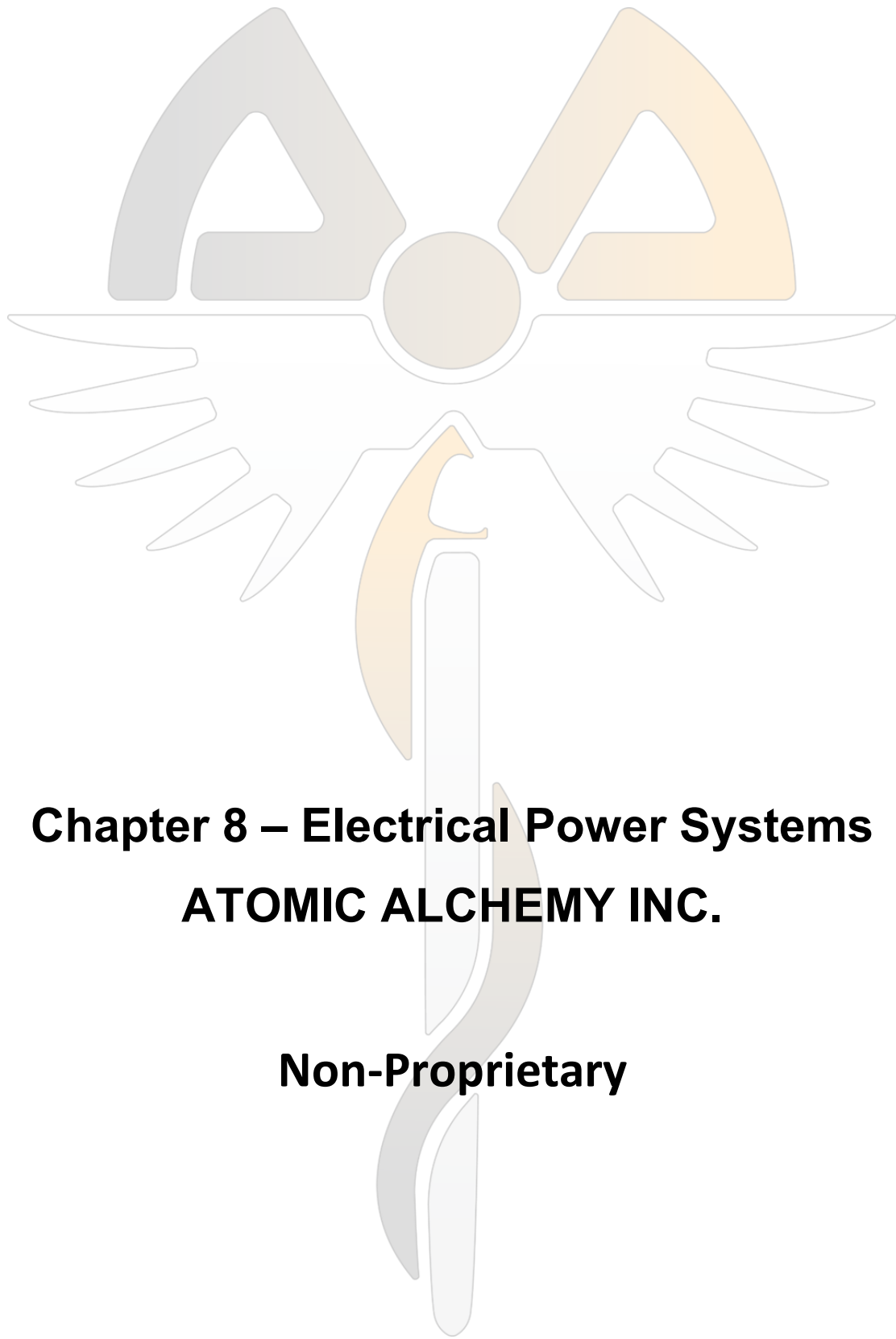




Chapter 8 – Electrical Power Systems

ATOMIC ALCHEMY INC.

Non-Proprietary

Document Number	Revision	Approved By	Template
AAI-PSAR-08 (P)	0		TEM-003 Rev 2 (05/14/25)



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-1

TABLE OF CONTENTS

Terms 8-3

Acronyms and Abbreviations.....	8-3
8 Electrical Power Systems	8-4
8.1 8-4	
8.1 Introduction	8-4
8.2 Normal Electrical Power Systems	8-4
8.2.1 Design Basis.....	8-6
8.2.2 Design for Safe Shutdown.....	8-6
8.2.3 Ranges of Electrical Power Required	8-6
8.2.3.1 Load Classification	8-6
8.2.4 Facility Substation	8-10
8.2.4.1 Shared Electrical Infrastructure.....	8-10
8.2.5 Special Processing of Electrical Service.....	8-10
8.2.6 Design and Performance Specification	8-10
8.2.6.1 Protection Against Dynamic Electrical Effects.....	8-10
8.2.7 Special Routing or Isolation	8-10
8.2.8 Deviation from National Codes.....	8-10
8.2.9 Technical Specifications	8-11
8.3 Emergency Electrical Power Systems	8-11
8.3.1 Design Basis.....	8-12
8.3.2 Ranges of Electrical Power Required	8-12
8.3.3 Power for Safety-Related Instruments	8-12
8.3.4 Power for Effluent, Process, and Area Radiation Monitors.....	8-12
8.3.5 Power for Physical Security Control, Information, and Communication Systems	8-13
8.3.6 Power to Maintain Experimental Facilities in Safe Condition	8-13
8.3.7 Power for Active Confinement/Engineered Safety Feature Equipment and Control Systems	8-13
8.3.8 Power for Coolant Pumps or Systems	8-13
8.3.9 Power for Emergency Cooling.....	8-13
8.3.10 Power for Engineered Safety Feature Equipment	8-14
8.3.11 Power for Emergency Lighting.....	8-14



CHAPTER 8

ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-2

8.3.12	Power for Instrumentation and Control Systems to Monitor Shutdown	8-14
8.3.13	Technical Specifications	8-14
8.3.14	Emergency Power Testing and Surveillance	8-14
8.4	References	8-15

LIST OF FIGURES

Figure 8-1: Offsite AC power system (Griffith 2015)	8-5
Figure 8-2: PART 1- Schematic one-line electrical diagram for the reactor confinement service	8-8
Figure 8-3: PART 2- Schematic one-line electrical diagram for the reactor confinement service	8-9

LIST OF TABLES

Table 8-1: Consolidated load and power classification	8-7
---	-----



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-3

TERMS

ACRONYMS AND ABBREVIATIONS

Common acronyms, abbreviations, and units of measurements may not be included here as it is assumed the reader is familiar with their meaning.

AAI	Atomic Alchemy Inc.
ATS	automatic transfer switch
CAS	criticality alarm system
INL	Idaho National Laboratory
MCC	motor control center
RMS	radiation monitoring system
UPS	uninterruptible power supply
VIPR	Versatile Isotope Production Reactor



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-4

8 ELECTRICAL POWER SYSTEMS

8.1 INTRODUCTION

This chapter describes the electrical power systems at the Meitner-1 facility. The electrical power systems support reactor operation. This facility does not rely on electrical power for reactor safety in any mode of operation.

8.2 NORMAL ELECTRICAL POWER SYSTEMS

The normal electrical power system is designed to provide reasonable assurance that use or malfunction of electrical power systems will not damage the facility or prevent safe reactor shutdown. In addition, the facility has a non-safety-related standby electrical power system to reduce or eliminate process downtime due to electrical outages. A combination of an uninterruptible power supply (UPS) and standby systems will provide emergency electrical power to the facility.

The normal electrical power system consists of 480 volts-alternating current offsite power service and an onsite commercial standby diesel generator. Normal power is used for normal operation and normal shutdown of the facility.

Figure 8-1 shows the offsite commercial power system that can supply normal power to Meitner-1. AAI is currently working with Idaho Power to either extend power infrastructure north toward the facility from the line south of HW 20 or east from the Antelope Substation located at the INL Central Facilities Area. The Antelope Substation is fed by a 230-287 kV line from the Western Interconnect.

AAI cannot legally utilize the DOE power infrastructure and will not be integrating into that power grid in any way.



CHAPTER 8

ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-5

[

]SEC

Figure 8-1: Offsite AC power system (Griffith 2015)



CHAPTER 8

ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-6

8.2.1 Design Basis

The normal electrical power system will be designed to provide sufficient and reliable electrical power to the reactor, supporting systems, and components requiring electrical power for normal operations.

There are no safety-related structures, systems, and components applicable to the normal electrical power system, per Chapter 13, Section 13.3.4.1, “Loss of Electrical Power” accident analysis. The normal electrical power will provide power to the active control systems through the instrumentation, monitoring, alarm, and related control systems.

8.2.2 Design for Safe Shutdown

In the event of the loss of normal electrical power, the UPS automatically provides power to the facility systems and components that support the safety functions protecting workers and the public. The following systems and components are supported with the UPS:

- Facility monitoring and control systems
- Facility communication and security systems
- Fire alarms
- Radiation monitoring system (RMS)

The UPS is designed to operate for several minutes and allow for switching over to a diesel generator. The fire protection system may have a separate UPS system.

8.2.3 Ranges of Electrical Power Required

The facility power service will be 480 V, 3-phase, 3000 amp, 60 Hz. The rough estimate of total power required for the facility will be approximately 4,052 kW. **Table 8-1** lists the loads for different locations and processes within the facility, including the load requirements of the generator backup.

8.2.3.1 Load Classification

Facility electrical loads are categorized as follows:

- Essential loads: Systems that support safety-related functions (e.g., CAS, RMS, fire alarms, key instrumentation and control (I&C) systems, emergency lighting) that are supplied via UPSs and diesel generator backup.
- Critical operational loads: Systems required to maintain production operations (e.g., HVAC, administrative systems) that are backed up by the diesel generator only.
- Nonessential loads: Office equipment, general lighting, and auxiliary support systems not required for a safe shutdown and are not backed up by emergency power.

A mapping of each load to its classification and power source is shown in **Table 8-1**.



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-7

Table 8-1: Consolidated load and power classification

Load ¹	Class	Normal Power (kW)	UPS	Diesel Power (kW)
Administrative Area (3,918 m ²)	Critical Operational	400	No	40
Facility, General ² (6,124 m ²)	Critical Operational	410	No	318
Reactor Primary Coolant Pumps	Critical Operational	480	No	-
Redundant MCC Loads (Exhaust Fans)	Critical Operational	Included	No	Supported via MCC
Equipment Area (3,542 m ²)	Critical Operational	2750	No	172
Facility Communication and Security Systems	Essential	<1	Yes	<1
Fire Alarms	Essential	<1	Yes	<1
Fire Protection System UPS	Essential	<1	Yes	<1
Instrumentation and Control	Essential	12	Yes	7
Radiation Monitoring System (RMS)	Essential	<1	Yes	<1
Auxiliary Support Systems	Nonessential	-	No	No
General Lighting	Nonessential	-	No	No
Office Equipment	Nonessential	-	No	No

¹Bounding values for a four-reactor facility.

²Source: U.S. EIA 2018. Electricity consumption by building activity in kWh/ft².



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-8

[

] PROP, ECI

Figure 8-2: PART 1- Schematic one-line electrical diagram for the reactor confinement service



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-9

[

]PROP,ECI

Figure 8-3: PART 2- Schematic one-line electrical diagram for the reactor confinement service



CHAPTER 8

ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-10

8.2.4 Facility Substation

The offsite electrical system and its relation to the Antelope/Scoville substation is described in Section 8.2 above. The use of a shared substation does not affect the ability to achieve safe shutdown of the Versatile Isotope Production Reactor (VIPR).

8.2.4.1 Shared Electrical Infrastructure

All facility-critical and essential systems are electrically and functionally isolated. Protective relays, automatic transfer switching, and local standby systems ensure that failures or interruptions in the shared infrastructure will not compromise the ability to maintain safe shutdown or perform essential functions.

Design segmentation and system autonomy are consistent with the single-failure criterion and align with the operational independence required by NUREG-1537.

8.2.5 Special Processing of Electrical Service

Details on special processing of the electrical service, such as isolation, transformers, noise limiters, lightning arresters, or constant voltage transformers, will be provided in the FSAR.

8.2.6 Design and Performance Specification

Design and performance specifications of principal and non-standard components will be provided in the FSAR.

8.2.6.1 Protection Against Dynamic Electrical Effects

The electrical power system is designed to prevent failure propagation due to dynamic electrical effects such as transient overvoltages, short circuits, and fault currents. Surge arresters, overcurrent protection devices, and coordinated relays are implemented to ensure local fault isolation and minimize impact to critical systems.

These designs ensure resilience against abnormal electrical conditions and alignment with best practices in system protection and coordination.

8.2.7 Special Routing or Isolation

Electrical circuits serving the UPS, standby, and normal power systems are separated physically and electrically to prevent common mode failure. Isolation is achieved using dedicated conduit systems, physical separation in cable trays, color-coded wiring and labeling, and isolation barriers in motor control centers (MCCs) and switchboards where applicable.

8.2.8 Deviation from National Codes

No deviations from national codes are anticipated. The electrical system will be designed to meet all required national codes and standards, as applicable. Compliance will be confirmed via design verification and system testing documented in the FSAR.



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-11

8.2.9 Technical Specifications

As evaluated in Chapter 13, the VIPR is designed to safely shut down without normal electrical power for occupational safety and for protection of the public and environment. The normal electrical power system will not require a technical specification.

8.3 EMERGENCY ELECTRICAL POWER SYSTEMS

Emergency electrical power is defined by NUREG-1537 as any temporary substitute for normal electrical service. A combination of the UPS and the standby diesel generator will provide emergency electrical power to the facility. An 800 kW (1,073 hp) diesel generator will provide standby emergency power.

Power from this generator will service the facility through an automatic transfer switch (ATS). The normal power side of the ATS will be connected to the service entrance switchgear, with the load side of the ATS connected to the standby switchboard. The standby emergency power system is designed to provide defense-in-depth by maintaining instrumentation, control, radiation monitoring, communications, and selected auxiliary systems during a loss of normal power. These functions enhance protection of workers, the public, and the environment, but are not credited safety functions required for safe shutdown or confinement. A figure will be provided in the FSAR to detail the electrical distribution topology for the standby emergency power system.

The standby emergency power system will include overcurrent protective devices, surge arresters, fusing, relays, and similar protective devices. These devices will conform to the requirements of relevant Institute of Electrical and Electronics Engineers (IEEE) and National Fire Protection Association (NFPA) standards and recommendations and local codes.

Relevant codes and standards will be applied to ensure the physical and electrical separation of safety-related I&C circuits from potential sources of electromagnetic interference, including adjacent power circuits. This separation will be maintained during both normal and emergency operating conditions, accounting for the distribution topology introduced by the automatic transfer switch (ATS) and associated power routing. This approach helps preserve the integrity of safety functions under all power system configurations.

Standby emergency power will be available to the exhaust system through a redundant electrical distribution topology. Approximately half of the exhaust electrical load requiring standby will be connected to an MCC, with the other half connected to a redundant MCC.

The standby switchboard will service equipment and devices in the hot cell, control room, exhaust system, ventilation system, and other loads requiring standby power. Feeders, busing, overcurrent protection, devices, and equipment will provide the conveyance and conductor protection throughout the building.

During normal operations, loads connected to the standby switchboard will be serviced through the ATS with normal and facility electric power. Any malfunctions of the standby emergency power system during facility operation with normal electrical power will not interfere with normal facility operations or prevent safe facility shutdown. When the ATS senses a loss of normal power, the switch will signal the on-site diesel generator to start up. When the diesel generator voltage and frequency are within



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-12

acceptable limits, the ATS will switch from the normal power source to the diesel generator power source. Loads connected to the standby switchboard will continue to be serviced by the diesel generator until the normal power source returns. The ATS will sense the normal power source voltage and frequency. Once the voltage and frequency are within acceptable limits and after a prescribed delay, the ATS will switch from the diesel generator power source to the normal power source.

A UPS bank will be provided to provide power to select loads while the diesel generator starts. The UPS system will include unit devices rack-mounted and/or larger capacity cabinet units. The facility loads requiring uninterruptable power on a short-term basis will be backed up by the on-site diesel generator to extend the duration of the UPS power available to connected loads.

The 800 kW (1,073 hp) diesel generator will be serviced with a 3,785 L (1,000 gal) diesel tank. This capacity enables the generator to operate for 12 hours without requiring additional fuel.

8.3.1 Design Basis

The facility is designed such that no active electrical power is required to achieve or maintain safe shutdown. On loss of normal power, the reactor protection system initiates a scram (control rod electromagnets fail open), control rods insert by gravity, natural circulation removes decay heat, and confinement isolation valves fail closed on de-energization. Confinement boundary integrity is therefore assured in the absence of electrical power. These passive features provide protection of workers, the public, and the environment during and following a total loss of power.

The emergency electrical power system, while not needed to ensure safe shutdown in the event of the loss of normal electrical power, is designed to provide uninterrupted power to instrumentation, control, communication systems, and devices at the levels of normal electrical power augmenting the safety functions protecting workers and the public. The system also provides standby electrical power to operate select process-related equipment to limit the impact from loss of normal electrical power on reactor and production operations.

8.3.2 Ranges of Electrical Power Required

The facility power service is 480 V, 3-phase, 2500 amp, 60 Hz. The total peak standby emergency power required for the facility is 537 kW (720 hp). **Table 8-1** lists the backup peak electrical power loads for different locations and processes within the facility.

8.3.3 Power for Safety-Related Instruments

A UPS will provide power to safety-related instruments while the diesel generator starts and will provide service loads requiring uninterruptable power on a short-term basis. The diesel generator will maintain power until the normal power system is operating within acceptable limits. The reactor can still safely shut down and maintain a shutdown state without the UPS or diesel generator.

8.3.4 Power for Effluent, Process, and Area Radiation Monitors

Effluent, process, and area radiation monitors will be provided with the UPS. The UPS will provide service loads requiring uninterruptable power. The diesel generator auto-starts and assumes the load within several seconds; the UPS bridges the transfer and remains online thereafter. The diesel



CHAPTER 8

ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-13

generator will continue to maintain power until the normal power system is operating within acceptable limits.

8.3.5 Power for Physical Security Control, Information, and Communication Systems

Physical security control, information, and communication systems will be provided with UPS. The UPS provides service loads requiring uninterruptable power, while the diesel generator will maintain power until the normal power system is operating within acceptable limits. In practice, the UPS bridges the brief transfer to the emergency diesel generator, which provides the long-term source of power. In the unlikely event of concurrent UPS and generator failure, safe shutdown and confinement remain unaffected because these functions are passive, and physical security is further ensured by design features and response measures described in the Physical Security Plan.

8.3.6 Power to Maintain Experimental Facilities in Safe Condition

There are no experimental facilities or equipment which require electrical power for safe operation, safe shutdown, or maintaining safe shutdown.

8.3.7 Power for Active Confinement/Engineered Safety Feature Equipment and Control Systems

Based on the analysis in Chapter 13, the confinement ensures the confinement of hazardous materials during normal and abnormal conditions including natural phenomena, fires, and explosions. After a loss of normal electrical power, the confinement exhaust ventilation subsystem will place itself into a passive mode. These subsystems include inlet bubble-tight isolation dampers that close to provide passive confinement.

The system will remain in this configuration until the voltage and frequency of power from the diesel generator are within acceptable limits. At that point, the system can be manually started and operated in a reduced ventilation mode with one operating group of HVAC fans and components. The confinement exhaust ventilation subsystems are designed such that, whether the system is operational or not, the confinement boundary continues to perform as described in Chapters 9 and 13, ensuring occupational safety and protection of workers, the public, and environment. Therefore, this system is not considered to be safety-related.

8.3.8 Power for Coolant Pumps or Systems

The coolant system does not require emergency electrical power. As described in Chapter 5, the coolant system does not perform a safety-related function when the reactor is in a shut-down state. Upon loss of power, the reactor automatically scrams (control rods fail safe via gravity) and natural convection removes residual decay heat from the reactor fuel without pumps.

8.3.9 Power for Emergency Cooling

As described in Chapter 5, an emergency cooling system is not required.



CHAPTER 8 ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-14

8.3.10 Power for Engineered Safety Feature Equipment

Engineered safety features that require power will be supported by the UPS. The UPS provides several minutes of backup power to maintain essential service loads until the diesel generator assumes the supply of power. The diesel generator then maintains power until the normal power system is restored to acceptable operating limits. Additional details will be provided in the FSAR..

8.3.11 Power for Emergency Lighting

Emergency lighting is installed in control rooms, egress paths, confinement areas, and critical workspaces. The lights automatically activate upon loss of normal power and operate on self-contained batteries. This ensures illumination continually until the diesel generator restores power.

8.3.12 Power for Instrumentation and Control Systems to Monitor Shutdown

Emergency power for instrumentation and control systems used to monitor safe shutdown will be provided with a dedicated UPS. The UPS will provide service loads requiring uninterruptable power and will bridge the transfer to the diesel generator. The diesel generator will maintain power until the normal power system is operating within acceptable limits, with on-site fuel to support continuous operation for 24 hours. Because safe shutdown and confinement are achieved by passive means without reliance on electrical power, continued monitoring beyond the UPS autonomy is not required for safety but is maintained by the diesel generator for defense-in-depth and operator awareness. Additional information will be provided in the FSAR.

8.3.13 Technical Specifications

As evaluated in Chapter 13, the VIPR is designed to safely shut down without emergency electrical power for occupational safety and for protection of the public and environment. The emergency electrical power system does not require a technical specification.

8.3.14 Emergency Power Testing and Surveillance

The emergency diesel generator and UPS systems will undergo routine surveillance and testing as follows:

- Diesel Generator: Monthly no-load start and annual full-load tests. Load transfer via ATS will be tested semi-annually.
- UPS: Quarterly battery health inspections and annual full discharge tests.
- ATS Functionality: Verified monthly through simulated loss of normal power.

All tests will be documented and tracked under the facility's maintenance and surveillance program. Acceptance criteria will be based on manufacturer specs and IEEE/NFPA standards



CHAPTER 8

ELECTRICAL POWER SYSTEMS

AAI-PSAR-08 (NP)

Rev 0

Page 8-15

8.4 REFERENCES

American National Standards Institute (ANSI). ANSI C2-1997, "National Electrical Safety Code."

Griffith, G. and Hoiland, S. 2015. INL/EXT-15-36721, "INL Site Conditions and Properties." Idaho National Laboratory.

U.S. Energy Information Administration (U.S. EIA).2018. "Table C22. Electricity consumption totals and conditional intensities by building activity subcategories." Survey Data.