is powered for six hours.

The UPSS is designed and tested to be resistant to the electromagnetic interference (EMI)/radio frequency interference (RFI) environment. When equipment (e.g., portable radios) poses risks to the UPSS equipment or distribution wiring, administrative controls prevent the use of the equipment where it can adversely affect the UPSS.

Safety-related UPSS equipment is located in a mild environment, is not subject to harsh environmental conditions during normal operation or transient conditions, and has no significant aging mechanisms. This equipment is designed and qualified by applying the guidance of Sections 4.1, 5.1, 6.1, and 7 of IEEE 323 (IEEE, 2003), and is qualified to the environmental parameters provided in Tables 7.2-2 and 7.2-3.

8a2.2.4 STANDBY GENERATOR SYSTEM DESIGN BASIS

The design of the SGS is based on Criterion 27, Electrical power systems, and Criterion 28, Inspection and testing of electric power systems, of the SHINE design criteria. The SHINE design criteria are described in Section 3.1.

The purpose of the SGS is to provide a temporary source of nonsafety-related alternate power to the UPSS and selected additional loads for operational convenience and defense-in-depth.

The SGS:

- Will provide for the separation or isolation of safety-related circuits from nonsafety-related circuits, including the avoidance of electromagnetic interference with safety-related instrumentation and control functions;
- Will provide an alternate source of power for the safety-related electrical buses;
- Will provide an alternate source of power to systems required for life-safety or important for facility monitoring;
- Will automatically start and supply loads upon a loss of off-site power; and
- Permits appropriate periodic inspection and testing to assess the continuity of the system and the condition of components.

8a2.2.5 STANDBY GENERATOR SYSTEM CODES AND STANDARDS

The SGS is designed in accordance with NFPA 70 - 2017, National Electrical Code (NFPA, 2017) as adopted by the State of Wisconsin (Chapter SPS 316 of the Wisconsin Administrative Code, Electrical).

8a2.2.6 STANDBY GENERATOR SYSTEM DESCRIPTION

The SGS consists of a 480Y/277 VAC, 60 Hertz (Hz) natural gas-driven generator, a 480 VAC switchgear, and transfer switches to allow the SGS switchgear to be connected to either or both emergency 480 VAC NPSS buses. Upon a loss of off-site power (LOOP) (i.e., undervoltage or overvoltage sensed on utility service), the SGS automatically starts, both non-vital breakers (NV BKR 1 and NV BKR 2) automatically open, and the transfer switches operate to provide power to the associated emergency 480 VAC NPSS bus. Upon a loss of normal power to any transfer switch, the SGS automatically starts, the associated non-vital breaker (NV BKR 1 or NV BKR 2) automatically opens, and the associated transfer switch operates to provide power to the associated emergency 480 VAC NPSS bus.

The loads supplied by the SGS include the loads supplied by the UPSS (see Table 8a2.2-1), as well as the following facility loads:

- Emergency lighting
- Facility data and communications system (FDCS) equipment
- Radiation area monitoring system (RAMS) detectors
- Continuous air monitoring system (CAMS) detectors
- Facility fire detection and suppression system (FFPS)
- Hot cell fire detection and suppression system (HCFD)
- PICS equipment
- PVVS equipment
- TPS SEC heaters
- Switchgear station batteries (NPSS, SGS)
- Facility access control system (FACS)
- Facility ventilation zone 4 (FVZ4) UPSS battery room and equipment room exhaust fans
- FDCS dedicated cooling systems

FDCS equipment, PICS equipment, and the FFPS contain nonsafety-related unit batteries or local uninterruptible power supplies to provide power to span the time between the LOOP event and the start of the SGS.

Emergency lighting located inside the main production facility is provided with unit batteries capable of supplying 90 minutes of illumination.

Operation of the SGS is not required for any safety function at the SHINE facility.

8a2.2.7 EMERGENCY ELECTRICAL POWER SYSTEM OPERATION

Electrical loads for the main production facility, site, and support buildings are normally supplied by the NPSS, as described in Section 8a2.1. When the NPSS is in operation, it supplies power to the UPSS battery chargers, which provide power to the loads on the 125 VDC bus and to the

208Y/120 VAC loads via the UPSS inverter. The battery charger is used to keep the battery bank fully charged and maintained at float charge.

Upon a LOOP, the loads supplied via the 208Y/120 VAC and 125 VDC UPSS buses are automatically picked up by the UPSS battery banks. A single division of UPSS in operation is sufficient to ensure and maintain safe facility shutdown and prevent or mitigate the consequences of design basis events.

Additional discussion of the LOOP event is provided in Section 8a2.1. Use of the UPSS during other design basis accidents is discussed throughout Chapter 13.

Although not required by the accident analysis, the SGS is designed to automatically start and begin step loading within one minute of and complete power transfers within five minutes of the LOOP. The SGS supplies power to the UPSS buses, re-charge the UPSS batteries, supply additional loads used for life-safety or facility monitoring, and allow operational flexibility while responding to the LOOP.

After the end of transient events, loads supported by the SGS are manually transferred to normal power via an open (dead bus) transition. The SGS is then manually shutdown.

8a2.2.8 TECHNICAL SPECIFICATIONS

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

Table 8a2.2-1 – UPSS Load List
(Sheet 1 of 2)

Load Description	kVA Loads UPS-A	kVA Loads UPS-B	Required Runtime
Target solution vessel (TSV) off-gas system (TOGS)			
Blowers	75.2	75.2	5 Min
Recombiner heaters	32.8	32.8	5 Min
Nitrogen purge system (N2PS) valves	0.5	0.5	5 Min
TSV dump valves	0.4	0.4	5 Min
Neutron flux detection system (NFDS)	12.0	12.0	120 Min
TSV reactivity protection system (TRPS)	1.5	1.5	120 Min
TRPS radiation monitors	7.7	7.7	120 Min
Engineered safety features actuation system (ESFAS) radiation monitors	7.7	7.7	120 Min
Neutron driver assembly system (NDAS) hold circuits Vacuum transfer system (VTS) hold circuits Molybdenum extraction and purification system (MEPS) pump hold circuits Radiological ventilation exhaust and supply fans hold circuit	0.1	0.1	120 Min
ESFAS	0.5	0.5	6 Hrs
Tritium purification system (TPS) tritium monitors	2.4	2.4	6 Hrs
Criticality accident alarm system (CAAS), nonsafety-related	0.8	0.8	120 Min
Stack release monitoring system (SRMS), nonsafety-related	0.0	3.8	120 Min

Table 8a2.2-1 – UPSS Load List
(Sheet 2 of 2)

Load Description	kVA Loads UPS-A	kVA Loads UPS-B	Required Runtime
TPS secondary enclosure cleanup (SEC) blowers, nonsafety-related	1.6	0.8	6 Hrs
Note: Required charger kVA does not include battery charging			
Total:	**143.2**	**146.2**	
Required Reserve:	**14.3**	**14.6**	
Minimum Charger kVA:	**157.5**	**160.8**	

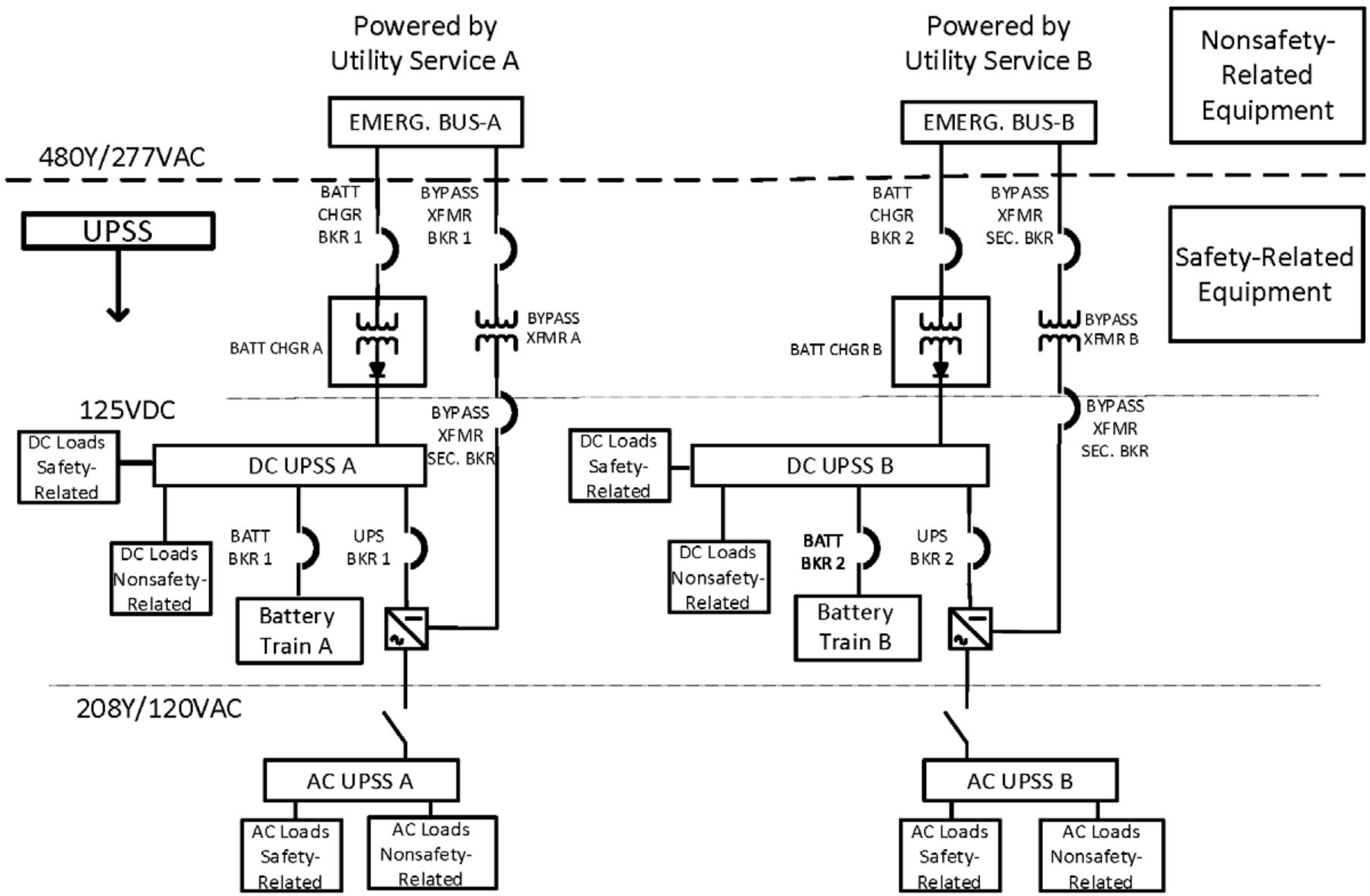
Table 8a2.2-2 – UPSS Battery Sizing
(Sheet 1 of 2)

Load Description	Amp-Hours Battery A	Amp-Hours Battery B
Target solution vessel (TSV) off-gas system (TOGS)		
Blowers	81	81
Recombiner heaters	32	32
Nitrogen purge system (N2PS) valves	1	1
TSV dump valves	1	1
Neutron flux detection system (NFDS)	310	310
TSV reactivity protection system (TRPS)	34	34
TRPS radiation monitors	198	198
Engineered safety features actuation system (ESFAS) radiation monitors	198	198
Neutron driver assembly system (NDAS) hold circuits Vacuum transfer system (VTS) hold circuits Molybdenum extraction and purification system (MEPS) pump hold circuits Radiological ventilation exhaust and supply fans hold circuit	3	3
ESFAS	34	37
Tritium purification system (TPS) tritium monitors	186	140
Criticality accident alarm system (CAAS), nonsafety-related	21	21
Stack release monitoring system (SRMS), nonsafety-related	0	99

Table 8a2.2-2 – UPSS Battery Sizing
(Sheet 2 of 2)

Load Description	Amp-Hours Battery A	Amp-Hours Battery B
TPS secondary enclosure cleanup (SEC) subsystem, nonsafety-related		
Blowers	61	61
Note: Total amp-hours include inverter efficiency		
Subtotal:	**1163**	**1218**
Subtotal with 1.25 aging factor:	**1453**	**1522**
Total with margin for future loads:	**1671**	**1751**

Figure 8a2.2-1 – Uninterruptible Power Supply System



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8b RADIOISOTOPE PRODUCTION FACILITY ELECTRICAL POWER SYSTEMS

8b.1 NORMAL ELECTRICAL POWER SYSTEMS

The SHINE facility has one common normal electrical power system. The common normal electrical power system is described in Section 8a2.1.

8b.2 EMERGENCY ELECTRICAL POWER SYSTEMS

The SHINE facility has one common emergency electrical power system. The common emergency electrical power system is described in Section 8a2.2.