CHAPTER 8

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CHAPTER 8

ELECTRIC POWER

8.1 INTRODUCTION

The electrical power systems include the equipment and systems necessary to generate power and deliver that power to the high voltage switchyard for further distribution throughout the power distribution system. The systems also include facilities for providing power for operation and control of all Beaver Valley Power Station - Unit 2 (BVPS-2) auxiliary electrical equipment and instrumentation during normal operation and for the protection system and engineered safety features (ESF) during abnormal and accident conditions.

8.1.1 Design Basis

The guidance documents listed in Table 8.1-1 were utilized in the design, construction, testing, and inspection of the electrical systems. Table 8.1-1 designates the sections of Chapter 8 which have prime relevance to the indicated document.

8.1.2 Transmission System

A diagram of the bulk power supply transmission system in the vicinity of the Beaver Valley Power Station (BVPS) is shown on Figure 8.1-1. The system consists of 345 kV and 138 kV high voltage aerial distribution lines which transmit electric power between the various switching points and facilities comprising the transmission system. The system interconnections and routings are designed to provide secure and reliable power distribution for supplying the needs of customers utilizing the Central Area Power Coordination Group (CAPCO) pool.

8.1.3 Interconnection to Other Grids

The transmission system is part of the CAPCO pool which in turn is part of the National Electric Reliability Council (NERC) East Central Area Reliability Coordination Agreement Region. The system load and power generation is shared, through interconnections to neighboring utilities, to enhance the availability and reliability of the power distribution system.

Two direct tie lines are provided between the two buses of the BVPS, 345 kV switchyard, and the Bruce Mansfield Plant operated by the Pennsylvania Power Company. Two tie lines terminated in double breakers with each breaker connected to a separate 345 kV bus are provided to facilities of the Ohio Edison Company: one to the Hanna substation and one to the Sammis Power Station. Additional ties are provided through other substations in the system; to the Tidd Power Station of the Ohio Power Company in the American Electric Power

System; and to the Mitchell and Springdale Power Stations of the West Penn Power Company in the Allegheny Power System.

8.1.4 Transmission System at the Site

The interconnections between the distribution system and BVPS are shown on Figure 8.1-2. The BVPS main generator is connected through the generator isolated phase bus duct to the main 21.5 kV-345 kV step-up transformer, which is rated at 1020 MVA. This transformer feeds the two separately protected buses of the 345 kV switchyard. Each 345 kV switchyard bus is connected through a 345 kV/138 kV autotransformer to separate buses in the 138 kV switchyard. The two 138 kV buses are tied together through two series-connected 138 kV tie breakers. The combined 345 kV and 138 kV switchyards form a major bulk transmission switching point for the system. Beaver Valley Power Station - Unit 1 and BVPS-2 generators, six transmission lines, and three 345 kV/ 138kV autotransformers are connected to the 345 kV buses in the 345 kV switchyard. Seven transmission lines are connected to the 138 kV buses in the 138 kV switchyard. Reliable offsite power is available to supply BVPS-2 station service and emergency systems through two separate feeds from the 138 kV switchyard. Each 138 kV bus supplies one of the two 138 kV - 4.36 kV - 4.36 kV system station service transformers. These transformers when selected feed the major onsite divisionalized load groups described in Section 8.1.5.

8.1.5 Onsite Power Systems

The onsite electrical system consists of the emergency Class 1E system and the normal non-Class 1E system, as shown on Figure 8.3-1.

The preferred source of power for the plant auxiliaries is the main generator through two 22 kV - 4.36 kV - 4.36 kV unit station service transformers. The high voltage windings of these transformers are connected to the main generator 22 kV isolated phase bus leads. The secondary windings are connected to four separate 4.16 kV normal buses, 2A through 2D. Buses 2A and 2D in turn provide power for the two redundant 4.16 kV emergency buses 2AE and 2DF, respectively.

During plant start-up and shutdown, the 4.16 kV normal and emergency buses receive power from two 138 kV - 4.36 kV - 4.36 kV system station service transformers, described in Sections 8.1.4 and 8.3.1.1.1.

In addition to being the source of power for plant start-up or shutdown, the system station service transformers are made available, via an automatic fast bus transfer scheme, in the event of loss of the normal power source (unit station service transformers) to ensure continuous power to both the non-Class lE and Class lE systems.

During normal plant operation, either the system station service transformers, unit station service transformers, or a combination of both can be selected as the power source to the normal and emergency plant loads. In the event of loss of the selected power source, an automatic fast bus transfer to the remaining power source will occur. Knife switches in the fast bus transfer breaker closing coil circuits prevent a reverse fast bus transfer. These switches are aligned under administrative control to allow transfer in the desired direction. Regulations (10 CFR 50 Appendix A GDC 17) only require immediate ("within a few seconds") access to offsite power in the event of a LOCA. Thus, the knife switches are normally aligned to allow transfer from the station service transformers to the system station service transformers regardless of the selected source.

Each emergency 4.16 kV bus (2AE and 2DF) is also provided with a diesel generator unit to supply power to the required safety-related loads in the event of loss of the normal and offsite power sources. Diesel availability is within a time consistent with the requirements of the ESF systems. With a loss of both power sources, the diesel generator units are auto-started, the emergency 4.16 kV buses are separated from their normal 4.16 kV bus power source, and the safety loads are sequenced onto the diesel generator units when the units are up to required speed and voltage. A detailed description of the onsite stand-by power supply is provided in Section 8.3.1.1.15.

All safety-related instrumentation is fed from four Class lE vital bus uninterruptible power supply (UPS) systems. Each vital bus UPS system has three separate sources of power available. The normal power source is from a 480 V motor control center (MCC) via a rectifier unit which feeds a 125 V dc to a 120 V ac inverter. Alternate power sources from a 480 V MCC through a 480 V regulator or directly from the 125 V batteries through the inverter are also available. A detailed description of the vital bus system is given in Section 8.3.1.1.17. Four separate 125 V batteries with associated charging equipment are provided for emergency circuit breaker control and as backup power supply to the vital bus UPS systems until normal power is restored or diesel generator unit supplied power is available. Two non-Class lE batteries are also provided for emergency lighting and miscellaneous services not related to the ESF. A detailed description of the dc system is given in Section 8.3.2.

8.1.6 Class lE Power System Loads

The Class lE power system supplies power to the ESF as presented in Table 8.1-2. This table includes each safety system, its function, and the type of Class lE power supply required.

Tables for Section 8.1

TABLE 8.1-1

ACCEPTANCE CRITERIA FOR ELECTRIC POWER

Criteria	Title	8.1	8.2	8.3.1	8.3.2	8.3.3	Remarks
		Applicable Sections					
1. General, Design Criteria (GDC), Appendix A to 10 CFR 50							
GDC-1	Quality Standards and Records	X	X	X	X	X	
GDC-2	Design Bases for Protection Against Natural Phenomena	X	X	X	X	X	
GDC-3	Fire Protection	X	X	X	X	X	
GDC-4	Environmental and Missile Design Bases	X	X	X	X	X	
GDC-5	Sharing of Structures , Systems, and Components	X	X	X	X	X	
GDC-16	Containment Design	X		X			
GDC-17	Electrical Power Systems	X	X	X	X	X	
GDC-18	Inspection and Testing of Electrical Power Systems	X	X	X	X	X	
GDC-50	Containment Design Basis	X		X	X		
GDC-52	Capability for Containment Leakage Rate Testing	X		X			
GDC-53	Provisions for Containment Testing and Inspection	X		X			
2. Institute of Electrical and Electronics Engineers (IEEE) Standards:							
IEEE Std 279-1971	Criteria for Protection Systems for Nuclear Power Generating Stations	X		X	X	X	Refer to 10 CFR 50.55a (h) and Reg. Guide 1.62
IEEE Std 308-1971	Standard Criteria for Class 1E Systems for Nuclear Power Generating Systems	X		X			See Note 3
IEEE Std 308-1974	Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations	X	X	X	X	X	Refer to Reg. Guide 1.32
IEEE Std 317-1976	Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations	X		X	X	X	Refer to Reg. Guide 1.63
IEEE Std 323-1971	Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations	X		X	X	X	Refer to Reg. Guide 1.89

TABLE 8.1-1 (Cont)

Criteria	Title	8.1	8.2	8.3.1	8.3.2	8.3.3	Remarks
		Applicable Sections					
IEEE Std 323-1974	Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations	X		X	X	X	
IEEE Std 334-1974	Standard for Type Tests of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations	X		X	X		Refer to Section 3.11
IEEE Std 336-1971	Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations	X	X	X	X		Refer to Reg. Guide 1.30
IEEE Std 338-1977	Trial-Use Criteria for the Periodic Testing of Nuclear Power Generating Station Class 1E Power and Protection Systems	X		X	X	X	
IEEE Std 344-1971	Recommended Practices for Seismic Qualification for Class 1E Equipment for Nuclear Power Generating Stations	X		X	X	X	Refer to Reg. Guide 1.100
IEEE Std 344-1975	Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations	X		X	X	X	Refer to Section 3.10B for clarification of dates (applicability of 1971 vs 1975)
IEEE Std 379-1972	Application of the Single Failure Criterion to Nuclear Power Generating Station Class 1E Systems	X		X	X	X	Refer to Reg. Guide 1.53
IEEE Std 379-1977	Standard Application of the Single Failure Criteria to Nuclear Power Generating Stations - Class 1E Systems	X		X	X		
IEEE Std 382-1972 (ANSI N41.6)	Trial-Use Guide for Type Test of Class I Electrical Valve Operators for Nuclear Power Generating Stations	X		X			Refer to Reg. Guide 1.73

TABLE 8.1-1 (Cont)

Criteria	Title	8.1	8.2	8.3.1	8.3.2	8.3.3	Remarks
		Applicable Sections					
IEEE Std 383-1974 (ANSI N41.10-1975)	Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations	X		X	X	X	Refer to Reg. Guide 1.131
IEEE Std 384-1974 (ANSI N41.14)	Trial-Use Standard Criteria for Separation of Class 1E Equipment and Circuits	X		X	X	X	Refer to Reg. Guide 1.75
IEEE Std 387-1972	Trial-Use Standard Criteria for Diesel-Generator Units, Applied as Standby Power Supplies for Nuclear Power Generating Stations	X		X			See Note 2
IEEE Std 387-1977 (ANSI N41.13)	Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Stations	X		X			Refer to Reg. Guide 1.108
IEEE Std 450-1975	Recommend Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations	X			X		Preoperational testing of the class 1E DC Power System conforms to guidelines of IEEE 450-1975. Refer to Reg. Guide 1.29
IEEE Std 450-1980	Recommended Practice for Maintenance Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations	X		X			Periodic testing conforms to the guidelines of IEEE 450-1980
IEEE Std 484-1975	Recommended Practice for Installation Design and Installation of Large Storage Batteries for Generating Stations and Substations						Refer to Reg. Guide 1.28
IEEE Std 485-1978	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations	X			X		
IEEE Std 535-1979	Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations	X			X		

TABLE 8.1-1 (Cont)

Criteria	Title	8.1	8.2	8.3.1	8.3.2	8.3.3	Remarks
		Applicable Sections					
IEEE Std 622-1979 Supplemented by Std 622A-1984	Recommended Practice for Design and Installation of Electric Pipe Heating Systems for Nuclear Power Generating Station	X		X			
IEEE Std 634-1978	Standard Cable Penetration Fire Stop Qualification Test	X				X	
IEEE Std 650-1979	Qualification of Class 1E Battery Chargers and Inverters	X		X			
3. Regulatory Guide (RG)							
RG 1.6-March 1971	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems	X		X	X	X	
RG 1.9-1971 (Safety Guide 9)	Selection of Diesel Generator Set Capacity for Standby Power Supplies	X		X			See Note 2
RG 1.9-Dec. 1979	Selection of Diesel Generator Set Capacity for Standby Power Supplies	X		X			
RG 1.22-Feb. 1972	Periodic Testing of Protection System Actuation Functions	X	X	X	X	X	
RG 1.29-Sept. 1978	Seismic Design Classification	X		X	X	X	
RG 1.30-Aug. 1972	Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment	X	X	X	X	X	
RG 1.32-1972 (Safety Guide 32)	Use of IEEE Std 308-1971, “Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations”	X		X			See Note 3
RG 1.32-Feb. 1977	Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants	X	X	X	X	X	
RG 1.41-March 1973	Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments	X		X	X		
RG 1.47-May 1973	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems	X	X	X	X		

TABLE 8.1-1 (Cont)

Criteria	Title	8.1	8.2	8.3.1	8.3.2	8.3.3	Remarks
		Applicable Sections					
RG 1.53-June 1973	Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems	X		X	X		
RG 1.62-Oct. 1973	Manual Initiation of Protective Actions	X		X	X	X	
RG 1.63-Jul. 1978	Electric Penetration Assemblies in Containment Structures for Water-Cooled Nuclear Power Reactors	X		X	X		
RG 1.73-Jan. 1974	Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants	X		X			
RG 1.75-Sept 1978	Physical Independence of Electric Systems	X		X	X	X	
RG 1.81-Jan. 1975	Shared Emergency and Shutdown Electric System for Multi-Unit Nuclear Power Plants	X		X	X	X	
RG 1.89-Nov. 1974	Qualification of Class 1E Equipment for Nuclear Power Plants	X		X	X	X	
RG 1.93-Dec. 1974	Availability of Electric Power Sources	X	X	X	X		
RG 1.100-Aug. 1977	Seismic Qualification of Electric Equipment for Nuclear Power Plants	X		X	X	X	
RG 1.106-March 1977	Thermal Overload Protection for Electric Motors on Motor Operated Valves	X		X			
RG 1.108-Aug. 1977	Periodic Testing of Diesel Generators Used as Onsite Electric Power Plants	X		X			
RG 1.118-June 1978	Periodic Testing of Electric Power and Protection Systems	X		X	X		
RG 1.128-Oct. 1978	Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants	X			X		
RG 1.129-Feb. 1978	Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants	X			X		

TABLE 8.1-1 (Cont)

Criteria	Title	Applicable Sections 8.1	8.2	8.3.1	8.3.2	8.3.3	Remarks
RG 1.131-Aug. 1979	Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants	X				X	
4. Branch Technical Positions (BTP) ICSB							
BTP ICSB 4	Requirements on Motor Operated Valves in the ECCS Accumulator Lines			X			
BTP ICSB 6	Capacity Test Requirement of Station Batteries	X			X		
BTP ICSB 7	Shared Onsite Emergency Electrical Power Systems for Multi-Unit Generating Stations	X		X	X		
BTP ICSB 8	Use of Diesel Generator Sets for Peaking	X		X			
BTP ICSB 10	Electrical and Mechanical Equipment Seismic Test Qualification Program	X		X	X	X	
BTP ICSB 11	Stability of Offsite Power Systems	X	X				
BTP ICSB 18	Application of the Single Failure Criterion to Manually Controlled Electrically-Operated Valves	X		X			
BTP ICSB 21	Guidance for Application of Reg. Guide 1.47	X		X	X		
BTP ICSB 27	Design Criteria for Thermal Overload Protection for Motors of Motor Operated Valves	X		X			Refer to Reg. Guide 1.106
BTP PSB-1	Adequacy of Station Electric Distribution System Voltages			X			
BTP PSB-2	Criteria for Alarms and Indications Associated with Diesel, Generator Unit Bypassed and Inoperable Status			X			
5. NUREG Reports NUREG/CR 0660	Enhancement of Onsite Diesel Generator reliability			X			

TABLE 8.1-1 (Cont)

NOTES:

1. The offsite power system is not a Class 1E system and is designed as a normal system based on good engineering practice and experience. The intent is to consider, where applicable to non-class 1E systems, the General Design Criteria, IEEE Standards, Regulatory Guides, and Branch Technical Positions as indicated.

2. The emergency diesel generator units, used as Class 1E standby power supply were procured in accordance with Regulatory Guide 1.9, Rev. 0 (1971) and IEEE Standard 387-1972, which were applicable at the time of procurement. However, the emergency diesel generators are in compliance with Regulatory Guide 1.9, Rev. 2 (1979) and IEEE STD 387-1977 with clarifications as explained in Table 1.8-1.

3. The emergency diesel generator units, used as Class 1E standby power supplies were procured in accordance with Regulatory Guide 1.32, Rev. 0 (1972) and IEEE Standard 308-1971. Since the applicable sections of IEEE Std-308-1971 and IEEE 308-1974, dealing with diesel generators, are identical, the emergency diesel generators follow the guidance of IEEE STD 308-1974 and Regulatory Guide 1.32, Rev. 2 (1977) with clarifications as explained in Table 1.8-1.

TABLE 8.1-2

SAFETY SYSTEMS IDENTIFICATION AND FUNCTION

Safety Load	Function
1. The following systems are powered from Class 1E ac sources:	
High head safety injection system	Emergency core cooling
Low head safety injection system	Emergency core cooling
Residual heat removal system	Normal core cooling
Containment spray systems	Emergency containment cooling
Primary component cooling water system	Provides cooling water for ESFsystem and RHRS
Service water system	Provides cooling of primary Component cooling, emergency diesel generators, and safety-related air conditioning
Auxiliary feedwater system	Provides water to the steam Generators when main feedwateris not available
Spent fuel pool cooling System	Provides cooling for the spentfuel pool
Safety-related air conditioning and ventilation systems	Provide cooling for Class 1E Electrical areas, control areas,and ESF areas
Post-DBA hydrogen control system	Maintains hydrogen concentration within containment at safe levels following a DBA
Supplementary leak collection and release system	Collects and filters radioactive leakage from containment following a DBA to prevent release into the atmosphere. Collects and releases activity following a fuel handling accident.

TABLE 8.1-2 (Cont)

Safety Load	Function
Emergency diesel generator system	Provides fuel oil transfer capabilities
Reactor coolant system	Provides for heat transfer from core to steam generators
Containment isolation system	Isolates containment atmosphere from environment
Control rod drive mechanism (CRDM) ventilation system	Provides cooling for CRDM shroud

2. The following systems are powered from the 120 V ac instrumentation and control Class 1E uninterruptible power supply system:

Reactor protection system	Protects reactor core, monitors plant parameters, and initiates safety-related systems
Engineered safety features actuation system	Monitors plant parameters
Radiation monitoring system	Mitigates the release of radioactivity to the environment during a DBA
Post-accident monitoring system	Provides post-accident indication and recording

3. The following systems contain loads that may, by manual loading, be powered from Class 1E ac sources:

Boric acid transfer pump	Support maintenance of hot standby under a blackout event
Pressurizer back-up heaters	Support maintenance of hot standby under a blackout event
Instrument air compressors	Support maintenance of hot standby under a blackout event

TABLE 8.1-2 (Cont)

Safety Load	Function
Auxiliary building ventilation	Support maintenance of hot standby under a blackout event
Control room air conditioning	Support maintenance of hot standby under a blackout event
Diesel room ventilation	Support maintenance of hot standby under a blackout event
Fire water pumps	Support maintenance of hot standby under a blackout event

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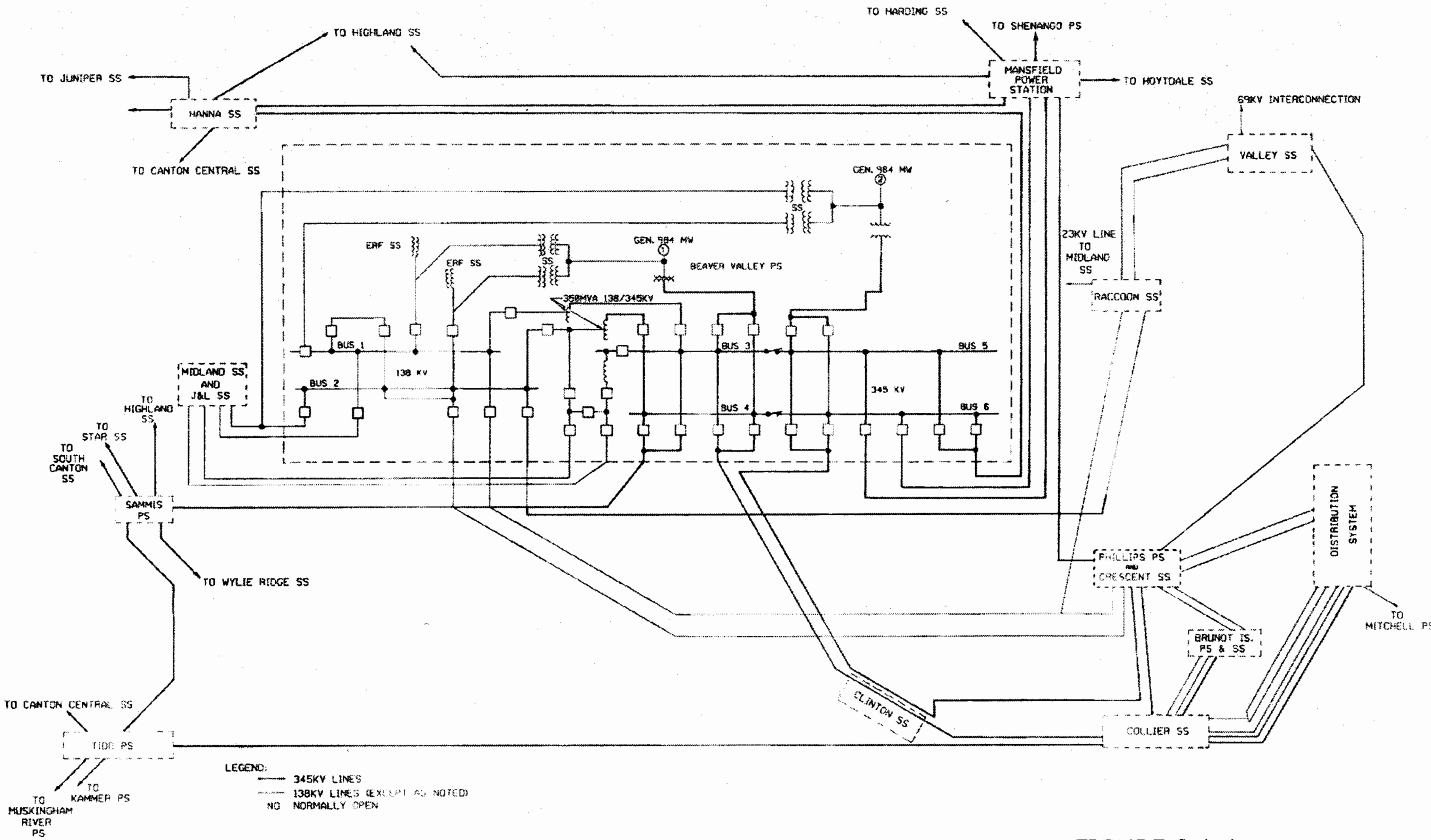


FIGURE 8.1-1

BULK POWER TRANSMISSION
SYSTEM UNIT 1 AND UNIT 2

BEAVER VALLEY POWER STATION-UNIT 2
UPDATED FINAL SAFETY ANALYSIS REPORT

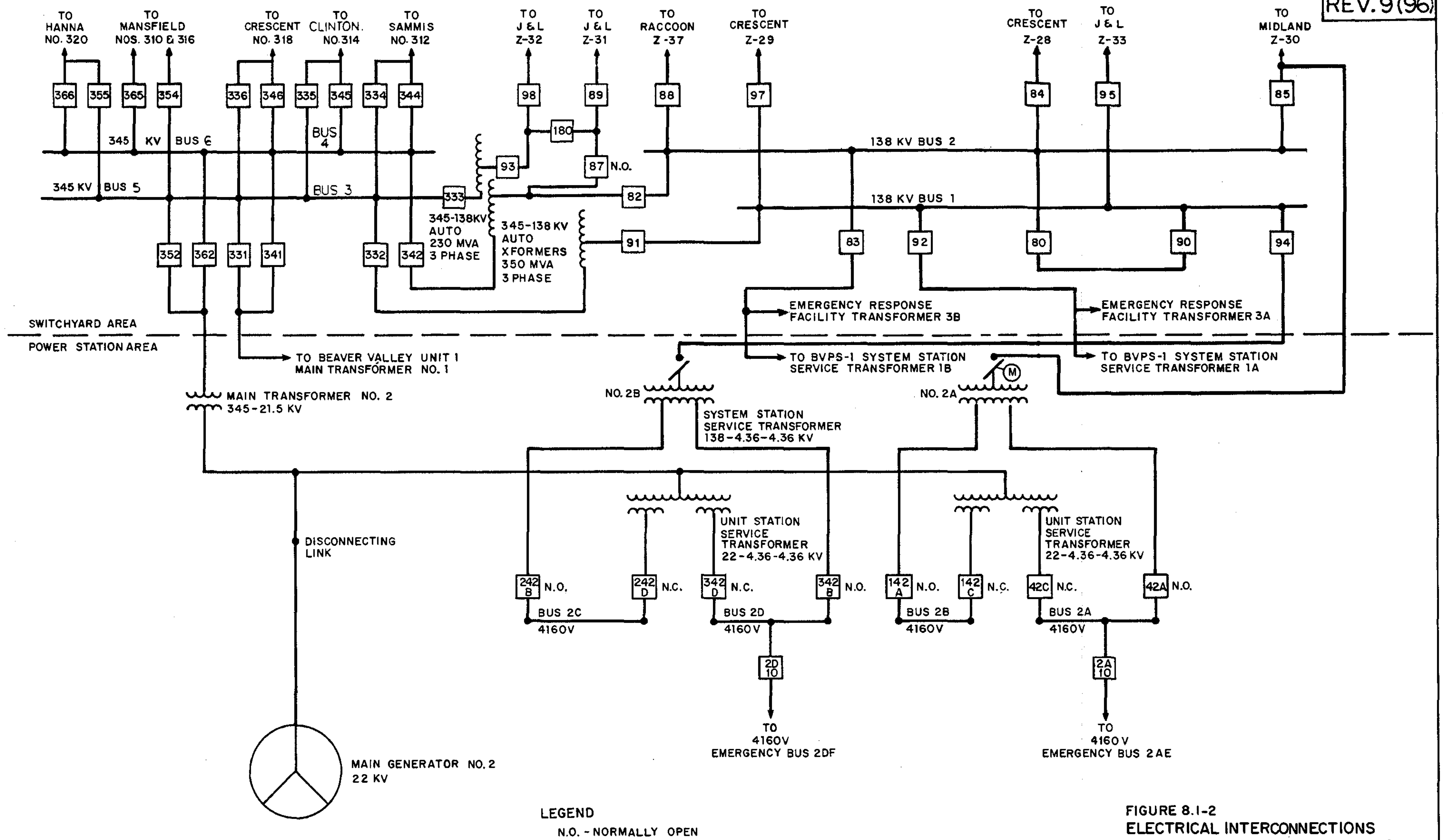


FIGURE 8.1-2
ELECTRICAL INTERCONNECTIONS
BEAVER VALLEY POWER STATION-UNIT 2
UPDATED FINAL SAFETY ANALYSIS REPORT

8.2 OFFSITE POWER SYSTEM

8.2.1 Description

The output of the main generator is fed into and operated as an integral part of the Duquesne Light Company (DLC) system. The combined 345 kV and 138 kV switchyard that serves the Beaver Valley Power Station - Unit 1 and Unit 2 (BVPS-1 and BVPS-2) forms a major bulk transmission switching point of the system. During plant operation, the BVPS-2 station service power is supplied from either the main generator, the 138 kV switchyard, or a combination of both. During plant shutdown, the BVPS-2 station service power is supplied from either the 345 kV switchyard, the 138 kV switchyard, or a combination of both. If desired, system controls can be preset so that on failure of the selected source, automatic bus transfer is provided to an alternate source to ensure continuous power to the station service buses being served. This section describes in detail the electrical system utility grid interconnections as shown on Figures 8.1-1 and 8.1-2.

8.2.1.1 Transmission Network

The 345 kV and 138 kV transmission lines shown on Figure 8.1-2 normally transmit power from Beaver Valley Power Station (BVPS). However, all transmission lines, except the J&L (Z-31, Z-32, Z-33), and the Midland (Z-30) 138 kV circuits, are capable of supplying power from remote sources to BVPS-1 and/or BVPS-2.

Six 345 kV overhead transmission lines connect to the BVPS 345 kV switchyard from the following offsite switchyards:

Beaver Valley-Hanna	Circuit No. 320	60.0 miles long
Beaver Valley-Mansfield No. 2	Circuit No. 310	1.9 miles long
Beaver Valley-Mansfield No. 1	Circuit No. 316	2.0 miles long
Beaver Valley-Crescent	Circuit No. 318	15.8 miles long
Beaver Valley-Clinton	Circuit No. 314	14.6 miles long
Beaver Valley-Sammis	Circuit No. 312	13.5 miles long

Seven 138 kV overhead transmission lines connect to the BVPS 138 kV switchyard from the following offsite switchyards:

Beaver Valley-Crescent	Circuit Z-28	11.41 miles long
Beaver Valley-Crescent	Circuit Z-29	14.76 miles long
Beaver Valley-Raccoon	Circuit Z-37	7.48 miles long
Beaver Valley-J&L	Circuit Z-31	2.56 miles long
Beaver Valley-J&L	Circuit Z-32	3.00 miles long
Beaver Valley-J&L	Circuit Z-33	3.03 miles long
Beaver Valley-Midland	Circuit Z-30	1.56 miles long

Lines converge on the switchyards by means of two or more widely separated routes. Separation of connections to the switchyard buses varies in center-to-center spacing, from more than 400 feet between the most widely separated lines to a minimum of 45 feet separation for lines terminating in adjacent bays. Both switchyards have a double bus arrangement. Buses are of a rigid type to provide maximum reliability.

8.2.1.2 345 kV Switchyard

The 345 kV switchyard at BVPS is shared by BVPS-1 and BVPS-2. Two transmission lines connect the switchyard to other switchyards in the system, and four other transmission lines provide direct ties to large neighboring power systems.

The switchyard consists of a double bus and double breaker arrangement, with each (except for the two Beaver Valley-Mansfield circuits) incoming or outgoing line connected to each main bus through a separate 345 kV power circuit breaker, and is operated with all power circuit breakers normally closed. Each 345 kV bus is connected to a 138 kV bus by circuit breakers and a 345/138 kV autotransformer. The 138 kV buses are tied together through two series-connected 138 kV tie breakers. Each bus, transformer, and transmission line connected to the buses is individually protected by two independent protective relay schemes. Additionally, breaker failure relaying is provided for each power circuit breaker to clear a faulted circuit of all sources of power in the event the primary breaker fails to operate. Transmission line and transformer breakers have separately protected dc control circuits, and each breaker is equipped with two electrically independent trip coils. The dual trip coils and their associated control circuits are powered by separate 125 V dc control storage batteries.

8.2.1.3 138 kV Switchyard

Seven transmission lines and station service transformers connect to the 138 kV switchyard at BVPS. The transmission lines connect the switchyard to other switchyards in the system. The 138 kV switchyard is connected to the 345 kV switchyard by three electrically and physically separated feeders through three bus tie autotransformers, as shown on Figure 8.1-2. Two of these autotransformers provide a bus tie between the 345 kV bus 3 and the 138 kV bus 1 and between the 345 kV bus 4 and the 138 kV bus 2. The third autotransformer connects the 345 kV bus 3 to 138 kV breakers in the switchyard which feed the J&L Midland Arc Furnace Substation.

The 138 kV switchyard has a double bus arrangement and is operated with all breakers normally closed. Each bus, transformer, and transmission line connected to the buses is individually protected by two independent protective relay schemes. Additionally, breaker failure protection is provided for each power circuit breaker to clear a faulted circuit of all sources of power in the event the primary breaker fails to operate. Transmission line and transformer breakers have separately protected dc control circuits, and each breaker is equipped with two electrically independent trip coils.

Direct current for operation of the dual trip coils, and their associated control circuitry, is obtained from separate 125 V dc control storage batteries.

Since offsite power is supplied to the two independent, redundant onsite power systems by two BVPS-2 system station service transformers, each powered from a different bus of the 138 kV switchyard, reliable offsite power is available to supply BVPS-2 station service and emergency systems. The 138 kV connections between the switchyard buses and the station service transformers are made with overhead lines, with separate towers for each line. The towers for each line are separated such that failure of one tower will not jeopardize the availability of the redundant circuit. Even with the loss of all but one source of power to the switchyard, sufficient power capacity will still be available for emergency systems.

The system station service transformers TR-2A and TR-2B, which are supplied by the 138 kV offsite power feeds are non-Class 1E transformers that supply offsite (preferred) power to the Non-Class 1E 4, 160 v buses. The automatic load tap changing capability of these transformers optimizes downstream voltage at Class 1E 4, 160 v buses (2AE and 2DF) when electrically connected to the upstream non-Class 1E buses as described in Section 8.3.1.1.

8.2.1.4 Compliance with Design Criteria and Standards

8.2.1.4.1 Compliance with General Design Criterion 5

Offsite power requirements are supplied by two overhead transmission lines from the 138 kV switchyard. These two circuits are independent and separate from the transmission lines which supply power to BVPS-1. Each offsite power source is capable of powering the engineered safety features (ESF) equipment required for a design basis accident and systems required for an orderly shutdown and cooldown. This complies with General Design Criterion (GDC) 5.

8.2.1.4.2 Compliance with General Design Criterion 17

Two separate, independent circuits are provided between the 138 kV switchyard and the onsite electric distribution system. The circuits are designed and located so as to minimize the likelihood of their simultaneous failure. Each of the circuits is provided with an independent 138 kV bus, transmission path, and system station service transformer, and supplies one of the two independent redundant load groups of the onsite Class 1E power distribution system. This is in accordance with GDC 17.

8.2.1.4.3 Compliance with General Design Criterion 18

The offsite power system circuitry is designed to permit periodic testing of operability and functional performance of power supplies, relays, and switches, as described in Section 8.2.1.5, and meets the requirements of GDC 18.

8.2.1.4.4 Compliance with IEEE Standard 308-1974 and Regulatory Guide 1.32

The offsite power system, described previously, meets the requirements of IEEE Standard 308-1974, which stipulates that each redundant load group have access to a preferred power source consisting of one or more power sources. Furthermore, the design conforms to the preferred design provisions outlined in Regulatory Guide 1.32 in that these circuits are operated with the 138 kV circuit breakers normally closed to provide immediate availability of this source in the event of a loss of onsite power.

8.2.1.4.5 Compliance with Regulatory Guide 1.47

The surveillance of the offsite power system is in accordance with Regulatory Guide 1.47 in that monitoring is provided to indicate the availability of the preferred power source as follows:

1. 138 kV breaker open (annunciated and monitored by the plant computer), and

2. 138 kV bus voltage level.

8.2.1.4.6 Compliance with Regulatory Guide 1.81

Compliance with Regulatory Guide 1.81 is discussed in Section 1.8.

8.2.1.4.7 Compliance with Regulatory Guide 1.93

As described in the Technical Specifications, the power operation is initiated and continued without restriction only when the limiting conditions for operation are met. If the limiting conditions for operation are not met, then power operation is restricted, as explained by the Technical Specifications.

8.2.1.4.8 Compliance with Branch Technical Position ICSB 11 (PSB)

Studies have shown that loss of the largest operating unit of the grid will not result in loss of grid stability and availability of offsite power. Section 8.2.2.2 provides the results of studies performed to demonstrate stability for BVPS-2 for the most severe case. This is, therefore, in compliance with Branch Technical Position ICSB 11 (PSB), Stability of Offsite Power Systems.

8.2.1.5 Tests and Inspections

The DLC Procedures and Routine Manual program for testing and inspection of the electrical equipment installation associated with the offsite power meets the intent of GDC 18. These procedures cover periodic testing of protective relays, instrument transformers, power transformers, circuit breakers, and various operating checks to ensure the operability and functional performance of the components of the system. Transfer of power to the onsite distribution system from the main generator or offsite power system meets the requirements of GDC 18.

Each of the four nonsafety-related 4,160 V buses has two input supply breakers, one fed from the unit station service transformer, the other fed from the system station service transformer. The control circuits for these two supply breakers are interlocked via breaker auxiliary contacts.

The opening of one supply breaker will automatically cause the closing of the other supply breaker. The closing will, however, be blocked by any of the following:

1. Overcurrent trip of the closed breaker,

2. Manual trip of the closed breaker, or

3. Loss of voltage at the input of the open breaker.

Automatic transfer will be alarmed in the main control room.

The transfer may also be accomplished by operator actuation of a test switch on the switchgear. Each of the four buses has two test switches to initiate transfer in each direction. Each 4,160 V bus can be independently transferred. The test switches do not have the capability of overriding the previously stated blocking conditions.

At no time during automatic initiated transfer will both supply breakers be closed simultaneously.

Plant operators will have the capability of deliberately causing both breakers to be simultaneously closed, thereby paralleling the power supplies. Synchronizing checks built into the control circuits will block a paralleling operation if power supplies are not in sync. A forced paralleling of supplies will be alarmed in the main control room.

Since the design of the transfer test switches causes a trip of the closed breaker and the subsequent operation of the normal transfer circuitry, this system tests actual operation and is in full compliance with GDC 18.

8.2.1.6 Systems Operability Surveillance

Surveillance information for the preferred power supply system is displayed in the main control room, is annunciated, and is monitored by the plant computer. The following information is available, as a minimum, to both the main control room annunciators and the plant computer:

1. Main transformer sudden pressure,
2. Main transformer high winding temperature,
3. Main transformer oil trouble,
4. Generator trip,
5. Unit station transformer and system station transformer over excitation,
6. Unit station transformer and system station transformer cooler power,
7. Unit station transformer and system station transformer trouble,
8. Unit station transformer and system station transformer oil trouble,
9. Unit station transformer and system station transformer over temperature,
10. Unit station transformer and system station transformer overcurrent, and
11. Emergency bus overcurrent trip.

The computer also monitors the status of the 4,160 volt bus supply breakers.

8.2.2 Analysis

8.2.2.1 Availability Considerations

The offsite power systems are designed with sufficient independence, capacity, and capability to meet the requirements of GDC 17. As required by GDC 17, the two separate 138 kV offsite power circuits between the point of connection with the power transmission system in the BVPS switchyard and the redundant safety-related distribution buses (4 kV emergency buses 2AE and 2DF) are physically routed along independent paths in order to minimize the likelihood of simultaneous failure due to a single event.

Each independent circuit is fed from a separate, rigid, 138 kV bus through independent circuit breakers, which are separated by a centerline spacing of 107 feet. These circuits are supported by separate transmission towers, which are located on centerlines of 228 feet at the switchyard. Between the switchyard and their respective system station service transformers, the two 138 kV offsite power feeds to BVPS-2 have a centerline spacing of 108 feet at their closest point. Each of these circuits from the offsite transmission network to the safety-related distribution buses has the capacity and capability to supply the assigned loads during normal and abnormal operating conditions, accident conditions, and plant shutdown conditions.

The normal source of power for the BVPS-2 auxiliaries is the main generator, through two 22 kV - 4.36 kV - 4.36 kV unit station service transformers. The high voltage windings of these transformers are connected to the main generator 22 kV output bus leads through isolated phase bus ducts. The two low voltage windings are connected to four separate 4.16 kV normal buses, two of which provide power for the two redundant 4.16 kV emergency buses.

During plant start-up and shutdown, the 4.16 kV normal and emergency buses receive power from two 138 kV - 4.36 kV - 4.36 kV system station service transformers that are fed by the two separate 138 kV offsite power circuits. In addition to being the source of power for plant start-up or shutdown, the system station service transformers are made available, via an automatic fast bus transfer scheme, in the event of loss of the normal power source (unit station service transformers) to ensure continuous power to both the Class 1E and non-Class 1E systems.

During plant shutdown, the 4.16 kV normal and emergency buses may also receive power from the unit station service transformers by backfeeding the main transformer.

During normal plant operation, either the system station service transformers, unit station service transformers, or a combination of both can be selected as the power source to the normal and emergency plant loads. In the event of loss of the selected power source, an automatic fast bus transfer to the remaining power source occurs. Measures to prevent the USST breakers from reclosing following a fast bus transfer from onsite to offsite power are discussed in Section 8.1.5.

A loss of either bus 1 or bus 2 of the 138 kV switchyard (offsite power circuits feeding system station service transformers) will reduce the station service power for BVPS-2 that is available from the switchyard to approximately one-half of full-load requirements. Without BVPS-2 station service power from the main generator and with either 138 kV bus 1 or 2 out of service, sufficient power capacity remains to provide for an orderly shutdown and to supply all ESF loads.

With the loss of all except one source of power from the power transmission system to the switchyard, sufficient power capacity required for emergency systems is available. In the unlikely event that a tornado, missile, hurricane, or severe icing should simultaneously take out all incoming transmission lines or both 138 kV switchyard buses, the unit is designed to continue in operation, supplying station service power from the main generator. In the unlikely event of simultaneous loss of offsite power and unit generator power, the buses supplying the emergency systems are automatically transferred to onsite emergency power. All indoor equipment and circuits required to ensure isolation of the onsite emergency power systems from the offsite power systems are protected by enclosures designed to withstand damage from tornadoes or missiles.

8.2.2.2 Stability Considerations

Load flow and stability studies show that a full load trip of both Beaver Valley units, or a tripping of one unit with the other unit either online or offline, or the tripping of a transmission line, will not impair the ability of the preferred source to provide power to the Class 1E systems.

Results of stability studies indicate that three-phase faults on the 345 kV and 138 kV systems will not impair the ability of the preferred source to provide power to the Class 1E system. The conditions studied include those faults which resulted in the loss of single circuits, two circuits, and complete bus sections. Both BVPS bus faults and far-end faults were considered.

For all of the tests that were run, generating units in the area were monitored for internal voltage angles, and non-faulted lines in the area were monitored for both watt and var flows. The unit angle swings, and the level of line flows indicated, preclude any hazard of additional line or unit trippings. For all cases, the BVPS units and the entire system proved stable and free of cascading.

8.2.2.3 Independence of Offsite Power Circuits Between the Switchyard and Class 1E System

The two immediate access offsite circuits being addressed originate within the 138 kV switchyard and end at the station 4,160 V ac power distribution system (refer to Figures 8.1-2 and 8.3-1 and IEEE Standard 308-1974, Figure 1). As depicted by Figure 8.1-2, and described in Section 8.1.4, the 138 kV switchyard is composed of two separate 138 kV buses, each of which provides power to one of the immediate access circuits (one circuit has sufficient capacity and capability to operate as a minimum the system equipment necessary to attain the performance requirements and effect the station conditions defined in GDC 17).

The principal components composing each of these circuits include a 138 kV switchyard bus, 138 kv disconnect switches, 138 kV circuit breaker, transmission line and supporting structures, a system station service transformer, 5 kV cable bus, and 4,160 V switchgear.

The two circuits are physically separated as follows: Within the switchyard, the 138 kV buses are separated 33 feet on center, the 138 kV circuit breakers are separated by 107 feet and disconnect switches are spaced a minimum of 80 feet on center. The transmission lines are routed in opposite directions when exiting the switchyard and come within 90 feet of each other at their closest point in the vicinity of transformer 2B. Figure 8.3-13 illustrates the independent locations provided in the siting of the two system station service transformers 2A and 2B. The transmission line spacing layout was specified such that any component failure in one line would not affect the opposite circuit.

The 5 kV cable bus circuits, from the station service transformer secondaries to the 4,160 V switchgear buses located in the service building, at el 760'-6", approach the switchgear area destination from opposite directions, as follows: the circuit starting from transformer 2A is routed through the northeast corner of the turbine building directly into the southeast side of the service building and terminates at 4,160V buses 2A and 2B on the north side of the service building and switchgear.

The 5 kV cable bus circuits, originating from transformer 2B, enters the 755'-6" elevation of the cable tunnel in the northwest area of the auxiliary building, traversing this tunnel west to east, and passing through the cable vault and rod control area (at el 769'-3") and entering into the northwest side of the service building, above el 773'-6", terminating at 4,160V buses 2C and 2D.

The four 4,160 kV buses are separated at the 760'-6" elevation of the service building such that the two access circuits are within approximately 14 feet of one another.

Controls and relaying are provided for these circuits as follows: controls are provided for the 138 kV circuit breakers and the station service transformers. Protective relaying is provided for the 138 kV buses, the transmission lines, the station service transformers, and the 5 kV cable bus. To assume availability of these circuits, primary and backup trips are provided for electrical faults including separate and different dc sources for the protective functions and controls.

Separate cable routings are provided for these circuits, including the controls and protective circuits of the system station service transformers.

At the closest point, the 5 kV cable bus routed between System Station Service Transformer (SSST) 2A and 4 kV bus 2A (which may feed emergency bus 2AE), is approximately 14 feet away from the 5 kV cable bus routed between SSST 2B and 4 kV bus 2D (which may feed emergency bus 2DF).

The feeder cables which connect emergency 4kV bus *2AE with bus 2A and emergency 4 kV bus *2DF with bus 2D are routed in physically separate, dedicated conduits. All 4 kV buses are located in the service building, with 4kV buses 2A and 2D on el 760’-6", and emergency 4 kV buses *2AE and *2DF on el 730’-6". At the closest point, the conduits between 2A and *2AE are approximately 7 feet from the conduits between 2D and *2DF. Refer to attached drawing 12241-RE-42A, B, C, D which indicate cable/conduit routing between Class 1E/non-Class 1E 4 kV buses.

Separate dedicated protective relaying circuits are provided for each of the 4 kV buses. Each normal 4 kV bus main circuit breaker is provided with a separate primary and backup trip for electrical faults, with each of the trip circuits supplied from a different dc source.

Control and relay circuits for the Class 1E breakers feeding the two emergency 4 kV buses are also Class 1E circuits and are therefore independent from each other and from all other 4 kV feeder breaker control and relay circuits.

The circuit from each diesel generator (standby onsite circuit) to its Class 1E 4 kV bus is routed in separate dedicated embedded conduit. The onsite circuits are routed through the floor from the diesel generator building, el 732’-6", to the emergency switchgear rooms in the service building, elevation 730’-6". The service building is directly southwest of, and adjacent to, the diesel generator building.

All four circuits (two onsite, two offsite) which feed the 4 kV Class 1E buses are, therefore, totally independent, with each circuit routed in a dedicated conduit. The circuits from the preferred offsite supply approach the Class 1E buses from a higher elevation of the same building (service building, el 745'-6") and enter the switchgear at the top, while the circuits from the onsite supply approach the Class 1E buses from an adjacent building (diesel generator building) through the floor, and enter the switchgear at the bottom.

Each one of the circuits is also provided with a separate, independent control and relay circuit.

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

The onsite ac power systems consist of various electrical systems designed to provide reliable electrical power to Class 1E and non-Class 1E station loads.

Redundant and independent equipment within the Class 1E onsite ac power system ensure safe reactor shutdown during a safe shutdown earthquake (SSE) or design basis accident (DBA) coincident with any single failure.

The onsite emergency ac power supply (emergency diesel generator units) ensures safe plant shutdown when the preferred power source (system station service transformers) is not available. The Class 1E 120 V uninterruptible ac electric power system (UPS) feeds power to reactor protection instrumentation and control systems, and to other Class 1E components and systems essential for safe reactor operation and shutdown.

8.3.1.1 Description

8.3.1.1.1 System Structure (Network)

Beaver Valley Power Station - Unit 2 (BVPS-2) station service auxiliary power is taken from unit station service transformers TR-2C and TR-2D, or from the (preferred) system station service transformers TR-2A and TR-2B, or a combination of both unit and system transformers. During normal operation, any combination of transformers TR-2A and TC-2C with TR-2B and TR-2D may be selected for operation (Figure 8.3-1).

The unit and system station service transformers are normally rated for 19.2/25.6/32 MVA OA/FOA/FOA operation at 55°C rise, which allows for continuous full-load operation with either pair of transformers. Both unit and system station service transformers have additional continuous capacity (12 percent) at their 65°C rise rating. The electrical calculation program evaluates modifications to station loads to assure the normal and operating Engineered Safety Features (ESF) loads remain within the rating of the station service transformers.

The primary side of each of the two system station service transformers, TR-2A and TR-2B, is connected through separate breakers to separate buses in the 138 kV switchyard, as described in Section 8.2.

The primary side of each of the two unit station service transformers is connected to the main generator isolated phase bus duct at a point between the generator and the low voltage connection of the main step-up transformer.

Each station service transformer has two half-sized secondary windings. Each secondary winding is connected to one of the four 4,160 V normal buses (2A through 2D). Two of the four 4,160 V normal buses, 2A and 2D, connect with the two redundant and independent 4,160 V emergency buses, 2AE and 2DF respectively. These ties each consist of two 4,160 V circuit breakers in series.

Failure of the selected source (either the unit or system transformers) to maintain adequate voltage to any station service 4,160 normal bus will initiate an automatic fast bus transfer to the backup source (upon verification of source voltage level). This transfer ensures continuous power to all station service loads. The normal alignment of knife switches in the closing circuit and measures to prevent the USST breakers from reclosing following a fast bus transfer from onsite to offsite power are discussed in Section 8.1.5.

Each system station service transformer is specified with an automatic load tap changer (LTC) in each low voltage winding. The LTC provides voltage regulation of the connected 4,160 V buses, and will supply rated power for all tap positions (16L through 16R) with a voltage range of ±10 percent of the 4,360 V center tap. In addition, the LTC control scheme will permit parallel or independent regulation of each winding, for different station operating conditions, and will have provisions for remote-manual, local-manual, and automatic control.

Each unit station service transformer is specified with a no load tap changer on the primary winding, providing 2.5 and 5.0 percent steps above and below the 22 kV center tap.

Each 4,160 V normal bus supplies two 480 V normal station service buses through one end of the two separate, double-ended 480 V unit substations, which include 4,160-480 V dry type AA/FA 1,000/1,333 kVA transformers. Each double-ended unit substation includes a normally open 480 V bus tie breaker. In the event that the usual power source is lost, the tie breaker is closed automatically and both 480 V buses are powered from the remaining 4,160 V source. The substation 480 V bus tie breaker may be closed by procedure while trying to determine the location of bus grounds or to allow maintenance on either set of bus feeder equipment. While the buses are tied together no single failure can cause the loss of both supply sources which could ultimately tie back to the physically independent circuits between the offsite transmission network and the onsite Class 1E distribution system.

Two non-Class 1E uninterruptible 208/120 V ac power supplies are provided for non-Class 1E 120 V ac electrical loads that require reliable power sources. The system is identified as the essential bus system, which consists of these power supplies that were developed from the following major components: rectifiers, inverters, static/manual bypass switches, and alternate source voltage regulators. This is illustrated on Figure 8.3-2. Each essential bus inverter is normally supplied from the normal 480 V system via a 480 V ac to 125 V dc rectifier. Each inverter is also connected to a nonsafety-related 125 V dc station battery, which provides a secondary source of power. Automatic transfer to the secondary dc source is accomplished without voltage interruption upon loss of the primary power source. In addition, upon loss of the inverter, its connected load is automatically transferred without voltage interruption, by means of the static switch, to the alternate source line voltage regulator power supply. The operator also has the option of manually transferring selected portions of one essential bus system (computer and page-party equipment) to the other system by means of the essential bus transfer switches 5D and 6D.

The 4,160 V emergency (Class 1E) system is divided into two independent redundant buses, which are continuously supplied from the normal 4,160 V ac switchgear during start-up, normal plant operation, and shutdown. Two independent Class 1E emergency diesel generator units supply the emergency buses whenever the preferred source of power is unavailable.

Each 4,160 V emergency (Class 1E) bus supplies a 480 V Class 1E substation through a 4,160-480 V dry type AA/FA 1,500/2,000 kVA transformer.

A single, onsite nonsafety diesel generator is provided for significant but non-Class 1E ac power loads. Power is supplied to equipment whose loss could result in substantial equipment damage or extended station outage. The turbine-generator ac lube oil pump constitutes such a component. The onsite nonsafety diesel generator is shared with BVPS-1, providing a power source for similar significant, but nonsafety, electrical loads.

The Class 1E uninterruptible power system (vital bus system) supplies 120 V ac instrument, control, and power for engineered safeguards protection channels and other Class 1E 120 V ac electrical loads. The uninterruptible power system includes four single-phase inverters, as shown on Figure 8.3-3 and described in Section 8.3.1.1.17. The Class 1E components and equipment in this system are grouped to form four independent 120 V ac buses.

8.3.1.1.2 Busing Arrangements

Two independent Class 1E 4,160 V buses, Bus 2AE Train A (orange) and Bus 2DF Train B (purple), are provided to supply redundant 4 kV Class 1E loads. These safety class loads are assigned to Trains A and B so that the failure of either train will not impair a controlled safe shutdown. The bus arrangement is shown on Figure 8.3-1.

The 4,160 V emergency buses 2AE and 2DF are supplied from normal 4,160 V buses 2A and 2D, respectively, with automatic transfer to the emergency diesel generator units in the event that normal power is lost, as detailed in Sections 8.3.1.1.1 and 8.3.1.1.15. Interconnections (bus ties) between buses 2AE and 2A, and 2DF and 2D, are accomplished by using approximately 100 feet of cable in seismic-supported conduit. Each bus tie includes two 1,200 ampere, 4,160 V ac, 350 MVA air circuit breakers in series, one of which is Class 1E and one non-Class 1E. The interface of the two safety classifications is at the terminals of the Class 1E breaker. Operation of these breakers is described in Section 8.3.1.1.11.

Physical separation of the emergency buses, tie lines, and switchgear is detailed in Section 8.3.1.1.6. Each 4,160 V Class 1E bus supplies one 480 V Class 1E bus through a 1,500/2,000 kVA dry type AA/FA transformer.

There are no manual or automatic connections between redundant Class 1E buses; however, there is an administratively controlled, manually connectable but normally disconnected cross-tie provided between 4160 V normal busses 2A and 2D for Station Blackout as described in Section 8.3.1.1.19. Physical separation and electrical isolation of redundant safety class buses, including connections to redundant electrical loads, are maintained throughout all voltage levels.

8.3.1.1.3 Loads Supplied From Each Bus

The principal loads are powered from the Class 1E and non-Class 1E buses. All redundant Class 1E loads are powered from separate Class 1E buses (Figure 8.3-1).

All 4,160 V emergency loads are powered via stored energy circuit breakers that provide circuit protection by interrupting an overcurrent condition, as detailed in Section 8.3.1.1.11. Control power for each 4,160 V Class 1E breaker is supplied from the associated Class 1E 125 V dc distribution system. The 125 V dc system is detailed in Section 8.3.2. Selected Class 1E 4,160 V circuit breakers may be operated remotely from the control board in the main control room (el 735 ft-6 in, control building), or from the emergency shutdown panel in the communications room (el 707 ft-6 in, control building). In addition, selected 4,160 V Class 1E circuit breakers, associated with one safety train (Train A - orange), may be operated remotely at the alternate shutdown panel, as further described in Section 7.4. Each 4,160 V Class 1E breaker may also be operated manually at the switchgear (el 735 ft-6 in, service building). If a Class 1E 4,160 V circuit breaker that is required to operate during an SI is tripped by a protective relay, the breaker will reclose automatically only if the fault condition is cleared, the lockout relay has been manually reset, and the safety injection signal is still present. Trip signals to 4,160 V emergency loads energize an annunciator in the main control room to alert the control room operating staff.

The Class 1E 480 V system consists of two independent 480 V unit substations supplied from the 4,160 V Class 1E buses. Each substation in turn powers 480 V Class 1E motor control centers (MCCs), which are conveniently located throughout the station, qualified and protected for their environment. All the 480 V engineered safety systems are powered either directly from the 480 V unit substation or from the 480 V MCCs.

Safety class equipment supplied from the Class 1E 480 V MCCs includes the pressurizer relief block valves 2RCS*MOV 535, 536, and 537 (Table 8.3-3). Consequently, this equipment is capable of being supplied from either the offsite power source, or the emergency diesel generators when the offsite source is not available, as described in Section 8.3.1.1.2. This capability satisfies NUREG-0737 (USNRC 1980), Item 11.G.1, Positions 1 and 2, for this equipment.

The BVPS-2 design of emergency power supply for pressurized equipment complies with each of the four clarifications listed in NUREG-0737, Item II.G.1, as follows:

(1) BVPS-2 PORVs are closable and are also capable of being opened. (Refer to block valve logic diagrams, Figure 7.2-1, Sheets 17 and 18, and Section 7.6.7.3). As discussed in Section 5.4.13.1, the PORVs are not required to open in order to prevent overpressurization of the RCS, and the ability to open the PORVs is a conservative design feature to keep the primary system pressure down.

(2) The motive and control power for the PORVs and block valves are supplied from different emergency power sources as follows: Each PORV is fed from a 125 V dc Class 1E source and its associated block valve is fed from 480 V ac Class 1E source where both power sources are associated with the same train (orange or purple).

(3 PORV and PORV block valves are Class 1E equipment. Therefore, on loss of offsite power, changeover in motive and control power from offsite to emergency onsite upon loss of offsite power is automatic, not manual.

(4) PORVs and PORV block valves for BVPS-2 are solenoid-operated and motor-driven respectively and therefore, do not require instrument air for their operation.

The Class 1E instrumentation is powered from the Class 1E 120 V ac vital bus UPS buses: *2-1, *2-2, *2-3, and *2-4. These buses are detailed Section 8.3.1.1.17.

1. Non-Class 1E Systems Supplied From Class 1E Systems

Table 8.3-2 lists all non-Class 1E loads supplied from the Class 1E power system. These loads are on the Class 1E systems in order to provide them with a very reliable source of power for all plant conditions, during which these components are required to operate. These loads, with the exception of the non-Class 1E loads connected to the Class 1E 120 V ac vital buses (refer to Section 8.3.1.1.17 for a detailed description of these loads), are shunt tripped; blocked from the emergency system upon receipt of a safety signal; or are not normally energized from the Class 1E bus. Administrative procedures are used in some cases to de-energize the load. If tripped or blocked, lockout relays prevent these non-Class 1E loads from automatic reconnection to the Class 1E systems. This assures the Class 1E system is not degraded by non-Class 1E loads and is in compliance with the provisions of Regulatory Guide 1.75 (refer to Section 8.3.1.4).

The backup pressurizer heater groups A,B,D, and E (which are necessary to establish and maintain natural circulation at hot standby conditions) are assigned to the Class 1E buses, as shown in Table 8.3-2. Thus, they are capable of being supplied from either the offsite power source or the emergency power source, as described previously. This satisfies the NUREG-0737 (USNRC 1980), Item II.E.3.1, Position 1, supply requirement for these heater groups. This is also true of the associated controls for the heaters, which are powered from 125 V dc Class 1E power system described in Section 8.3.2.1.

Once an accident signal has been reset, the operator can operate selected heater backup groups by performing two operator actions from the pressurizer heater panel at the main control board. If the heaters are energized manually, they will operate continuously until turned off via "safety grade" level signals. Automatic operation by cycling on "control grade" signals is allowed only when the control switch is in AUTO-AFTER-OFF position. These control features satisfy the ability for the timely initiation and maintenance of natural circulation conditions (NUREG-0737 (USNRC 1980), Item II.E.3.1, Position 3). Either heater group set 2A and 2B or 2D and 2E may be operated; however, only one set is needed. Procedures and training are established to assure proper sequence and loading of these heaters is performed. This satisfies NUREG-0737 (USNRC 1980), Item II.E.3.1, Position 2.

Cables from safety-related buses to non-Class 1E loads are color coded similar to Class 1E circuits. These cables are identical to Class 1E cables and are treated (separation of raceways, cables, seismic designed raceways, etc.) as if they belonged to Class 1E circuits.

The pressurizer heaters are interconnected with the emergency buses via Class 1E unit substations. The latter are safety grade distribution components that are qualified to applicable industry standards and codes, as detailed in Sections 8.3.l.2 and 8.3.1.1.16. This satisfies the interface requirements for power sources, as specified in NUREG-0737 (USNRC 1980), Item II.E.3.1, Position 4.

The BVPS-2 design of the emergency power supply for pressurizer heaters complies with each of the seven clarifications listed in NUREG-0737, Item II.E.3.1, as follows:

(1) Redundant heater capacity is provided, as listed in Table 8.3-2, and shown on the one line diagram, Figure 8.3-1 Sheet 1 of 2. Per the one line diagram, each group of heaters has access to only one Class 1E division power supply.

(2) The BVPS-2 design exceeds the requirements. Only one backup heater group is required to maintain natural circulation at hot standby conditions per the NSSS supplier. However, there are two backup heater groups fed from each Class 1E division power supply which provide additional redundancy (Refer to Table 8.3-2).

(3) The BVPS-2 emergency power sources exceed the design requirements. The sum of backup pressurizer heater load required to maintain natural circulation at hot standby condition, plus the total load required for a loss-of-coolant accident, is below the continuous rating of the emergency power supplies.

(4) On loss of offsite power, all non-Class 1E loads, which include the backup pressurizer heaters, are stripped and blocked from starting, per Section 8.3.1.1.8 and above. After automatic load sequencing, the heaters can be manually connected.

(5) (a) Refer to the response to clarification (3). There is no need, at present to shed ESF loads in order to connect a backup heater group to an emergency power supply.

(b) Refer to the description of accident signal reset/backup group heater selection from main control board as described above and in Section 7.6.

(c) Refer to the response to clarification (3). Main control board instrumentation is provided to monitor the loading of the diesel generators.

(6) Components of the power and control power distribution supply equipment for the backup heaters are safety-grade, as described above.

(7) Pressurizer heaters are automatically shed from the emergency power sources upon the occurrence of a safety injection signal as stated above.

2. Heat Tracing

The majority of safety related piping and valves are located in heated areas and are therefore not subject to freezing. However, piping and in-line equipment that are subject to freezing or chemical precipitation are electrically heat traced and insulated. Any abnormal condition in the heat tracing system is indicated by a common annunciator window located in the main control room. The individual panel giving the alarm is indicated in an alarm display in the main control room, while the individual heat tracing circuits are also alarmed locally at their respective heat tracing panels.

Heat tracing circuits fed from Class 1E power supplies follow the guidance of IEEE Standard 622-1979 and its supplement Standard 622A-1984.

The portions of fluid systems that are heat traced include:

a. Condensate system - Heat tracing is provided to preclude potential freezing of piping and instrumentation associated with the 200,000 gallon demineralized water storage tank to enhance system availability during normal plant operation. The heat tracing circuits are non-redundant and powered from non-Class 1E sources.

b. Chemical and volume control system - Portions of the chemical and volume control system are heat traced to provide added assurance that precipitation of the 4 percent by weight boric acid solution does not occur in stagnant lines. Building temperatures are maintained at sufficient levels to prevent precipitation of boric acid during all modes of plant operation. In specified cases, duplicate heat tracing is provided. These circuits are non-Class 1E.

c. Quench spray system - All piping and instruments located in the yard, excluding the refueling water storage tank are provided with heat tracing to prevent freezing. Piping and equipment associated with the safety related portions of the Quench Spray System that initiate automatic actions are heat traced with circuits powered from Class 1E sources.

d. Safety injection system - The purpose of the heat tracing provided is to prevent freezing in safety injection system piping. Lines are traced with redundant heat tracing circuits. The circuits are energized from Class 1E sources. Only one circuit is energized at a time. The redundant circuits are electrically isolated from their supply to provide required independence of safety trains.

e. Containment vacuum and leakage monitoring system - A small portion of the leakage monitoring piping is heat traced to prevent condensation in the reactor containment particulate and air activity radiation monitor during normal plant operation. Heat tracing circuits are not redundant and are non-Class 1E.

f. Gaseous waste disposal system - A small portion of the gaseous waste piping is heat traced to maintain the inlet temperature to the air ejector charcoal delay beds during normal plant operation. Heat tracing circuits are non-redundant and powered from non-Class 1E sources.

g. Steam generator blowdown system - Certain piping lines associated with the steam generator blowdown cleanup system utilize heat tracing to prevent solidification of boric acid and steam generator chemicals during normal plant operation. These heat tracing circuits are non-redundant and powered from non-Class 1E sources.

h. Demineralized water and cask washdown system - Heat tracing is provided on the piping associated with the 600,000 gallon demineralized water storage tank to prevent freezing to enhance system availability during normal plant operation. These circuits are nonredundant and non-Class 1E.

i. Solid waste system - Heat tracing is used for the caustic buffering tank and piping associated with the tank to prevent the 50 percent by weight sodium hydroxide in solution from precipitating to enhance system operability during normal plant operation. The heat tracing circuits are nonredundant and powered from non-Class 1E sources.

j. Spent fuel pool cooling and cleanup system - Heat tracing is utilized to prevent freezing of the cleanup line connected to the Refueling Water Storage Tank to enhance system availability during normal plant operation.

8.3.1.1.4 Manual and Automatic Interconnection Between Class 1E Buses and Loads

The charging/high head safety injection (HHSI), service water, and primary component cooling water pumps are three each in number and motor-driven. In each group of these pumps, the third pump motor is a redundant or swing 4 kV motor which may be supplied from either 4,160 V emergency bus (2AE or 2DF). Only one connection to an emergency bus is possible, which is discussed in the following paragraphs.

Transfer of the preceding loads between the 4,160 V emergency buses is accomplished through a manual, key-interlocked transfer scheme. Each set of 4,160 V swing breakers is connected to a three-pole, double-throw manual transfer switch (two three-pole, single-throw switches bused together on the load side) which is key interlocked with the 4,160 V feeder breakers. The key interlock feature prevents a bus tie since only one switch and its associated feeder breaker can be closed at one time. The breaker which is not required to operate is locked in the racked out or disconnected position. The switches are located at el 730 ft-6 in of the service building.

One 480 V motor (containment air circulation fan) also has a third swing unit, which may be supplied from either 480 V emergency bus (2N or 2P). Transfer of the fan motor between the 480 V buses is accomplished through a manual, electrically, and key interlocked transfer scheme. Each set of 480 V supply breaker and transfer switches are electrically and key interlocked to prevent interconnection of both 480 V buses. Only one supply breaker and its associated transfer switch can be closed at one time. Physical separation of alternate feeds is accomplished by ensuring that the manual transfer switch cubicle is electrically supplied by only one of the redundant trains.

The supply fan for the "C" cubicle of the intake structure, which is associated with the swing service water pump, may be supplied from either of the two redundant Class 1E 480 V buses through 480 V ac MCC*2-E01 or MCC*2-E02. A key-interlocked manual transfer device is provided to align the supply fan and associated motor-operated dampers to the safety train which is supplying the service water pump motor.

The residual heat removal (RHR) pump suction valves 2RHS*MOV702A and 2RHS*MOV701B, associated with the RHR pumps 2RHS*P21A and 2RHS*P21B, may be supplied from either of two redundant 480 V MCCs, MCC*2-E05 or MCC*2-E06. Again, a key-interlocked manual transfer switch is provided to prevent the interconnection of these two 480 V buses. For details of this system, refer to Section 5.4.7.2.4.

The use of a third redundant or swing unit allows maintenance to be performed on the pump or motor of a Class 1E system while satisfying the single failure criterion. Selection of the operating breaker of a swing pump depends on station requirements (and proper alignment of the fluid system) and is, therefore, under administrative control.

Cables supplying swing equipment, from the transfer switch to the equipment, are routed independent of both safety trains to maintain independence of both safety trains regardless of the train to which the motor is connected. Refer to Sections 8.3.1.3 and 8.3.1.4 for a detailed description of identification and routing.

8.3.1.1.5 Interconnections Between Safety-Related and Nonsafety-Related Buses

Two interconnections between safety-related (Class 1E) and nonsafety-related buses are made at the 4,160 V level via the 4,160 V bus ties described in Sections 8.3.1.1.2 and 8.3.1.1.6. The only other interconnection made at the 4,160 V level is for the Station Blackout cross-tie described in Section 8.3.1.1.19.

There are no interconnections between safety-related (Class 1E) and nonsafety-related buses at the 480 V level.

There are no interconnections between safety-related (Class 1E) and nonsafety-related buses at the 120 V ac or 125 V dc levels.

8.3.1.1.6 Redundant Bus Separation

All Class 1E buses of all service levels are arranged such that Train A and Train B bus equipment and raceways are electrically and physically isolated from each other to satisfy the single failure criterion, as addressed by both General Design Criterion (GDC) 17 and Institute of Electrical and Electronics Engineers (IEEE) Standards 279-1971. Separation and independence of buses and related raceways, as addressed by Regulatory Guide 1.75 and IEEE Standard 384-1974, are discussed in Section 8.3.1.4.

Redundant 4,160 V metal-clad switchgear and 480 V unit substation Class 1E equipment assemblies are located in separate rooms in the Seismic Category I service building at el 730 ft-6 in. Each of the two separate rooms contains only electrical equipment, thus precluding exposure to missiles and other hazards that could be caused by equipment or component failure.

The feeder to redundant Class 1E 4,160 V buses from the non-Class 1E 4,160 V switchgear is provided by a circuit breaker which is in series with an incoming supply circuit breaker of the Class 1E 4,160 V switchgear. This assures that no single failure of the interconnecting series circuit breakers will cause paralleling of the emergency power supply with the normal system. Refer to Figure 8.3-1 for a one-line diagram depicting the electrical bus connections. Physical separation of all series-connected circuit breakers between Class 1E and non-Class 1E 4,160 V switchgear buses is maintained by locating the latter on a separate floor (el 760 ft - 6 in) in the service building.

8.3.1.1.7 Equipment Capacities

All switchgear is adequately sized and coordinated to support safe and reliable operation under all normal operating conditions and to protect the ac power distribution system under short circuit conditions.

Interrupting ratings of Class 1E switchgear, unit substations, MCCs, and ac distribution panels are as follows:

Equipment	Voltage Class	Interrupting Rating
4.16 kV switchgear	4,160 V	48,600 A
480 V unit substations	600 V	25,000-65,000 A
480 V MCC	600 V	22,000 A
120 V ac distribution panels	600 V	5,000 A

The Class 1E 480 V unit substation transformers (4,160-480 V) are rated 1,500/2,000 kVA dry type AA/FA, 80°C rise, with a nominal impedance of 8.7 percent. The aggregate demand load is determined on the basis of motor nameplate rating, pump pressure and flow conditions, or pump run out conditions.

The emergency diesel generator units are designed and manufactured so that the capacity of each diesel generator unit is sufficient to start and accelerate all connected loads to their rated condition in the specified time sequence, so that required mechanical system flows are established. Also, each diesel generator unit is capable of carrying the aggregate load required to complete the actuated safety functions. The nameplate loads are tabulated in UFSAR Table 8.3-3. The aggregate loading is maintained in the Emergency Diesel Generator loading analysis. The Emergency Diesel Generator loading analysis monitors the loading as detailed in section 8.3.1.1.15.

8.3.1.1.8 Automatic Loading and Load Shedding

In the event an undervoltage or degraded voltage condition occurs on a 4,160 V Class 1E bus, the following automatic control actions will be initiated:

1. The emergency diesel generator unit assigned to this bus will be started,

2. The bus tie to the normal 4 kV bus will be tripped, and

3. All 4 kV loads, except the connected 480 V unit substation, will be stripped from the bus.

When the emergency diesel generator attains the required speed and voltage, the diesel generator output breaker will be closed and the reconnection of loads will commence, sequentially, in specified load blocks (Table 8.3-3).

In the event a safety injection signal occurs, the diesel generator unit corresponding to the developed safety injection system train signal will automatically start and non-Class 1E loads connected to the emergency buses will be stripped and blocked from starting, with the possible exception of the standby service water pump motors. If offsite power is available and these pumps are running, they will not be tripped (Table 8.3-2). However, if offsite power is not available and these pumps are running, they will be tripped. Automatic loading or load shedding actions will occur, depending upon the status of the normal ac station service power system as follows:

1. If the normal power source (unit station service transformer) is lost (Figure 8.3-1), the entire Class 1E and non-Class 1E running station load, except the steam generator feedwater pumps, will be fast-transferred to the preferred (offsite) power source.

2. If the offsite source is not available or is lost during the safety injection signal event (the fast-transfer fails to occur and/or the offsite source is not available or the emergency bus load terminals are degraded below 90 percent of 4,160 V for a sustained period of time, Section 8.3.1.1.11.7), all bus loads are stripped and the normal bus tie opened, as described previously in automatic-control action items 1, 2, and 3, and the diesel generator (when at required voltage and speed) output breaker is closed onto the bus. The automatic control actions will be conditional upon a bus fault not existing on the bus. Two levels of undervoltage protection are provided. The first level detects the complete loss of power. The second level detects a degraded voltage condition which, if not improved within 90 seconds, initiates the control actions described previously. With bus voltage reestablished, the required safety class loads will be sequenced onto the bus (Table 8.3-3). During the automatic loading sequence of safety loads, the standby service water pumps will be blocked from starting until the automatic loading sequence is complete.

The loading sequences for the loss of offsite power (LOOP) event without a safety injection signal and a LOOP event with a safety injection signal are as indicated in Table 8.3-3.

The undervoltage relays that detect undervoltage on the emergency 4,160 V buses are located in the safety class switchgear and are described in Section 8.3.1.1.11.

8.3.1.1.9 Safety-Related Equipment Identification

Each major piece of safety-related electrical equipment has an equipment identification number. This equipment identification number identifies the assigned emergency train or channel. Refer to Section 8.3.1.3 for a description of the equipment numbering system. Cable and raceway identification are also described in Section 8.3.1.3.

8.3.1.1.10 System Instrumentation and Control

Remote monitoring of the 4,160 V Class 1E system is provided by bus voltmeters and ammeters located in the main control room. Bus voltmeters are also provided at the emergency shutdown panel (ESP).

Each 4,160 V load is provided with a local ammeter at the switchgear section and an ammeter in the main control room. A control switch for each load is mounted on the main control board. A control switch for selected 4,160 V loads is also located on the ESP.

The controls for the two Class 1E diesel generator units are located at three remote stations: the main control room, emergency shutdown panel (ESP), and the alternate shutdown panel (ASP) (orange diesel only). All controls and power supplies are fully designed and qualified to all Class 1E requirements.

These remote stations are utilized to provide localized control where required. This control is provided by means of local transfer relays operated by transfer pushbuttons, as described in Chapter 7. The ASP is used to provide alternate safe shutdown capability in the event of a single exposure fire postulated in fire areas that would disable safe shutdown cables and equipment (main control room and ESP). All control power for the ASP is fed from different Class 1E power supplies than control power to the ESP. Transfer control to the ASP (including local power supplies) electrically severs all fire-induced failed cabling end equipment and allows for safe shutdown.

Control power for Class 1E equipment is provided as follows:

Class 1E Equipment	Class 1E Control Power Source
4,160 V breaker and associated protective relaying	125 V dc system
480 V load center breakers protection relaying	125 V dc system for external relaying only. Breaker solid state protective system develops its own trip signals
480 V MCC starters	120 V ac derived from internal control transformers
Control relays, panels, and instrument racks	125 V dc and 120 V ac vital buses

8.3.1.1.11 Electrical Protection

8.3.1.1.11.1 Philosophy

The primary considerations on which this protection is based are the following:

1. A faulted piece of equipment is cleared by isolating the smallest downstream portion of the system in the minimum possible time to limit damage to equipment and stress on the remainder of the system.

2. In the event of primary protective device failure to clear a fault, a backup device operates to clear it after a suitable coordination interval. Operation of the backup device usually results in de-energizing a larger upstream portion of the system compared with the primary device.

3. Overcurrent devices provide a first line of protection, tripping at 4,160 V and lower level voltages. These protective devices are calibrated primarily for fault sensing. Overload protection is provided where possible.

4. For greater reliability, whenever time overcurrent relays are used to protect against phase faults at the incoming feeders to 4,160 V or 480 V switchgear, three single-phase relays are provided. These relays have both time delay and instantaneous trip elements, but instantaneous elements are not used in all applications.

5. All motor feeders have a single three-phase device to protect against overloads and phase faults.

6. Whenever overcurrent devices other than relays are used which require coordination with the downstream circuits, long-time and short-time elements rather than long-time and instantaneous elements are used.

7. Overcurrent relays provide ground fault protection for all 4,160 V feeders. The 480 V system is ungrounded except transformers at unit substation 480 V US-2-6 whose secondary neutral is grounded. However, provision is provided in the remaining 480 V unit substation transformers, circuit breakers, and the 480 V MCCs for future system neutral grounding.

8. Whenever protection at the 4,160 V incoming supply breaker does not protect the reactor penetration, for loads inside the containment, redundant protection is provided by additional overcurrent relays at the load circuit which trip the incoming feeder breaker after a proper coordination interval. Redundant protection for 480 V reactor penetrations is provided by an additional overcurrent trip device in series with the load circuit.

8.3.1.1.11.2 Practices

1. Incoming Supply Feeder to 4,160 V Switchgear from Station Service Transformers

   Incoming supply to each 4,160 V bus is obtained from the wye connected secondaries of the unit or system station service transformers. Each station service transformer has dual secondaries with the neutrals commoned and then resistor-grounded to provide 1,000 amperes of ground fault current for relaying purposes, and to prevent excessive overvoltages to the remainder of the system during ground faults.

   Primary fault protection for 4,160 V buses is provided by definite time overcurrent relays. In conjunction with these relays, long-time overcurrent relays are used for overload protection. Sensitive ground protection is obtained by residually connected, low burden, inverse time overcurrent static relays.

   In addition to the protection functions described previously, the incoming supply feeder is equipped with undervoltage protection, unbalance voltage protection, and synchronism check. Undervoltage or loss of supply initiates a transfer of the 4,160 V bus to the alternate power source provided there is no fault indicated on the bus and the alternate source has an adequate voltage.

   Synchronizing check will prevent paralleling on manual transfers on out-of-phase conditions.

2. Emergency 4,160 V Switchgear Bus and Tie Line

   Incoming supply to each emergency bus is obtained from the normal 4,160 V bus through a tie line. This tie line is protected by high speed differential relays, sensitive to both phase and ground faults, for fast clearance of tie line faults and isolation of emergency bus from normal bus.

   At the emergency bus end, extremely inverse time overcurrent relays and directional instantaneous relays looking towards the normal bus are provided. During the diesel generator unit exercise period, the directional instantaneous relays will isolate the emergency bus from the normal bus for a phase fault on the normal bus, after allowing sufficient time for feeder breakers to clear faults. Time overcurrent relays will provide protection against phase faults during normal supply at the emergency bus.

   Also provided is an overcurrent relay with a ground sensor at the emergency bus end to protect for a ground fault at the emergency bus during normal supply, and at the normal bus during diesel generator exercise periods.

3. 4,160 Single Motor Feeder

   a. Motors larger than 1,500 horsepower (hp) - All motors larger than 1,500 hp have differential protection provided by a three-phase percentage differential relay. Sensitive ground protection is provided by a ground sensor and an overcurrent relay.

      These motors also have overload protection provided by a three-phase solid-state relay.

      For reactor coolant pump motors, the hot loop overload relays are desensitized during cold loop conditions by a contact from a temperature detector in the cold leg of the coolant system. A three phase, long-time/inverse instantaneous overcurrent relay provides cold loop overload and locked rotor protection, in conjunction with a three-phase distance relay.

      Another three-phase, long-time overcurrent relay provides redundant electrical penetration protection for these motor feeds which trips the incoming feeder breakers if the feeder breaker fails to trip.

   b. Motors 1,500 hp and smaller - Each of these motor feeders is protected by a three-phase, long-time inverse-instantaneous overcurrent relay. The long-time element of this relay provides overload and locked rotor protection. The inverse instantaneous element protects against faults greater than asymmetrical starting and locked rotor currents.

      Ground fault protection is provided by a ground sensor and an overcurrent relay.

4. Feeder to 4,160 V Side of 4,160-480 V Unit Substation Transformers

   Each transformer feeder is protected by three single phase long-time the overcurrent relays with instantaneous elements for phase fault protection. A ground sensor current transformer (CT) with an overcurrent relay provides ground fault protection for the feeder and transformer. The transformer is delta-wye connected.

   When relays at the incoming feeder to the 4,160 V bus are insensitive to the 480 V switchgear phase faults, a backup scheme is provided. This scheme consists of a three-phase, long-time overcurrent relay and a three-phase distance relay connected across separate CTs between the 4,160 V bus and feeder breaker. The distance relay discriminates between loads and faults on both sides of the transformer, and torque controls the time overcurrent relay.

5. 4,160 V Emergency Diesel Generator Unit On Class 1E Bus

   Primary protection for internal faults in the generator is provided by a static percentage differential relay. In addition, the generator has loss-of-field, anti-motoring volts/hertz, field overcurrent, and field ground fault protection. Backup phase fault protection is provided by a scheme whereby overcurrent relays are torque-controlled externally by a distance relay. The distance relay is required to discriminate between transient currents that result from step loading of the diesel generator and fault currents which may be of the same order of magnitude. The generator can be grounded through a 2.4 ohm resistor to provide 1,000 amperes of ground fault current for relaying purposes. Backup ground protection is provided by a definite time overcurrent relay connected to a neutral CT.

6. Incoming Supply to 480 V Bus from 4,160-480 V Transformer

   The normal 480 V substations are of a double-ended configuration which consists of two buses connected through a tie breaker operated normally open. Emergency substations are of a single-ended configuration with only one bus. Each normal and emergency bus is fed from a delta-wye connected transformer. Each of these breakers has long time and short time delay elements for overload and phase-to-phase fault protection.

   Ground faults at the ungrounded 480 V systems are detected by an overvoltage relay across a wye-broken delta-connected potential transformer. Persistent undervoltage at the normal bus feeder initiates automatic throwover to the adjacent bus via the tie breaker, unless transfer is blocked by a fault detection at the bus. Ground faults at the grounded south office shops building 480 V systems are detected by the ground protection provided as an integral part of the individual breakers. The incoming supply breaker is a low voltage power circuit breaker with a long-time and short-time adjustable solid state trip device.

7. 480 V Single Motor Feeders

   Each single motor feeder has overcurrent fault protection consisting of a low voltage power circuit breaker with a long-time and instantaneous solid state trip device. This device also includes ground protection; however, this feature the 480 V ungrounded systems.

8. 480 V Motor Control Center Feeders

   Each motor control center feeder has overcurrent fault protection consisting of a low voltage power circuit breaker with a long-time and short-time adjustable solid state trip device. A ground protection feature is provided; however, it is disabled for the 480 V ungrounded systems.

9. 480 V Motor Control Centers

   The motors fed from these centers will be, with few exceptions, 50 hp or less. Single motor circuits are provided with a combination motor starter which includes three single-phase, ambient temperature-compensated overload heaters to protect for low level fault currents and motor overloads.

   Ambient temperature compensated overload heaters for motor-operated valves (MOVs) will be of a special type, designed for this application.

   The thermal overload contacts associated with motor-operated valves are wired out to an auxiliary relay which is normally energized. The auxiliary relay has normally open contacts that are wired in series with the forward and reverse overload contacts of each motor starter. For normal operation, if a thermal overload occurs, the auxiliary relay will be deenergized, opening its contacts in the starter circuit and preventing manual energization of the motor-operated valve. During an accident, an accident signal contact, which is in parallel with the thermal overload relay contacts, will allow the motor-operated valve to operate regardless of the existence of an actual thermal overload. This method fully complies with Regulatory Guide 1.106.

   Higher fault current protection is provided for these circuits by a specially designed, adjustable, magnetic, instantaneous trip air circuit breaker. Only in a special application does a single breaker and reversing starter feed several starters with individual overload heaters for the simultaneous operation of non-Class 1E turbine drain valves.

Feeders to a remote starter, a group of motors, or a group of heaters are normally protected by a thermal-magnetic, non-adjustable, molded case air circuit breaker. Special circuits for welding receptacles are protected by molded case air circuit breakers with an adjustable instantaneous trip.

8.3.1.1.11.3 Coordination Bases

The overcurrent devices are coordinated based on the guidelines outlined as follows:

1. Solid-state relay-to-relay coordination interval shall be determined by the breaker clearing time plus a safety factor. Where electro-mechanical relays are used; two additional factors must be considered: overtravel and, if the application warrants, backup relay reset time.

2. Where relays coordinate with a 480 V, solid-state long-time device, an appropriate increment of time should separate the maximum clearing time of the long-time trip of the 480 V trip device and relay curve, when plotted on log-log paper. Where solid-state relays coordinate with the short-time or instantaneous curves of the 480 V solid-state trip device, the coordinating interval should be a minimum of 24 milliseconds.

3. On the 480 V system where a solid-state trip device is coordinated with another solid-state trip device, the time current characteristics should be as close as possible, but not overlap. The upstream device must have appropriate short-time delay tripping rather than instantaneous tripping.

4. On the 480 V system where a solid-state trip device is to coordinate with a molded case thermal-magnetic breaker, or with a thermal overload relay and instantaneous breaker at an MCC, the time current characteristic bands of both devices should not overlap, if possible, and the solid-state trip device must have a short-time delay trip characteristic rather than instantaneous trip.

5. Where thermal-magnetic molded case circuit breakers in 480 V MCCs are used to feed circuits with local protection, the molded case breakers need not coordinate with the local protection.

6. The setting of the overcurrent devices, at the incoming supply to the 4,160 V buses, 480 V buses, and 480 V MCCs must not exceed the thermal limit of the containment penetration for circuits fed from these distribution centers into the containment structure.

8.3.1.1.11.4 Test Points

Each protective device is checked slightly above its pickup settings, if possible. The settings of the most commonly used overcurrent devices are verified as follows:

1. Three checkpoints, one at 1000 percent of the pickup of the time overcurrent element, one at a critical coordinating point, and a third for the instantaneous element (if enabled) at 145 percent of pickup, are provided for all 4160 V phase overcurrent relays.

2. One checkpoint at 200 percent of the relay pickup is provided for all 4160 V ground overcurrent relays.

3. Two checkpoints, between the long-time pickup and short-time pickup, provide a check for the 480 V low voltage power circuit breakers for long-time delay settings with the normal band selected.

4. Normal operating time for the short-time or instantaneous band of the 480 V low voltage power circuit breakers is checked on flat portion of the time band at a current value approximately two times the pickup setting.

5. An in-service functional testability feature is provided for all static relays.

8.3.1.1.11.5 Protection Procedures And Settings Bases of Overcurrent Devices

1. Normal (Non-Class 1E) 4,160 V Switchgear (Bus)

   The normal (non-Class 1E) 4,160 V station service power system consists of four buses. The incoming supply to each bus is obtained from the wye connected secondaries of station service transformers whose primaries are connected to either the main generator leads or to a source of offsite preferred power. Each station service transformer has dual secondaries with the neutrals commoned and grounded through a 2.4 ohm resistor to provide 1,000 amperes of ground fault current.

   Time-overcurrent relays at the incoming feeder breakers provide overload as well as phase fault protection. Three single-phase definite-time overcurrent relays provide phase fault protection and three single-phase long-time overcurrent relays provide overload protection. These relays are set to achieve overall composite characteristics so that minimum pickup is approximately equal to 1.2 x (bus demand, minus demand of the largest motor, plus starting characteristics of the largest motor). These relays back up all feeder overcurrent relays and are themselves backed up by overcurrent relay in the neutral of the station service transformers.

A directional torque-controlled instantaneous relay is connected to the current transformer located at the incoming supply and looking toward the normal bus. This relay discriminates between bus faults and incoming feeder faults. It blocks a bus transfer during a bus fault condition.

Ground protection for this bus is provided by a residually connected, low burden, inverse time overcurrent static relay. This relay backs up all the feeder breaker relays and is itself backed up by a time-overcurrent relay in the neutral of the station service transformer.

2. Emergency (Class 1E) 4,160 V Switchgear (Bus and Tie Line)

Emergency (Class 1E) 4,160 V auxiliary power system consists of two completely segregated buses. Incoming supply to each bus is obtained from the normal 4,160 V bus through a 100-foot cable tie line. Due to this cable exposure, the tie line is protected by three high-speed percentage bus differential relays. These relays are connected on the delta side of wye-delta auxiliary CTs. The relays detect both phase and ground faults, and provide fast clearance and isolation of the emergency bus from the faulted tie line. The wye-delta connection allows detection of all tie line phase and ground faults even if one phase of the differential relay fails.

The emergency bus side of this tie line is equipped with three single-phase extremely inverse time overcurrent relays, a ground relay, three single-phase instantaneous overcurrent relays with built-in timers, and two three-phase directional relays.

The extremely inverse time overcurrent relays provide overload and phase fault protection for the emergency bus during normal supply. These relays are set to coordinate with the largest feeder off this bus. The minimum pickup is approximately equal to 1.2 x (bus demand, minus demand of the largest motor, plus starting characteristics of the largest motor).

The pickup of the ground relay is chosen so that it allows third harmonic circulation during diesel generator unit exercise mode. This relay coordinates with the ground overcurrent relays at the normal bus incoming feeder breakers, the ground overcurrent relay in the diesel generator unit neutral, and provides backup protection for the ground overcurrent relays at the emergency bus feeder breakers during normal supply.

With the diesel generator unit in the exercise mode, the three-phase directional relays and instantaneous overcurrent relays with built-in timers trip the emergency bus side of the tie line for a fault occurring on the associated normal bus. One directional relay torque controls one instantaneous overcurrent relay in Phase A and one in Phase B. A second directional relay torque controls the same instantaneous overcurrent relay in Phase B and an additional one in Phase C. This arrangement permits any one relay to be removed for maintenance without degrading protection. These relays look toward the normal bus and are meant to isolate the emergency bus for any fault on the normal bus. These relays are set as follows:

a. The pickup of these relays is sensitive enough to operate for the fault current supplied from the diesel generator unit.

b. The minimum pickup is selected to be above the current contributed by the diesel generator (in exercise mode) while the largest motor at the normal bus is starting.

c. The built-in timers of these relays are set to allow the instantaneous relays at the feeders off the normal bus to operate and clear a fault on these feeder circuits.

3. Emergency Diesel Generator Unit for 4,160 V Class 1E Switchgear (Bus)

Each 4,160 V Class 1E bus has a diesel generator unit to ensure the availability of auxiliary (onsite) power during a complete blackout. The primary protection for each emergency diesel generator unit is a three-phase percentage differential relay sensitive to both phase and ground faults. The backup protection consists of two three-phase distance relays, three single-phase long-time overcurrent relays, and three three-phase instantaneous overcurrent relays with a built-in timer. The distance relay torque controls the overcurrent relays and discriminates between faults and step load currents from the diesel generator unit. Regulatory Guide 1.9 is satisfied by the use of two distance relays and connection of the overcurrent relays in a coincidence logic scheme.

Overcurrent relays are set to clear a bus fault and coordinate with the largest feeder off the emergency bus. This backup protection arrangement also has the advantage of providing a backup protection for faults that may or may not be properly cleared by the feeder breakers.

Two volts per hertz relays at the generator potential transformer trip for overexcitation conditions. When the diesel generator unit is paralleled with the normal system during the exercise mode, a damaging field overcurrent condition could exist that may not be detected by the volts per hertz relays. A field overcurrent relay provides protection against this condition. A field ground relay provides protection for a sustained ground at the generator field. Reverse power and loss of field protection for the generator are also provided during the exercise mode, but these relays, including the field overcurrent and ground relays, are disabled when the normal supply to the emergency bus is not available. The purpose of this protection method is to reduce the possibility of relay failures stopping the diesel generator unit during an emergency condition.

While in the exercise mode, the generator neutral is grounded through a 2.4 ohm resistor to limit ground fault current to approximately 25 percent of the maximum generator three-phase fault, a magnitude of 1,000 amperes. A non-safety related motor-operated disconnect switch removes this ground source from the generator neutral when the normal incoming supply to the emergency bus is not available. The removal of the ground source disables all the ground protection at the 4,160 V emergency system, including the individual 4KV motor ground sensors, and helps in maintaining the availability of the emergency supply during an accident with a single ground fault. A definite time overcurrent relay across the generator neutral current transformer provides backup ground protection for the generator differential relay, the ground relays at the feeder breakers, and the ground relay at the tie line between the normal and emergency bus during the exercise mode of the diesel generator. This relay is set above the normal third harmonic currents produced by the diesel generator.

4. 4,160 V Single Motor and Motor Feeder

   a. Motors Larger Than 1,500 Hp

      All motors larger than 1,500 hp have differential and ground protection due to the value of the motors. The differential protection includes the entire feeder circuit and is provided by a three-phase, solid-state percentage differential relay sensitive to both phase and ground faults.

      Sensitive ground protection is also provided by a solid-state ground sensor scheme. The relay used with this scheme is set above normal imbalances at approximately 10 amperes primary fault current and the operating time is 100 milliseconds.

      Large motors also have overload protection which is provided by a three-phase, solid-state relay.

b. Condensate (3,500 Hp) and Cooling Tower (3,000 Hp) Pumps

The solid-state relay provides overload protection for the motors of these pumps as well as limiting inadvertent successive starts during testing.

c. Steam Generator Feed (4,000 Hp) Pumps

The solid-state relay provides overload protection for motors of these pumps during running conditions. A programmable controller is provided to achieve the following restrictions of the manufacturer: two successive starts, followed by a third in 5 minutes; the motor is then permitted to cool by either running for a period of 20 minutes or standing idle for a period of 45 minutes. The full duty cycle is then allowed to repeat.

d. Reactor Coolant (6,000 Hp) Pumps

Motors for these pumps are subjected to different load requirements during cold-loop and hot-loop reactor operation. These motors are rated at 6,000 hp for hot-loop operation but are permitted by the manufacturer to operate at 7,200 hp during cold-loop conditions. Protection for these two loop conditions is outlined as follows:

1) Cold Loop and Locked Rotor Protection - A single three-phase long-time/inverse instantaneous overcurrent relay provides overload and locked rotor protection in conjunction with a three-phase distance relay and a dc motor-driven timer. The distance relay detects a change in impedance to verify rotor rotation. The long-time element of the overcurrent relay is set to pick up above 120 percent of the motor cold-loop full load current. Due to the close proximity of the motor thermal limit

curve and the motor starting curve, the operating characteristics of this element intersect the motor starting curve; however, tripping by this element is blocked by the distance relay if the motor begins to rotate within rotor thermal limitations. After the motor attains full speed, this blocking is removed by a timer and the long-time overcurrent relay provides cold-loop overload protection. The inverse instantaneous element is set to pick up at a minimum of 120 percent of motor locked rotor current.

2) Hot-Loop Protection - Under normal operating conditions, these motors are running under hot-loop conditions and the preceding cold-loop protection is not sensitive enough to protect them against overload conditions during these normal running conditions. The solid-state hot loop protection relay protects for this condition. This relay is desensitized during cold-loop by a contact from a temperature detector in the cold leg of the coolant system.

3) Redundant electrical protection is provided by a three-phase long-time overcurrent relay connected across a separate set of current transformers which trips the incoming feeder breakers. The pickup and time dial of this relay is set to coordinate with the cold loop overcurrent protection of the motor and thermal rating of the penetration.

e. Motors 1,500 Hp and Smaller

Each of these 4,160 V motor feeders is protected by a single three-phase, long-time/inverse instantaneous overcurrent relay. The long-time overcurrent element of this relay provides overload and locked rotor protection. The pickup of this element is set for a minimum of 120 percent of motor full load and the operating characteristics are positioned midway between the motor thermal limit and motor starting curves.

The inverse-time and instantaneous element of the relay is set to pick up at a minimum of 120 percent of locked rotor current of the motor. The inverse characteristics provide protection in the region greater than locked rotor current, where asymmetrical starting or fast transfer currents could cause misoperation of this relay. A ground sensor at the motor feeder breaker provides the ground protection. The relay used with the scheme is set above normal imbalances at approximately 10 amperes primary fault current. The operating time of relay is approximately 100 milliseconds.

5. 4,160 V Side of the Feeder to 4,160-480 V Unit Substation Transformer

   a. Normal Unit Substation Transformer Feeder

      Two 1,000/1,333 kVA dry type AA/FA transformers are fed from a single 4,160 V breaker, with the exception of the transformer feeders associated with unit substations 2-5 and 2-6. The 4,160 V feeders to these double-ended substations feed only one transformer (Figure 8.3-1, Sheet 2). Each of these transformer feeders has a primary protection provided by three single-phase, long-time/instantaneous overcurrent relays. The instantaneous elements of these relays are set to see faults halfway into the transformer. The pickup of the time overcurrent elements is determined as follows:

      1) The settings coordinate with the protection device at the low side of the transformer.

      2) Maximum pickup does not exceed 200 percent of the bank full load current based on its forced air ratings.

      3) The setting does not exceed the thermal limit at the short circuit capability of the transformer (two seconds).

      4) The cable ampacity protective by the secondary protective device at the 480 V unit substation.

         Sensitive ground protection is provided by a solid-state ground sensor scheme. The relay used with this scheme is set above normal imbalances at approximately 10 amperes primary fault current. The operating time is approximately 100 milliseconds.

         Normal unit substation transformer feeders also require a backup phase fault protection, because the phase overcurrent relays at the 4,160 V bus incoming feeder breakers do not detect a fault at the low side of the transformers. The backup scheme protecting both feeders from a single breaker consists of a three-phase, long-time overcurrent relay, and a three-phase distance relay connected across separate current transformers between the 4,160 V bus and feeder breaker. The distance relay torque controls the time overcurrent relay and is set to discriminate between loads and faults on both sides of the transformers. The overcurrent relay is set to select with the primary overcurrent relays.

b. Emergency Unit Substation Transformer Feeder

Feeders to these 1,500/2,000 kVA emergency (Class 1E) unit substation transformer feeders have the same primary protection as described previously for the normal unit substation transformer feeders except for the addition of three instantaneous overcurrent relays with built-in timers. These relays are added to tailor the coordination so as to provide a desired flexibility of 4,160 V emergency bus undervoltage relay setting. These feeders do not require the addition of backup protection.

6. 480 V Unit Substation Bus (Switchgears)

There are six normal and two emergency 480 V unit substations. Two buses are connected through a normally open tie breaker to form each double-ended normal 480 V substation. Each emergency substation consists of a single 480 V bus.

Incoming supply to each normal or emergency bus is obtained from a delta-wye connected 4,160-480 V transformer with secondary neutral ungrounded except transformers of unit substation 480 V US-2-6, whose secondary neutral is grounded. The low voltage power circuit breaker, which has a solid-state device with adjustable long-time and short-time delay trip units provides overload and phase fault protection for each 480 V bus. The time bands and short time delay pickup are chosen for the incoming feeder breaker to coordinate with the tie line breaker of similar tripping adjustments for normal substation or with the largest feeder breaker off the emergency bus. The long-time pickup is determined as follows:

a. Minimum pickup is approximately equal to 1.2 x (diversified load that can be supplied by the transformer, minus demand of the largest motor, plus starting characteristics of the combination of largest motor loads or motor, whichever is greater).

b. Maximum pickup provides cable protection for the 4,160 V feeder to the substation transformer and does not exceed 110 percent of the derated value of the cable ampacity (Section 8.3.1.1.16).

c. Maximum pickup is chosen approximately 150 percent of the transformer self cooled rating. This pickup provides a margin of 12.5 percent over the forced cooled rating of the transformer. For normal substation, this setting permits carrying the load of both busses by one transformer.

d. The pickup setting, which is above the forced rating of the transformer, is considered acceptable to achieve coordination since a thermal alarm is provided with the transformer to alert personnel of an overload condition.

e. The 480 V tie breaker pickup value is chosen approximately 75 percent of one transformer self cooled rating (56% of forced rating). This setting permits carrying the load of one bus through the tie breaker with a margin of 12.5 percent. The time hands and the short time delay pickup is chosen to coordinate with the feeder breaker having the slowest characteristics.

7. Feeder Circuits off the 480 V Unit Substation (Bus)

   a. 480 V Single Motor

      All single motor feeders have overload and phase fault protection provided by a low voltage power circuit breaker which has a three-phase, solid-state trip device with adjustable long-time delay and instantaneous trip units. The pickup of the long-time unit is set at a minimum of 120 percent of the motor full load current and does not exceed the derated value of the feeder cable ampacity. The instantaneous pickup is set at a minimum of 10 times the motor full load current to override the starting asymmetrical currents.

b. 480 V Multiple Motors and Heater Loads

Multiple motors and heater loads which have their individual local protection, or feeders which required downstream coordination, and are fed by a single feeder from the 480 V bus, are protected by a low voltage power circuit breaker, which has a three-phase, solid-state trip device with adjustable long-time and short-time delay trip units. The pickup of the long-time unit is set at a minimum of 120 percent of the sum of full load currents but does not exceed the derated feeder cable ampacity. The short-time pickup is set at approximately 1.2 x (sum of the full load currents, minus the largest motor full load current, plus largest motor starting characteristics).

c. 480 V Motor Control Centers

Each 480 V MCC feeder is protected by a low voltage power circuit breaker, which has a three-phase, solid-state trip device with adjustable long-time and short-time delay trip units. The pickup setting of the long-time unit does not exceed 110 percent of the derated current carrying capacity of the feeder cable. Also, the long-time unit is coordinated with the largest overload device in the MCC. The short-time delay is coordinated with the maximum instantaneous device clearing in the MCC. For control centers where the largest connected motor is less then 50 hp, it is assumed that a 50 hp motor is present for coordination purposes.

8. Feeder Circuits off the 480 V Motor Control Centers

a. Single Motor Feeders

Motors fed from the MCCs are normally 50 hp or less. Overload and phase fault protection for each motor feeder is provided by three single-phase, ambient temperature compensated heaters in a combination starter. Currents in excess of locked rotor are sensed by a three-phase instantaneous clearing magnetic circuit breaker.

b. Group Motors, Heater, or Other Loads

The feeder to a remote starter, a group of motors, or a group of heaters is protected by a three-phase molded case air circuit breaker. This thermal magnetic breaker is selected by its continuous current rating to be above 120 percent of the circuit full load current and below the feeder cable ampacity. Instantaneous trip is selected to accommodate the possibility of all the motors in the group starting simultaneously unless such starting is definitely prevented.

Whenever such loads are protected by ambient compensated heaters and a magnetic circuit breaker in a combination starter at the MCC, heaters are selected based on total circuit full load current rating and the magnetic circuit breaker is selected based on total locked rotor current of the motors. The selection of the heaters also protects the cable based on its derated ampacity.

c. Motor-Operated Valves

Each MOV has a combination starter with a three-phase directly heated bimetal overload relay, with manual reset, providing complete thermal protection for all three individual phases. The time current characteristics of these heaters resemble as closely as possible the temperature rise curve of the motor. During an accident, this protection at the emergency MCC is bypassed by a safeguard actuation signal for all the MOVs that are required for a safe shutdown of BVPS-2. Completion of an MOV’s travel de-energizes this circuit by a position switch contact. For an overload, the output from this protection annunciates and goes to the sequence of events recorder only.

8.3.1.1.11.6 Bus Transfers and Voltage Monitoring Schemes

1. Normal 4,160 V Bus Transfer

Whenever a supply to a normal 4,160 V bus is lost due to a fault on the system or unit station service transformers, a 138 kV switchyard bus, or the 22 kV generator leads, a transfer is made to the alternate source provided that source has normal voltage and the 4,160 V bus is not faulted. Either system or unit sources may be selected as the alternate source. Two transfer schemes provided for this unit are briefly discussed as follows:

a. Fast Transfer

A fast transfer is initiated for a fault in either of the 4,160 V sources and the transfer takes place within 0.15 seconds.

b. Delayed Transfer

Delayed transfer of 4,160 V bus are initiated by a sustained undervoltage detection at 4,160 V source. This transfer is effected when the condition results in a voltage reduction for 0.33 second and the bus voltage is less than 30 percent of the normal after the preferred source is tripped. Also, the alternate source must have an adequate voltage. This transfer is not intended to supply power to maintain unit operation but to provide a ready source of power for orderly restoration of service.

8.3.1.1.11.7 Selection of Voltage Relays and Their Setting Bases

Apart from the overcurrent devices described in the earlier sections, undervoltage relays play an equally important role in the overall protection scheme and ensure the availability of the auxiliary power system. Blown fuse protection for the potential transformers used for these relays is provided by a three-phase negative sequence (phase balance) relay. A blown fuse creates enough negative sequence voltage to be sensed by these relays. Presence of negative sequence voltage is also possible due to certain external faults; therefore, output from these relays is used in a logic. Undervoltage relays used for monitoring 4,160 V and 480 V systems are also three-phase relays which have the same dropout for a phase-to-phase fault as for a three-phase fault. Functions of these relays and their setting procedures are outlined as follows:

1. Station Service Transformer Bank Feeding 4,160 V System

Each of these transformer banks feeding 4,160 V systems has two instantaneous undervoltage relays. One relay is used to initiate a transfer while the second relay is used for voltage checking.

The transfer initiating relays are set to drop out below the maximum voltage dip expected when starting a large motor and operate a time delay relay. The time delay relay is set to be shorter than the motor trip timer (to transfer loads prior to motor trip) and still allow sufficient time for clearing close-in high voltage line faults.

The transformer voltage checking relays are to advise the transfer scheme that the source being transferred to is a suitable source. These relays are set to ensure that a voltage of 90 percent or greater will be available if a bus is transferred.

2. Normal 4,160 V Bus

Each normal 4,160 V bus has one instantaneous undervoltage relay and two undervoltage relays with built-in timers. Also, the three busses with reactor coolant pump loads have reactor coolant pump bus undervoltage relays.

The instantaneous undervoltage relay is used as a 30 percent voltage checking relay and is used in the slow transfer scheme. This relay prevents slow transfer from occurring until the bus voltage has decayed to approximately 30 percent to prevent motor damage.

The other two relays are motor trip relays and are set to drop out below the maximum voltage dip expected when starting a large motor. The relay pickup value should be low enough so that if a slow transfer occurs, the voltage transient during restart of the motor load will not cause continued motor trip timing. The relay timers should be set long enough to allow: (1) some time for momentary voltage dips greater than 25 percent, (2) slow transfer to occur prior to tripping the motor loads, and (3) line relays to clear close-in high voltage faults.

The reactor coolant pump bus undervoltage relays should have the same settings as the motor trip relays; however, the pickup value should ensure at least 90-percent voltage is available at the motor terminals. The time delay must be set to satisfy Technical Specification requirements.

3. Emergency 4,160 V Bus

Each 4,160 V emergency system has undervoltage relays arranged in three sets as follows:

1. Two motor trip relays
2. One diesel start on undervoltage relay
3. Two sustained undervoltage relays

Each set of these relays starts the diesel generator independently after adequate time delay.

The motor trip relays are set to drop out below the maximum voltage dip expected when starting a large motor on the normal busses. The pickup value is of no consequence after an undervoltage trip has occurred because this protection is cut-out when the diesel generator is the only source on the bus. The time delay should be set long enough to allow operation of the slow transfer scheme on the normal busses.

The diesel start on undervoltage is accomplished by an undervoltage relay with a built-in timer connected to a bus potential transformer. This relay is set similar to the motor trip relays; however, the pickup setting should ensure adequate voltage (90 percent) on the bus for the emergency bus equipment. The timer is set to start the diesel generator any time a slow transfer on the 4,160 V normal busses occurs. This will ensure that the diesel generator is ready, should the slow transfer be unsuccessful.

The sustained undervoltage relays consist of two undervoltage relays, each connected to separate potential transformers. They are set to ensure at least 90 percent voltage is available at the emergency bus load terminals. Because the 4,160 V sustained undervoltage relays are located at the bus, they are actually set above 90% to account for setpoint inaccuracy of the relays and voltage drop of the leads supplying the emergency bus loads. These relays operate a time delay relay which is set long enough to ride through voltage transients while preventing any equipment damage. This time relay is also operated by sustained undervoltage relays on the 480 V emergency bus.

4. Normal 4,160-480 V Unit Substation Transformer Bank

Each of these transformer banks feeding a normal 480 V bus has an undervoltage relay with a timer. This relay is set to drop out below the normal expected transient undervoltages. The time setting allows the 4,160 V delayed bus transfer to be completed before tripping this feeder and closing the tie breaker. Each transformer bank also has a transformer voltage checking relay, set to ensure adequate alternate source voltage (90 percent) prior to transfer.

5. Normal 480 V Bus

Each normal 480 V bus has an undervoltage relay with a built-in timer. This relay is set to drop below the normal expected transient undervoltages. The time setting allows the transfers to be completed at 4,160 V system before stripping the bus. Upon transfer, motor trip relays ensure that at least 90 percent of rated voltage is available at the motor terminals prior to reset.

6. Emergency 480 V Bus

Each emergency system has two undervoltage relays with built-in timers. These relays are set to drop below the normal expected transients caused by the starting of large motors. The time settings of these relays allow the 4,160 V normal buses to transfer before stripping the bus. Also, each 480 V emergency system has two undervoltage relays, which drive the timer at the associated 4,160 V emergency bus to detect a sustained undervoltage condition at the 480 V system to isolate the 4,160 V emergency system from the normal system. The undervoltage relays are set to drop out when the voltage at the emergency bus load terminals is 90% of normal voltage. Because the 480 V sustained undervoltage relays are located at the bus, they are actually set higher than 90% to account for setpoint inaccuracy of the relays and voltage drop of the leads supplying the emergency bus loads. The undervoltage protection is cut out when the diesel generator is the only source to the emergency 4,160 V bus.

7. Coordination of Undervoltage Tripping

It is important to coordinate all the undervoltage tripping to ensure that the motors and overcurrent controls are not damaged due to low voltage conditions. Also, it is necessary to ensure that voltage protection functions correctly during motor starting. These conditions are investigated for the maximum and minimum load conditions as well as for the various combinations of transformer tap ratios.

8.3.1.1.11.8 Philosophy, Practices, Coordination and Setting for 120 V ac and 125 V dc Systems

1. Philosophy and Coordination Base

The primary consideration on which this protection is based are the following:

a. A faulted piece of equipment is cleared by isolating the smallest portion of the system in a minimum possible time to limit damage to the equipment and stress on the remainder of the system.

b. In the event of primary protective device failure to clear a fault, a backup device operates to clear it after a suitable coordination interval. Operation of the backup device usually results in deenergizing a larger portion of the system compared with the primary device.

c. Only overcurrent devices provide protection at 125 V dc and 120/208 V systems.

d. Whenever overcurrent devices require coordination with the downstream circuits, long-time and short-time delay elements rather than long-time delay and instantaneous elements are used i.e., if possible.

e. For 125 V dc and 120/208 V ac distribution systems advantage is taken of the reduction of short circuit currents available at different levels of distribution along with the use of adjustable long-time delay, short-time delay and instantaneous trip elements.

f. For 120/208 V ac system, solid state trip devices with adjustable long-time delay, short-time delay and instantaneous elements are used to help coordination for both overloads and faults.

g. 120/208 V ac and 125 V dc panels do not have an automatic breaker at the incoming supply to provide optimum selective coordination for faults if possible.

h. Alarms are provided for undervoltage conditions at 125 V dc and 120/280 V ac distribution systems.

i. Two checkpoints, between the long-time pickup and short-time pickup, check the power circuit breakers for long-time delay settings with the normal band selected. Timing for short-time or instantaneous setting is checked on the flat portion of the time band at a current value approximately two times the pickup setting.

8.3.1.1.11.9 125 V dc Systems

1. Normal 125 V dc Switchgear

Normal 125 V dc system consists of two batteries. Each battery has its own battery charger and feeds a 125 V dc switchgear through a power circuit breaker with long-time and short-time delay elements. The pickup and time bands for both long-time and short-time delays are selected to coordinate with the feeder breakers off the switchgear. The long-time delay pickup does not exceed 110 percent of battery cable derated ampacity and allows the maximum use of the battery capabilities.

Each switchgear primarily feeds only three circuits, i.e., normal 125 V dc switchboard, essential 120/208 V inverter and a turbine lubrication dc motor.

2. Normal 125 V dc Switchboard

There are two normal dc control switchboards providing dc control power to the non-Class 1E circuits. In the event, one dc control source is not available, control power can be switched over to the other manually for reliability.

The feeder breaker to each switchboard at the switchgear has long-time and short-time delay elements. The long-time delay pickup does not exceed 110 percent of the cable derated ampacity and time bands for both long-time and short-time delay elements are selected to coordinate with the battery breaker and feeder breakers off the switchboard as well as the inverter between the two switchboards and dc panels fed from the switchboard.

3. 125 V dc Supply to Essential 120/208 V ac System

   Each normal 125 V dc switchgear feeds an essential 120/208 V ac inverter. The breaker for this feed has long-time and short-time delay elements to provide selective tripping for downstream faults. The pickup and time bends for both delays are selected to provide coordination with the feeder breaker from the battery. The long-time delay pickup also provides feeder cable protection and does not exceed 110 percent of the derated cable ampacity.

4. 125 V dc Motor Feeder

   Breaker for each motor feeder primarily provides the cable protection which has long-time delay and instantaneous elements. Due to the special requirements for these turbine lubrication motors, the long-time delay pickup is set at approximately 185 percent of motor full load current and below the ampacity of the feeder cable. The instantaneous element is set at approximately 350 percent of the maximum motor starting current and provides protection against feeder faults.

5. Feeders from the Normal 125 V dc Switchboard

   Molded case circuit breakers provide protection against overloads and faults for all the circuits fed off the switchboard. The rating of these breakers is selected within 110 percent of the derated cable ampacity to provide cable protection and adjustable instantaneous element is set at the maximum trip value.

6. Emergency 125 V dc Switchboard

   There are two emergency dc control switchboards providing dc control power to Class 1E circuits. Each switchboard is fed from a dc battery having its own 100A battery charger. The battery breaker feeding the switchboard is a power circuit breaker with long-time and short-time delay elements. The pickup and time bands for both long-time and short-time delay elements are selected to coordinate with the feeder breakers off the switchboard. The long-time delay pickup does not exceed 110 percent of the derated cable ampacity and allows the maximum use of the battery’s capability.

7. Emergency 125 V dc Supply to Vital 120 V ac System

   Each emergency 125 V dc switchboard provides dc power to a vital bus inverter. The breaker for this feed is a molded case circuit breaker with adjustable instantaneous set at the maximum trip value. The breaker rating is selected within 110 percent of the derated cable ampacity to provide feeder cable protection and is rated, above maximum demand of the inverter and coordinates with the incoming switchboard feeder breaker from the battery.

8. Other Feeders off the Emergency 125 V dc Switchboard

   Molded case circuit breaker provide protection against overloads and faults for all the feeders off the switchboard. The rating of these breakers is selected within 110 percent of the derated cable ampacity to provide cable protection and adjustable instantaneous element is set at the maximum trip value.

8.3.1.1.11.10 120/208 V ac and 120 V ac Systems

1. Essential 120/208 V ac Primary Panels

   There are two essential 120/208 V ac primary panels which provide the essential but non-Class 1E 120/208 V ac power source. The incoming supply to each of these panels is from a static switch which receives its power supply either from a 75 kVA inverter or from a 460/208-120-150 kVA line voltage regulator.

   Normally, the power supply to these panels is received from the inverter, which may not provide enough fault current for the tripping of overcurrent devices. Therefore, whenever loss of power from the inverter source is detected, static switch operates automatically to receive its power from the line voltage regulator. This source provides enough short circuit current for selective tripping of overcurrent devices.

   Line voltage regulator receives its power supply from a circuit breaker at 480 V unit-substation which has a solid-state trip device with adjustable long-time and short-time delay elements. The pickup and time-band of long-time and short-time delay elements are selected so that its tripping characteristics lies in between panel feeder breakers and static-switch fuse (provided for static switch protection). This minimizes the need of static-switch fuse replacement for essential system faults.

   There is no incoming feeder breaker at the panels which makes the time current coordination possible. The feeder breaker off the primary panels have solid-state trip devices with adjustable long-time delay, short-time delay and instantaneous over-ride elements. The pickup and time bands of long-time and short-time delay elements are selected to coordinate with the feeder breakers off the secondary panels fed from these primary panels. The instantaneous pickup is above the short circuit available at the secondary panels and does not cause false tripping.

2. Vital 120 V ac Panels

Vital 120 V ac system consists of four 20 kVA Uninterruptible Power Supplies (U.P.S) feeding the 120 V ac vital panels. Each U.P.S system has an inverter receiving its power source from 125 V dc battery or a 480 V ac MCC through a rectifier. Fault currents available from the inverter are so low that overcurrent devices need only be coordinated for overloads.

Each U.P.S system has also a line voltage regulator feeding the vital system through a manual or static switch. Normally, the power supply to the vital panels is received from the inverter. Whenever, loss of power from the inverter source is detected, static switch operates automatically to provide vital power from the line voltage regulator. This source provides enough short circuit current which can be seen by instantaneous elements of overcurrent devices. Therefore, feeder breaker at the 480 V MCC feeding the line voltage regulator is selected with adjustable instantaneous if it facilitates selective coordination with feeder breakers off the vital panels fed from the U.P.S system. Breakers inside the U.P.S system are all nonautomatic and are provided for manual deenergization of a circuit.

There is no-incoming feeder breaker at a vital panel. Each feeder breaker off the panel has time-overcurrent and instantaneous overcurrent tripping elements. These breakers are selected to coordinate with the upstream overcurrent devices for both overloads and faults.

8.3.1.1.12 System Testing During Power Operation

System testing during power operation is designed such that testing may be accomplished without jeopardizing the availability of any of the redundant Class 1E safety systems, in accordance with Regulatory Guides 1.108 (diesel generator units) and 1.118 (electric power and protection systems).

Should any accident event occur, for example, loss-of-coolant accident (LOCA) during the periodic system testing, the onsite Class 1E ac power systems are designed to perform their required safety functions while meeting the single failure criterion. Safety class switchgear and circuit breakers are specified with the built-in capability to allow Safety Class system testing during station operation, retaining protection and control features and single failure criterion. Electrical schematics (elementary diagrams), referenced in Section 1.7, illustrate these design qualities. In addition, equipment arrangement provides ready access to this equipment for test and inspection functions. The ac power system testing will also conform to the requirements of Regulatory Guide 1.47 and Branch Technical Position (BTP) ICSB 21 (PSB). For bypassed and inoperable status indication, testing of the reactor trip system, engineered safety features actuation systems, and systems required for safe shutdown are discussed in Sections 7.2, 7.3, and 7.4, respectively.

Should an accident event occur during a diesel generator unit test, which would be conducted in accordance with Regulatory Guide 1.108, the response control actions for the accident condition would override the test and provide full diesel generator capability for sequential load acceptance.

Also, the Class 1E 120 V ac vital bus UPS and 125 V dc systems can be fully tested during plant operation without jeopardizing the availability of any of its redundant channels. Testing can be performed on the chargers, rectifiers, inverters, switches, voltage regulating isolation transformers, and 125 V dc batteries.

8.3.1.1.13 Sharing of Equipment Between Two Units

Under Station Blackout (SBO) conditions as described in Section 8.3.1.1.19, any available emergency diesel generator at either BVPS-1 or BVPS-2 can supply power to the required SBO loads at both units.

8.3.1.1.14 Basis of Power Requirements for Loads

The power requirements for safety (Class 1E) loads are based upon the following conditions:

1. 4,160 V motors - Nameplate data or pump actual operating conditions.

2. 480 V motors (supplied by unit substations) Nameplate data or fan/pump actual operating conditions.

3. 480 V motors and MOVs (supplied by MCCs)- Nameplate data and conservative demand factors based on its associated system operation and reasonable engineering judgement.

4. 120 V ac and 125 V dc loads - Actual vendor load requirements and conservative demand factors based on load.

5. Torque and acceleration performance required to satisfy pump operation.

Specific data for large motors is provided in the Emergency Diesel Generator Loading analysis. Continuous duty safety class motors have a nameplate service factor of 1.15 except for totally enclosed air-over motors, which are available only with a 1.0 service factor. The maximum load requirements for the operating scenario is included in determination of load power requirements.

8.3.1.1.15 Onsite Emergency Power Supply

Description

The onsite emergency power supply consists of two 4,160 V, three-phase, 60 Hz diesel-driven synchronous generator units which supply the emergency Class 1E buses, as shown on the main one-line diagram (Figure 8.3-1). The diesel generator units are manufactured by Colt Industries, Fairbanks Morse Power System Division, and are Model Pielstick PC2, Type V. In accordance with BTPs ICSB 7 and 8, the emergency diesel generators are not shared with other units nor used to supply power to the electrical system during peak demand periods.

An electrical calculation program is in place to monitor emergency bus load conditions, changes, and deletions to update emergency bus loading calculations. This program ensures the capacity of the emergency diesel generators continues to be adequate to power prescribed loads, to start and accelerate to rated speed for all required loads in the required sequence, and within time intervals established by safety analysis.

Following a unit trip and the loss of preferred (offsite) power, the emergency buses are powered solely from the emergency power sources. The design of the feeder-isolation breaker in each preferred power circuit precludes the automatic connection of preferred power to the respective emergency bus upon loss of emergency power. The design includes the capability for restoring preferred power to the respective emergency buses by manual operation only. The diesel generator units and the preferred (offsite) source are not synchronized except during periodic testing or restoration of service. Synchronization is done manually and the capability for automatic synchronization is not provided.

The diesel generator units can never be paralleled and are so arranged that the generator of one load group is separate, both physically and electrically, from the generator of the other load group.

Cooling water for each diesel generator unit is supplied by the service water system. Section 9.5.5 fully describes the emergency diesel generator cooling water system.

Each diesel generator set has an independent combustion air intake and exhaust system. Exhaust gases are prevented from entering the intake opening by locating the intake and exhaust openings at opposite ends of the diesel generator building. These openings are missile protected. A complete description of the emergency diesel generator combustion air intake and exhaust system is provided in Section 9.5.8.

Onsite fuel storage is adequate for operating each emergency diesel generator at rated load for seven days. This includes one day tank for each diesel, with a capacity of 1,100 gallons. Separate concrete-encased fuel oil storage tanks are provided, complete with all necessary equipment. Each diesel generator fuel oil storage tank has two full capacity transfer pumps that are operated automatically at preset level points in the corresponding day tank. Section 9.5.4 discusses the emergency diesel generator fuel oil storage and transfer system in detail.

The diesel generator sets are located in separate rooms in the diesel generator building. There are no openings or common passageways between the operating rooms (el 732 ft-6 in) of the diesel generator sets. Sleeves between both rooms are provided for communication cables above the operating floor level and are sealed following cable installation. Each of the rooms has a separate drainage system to prevent liquids from flowing from one room to the other. The separate drainage system for each diesel is sized to accommodate any release of fluid associated with that diesel generator. Because of these features, a fire in one diesel generator room cannot spread to the other room. In addition, the fire protection system is adequate to extinguish all types of fires that could occur.

The diesel generator building is a Seismic Category I structure and is capable of withstanding tornado-generated missiles. Section 3.5 outlines the building structure and type of missiles.

The safety-related ventilation system for the diesel generator building is detailed in Section 9.4.6.

Sizing

The diesel generator sets have the capacity and reliability to provide all required power for safe shutdown of BVPS-2 after a LOOP. The diesel generator sets are specified to comply with the requirements of Regulatory Guide 1.9 and IEEE Standard 387-1972, as indicated in Table 8.1-1.

The diesel generator unit ratings as stated by the vendor are:

Continuous duty (8,760 hours)	-	4,238 kW
2,000 hours	-	4,535 kW
160 hours	-	4,662 kW
30 minutes	-	5,086 kW

This capacity is adequate to meet the engineered safety features (ESF) demand load occurring under conditions caused by a LOCA. The established combined load demand is in the Emergency Diesel Generator loading analysis.

Except during a station blackout, the maximum load imposed on the emergency diesel generator does not exceed the smaller of the 2,000-hour rating, or 90 percent of the 30-minute rating specified by Regulatory Guide 1.9, and is less than the continuous rating of the machine. During a station blackout, the maximum load on the generator does not exceed the generator 2,000-hour rating.

The emergency diesel generators are periodically inspected in accordance with a licensee controlled maintenance program. The emergency diesel generator maintenance program specifies required inspections based on the manufacturer's and Diesel Generator Owners Group recommendations and industry operating experience. Changes to the emergency diesel generator maintenance program are controlled under 10 CFR 50.59.

Each diesel generator set has the capacity of sequentially starting and accelerating to rated speed all the required ESF and essential shutdown loads within the maximum time intervals established by DBA analyses.

1. Starting circuits

   Each diesel generator set automatically starts whenever any of the following conditions occur:

   a. Degraded voltage on its respective emergency bus,

b. Loss of voltage on its respective emergency bus,

c. Opening of the series-connected normal supply breakers to the 4,160 V emergency bus, or

d. Safety injection actuation signal, which is initiated by any of the following events:

   1) High containment pressure,

   2) Low pressurizer pressure,

   3) Low steam line pressure, or

   4) Manual initiation of safety injection signal from the main control room.

Following an accident with a unit trip, the emergency buses are fed from the preferred offsite power source. If the preferred source is not available, undervoltage relays on the Class 1E buses open the series-connected normal supply breakers and initiate load shedding of all 4 kV loads, except the connected 480 V unit substations, that are supplied from the Class 1E buses. No single protective relay or interlock failure will prevent separation of both emergency buses from the offsite power system. The relays are set to prevent opening of the normal supply breakers and disconnection of loads during automatic bus transfer. When the diesel generator attains the required voltage and speed, the diesel generator output breaker closes and permits sequential application of the loads to the diesel generator. Automatic loading is detailed in Section 8.3.1.1.8.

Each diesel generator unit is capable of attaining rated voltage and frequency and is ready to accept the load within 10 seconds after receiving a starting signal. Generator reactance and the characteristics of the static exciter and voltage regulator are coordinated to provide satisfactory starting and acceleration of sequenced loads. The exciter-regulator system design ensures rapid voltage and frequency recovery when starting large motor loads. Voltage and frequency drops between sequencing steps do not exceed the limits established in Regulatory Guide 1.9.

Starting of the diesel engines is accomplished by a compressed air system, as described in Section 9.5.6.

Fast starting and load acceptance are facilitated by maintaining engine temperature by heating, and by forced circulation of cooling water and lube oil. In addition, the units are located in heated and ventilated rooms. Sections 9.5.5 (cooling water system) and 9.5.7 (lubrication system) present a detailed description of these systems.

The emergency diesel generator loading sequence is shown in Table 8.3-3. The sequence starting of motors and equipment is based on the BVPS-2 system requirements and engineering arrangement of remaining loads to reduce the instantaneous loads on the diesel generator. The loading sequence consists of six load steps, as defined in Table 8.3-3, which describes the emergency diesel generator loading requirements for different station conditions.

When loaded in accordance with the sequential load test loading table (which included 1750 hp motors), the diesel generators meet the guidance of Regulatory Guide 1.9 for frequency in that at no time during the loading sequence does the frequency decrease to less than 95 percent of nominal, and the frequency is restored to 98 percent of nominal within 60 percent of each load sequence time interval. The diesel generators meet the intent of Regulatory Guide 1.9 for voltage because although voltage dips slightly below 75 percent, it recovers to 90 percent of nominal well within 60 percent of each load sequence time interval, when compared to the actual load intervals presented in Table 8.3-3.

Upon recovery from transient caused by load step increases or resulting from the disconnection of the largest single load, the diesel generator unit speed does not exceed 109 percent of rated speed for all load rejection conditions.

2. Protection System

The diesel generator unit protection systems initiate automatic and immediate protective actions to prevent or limit equipment damage and allow restoration of the equipment upon correction of the trouble. Excluding a loss of normal power start signal, tripping of the diesel generator units occurs for any of the following reasons:

a. Lube oil pressure low,

b. Engine overspeed,

c. Generator current differential,

d. Reverse power flow,

e. Jacket water temperature high,

f. Loss of excitation,

g. Lube oil temperature high,

h. Generator overexcitation,

i. Generator overcurrent,

j. Generator ground, or

k. Generator field ground

l. Backup phase fault.

With the exception of generator current differential, generator overexcitation, backup phase fault detection, and engine overspeed protection, the preceding trips are bypassed when the diesel generators receive a start signal due to a loss of normal power. Electrical trips are discussed in Section 8.3.1.1.11. The generator overexcitation and back-up phase fault detection use redundant logic in order to cause a trip.

Surveillance instrumentation is provided to monitor the status of the diesel generator units. Provisions for surveillance are an essential requirement in the design, manufacture, testing, operation, and maintenance of the diesel generator units. Such surveillance not only provides continuous monitoring of the status of the diesel generator units so as to indicate their readiness to perform their intended function, but also serves to facilitate testing and maintenance of the equipment. Conditions which can adversely affect performance of the emergency diesel generators are annunciated in the main control room. The following list shows the events or conditions that are annunciated in the main control room:

a. Diesel generator air circuit breaker auto close-trip,

b. Diesel generator ground switch not fully open,

c. Diesel generator electrical fault,

d. Diesel generator loss of field/low excitation,

e. Diesel generator local panel trouble,

f. Diesel generator potential transformer blown fuse,

g. Diesel generator reverse power,

h. Diesel generator auto start,

i. Diesel generator system inoperable,

j. Diesel generator support system inoperable,

k. 4,160 V emergency bus undervoltage,

l. 4,160 V to 480 V emergency substation feeder auto trip,

m. 4,160 V emergency bus overcurrent trip,

n. 4,160 V emergency electrical system inoperable,

o. 480 V emergency bus trouble,

p. 480 V emergency bus supply air circuit breaker auto trip

q. 480 V emergency electrical system inoperable, and

r. 125 V dc electrical system inoperable.

The emergency diesel generator local panel trouble alarm is actuated by any of the following alarms provided for each diesel unit. These alarms are also displayed in a main control room alarm display and recorded by the sequence of events recorder.

a. Starting air pressure low - Reservoir No. 1,

b. Starting air pressure low - Reservoir No. 2,

c. Jacket coolant level low,

d. Engine overspeed,

e. Rocker arm lube oil level high,

f. DELETED.

g. Day tank fuel oil level low,

h. Lube oil level low,

i. Lube oil temperature low,

j. Jacket coolant pressure low,

k. Start failure,

l. Rocker arm lube oil pressure low,

m. Day tank fuel oil level high,

n. Lube oil level high,

o. Lube oil temperature high,

p. Jacket coolant temperature low,

q. Control circuit failure,

r. Fuel oil pressure low,

s. Lube oil pressure low,

t. Crankcase pressure high,

u. Jacket coolant temperature high,

v. Barring device engaged,

w. Storage tank fuel oil level low, or

x. Fuel oil strainer high pressure.

3. Testability

   The diesel generator units were tested after final assembly and preliminary start-up. Site acceptance tests were performed on each diesel generator unit to demonstrate its required capabilities (Section 14.2.12). Sequential loading tests were performed, utilizing where possible, installed BVPS-2 equipment loads.

   Circuit design provisions incorporate test capability toperiodically monitor the operational capability of the safety-related Class 1E systems during power operation. All safety-related equipment was tested during the initial startup testing phase.

   The program of field testing was used to reaffirm acceptance criteria previously established during the manufacturer's factory testing program.

4. Fuel oil storage and transfer system

   The diesel generator fuel oil storage and transfer system is described in Section 9.5.4.

5. Cooling water and heating system

   The diesel generator cooling water and heating system is described in Section 9.5.5.

6. Air starting system

   The diesel generator air starting system is described in Section 9.5.6.

7. Lubrication system

   The diesel generator lubrication system is described in Section 9.5.7.

8. Control system

The diesel generator starting mode selector switch has auto/local positions and is normally in the auto mode position. It is in the local position for local manual starting during maintenance and non-routine testing. If the switch is not returned to the remote position, an alarm in the main control room persists until the switch is returned to the automatic mode. Other manual controls of the auxiliary systems of the diesel generator are also alarmed if failure to return to their auto-start position would inhibit automatic operation of the diesel generators.

Dc power required by each diesel generator for controls, alarms, protective relays, air starting solenoid valves, and generator field flashing is supplied by the Class 1E dc system of the associated train.

9. Prototype qualification testing

Diesel generator units supplied for BVPS-2 are similar to those previously qualified by Alabama Power Company; however, qualification by similarity was not pursued. Verification of suitability of the diesel generator units was made by performing the following tests, which meet the requirements of the engine qualification and load acceptance tests of IEEE Standard 387-1977 and Regulatory Guide 1.108.

Each diesel generator unit has successfully passed the following series of system acceptance tests performed at the factory as part of the manufacturer's extensive test program:

a. Fast start capability

This test requires the engine be capable of accelerating to rated speed and full voltage and be ready to accept load in its rated capacity within 10 seconds.

Performance of the diesel generator units met the criteria.

b. Sequential step load acceptance capability test

This test requires the diesel generator unit accelerate to rated speed and voltage and be ready to accept load within 10 seconds from receipt of start signal. When loaded in accordance with the sequential load test loading table (which included 1750 hp motors), the diesel generators met the guidance of Regulatory Guide 1.9 for frequency in that at no time during the loading sequence did the frequency decrease to less than 95 percent of nominal, and the frequency was restored to 98 percent of nominal within 60 percent of each load sequence time interval. The diesel generators met the intent of Regulatory Guide 1.9 for voltage because although voltage dipped slightly below 75 percent, it recovered to 90 percent of nominal well within 60 percent of each load sequence time interval, when compared to the actual load intervals presented in Table 8.3-3. The largest motor currently on the diesel generator loading sequence (Table 8.3-3), is 1,250 hp (2SWE-P21A,B).

During recovery from the transients caused by load increases or resulting from the disconnection of the largest single load, the speed of the units did not exceed 109 percent of nominal speed.

Performance of the diesel generator units met the acceptance criteria.

c. Load carrying capability

This test requires the temperature of jacket coolant out of the engine after attaining equilibrium not exceed 152.7°F, the temperature of the lube oil out of the engine after attaining equilibrium not exceed 160°F, and the temperature rise of jacket water through the engine not exceed 15°F.

Performance of the diesel generator units met the acceptance criteria.

d. Synchronous operating capability

This test requires the diesel generator set be synchronized and accept load under operator control.

Performance of the diesel generator units met the acceptance criteria.

e. Load rejection capability

This test requires the engine speed, after full load rejection, not be greater than 109 percent of rated speed.

Performance of the diesel generator units met the acceptance criteria.

f. Air start redundancy test

This test requires the engine be capable of accelerating to rated speed, full voltage, and be ready to accept load to its rated capacity in not more than 10 seconds.

Performance of the diesel generator units met the acceptance criteria.

g. Engine performance during switch from engine-driven to auxiliary dc motor-driven fuel pump

   This test requires the frequency during transfer to auxiliary dc fuel pump not vary more than 0.3 Hz from nominal 60 Hz.

   Performance of the diesel generator units met the acceptance criteria.

h. Start on auxiliary dc motor-driven fuel pump only

   This test requires both the engine rpm and generator voltage reach rated values in 10 seconds or less.

   Performance of the diesel generator units met the acceptance criteria.

i. Operation of system alarm and safety function

   This test requires a demonstration that the alarm, shutdown, and protective circuits (including the portion installed in the contract control panel) function as intended.

   Performance of the diesel generator units met the acceptance criteria.

j. Air compressor test

   This test requires confirmation that the time needed to recharge the air storage reservoir from 300 to 425 psig not exceed 30 minutes.

   Performance of the diesel generator units met the acceptance criteria.

k. Overspeed tests

   This test requires the overspeed protective trip function prevent the engine speed from exceeding 576 rpm.

   Performance of the diesel generator units met the acceptance criteria.

l. 115 percent load test portion of margin test

   This test requires the diesel generator unit carry 6,784 brake horsepower (bhp) without exceeding equilibrium temperatures of 160°F lube oil temperature and 152.7°F jacket water temperature from the engine.

   Performance of the diesel generator units met the acceptance criteria.

m. Motor starting test portion of margin test

This test requires the diesel generator unit be capable of accepting the resistive and motor loads:

1) Without experiencing instability resulting in generator voltage collapse or significant evidence of the failure of the voltage to recover, and

2) Demonstrate that there is sufficient torque available to prevent engine stall and to permit engine speed to recover.

It was demonstrated that the unit could successfully start a 1,750 hp motor while the unit was carrying a load equal to 50 percent of its rated load. For the BVPS-2 load sequence, the largest single load step block in the sequence is approximately 1,300 hp total step load. The 1,750 hp motor used for the margin test represents a 35 percent margin above the most severe single step load within the design load sequence. This exceeds the requirements of IEEE Standard 387-1977, Section 6.3.3, which requires only a 10 percent load test margin.

n. Operation on hydraulic governor test

This test demonstrates that the engine continues to operate and carry load in response to a step load change, without a frequency change in excess of a determined setting on the hydraulic case dial.

Performance of the diesel generator units met the test criteria.

o. Variable load run

This test requires the variable load run be demonstrated according to the following parameters:

Load (%)	bhp	Brake Specific Fuel Consumption (lb/bhp-hr)
50	2,950	0.374
75	4,425	0.366
100	5,900	0.375

Performance of the diesel generator units met the acceptance criteria.

The vendor also performed a series of 270 keep warm starts and 30 hot starts, which were performed on one unit and which met the test criteria for the 300 start test of no more than one failure per 100 sequential starts. The load applied was a single step resistive load equal to or greater than 50 percent of the generator nameplate continuous kW rating. Upon loading, the diesel generator set was allowed to continue to operate until the jacket water and lube oil temperatures were within 5°F of the normal engine operating temperature for the corresponding load.

The diesel generator voltage and frequency were monitored, recorded, and verified when starting the unit and applying a 50 percent load for each of the 300 start-load tests in full compliance with IEEE Standard 387-1977.

p. Load Capability Qualification Test

This test demonstrates the diesel engines ability to accept and reject loads. The test is specified in IEEE Standard 387-1977 and Regulatory Guide 1.9.

The load rejection portion of the test has been performed by the manufacturer as stated in paragraph e. above.

The load carrying portion of the test will be performed on site. Loading will be applied in the order specified in Section C.14 of Regulatory Guide 1.9 (2 hour short-time load capability run followed by 22 hour full load test) rather than the order specified in Section 6.3.1 of IEEE Standard 387-1977 (22 hour full load test followed by 2 hour short-time load).

10. Operating procedures, maintenance, and training

a. Operating procedures for diesel generators provide assurance that diesel generator reliability and operation will not be degraded. In particular, procedures include appropriate restrictions on no-load operation and adequate provisions for post-maintenance checkout and testing to assure operability and return to required standby service.

b. A preventive maintenance program for the diesel generators provides for adequate testing, which is generally in accordance with IEEE Standard 308-1974,

and replacement of identified malfunctioning components, with particular attention to assuring repeated malfunctioning components are replaced with other components of proven reliability.

c. A training program for diesel generator operations and maintenance personnel exists to assure an adequate level of personnel experience, which assures a high degree of diesel generator reliability and availability.

8.3.1.1.16 Class 1E Equipment Design Criteria

1. Motor

a. Motor Size

Safety-related motors are sized to develop sufficient horse power to drive the mechanical load under runout or maximum flow and pressure, whichever is greater, and to permit the driven equipment to develop its specified capacity without exceeding the temperature rise rating of the motor when operated at the duty cycle of the driven equipment. Safety-related motors for large station loads (50 hp or larger) are, in general, provided with a 1.15 service factor and sized to handle the driven equipment requirements without encroaching on the service factor during normal operating conditions. One exception is the high head safety injection/charging pumps, which operate above brake horsepower up to and slightly above the service factor for short durations during CIA and DBA scenarios. For the high head safety injection pumps, the effect on the motor life has been evaluated for the maximum flow/pressure condition. Another exception is the primary component cooling water pumps, which operate above brake horsepower at service factor for short durations during all LOOP scenarios. A third exception is the Low Head Safety Injection Pump BV-2SIS-P21B. Under Design Basis conditions, the motor will operate slightly above the 1.15 Service Factor. This increased load on the Low Head Safety Injection Pump Motor has been evaluated for the effect on motor life and equipment performance. For safety-related totally enclosed motors with a 1.0 service factor rating, the motor nameplate rating is selected on the basis of maximum bhp or runout conditions, whichever is larger. During construction, safety-related motors were purchased with the driven equipment. Each motor was factory-tested in accordance with National Electrical Manufacturers Association MG-1. The driven equipmentwas factory performance-tested using its respective motor. The motor and driven equipment were preoperationally tested to verify the system requirements. These tests verified that the margin of motor torque over the torque required by driven equipment was adequate.

b. Motor Starting Voltage

Safety-related motors are designed with the capability of accelerating the driven equipment to its rated speed with 80 percent of motor nameplate voltage applied at the motor terminals. Motor torque capability is designed to satisfy performance requirements of the driven equipment. Motor safe locked rotor time at rated locked rotor current is equal to, or greater than, the maximum accelerating time at minimum specified starting voltage.

c. Motor Insulation

The insulation systems for continuous duty safety-related motors are for a 40-year life at continuous operation under the specified ambient conditions. Where applicable, continuous duty Class 1E motors were qualified in accordance with IEEE Standard 334-1974. Intermittent duty motors are similarly rated for the number of duty cycles expected over the 40-year life of BVPS-2. The renewed operating license permits operation of the site for 20 years beyond the original 40-year life. Motors that may be exposed to harsh environments are managed by the Environmental Qualification (EQ) of Electrical Components Program (Section 19.1.14), which manages the effects of thermal, radiation, and cyclic aging through the use of aging evaluations based on 10 CFR 50.49 qualification methods. As required by 10 CFR 50.49, environmental qualification program components not qualified for the current license term are refurbished, replaced, or their qualification extended prior to reaching the aging limits established in the evaluations. Aging evaluations for environmental qualification program components are time-limited aging analyses (TLAAs) for license renewal. Motors not within the scope of the EQ program are inspected, tested, and maintained per other requirements, such as IST and the Maintenance Rule to ensure their continued operability.

For safety-related motors located inside the containment, the insulation systems are designed to withstand the expected environmental conditions of ambient pressure, temperature, chemical spray, and radiation dosage, as specified in Section 3.11.

All safety-related motors are provided with either Class B, Class F, or Class H insulation, and are specified to be compatible with qualified life and service requirements. The insulation temperature rating is greater than the sum of the motor temperature rise, the ambient temperature at the motor location, and the hot spot temperature allowance. The motor stator winding temperature is determined by a resistance measurement at rated load (plus service factor), or by embedded temperature detectors at rated load (plus service factor).

d. Temperature Monitoring of Large Motors

The 4,160 V motors, 1,500 hp or larger, are provided with two temperature detectors embedded in each phase of the stator windings. The detectors provide input to the BVPS-2 computer, which continuously monitors winding temperature, and alarms any abnormal conditions.

2. Interrupting Capacity of Distribution Equipment

Safety-related 4,160 V switchgear, load centers, MCCs, and distribution panels are sized for interrupting capacity based on the maximum short circuit current available at their location. The 4,160 V switchgear is sized within its interrupting and close and latch ratings in accordance with ANSI C37.04, Ratings for AC High Voltage Circuit Breakers. The short circuit calculations used in equipment sizing take into account the fault contributions from the rotating machine and from the system, through the source transformers, making proper allowance for system X/R ratio at the point of fault. System impedances are kept low enough to ensure sufficient motor starting voltage. Load center transformer impedance is selected to limit short circuit currents at load center and MCC buses. Low voltage metal enclosed breakers at load centers and molded case breakers at MCCs are adequately sized for the maximum available short circuit currents.

3. Electrical Circuit Protection

Electrical circuit protection is detailed in Section 8.3.1.1.11.

4. Grounding Requirements

All grounding shall be in general accordance with the National Electric Code as adopted by the National Fire Protection Association.

System and equipment grounding is provided to reduce the hazard to BVPS-2 personnel.

The 4,160 V system is low resistance-grounded and designed to trip on ground faults to protect the 4,160 V equipment. The diesel generator unit neutral is resistor-grounded while in the exercise mode. A motor-operated disconnect switch removes this ground source from the generator neutral during standby operation to provide increased operating reliability.

The design criteria for equipment grounding of safety-related systems are:

a. Equipment hardware, exposed surfaces, and potential induced-voltage hazards are adequately protected to minimize danger to BVPS-2 personnel.

b. A low impedance ground return path is provided to facilitate the operation of ground fault detection or protective devices in the event of a ground fault or insulation failure on any 4,160 V electrical circuits.

Large electrical loads, including motors larger than 20 hp, are solidly grounded to the BVPS-2 grounding grid by means of a suitably sized cable connection to the motor housing.

Motors of 20 hp and below, and other miscellaneous electrical devices such as solenoid operators and lighting fixtures, are grounded in one of two ways. Conduit connections are used as grounding ties to conduit-fed equipment. Other equipment is grounded either directly to the BVPS-2 grounding grid or to the building steel which in turn is connected to the BVPS-2 grid.

5. Containment Electrical Penetrations

Electrical penetration assemblies are located in the southwest quadrant of the reactor containment building, facing the cable vault and rod control building, above el 735 ft-6 in and 755 ft-6 in. The penetrations are housed in reactor containment sleeves (nozzles) fabricated from 12-inch diameter and 18-inch diameter schedule 80 steel pipes and installed with a minimum center-to-center separation of 4 feet.

There are eighty six 12-inch diameter and ten 18-inch diameter sleeves occupied by a total of 84 (77 active, 7 spare) penetrations. The remaining 12 sleeves are capped.

The penetration locations form a matrix which consists of 21 columns by 5 rows. Minimum vertical and horizontal separation (center-to-center) is maintained as follows:

a. Four feet between related channels (white to yellow and red to blue),

b. Eight feet between redundant trains, (orange to purple), and

c. Eight feet between train and channel (with the exception of the nuclear instrumentation system discussed in this section).

The penetrations are also arranged (outside containment) in separate cable vault groupings defined by distinct fire areas:

1. CV-1: 735 feet-6 inches, Class 1E (orange, red, and blue) and non-Class 1E (black).
2. CV-2: 735 feet-6 inches, Class 1E (purple and green) and non-Class 1E (black).
3. CV-3: 755 feet-6 inches, Class 1E (yellow and white) and non-Class 1E (black).

This arrangement (outside containment) provides for distinctive groups of Class 1E penetrations to their redundant counterparts.

Each penetration is identified by a matrix number and a letter, and by a type number, which designates it as an instrument, control, or power penetration.

In addition to the spatial separation, the concrete walls of cable vault and rod control building isolate color coded trains, their cables, and terminations on the outboard end of penetration assemblies.

Cable separation for the BVPS-2 is detailed in Section 8.3.1.4.

Fire detection and protection features for these areas containing penetration assemblies are described in the Fire Safety Analysis, Volume 2-2.

The penetrations are completely isolated from any pipelines by concrete walls, floors, and steel doors outside the containment, and concrete floors inside the containment, except for a low pressure air duct (purge duct) located in the vicinity of the penetrations. There is no high pressure piping in the vicinity of the electrical penetrations.

The electrical containment penetrations meet the design requirements of GDC 50 of Appendix A to 10 CFR 50. The calculated containment environmental conditions are documented in the BVPS-2 Equipment Qualification Report (refer to Table 1.7-3).

These environmental conditions are calculated using the mass-energy release analyses as described in Sections 6.2.1.3 and 6.2.1.4. Potential energy sources are considered within the mass-energy release evaluations. Metal-water and chemical reactions are considered, per 10 CFR 50.54, and are discussed in Section 6.2.5. The models and input parameters used to calculate mass-energy releases ensure conservatism in the calculated containment design parameters.

The design parameters are used by the manufacturer, Westinghouse Electric Corporation, for the design, manufacture, and qualification testing of the containment electrical penetrations. The test results, analysis, and conclusion, as verified in Westinghouse Qualification Report Nos. PEN-TR-77-66 and PEN-TR-80-27, meet the requirements of GDC 50.

The penetrations' assemblies are designed, manufactured, and tested in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NE (Class MC) Vessel Nuclear Power Plant Components, Regulatory Guide 1.63, and IEEE Standard 317-1976, both entitled Electrical Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations, IEEE Standard 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations, and IEEE Standard 344-1975, Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations. The only exceptions taken to these standards are that an ASME Code data report, (ANI) third party inspection and code stamping at the penetrations are not required as the penetrations are an extension of the containment liner boundary which is not code stamped as discussed in Section 3.8.1.2.1.2.

Electrical penetration assemblies consist of terminal cabinets located in the rod control building el 735 ft-6 in and 755 ft-6 in, pigtail conductors, short or long canisters with a redundant pressure boundary, feed through modules, pigtails, and terminal cabinets, located inboard of the containment.

Nuclear instrumentation system (NIS) triaxial penetrations are similar to the ones mentioned previously; however, they will have connectors in place of terminal cabinets, with pull boxes inboard and outboard of the containment. Two NIS triaxial penetrations, 2RCP*21E (white) and 2RCP*06B (blue), deviate from the spatial separation requirements of item 5C above. The separation is 4'-0" between the respective train and channel. This arrangement precludes NIS noise interference concerns, and is acceptable based on the availability of a separate safety-related nuclear instrumentation system.

The 5 kV cable penetrations are of the bushing type with suitable connectors.

6. Fire Stops and Seals

Fire stops and seals are detailed in Section 8.3.3.3.

7. Cable

All Class 1E cable is type-tested in accordance with IEEE Standard 383-1974 to ensure its ability to perform its required function for all normal and accident environments.

Power cables are sized in accordance with Power Cable Ampacities, published by the Insulated Power Cable Engineering Association (IPCEA), or manufacturers data. Cable sizes for safety-related motors are based on maximum expected running currents, 90°C conductor temperature, and 40°C ambient temperature for cable installation one layer deep with maintained horizontal spacing (refer to Table 8.3-4). Cable trays have a depth of 4 in. Cable tray fill for K cables is limited to 50 percent of the available cross-sectional area of a 3-inch deep cable tray for randomly filled trays (Table 8.3-4) and is derated accordingly. In actual practice, the cables in randomly filled trays are not as tightly packed as assumed in IPCEA P-54-440, Ampacities in Open-Top Cable Trays, and the calculated cable derating is conservative.

8.3.1.1.17 120 V AC Vital Bus Uninterruptible Power Supply System

There are four independent Class 1E vital bus power supplies constituting the 120 V ac vital bus UPS. Each bus provides 120 V ac instrumentation and control power for the ESF protection channels, and is uniquely identified by the assigned colors red, white, blue, or yellow corresponding respectively to vital buses UPS*VITBS2-1, 2-2, 2-3, and 2-4. Each vital bus UPS consists of an inverter, rectifier, static switch/manual bypass switch, and alternate source line voltage regulator (Figure 8.3-3).

Each vital bus (*2-1, *2-2, *2-3, *2-4) is capable of providing 120 V ac ±2.4 V, single-phase, 60 HZ ±.03 Hz, at the output of the inverter unit. Vital bus UPS units *2-1 and *2-2 provide 20 kVA output at 0.8 power factor. Vital bus UPS units *2-3 and *2-4 provide 15 kVA output at 0.8 power factor.

Each bus normally receives power from the rectifier units via an emergency 480 V MCC. The rectifiers convert 480 V ac to 125 V dc and supply it to the inverter input. The interconnection with an emergency 480 V MCC provides the vital buses with the capability of an offsite (preferred) power source or an on-site (emergency) power source. This satisfies NUREG-0737 (USNRC 1980), Item II.G.1, Position 4, with regard to pressurizer level indicators which are supplied from the vital instrument buses. The inverter shapes the output voltage waveform to 120 V ac, single-phase, 60 hertz by means of internally-triggered silicon control rectifiers. In the event that the rectifier source is lost, the inverter will receive 125 V dc directly from the 125 V dc battery input. Each system is designed such that the battery will not supply current to the UPS while ac power (rectifier input) is available and within specified limits. In the event that both the rectifier and battery sources are unavailable or the inverter malfunctions, the systems load is transferred within 1/4 cycle to the 480-120 V alternate source line voltage regulator by means of the static switch. The alternate source is regulated at 120 V ± 3.6 V.

The BVPS-2 operator also has the option, by means of the manual bypass switch, of manually overriding the automatic transfer feature to allow for manual transfer. The automatic transfer permissives, however, can not be manually defeated.

Vital buses *2-1 (red) and *2-2 (white) receive their dc inputs from Class 1E batteries *2-1 and *2-2, respectively, via dc switchboards *2-1 (orange) and *2-2 (purple), respectively. The dc switchboards exist on these two buses since there are several Class 1E dc loads which are not associated directly with the vital bus system. These non-vital bus loads are also supplied via the dc switchboards.

Vital buses *2-3 (blue) and *2-4 (yellow) receive their dc inputs directly from Class 1E batteries *2-3 and *2-4. The dc loads on these buses are limited by design to only blue and yellow channel 125 V dc circuits; therefore, no dc switchboards exist on these buses.

Each of the four vital buses are provided with separate battery chargers. Blocking diodes have been provided at the input circuits of the inverters for each of the four buses. These blocking diodes prevent inverter rectifier output from back-feeding dc input to their respective battery bus. This ensures that each inverter rectifier output feeds only its intended Class 1E vital bus load. Upon loss of ac input to a rectifier, the diode allows for the battery power to carry the affected vital bus load.

Spare battery chargers are also available to provide charging current to the Class 1E batteries during charger maintenance or in the event that a Class 1E battery charger fails. These spare chargers and their associated connecting receptacles are qualified for Class 1E use.

There are four Class 1E isolating voltage regulating transformers allocated to the four vital bus systems. They serve to isolate certain designated non-Class 1E loads from the Class 1E portion of the system (red, blue, yellow, white). These isolating regulators are identified as follows:

Vital Bus System	Isolating Transformer	Isolating Function
*2-1	REG*VITBS2-1B	Red-Black
*2-2	REG*VITBS2-2B	White-Black
*2-3	REG*VITBS2-3B	Blue-Black
*2-4	REG*VITBS2-4B	Yellow-Black

Class 1E isolating voltage regulating transformer TRF*IRT-ASP (orange-black) is used in the alternate shutdown panel room to supply nonsafety-related auxiliary loads during safe shutdown in the event of a single exposure fire.

MCC*2-E15	TRF*IRT-ASP	Orange-Black

Each Class 1E isolating voltage regulating transformer is fully qualified to IEEE Standard 323-1974, and is designed such that a continuous bolted short circuit on the secondary winding will not be reflected on the primary winding.

Regulating transformer output circuits are run in completely dedicated conduits, not only from the transformer secondary to its distribution panel but also from its assigned distribution panel to each individual load.

The regulating transformer supplying the alternate shutdown panel is an exception. The cables are either run in raceways containing circuits of 120 V ac or 125 V dc or in dedicated conduits.

8.3.1.1.18 Physical Arrangement of Class 1E Electrical Equipment

Class 1E electrical equipment is located so as to minimize potential damage commensurate with the in situ identified hazard in a particular area, as well as maintaining adequate separation from equipment of the redundant train or channel or from non-Class 1E equipment. Separation is achieved by physical distance when possible, location in separate rooms, or providing barriers if either of the preceding two methods is not attainable.

The location of all Class 1E equipment takes into account the ease of personnel access and the provision of adequate physical space for performing testing and maintenance as well as equipment removal.

Where practical, Class 1E electrical equipment is located away from mechanical equipment and piping in order to minimize damaging effects from pipe whip, pipe rupture, jet impingement, and internally-generated missiles propelled from rotating machinery. In addition, floor levels have adequate drainage provisions to preclude accumulation of fluids in the case of a pipe rupture.

Separation of major Class 1E equipment is as follows:

1. Unit station service and system station service transformers are located outdoors and are physically separated from each other, as shown on Figure 8.3-13. Each transformer is protected by a water deluge fire protection system. These protective measures ensure extinguishment of oil fires and confinement of the fire to one transformer. A crushed stone-filled sump is installed for each transformer and is capable of containing the volume of oil in the transformer. The main transformer is separated from each unit station service transformer by a firewall.

   Although these transformers are not classified as Class 1E equipment, careful attention is given to the design of these facilities to ensure reliable and continuous operation since these transformers provide normal and preferred sources of power to the Class 1E buses.

2. Separate rooms in the Seismic Category I service building at el 730 ft-6 in provide adequate separation for the redundant Class 1E 4,160 V switchgear buses and 480 V load centers. These rooms are located above the probable mean flood level. Piping containing fluids is excluded from these rooms. Rooms containing Train A equipment are separated from rooms containing Train B equipment by walls having a minimum 3-hour fire rating. Any failure, whether electrical or physical, in one room will not have any effect on the redundant equipment in the second room.

3. The Class 1E orange train (including red and blue channels) 120 V ac vital bus system equipment is located in the orange switchgear room at el 730 ft-6 in of the service building, and is physically separated by a minimum 3-hour fire rated wall from its purple (including white and yellow channel) counterpart.

4. The 480 V ac MCCs are located in areas of electrical load concentration. Redundant Class 1E MCCs are located within Seismic Category I structures and separated by location in separate rooms, on different floor elevations, or physically spaced apart to preclude a single failure from defeating the operation of both trains.

5. The Seismic Category I diesel generator building provides for separation between the redundant emergency diesel generator units in the building. This is accomplished by locating each diesel generator unit in a separate room, partitioned by a concrete wall designed to withstand a SSE, fire, or missiles. Each diesel generator unit and its associated starting equipment and auxiliaries are located in the same room. This arrangement results in a complete

system that is independent and isolated from the redundant diesel generator and its systems. Each diesel generator unit is provided with separate room ventilation air intake and air discharge openings, and independent engine inlet (combustion air) and engine exhaust ducts. Any single failure does not disable both diesel generator units or their auxiliary systems.

6. The arrangement of containment electrical penetrations provides access for connecting cables, leak testing during operation, and space for removal and replacement. Separation of penetrations meets independence criteria.

   Separate penetration are provided for high voltage and low voltage power, control, and instrumentation functions. The maximum possible separation between Class 1E electrical penetrations of redundant trains and any large piping penetration is provided to prevent damage from steam line or water line rupture.

8.3.1.1.19 Station Blackout (SBO) 4,160 V Cross-Tie

A cross-tie connecting the 4,160 V normal busses 1A, 1D, 2A, and 2D of BVPS-1 and BVPS-2, as shown on Figure 8.3-1 Sheet 1 of 2, provides the capability to power up either of the emergency busses at one unit from either of the emergency diesel generators (EDGs) at the other unit.

In conformance with the SBO Rule 10 CFR 50.63, BVPS utilizes the EDGs at each unit as an alternate AC (AAC) power source to operate systems necessary for the required SBO coping duration and recovery therefrom. With the cross-tie, BVPS can cope with a postulated total loss of offsite power to both units coincident with the loss of all onsite power (EDGs) at one unit, by enabling any single available EDG at either unit to supply power to the required SBO loads at both units within one hour.

The design of the SBO cross-tie circuit conforms with guidance provided by Regulatory Guide 1.155 and NUMARC 87-00. The circuit consists of four locally operated 4,160 V breakers installed at switchgear busses 1A, 1D, 2A, and 2D, and interconnected by 5 kV power cables protected against the effects of likely weather-related events. The normal to emergency 4,160 V bus connections, described in Sections 8.3.1.1.2 and 8.3.1.1.6, complete the circuit to the AAC power source.

The cross-tie between the normal 4,160 V busses is disconnected (breakers racked out) during normal plant operation and requires manual operator action to place into service during SBO conditions. Energization of the cross-tie and startup of equipment to cope with a SBO is administratively controlled and procedurally addressed by Emergency operating Procedures for BVPS-1 and BVPS-2.

8.3.1.2 Analysis

The onsite electrical power system (EPS) is designed to provide full capability and capacity to enable BVPS-2 to provide for normal plant operation, shutting down the reactor safely, maintaining a safe shutdown condition, and operating all essential BVPS-2 systems required for public safety under all normal, transient, and accident conditions.

The following general design bases apply:

1. Each of the two Class 1E emergency diesel generator units is fully capable of supplying all necessary power to each of the redundant Class 1E load groups which are essential to BVPS-2 safe shutdown and public safety.

2. Each of the two redundant Class 1E 4,160 V ac buses and electrically-connected downstream 480 V ac and 120 V ac buses are arranged such that they can be supplied from normal, preferred, or onsite emergency power sources.

3. The Class 1E electrical distribution system is designed to provide for an adequate voltage profile for all voltage levels of distribution, that is, 4,160 V ac, 480 V ac, 120 V ac, and 125 V dc under all normal, transient, and accident conditions.

4. All Class 1E electrical equipment is properly identified, as addressed in Section 8.3.1.3.

5. Figure 8.3-1 depicts 4,160 V ac and 480 V ac (unit substations) Class 1E electrical loads. It demonstrates the provisions of ac power system redundancy features as stipulated by redundant electrical load power assignments.

6. All Class 1E electrical equipment is designed and manufactured to provide for testing, maintenance, and surveillance. Critical instrumentation, which monitors equipment and bus status, is also provided as addressed in Section 8.3.1.10.

7. Physical arrangements, hostile environments, and independence of Class 1E equipment are addressed in Sections 8.3.1.1.18, 8.3.1.2.3, and 8.3.1.4, respectively.

8.3.1.2.1 Compliance

Compliance with General Design Criterion 2

The Class 1E ac power system is housed in structures that are designed to, and are capable of, withstanding the effects of natural phenomena such as earthquakes, tornados, hurricanes, and floods without loss of capability to perform its functions.

Compliance with General Design Criterion 4

The Class 1E ac power system is designed to accommodate the effects of the environmental conditions associated with normal operation and postulated accidents, and the structures the system is housed in are protected against internally and externally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks such that safety functions will not be precluded.

Compliance with General Design Criterion 5

The Class 1E ac power system is designed in accordance with this criterion, as it relates to the capability of systems and components important to safety being capable of performing required safety functions including an ordinary shutdown and cooldown of BVPS-2. The BVPS-2 Class 1E ac power system is not shared between any nuclear power plants.

Compliance with General Design Criterion 17

The onsite EPS is designed with sufficient capacity, capability, electrical independence, and redundancy (Sections 8.3.1 and 8.3.2) to ensure adequate performance of all necessary safety functions in the event of postulated accidents while assuming a single failure.

The offsite EPS is also designed and provided with adequate capacity and capability (Sections 8.1 and 8.2) to assure the same safety function performances.

The design of the onsite power system provides required independence and redundancy for all voltage levels, including 4,160 V ac, 480 V ac, 125 V dc, and 120 V ac, to ensure an available source of power to all Class 1E loads.

The offsite power system provides for two physically independent circuits with a common switchyard. The design is such as to provide for an adequate power supply, with careful consideration as to minimizing simultaneous failure under operating and postulated accident and environmental considerations. For example, transmission towers are located so that the failure of one tower will not affect towers of the alternate circuit. These systems are designed, and protective relaying and control features are included, so that a failure in one of these sources will not cascade into and degrade the remaining available EPS.

Compliance with General Design Criterion 18

All Class 1E power systems and their associated equipment are designed and manufactured to permit onsite inspection and testing.

Periodic testing is performed on a regularly scheduled basis to demonstrate the operability and continuity of all Class 1E systems and components. Testing of the onsite Class 1E emergency diesel generator units, which will be in accordance with Regulatory Guide 1.108, is addressed in Section 8.3.1.1.15.

All periodic testing and inspection will be performed with full integrity and availability of the entire Class 1E power systems in conformance with the bypassed or deliberately inoperable status requirements of Regulatory Guide 1.47.

Periodic testing and maintenance will be performed for all Class 1E protection systems in conformance with the requirements of Regulatory Guide 1.118.

Compliance with Regulatory Guide 1.6

The design of the onsite electrical safety-related (Class 1E) power systems is in compliance with Regulatory Guide 1.6. The Class 1E loads for all BVPS-2 voltage levels, that is, 4,160 V ac, 480 V ac, 120 V ac, and 125 V dc, are separated into redundant and completely independent load groups. Manual and automatic interconnections between buses and loads, interconnections between safety-related (Class 1E) and nonsafety-related (non-Class 1E) buses, automatic loading and stripping of buses, and independence of redundant systems are fully described in Sections 8.3.1.1.4, 8.3.1.1.5, 8.3.1.1.8, and 8.3.1.4, respectively.

The 125 V dc Class 1E system includes four battery and battery charger combinations, with redundant dc load groups specifically assigned to each dc bus without automatic connection to any other load group.

Each of the two emergency diesel generator units (Section 8.3.1.1.15) is completely redundant, physically and electrically separated relative to the other, and is connected exclusively to its designated 4,160 V ac Class 1E bus. This design ensures complete independence for the onsite emergency power sources.

Compliance with Regulatory Guide 1.9

Diesel-generator units used as onsite electric power systems at BVPS-2 have been selected, designed, and qualified following the guidance of this Regulatory Guide with the following clarifications:

The Class 1E diesel generators have been procured in compliance with IEEE Standard 387-1977 with the following clarifications:

1. Section 4.1(8): The BVPS-2 Class 1E diesels are qualified utilizing the mild environment concept acknowledged by 10 CFR 50.49(c).

2. Section 4.1(12): The BVPS-2 Class 1E diesels are seismically qualified in accordance with IEEE Standard 344-1971.

3. Section 5.4: The BVPS-2 Class 1E diesels are qualified utilizing the mild environment concept acknowledged by 10CFR50.49(c).

4. Section 6.3.1: All required tests or analyses have been performed by the manufacturer with the exception of the 2-hour short-time/22-hour continuous rating test. This test will be performed at the site in accordance with Section 6.3.1 and the loading sequence specified in Paragraph C.14 of Regulatory Guide 1.9.

Compliance with Regulatory Guide 1.32

The design of the safety-related (Class 1E) power systems is in compliance with Regulatory Guide 1.32. Two immediate access circuits are provided for the preferred (offsite) power sources from the transmission network. Each circuit is electrically connected and energized from the common switchyard and available at all times.

Each battery charger that supplies Class 1E 125 V dc systems is designed with full capacity and capability to supply the largest combined demands of the various steady state loads, while simultaneously providing sufficient power to restore the battery from the design minimum charged state to the fully charged state, irrespective of the BVPS-2 status during which these demands occur.

Periodic test methods, procedures, and intervals for all Class 1E battery performance discharge and service tests will be in compliance with IEEE Standard 450-1980.

Independence of redundant standby sources is addressed in Sections 8.3.1.2.1 and 8.3.1.1.15.

Connection of non-Class 1E equipment to Class 1E systems is addressed in Sections 8.3.1.1.5, 8.3.1.1.15, and 8.3.1.2.1.

Selection of diesel generator set capacity for emergency power supply is addressed in Section 8.3.1.1.15.

Compliance with Regulatory Guide 1.63

Each containment electrical penetration is protected for loss of mechanical integrity for all possible values of current which can flow through the penetration. This includes all possible values of overload and short circuit currents.

Where values of overload and short circuit currents are calculated or determined to fall within the thermal limits of the penetration, the penetration is deemed to be self-protecting.

Where overload and short circuit currents are in excess of the thermal capability of a penetration, two overcurrent protective devices (primary and backup) are provided. These devices provide reliable protection given a single random failure of one of these protective devices. These devices consist of existing protection devices or additional devices when necessary, are qualified for their intended purpose, and are mechanically and electrically independent with the exception of the 4,160 V residual heat removal motor circuits, which require the same dc control power source.

The modifications cited in Sections C.2 and C.3 of Regulatory Guide 1.63 to Paragraph 4.2.4, Rated Short-Circuit Current and Duration, of IEEE Standard 317-1976; the supplement cited in Section C.4 of Regulatory Guide 1.63 to Paragraph 6.4.4, Dielectric Strength Test, and the corrections (Sections C.5 and C.6), are all included in the component design requirements. The design and construction of the penetrations satisfy the requirements of this Regulatory Guide except that an ASME Code data report, (ANI) third party inspection, and ASME Code stamping of the penetrations are not required as the penetrations are an extension of the containment liner boundary which is not code stamped as discussed in section 3.8.1.2.1.2.

Compliance with Regulatory Guide 1.75

The design features of BVPS-2 provide independence of redundant Class 1E ac systems and are fully discussed in Section 8.3.1.4.

Compliance with Regulatory Guide 1.81

The design of the BVPS-2 emergency and shutdown electric systems is in compliance with Regulatory Guide 1.81.

Compliance with Regulatory Guide 1.89

The BVPS-2 qualification of Class 1E electric equipment is addressed in Section 3.11 for compliance with Regulatory Guide 1.89 and IEEE Standards 323-1971 and 323-1974.

Class 1E distribution equipment, interconnecting the backup pressurizer heater groups A,B,D, and E, and the pressurizer relief and block valves with the emergency power sources, is qualified in accordance with regulatory guide and cited standards, thus satisfying the safety grade requirements imposed by NUREG-0737 (USNRC 1980), Items II.E.3.1, Position 4, and II.G.1, Position 3.

Compliance with Regulatory Guide 1.93

The availability of the BVPS-2 electric power sources is in compliance with Regulatory Guide 1.93.

Compliance with Regulatory Guide 1.100

All components, cables, and raceways for Class 1E a-c power system are specified and seismically qualified in accordance with the alternate acceptable program outlined in Section 3.10.

As discussed in Section 3.2.1, all non-Class 1E components in areas where Class 1E components and nuclear safety-related equipment are located are seismically supported where potential interaction exists.

Compliance with Regulatory Guide 1.108

Periodic testing of emergency diesel generator units will be performed in accordance with this document, as discussed in Sections 8.3.1.1.12 and 8.3.1.1.15.

Compliance with Branch Technical Position ICSB 18

Manually-controlled, electrically-operated safety class valves, for which power is removed, are listed in Table 8.3-5. All of these valves, except for the hydrogen control system isolation valve 2HCS*MOV110A are controlled from the main control room. Power is removed from all of these valves to meet single failure criterion. Redundant position indication is provided in the main control room for all of these valves except for the HCS valves and the charging pump minimum flow header isolation valve (2CHS*MOV373).

The HCS valves are controlled from remote electrical control stations in the plant and are closed during normal and post-accident operation. The only time the HCS valves are intended to be open is for testing purposes during normal plant operation. To ensure that spurious opening of the subject valves does not cause failure of the hydrogen control system to perform its safety function in a post-accident condition, an administrative procedure will be implemented to require that the valve breakers are maintained de-energized during normal and post-accident modes of operation.

There is no accident or operational event which requires the charging pump minimum flow header isolation valve (2CHS*MOV373) to be closed. To ensure that spurious closing does not isolate the charging pump minimum flow and cause failure of the charging pumps during an accident, an administrative procedure will be implemented to require that the valve handwheel is locked and the valve breakers are maintained de-energized and locked during normal and post-accident modes of operation.

Further discussion of the functions of these valves is provided in the sections cross-referenced in Table 8.3-5.

8.3.1.2.2 Analysis of Uninterruptible AC Electric Power System

The Class 1E 120 V ac vital bus UPS, which provides power to Class 1E instrumentation and control circuits, is designed to the same criteria as that for the onsite Class 1E ac power system.

Redundant vital buses are provided to meet the redundancy requirements of the safety class instrument and control circuit loads served. No more than four divisions of redundant UPS loads occur in the BVPS-2 design. The UPS, the 125 V dc support system supplying backup power to the vital buses, the alternate regulating transformer sources, and the instrumentation and control cable raceways all have four redundant subsystems, corresponding to the degree of redundancy in the UPS loads.

The failure of any BVPS-2 equipment that could damage a component in one of the vital buses will not, by virtue of design provisions, including final component location and protection, involve a redundant vital bus. This is true of the final raceway design as well. Components of the UPS are specified and qualified to operate without damage during and after a design basis earthquake, and are qualified for the environment occurring within the structure that contains them. Therefore, a component failure as a result of exposure to an external hazard would only affect that component, the event being a single random failure.

Each vital bus has non-Class 1E as well as Class 1E loads connected to it. The non-Class 1E loads are important to BVPS-2 monitoring and control, although not required for BVPS-2 safety. These non-Class 1E loads are segregated by an isolating Class 1E circuit breaker and a regulating transformer. The non-Class 1E loads are supplied from their own distribution panel. In addition, an electrical failure in one vital bus (short circuit, open circuit, or electrical transient) will not influence a redundant vital bus by virtue of the isolating features of the vital bus inverters and the alternate regulating transformer supply. Further analysis on the separation provisions for independence of equipment, cables, and raceways is found in Section 8.3.1.4.

Determination of the capacity requirements of the 125 V dc Class 1E battery systems includes a power requirement in the 2-hour duty cycle representing the required supply to the vital bus inverters.

The inverter output requirements for UPS*VITBS2-1, UPS*VITBS2-2, UPS*VITBS2-3 and UPS*VITBS2-4 have been verified by calculation. UPS*VITBS2-1 and UPS*VITBS2-2 fall within their 20 kVA output rating. UPS*VITBS2-3 and UPS*VITBS2-4 fall within their 15 kVA output rating. Furthermore, sufficient capacity exists to supply a future load increase, if required, for each of the vital buses.

The alternate supply transformers are sized accordingly at 20 kVA and 15 kVA output. The other system regulating transformers, serving non-Class 1E loads, are specified with capacities of 10.0 kVA. The total connected non-Class 1E loads do not exceed 5.5 kVA. Also, cables are sized to correspond to the distribution breaker rating and allowable voltage drop limit. This assures sufficient voltage at the load. In general, voltage drop in the cable (from the distribution panel to the load) is confined to 1 percent. Final routing of cables (from distribution panels to the load) is controlled by a computer program. Routing includes circuit assignment to cable tray, conduit, junction boxes, etc, and does not allow, by program design, the sharing of a raceway with non-Class 1E cables or redundant color coded cables. Circuit routings have been sampled and verified for conformance with regard to the prescriptive implementation of separation requirements. Redundant components, cables, and raceways are uniquely identified by a mark number which includes a distinguishing color code. The color code is visually apparent as well.

Ventilation systems supporting the UPS equipment and circuits (Sections 9.4.1, 9.4.3, and 9.4.10) maintain temperature conditions between 55°F and 104°F, a range cited and integrated into the design requirements of relevant equipment performance specifications. Any single failure in a ventilation system will not preclude the system's function. It is 100 percent redundant and satisfies independence criteria.

The buildings and structures housing the UPS (service building, control building, cable tunnels, safeguards area, auxiliary building, fuel building, and cable vault) are Seismic Category I designed structures, and provide a controlled environment for the UPS equipment, to which the latter is qualified. This environment is fully described in Chapter 3.

The vital bus system load assignments and provisions for future connected loads are tabulated as part of a calculation to determine the sizing of the vital bus system. Correct final load assignments (proper correspondence between the safety class load and its designated vital bus source) have been confirmed utilizing this table.

Pre-operational and initial system testing will be specified in accordance with Regulatory Guides 1.41 and 1.68, and GDC 1. In addition, periodic onsite testing programs permit integral testing when the station is in operation, in accordance with Regulatory Guides 1.22 and 1.47. The test program capabilities satisfy the requirements of GDC 18 and 21. Any one of the vital bus inverters can be removed for testing without diminishing the system's ability to perform its safety functions. Also any battery charger can be removed for maintenance and replaced by a spare charger. The alternate source regulating transformers can be isolated for testing without limiting the capability of the UPS.

The following instrumentation and monitoring devices provide system surveillance capability: an output voltmeter, ammeter, and a frequency meter for each inverter (detect inverter trouble); an elapsed time meter to indicate total operating time of the inverter (facilitate performance of scheduled maintenance); alarms for abnormal conditions including inverter low output voltage, low output current, and loss of cooling air to the inverter (provide system information to main control room operator); undervoltage and overvoltage alarms on each vital bus and voltage transducers on each distribution panel (provide continuous vital bus voltage indication and monitoring to the main control room operation).

The UPS equipment and cable are qualified to the most severe credible hostile environment in the equipment's location, including seismic conditions, radiation, thermal excursions, pressure, and temperature conditions, all assumed to occur at the end of the component's design life. Components are qualified to function for the required duration of the design basis conditions. The active UPS electrical equipment is located in the service building, a structure which protects the equipment and limits its exposure to moderate accident levels of radiation, temperature, and humidity.

8.3.1.2.3 Class 1E Equipment in a Hostile Environment

Class 1E equipment in a hostile environment is discussed in Section 3.11.

8.3.1.3 Physical Identification of Safety-Related Equipment

The identification scheme for the onsite safety-related (Class 1E) power system equipment, for cable/raceway equipment, and for terminal equipment is designed to ensure:

1. Marking permanence,

2. That the safety classification of equipment can be readily obtained,

3. That component designations clearly identify which unit the component serves,

4. That any association of non-Class 1E equipment with Class 1E equipment is revealed,

5. The unique distinction of redundant safety class cables, raceways, and components providing redundant channel, divisions, or train functions,

6. The clear identification of non-safety cables by the letter "N", and

7. The identification of safety class wiring that is internal to the main control board.

The identification method was implemented during design, construction, and testing operations and supports the evaluation of system availability, goals during operations, and the performance of maintenance tasks. The identification method includes the following:

1. Color Coding Channels and Trains

   a. Channels are identified as follows:

      Channel I: red color and code letter "R"

      Channel II: white color and code letter "W"

      Channel III: blue color and code letter "B"

      Channel IV: yellow color and code letter "Y"

   b. Trains are identified as follows:

      Train A: orange color and code letter "O"
      (includes post-accident monitoring (PAM) Channel 1)

      Train B: purple color and code letter "P"
      (includes post-accident monitoring (PAM) Channel 2)

      Train C: green color and code letter "G"

2. Identification of Cables

All exposed safety-related cables are color coded at intervals not exceeding 15 ft. In addition, a permanent color coded tag containing a ten character cable code designation is attached to each end of the cable. The sixth character of the code identifies the redundant train associated with the cable.

3. Raceways

The raceway code designation is a seven to nine character alphanumeric code with each part indicating specific information, such as unit number, raceway type, service level, raceway identification number, and color code.

Tray identification is by alphanumeric markings applied on the outside of tray side rails on one side, where practical, and in such locations as to be readily visible from the floor. Markers are provided at each designated end of each tray section, and at points of entry to and exiting from enclosed areas, except that a tray section 8 ft or less in length will have markers at the midpoint of the section with a vertical black line marker at each end to identify section extremities. For each tray section longer than 50 ft, additional markers are located at or near midpoint to provide identification not more than 50 ft apart. Trays identified as Class 1E have color coded redundancy markers adjacent to each tray identification marker and at intervals not exceeding 15 ft.

Alphanumeric identification markings are applied to all floor sleeves and wall sleeves in such a manner as to be readily visible. Alphanumeric identification markings are required at each end of each scheduled conduit and at each end of each conduit through which scheduled cable is routed, except when a conduit is 8 ft or less in length and both ends are visible where only one marker is used in approximately the middle of the conduit run. Each conduit that carries cables servicing Class 1E equipment has a colored marker adjacent to each conduit identification marker at intervals not exceeding 15 ft, and at points of entry from and exit enclosed areas. For floors and wall sleeves, an identification marker is applied adjacent to each end of each sleeve. Each sleeve that carries cables serving Class 1E equipment has a colored marker adjacent to each identification marker.

4. Electrical Equipment

All major Class 1E electrical equipment has attached to it an equipment identification number. The Asset Equipment List (AEL) is used to cross-reference the equipment identification number to the QA category of the component. Color coding following the equipment identification number identifies the assigned train.

8.3.1.4 Independence of Redundant Systems

8.3.1.4.1 Principal Criteria

The principal design criterion that establishes the minimum requirements for preserving the independence of redundant Class 1E power systems through physical arrangement and separation and for ensuring the minimum required equipment availability during any design basis event (Class 1E power system and design basis event are defined in IEEE Standard 308-1974) is as follows:

Class 1E electrical equipment is physically and electrically separated from its redundant counterpart or mechanically protected, as required, to prevent the occurrence of common mode failures. Separation of equipment is maintained to prevent loss of redundant features from single failures.

8.3.1.4.2 Equipment, Raceway, and Cable (in air) Considerations

Design features of the major Class 1E system components which ensure conformance to the design bases are described below.

The safety-related portions of the onsite ac power system are divided into two load groups (trains). The safety-related actions of each load group are redundant and independent of the safety actions provided by its redundant counterpart.

Redundant safety-related systems are not subject to common mode failure through failure of the ventilation systems. The ventilation systems are discussed in Section 9.4.

Redundant safety-related systems are located in fire protected areas. The fire protection features for these areas are described in the Fire Safety Analysis, Volume 2-2.

Safety-related equipment in all plant areas is either protected from automatic fire protection effluents or, on the basis of test data, has demonstrated its operability in the environment that may be caused by the fire protection effluents.

Redundant safety-related systems (including cable, electrical equipment, actuated equipment, sensors, and sensor to processor connections) are located in protected areas. Missile protection is discussed and analyzed in Section 3.5. Flood protection is discussed and analyzed in Sections 3.4 and 3.11. Protection against postulated pipe rupture is discussed and analyzed in Section 3.6. Seismic design is discussed and analyzed in Sections 3.7 and 3.10. Wind, hurricane, and tornado protection is discussed and analyzed in Section 3.3. Environmental (normal and postulated accident) design is discussed and analyzed in Section 3.11. Protection from rain, ice, snow, and lightning is inherent in both station building and electrical system design.

The design criteria for redundant safety-related systems ensure that no single equipment maintenance outage, equipment malfunction, or operator action will prevent a safety-related system from performing its intended safety function.

The loss of the preferred power supply in conjunction with any postulated natural phenomenon will not prevent a safety-related system from performing its intended safety function.

The independence of the redundant safety-related systems is preserved by physical as well as electrical separation.

Separation is accomplished as follows:

1. The emergency generator, switchgear, load centers, motor control centers, and distribution panels associated with one safety-related train are physically separated from their redundant counterparts of the other safety-related train as discussed in Section 8.3.1.1.

2. The physical description of the containment electrical penetration areas is discussed in Section 8.3.1.1.16.

3. Associated circuits in accordance with Regulatory Guide 1.75 are identified with the same color code as, and meet all the requirements of, the Class 1E circuit with which they are associated up to and including an isolation device. Beyond the isolation device they are identified as nonsafety-related.

4. The minimum separation distance between redundant Class 1E cables and between Class 1E cables and non-Class 1E cables is:

General Plant Areas (GPA)

(Refer to Table 8.3-6 for specific areas)

5 feet vertically (l" vertically for lighting fixture drops)
1 foot horizontally (l" horizontally for lighting fixture drops)

Cable Spreading Areas (CSA)

(Main control room, cable spreading room, and computer room)

3 feet vertically (l" vertically for lighting fixture drops)
1 foot horizontally (l" horizontally for lighting fixture drops)

The vertical spacing distance between trays is measured from the top of the side rail of the lower tray to the bottom of the side rail of the upper tray. The horizontal spacing distance between trays is measured from outside of side rail flange to outside of side rail flange.

In general, the minimum vertical free air space between trays is 8 inches.

Where a plant arrangement precludes the minimum separation distance, actual installations conform to one of the acceptable arrangements listed below. These acceptable arrangements between redundant Class 1E cables and between Class 1E and non-Class 1E cables is achieved by maintaining lesser distances in conjunction with the use of tray covers, enclosed raceway, protective wraps, or barriers.

Acceptable arrangements are as follows:

a. Tray to Tray Separation

1. In the GPA, where a 1 inch minimum vertical free air space is maintained between redundant Class 1E trays, a tray cover on the top of the lower tray or a tray cover on the bottom of the upper tray is installed.

2. In the GPA, where a 1 inch minimum horizontal free air space is maintained between redundant Class 1E trays, tray covers top and bottom of one of the trays are installed.

3. In the GPA, where a 1 inch minimum vertical free air space is maintained between non-Class 1E and Class 1E, a tray cover on the top of the lower tray or a tray cover on the bottom of the upper tray is installed.

4. In the GPA, where a 1 inch minimum horizontal free air space is maintained between non-Class 1E and Class 1E trays, tray covers on the top and bottom of one of the trays are installed.

5. In the GPA, where a 1 inch minimum horizontal free air space is maintained between a Class 1E tray running vertically and a redundant Class 1E tray running horizontally, a tray cover on either tray is installed. A tray cover is installed on the vertical tray, extending continuously for a minimum of 1 foot beyond the top and bottom of the horizontal tray; or a tray cover is installed on the top of the horizontal tray, extending continuously for a minimum of 1 foot beyond each side of the vertical tray.

6. In the GPA, where a 1 inch minimum horizontal free air space is maintained between a Class 1E tray running vertically and a non-Class 1E tray running horizontally, a tray cover on either tray is installed. A tray cover is installed on the vertical tray, extending continuously for a minimum of 1 foot beyond the top and bottom of the horizontal tray; or a tray cover is installed on the top of the horizontal tray, extending continuously for a minimum of 1 foot beyond each side of the vertical tray.

7. In the GPA, where a 1 inch minimum horizontal free air space is maintained between a non-Class 1E tray running vertically and a Class 1E tray running horizontally, a tray cover on either tray is installed. A tray cover is installed on the vertical tray, extending continuously for a minimum of 1 foot beyond the top and bottom of the horizontal tray; or a tray cover is installed on the top of the horizontal tray, extending continuously for a minimum of 1 foot beyond each side of the vertical tray.

8. In the CSA, where a 1 inch minimum vertical free air space is maintained between redundant Class 1E trays, a tray cover on the bottom of the upper tray or on the top of the lower tray is installed.

9. In the CSA, where a 1 inch minimum horizontal free air space is maintained between redundant Class 1E trays, tray covers on the top and bottom of one of the trays are installed.

10. In the CSA, where a 1 inch minimum vertical free air space is maintained between a non-Class 1E tray and a Class 1E tray, a tray cover on the bottom of the upper tray or a tray cover on the top of the lower tray is installed.

11. In the CSA, where a 1 inch minimum horizontal free air space is maintained between non-Class 1E and Class 1E trays, tray covers on the top and bottom of one of the trays are installed.

12. In the CSA, where a 1 inch minimum horizontal free air space is maintained between a Class 1E tray running vertically and a redundant Class 1E tray running horizontally, a tray cover on either tray is installed.

13. In the CSA, where a 1 inch minimum horizontal free air space is maintained between a Class 1E tray running vertically and a non-Class 1E tray ruining horizontally, a tray cover on either tray is installed.

14. In the CSA, where a 1 inch minimum horizontal free air space is maintained between a non-Class 1E tray running vertically and a Class 1E tray running horizontally, a tray cover on either tray is installed.

15. In the GPA, where a 1 inch minimum vertical free air space is maintained between a Class 1E tray and a redundant Class 1E tray which cross in a vertical plane, a tray cover on the top of the lower tray or on the bottom of the upper tray is installed as described below. A tray cover is installed on the bottom of the upper tray, extending continuously for a minimum of 1 foot beyond each side of the lower tray; or a tray cover is installed on the top of the lower tray, extending continuously for a minimum of 1 foot beyond each side of the upper tray.

16. In the GPA, where a 1 inch minimum vertical free air space is maintained between a Class 1E tray and a non-Class 1E tray which cross in a vertical plane, a tray cover on the top of the lower tray or on the bottom of the upper tray is installed as described below. A tray cover is installed on the bottom of the upper tray, extending continuously for a minimum of 1 foot beyond each side of the lower tray; or a tray cover is installed on the top of the lower tray, extending continuously for a minimum of 1 foot beyond each side of the upper tray.

17. In the GPA, where a 1 inch minimum vertical free air space is maintained between a non-Class 1E tray and a Class 1E tray which cross in a vertical plane, a tray cover on the top of the lower tray or on the bottom of the upper tray is installed as described below. A tray cover is installed on the bottom of the upper tray, extending continuously for a minimum of 1 foot beyond each side of the lower tray; or a tray cover is installed on the top of the lower tray, extending continuously for a minimum of 1 foot beyond each side of the upper tray.

18. In the CSA, where a 1 inch minimum vertical free air space is maintained between a Class 1E tray and a redundant Class 1E tray which cross in vertical plane, a tray cover on the top of the lower tray or on the bottom of the upper tray is installed as described below. A tray cover is installed on the bottom of the upper tray, extending continuously for a minimum of 1 foot beyond each side of the lower tray; or a tray cover is installed on the top of the lower tray, extending continuously for a minimum of 1 foot beyond each side of the upper tray.

19. In the CSA, where a 1 inch minimum vertical free air space is maintained between a Class 1E tray and a non-Class 1E tray which cross in a vertical plane, a tray cover on the top of the lower tray or on the bottom of the upper tray is installed as described below. A tray cover is installed on the bottom of the upper tray, extending continuously for a minimum of 1 foot beyond each side of the lower tray; or a tray cover is installed on the top of the lower tray, extending continuously for a minimum of 1 foot beyond each side of the upper tray.

20. In the CSA, where a 1 inch minimum vertical free air space is maintained between a non-Class 1E and a Class 1E tray which cross in a vertical plane, a tray cover on the top of the lower tray or on the bottom of the upper tray is installed as described below. A tray cover is installed on the bottom of the upper tray, extending continuously for a minimum of 1 foot beyond each side of the lower tray; or a tray cover is installed on the top of the lower tray, extending continuously for a minimum of 1 foot beyond each side of the upper tray.

21. In the CSA and the GPA, where a 1 inch minimum vertical free air space is maintained between Class 1E multi-stack trays and either redundant Class 1E multi-stack trays or non-Class 1E multi-stack trays, a tray cover is installed on the top of the lower multi-stack trays; or a tray cover is installed on the bottom of the upper multi-stack trays.

    In the above cases, where tray covers are not used; a barrier is provided per IEEE Standard 384-1974, Figure 2, 3, or 4.

b. Tray to Conduit Separation

1. In the GPA, vertical separation between a Class 1E tray and a redundant Class 1E conduit may be reduced to 1 inch.

2. In the GPA, vertical separation between a Class 1E conduit and a redundant Class 1E tray may be reduced to 1 inch.

3. In the GPA, horizontal separation between a Class 1E conduit and a redundant Class 1E tray may be reduced to 1 inch.

4. In the GPA, vertical separation between a Class 1E tray and a non-Class 1E conduit may be reduced to 1 inch.

5. In the GPA, vertical separation between a Class 1E conduit and a non-Class 1E tray may be reduced to 1 inch.

6. In the GPA, horizontal separation between a Class 1E conduit and a non-Class 1E tray may be reduced to 1 inch.

7. In the GPA, vertical separation between a non-Class 1E tray and a Class 1E conduit may be reduced to 1 inch.

8. In the GPA, vertical separation between a non-Class 1E conduit and a Class 1E tray may be reduced to 1 inch.

9. In the GPA, horizontal separation between a non-Class 1E conduit and Class 1E tray may be reduced to 1 inch.

10. In the CSA, vertical separation between a Class 1E tray and a redundant Class 1E conduit may be reduced to 1 inch.

11. In the CSA, vertical separation between a Class 1E conduit and a redundant Class 1E tray may be reduced to 1 inch.

12. In the CSA, horizontal separation between a Class 1E conduit and a redundant Class 1E tray may be reduced to 1 inch.

13. In the CSA, vertical separation between a Class 1E tray and a non-Class 1E conduit may be reduced to 1 inch.

14. In the CSA, vertical separation between a Class 1E conduit and a non-Class 1E tray may be reduced to 1 inch.

15. In the CSA, horizontal separation between a Class 1E conduit and a non-Class 1E tray may be reduced to 1 inch.

16. In the CSA, vertical separation between a non-Class 1E tray and a Class 1E conduit may be reduced to 1 inch.

17. In the CSA, vertical separation between a non-Class 1E conduit and a Class 1E tray may be reduced to 1 inch.

18. In the CSA, horizontal separation between a non-Class 1E conduit and a Class 1E tray may be reduced to 1 inch.

c. Conduit to Conduit Separation

In the GPA and CSA, separation between Class 1E and redundant Class 1E conduit or Class 1E and non-Class 1E conduit may be reduced to 1 inch.

d. Cable in Air to Cable in Air Separation (including lighting fixture drops)

1. In the GPA, where cables are appropriately grouped together and either Class 1E group is installed in conduit or enclosed in protective wrap, separation between the redundant Class 1E cables may be reduced to 1 inch.

2. In the GPA, where cables are appropriately grouped together and both Class 1E groups are enclosed in a protective wrap, separation between the redundant Class 1E cables may be reduced to 0 inches.

3. In the GPA, where cables are appropriately grouped together and the non-Class 1E group is installed in conduit or enclosed in a protective wrap, separation between the Class 1E cables and the non-Class 1E cables may be reduced to 1 inch.

4. In the GPA, where cables are appropriately grouped together and are enclosed in a protective wrap, separation between Class 1E cables and non-Class 1E cables may be reduced to 0 inches.

5. In the GPA, where cables are appropriately grouped together and the Class 1E group is installed in conduit or enclosed in a protective wrap, separation between the non-Class 1E cable and the Class 1E cable may be reduced to 1 inch.

6. In the GPA, where cables are appropriately grouped together and are enclosed in a protective wrap, separation between non-Class 1E cables and Class 1E cables may be reduced to 0 inches.

7. In the CSA, where cables are appropriately grouped together and either Class 1E group is installed in a conduit or enclosed in a protective wrap, separation between redundant Class 1E cables may be reduced to 1 inch.

8. In the CSA, where cables are appropriately grouped together and both Class 1E groups are enclosed in a protective wrap, separation between redundant Class 1E cables may be reduced to 0 inches.

9. In the CSA, where cables are appropriately grouped together and the non-Class 1E group is installed in conduit or enclosed in a protective wrap, separation between the Class 1E cables and the non-Class 1E cables may be reduced to 1 inch.

10. In the CSA, where cables are appropriately grouped together and are enclosed in a protective wrap, separation between Class 1E cables and non-Class 1E cables may be reduced to 0 inches.

11. In the CSA, where cables are appropriately grouped together and the Class 1E group is installed in conduit or enclosed in a protective wrap, separation between the non-Class 1E cables and the Class 1E cables may be reduced to 1 inch.

12. In the CSA, where cables are appropriately grouped together and are enclosed in a protective wrap, separation between non-Class 1E cables and Class 1E cables may be reduced to 0 inches.

    In the above cases, where conduit or protective wraps are not used, a barrier is provided in accordance with IEEE Standard 384-1974, Figure 2, 3, or 4.

e. Cable in Air to Tray Separation (including lighting fixture drops)

1. In the GPA, where a 1 inch minimum vertical free air space is maintained between redundant Class 1E trays and a tray cover is installed on the top of the lower tray (in accordance with item a.1 above), where a cable enters the upper tray, separation between the Class 1E cable and the redundant Class 1E tray may be reduced to 1 inch.

2. In the GPA, where a 1 inch minimum vertical free air space is maintained between redundant Class 1E trays and a tray cover is installed on the top of the lower tray (in accordance with item a.1 above), where a cable enters the upper tray and is enclosed in a protective wrap, separation between the Class 1E cable and the redundant Class 1E cable tray may be reduced to 0 inches.

3. In the GPA, where a 1 inch minimum vertical free air space between Class 1E and non-Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.3 above), where a Class 1E cable enters the Class 1E tray, separation between the Class 1E cable and the non-Class 1E tray may be reduced to 1 inch.

4. In the GPA, where a 1 inch minimum vertical free air space between Class 1E and non-Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.3 above), where a Class 1E cable enters the Class 1E tray and is enclosed in a protective wrap, separation between the Class 1E cable and the non-Class 1E tray may be reduced to 0 inches.

5. In the GPA, where a 1 inch minimum vertical free air space between non-Class 1E and Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.3 above), where a non-Class 1E cable enters the non-Class 1E tray, separation between the non-Class 1E cable and the Class 1E tray may be reduced to 1 inch.

6. In the GPA, where a 1 inch minimum vertical free air space between non-Class 1E and Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.3 above), where a non-Class 1E cable enters the non-Class 1E tray and is enclosed in a protective wrap, separation between the non-Class 1E cable and the Class 1E tray may be reduced to 0 inches.

7. In the CSA, where a 1 inch minimum vertical free air space is maintained between redundant Class 1E trays and a tray cover is installed on the top of the lower tray (in accordance with item a.8 above), where a cable enters the upper tray, separation between the Class 1E cable and the redundant Class 1E tray may be reduced to 1 inch.

8. In the CSA, where a 1 inch minimum vertical free air space is maintained between redundant Class 1E trays and a tray cover is installed on the top of the lower tray (in accordance with item a.8 above), where a cable enters the upper tray and is enclosed in a protective wrap, separation between the Class 1E cable and the redundant Class 1E cable tray may be reduced to 0 inches.

9. In the CSA, where a 1 inch minimum vertical free air space between Class 1E and non-Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.10 above), where a Class 1E cable enters the Class 1E tray, separation between the Class 1E cable and the non-Class 1E tray may be reduced to 1 inch.

10. In the CSA, where a 1 inch minimum vertical free air space between Class 1E and non-Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.10 above), where a Class 1E cable enters the Class 1E tray and is enclosed in a protective wrap, separation between the Class 1E cable and the non-Class 1E tray may be reduced to 0 inches.

11. In the CSA, where a 1 inch minimum vertical free air space between non-Class 1E and Class 1E trays is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.10 above), where a non-Class 1E cable enters the non-Class 1E tray, separation between the non-Class 1E cable and the Class 1E tray may be reduced to 1 inch.

12. In the CSA, where a 1 inch minimum vertical free air space between non-Class 1E and Class 1E tray is maintained and a tray cover is installed on the top of the lower tray (in accordance with item a.10 above), where a non-Class 1E cable enters the non-Class 1E tray and is enclosed in a protective wrap, separation between the non-Class 1E cable and the Class 1E tray may be reduced to 0 inches.

    In either the GPA or the CSA, where less than one foot horizontal separation is not maintained between a redundant tray or cable, the distance may be decreased to 1 inch minimum if either the cable is enclosed in protective wrap or the tray is totally enclosed. This distance may be decreased to 0 inch if the cable is enclosed in protective wrap and the tray is totally enclosed. The above minimum distances are required between the cable and tray if both the cable and tray are redundant Class 1E or either the cable or tray is Class 1E and the other is non-Class 1E.

f. Cable in Air to Conduit Separation (including lighting fixture drops)

1. In the GPA, separation between Class 1E cables and a redundant Class 1E conduit may be reduced to 1 inch.

2. In the GPA, separation between Class 1E cables and a non-Class 1E conduit may be reduced to 1 inch.

3. In the GPA, separation between non-Class 1E cables and a Class 1E conduit may be reduced to 1 inch.

4. In the CSA, separation between Class 1E cables and a redundant Class 1E conduit may be reduced to 1 inch.

5. In the CSA, separation between Class 1E cables and a non-Class 1E conduit may be reduced to 1 inch.

6. In the CSA, separation between non-Class 1E cables and a Class 1E conduit may be reduced to 1 inch.

5. In addition to separation by train and channel, there is also separation by voltage level and service within a train or channel. A computer program for the routing of cables prohibits the scheduling of a Class 1E cable in an assigned raceway of either a redundant Class 1E cable or a non-Class 1E cable. In addition, cables are routed in separate raceway systems according to the voltage service levels given in Table 8.3-4. Each voltage service level corresponds to the raceway/cable identification letter given in this table (i.e., H, L, K, C, or X). Each cable with one identification number would be separated from cables with a different identification number (i.e., H (4160 V) cables are not run with L (large 480 V) cables). In special cases, C and K cables may be run together in the same tray and the raceway would be designated a K tray. In other special cases, K and L cables may be run together in the same tray if maintained spacing is provided to the cables in accordance with the L spacing in Table 8.3-4. The raceway would then be designated an L tray.

   Trays for cables of different voltage levels are generally stacked in descending voltage order with the highest voltage cables in the uppermost trays. Instrument cables are generally installed in the lowest tray.

6. In general, Class 1E equipment is not installed in potential missile-producing areas. Where this is not practical, suitable missile protection is provided as discussed in Section 3.5.

7. In general, trays in the same vertical stack are separated by 8 3/4 inches minimum as measured from the bottom of the side rail of the upper tray to the top of the side rail of the lower tray.

8. In Seismic Category I areas, H (4160 V) and L (large 480 V) cables will be enclosed either by use of rigid or flexible conduit, protective wraps, or top and bottom tray covers. In Seismic Category II areas, H (4160 V) and L (large 480 V) cables whose separation is reduced below 5 ft vertical and 1 ft horizontal will be enclosed as detailed for Seismic Category I areas above. Refer to Section 3.2 for explanation of Seismic Category I and Seismic Category II areas and listing of Seismic Category I areas.

9. Ventilated cable tray covers are equivalent to solid cable tray covers.

10. Lengths of cable enclosed in a protective wrap of woven silicon dioxide (trade name - Sil-Temp) and glass tape are considered to be protected from electrically induced problems in adjacent cables to the same degree as the same cable in an enclosed raceway.

11. Enclosures provided to meet the requirements of BTP CMEB 9.5-1 are considered equivalent to enclosures provided for electrical separation and will have 1-hour or longer fire rating.

12. Fire barriers are installed at all locations where trays penetrate a fire rated wall or floor.

13. Cable splices in raceways are prohibited with the exception noted for Regulatory Guide 1.75, Paragraph C.9 in Table 1.8-1.

14. The cable spreading areas (main control room, cable spreading room, and computer room) are protected areas and are not exposed to potential hazards such as high pressure piping, missiles, flammable material, flooding, or wiring that is not flame retardant. They do not contain high energy equipment such as switchgear, transformers, rotating equipment, or potential sources of missiles or pipe whip and are not used for storing flammable materials.

15. The General Plant Areas (GPA) have been analyzed for potential hazards and as such are categorized as areas where damage potential is limited to failures or faults internal to the electrical equipment or circuits.

16. Cables in the cable spreading areas (CSA), that converge prior to entering control and instrument panels, in general perform control and instrument functions. Power cables are limited to feeders supplying power to equipment or ventilation units used for those areas. Power cables in these areas are installed in conduit.

17. In general, the minimum separation distance between redundant Class 1E circuits and between Class 1E and non-Class 1E circuits, internal to control switch boards and instrument cabinets is as follows:

    For Exposed Contacts and Terminals
    6 inches

    For Wire Bundles
    1 inch

    Where device arrangement precludes the minimum separation at exposed contacts or terminals, a barrier or enclosure is provided. The barrier or enclosure extends 1 inch beyond exposed contacts or terminals.

Where wire bundle arrangement precludes the minimum separation, a barrier is provided or both bundles are enclosed in a protective wrap.

Where the minimum separation between Class 1E circuits and non-Class 1E circuits is not maintained and installation of a barrier is not possible, the non-Class 1E circuit is classified as part of the Class 1E circuit up to an isolation device to prevent interaction between Class 1E and non-Class 1E circuits.

Separation requirements for Westinghouse NSSS equipment are specifically addressed in Section 7.1.2.2.

18. A raised floor panel can be used as a barrier. Panels are 1 in. thick particle board with 22 gauge steel top and bottom sheets and are fire rated Class A. These panels are considered a barrier when used in a configuration as shown in IEEE Standard 384-1974, Figure 2, 3, or 4.

19. Separation of cables (i.e., between redundant Class 1E circuits and between Class 1E and non-Class 1E circuits) at entrances to control panels and cabinets is consistent with the area in which they are located.

20. Separation is not required between either Train A (orange) and Channel I (red), or Train B (purple) and Channel II (white) except for service (or voltage class) considerations.

8.3.1.4.3 Justified Exceptions to Established Physical Separation Criteria

Table 8.3-10 lists cases where physical and electrical separation is maintained by methods other than those established in Section 1.8 (R.G. 1.75, Rev. 2 Position). These methods are designed and implemented to preclude degrading the Class 1E busses due to interaction with non-Class 1E equipment.

8.3.2 DC Power Systems

8.3.2.1 Description

8.3.2.1.1 Class 1E DC Power System

The Class 1E dc power system includes 125 V dc power supplies, distribution equipment, and load groups arranged to provide dc power to the safety class dc loads as depicted on Figure 8.3-14. This system is divided into four independent subsystems and two redundant trains with regard to power sources and corresponding distribution equipment. These four subsystems are designated with the following principal equipment as follows: Class 1E battery 2-1 (orange), battery charger 2-1 (orange), and distribution switchboard 2-1 (orange); Class 1E battery 2-2 (purple), battery charger 2-2 (purple) and distribution switchboard 2-2 (purple); Class 1E battery 2-3 (blue), battery charger 2-3 (blue) and distribution panel 2-19 (blue); Class 1E battery 2-4 (yellow), battery charger 2-4 (yellow) and distribution panel 2-20 (yellow).

Class 1E batteries 2-1 and 2-2 are connected to Class 1E 480 V MCCs via their respective battery chargers. These 480 V feeds maintain the batteries fully charged, and can also carry the redundant and independent 125 V dc load groups, which are supplied from these sources via distribution switchboards 2-1 and 2-2. Included in these loads groups are the vital bus inverters, namely 2-1 (output red) and 2-2 (output white).

Class 1E batteries 2-3 and 2-4 are connected to Class 1E 480 V MCCs via their respective battery chargers. These 480 V feeds maintain the batteries fully charged, and can also carry the redundant and independent 125 V dc load groups via the dc distribution panels 2-19 and 2-20, and drive the vital bus inverters 2-3 (output blue) and 2-4 (output yellow).

Connection of battery chargers assigned to redundant subsystems to the same safety train does not depreciate subsystem independence. The battery chargers are specified to isolate the effects of any electrical perturbation due to an abnormality in a subsystem. Each train has been provided with a fully qualified spare battery charger. These units can be connected to a permanent, enclosed safety switch with interlocked receptacle. One safety switch is provided for each battery to provide a backup method for battery charging and bus supply if the primary charger is out of service.

These features demonstrate that safety grade equipment is utilized in accomplishing the interconnection of the Class 1E 125 V dc system and the emergency buses, satisfying NUREG-0737, (USNRC 1980), Item II.E.3.1, Position 4, for control power for pressurizer heaters.

Each of the two redundant 125 V dc Class 1E buses switchgear 2-1 and switchgear 2-2 supply Class 1E loads for the following safety class items:

1. Reactor protection system,

2. Engineered safety features actuation system,

3. Class 1E 120 V ac vital bus inverters,

4. Class 1E 4,160 V and 480 V ac switchgear controls,

5. Emergency diesel generator field flashing.

Each 125 V dc bus voltage level is continuously monitored and displayed in the main control room. Alarms in the control room give warning in the event of low voltage, charger failure, battery breaker overcurrent trip, and supply breaker trips to 125 V dc switchgear and distribution panels. All electrical equipment connected to the Class 1E 125 V dc system is capable of operating over the 125 V dc system voltage range. The 125 V dc system operates ungrounded. Each dc bus is provided with a voltmeter which will indicate a grounded condition on either the positive or negative bus. The grounded dc bus condition is also annunciated in the main control room. The most probable mode of battery failure, a single cell deterioration, is indicated well in advance by the routine tests regularly performed on the unit batteries.

Batteries 2-1 and 2-2 are connected to their respective buses via circuit breakers. Distribution breakers feeding bus loads are coordinated for circuit protection. Circuit breakers are provided for each battery, with only longtime and shorttime trip attachments.

The independence of the redundant dc systems is implemented by analyzing the system for all identifiable sources of coupling, and either by physically separating or mechanically protecting and electrically isolating them from their redundant counterparts, preventing the occurrence of nonrandom failures in the system.

8.3.2.1.2 Non-Class 1E DC Power System

The non-Class 1E dc power system includes 125 V dc power supplies, distribution systems, and load groups arranged to provide dc power to the dc loads as depicted on Figure 8.3-15. This 125 V dc system comprises two 125 V dc, 120 cell lead-calcium type batteries (battery 2-5 and battery 2-6), each connected to its 125 V dc bus (switchgears 2-5 and 2-6) and battery charger (battery chargers 2-5 and 2-6). Battery 2-5 and battery 2-6 are each comprised of two strings of 60 cells in parallel, for a total of 120 cells for each battery set. Under normal conditions, 480 V MCCs (non-Class 1E) will supply power to each 125 V dc battery via a battery charger. Essential 120 V ac buses 2-5 and 2-6 are supplied from the essential bus inverters 2-5 and 2-6. The inverters are supplied from the non-Class 1E dc buses, switchgear 2-5 and 2-6, or from the 480 V ac switchgear 2-5 via rectifiers.

There is no interaction, sharing, or interface between the non-Class 1E and Class 1E dc systems, their equipment, raceways, loads, and support systems.

8.3.2.1.3 DC Power System Arrangement and Sizing

The arrangement of the Class 1E dc system equipment provides for four individual rooms for the four Class 1E batteries, and separate areas for the corresponding battery chargers, static switches, circuit breakers, dc switchboards, and vital bus inverters. The latter are arranged in corresponding sets all located on el 730 ft-6 in of the service building (Figure 8.3-13). Since variations in electrolyte temperature of more than 2.8°C between cells may cause the warmer cells to become unequal in output, proper battery location, ventilation, and cell configuration are provided to keep this variation within the preceding limits, thus minimizing deterioration of the positive plates and prolonging battery life. The battery rooms are ventilated to prevent accumulation of hydrogen. The battery room ventilation system (Section 9.4.10.2) provides a minimum of 16 air changes per hour, which assures that hydrogen accumulation is limited to less than 2 percent of the total volume of each battery room.

Each dc subsystem has a charging component which is sized to supply all normal continuous loads and to simultaneously recharge the battery, after the design 2-hour duty cycle discharge, to the fully charged condition in 24 hours. The maximum equalizing voltage setting ensures that equipment connected to the batteries is not subjected to voltages greater than it was qualified for.

The Class 1E batteries have the ability to supply normal loads for a minimum of 2 hours. The battery and battery charging system then perform any necessary switching operations without help from any other source. The capacity of each Class 1E battery with the charger inoperable is large enough to cope with DBA conditions. Each battery system is sized in conformance with the principles set out in IEEE Standard 308-1974. The battery capacities for batteries 2-1 and 2-2 are 1,700 ampere hours (Ah) each. The capacities for batteries 2-3 and 2-4 are 1,140 Ah each. These capacities are sufficient to operate all connected dc loads under DBA conditions for a minimum of 2 hours.

An electrical calculation program is in place to monitor battery load additions and deletions and to periodically update the battery calculations. A new battery duty cycle shall be calculated for each load addition unless the loads being added are encompassed by the design margin calculation. This program ensures the capacity of the batteries continues to be adequate to power the prescribed loads.

The Class 1E batteries are lead-calcium type, consisting of 60 cells, each with a recommended float voltage of 2.25 V per cell. Battery cells are of the sealed type, having covers fixed in place with a permanent leakproof seal. Cell covers have vent and filler openings with vent plugs of the explosion-resistant type. Cell posts and all connectors have adequate capacities to prevent excessive losses and overheating.

Jumpering cells out of the battery sets may be allowed provided an engineering evaluation or calculation is performed to show that the battery still would have the capacity for the two hour duty cycle and maintain the required minimum voltage at load.

Batteries will be mounted on all-steel battery racks. These racks are provided with corrosion protection and are seismically designed, with restricting members to prevent cell motion. Design features include minimizing temperature differential between battery cells and cell accessibility for ease of inspection and maintenance.

Battery chargers convert ac power into regulated dc output voltage and are used to float and charge the batteries connected to them. Output voltage is regulated within ±1.0 percent of set point from no load to full load operation. Each battery charger has a nominal output of 130 V dc with an input of 480 V ac three-phase. The charger includes an input circuit breaker, an input transformer, power rectifier units, a voltage regulator, a current limiter, filters, and an output circuit breaker. The output circuit includes component as required to prevent damage to the charger from voltage transients originating in the dc distribution system. The output circuit breaker provides protection of the battery and the charger against internal charger faults and also serves as a manual disconnecting device. A circuit breaker in the input circuit provides protection for internal charger faults and can also be used as a manual disconnecting device. The charger is automatically current limiting. Its design is such that it can tolerate overloads, including a sustained short circuit at the output terminals, without damage to the components. The charger is designed to operate without the battery connected. The battery charger output is filtered to control the amplitude of ripple voltage.

8.3.2.1.4 DC Power System Distribution

Each battery distribution panel includes a low voltage dc power circuit breaker connecting the battery to the bus, molded case circuit breakers or fuses feeding the dc loads, coordinated overcurrent protection, instrumentation for overcurrent protection, instrumentation for system monitoring, and ground detection equipment. Buses are sized to carry rated full load current continuously with a maximum temperature rise of 50°C. The bus bars are braced to withstand mechanical forces of short circuit currents equal to or greater than the smallest interrupting current rating of the circuit breakers.

Cable design is based on a conductor temperature of 90°C and an ambient temperature of 40°C. The individual conductor insulation material is 90°C thermosetting type. The overall jacket is of a thermosetting material. Non-hygroscopic, flame-retardant fillers and binders are used, as necessary, to round the cable. All 600 V power cables are of stranded copper construction. Where the ambient temperature differs from 40°C, the cable is derated accordingly or high temperature construction has been specified. Power cables have been sized and derated on the basis of current carrying capability and voltage drop considerations. Cables interconnecting the dc equipment and dc loads have passed the Nuclear Incident Qualification Test and Cable Tray Fire Propagation Tests outlined in IEEE Standard 383-1974, Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations or have been determined to be adequate for the hazard in accordance with NRC Generic Letter 86-10. Cables are identified with distinctive markers indicating, by unique color code, their associated train or channel.

8.3.2.1.5 Alarm and Indication

The Class 1E dc system instrumentation functions include indication of the battery output current to the distribution system and display of battery voltage at the distribution panel. The dc bus voltage is also monitored in the main control room through voltage-to-current transducers. Undervoltage relays alarm in the control room for low voltage conditions. The battery chargers are provided with an output voltmeter and ammeter, and pilot lights to indicate that input voltage is available. In addition, relays are provided to alarm on off-normal output voltage and ac failure (phase monitoring) to the charger.

8.3.2.1.6 Maintenance

The Class 1E station batteries and other equipment of the 125 V dc system are easily accessible for maintenance and testing. The batteries are periodically checked for specific gravity and individual cell voltages. An equalizing (overvoltage) charge, where recommended by the battery manufacturer, is applied to bring all the cells up to an equal voltage. Over a period of time, if the previous tests reveal a weakening trend in any cell, replacement is made, as necessary. Battery maintenance includes: assuring correct electrolyte level, tightening of connector bolts, and periodic cleaning of cell jars and covers. Periodically, the charger is disconnected to verify the ability of the unit battery to maintain voltage and assume the dc load. This test reveals any high-resistance connections or cell internal malfunctions. Testing complies with IEEE Standard 308-1974, Criteria For Class 1E Power Systems for Nuclear Power Generating Stations. Periodic testing requirements of each battery system are described in the Technical Specifications. Provisions are made in the dc power system so that service tests can be performed in accordance with IEEE Standard 450-1980, Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations. Battery charger maintenance includes keeping the transformers and semiconductor heat sinks clean to assure proper heat removal. The battery charger is inspected periodically to assure it is clean, dry, and dust free. During preventive maintenance on any Class 1E battery charger, the spare charger will be connected, if required, to supply power to the bus. The spare charger will be fed from a receptacle powered by the corresponding 480 V bus.

8.3.2.2 Analysis

A failure modes and effects analysis (FMEA) to determine if the instrumentation and controls (I&C) and electrical portions meet the single failure criterion, and to demonstrate and verify how the GDC and IEEE Standard 279-1971 requirements are satisfied, has been performed on the Class 1E dc power system. The FMEA methodology is discussed in Section 7.3.2. The results of this analysis can be found in the separate FMEA document (Section 1.7).

The reliability of this system has been evaluated based on historical failure rate and repair time data. Reliability success diagrams have been developed. Based on the results of the FMEA prepared for this system, there are adequate design features to prevent the failure of any one element from rendering the system incapable of performing its safety functions. The unavailability calculation for the Class 1E dc system is 0.00005, which equates to an overdue outage of 0.5 hr/yr. The outage estimate satisfies the numerical goal of 1.0 hr/yr.

The Class 1E dc power system satisfies GDC 17 and 18, IEEE Standards 308-1974, 323-1974, 379-1972, 384-1974, 450-1980, 535-1979, and 650-1979, as well as Regulatory Guides 1.6, 1.32, 1.75, and 1.81. Additionally, the system satisfies Regulatory Guides 1.30, 1.63, 1.89, 1.93, 1.100, 1.128, and 1.129.

The structures housing the Class 1E dc system and its components satisfy GDC 2, 4, and 5, and Regulatory Guides 1.32 and 1.81. In addition, the interfacing support systems (Sections 3.2, 9.4.10.2, and 9.5.1) satisfy these GDC and Regulatory Guides.

General Design Criterion 2

The Class 1E dc power system is housed in structures that are designed to and are capable of withstanding the effects of natural phenomena such as earthquakes, tornados, hurricanes, and floods without loss of capability to perform its functions.

General Design Criterion 4

The Class 1E dc power system is designed to accommodate the effects of the environmental conditions associated with normal operation and postulated accidents, and the structures the system is housed in are protected against internally-and externally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks such that safety functions will not be precluded.

General Design Criterion 5

The Class 1E dc power system is designed in accordance with this criterion, as it relates to the capability of systems and components important to safety being capable of performing required safety functions including an ordinary shutdown and cooldown of BVPS-2.

The BVPS-2 Class 1E dc system is not shared with any other nuclear power plants.

General Design Criterion 17

The Class 1E dc power system is designed to permit the functioning of structures, systems, and components important to safety. In addition, the dc power sources and the dc distribution systems have sufficient independence, redundancy, and testability to perform their safety functions, assuming a single failure, to meet the requirements of GDC 17. In the analysis of this system, single failures are postulated to occur both external and internal to the system. When a component, cable, or raceway indigenous to the system is postulated to fail, all the components that share the enveloping area protecting the failed element are assumed to be lost as well.

General Design Criterion 18

The Class 1E dc power system is designed to permit periodic inspection and testing to assess the condition of the system's components and their capability to perform their intended functions in order to meet the requirements of GDC 18 and Regulatory Guide 1.118.

Regulatory Guide 1.6

The Class 1E dc power system consists of four redundant and independent dc systems, each consisting of a battery with its own charger and distribution system. The Class 1E dc redundant load groups have no automatic connection to any other load group and no provision for automatically transferring loads between these redundant load groups. A safety class backup battery charger is redundant to each of the operating chargers and supplies 125 V dc power during maintenance periods. The system design meets the independence requirements of Regulatory Guide 1.6.

Regulatory Guide 1.30

The Class 1E dc power system follows the positions of this guide for Quality Assurance Program Requirements (namely the application and use of ANSI N45.2.4). The Class 1E dc power system conforms to Regulatory Guide 1.30.

Regulatory Guide 1.32

The Class 1E dc power system is operated at a normal float charge voltage level (135 V dc) to maintain the batteries in a fully charged condition. The chargers associated with each safety class battery are rated to supply the largest combined demands of the various steady state loads. It has charging capacity to restore the battery from the design minimum charged state, to the fully charged state, irrespective of the status of BVPS-2 when these demands occur, to meet the requirements of Regulatory Guide 1.32. Each battery is sized to carry safety loads for at least 2 hours following loss of all ac power. Each battery cell is specified for a final voltage of 1.84 V rather than the usual 1.75 V. Each battery voltage level is continuously monitored and displayed in the main control room. Low battery voltage and low charger input ac voltage are alarmed in the control room.

Regulatory Guide 1.63

Class 1E 125 V dc circuits requiring electrical containment penetrations are either provided with primary and backup fault protection assigned to penetrations that are specified to sustain the fault current, or are analyzed to show that the fault will terminate before a containment penetration is damaged. These procedures will be the basis to assure that the mechanical properties of the penetration are maintained for all BVPS-2 conditions of operation and shutdown.

Regulatory Guide 1.75

The physical independence of redundant Class 1E dc power systems adheres to the same criteria and guidelines described in Sections 8.3.1.1.4, 8.3.1.1.5, and 8.3.1.1.6 for the ac power systems. Each charger, inverter, battery breaker, switchgear, and distribution switchboard associated with a given redundant configuration is grouped together in one area. Each safety class battery is located in its own separate room. Separation from non-Class 1E systems is attained by housing the redundant system in separate rooms in the seismic, tornado missile-protected service building. Safety class raceways are installed in seismic and protected structures, separated from redundant counterparts by barriers and/or physical spacing. Safety class raceways are also physically separated and electrically isolated from non-Class 1E raceways. The provisions assure that a single event, either internal or external to the Class 1E dc system, will not degrade this system's performance of required safety functions. Redundant systems are independent, thus, meeting the requirements of Regulatory Guide 1.75.

Regulatory Guide 1.81

The Class 1E dc power system's components, cable, or raceway do not share any facility with those of BVPS-1 (Section 8.3.1.1.13).

Regulatory Guide 1.89

To the extent described in Section 3.11, the equipment, cables, and raceways that constitute the Class 1E dc power system are qualified in accordance with Regulatory Guide 1.89 for their normal design plant environment and potential accident environment for the specified design life of BVPS-2, plus any extended operating period to complete performance requirements, plus any equipment storage time. Qualification will involve aging, temperature and humidity conditions, levels and duration of radiation exposure, and operational cycles.

Regulatory Guide 1.93

In general, a component failure in the Class 1E dc power system will change the system status to one less than limiting condition for operation (LCO). A spare charger is provided that may be readily substituted for a failed battery charger. Preventive maintenance, testing, and surveillance procedures serve to minimize the probability of a one less than LCO state. The batteries are maintained at a minimum 2-hour capability for a sudden loss of onsite ac power.

Regulatory Guide 1.100

All components, cables, and raceways for the Class 1E dc power system are specified and seismically qualified in accordance with the alternate acceptable program outlined in Section 3.10.

Regulatory Guide 1.128

Provisions in the design of the Class 1E dc power system are made to comply with the specific items of design described in the document. Specifically:

1. The ventilation system's design will limit hydrogen concentration to less than 2 percent by volume at any location within the battery area,

2. Channel beams end tie rods are electrically insulated,

3. Well ventilated locations are provided, with adequate aisle space and space above the cells,

4. Temperature differentials between cells are held to specified limits by battery rack design,

5. Recommendations with regard to battery storage and monitoring of electrolyte level are followed, and

6. Instrumentation and alarms are provided for fire detection and identification of an inadequate ventilation condition.

Regulatory Guide 1.129

The Class 1E dc power system design is developed to accommodate the tests and procedures described in this Regulatory Guide, and IEEE Standard 450-1980. Battery service testing, at the intervals described, are recommended in addition to battery performance discharge testing.

Regulatory Guides 1.22, 1.41, 1.47, 1.68, and GDC 1 and 21

The pre-operational and initial system startup test program for the Class 1E dc power system shall be in accordance with Regulatory Guides 1.41, 1.68, and GDC 1. In addition, periodic onsite testing programs will permit integral testing when the reactor is in operation, in accordance with Regulatory Guides 1.22 and 1.47, and the test program capabilities shall satisfy the requirements of GDC 18 and 21.

Branch Technical Position CMEB 9.5-1

Branch Technical Position CMEB 9.5-1, Section 7, discusses fire protection guidelines for specific plant areas. The safety-related battery rooms comply with these guidelines. Fire protection features for the battery rooms are described in the Fire Safety Analysis, Volume 2-2.

IEEE Standard 308-1974

The Class 1E dc power system conforms with this standard, as indicated in Table 8.1-1.

IEEE Standard 450-1980

Provisions are made in the Class 1E dc power system so that surveillance and service tests can be performed in accordance with this standard. The reliability of the dc supplies is assured by periodic discharge tests of the batteries, as described in IEEE Standard 450-1980. Additional identified requirements are discussed in the referenced sections following.

Conformance with appropriate Quality Assurance Standards (Section 8.3.1.2).

Independence of Redundant Systems (Section 8.3.1.4)

Physical Identification of Equipment (Section 8.3.1.3)

Test Documentation to Qualify Electrical Equipment (Section 8.3.1.2.3).

8.3.3 Fire Protection for Cable Systems

Specifications of electrical cables include flame-retardant requirements, low gas generation during combustion, and the ability to operate in a wet environment. All cables installed in trays at BVPS-2, either:

1. have passed the vertical cable tray gas burner flame test delineated in Section 2.5.4.4 of IEEE-383-1974 or have been determined to be adequate for the hazard in accordance with NRC Generic Letter 86-10 or,

2. additionally, the flame testing for cables specified after January 1978 was modified in accordance with Reg. Guide 1.131-77 or,

3. for non-safety applications, are flame retardant and have passed equivalent industry flame testing as approved by engineering evaluation.

Single conductor 600 V control, coaxial, and triaxial cables installed after December 5, 2000, meet the vertical flame testing listed in item a above. Single conductor 600 V control, coaxial, and triaxial cables installed prior to December 5, 2000, are flame resistant, meeting the vertical flame test provisions of the appropriate ICEA standards. These cables were not subjected to the gas burner vertical cable tray flame test of IEEE-383-1974, and as such, are restricted to installation in conduit and electrical enclosures (i.e., panels and junction boxes).

The cables are also suited to provide undiminished performance while subjected to a water spray as would occur during fire fighting or activation of fire suppression systems.

Only noncombustible materials (aluminum and steel) are used in the construction of cable trays.

In the fabrication of indoor conduit, only aluminum and steel are utilized.

Cable, conduit, and raceway penetrations of all fire barriers are sealed to provide a level of protection equal to or greater than that of the barrier. Refer to Section 8.3.3.3 for a description of fire stops and seals for cables.

Cable trays, conduit, electrical trenches, culverts, and ducts are used only for cables. Miscellaneous storage or piping for flammable or combustible liquids or gases is not permitted in these areas. Fire suppression of safety-related cable tray areas is accomplished by total flooding with CO_2, while fire water hose stations serve as the back-up system. Cable tray areas that are not protected with CO_2 are provided with fire water hose stations.

For a detailed description of fire protection in specific compartments refer to the Fire Safety Analysis, Volume 2-2. Fire Safety Analysis, Volume 3, Enclosure 3 describes compliance of the BVPS fire protection program with requirements of NFPA 805, Chapter 3, Fundamental Fire Protection Program and Design Elements.

8.3.3.1 Fire Protection and Suppression

Fire detection and protection systems, either automatically or manually initiated, are provided in those areas required to preserve the integrity of circuits for redundant safety-related services.

Class 1E equipment are either protected from the byproducts and effluents of automatic fire protection system actuation, are located in such areas that the Class 1E equipment is not affected by these effluents, or on the basis of test data have demonstrated their operability (Cardox Corporation Test Report, July 1955 and Consolidated Edison tests for Three Mile Island Nuclear Power Station, March 1977).

8.3.3.2 Fire Barriers and Cable Tray Separation

Fire barriers for electrical raceways and cable are described for each fire compartment in the Fire Safety Analysis, Volume 2-2. Cable tray separation is described in Section 8.3.1.4.

8.3.3.3 Fire Stops and Seals

Fire stops and seals for electrical cable and raceway penetrations for BVPS-2 are resistant to heat, water spray, moisture, and nuclear radiation (where applicable). These fire stops also prevent the passage of fire for a minimum of 3 hours. In addition, certain stops will maintain an air pressure differential under normal plant conditions and/or hydrostatic pressure.

The types of fire stops and seals are either foam, damming, mechanical, or combinations thereof. All fire stops and seals will be approved by American Nuclear Insurers, as well as be in compliance with IEEE Standard 634-1978. Fire stops and seals that contain asbestos or other hazardous material are prohibited.

The design criteria for the fire stops and seals include the following:

1. Noncombustible and heat resistant materials in compliance with Table 8.1-1 and GDC 3,
2. A fire rating (minimum 3 hours) is used consistent with the fire rating requirements of the penetrated wall, floor, or ceiling, with performance proven by test,
3. Ability to function as a seal to maintain any existing pressure differential, prevent passage of hot gases, smoke, water, and radiation (where applicable),
4. Suitability to penetration, geometry, and arrangement,
5. Compatibility with cable and insulation materials,
6. Effect of cable ampacity derating, if any,
7. Allowance for future addition or removal of cables,
8. Installation procedures to vary with the material selected, and
9. Inspection of fire stops and seals during construction is in accordance with the quality assurance program in effect.

8.3.4 Reference for Section 8.3

U.S. Nuclear Regulatory Commission (USNRC) 1980. Clarification of TMI Action Plan Requirements. NUREG-0737.

Tables for Section 8.3

TABLE 8.3-2

NON-CLASS 1E LOADS SUPPLIED FROM CLASS 1E BUSES

Equipment Mark No.	Description	Source	Shunt Trip on Safety Signal	Safety Signal Type
2SWE-P21A	Standby service water pump	4KVS*2AE	Yes	Loss of offsite power
2SWE-P21B	Standby service water pump	4KVS*2DF	Yes	Loss of offsite power
2HVR-FN202A1	CRDM fan	480VUS*2-8	Yes	SIS
2HVR-FN202A2	CRDM fan	480VUS*2-9	Yes	SIS
2HVR-FN202B1	CRDM fan	480VUS*2-8	Yes	SIS
2HVR-FN202B2	CRDM fan	480VUS*2-9	Yes	SIS
2HVR-FN202C1	CRDM fan	480VUS*2-8	Yes	SIS
2HVR-FN202C2	CRDM fan	480VUS*2-9	Yes	SIS
2HVW-FN269A	Alternate intake structure exhaust fan	MCC*2-E07	Yes	SIS
2HVW-FN269B	Alternate intake structure exhaust fan	MCC*2-E08	Yes	SIS
2FPW-P36	Emergency fire booster pump	MCC*2-E04	No(1,3)	-
PNL-VITBS2-1B	Non-Class 1E vital bus panel	Vital Bus*2-1	No(2)	-
PNL-VITBS2-2B	Non-Class 1E vital bus panel	Vital Bus*2-2	No(2)	-
PNL-VITBS2-3B	Non-Class 1E vital bus panel	Vital Bus*2-3	No(2)	-
PNL-VITBS2-4B	Non-Class 1E vital bus panel	Vital Bus*2-4	No(2)	-

TABLE 8.3-2 (Cont)

Equipment Mark No.	Description	Source	Shunt Trip on Safety Signal	Safety Signal Type
2RCP*H2A	Pressurizer heater backup Group A	480VUS*2-8	Yes[(1)]	SIS
2RCP*H2D	Pressurizer heater backup Group D	480VUS*2-8	Yes[(1)]	SIS
2RCP*H2B	Pressurizer heater backup Group B	480VUS*2-9	Yes[(1)]	SIS
2RCP*H2E	Pressurizer heater backup Group E	480VUS*2-9	Yes[(1)]	SIS
2HVR-FN201A	Containment air recirculation fan A	480VUS*2-8	Yes	SIS
2HVR-FN201B	Containment air recirculation fan B	480VUS*2-9	Yes	SIS
2HVR-FN201C	Containment air recirculation fan C	480VUS*2-8& 2-9	Yes	SIS
2RHS*P21A	Residual heat removal pump	4KVS*2AE	Yes[(1)]	CIB
2RHS*P21B	Residual heat removal pump	4KVS*2DF	Yes[(1)]	CIB
2EGS*DG2-1	Emergency diesel generator aux equip	MCC*E07	[(4)]	[(4)]
2EGS*DG2-2	Emergency diesel generator aux equip	MCC*E08	[(4)]	[(4)]

TABLE 8.3-2 (Cont)

Equipment Mark No.	Description	Source	Shunt Trip on Safety Signal	Safety Signal Type
2EGO*P24A	Emergency diesel generator prelube pump	MCC*2-E07	Yes(1)	
2EGO*P24B	Emergency diesel generator prelube pump	MCC*2-E08	Yes(1)	
4KVS-2A-A10	Bus differential relay circuit	-	(5)	-
4KVS-2D-D10	Bus differential relay circuit	-	(5)	-
4KVS*2AE-2E7	Bus differential relay circuit	-	(5)	-
4KVS*2DF-2F7	Bus differential relay circuit	-	(5)	-
PNL*REL-245 (87-VE207)	Bus differential relay circuit (ENSAE, ENSAF)	-	(5)	-
PNL*REL-255 (87-VF207)	Bus differential relay circuit (ENSBE, ENSBF)	-	(5)	-
2PNL*RCPBP-07	Bus differential relay circuit (ENSAE)	-	(5)	-
2PNL*RCPBP-08	Bus differential relay circuit (ENSBE)	-	(5)	-
2MSS-TSV106A1, A2 to	Condenser steam dump circuits (MSSAM, MSSBM)	-	(5)	-
2MSS-TSV106P1, P2	Condenser steam dump circuits (MSSAN, MSSBN)	-	(5)	-
2MSS-PSV106A1, A2 to	Condenser steam dump Circuits (MSSAK, MSSBK)	-	(5)	-
RK*2AUX-RPST-A	Condenser steam dump circuits (MSSAK,MSSAM,MSSAN)	-	(5)	-

TABLE 8.3-2 (Cont)

Equipment Mark No.	Description	Source	Shunt Trip on Safety Signal	Safety Signal Type
RK*2AUX-RPST-B	Condenser steam dump circuits (MSSBK,MSSBM,MSSBN)	-	(5)	-
2JB-7045	Turbine emergency trip circuits (TMABD)	-	(5)	-
2TMA-SOV20RPT	Turbine emergency trip circuits (TMAAD)	-	(5)	-
RK*2RC-PRT-A	Turbine emergency trip circuits (TMAAA)	-	(5)	-
RK*2RC-PRT-B	Turbine emergency trip circuits (TMABA)	-	(5)	-
RK*2P-TST-A	Turbine emergency trip circuits (TMAAA)	-	(5)	-
RK*2P-TST-B	Turbine emergency trip circuits (TMABA)	-	(5)	-
REAC*2T-SWGR	Turbine emergency trip circuits (TMAAD, TMABD)	-	(5)	-
2PNL*RCPBP-02	Turbine emergency trip circuits (TMAAD)	-	(5)	-
2PNL*RCPBP-03	Turbine emergency trip circuits (TMABD)	-	(5)	-

NOTES:

1. Started by manual action only.

2. Isolated from Class 1E source via isolating regulating transformers. Refer to section 8.3.1.1.17.

TABLE 8.3-2 (Cont)

3. Power to be manually disconnected and administratively controlled.

4. Auxiliary equipment of the emergency diesel generators which are non-Class 1E are either not normally running or are automatically tripped by the diesel generator control systems.

5. Equipment in circuits isolated from Class 1E source by the use of two (2) independent Class 1E overcurrent devices in series. Refer to Table 1.8-1, R.G. No. 1.75 Rev. 2, No. 8, Paragraph C.1.

TABLE 8.3-3
EMERGENCY DIESEL GENERATOR LOADING

Service Equipment and Mark No.	Total Units (8) No.	Total Units (8) Nameplate each mtr Hp	DBA Mode of Operation CIB Phase (1) No. Units Oper	DBA Max Oper Time	DBA Time[5][11] Delay (Min)	DBA Load[3] Step[10]	Loss of Normal Power with Unit Trip (1) No. Units Oper	LNP Max Oper Time	LNP Time[5] Delay (Min)	LNP Load[3] Step[9]	Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1) No. Units Oper	SIS Max Oper Time	SIS Time[5] Delay (Min)	SIS Load[3] Step[10]
4,160 System														
HHSI/chgng pumps (2CHS*P21A,B,C)	3	600	1	-	0	2	1	-	0	2	1	-	0	2
LHSI pumps (2SIS*P21A,B)	2	250	1	-	0	3	1	-	-	3	1	-	0	3
Service wtr pumps (2SWS*P21A,B)[11]	3	900	1	-	0	3	1	-	0	3	1	-	0	3
Stm gen aux fdwtr pumps (2FWE*P23A,B)	2	400	1	-	0	4	1	-	0	4	1	-	0	4
Quench spray pumps (2QSS*P21A,B)	2	350	1	4 hrs	0	4	0	-	-	-	0	-	-	-
Recir spray pumps (2RSS*P21A-D)	4	350	2	-	37	5	0	-	-	-	0		-	-
Resid ht rmvl pumps (2RHS*P21A,B)	2	300	0	-	-	-	1	-	240	TD	1	-	240	TD
Primary CCW pumps (2CCP*P21A,B,C)	3	400	0	-	-	-	1	-	0	6	1	-	0	6
Standby service wtr pump[6] (2SWE*P21A,B)	2	1,250	0	-	-	-	1	-	-	-	0	-	-	-

TABLE 8.3-3 (Cont)

	Total Units (8)		DBA Mode of Operation CIB Phase (1)				Loss of Normal Power with Unit Trip (1)				Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1)			
Service Equipment and Mark No.	No.	Nameplate each mtr Hp	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[9]	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]
480 V System														
Leak cltn fltr exch fans (2HVS*FN204A,B)	2	200	1	-	0	5	1	-	0	5	1	-	0	5
Emer swgr sply fans (2HVZ*FN261A,B)	2	75	1	-	0	6	1	-	0	6	1	-	0	6
Emer Swgr exh fans (2HVZ*FN262A,B)	2	60	1	-	0	6	1	-	0	6	1	-	0	6
Main steam fans (2HVR*FN206A,B)	2	75	1	-	0	6	1	-	0	6	1	-	0	6
Cont air recirc fans (2HVR-FN201A,B,C)	3	300	0	-	-	-	1	-	3	TD	0			
Leak sys elec htr (2HVS*CH219A,B)	2	230 (kW)	1	-	1	TD	1	-	1	TD	1	-	1	TD
Press htr backup (2RCP*H2D,E)	2	270 (kW)	0	-	-	-	1	-	60	TD	0	-	-	-
CRDM shroud fan (2HVR-FN202 A1,A2)	2	75	0	-	-	-	1	-	3	TD	0	-	-	-
CRDM shroud fan (2HVR-FN202 B1,B2)	2	75	0	-	-	-	1	-	3	TD	0	-	-	-
CRDM shroud fan (2HVR-FN202 C1,C2)	2	75	0	-	-	-	1	-	3	TD	0	-	-	-
Alt supply vv's (21AC*MOV130,133)	2	.46	2	3 min	0	6	2	3	0	6	2	3 min	0	6
Load & Cooling Sys losses (XFMR 2-8N)	1	49 (kW)	1	-	-	6	1	-	-	6	1	-	-	6

TABLE 8.3-3 (Cont)

Service Equipment and Mark No.	Total per Diesel No.	Total per Diesel Hp	DBA Mode of Operation CIB Phase (1) No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]	Loss of Normal Power with Unit Trip (1) No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[9]	Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1) No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]
H_2 Recombiner Pkg	1	67.9 (kW)	1	-	8 hr	-	0	-	-	-	0	-	-	-
(2HCS*	1	5	1	-	8 hr	-	-	-	-	-	-	-	-	-
RBR21A)	1	10	1	-	8 hr	-	-	-	-	-	-	-	-	-
AC distr transf (TRF*PWR2-E5)	1	15 (kVA)	1	-	0	2	1	-	0	2	1	-	0	2
Service wtr Vs (2SWS*MOV 102A, 102C1, 170A)	3	3.33	3	3 min	0	2	3	3 min	0	2	3	3 min	0	2
SWP lube wtr strainer (2SWS*STRM 47)	1	.5	1	-	0	2	1	-	0	2	1	-	0	2
Intake supply fan (2HVW*FN257 A,C)	2	6	2	-	0	2	2	-	0	2	2	-	0	2
AC distr transf (TRF*PWR2-E3)	1	15 (kVA)	1	-	0	6	1	-	0	6	1	-	0	6
Cont rm ac unit (2HVC*ACU 201A)	1	40	1	-	0	6	1	-	0	6	1	-	0	6
Cont rm air prsszr fan (2HVC*FN 241A)	1	5	1	-	0	6	1	-	0	6	1	-	0	6
Cont rm air prsszr htg coil (2HVC*CH222A)	1	5.1 kW	1	-	0	6	1	-	0	6	1	-	0	6
Refrigeration cond unit (2HVC*REF 24A,B)	2	75	1	-	0	6	1	-	0	6	1	-	0	6
CR exh air dmpr (2HVC*MOD201C, 201A, 204A)	3	6.53	3	3 min	0	6	3	3 min	0	6	3	3 min	0	6
AC distr transf (TRF*PWR2-E9)	1	15 (kVA)	1	-	0	2	1	-	0	2	1	-	0	2
Elec heat xfmr (2HTS*TRFA1SG)	1	15 (kVA)	1	-	0	2	1	-	0	2	1	-	0	2

TABLE 8.3-3 (Cont)

Service Equipment and Mark No.	Total per Diesel No.	Total per Diesel Hp	DBA Mode of Operation CIB Phase (1) No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]	Loss of Normal Power with Unit Trip (1) No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[9]	Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1) No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]
Alt shut dn rm ACC	1	7.5	0	-	-	-	1	-	0	2	0	-	-	-
(2HVP*ACUS301)	1	2.0	0	-	-	-	1	-	0	2	0	-	-	-
Chgng pump min flow Vs (2CHS*MOV8130A. 8131A, 8132A, 8133A)	4	7.6	4	3 min	0	2	4	3 min	0	2	4	3 min	0	2
Chgng pump suct Vs vol tk (2CHS*LCV 115B,C)	2	3.8	2	3 min	0	2	2	3	0	2	2	3 min	0	2
Recirc spray ht exch inlet valve (2SWS*MOV 103A, 106A, 120A, 107A,C, 148A)	6	3.22	6	3 min	0	2	6	3 min	0	2	6	3 min	0	2
Pri cmpnt clg sply & rtn Isol Vs (2CCP*MOV 175-1 thru 8, 128A)	5	.65	5	3 min	0	2	5	3 min	0	2	5	3 min	0	2
Chemical inj to SWS V (2SWM*MOV 562, 564)	2	.26	2	3 min	0	2	2	3 min	0	2	2	3 min	0	2
Boron Inj tk Inlet Isol V (2SIS*MOV 867A)	1	1.9	1	3 min	0	2	1	3 min	0	2	1	3 min	0	2
Standby SWS pmp disch Vs (2SWE*MOV 116A)	1	1.6	1	3 min	0	2	1	3 min	0	2	1	3 min	0	2
Fuel pool cooling pump (2FNC*P21A)	1	25	1	-	0	2	1	-	0	2	1	-	0	2
Cont bldg air exch & sply fan (2HVC*FN265A & 266A)	2	40	2	-	0	2	2	-	0	2	2	-	0	2

TABLE 8.3-3 (Cont)

Service Equipment and Mark No.	Total per Diesel No.	Total per Diesel Hp	DBA Mode of Operation CIB Phase (1) No. Units Oper	DBA Max Oper Time	DBA Time[5] Delay (Min)	DBA Load[3] Step[10]	Loss of Normal Power with Unit Trip (1) No. Units Oper	LNP Max Oper Time	LNP Time[5] Delay (Min)	LNP Load[3] Step[9]	Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1) No. Units Oper	SIS Max Oper Time	SIS Time[5] Delay (Min)	SIS Load[3] Step[10]
ISCL reg xfmr Alt shut dr TRF*IRT-ASP	1	10 (kVA)	1	-	0	2	1	-	0	2	1	-	0	2
Chrg pump cub exch fan (2HVP*FN264A)	1	30	1	-	0	2	1	-	0	2	1	-	0	2
AC dist transf (TRF*PWR2-E1)	1	15 (kVA)	1	-	0	2	1	-	0	2	1	-	0	2
CRDM shrd coil Vs (2CCP*MOV114,112A, 156-2, 150-2, 103A, 151-1, 157-1)	7	1.91	7	3 min	0	2	7	3 min	0	2	7	3 min	0	2
Resid ht rmvl Isol Vs (2RHS*MOV 701A, B, 702A, 720A)	4	13.6	4	3 min	0	2	4	3 min	0	2	4	3 min	0	2
Chrg pmp to HHSI and accumulator Isol Vs (2SIS*MOV 869A, 865A, 867C, 836)	4	28.1	4	3 min	0	2	4	3 min	0	2	4	3 min	0	2
Chrg hdr Isol Vs (2CHS*MOV378, 289, 308 A,B,C)	5	6.0	5	3 min	0	2	5	3 min	0	2	5	3 min	0	2
MCC cub exch fan (2HVP*FN265A)	1	3	1	-	0	2	1	-	0	2	1	-	0	2
Serv wtr hdr Isol Vs (2SWS*MOV161, 152-1, 163, 153-1, 164, 154-1, 167, 155-1)	8	1.04	8	3 min	0	2	8	3 min	0	2	8	3 min	0	2
Presszr relief Isol Vs (2RCS*MOV536, 537)	2	4	0	-	-	-	1	3 min	0	2	0	-	-	-

TABLE 8.3-3 (Cont)

Service Equipment and Mark No.	Total per Diesel No.	Total per Diesel Hp	DBA Mode of Operation CIB Phase (1) No. Units Oper	DBA Max Oper Time	DBA Time[5] Delay (Min)	DBA Load[3] Step[10]	Loss of Normal Power with Unit Trip (1) No. Units Oper	LNP Max Oper Time	LNP Time[5] Delay (Min)	LNP Load[3] Step[9]	Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1) No. Units Oper	SIS Max Oper Time	SIS Time[5] Delay (Min)	SIS Load[3] Step[10]
Alt Intk struct exh fan (2HVW*FN269A)	1	10	0	-	-	-	1	-	0	3	0	-	-	-
DG fuel oil xfr pumps (2EGF*P21 A,B)	2	2	1	-	0	3	1	-	0	3	1	-	0	3
DG bldg supply fan (2HVD*FN270A)	1	50	1	-	0	3	1	-	0	3	1	-	0	3
DG crank case vacuum pump (2EDG*P21A)	1	1	1	-	0	3	1	-	0	3	1	-	0	3
Vital bus rect (2UPS*VITBS2-3)	1	20 (kVA)	1	-	0	2	1	-	0	2	1	-	0	2
DG bldg supply fan (2HVD*FN271A)	1	50	1	-	0	3	1	-	0	3	1	-	0	3
DG bldg exch fan (2HVD*FN222A)	1	1	1	-	0	3	1	-	0	3	1	-	0	3
DG 2-1 ht exch hdr (2SWS*MOV 113A,C)	2	.34	2	3 min	0	3	2	3 min	0	3	2	3 min	0	3
Recirc spray pump suct valve (2RSS*MOV 155A,C 156A,C, 154C)	5	3.96	5	3 min	0	2	5	3 min	0	2	1	3 min	0	2

TABLE 8.3-3 (Cont)

Service Equipment and Mark No.	Total per Diesel: No.	Total per Diesel: Hp	DBA Mode of Operation CIB Phase (1): No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]	Loss of Normal Power with Unit Trip (1): No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[9]	Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1): No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]
DG prelube pump (2EGO*23A)	1	.5	0	-	-	-	1	-	0	3	0	-	-	-
H_2 analyzer (2HCS*HA100A)	1	2.2 (kVA)	1	-	0	3	0	-	-	-	1	-	0	3
Quench pump suct valve (2QSS*MOV 100A, 101A, 102A)	3	2.03	3	3 min	0	2	0	-	-	-	0	-	-	-
Recirc spray ht exch Vs (2SWS*MOV 104A,C 105A,C)	4	6.4	4	3 min	0	2	4	3 min	0	2	4	3 min	0	2
LHSI pump suct Vs (2SIS*MOV 863A, 864A, 8809A, 8888A, 8890A, 8811A)	6	32.3	6	3 min	0	2	6	3 min	0	2	6	3 min	0	2
Atmos steam dump vv. (2SVS*PCV101A)	1	.4	1	3 min	0	2	1	3 min	0	2	1	3 min	0	2
Cool wtr inst air comp (2CCP*MOV118)	1	.13	1	3 min	0	2	1	3 min	0	2	1	3 min	0	2
Aux fd wtr control (2FWE*HCV100 A,C,E)	3	1.2	3	3 min	0	6	3	3 min	0	6	3	3 min	0	6
SG area A/C unit (2HVR*ACU207A)	1	20	1	-	0	2	1	-	0	2	1	-	0	2
HHD Saf. inj. Isol. Valves (2SIS*MOV840)	1	.7	1	-	0	2	0	-	-	-	1	-	0	2
Pri. comp. cig. p. recirc. (CCP*DCV100-2)	1	.4	1	-	0	2	1	-	0	2	1	-	0	2

TABLE 8.3-3 (Cont)

	Total per Diesel		DBA Mode of Operation CIB Phase (1)				Loss of Normal Power with Unit Trip (1)				Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1)			
Service Equipment and Mark No.	No.	Hp	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[9]	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]
Hydrogen cont sys inl Vs (2HCS*MOV110A)	1	.645	5	3 min	8 hours	TD	0	-	-	-	0	-	-	-
Vital bus rect 2-1 (UPS*VITBS2-1)	1	20 (kVA)	1	-	0	6	1	-	0	6	1	-	0	6
Cable vault & RC area A/C unit (2HVR*ACU 208A)	1	25	1	-	0	6	1	-	0	6	1	-	0	6
Cont isol purge exch dmpr (2HVR*MOD 23A,25A)	2	6.6	2	3 min	0	6	2	3 min	0	6	2	3 min	0	6
Boric acid trans pump (2CHS*P22A)	1	15	1	-	0	6	1	-	0	6	1	-	0	6
Battery room exch fan (2HVZ*FN216A)	1	7.5	1	-	0	6	1	-	0	6	1	-	0	6
Recirc pump (2SWS*P25A)	1	1	1	-	0	6	1	-	0	6	1	-	0	6
LTDNV to cool recovery (2CHS*MOV100A,B)	2	.26	2	3 min	0	2	2	3 min	0	2	2	3 min	0	2
AC dist xfmr (TRF*PWR2-E7)	1	15 (kVA)	1	-	0	6	1	-	0	6	1	-	0	6
AC dist. xfmr (TR*PWR2-E11)	1	15 (kVA)	1	-	0	6	1	-	0	6	1	-	0	6
Atmos. stm damp. v. (2SVS*PCV 101B,C)	2	.8	2	-	0	6	2	-	0	6	2	-	0	6

TABLE 8.3-3 (Cont)

Service Equipment and Mark No.	Total per Diesel		DBA Mode of Operation CIB Phase (1)				Loss of Normal Power with Unit Trip (1)				Safety Injection Signal, CIA Phase Loss of Power, Unit Trip (1)			
	No.	Hp	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[9]	No. Units Oper	Max Oper Time	Time[5] Delay (Min)	Load[3] Step[10]
Letdown cross connect valve (2RHS*MOV 750A)	1	.7	1	3 min	0	6	1	3 min	0	6	1	3 min	0	6
Battery Charger (BAT*CHG 2-1)	1	20 KVA	1	-	0	2	1	-	0	2	1	-	0	2

TABLE 8.3-3 (Cont)

	Total Units (8)		DBA Mode of Operation CIB Phase - Recirc. Mode				Safety Injection Signal, CIA Phase Loss of Power, Unit Trip - Recirc. Mode			
Service Equipment and Mark No.	No.	Nameplate, each mtr Hp	No. Units Oper	Max Oper Time	Time(5)(11) Delay (Min)	Load(3) Step(9)	No. Units Oper	Max Oper Time	Time(5) Delay (Min)	Load(3) Step(9)
4,160 System										
HHSI/chgng pumps (2CHS*P21A,B,C)	3	600	1	-	0.9 sec	-	1	-	0.9 sec	-
LHSI pumps (2SIS*P21A,B)	2	250	1	-	0	3	1	-	0	3
Service wtr pumps (2SWS*P21A,B,C)	3	900	1	-	0	3	1	-	0	3
Stm gen aux fdwtr pumps (2FWE*P23A,B)	2	400	1	-	0	4	1	-	0	4
Quench spray pumps (2QSS*P21A,B)	2	350	1	4 hrs	0	4	0	-	-	-
Recirc spray pumps (2RSS*P21A-D)	4	350	1	-	37	5	1	-	-	5
Resid ht rmvl pumps (2RHS*P21A,B)	2	300	0	-	-	-	1	-	240	TD
Primary CCW pumps (2CCP*P21A,B,C)	3	400	0	-	-	-	1	-	0	6
Standby service wtr pump(6) (2SWE*P21A,B)	2	1,250	0	-	-	-	0	-	-	-

TABLE 8-3-3 (Cont)

NOTE:

(1) Electrical calculation program monitors emergency bus load additions, changes and deletions. The calculation program also monitors inrush current and kW loading for various operating scenarios.

(3) Load steps are defined as follows:

	Case (A) Loss of Offsite Power (Loop) Only	Case (B) CIA or CIB coincident with or subsequent to Loop
Load Step 1:	Begins when diesel generator breaker has closed (maximum of 10 seconds after start signal)	Same as loop only case
Load Step 2:	Begins 0.36 second after Load Step 1	Begins 0.9 second* after Load Step 1
Load Step 3:	Begins 5 seconds after Load Step 1	Begins 5 1/2 seconds* after Load Step 1
Load Step 4:	Begins 15 seconds after Load Step 1	Begins 15 1/2 seconds* after Load Step 1
Load Step 5:	Begins 20 seconds after Load Step 1	Begins 20 1/2 seconds* after Load Step 1
Load Step 6:	Begins 40 seconds after Load Step 1	Begins 40 1/2 seconds* after Load Step 1

(*Accounts for 1/2 second resetting time.)

(5) Time Delay - Describes delays in component operation other than the Sequential Start time delay. (See Note 3, above.)

(6) The following non-Class 1E loads are loaded manually if required:

Standby service water pumps (2SWE*P21A, B)
Residual heat removal pumps (2RHS*P21A, B)
Pressurizer heater backups (2RCP*H2A, B, D, E)
CRDM Shroud Cool Fn (2HVR-FN202A1, A2, B1, B2, C1, C2)
AL Intake Struct Exch Fn (2HVW-FN269)

(8) Orange train D.G. loads only have been shown in the sequence. Purple train D.G. loads are similar. Pages 1 and 2 list the total heavy load items that are available.

(9) Reference above, Note 3 Case (A) for Load Step sequencing.

(10) Reference above, Note 3 Case (B) for Load Step sequencing.

(11) Recirc Spray Pumps (2RSS*P21A-D) start on RWST low level setpoint.

TABLE 8.3-4

CABLE IN TRAYS

Tray Identification	Voltage	Conductors Size	Service	Maximum Tray Fill	Notes
H	601 V to 4,160 V	All	Power	1 Layer	Maintained spacing* Conductors produce heat from I^2R losses
L	600 V	All	Power	1 Layer	Maintained spacing* Conductors produce heat from I^2R losses
K***	600 V	No. 8 AWG copper and smaller	Miscellaneous services	50%****	1. No conductor I.^{2}R loss heating or 2. Intermittent service ** or 3. Sized and derated in accordance with I PCEA Publications No. P-54-440
C	120, 240 V ac 125 V dc	As required	Control and alarm	50%****	600 V insulation
X	Low level	As required	Instrument, communication, etc.	50%****	Generally shielded cables

NOTES:

* Maintained spacing of 0.25 to 1.0 cable diameter on both sides of each cable in a tray, cables derated per IPCEA Table VII, Line 1.

** Intermittent is understood to mean operation for not more than 40% of the time and for not longer than 30 minutes for any one operation.

*** The K tray cables may be composed of any one or any combination of the three types. Only the Type 3 cables need to have a derating factor applied.

**** Specified percent fill can be exceeded upon written approval from Engineers. 50 percent tray fill is achieved when the sum of the cross-sectional areas of all cables routed in the tray section equals 50 percent of the available cross-section area of the tray. For this condition, the design basis computer system, which calculates tray fill based on 3-inch deep tray whether 3-inch or 4-inch deep tray is used would report the tray section fill as 100 percent. In a typical installation, 50 percent cross-sectional fill will result in cable being level with or below the top of the tray side rail maximum calculated cable depth in “C” or “X” trays will be limited to 1.5 in above the top of the tray side rail. For those trays with cables extending above the side rail, a tray with solid top and solid sides will be used.

TABLE 8.3-5

MANUALLY-CONTROLLED, ELECTRICALLY-OPERATED, SAFETY CLASS VALVES FROM WHICH POWER IS REMOVED

	Valve Mark No.	Description	UFSAR Section
1.	2CHS*MOV8132A,B 2CHS*MOV8133A,B	HHSI/charging pump discharge cross connect valves	6.3.2.2
2.	2SIS*MOV865A,B,C	Accumulator discharge isolation valves	6.3.2.2
3.	2SIS*MOV869A,B	HHSI/charging pump to hot leg isolation valves	6.3.2.2
4.	2SIS*MOV841	HHSI/charging pump to cold leg isolation valve	6.3.2.2
5.	2SIS*MOV8889	Low head safety injection pump discharge valve	6.3.2.2
6.	2HCS*MOV110A	Hydrogen control system isolation valve	6.2.5
7.	2CHS*MOV373	HHSI/charging pump minimum flow header isolation valve	6.3.2.2

TABLE 8.3-6

CLASSIFICATION OF ELECTRICAL EQUIPMENT AREAS

Area	Elevation	Classification
Control Building (CB)		
Main control & computer rooms	735′ 6″	CSA[2]
Instrument & communications rooms	707′ 6″	GPA[1]
Ac equipment room	735′ 6″	GPA
Cable spreading room	725′ 6″	CSA
Cable Tunnel		
From CB to auxiliary building	712′ 6″	GPA
Auxiliary building	755′ 6″	GPA
Auxiliary building, relay panels room	755′ 6″	GPA
Auxiliary building	735′ 6″	GPA
Turbine Building	All	GPA
Service Building		
Main steam line area	780′ 6″	GPA
West	760′ 6″	GPA
West, battery room 2-5	760′ 6″	GPA
East	760′ 6″	GPA
West, cable raceway system	745′ 6″	GPA
East, cable raceway system	745′ 6″	GPA
West, battery room 2-1	730′ 6″	GPA
West, battery room 2-3	730′ 6″	GPA
West, switchgear	730′ 6″	GPA
East, switchgear	730′ 6″	GPA
East, battery room 2-2	730′ 6″	GPA
East, battery room 2-4	730′ 6″	GPA
Auxiliary Building		
Storage tanks	718′ 6″	GPA
Pumps, tanks	735′ 6″	GPA
MCCs, equipment	755′ 6″	GPA
Cable raceway area	773′ 6″	GPA
Valves	710′ 6″	GPA
Cable Vault and Rod Control Area, North Side		
Equipment, mechanical	718′ 6″	GPA
Equipment, electrical	735′ 6″	GPA
Electrical equipment	755′ 6″	GPA
Electrical equipment	773′ 6″	GPA

TABLE 8.3-6 (Cont)

Area	Elevation	Classification
Cable Vault and Rod Control Area, South Side		
Electrical equipment	735’ 6”	GPA
Electrical equipment	755’ 6”	GPA
Conduit	718’ 6”	GPA
Conduit	773’ 6”	GPA
Reactor Containment		
North + South (N+S)	692’ 11”	GPA
N+S	718’ 6”	GPA
N+S	738’ 10”	GPA
North, outside ring & seal table	735’ 6”	GPA
South, outside ring	735’ 6”	GPA
N+S, outside ring 735’ 6” to	767’ 10”	GPA
South, outside ring	756’ 6”	GPA
N+S	767’ 10”	GPA
Safeguards Area		
ESF pumps, N+S	718’ 6”	GPA
Recombiner, N+S	737’ 6”	GPA
Drains, pumps, N+S	680’ 11”	GPA
Fuel Building		
Plan below 757’ 3”	<757’ 3”	GPA
Plan above 757’ 3”	>757’ 3”	GPA
Diesel Generator Building		
D-G units	732’ 6”	GPA

NOTES:

1. GPA = General plant area (Reference IEEE Standard 384-1974).
2. CSA = Cable spreading area (Reference IEEE Standard 384-1974).

TABLE 8.3-10

ELECTRICAL EQUIPMENT REQUIRING INTERNAL WIRING SEPARATION JUSTIFICATION

1. Westinghouse Equipment

The Westinghouse NSSS equipment wiring is referenced and justified in Section 7.1.2.2.1.

2. Reactor Coolant Loop Isolation Valves

The non-Class 1E power source (with train-related control cabling) of the reactor coolant loop isolation valves is administratively locked out during normal plant operation.

During plant start-up, the valves perform their intended function by using a control circuit designed such that the non-Class 1E power will not adversely affect the Class 1E components and a master/slave arrangement for their motor-starters.

The following equipment is included:

Equipment ID No.	Description	Color
2RCS*MOV590	Reactor Coolant Loop Isolation Valve	Orange/Black
2RCS*MOV591	Reactor Coolant Loop Isolation Valve	Orange/Black
2RCS*MOV592	Reactor Coolant Loop Isolation Valve	Orange/Black
2RCS*MOV593	Reactor Coolant Loop Isolation Valve	Orange/Black
2RCS*MOV594	Reactor Coolant Loop Isolation Valve	Orange/Black
2RCS*MOV595	Reactor Coolant Loop Isolation Valve	Orange/Black
MCC-2-17-5A	Reactor Coolant Loop Isolation Valves	Orange/Black
MCC-2-17-5C	Reactor Coolant Loop Isolation Valves	Orange/Black
MCC-2-19-1-5A	Reactor Coolant Loop Isolation Valves	Orange/Black
MCC-2-19-1-5C	Reactor Coolant Loop Isolation Valves	Orange/Black
MCC-2-18-10A	Reactor Coolant Loop Isolation Valves	Orange/Black
MCC-2-18-10C	Reactor Coolant Loop Isolation Valves	Orange/Black
MCC-2-17S-A	Reactor Coolant Loop Isolation Valves	Purple/Black

TABLE 8.3-10 (Cont)

Equipment ID No.	Description	Color
MCC-2-17S-B	Reactor Coolant Loop Isolation Valves	Purple/Black
MCC-2-17S-C	Reactor Coolant Loop Isolation Valves	Purple/Black
MCC-2-17S-D	Reactor Coolant Loop Isolation Valves	Purple/Black
MCC-2-17S-E	Reactor Coolant Loop Isolation Valves	Purple/Black
MCC-2-17S-F	Reactor Coolant Loop Isolation Valves	Purple/Black
2CAB-RCP BP-01-R1A	Reactor Coolant Loop Isolation Valves	Orange/Black
2CAB-RCP BP-01-R1B	Reactor Coolant Loop Isolation Valves	Orange/Black
2CAB-RCP BP-01-R1C	Reactor Coolant Loop Isolation Valves	Orange/Black
2CAB-RCP BP-02-R1A	Reactor Coolant Loop Isolation Valves	Orange/Black
2CAB-RCP BP-02-R1B	Reactor Coolant Loop Isolation Valves	Orange/Black
2CAB-RCP BP-02-R1C	Reactor Coolant Loop Isolation Valves	Orange/Black

3. Reactor Coolant Loop Bypass Valves

The above discussion for No. 2 applies, except that the master/slave MCC control arrangement is not required or used, and the non-1E power source is not administratively locked out during normal operation.

The following equipment is included:

Equipment ID No.	Description	Color
2RCS*MOV585	Reactor Coolant Loop Bypass Valve	Orange/Black
2RCS*MOV586	Reactor Coolant Loop Bypass Valve	Orange/Black
2RCS*MOV587	Reactor Coolant Loop Bypass Valve	Orange/Black
MCC-2-17-6A	Reactor Coolant Loop Bypass Valves	Orange/Black
MCC-2-19-1-5F	Reactor Coolant Loop Bypass Valves	Orange/Black
MCC-2-18-11A	Reactor Coolant Loop Bypass Valves	Orange/Black
2CAB-RCP BP-03-R3A	Reactor Coolant Loop Bypass Valves	Orange/Black

TABLE 8.3-10 (Cont)

Equipment ID No.	Description	Figure No.	Color
2CAB-RCP BP-03-R3B	Reactor Coolant Loop Bypass Valves		Orange/Black
2CAB-RCP BP-03-R3C	Reactor Coolant Loop Bypass Valves		Orange/Black

4. Swing Equipment and Transfer Switches

Separation is not required since mechanical interlocks and administrative procedures are utilized to preclude the possibility of simultaneous connection to both redundant power trains. Refer to applicable figures indicated.

The following equipment is included:

Equipment ID No.	Description	Color
2SWS*TRS-P21C	Transfer Switch	Orange/Purple/Green
2CCP*TRS-P21C	Transfer Switch	Orange/Purple/Green
2CHS*TRS-P21C	Transfer Switch	Orange/Purple/Green
2HVR*TRS-FN201C	Transfer Switch	Orange/Purple/Green
2HVW*TSW-FN257C	Transfer Switch	Orange/Purple/Green
2RHS*TRS-MOV702A	Transfer Switch	Orange/Purple/Green
2RHS*TRS-MOV701B	Transfer Switch	Orange/Purple/Green
2RHS*MOV702A	RHS Pump A Suction Valve	Purple/Green
2RHS*MOV701B	RHS Pump B Suction Valve	Orange/Green

5. Vital Bus Inverters

Separation is not required since the subject channels are integrally associated with each other. Refer to Figure 8.3-3.

The following equipment is included:

Equipment ID No.	Description	Color
UPS-VITBS-2-3	Inverter	Orange/Blue
UPS-VITBS-2-4	Inverter	Purple/Yellow

TABLE 8.3-10 (Cont)

6. Isolating Regulating Transformers

Separation is achieved by the description provided in Section 8.3.1.1.17.

The following equipment is included:

Equipment ID No.	Description	Color
REG*VITBS-2-1B	Isolating Transformer	Red/Black
REG*VITBS-2-2B	Isolating Transformer	White/Black
REG*VITBS-2-3B	Isolating Transformer	Blue/Black
REG*VITBS-2-4B	Isolating Transformer	Yellow/Black
TRF*IRT-ASP	Isolating Transformer	Orange/Black

7. Turbine Trip Circuit

Separation for the wiring is maintained within the turbine building by routing each circuit in a dedicated conduit meeting the minimum separation requirements but maximizing separation where possible up to the terminal boxes.

For all other plant areas, raceways are color-coded providing separation consistent with R. G. 1.75.

The following equipment is included:

Equipment ID No.	Description	Color
2JB-7012	Turbine Trip Junction Box	White/Yellow/Black
2JB-7013	Turbine Trip Junction Box	Red/Blue/Black

8. Emergency Generator Neutral Grounding Circuit Disconnect Switch

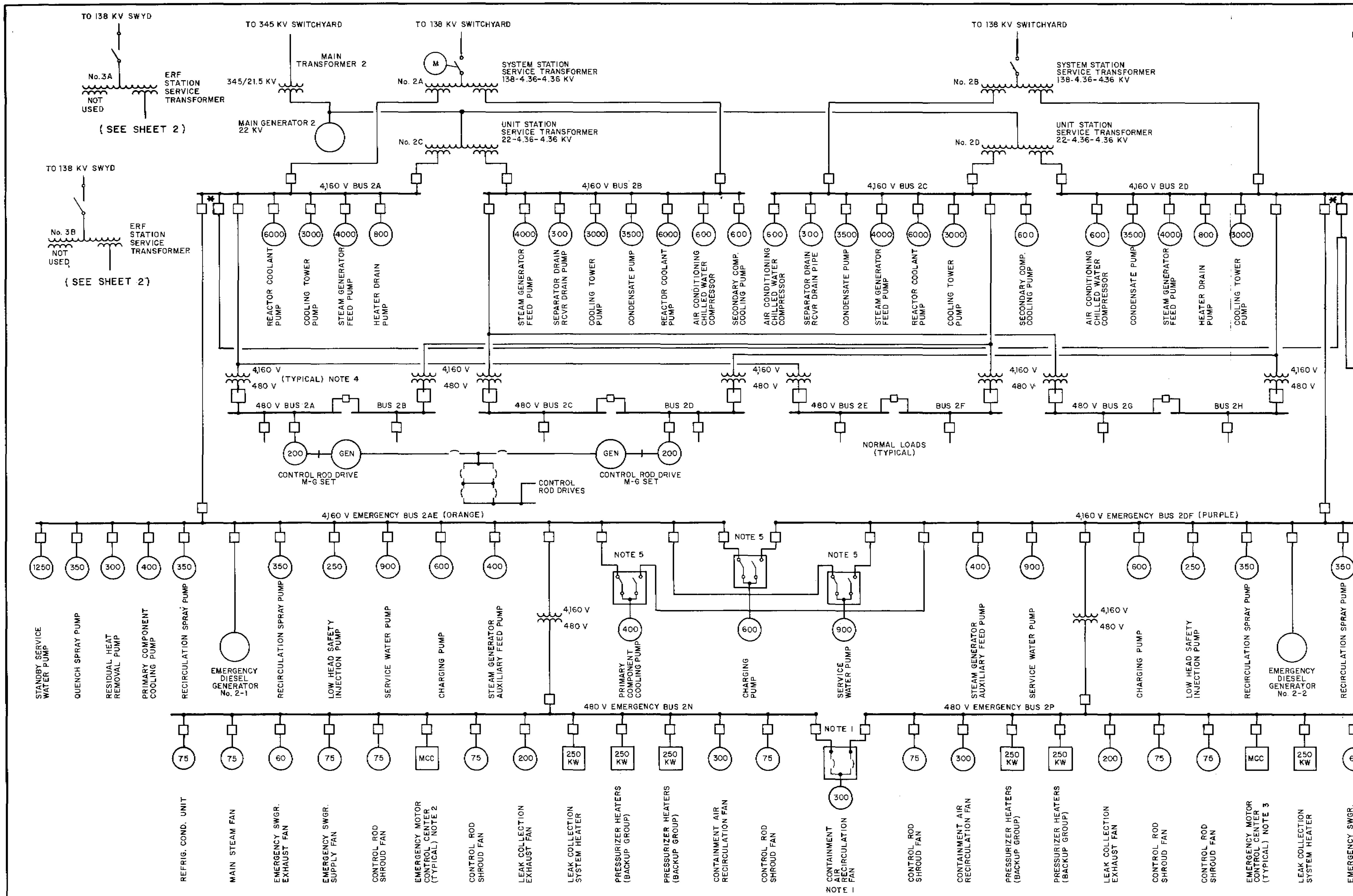
The emergency generator neutral grounding circuit is only connected to the system during the periodic diesel generator testing. For all other modes, the motor operated disconnect switch (MODS) is open, and the generator is run ungrounded.

Administrative procedures ensure that the MODS will be switched open during non-test mode periods. Also, the MODS are tripped upon receipt of an emergency start signal.

TABLE 8.3-10 (Cont)

Equipment ID No.	Description	Color
2EGS-GS2-1	Emergency Generator Neutral Grounding Switch	Orange/Black
2EGS-GS2-2	Emergency Generator Neutral Grounding Switch	Purple/Black

REV. 6



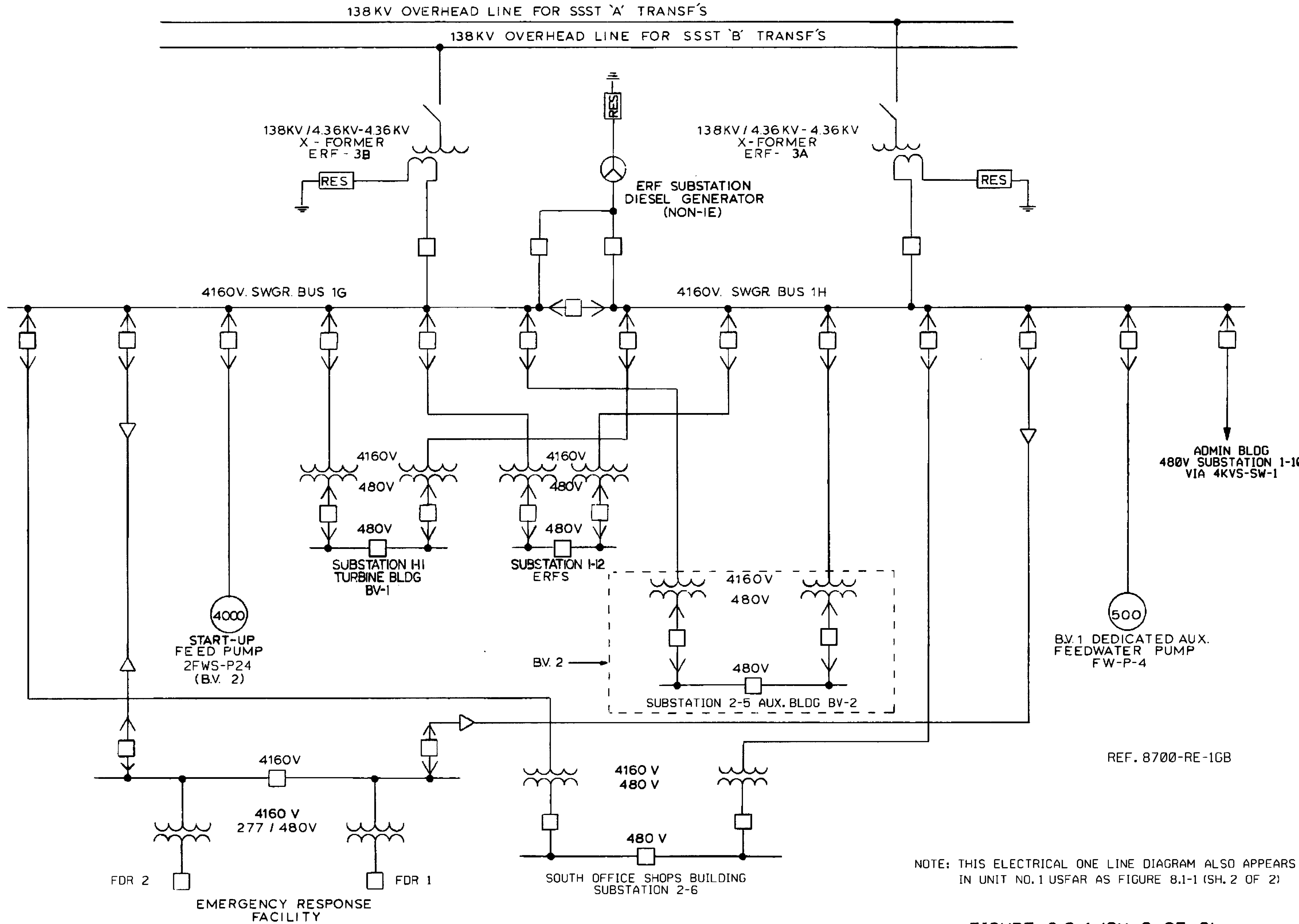
NOTES:

1. KEY INTERLOCKS PREVENT BOTH SWING MOTOR BREAKERS AND BOTH TRANSFER SWITCHES FROM BEING CLOSED AT SAME TIME. (TRANSFER SWITCH CONSISTS OF TWO (2) 480V MANUAL CLOSE, SHUNT TRIP BREAKERS). ON TRANSFER, ELECTRICAL INTERLOCKS PREVENT TRANSFER SWITCHES FROM OPENING OR CLOSING UNDER LOAD.
2. 480-V EMERGENCY BUS 2N FEEDS THE FOLLOWING EMERGENCY MOTOR CONTROL CENTERS * 2-E1, 2-E3, 2-E5, 2-E7, 2-E9, 2-E11, 2-E13 AND 2-E15.
3. 480-V EMERGENCY BUS 2P FEEDS THE FOLLOWING EMERGENCY MOTOR CONTROL CENTERS * 2-E2, 2-E4, 2-E6, 2-E8, 2-E10, 2-E12 AND 2-E14.
4. ALL NORMAL UNIT SUBSTATION TRANSFORMERS ARE RATED 1000/1333 KVA.
5. KEY INTERLOCKS PROVIDED ON "SWING" MOTOR BREAKERS AND KEY TRANSFER STATIONS PROVIDED ON TRANSFER SWITCHES PREVENT BOTH SWING MOTOR BREAKERS FROM BEING CLOSED AT THE SAME TIME. THE INTERLOCKS ALSO PREVENT THE OPENING OR CLOSING OR EITHER TRANSFER SWITCH UNLESS THE ASSOCIATED BREAKER IS OPEN.

* SBO BREAKERS ARE ADMINISTRATIVELY CONTROLLED AND NORMALLY DISCONNECTED FROM BUSSES. BREAKERS ARE LOCALLY OPERATED.

FIGURE 8.3-1 (SHEET 1 OF 2)
MAIN ONE LINE DIAGRAM
BEAVER VALLEY POWER STATION-UNIT 2
FINAL SAFETY ANALYSIS REPORT

REV. 22



REF. 8700-RE-1GB

NOTE: THIS ELECTRICAL ONE LINE DIAGRAM ALSO APPEARS IN UNIT NO. 1 USFAR AS FIGURE 8.1-1 (SH. 2 OF 2)

FIGURE 8.3-1 (SH. 2 OF 2)
ELECTRICAL ONE LINE DIAGRAM

BEAVER VALLEY POWER STATION UNIT NO. 2
UPDATED FINAL SAFETY ANALYSIS REPORT

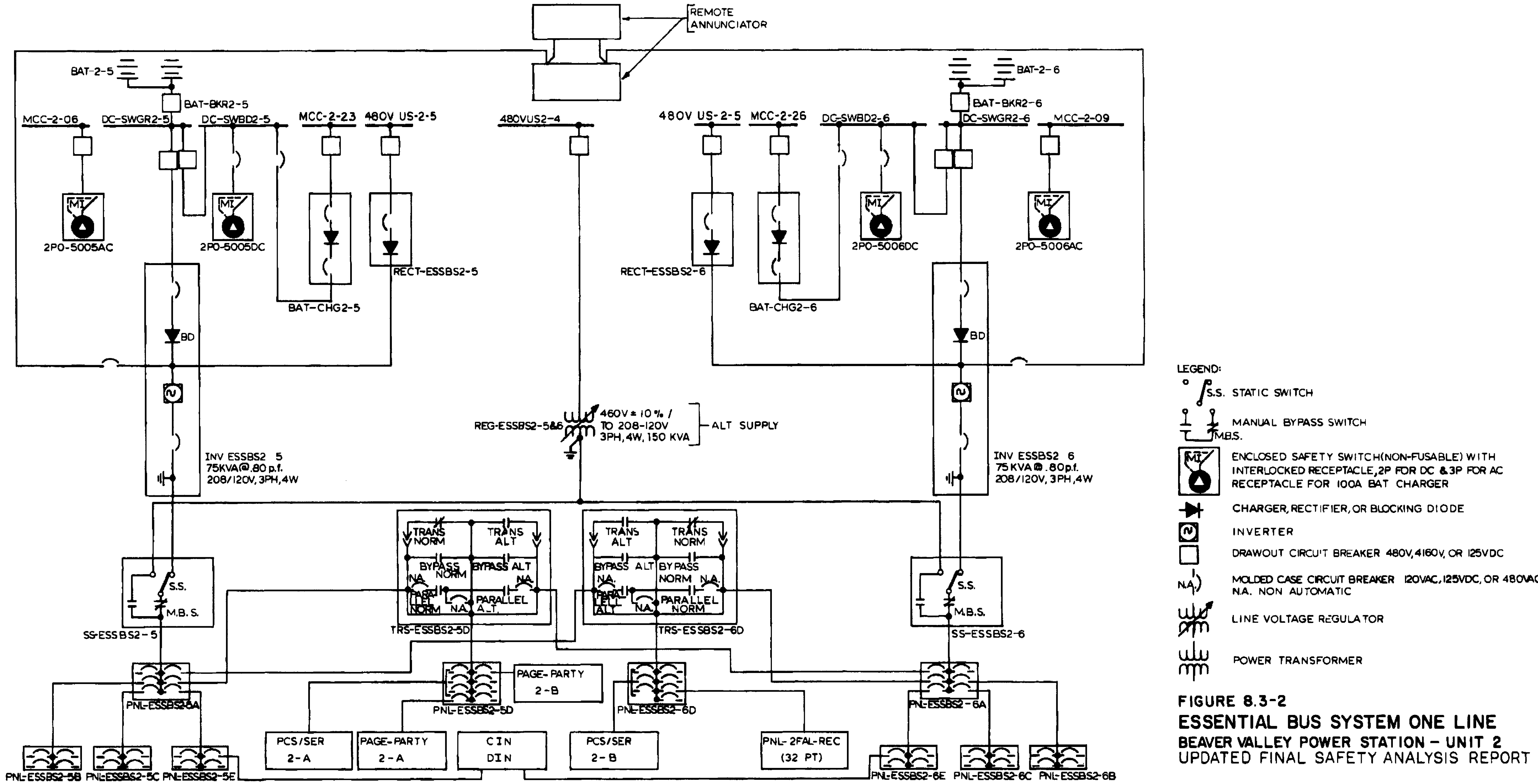


FIGURE 8.3-2

ESSENTIAL BUS SYSTEM ONE LINE

BEAVER VALLEY POWER STATION – UNIT 2

UPDATED FINAL SAFETY ANALYSIS REPORT

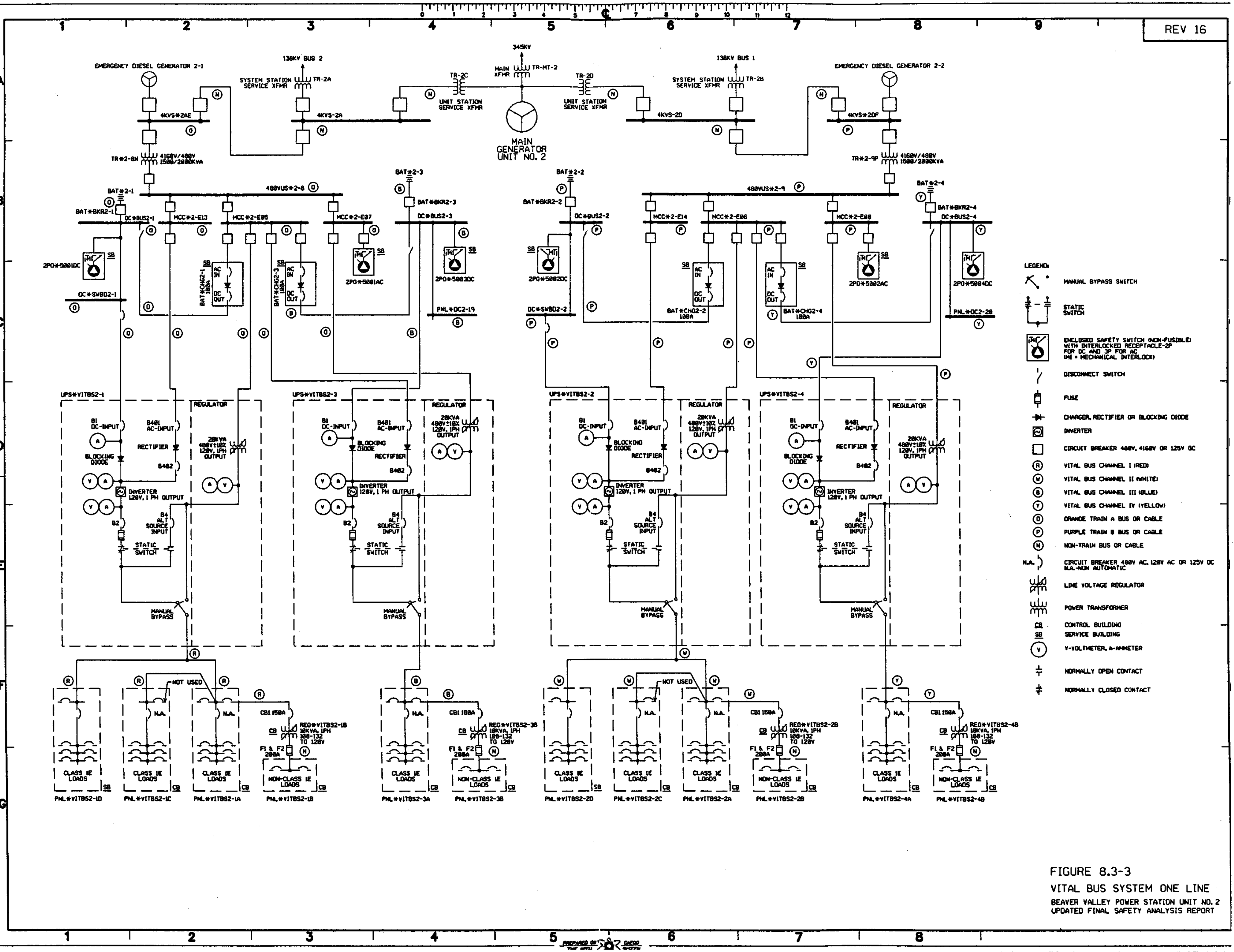


FIGURE 8.3-3
VITAL BUS SYSTEM ONE LINE
BEAVER VALLEY POWER STATION UNIT NO. 2
UPDATED FINAL SAFETY ANALYSIS REPORT

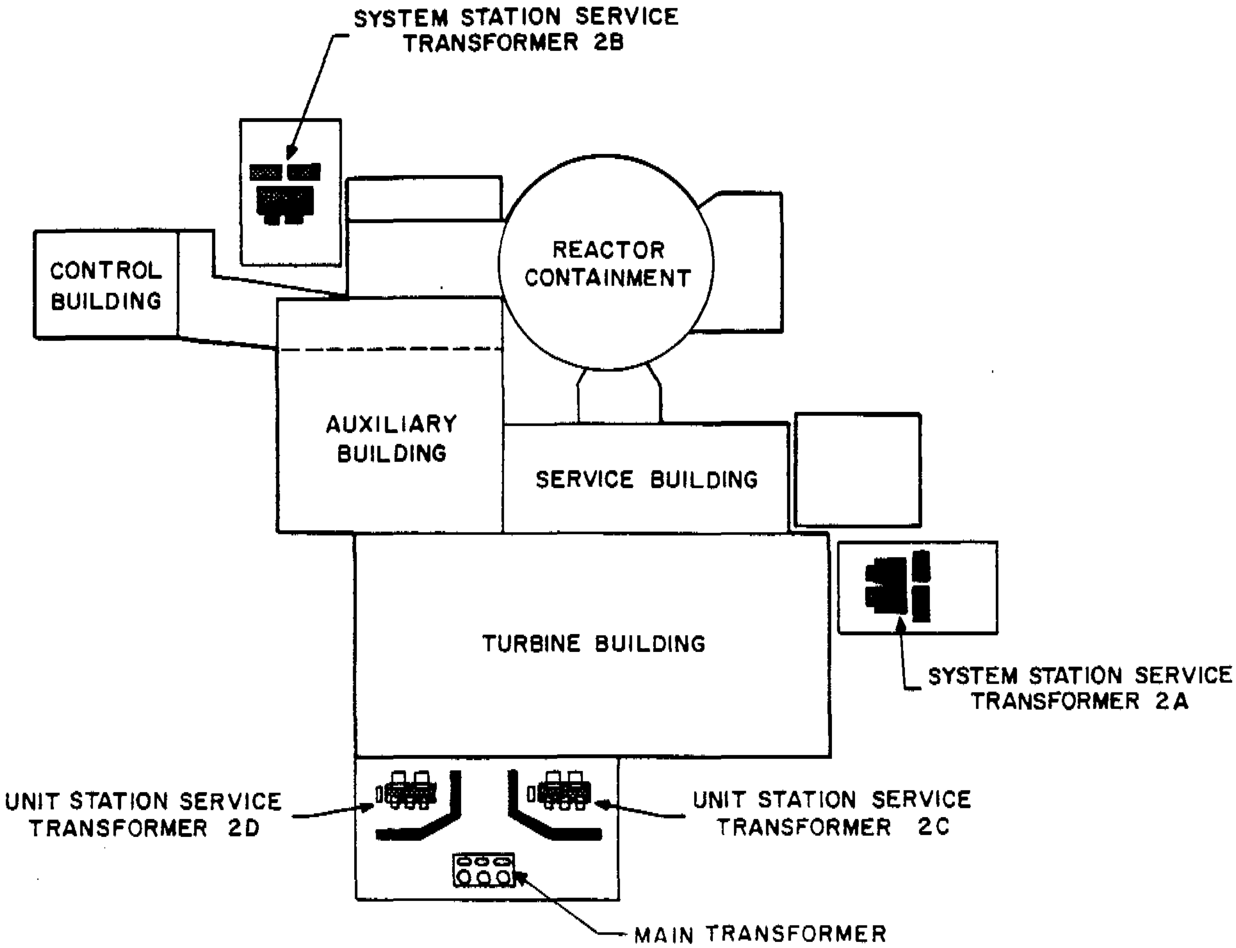


FIGURE 8.3-13
SYSTEM AND UNIT STATION SERVICE TRANSFORMER ARRANGEMENT
BEAVER VALLEY POWER STATION-UNIT 2
FINAL SAFETY ANALYSIS REPORT

REV 16

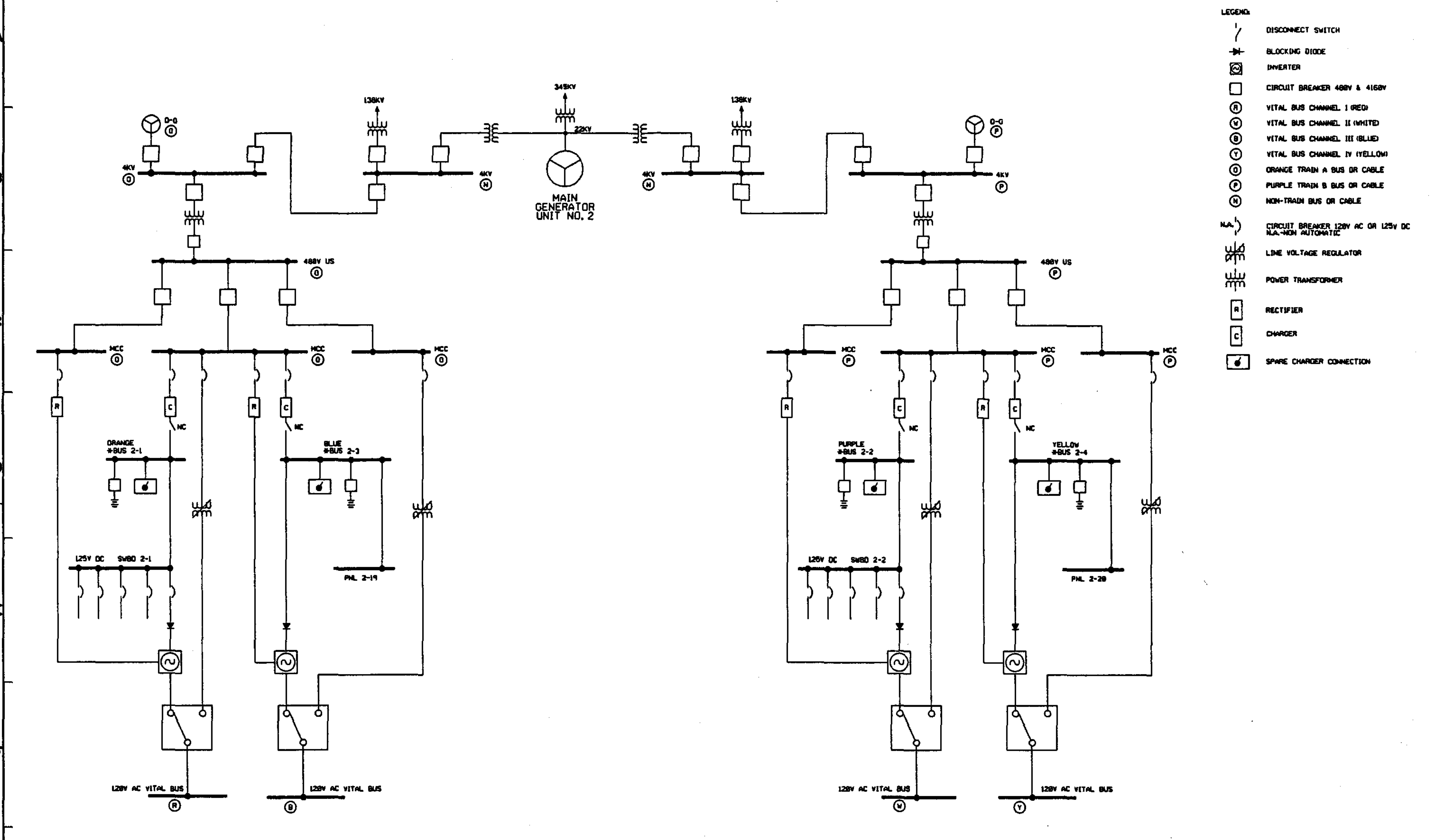


FIGURE 8.3-14

CLASS 1E 125V DC
DISTRIBUTION SYSTEM

BEAVER VALLEY POWER STATION UNIT NO. 2
UPDATED FINAL SAFETY ANALYSIS REPORT

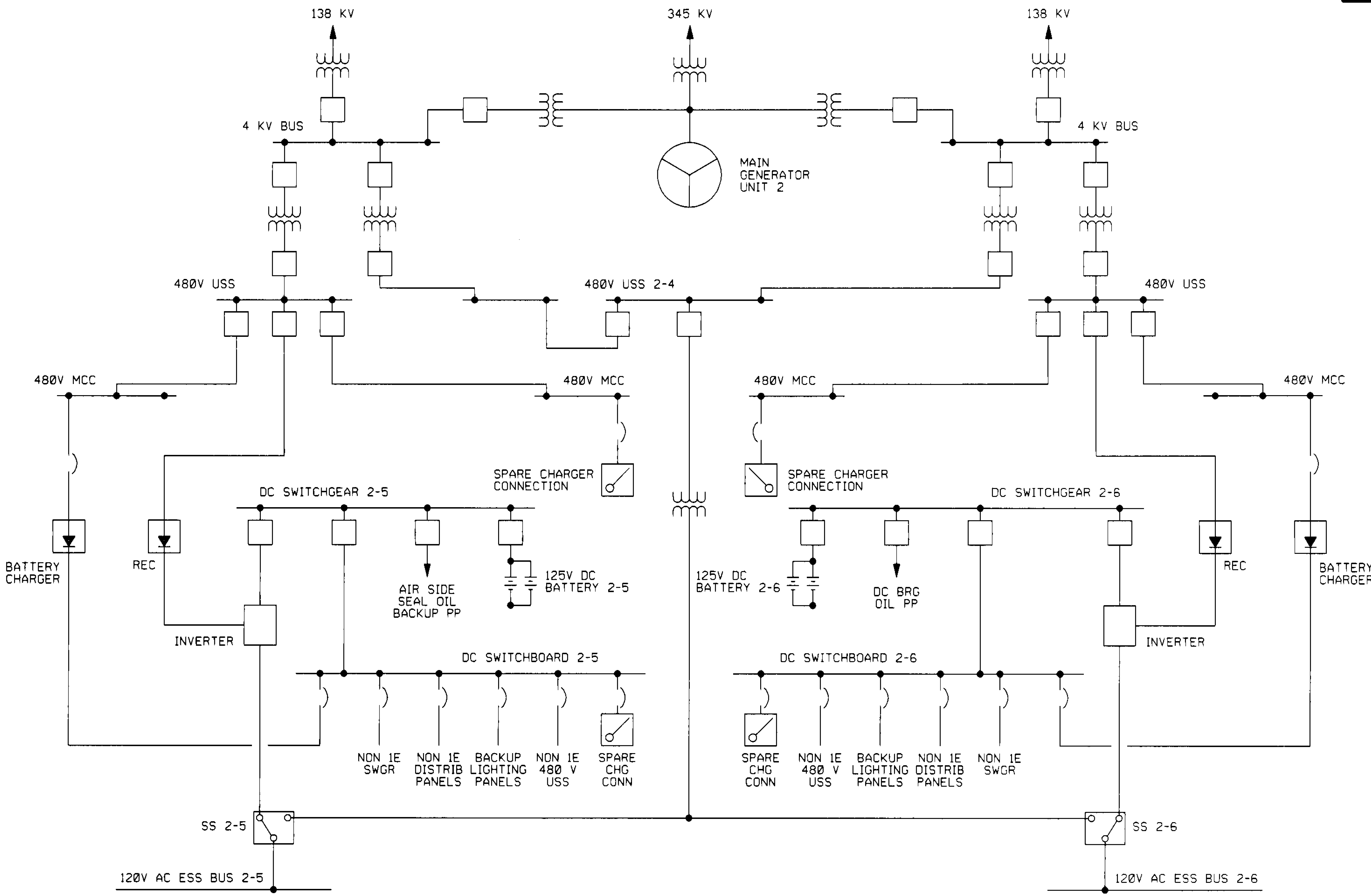


FIGURE 8.3-15
NON-CLASS 1E, ESSENTIAL
125V DC DISTRIBUTION SYSTEM
BEAVER VALLEY POWER STATION UNIT NO. 2
UPDATED FINAL SAFETY ANALYSIS REPORT