

YGN 1 & 2 FSAR

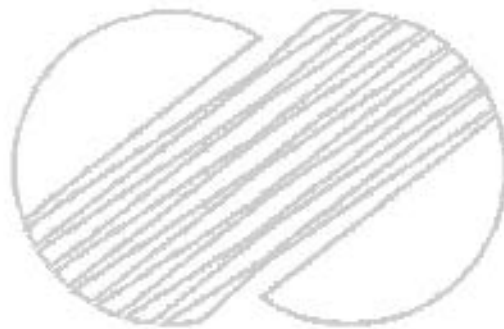
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8. ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 UTILITY GRID DESCRIPTION

The Korea Electric Power Corporation (KEPCO) grid system consists of interconnected hydroelectric plants, fossil fuel plants, and nuclear plants supplying electric energy over a system of 345 kV and 154 kV transmission lines and lower voltage distribution networks. Figure 8.1-1 shows the 345 kV systems in the vicinity of Korea Nuclear Units 7 and 8 (YGN 1 & 2).

Korea Electric Power Corporation provides all of the electric power used in South Korea.

8.1.2 ONSITE POWER SYSTEM DESCRIPTION

The Main Single-Line Diagram for the onsite power system is shown in figure 8.3-1. The onsite power source for the non-Class 1E loads of each unit is the main generator through two unit auxiliary transformers. The preferred power sources for the Class 1E loads are from two startup transformers. AC power is supplied to Class 1E loads at 4.16 kV, 480V, and 120V and to non-Class 1E loads at 13.8 kV, 4.16 kV, 480V and 120V voltage levels. During an emergency, if offsite power is not available, onsite power is provided to the Class 1E loads by two Class 1E diesel generators per unit. For each unit the onsite Class 1E power system is divided into two separate load groups.

In addition to the Class 1E diesel generators described above, another non-Class 1E diesel generator, which is in the independent AAC building separated from the existing power blocks, is provided as an alternate AC(AAC) source for common use of YGN 1&2. DC power is supplied at 250V for non-Class 1E loads only, and 125V for non-Class 1E and Class 1E loads. The Class 1E electric system provides auxiliary ac and dc power for equipment used to shut down the reactor and limit the release of radioactive material following a design basis event. Criteria for the Class 1E electric system are defined in IEEE Standard 308. The Class 1E dc system provides four independent sources of 125V dc power, two for each load group, for Class 1E switchgear, essential ac power inverters, and other safety-related equipment. The single line diagram for the Class 1E dc power system is shown in figure 8.3-3.

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8.1.3 OFFSITE POWER SYSTEM DESCRIPTION

Two sources of offsite power are provided to each unit to supply preferred power to the onsite Class 1E system. The two sources are through 345 kV startup transformers. The two startup transformers feed only the station auxiliary loads of their own unit.

8.1.4 SAFETY-RELATED LOADS

The Class 1E loads supplied by the Class 1E ac system are listed in table 8.3-1. Class 1E loads supplied by the Class 1E dc system are listed in table 8.3-3.

8.1.5 DESIGN BASES

8.1.5.1 Offsite Power System

The following principal design bases are applied to the offsite power system:

8.1.5.1.1 Design Basis One

Electric power from the offsite power grid to the onsite Class 1E power system is supplied by two physically independent circuits designed and located so as to minimize the likelihood of simultaneous failure.

8.1.5.1.2 Design Basis Two

Two independent startup transformers are provided to supply the onsite Class 1E electrical distribution system of each unit.

8.1.5.2 Onsite Power System

8.1.5.2.1 Design Bases

The following principal design bases are applied to the onsite power system:

8.1.5.2.1.1 Design Basis One. The onsite power system includes a Class 1E electric power system for each unit.

8.1.5.2.1.2 Design Basis Two. The onsite Class 1E electric power system of each unit is divided into two independent load groups (defined in IEEE Standard 308), each with its own power supplies, buses, transformers, loads, and associated 125V dc control power. There is a standby charging pump which may receive power from each of the two load groups by means of a transfer switch. Each load group is capable of supplying power to all essential equipment in its redundant group during emergency plant conditions.

8.1.5.2.1.3 Design Basis Three. One diesel generator is provided for each independent Class 1E ac load group.

8.1.5.2.1.4 Design Basis Four. Automatic transfers are not provided between redundant load groups.

8.1.5.2.1.5 Design Basis Five. No portion of either the onsite Class 1E ac or dc power systems is shared between units.

8.1.5.2.1.6 Design Basis Six. The Class 1E electric systems are designed to satisfy the single failure criterion.

8.1.5.2.1.7 Design Basis Seven. For each protection channel, one independent 125V dc and one 120V vital ac power source are provided. Batteries are sized for 2.2 hours of operation without the support of a battery charger.

8.1.5.2.1.8 Design Basis Eight. A separate non-Class 1E dc system is provided for non-Class 1E controls and loads.

8.1.5.2.1.9 Design Basis Nine. Raceways are not shared by Class 1E and non-Class 1E cables.

8.1.5.2.1.10 Design Basis Ten. Special identification criteria apply for Class 1E equipment, cabling and raceways.

8.1.5.2.1.11 Design Basis Eleven. Separation is provided in accordance with IEEE 304 criteria to assure the independence of redundant Class 1E electric systems as described in paragraph 8.3.1.4.

8.1.5.2.1.12 Design Basis Twelve. Class 1E equipment is designed with the capability of being tested periodically.

8.1.5.2.2 Design Criteria, Regulatory Guides, and IEEE Standards

The onsite power system is designed in accordance with IEEE Standards 279, 306, 317, 323, 334, 338, 344, 382, 383, 384, 387, 420, 450, 484, 485, and 650. Compliance with General Design Criteria 17 and 18 of 10 CFR 50, Appendix A, is discussed in paragraph 8.3.1.2 and subparagraph 8.3.2.2.1

8.1.5.2.2.1 Regulatory Guide 1.6, Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (March 1971). Refer to subparagraph 8.3.2.2.1.3 and appendix 3A for discussion of this guide.

8.1.5.2.2.2 Regulatory Guide 1.9, Selection of Diesel Generator Set Capacity for Standby Power Supplies (Revision 2, December 1979). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.3 Regulatory Guide 1.22, Periodic Testing of Protection System Actuation Functions (February 1972). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.4 Regulatory Guide 1.28, Quality Assurance Program Requirements (Design and Construction Revision 2, February 1979). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.5 Regulatory Guide 1.29, Seismic Design Classification (Revision 3, September 1978). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.6 Regulatory Guide 1.30, Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment (August 1972). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.7 Regulatory Guide 1.32, Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants (Revision 2, February 1977). Refer to appendix 3A and 8.3.2.2 for discussion of this guide.

8.1.5.2.2.8 Regulatory Guide 1.38, Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage and Handling of Items for Water-Cooled Nuclear Power Plants (Revision 2, May 1977). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.9 Regulatory Guide 1.40, Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants (March 1973). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.10 Regulatory Guide 1.41, Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments (March 1973). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.11 Regulatory Guide 1.47, Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems (May 1973). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.12 Regulatory Guide 1.53, Application of Single Failure Criterion to Nuclear Power Plant Protection Systems (June 1973). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.13 Regulatory Guide 1.62, manual Initiation of Protective Actions (October 1973). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.14 Regulatory Guide 1.63, Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants (Revision 2, July 1978). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.15 Regulatory Guide 1.64, Quality Assurance Requirements for the Design of Nuclear Power Plants (Revision 2, June 1976). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.16 Regulatory Guide 1.73, Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants (January 1974). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.17 Regulatory Guide 1.75, Physical Independence of Electric Systems (Revision 2, September 1978). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.18 Regulatory Guide 1.81, Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants (Revision 1, January 1975). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.19 Regulatory Guide 1.89, Qualification of Class 1E Equipment for Nuclear Power Plants (November 1974). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.20 Regulatory Guide 1.93, Availability of Electric Power Sources (December 1974). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.21 Regulatory Guide 1.100, Seismic Qualification of Electric Equipment for Nuclear Power Plants (Revision 1, August 1977). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.22 Regulatory Guide 1.106, Thermal Overload Protection for Electric Motors on Motor-Operated Valves (Revision 1, March 1977). Refer to appendix 3A for discussion of this guide.'

8.1.5.2.2.23 Regulatory Guide 1.108, Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants (Revision 1, August 1977; Supplemented September 1977). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.24 Regulatory Guide 1.118, Periodic Testing of Electric Power and Protection Systems (Revision 2, June 1978). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.25 Regulatory Guide 1.128, Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants (Revision 1, October 1978). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.26 Regulatory Guide 1.129, Maintenance, Testing and Replacement of Large Lead Storage Batteries for Nuclear Power Plants (Revision 1: February 1978). Refer to appendix 3A for discussion of this guide.

8.1.5.2.2.27 Regulatory Guide 1.131, Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants (August 1977). Refer to appendix 3A for discussion of this guide.

406 | 8.1.5.2.2.27A Regulatory Guide 1.155, Station Blackout (August 1988).
Refer to appendix 3A for discussion of this guide

8.1.5.2.2.28 IEEE Standard 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations. Refer to section 7.1 and paragraph 8.3.1.4 for discussion of this standard.

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8.1.5.2.2.29 IEEE Standard 3084978, Criteria for Class 1E Power Systems for Nuclear Power Generating Stations. Refer to subparagraphs 7.1.2.23, 8.3.1.2.1, 8.3.2.2.1.9, and table 8.3-4 for discussion of this standard.

8.1.5.2.2.30 IEEE Standard 317-1976, Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations. Refer to subparagraph 3.11.2.2.2 and paragraph 7.1.2.24 for discussion of this standard.

8.1.5.2.2.31 IEEE Standard 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations. Refer to sub-paragraphs 3.11.2.1.1 and 3.11.2.2.2, and sub-sections 3.11.3.2 and 7.1.2.25 for discussion of this standard.

8.1.5.2.2.32 IEEE Standard 334-1974, Type Tests of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations. Refer to subparagraph 7.1.2.26 for discussion of this standard.

8.1.5.2.2.33 IEEE Standard 338-1977, Criteria for the Periodic Testing of Nuclear Power Generating Station Safety Systems. Refer to paragraph 7.1.2.28 for discussion of this standard.

8.1.5.2.2.34 IEEE Standard 344-1975, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations. Seismic qualification of Class 1 electric equipment-and the extent of compliance with IEEE Standard 344 are discussed in section 3.10 and paragraphs 3.11.3.2 and 7.1.2.29.

8.1.5.2.2.35 IEEE Standard 382-1972, Guide for Type Test of Class 1E Electric Valve Operators for Nuclear Power Generating Stations. Refer to subparagraphs 3.11.2.2.2.D, 3.9.3.2.2.2 and 7.1.2.31 for discussion of this standard.

8.1.5.2.2.36 IEEE Standard 383-1974, Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations. Refer to subparagraph 3.11.2.2, for discussion of this standard.

8.1.5.2.2.37 IEEE Standard 384-1977, Trial Use Standard Criteria for Independence of Class 1E Equipment and Circuits. Refer to appendix 3A and section 8.3 for a description of the degree of compliance with Regulatory Guide 1.75.

8.1.5.2.2.38 IEEE Standard 3874977, Standard Criteria for Diesel Generator Units Applied as Stand by Power Supplies for Nuclear Power Generating Stations. The following paragraphs analyze compliance with the design criteria of IEEE Standard 387.

Each diesel generator system will include lube oil standby heating and jacket cooling water standby heating as discussed in sections 8.3 and 9.5.

Adequate cooling and ventilation equipment is provided to maintain an acceptable service environment within the diesel generator rooms during and after any design basis event even without support from the preferred power supply.

Each diesel generator is capable of starting, accelerating, and accepting load, as described in subparagraph 8.3.1.1.3. The diesel generator automatically energizes its cooling equipment within an acceptable time after starting.

Frequency and voltage limits, and the basis of the continuous rating of the diesel generator, are discussed in appendix 3A in accordance with Regulatory Guide 1.9.

Mechanical and electric systems are designed so that a single failure affects the operation of only a single diesel generator.

Diesel generator design conditions such as vibration, torsional vibration, and overspeed are considered in accordance with the requirements of IEEE Standard 387.

Each diesel governor can operate in either the isochronous or the droop modes and the voltage regulator can operate in the parallel mode during diesel generator testing.

Special underfrequency protection is provided for safely separating the diesel generator from the preferred source (when previously synchronized to it for testing) without damage to or shutdown of the diesel generator.

Each diesel generator is provided with control systems permitting automatic and manual control. The automatic start signal is functional except when the diesel generator is in the maintenance mode. Provision is made for controlling each diesel generator remotely from the control room and locally from the diesel generator room.

Subparagraph 8.3.1.1.3 provides a further description of the diesel generator system.

8.1.5.2.2.39 IEEE Standard 420-1973, Guide for Class 1E Control Switchboards for Nuclear Power Generating Stations. Refer to subparagraph 8.3.1.4.1.2 for discussion of this standard.

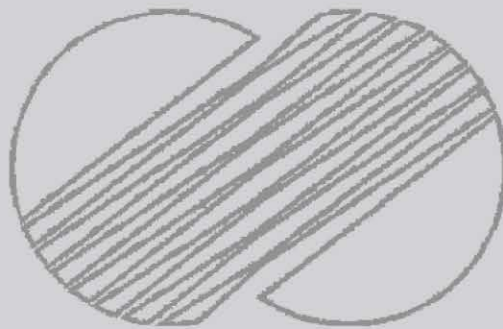
8.1.5.2.2.40 IEEE Standard 450-1975, Recommended Practice for Maintenance, Testing, and Replacement- of Large Lead Storage Batteries for Generating Stations and Substations. Refer to subparagraphs 8.3.2.1.1.2.3 and 8.3.2.2.1.10 for discussion of this standard.

8.1.5.2.2.41 IEEE Standard 484-1975, Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations. Refer to construction package CP7A.D.6 for discussion of this standard.

8.1.5.2.2.42 IEEE Standard 485-1978, Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations. The calculations for sizing all of the large lead storage batteries were made using-the practices recommended in this standard.

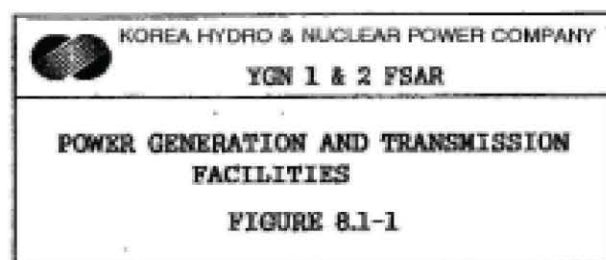
8.1.5.2.2.43 IEEE Standard 650-1979, Class 1E Battery Chargers and Inverters for Nuclear Power Generating Stations

OFFSITE POWER SYSTEM



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8.2 OFFSITE POWER SYSTEM

8.2.1 DESCRIPTION

Electric power for startup, shutdown, and normal operation of safety-related equipment of Korea Nuclear Units 7 and 8 is supplied from the Korea Electric Power Corporation (KEPCO) transmission system as shown in figure 8.1-1. In the event a unit auxiliary transformer is out of service, all inplant auxiliary equipment may receive power from the offsite source. There will be four 345kV circuits connected to the 345 kV switching station located at the plant site. These circuits will be carried on two sets of double circuit towers. This station uses a breaker-and-a-half arrangement as shown in figure 8.2-2. Two 345 kV lines (a double circuit) are connected from Singwangju substation, identified as Route A, and two 345 kV lines (a double circuit) are connected from (YGN 3 & 4 SWITCHYARD) identified as Route B.

The physical routing of offsite power sources is shown in figure 8.2-1. The 345 kV transmission lines and their associated structures are routed on separate and independent rights-of-way. They are designed to withstand the loading conditions for environmental conditions such as wind, temperature, salt contamination, lightning, flood, etc., so as to minimize the number of line failures.

8.2.1.1 Transmission System

Four 345 kV transmission lines connect YGN 1 & 2 to the KEPCO transmission system at the 345 kV switchyard, as indicated in figure 8.2-2. Route A provides two of the four 345 kV transmission line connections between the Singwangju substation and the YGN 1 & 2 switchyard. The remaining two 345 kV transmission line connections, 1) between the YGN 3 & 4 switchyard and are shown on the right of-way identified as route B, identified as Route A and Route B respectively, are run on identical double circuit, steel towers. The transmission lines enter the switchyard on separate rights-of-way and no other lines cross these circuits. The physical separation is such that no single event, such as a tower falling or a line breaking, can simultaneously affect these circuits in such a way that one 345kV transmission line cannot be returned to service in time to perform its intended function.

The structural design of the transmission towers and lines is based upon Korea standard design practices. Four 954 MCM AC3R conductors per phase are supported on insulator hardware assemblies on the lattice type steel towers. Maximum tension of the conductor is limited to 4202 kg per subconductor. The use of bundled conductors with spacers and dampers reduces vibration to acceptable levels.

A single ground wire is installed above the phase wires of each tower line to provide protection against outages caused by lightning.

The offsite sources are capable of operating independently of the onsite sources and are provided with electrical protective relays, breaker control circuits, and power supplies to assure that loss of one preferred system circuit will not cause or result in loss of the redundant counterpart.

8.2.1.2 Switchyard

The 345 kV switchyard for YGN 1 & 2 is shared by both units. The switchyard is designed such that three circuit breakers are provided for every two lines. This configuration is referred to as a breaker-and-a-half arrangement. The breaker-and-a-half scheme provides flexibility and reliability of operation and ease of maintenance in that any one line or any one breaker may be removed from service without loss of performance of the remaining lines and breakers in the switchyard. The switchyard is connected to the four 345 kV transmission lines and the 362/22 kV main transformers. Figure 8.2-2 includes a one line diagram of the 345 kV switchyard and connections to the power plant.

The switchyard operates with all circuit breakers normally closed. Each circuit is provided with redundant high-speed primary relays for rapid isolation of components in the event of failure or abnormal conditions. Static or electromechanical relays are provided on each circuit for backup protection. Also, if one of the power circuit breakers fails to clear a fault, breaker failure

protection relaying is provided to clear the faulted circuit of all sources of power. Direct current for operation of the sub-station power circuit breakers is obtained from redundant batteries independent of the plant batteries. A switchyard control house is provided.

The structural arrangement of the 345 kV switchyard is based upon designs derived from experience under seismic, wind-loading, and short circuit conditions. Bus and line insulation is in accordance with proven practice for seaside installations.

Two physically independent circuits provide offsite preferred sources of power from the switchyard to the onsite ac distribution system in the plant. These two 345 kV circuits are routed underground through 345kV CV Cables to two physically separated 345 kV startup transformers installed near the turbine building, as shown in figure 8.2-3 for each unit. The startup transformers step down the 345 kV offsite preferred power supply to the 13.8 kV and 4.16 kV distribution systems. Each 345 kV-13.8/4.16 kV startup transformer is connected to 13.8 kV and 4.16 kV switchgear assemblies in the plant.

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During normal power operation, the non-Class 1E auxiliary system is supplied by the main generator through the unit auxiliary transformers. During startup, shutdown, or any time the main generator becomes unavailable, power can be supplied from the 345 kV startup transformers. The Class 1E system is normally supplied power through the startup transformers. In addition to the above, diesel generators are provided for each 4.16 kV Class 1E bus for emergency power supply.

8.2.1.3 Switchyard and Breaker Control

The 345 kV switchyard arrangement is of the circuit breaker-and-a-half bus scheme, with 15 breakers to allow connection of five lines, two lines for step-up main transformer banks, and three lines for startup transformers, as shown on figure 8.2-2.

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The specific features of the switchyard breaker control, relay protection, and operation are shown on figure 8.2-4 and as summarized below:

- A. A duplicate relay system is provided for the protection of buses, lines, and circuit breakers.
- B. Each circuit breaker has two independent trip circuits, for primary and backup protection.

- C. There are two separate dc batteries, one for primary and the other for backup relaying and control to provide highly reliable and available dc sources.

Each circuit breaker is capable of at least three positive open/close operations starting with normal operating pressure without the assistance of the air compressors.

- D. Any transmission line can be opened under normal or fault condition without affecting any other transmission line.
- E. Any transmission line can be isolated by no-load break disconnect switches, after tripping associated breakers, for maintenance without interrupting normal plant operation.
- F. Any bus fault can be isolated without interrupting service to other circuits not connected to the faulty bus section.
- G. A stuck circuit breaker should not cause tripping of more than one additional unit or line.
- H. Any circuit breaker can be isolated by no-load break disconnect switches for inspection and maintenance.

There are four independent 345 kV circuits (see figure 8.2-2) providing offsite power sources. These sources provide power for the engineered safety feature (ESF) buses from the 345 kV switchyard through the 345 kV startup transformers.

Inspection and testing of the 345 kV circuit breakers and the associated protective relaying will be routinely performed without interrupting the power supply to the ESF buses. The operability and functional performance of the components of the system will comply with the General Design Criteria.

8.2.1.4 Compliance With Criteria

A. Compliance with General Design Criterion 17

Electrical power from the transmission network to the switchyard is provided by two physically independent 345 kV transmission systems. The design of the offsite power system is in full compliance with the requirements of General Design Criterion 17.

B. Compliance with General Design Criterion 18

The inspection and testing of 345 kV circuit breakers and the transmission line protective relaying will be done on a routine basis, without interrupting the normal operation of the ESF loads.

During these routine inspections and tests the operability and functional performance of the components of the system will comply with General Design Criterion 18.

8.2.1.5 Industry Standards

The preferred power system is not a Class 1E system and is designed as a normal power system on the basis of good engineering judgment, experience, and the applicable standards and recommendations of:

Institute of Electrical and Electronics Engineers (IEEE)

National Electrical Manufacturers Association (NEMA)

American Society of Civil Engineers (ASCE)

USNRC General Design Criteria (GDC), Appendix A to
10 CFR Part 50.

8.2.2 ANALYSIS

Two independent routes, each with one 345 kV double circuit line, supply ac offsite power with adequate separation to YGN 1 & 2. Failure of one transmission line will not cause failure of the other line since these two lines are connected to separate remote substations and each enters the switchyard on a separate right-of-way. The KEPCO transmission system is designed to withstand the outage of a double circuit transmission line or of an entire power plant without uncontrolled widespread tripping of line and/or unit. This means that sequential loss of two units at YGN 1 & 2 would not adversely affect the transmission system and the power to replace the loss of generation could be partly supplied by the spinning reserve. Under these circumstances, the 345 kV line serving the plant would continue to be energized from the grid system so that the supply of offsite power to the ESF buses would not be lost. The transmission lines to the plant are designed to meet the requirements of General Design Criterion 17 and Regulatory Guide 1.32. System design for dynamic stability will prevent the tripping of any one line from causing the unit to trip and/or the sudden loss of one unit from causing the second unit to trip.

8.2.2.1 Stability Considerations

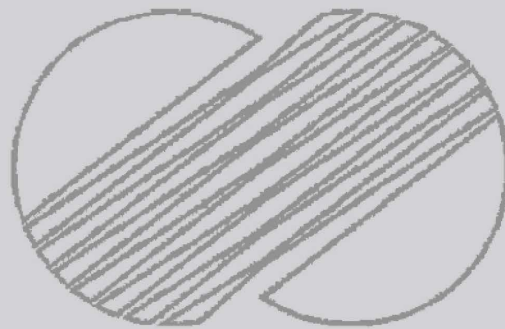
Transient stability studies were conducted on the YGN 1 & 2 transmission system using a digital computer program. Three-phase faults were simulated at the YGN 1 & 2 345 kV bus with the resulting outage of two critical transmission circuits. Normal fault clearing time was assumed to be five cycles: one-cycle relay operation time, three-cycle breaker time, and one-cycle margin.

315 | The study results demonstrate that the KEPCO transmission network is adequate to maintain stable system operation for three-phase faults cleared within five cycles and forced to be disconnected with one or two YGN units with the simultaneous loss of two 345 kV transmission elements. The study results also demonstrate the satisfactory recovery of the transmission voltage after the fault has been cleared.

Further analysis indicates that an accident signal causing the loss of either YGN 1 & 2 does not result in system instability or impairment of the Class 1E system capability to start and accelerate the emergency shutdown loads.

406 | It is extremely improbable that all 345 kV transmission lines would be out of service simultaneously. However, such an event would not jeopardize the safe shutdown of the plant since there are onsite standby diesel generators. These would be capable of supplying the necessary power required for safe shutdown. Relay settings are calculated to start the diesels if the offsite power system voltage falls below the minimum required for safety-related equipment. And, in addition to onsite standby diesel generators, another non-Class 1E diesel generator, which is in the independent AAC building separated from the existing power blocks, is provided as an alternate AC(AAC) source for common use of YGN 1&2 to cope with Station Blackout(SBO).

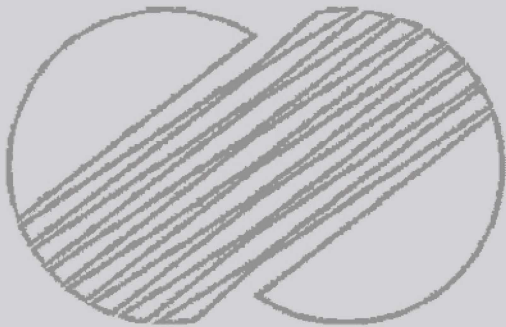
The grid stability analysis also shows that the loss, through a single event, of the largest single supply to the grid or removal of the largest load from the grid, does not result in the complete loss of the preferred onsite power. In addition, the study shows that the frequency decay rate of the grid will not result in a reactor coolant pump motor braking action, sufficient to create an unsafe condition due to reduced reactor coolant flow.




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YGN 1 & 2 FSAR

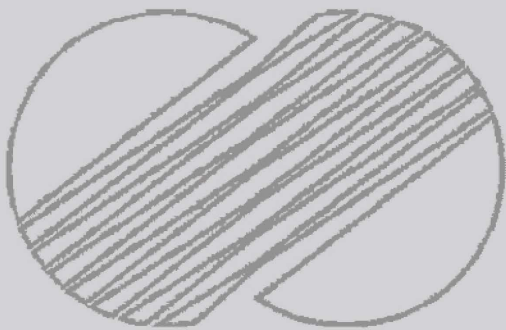
345KV TRANSMISSION LINE ROUTES

FIGURE 8.2-1




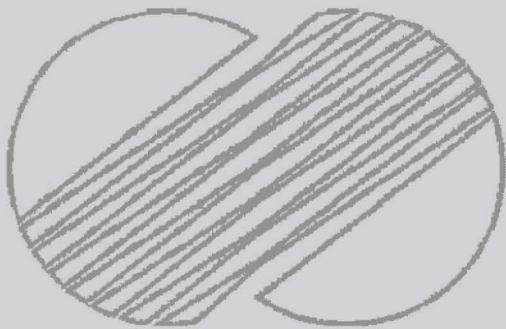
Amendment 676
2018. 1. 23

	KOREA HYDRO & NUCLEAR POWER COMPANY YGN 1 & 2 FSAR
	SWITCHYARD ONE LINE Figure 8.2-2



Amendment 628
2016. 5. 27

 KOREA HYDRO & NUCLEAR POWER COMPANY
YGN 1 & 2 FSAR
PHYSICAL ARRANGEMENT OF SWITCHYARD
AND TRANSMISSION LINE CONNECTIONS
Figure 8.2-3



Amendment 451
2010. 2. 9

KOREA HYDRO & NUCLEAR POWER
COMPANY
YGN 1 & 2 FSAR
345kV SWITCHYARD ONE LINE
DIAGRAM FOR PROTECTION
Figure 8.2-4

Amendment 3

YGN 1 & 2 FSAR

8.3 ONSITE POWER SYSTEMS

8.3.1 AC POWER SYSTEMS

8.3.1.1 Description

As shown in figure 8.3-1, the onsite ac power system for each unit consists of the main generator, two unit auxiliary transformers, two startup transformers, two Class 1E diesel-generators, one non-Class 1E diesel-generator and the 13.8 kV, 4.16 kV, and 480V distribution systems. In addition to 480V power, the motor control centers (MCCs) (in figure 8.3-1) provide power to 380/220V and 208/120V loads through transformers.

In addition to the above mentioned onsite AC power system, another non-Class 1E diesel generator, which is in the independent AAC building separated from the existing power blocks, is provided as an alternate AC(AAC) source for common use of YGN 1&2 to cope with Station Blackout(SBO)

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Nominal rating and characteristics of the main generator are as follows:

- | | |
|--|-----|
| A. Rating: <u>1,163,330</u> kVA at 0.9 pf at 75 psig hydrogen pressure | 479 |
| B. Voltage: <u>22</u> kV, 3 phase, 60 hertz | |
| C. Speed: 1800 rpm | |
| D. Short circuit ratio: <u>0.60</u> | 160 |
| E. Subtransient reactance $X''_{dv} = 0.305$ per unit
(dv - direct axis unsaturated) | 361 |
| F. Stator current: <u>33,696</u> amperes | |
| G. Field current: <u>6,522</u> amperes dc | |
| H. Field voltage: <u>540V</u> dc | |
| I. Current transformers: <u>40,000/5</u> amperes, three per phase
on neutral and line terminals | |
| J. Winding capacitance for three phases : <u>1.3956</u> microfarad | |
| K. AC auxiliaries: 460V, 3 phase, 60 hertz, open drip-proof,
fully guarded enclosure Class B and class F insulation | 160 |
| L. DC auxiliaries: 250V nominal, (210V-280V range),open
drip-proof, Class F insulation | |
| M. AC controls: 120V $\pm 10\%$, 1 phase, 60 $\pm 5\%$ hertz | 160 |
| N. DC controls: 125V, nominal (105V-140V range) | |
| O. Rotor cooling: hydrogen | |
| P. Stator cooling: water | |

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- Q. Insulation class: F (Rotor : Epoxy Glass, Nomex/Epoxy Glass composite system
Stator : Epoxy Mica based system)
R. Excitation type : Static(PSCR)

Ratings and characteristics of the unit auxiliary transformers are as follows :

- A. Two each half load sized auxiliary transformers with three windings, delta/wye/wye, subtractive polarity.
B. Ratings:
22 kV winding (h) : 34.9/46.525 MVA, OA/FA at 55C rise
39.08/52.104 MVA, OA/FA at 65C rise
13.8 kV winding (x) : 18.4/24.53 MVA, OA/FA at 55C rise
20.60/27.47 MVA, OA/FA at 65C rise
4.16 kV winding (y) : 16.5/21.995 MVA, OA/FA at 55C rise
18.480/24.634 MVA, OA/FA at 65C rise
C. Taps : High voltage side, manual, no-load tap changing equipment, ± 5 percent in 2.5 percent steps
D. Impedance : $Z_{hx} / Z_{hy} / Z_{xy} = 9.22/15.74/29.5$ percent (design value) on 34.9 MVA base and center tap
E. Insulation level, BIL : 22 kV bushing and winding
150 kV: 13.8 kV bushing, winding, and neutral 110 kV:
4.16 kV bushing, winding, and neutral 75 kV
F. Neutral grounding resistors:
13.8 kV neutral : 8 ohm, 1000 amperes, 8 kV, 10 sec, edgewound stainless steel type.
4.16 kV neutral : 2.4 ohms, 1000 amperes, 2.4 kV, 10 sec, edgewound stainless steel type.

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Ratings and characteristics of the excitation transformers are as follows :

- A. Each excitation transformer with two windings, wye/delta, subtractive polarity.
B. Rating: 7,500 kVA, OA at 55C rise
C. Voltage: 22,000V(HV), 740V(LV)
D. Taps : High voltage side, manual, no-load tap changing equipment, ± 5 percent in 2.5 percent steps
E. Impedance : Z = 8 percent (design value) on center tap
F. Insulation level, BIL : 110 kV(HV), 10 kV(LV)

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Ratings and characteristics of the startup transformers are as follows:

- A. Two each half load sized startup transformers with four windings, wye/wye/wye/delta (tertiary).

B. Ratings

345 kV winding(h) : 37.24/49.65 MVA, OA/FA 55C
41.71/55.61 MVA, OA/FA 65C

13.8 kV winding(x) : 18.40/24.53 MVA, OA/FA 55C
20.6/27.47 MVA, OA/FA 65C

4.16 kV winding(y) : 18.84/25.12 MVA, OA/FA 55C
21.11/28.14 MVA, OA/FA 65C

C. Taps: High voltage side, manual, no-load tap changing equipment, ± 5 percent in 2.5 percent steps

D. Impedance : $Z_{hx}/Z_{hy}/Z_{xy} = 9.93/23.92/32.85$ on 37.24 MVA base and center tap

E. Insulation level, BIL : 345 kV bushing and winding 1300/1050 kv
13.8 kV bushing and windings 110 kv
4.16 kv bushing and winding 75 kv
345/13.8/4.16 kv neutral 450/110/75 kv

F. Neutral grounding resistors:

345 kv neutral : 108 kv surge arrester in parallel with a 123 kv disconnect switch.

13.8 kv neutral : 8 ohm, 1000 amperes, 8 kv, 10 sec, edgewound stainless steel type.

4.16 kv neutral : 2.4 ohm, 1000 amperes, 2.4 kv 10 sec, edgewound stainless steel type.

Descriptions of the diesel generators and the power distribution systems are included in the sections that follow.

The onsite ac power system includes a Class 1E system and a non-Class 1E system.

8.3.1.1.1 Non-Class 1E AC System

The non-Class 1E ac system is that part of the onsite power system outside the dashed-line enclosures indicated in figure 8.3-1, Main Single Line Diagram. The non-Class 1E ac system distributes power at 13.8 kV, 4.16 kV, 480V, 380/220V, and 208/120V for all nonsafety-related loads.

The non-Class 1E ac system also supplies preferred (offsite) power through the startup transformers to the onsite Class 1E power system as discussed in subparagraph 8.3.1.1.2.

Each of the unit auxiliary and startup transformers has two secondary windings. One winding is rated at 13.8 kV while the other is rated at 4.16 kV.

Four 13.8 kV buses per unit supply power to nonsafety-related loads. Two 13.8 kV buses are connected to each of the startup transformers. In addition, the same two 13.8 kV buses are also connected to one of the unit auxiliary transformers. During startup of the unit, all 13.8 kV buses are supplied power from the startup transformers. The buses are transferred, by manual initiation, to the unit auxiliary transformers after power is available from the unit turbine-generator. Once in this operating mode, an automatic transfer of the 13.8 kV buses from the unit auxiliary transformers to the startup transformers is provided in accordance with the following criteria:

- A. A bus transfer is performed in less than 6 cycles following electrical faults in the generation system, in which case the generator/network can no longer supply power to the reactor coolant pumps. In the event of failure of the fast transfer, an automatic transfer will be accomplished only when the residual motor voltage decays to approximately 25 percent of the rated voltage.
- B. For critical turbine or generator trips (trip conditions immediately hazardous to the turbine or the generator), the 345 kV switchyard circuit breaker is tripped and a fast bus transfer is performed simultaneously after the protection relay is actuated.
- C. A delayed fast bus transfer is performed following non-critical turbine generator trips not involving electrical faults. The turbine generator and unit auxiliary transformers will remain connected to the switchyard for 30 seconds (before any transfer is made) to allow the switchyard to continue supplying power to the reactor coolant pump buses.

The 13.8 kV non-Class 1E switchgear is located in the Seismic Category II switchgear building. Four metal-clad, three-phase lineups are provided with drawout stored energy type circuit breakers. Each unit is provided with auxiliary cubicles equipped with potential transformers, meters, and relays. Circuit breaker cubicles are equipped with current transformers, relays and metering.

The 13.8 kV non-class 1E switchgear bus and breaker nominal ratings are as follows:

A. Nominal voltage	13.8 kV, 3 phase, 60 hertz
B. Nominal current	1200 amperes
C. Nominal interrupting capacity	750 MVA
D. Rated maximum voltage	15.0 kV
E. Rated voltage range factor K	1.3
F. Rated main bus continuous current	1200 amperes rms
G. Rated short circuit current at rated maximum voltage	28,000 amperes rms
H. Closing and latching capability	58,000 amperes rms
I. Asymmetric rating factor	1.6
J. Control voltage	125V dc (105V-140V range)
K. Space heaters Rated	240V, 60 hertz, (connected to 120V, 60 hertz)

A backup circuit breaker located in the auxiliary building is provided for each reactor coolant pump motor, in series with the breaker located in the switchgear. The backup breakers are in separate cubicles and are Class 1E. In addition to providing backup protection for containment electrical penetration conductors, as required by NRC Regulatory Guide 1.63, the second breakers provide Class 1E tripping of the reactor coolant pumps in order to assure disengagement of the pumps from the power grid to meet the requirements of the safety grade cold shutdown design, and to avail the system of their kinetic energy for flow coastdown.

In compliance with the functional requirement for underfrequency trip stated in section 7.2.1.1.2.4.C, two underfrequency sensing relays for each reactor coolant pump motor, the output of each relay feeding a separate N388 2 out of 3 bus failure logic, are used to achieve proper train separation.

The reactor coolant pumps motors are each fed from separate 13.8 kV buses, one from bus number N-7E-NA-301, one from N-7E-NA-302 and one from N-7E-NA-303

During normal Operation buses N-7E-NA-301 and N-7E-NA-302 are both fed from the same unit auxiliary transformer N-7E-MA-X04, and bus N-7E-NA-303 is fed from unit auxiliary transformer N-7E-MA-X05.

During startup, buses N-7E-NA-301 and N-7E-NA-302 are both fed from the same startup transformer N-7E-MC-X01 and bus N-7E-NA-303 is fed from the startup transformer N-7E-MC-X02. The loss of transformer N-7E-MA-X04 during normal operation, or the loss of startup transformer N-7E-MC-X01 during startup would result in the loss of two buses, and consequently two reactor coolant pumps.

Two 4.16 kV buses supply power to the balance of the non-safety-related motor loads, 4.16 kV/480V load center transformers, and associated 480V buses. Both 4.16 kV buses can receive power from a secondary winding of either startup transformer. In addition, one 4.16 kV bus can be connected to the secondary winding of each unit auxiliary transformer. The 4.16 kV bus transfer functions are essentially the same as those described for the 13.8 kV buses.

Each unit auxiliary transformer has the capacity to supply two 13.8 kV buses and one non-Class 1E 4.16 kV bus. Each startup transformer has the capacity to supply the startup loads on two 13.8 kV buses and two 4.16 kV buses (one non-Class 1E and one Class 1E).

The 4.16 kV switchgear for the non-Class 1E system is located in the Seismic Category II switchgear building, and is metal-clad, including stored energy operated drawout type circuit breakers. The circuit breakers are arranged in two isolated bus lineups rated as follows:

A. Nominal voltage	4.16 kV, 3 phase, 60 hertz
B. Nominal current	3000 amperes
C. Nominal interrupting capacity	350 MVA
D. Rated maximum voltage	4.76 kv
E. Rated main bus continuous current	3000 amperes
F. Rated short circuit current at rated maximum voltage	41,000 amperes rms
G. Closing and latching capability	70,000 amperes rms
H. Control voltage	125V dc nominal (105V-140V range)
I. Space heaters	Rated 240V, 60 hertz (connected to 120V, 60 hertz)

During normal operation, each non-Class 1E 4.16 kV bus receives power from its associated unit auxiliary transformer for distribution to the normally connected loads. The offsite power source is paralleled momentarily with the unit auxiliary transformer power source during manual transfer operations. Parallel operation of the startup transformer and the unit auxiliary transformer is alarmed if the offsite source breaker has not been tripped within three seconds.

The non-Class 1E 480V load centers are unit substations, each complete with a 3 phase transformer, circuit breaker compartments, and metering and relaying compartments.

The non-Class 1E 480V load centers receive their power from the non-Class 1E 4.16 kV system. The secondary winding of each load center transformer is connected, through a power circuit breaker, to a 480V bus feeding non-Class 1E electrical loads. All load centers are normally continuously energized.

The power supply system for two of the turbine building 480V load centers, and the common load centers, consists of two sources for each bus. All other non-Class 1E 480 volt load center buses have only one source.

The 480 volt load centers for the non-Class 1E system are metal-enclosed, including stored-energy-operated, drawout type circuit breakers. These load centers are distributed throughout the plant area, located indoors, in various Seismic Category II rooms, and rated as follows:

A. Transformer	1000/1333 kVA, AA/FA, 150C rise, indoors
B. Distribution system	3 phase, 3-wire
C. Nominal voltage	480 volt, 3 phase, 60 hertz
D. Nominal current	1600 amperes continuous
E. Rated main bus continuous current	1600 amperes continuous
F. Rated short circuit current at rated voltage	30,000 amperes rms symmetrical (800 amperes frame) 50,000 amperes rms symmetrical (1600 amperes frame)
G. Control voltages	125V dc (105V-140V range).
H. Space heaters	120 \pm 10% Vac -Rated 240V, 60 hertz, 1 phase (connected to 120V, 60 hertz)

All non-Class 1E 480V, motor control centers receive power from the non-Class 1E load centers, except eight motor control centers per unit. Four non-Class 1E motor control centers per unit located in the diesel generator building, which receive power from Class 1E load centers through Class 1E motor control centers. The other four are fed directly from Class 1E load centers and are located in the turbine switchgear and auxiliary buildings. These eight motor control centers are disconnected automatically from their Class 1E sources in the event of a safety injection signal (SIS), or loss-of-voltage signal (LOVS). These motor control centers and their loads, can be reconnected to the Class 1E power source under administrative control. This allows certain non-Class 1E loads which are required to operate after a loss-of-coolant accident (LOCA), to be reconnected to an onsite source of power.

There are four non-Class 1E 480V, pressurizer backup heater panels and one pressurizer heater power controller (variable) installed per unit. The four backup heater panels receive power from Class 1E load centers. The pressurizer heater power controller receives power from a non-Class 1E load center. All pressurizer heater panels are disconnected automatically from their power sources in the event of an SIS, or LOVS. Later, the panels connected to Class 1E load centers can be reconnected under administrative control.

One non-Class 1E MCC is normally fed from a non-Class 1E load center with a backup feed from the non-Class 1E diesel generator.

Non-Class 1E motor control centers and power distribution panels are located in various areas of the plant. They are classified as Seismic Category II, NEMA Class II, Wiring type B, NEMA enclosure type 1A. Each motor control center is free standing, totally enclosed, with provision for back-to-back compartment mounting. The protective devices are mounted in individual compartments and are of the plug-in type. The motor control centers and distribution panels are rated as follows:

Motor Control Center

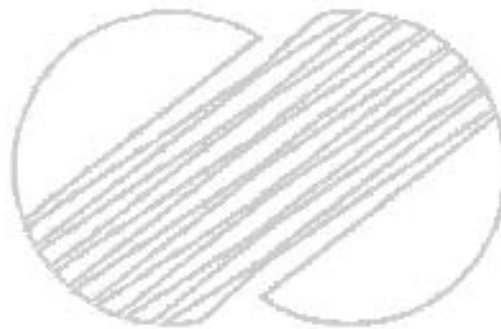
Nominal voltage	480V, 3 phase, 60 hertz
Nominal current of supplies	600 amperes
Rated main bus continuous current	600 amperes
Short circuit bracing	25,000 amperes rms symmetrical, minimum

Distribution Panels

Nominal voltage	208/120V, 3 phase, 60 hertz
Nominal current of supplies	200 and 400 amperes
Rated main bus continuous current	200 and 400 amperes
Short circuit bracing	10,000 amperes symmetrical minimum.

The 380/220V system furnishes power only to the lighting and convenience receptacles. The 380/220V system voltage is obtained from 480 - 380/220V transformers through the motor control centers.

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The non-Class 1E regulated power supply system for each unit consists of one 120V ac subsystem for station computer power and, six 208/120V ac subsystems for instrument power.

The non-Class 1E 208/120V ac instrument and uninterruptible power supply subsystem distributes power thru six panels (two with battery/inverter backup, four with non-Class 1E diesel generator backup) to all non-Class 1E instrumentation systems.

The 120V ac subsystem, through which power is distributed to the various computer cabinets, is normally fed from a non-class 1E MCC through a transformer and rectifier, to an inverter whose backup power source is the station 125V dc battery. The backup to the inverter system, through a static transfer switch, is powered from a motor control center fed from the non-class 1E power system with a backup feed from the non-Class 1E diesel generator set located in the lower level of the switchgear building.

In the event the inverter is taken out of service for maintenance, power for the computer distribution panel can be obtained from a backup source by means of a manual transfer switch through a regulating transformer.

298 Two of the 208/120V ac subsystems for instrument power are provided with
uninterruptible power sources. Each panel is fed from a 50kVA, 3 phase,
13 208/120V inverter, with backup through automatic static transfer switch
which can be bypassed by maintenance switch from a 50kVA, 480/208-120V, 3 phase
regulating transformer. 13 The transfer time of the static transfer switch is
about 1/4 cycle. The inverter is fed from a non-class 1E motor control center
with backup power from the 125V dc non-class 1E station battery. The
regulating transformers are fed from non-Class 1E motor control centers.
These two subsystems feed equipment that cannot tolerate a transfer
switching-time delay of more than 1/4 cycle. The transfer from the backup
source (regulating transformer) to the primary source (inverter) is manual.

160 The remaining four 208/120V ac instrument power subsystems are paired off,
such that the backup power for each pair is from a non-class 1E motor control
center fed by the non-Class 1E station power, with backup from the non-Class
1E diesel generator set through a 50kVA, 480/208-120V, 3 phase regulating
transformer. The normal source of power for each of these subsystem panels
is a non-Class 1E motor control center through a 50kVA, 480/208-120V, 3
phase regulating transformer. Each distribution panel is fed through an
automatic transfer switch which automatically transfers to backup power
upon loss of normal power. Transfer back to the normal source is a automatic
operation.

Figure 8.3-1 shows the transformers, feeders, buses, and their interconnections including a listing of all loads directly supplied from each 13.8 and 4.16kV bus.

The non-Class 1E 13.8 kV and 4.16 kV switchgear is fed through non-segregated bus duct and circuit breakers from either the startup transformers or the unit auxiliary transformers.

8.3.1.1.2 Class 1E AC System

The Class 1E ac system is that part of the onsite power system inside the dashed-line enclosures shown in figure 8.3-1, Main Single Line Diagram. The system includes two load groups (A and B) for each unit.

The Class 1E ac system distributes power at 4.16 kV, 480V, and 120V to all safety-related loads. The Class 1E ac system also supplies selected nonsafety-related loads that are important to the plant operation. Table 8.3-1 lists all the safety-related loads and isolated nonsafety-related loads supplied from the Class 1E ac system.

The 4.16 kV Class 1E system normally receives power from the 345 kV system through the startup transformers. The switchyard is fed power at 345 kV voltage level from the Korea Electric Power Corporation (KEPCO) offsite power transmission system. The 345 kV system power is transformed by two startup transformers to 4.16 kV. The secondaries of the startup transformers are connected by non-segregated bus duct through power circuit breakers to the 4.16 kV buses of Class 1E electrical load groups A and B for each nuclear unit. The capacity of each startup transformer is one-half the total load requirements of one unit with spare capacity for future growth.

The 4.16 kV switchgear for the Class 1E system is located in the control building and is metal-clad, stored energy-operated drawout type. The switchgear is arranged in two independent bus systems for each of the nuclear generating units 7 and 8. Each of the independent bus systems is located in a separate Seismic Category I room.

The 480V Class 1E ac distribution is accomplished using load centers for the larger loads and motor control centers for the smaller loads.

The 480V Class 1E load centers are unit substations, complete with 3-phase transformers, circuit breaker compartments, and metering and relaying compartments. There are two redundant load groups, A and B. Normally the buses of both load groups are energized from different offsite sources. Minimum safety requirements are met if at least one of the two ESF load groups is supplied with power. Load group A load center transformers receive their power from the load group A 4.16 kV Class 1E switchgear bus, while load group B load center transformers receive their power from load group B 4.16 kV Class 1E switchgear bus.

The Class 1E motor control centers are located in the auxiliary building, control building, diesel generator building, and the nuclear service cooling water intake structure. They are classified as Seismic Category I, NEMA enclosure type 1A. Each motor control center is free standing, totally enclosed, with provision for back-to-back compartment mounting. The protective devices are mounted in individual compartments and are the plug-in type.

The motor control centers are arranged in two isolated load groups A and B, and are located in Seismic Category I structures.

Each Class 1E 480V motor control center is associated with one of the Class 1E 480V load centers. Feeder circuits from 480V load center circuit breakers are directly connected to the motor control center buses. Normally, each load group is fed from the offsite power through a startup transformer, and 4.16 kV switchgear.

Four independent, Class 1E, 120V vital instrumentation and protection ac power supplies are provided to supply the four channels of the reactor protection system and ESFAS. The four-bus arrangement provides for a separate single-phase electric power supply to each of the protection channels that is electrically and physically isolated from the power supplies of the other channels.

The four instrumentation, and protection channels are identified as Channel A, Channel B, Channel C and Channel D.

There are no provisions for manual or automatic transfer of loads among the four 120V vital buses. The 480V ac power source for channels A and C is from load group A, and that for channels B and D is from load group B.

Each of the four channels has one single-phase, ungrounded 120V ac distribution panel, powered by a 7.5 kVA inverter, with a backup 7.5 kVA regulating transformer available through an automatic static transfer switch which can be bypassed by maintenance switch. Additionally, each of the load groups has two single phase, ungrounded 120V ac distribution panels. A 25 kVA inverter is the power source for one of these two panels. The other has, as primary power source, a 30 kVA regulating transformer. These two panels have, as a common backup power source, a 30 kVA regulating transformer. One panel is fed through an automatic transfer switch which can be bypassed by maintenance switch from one source to the other. The other panel is fed through a manual transfer switch, which permits transferring from one source to the other under administrative control.

Each of the inverters (7.5 kVA, 25 kVA) is fed from a 480V ac Class 1E power source from an MCC, and a separate Class 1E 125V dc subsystem as described in subsection 8.3.2.

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Each of the regulating transformers (7.5 kVA, 30 kVA) is fed from a 480V ac Class 1E power source from an MCC.

Busing arrangements are shown in figure 8.3-3.

The following subsections describe various features of the Class 1E systems:

8.3.1.1.2.1 Power Supply Feeders. In addition to the two preferred power supply feeders discussed in subparagraph 8.3.1.1.2, each 4.16 kV load group is supplied by one Class 1E diesel generator (standby) supply feeder. Each 4.16 kV bus supplies motor loads, and 4.16 kV/480V load center transformers.

8.3.1.1.2.2 Bus Arrangements. The Class 1E ac system is divided into two load groups per unit (load groups A and B). For each unit, either of the two load groups is capable of providing power required to safely achieve cold shutdown. Each ac load group consists of a 4.16 kV bus, 480V load centers, 480V motor control centers, and miscellaneous low voltage ac supplies.

8.3.1.1.2.3 Loads Supplied From Each Bus. Table 8.3-1 provides a listing of the Class 1E ac system loads and their respective buses.

8.3.1.1.2.4 Manual and Automatic Interconnections Between Buses, Buses and Loads, and Buses and Supplies. No provisions exist for automatically connecting one Class 1E load group to the redundant Class 1E load group, or for automatically transferring loads between load groups of a unit, or for interconnections with load groups of the second unit. The incoming preferred power supply of a load group can supply the 4.16 kV Class 1E bus of the redundant load group by manual operation and administrative control to assure that one load group is connected to a given offsite source at a time.

The two 4.16 kV circuit breakers that control the incoming preferred source power to a 4.16 kV Class 1E bus are interlocked so that only one breaker can be closed at any one time. This is to prevent parallel operation of the preferred sources.

When operating from the Class 1E diesel generator supply during loss of offsite power, redundant load groups shall not be manually interconnected. During manually initiated testing, one diesel generator at a time may be paralleled with a preferred source.

8.3.1.1.2.5 Common Class 1E Loads. There are three charging pumps. One is powered from load group A, one from a load group B, and the third (or common) pump is capable of being powered from either source. The common charging pump is the only Class 1E equipment which has the capability of being powered from either of the redundant Class 1E buses. Power is supplied through a manual transfer switch. The common charging pump is normally connected to one or the other of the redundant Class 1E buses by means of the transfer switch, but only during that period of time when one of the other two redundant pumps has been removed from service for maintenance or following abnormal plant conditions involving failure of one of the Class 1E buses. In the event 4.16 kV power, 125V dc control power, and 120V ac motor space heater power of the shared charging pump will be transferred to the other Class 1E bus. The use of the transfer switch assures that the common pump can be powered from only one of the redundant buses at a time. Key interlocks are provided to prevent operation of the transfer switch if either of the feeder circuit breakers is closed, since the manual transfer switch is not a rated load-break switch.

406 8.3.1.1.2.6 Interconnections Between Safety-Related and Nonsafety-Related Buses. There is no interconnection between the Class 1E and non-Class 1E buses. Except for an AAC power supply bus as described in paragraph 8.3.1.1.3.10. The feeders originating from the secondary winding(s) of a transformer which supplies normal or preferred power to both Class 1E and non-Class 1E buses are not considered as bus interconnections. The non-Class 1E loads fed from Class 1E sources are fed through qualified isolation devices and are tripped from the Class 1E bus upon receipt of an SIS signal.

8.3.1.1.2.7 Redundant Bus Separation. The Class 1E 13.8 kV and 4.16 kV, switchgear, 480V load centers, and motor control centers for the redundant Class 1E load groups are located in separate rooms of the control building, auxiliary building, diesel generator building or nuclear service cooling water building in such a way as to ensure separation.

8.3.1.1.2.8 Automatic Loading and Stripping of Buses. Table 8.3-2 indicates the automatic loading sequence of the Class 1E buses by defining the different loads in kw, and the time of loading by the sequencer control system. The total kW per sequencing step is also shown in this table. Figure 8.3-2 gives the diesel generator automatic loading sequence logic and a listing of the equipment loads that are shed prior to sequential loading. The diesel generator is sized in accordance with subparagraph 8.3.1.1.3.

The Class 1E load criteria is consisted with the criteria for Class 1E equipment design in subparagraph 8.3.1.1.8.

If preferred power is available to a Class 1E bus following a loss-of-coolant accident (LOCA) the Class 1E loads normally connected will continue running and the required additional ESF loads will start sequentially as indicated in table 8.3-2. The emergency standby diesel generator will be started but not connected to the bus. In the event that preferred power is lost, the diesel generator sequencer will shed loads and connect the diesel generator power source to the Class 1E bus and will start the required Class 1E loads in a programmed time sequence. See tables 8.3-1, 8.3-2, and 8.3-3.

Transfer of the non-Class 1E reactor coolant pump (RCP) buses to the preferred offsite power source(s) is a function of the type of turbine generator trip (critical or noncritical) and the availability of power. If no preferred power is available, the RCP motors will be disconnected to permit pump coastdown. A Class 1E backup power circuit breaker contained within a separately mounted, individual (one per pump) switchgear unit, and connected in series with each RCP motor feeder, assures the disconnection of RCP motors in the event of an underfrequency situation. The Class 1E underfrequency signal is detected by relays located within these same switchgear units. This underfrequency signal is sent to a solid-state logic, which in turn generates two independent RCP trip signals for each pump and the reactor.

Subparagraph 8.3.1.1.3.5 provides additional information on load shedding and sequencing in the event of a loss of offsite voltage signal (LOVS) or safety injection signal (SIS).

8.3.1.1.2.9 Safety-Related Equipment Identification. Paragraph 8.3.1.3 provides information regarding the physical identification of Class 1E equipment.

8.3.1.1.2.10 Instrumentation and Control Systems for the Applicable Power Systems With the Assigned Power Supply Identified. The dc control power for redundant Class 1E 4.16 kV switchgear and 480V load centers is provided from battery systems which are physically and electrically separate and independent, so that dc subsystem A supplies Class 1E load group A. The battery chargers for dc subsystem A are fed from the same load group. The dc subsystem B supplies Class 1E load group B. For further discussion of the dc power system, refer to subsection 8.3.2. The Class 1E 120V ac instrument power system is described in subparagraph 8.3.1.1.2.

Each Class 1E and non-Class 1E 4.16 kV and 480V bus is equipped with an undervoltage relay for annunciation in the control room. The voltage of each bus is monitored by instruments in the control room.

8.3.1.1.2.11 Electric Circuit Protection System Network.

Protective relay schemes and direct-acting trip devices on primary and backup circuit breakers are provided throughout the onsite power system in order to:

- A. Isolate faulted equipment and/or circuits from unfaulted equipment and/or circuits.
- B. Prevent damage to equipment.
- C. Protect personnel.
- D. Minimize system disturbances.
- E. Act as isolation devices (fuses). (Control circuits only).

507 Figure 8.3-4 shows electrical protective and relaying devices of the diesel generator which are bypassed on plant accident conditions (see subparagraph 7.3.1.1.4.2.G). The only electrical protection devices that remain functional during these conditions are diesel generator differential current relays. For discussion of other diesel generator trip signals, see Subparagraph 8.3.1.1.3.2.

Major types of protective measures employed in the Class 1E power system include the following:

A. Overcurrent Relaying

Each 4.16 kV bus incoming power supply breaker is equipped with three inverse-time overcurrent relays, and one inverse-time ground fault relay, to sense bus faults and to provide backup for feeder circuit protective relays.

Each 4.16 kV motor circuit breaker has three overcurrent relays, each with one inverse time and two instantaneous elements, for overload, locked rotor, and short circuit protection. Each 4.16 kV motor circuit breaker is also equipped with an instantaneous ground overcurrent relay.

For 4.16 kV motors, the circuit breaker inverse-time relaying is set at or above 115 percent of motor rated current for alarm and at 175 percent of motor rated current for trip. The current for these motors is monitored in the control room.

Each 4.16 kV feeder circuit breaker to a load center transformer has three overcurrent relays with long-time inverse and instantaneous elements. An instantaneous ground overcurrent sensor relay provides ground fault protection.

B. Undervoltage Relaying

Each 4.16 kV Class 1E bus is equipped with one set of three, undervoltage relays for alarm at a given level of undervoltage, and another set of four for diesel generator starting and load shedding at a lower level of undervoltage on a two-out-of-four basis. A relay is also provided on each bus for undervoltage annunciation. Each 480V Class 1E load center bus is equipped with undervoltage relays for undervoltage annunciation.

C. Differential Relaying

Non-Class 1E transformers such as the main, unit auxiliary, and startup transformers are equipped with differential relays. These relays provide high speed disconnection to prevent severe damage in case of internal faults. The 7000 horsepower RCP motors, 3000 horsepower condensate pump motors, 1500 horsepower circulating water pump motors, and diesel generators are also equipped with differential protection.

D. 480 Volt Load Center Protection

Each load center main feeder breaker is equipped with three overcurrent relays and one ground overcurrent relay. Each load center supply breaker and each load center motor control center feeder circuit breaker is equipped with a solid state, direct acting, self-powered trip device system with adjustable long-time and short-time trip elements. Each load center motor feeder breaker is equipped with a solid-state, direct acting, self-powered trip device system with adjustable long-time, and instantaneous trip elements, and separate ground overcurrent sensor. In addition each motor control center feeder breaker and each non-motor load feeder breaker is provided with current limiting fuses to limit the fault current.

E. 480 Volt Motor Control Center Protection

Molded-case circuit breakers provide inverse time overcurrent and/or instantaneous short circuit protection for all connected loads. For motor circuits, the molded-case circuit breakers are equipped with adjustable instantaneous trip function only. Motor thermal overload protection is provided by the thermal-element trip units of the motor starter. The molded

case breakers for non-motor feeder circuits provide inverse time thermal overcurrent protection and instantaneous short circuit protection.

The thermal overload relays in motor starters for all Class 1E valve motor operators are equipped with heaters rated at 130 percent of the normal rating to prevent spurious trips. The normal rating is based on the nameplate current characteristics and recommended settings provided by the valve actuator manufacturers and/or the National Electric Code.

The torque switches of all Class 1E motor-operated valves are set at the manufacturer's recommended maximum setting to avoid invalid interruption of operation due to mechanical binding of the valve mechanism and yet insure the structural integrity of the valve.

The short circuit protective system is analyzed to ensure that the various adjustable devices are applied within their ratings, and are set to be coordinated with each other to attain selectivity in operation. The combination of devices and settings applied affords the selectivity necessary to isolate a faulted load with a minimum of disturbance to the rest of the system.

F. Electric Penetrations Backup Protection

Circuits going into the containment through penetrations have the following backup protection against overcurrents.

- | | |
|---|---|
| 0 Load Centers loads | - Circuit breakers with current limiting fuse backup |
| 0 All three phase and single from MCCs and distribution panels. | - Two thermal magnetic circuit breakers in series for each non-motor circuit, phase loads
- One thermal magnetic circuit breaker and one combination of starter/magnetic circuit breaker in series for each motor circuit. |
| 0 Control circuits | - Backup protection fuses/breakers for circuits in which short circuit current exceeds penetration thermal damage limit. |

8.3.1.1.2.12 Testing of the AC Systems During Power Operation.

All Class 1E circuit breakers and motor starters, except for equipment associated with certain Class 1E loads identified in paragraph 7.1.2.5, are testable during reactor operation. During periodic safety-related system tests, subsystems of the ESF system such as safety injection, containment spray, and containment isolation are actuated, thereby causing appropriate circuit breaker or contactor operation. The 4.16 kV.

switchgear and 480V load center circuit breakers and control circuits can also be tested independently while individual equipment is shut down. The circuit breakers can be placed in the test position and exercised without operation of the supplied equipment.

8.3.1.1.2.13 Systems and Equipment Shared between Units

No Class 1E equipment is shared between units, nor is any provision made to feed any equipment from power supplies of both Unit 7 and Unit 8.

8.3.1.1.3 Standby Power Supply

The standby power supply for each Class 1E load group consists of one diesel generator complete with its accessories and fuel storage and transfer systems. It is capable of supplying all loads necessary to shut down and maintain the plant in a safe shutdown condition to mitigate the consequences of postulated accidents. Each diesel generator is rated at 7000 kW for continuous operation, and 7700 kW for short time (2-hour) operation. Each diesel generator is connected exclusively to the 4.16 kV bus of a load group, and no provision exists for parallel operation of the diesel generator of one load group with the diesel generator of the redundant load group.

Each unit has two redundant Class 1E load groups. Each load group is adequate to satisfy minimum Class 1E demand caused by a LOCA and simultaneous loss of preferred power supply.

The diesel generators are electrically isolated from each other. Physical separation for fire and missile protection is provided between the diesel generators since they are housed in separate rooms of a Seismic Category I structure. Power and control cables for the diesel generators and associated switchgear are routed so as to maintain physical separation.

Ratings for diesel generator sets are calculated to satisfy the requirements set forth in Regulatory Guide 1.9 (discussed in section 1.8).

The continuous rating of the diesel generator is based on the maximum total load required at any one time and is determined on the basis of motor nameplate or service factor rating, and load requirements. The loads, which are capable of being powered from each diesel generator, are listed in table 8.3-1.

The functional aspects of the diesel generator are discussed below.

The emergency diesel generators are tested regularly to ensure their reliability. The testing program is in compliance with Reg. Guide 1.9 Rev.3. Also, the emergency diesel generator reliability program is applied to maintain and monitor their target reliability 0.975.

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8.3.1.1.3.1 Starting Initiating Circuits. The diesel generators are started in the event of the following occurrences:

- A. Automatic
 - 1. Receipt of a NSSS ESFAS signal (SIS).
 - 2. Receipt of a two-out-of-four loss of voltage (LOV) signal from the 4.16 kV Class 1E bus to which the generator is connected.
- B. Manual
 - 1. Remote switch actuation (main control room).
 - 2. Local switch actuation (diesel generator room).
- C. Emergency Manual

Emergency manual actuation is accomplished by breaking a glass disc to release the emergency pushbutton.

For additional discussions regarding diesel generator starting see subparagraph 8.3.1.1.2.8.

The diesel generator starting system as described in subsection 9.5.6 assures fast and reliable starting of the diesel engine, with respect to maintaining jacket cooling water and lubricating oil temperatures, each diesel engine is provided with immersion heaters in the jacket water and lube oil systems to maintain the engine coolant and lube oil temperatures within acceptable ranges. The immersion heaters are thermostatically controlled and, in conjunction with circulating pumps, will maintain the jacket water and the lube oil at steady temperatures. Refer to subsections 9.5.5 and 9.5.7 for further information.

8.3.1.1.3.2 Tripping Devices. In addition to the normal (non-emergency) stop pushbutton S, at both the main control room and diesel generator room panels, protective tripping devices are provided for each diesel generator to detect the following mechanical conditions:

- A. Start failure
- E. High jacket water temperature
- C. Low jacket water pressure
- D. High crankcase pressure
- E. Low turbo oil pressure
- F. High bearing temperature
- G. High lube oil temperature
- H. High vibration

- I. Low lube oil pressure
- J. Engine overspeed

In addition to the above mechanical trip functions, protective devices are also provided to detect the following electrical conditions:

- A. Generator differential current
- B. Reverse power
- C. Generator load unbalance (negative phase sequence)
- D. Ground fault
- E. Volts per hertz (overexcitation)
- F. Underfrequency
- G. Loss of excitation
- H. Generator voltage restrained overcurrent.

The start-failure relay operates to interrupt the starting of the diesel generator if a lube oil pressure is not established 1 within a predetermine time limit following the start initiation.

1

Certain critical protective functions, which act to trip the diesel generator during manually initiated testing, are also retained during emergency operation. Following emergency activation only the protective functions listed below will annunciate and trip the diesel generator. All other protective functions will annunciate only.

- A. Engine overspeed
- B. Low lube oil pressure with 2/3 logic
- C. Generator differential current
- D. Manual emergency trip (main control room)
- E. Manual emergency trip (diesel generator room).

Manual emergency tripping is accomplished either remotely from the main control room through simultaneous depression of two pushbuttons or locally from the diesel generator room by the breaking of a glass disc to release the emergency pushbutton to the actuated position. In either case, automatic or manual starting functions are blocked until a local emergency stop reset pushbutton is depressed.

Although the diesel generators are vital to the safety of the plant, no automatic bypass is provided around the critical protective devices listed above, which function during an emergency. This is due to the fact that each load group is provided with one diesel generator. Therefore, should one diesel generator be tripped by a protective device, the other redundant load group functions to provide emergency power.

To provide additional reliability, low lube-oil pressure will initiate shutdown only upon coincidence of two-out-of-three logic. Therefore, a spurious trip of one device does not erroneously shutdown the diesel generator. The diesel generators are monitored from the control room, and alarm devices are provided which initiate an annunciator in the main control room as well as locally in the diesel generator room. The alarms, where possible, are set so that they provide a warning of impending trouble prior to trip of the diesel.

8.3.1.1.3.3 Interlocks. Circuit breaker electrical interlocks are provided to prevent automatic closing of a diesel generator breaker onto an energized or faulted bus.

8.3.1.1.3.4 Permissives. Diesel generator operational mode selection is provided at the main control room via a LOCAL/REMOTE selector switch. Selection of the LOCAL mode blocks remote manual start and stop functions from the main control room, and enables these functions locally at the diesel generator room. LOCAL mode selection is annunciated in the main control room. Automatic start and emergency trip functions are not blocked by LOCAL mode selection.

Selection of the LOCAL mode also enables the MAINTENANCE/RETURN TO OPERATIONAL mode pushbutton. Depression of this pushbutton blocks all automatic or manual start functions. This mode of operation remains in effect until depression of the RETURN TO OPERATIONAL pushbutton returns the diesel to an operational mode. Blocking of automatic or manual start functions by the emergency trip pushbuttons are discussed in subparagraph 8.3.1.1.3.2.

During periodic diesel generator tests subsequent to diesel start and synchronization to the preferred system, a switch in the control room allows parallel operation with the preferred system.

8.3.1.1.3.5 Load Shedding Circuits. Upon recognition of a LOV on a 4.16 kv Class 1E bus, a logic signal is initiated to effect the following on the respective load group :

8.3.1.1.3.5.1 Loss of Voltage (LOV) on Class 1E 4.16 kV Bus

- A. Trip all 4.16 kV Class 1E incoming power supply breakers.
- B. Send signal to start the diesel generator.
- C. Trip all 4.16 kV Class 1E feeder breakers to individual loads except load centers feeder breakers.
- D. Shed all 480V Class 1E and non-Class 1E loads connected to Class 1E buses by tripping the main 480V breakers to the load center buses.
- E. Trip 480V Class 1E feeder breakers to selected individual loads per figure 8.3-2.
- F. Generate signal to load sequencer to initiate sequential actuation system (refer to figure 8.3-2 for sequential actuation logic).

A degraded level of voltage is sensed by a relay set at a point below operating voltage but above the level of the four relays set to start the diesel. The actuation of this relay is annunciated in the control room.

To sense a loss of voltage, four time delay type undervoltage relays are provided. These relays input to a two-out-of-four coincidence logic within the diesel sequencer which, after a 1/10 second delay, provides for tripping of incoming breakers, starting the diesel, and tripping of Class 1E breakers that power non-Class 1E loads. After a 2/10 second delay a 1 second pulse is generated for tripping of Class 1E loads. The voltage relays are set below the minimum expected voltage during load sequencing. The diesel generator is sized to not permit voltage dips below 75 percent motor rated voltage at any designated sequencing step as required by Regulatory Guide 1.9.

As each generator reaches rated voltage and synchronous speed, relays at the diesel generator detect these conditions and provide a permissive interlock for the closing of the generator circuit breaker to the corresponding 4.16 kV bus.

8.3.1.1.3.5.2 SIS with Offsite Power Available

When the diesel generator is started on ESFA3-SIS, connection of the diesel generator to the 4.16 kV bus is not made unless the preferred source of power is lost. The load sequencer will immediately begin loading of the required ESF loads after receipt of a starting signal. All required safety-related loads are connected to the Class 1E bus within 60 seconds thereafter.

8.3.1.1.3.5.3 SIS with Loss of Preferred Source of Power

In the event of loss of a preferred source of power, the bus undervoltage system initiates the starting of its associated diesel generator and sheds all loads. After the diesel generator has attained speed and correct voltage, and the circuit breaker connecting it to its 4.16 kV bus has been closed, the load sequencer automatically initiates the starting of the required ESF loads.

Following diesel start and connection to the Class 1E bus, the required safety-related loads are connected to the bus at programmed time intervals. This prevents diesel generator instability and minimizes motor accelerating time. A fast responding exciter and voltage regulator ensures voltage recovery of the diesel generator after each load step in accordance with requirements of Regulatory Guide 1.9. Field flashing is utilized on the diesel generators for fast voltage buildup during the start sequence.

8.3.1.1.3.6 Testing. The type and size of diesel generator units being furnished for this project has been qualified previously as a standby emergency power source for a nuclear power plant in the United States, in accordance with Regulatory Guide 1.9, Revision 1. Accordingly, these same qualification tests were not required to be performed on the actual units being supplied for KNU 7 and 8. Refer to appendix 3A for a discussion of compliance with Regulatory Guide 1.9, Revision 2.

After final assembly and preliminary startup testing, each diesel generator is to be tested at the site, prior to fuel load, to verify actual electrical loading, and to demonstrate its ability to perform its intended function. These pre-operational tests will be conducted in accordance with the provisions of Regulatory Guide 1.108, as follows, with the exception of Regulatory Position C.1, 6.5 regarding surveillance systems (Refer to appendix 3A):

- A. Starting tests to demonstrate the ability to attain and stabilize frequency and voltage within the rated limits and time.
- B. Load acceptance tests to demonstrate the ability to accept the desired loads in the desired sequence and time duration.

- C. Operation tests to demonstrate the ability to carry the continuous rated load without exceeding the manufacturers design limits.
- D. Load rejection tests to demonstrate the ability to reject the maximum rated load without exceeding speeds or voltages that cause tripping, mechanical damage, or harmful overstresses.
- E. Rated load tests, with the diesel in parallel with the offsite system, to demonstrate the ability to carry continuous rated load for not less than 24 hours of which the first 2 hours are at 110 percent rated load followed by 22 hours at rated load, without exceeding the manufacturer's design limits.
- F. Functional tests to demonstrate diesel generator capability at full load temperature conditions by rerunning tests A and B above immediately following C above.
- G. Design load tests to demonstrate the ability to carry the design load for a time required to reach equilibrium temperature plus 1 hour without exceeding the manufacturer's design limits.
- H. Electrical tests to demonstrate that the electrical properties of the generator, excitation system, voltage regulator, engine governor system, and the control and surveillance systems are acceptable for the intended application including:
 - 1. Manually synchronize the diesel generator unit with offsite system while the unit is connected to the emergency load.
 - 2. Transfer the emergency load to the offsite system.
 - 3. Isolate the diesel generator unit from the offsite System.
 - 4. Restore diesel unit to standby status.
- I. A minimum of 35 consecutive valid tests with no failures are to be run to demonstrate the required reliability.
- J. Subsystem tests to demonstrate the capability of the control, surveillance, and protection systems to function in accordance with their intended application
- K. Tests to demonstrate the capability of the diesel generator unit to respond to an ESFAS within the required time.

After being placed in service, the standby power system is tested periodically through the load sequencer at the solid state interposing logic system (SSILS) cabinet to demonstrate the continued ability of the unit to perform its intended function. The following tests are performed periodically:

- A. After manual diesel generator synchronization to the bus and adjustment to take the bus load, an undervoltage signal can be simulated which trips the preferred supply breakers. Testing of these functions is possible during normal operation.
- B. Undervoltage signals can be simulated during normal operation to initiate starting of the diesel generator.
- C. An ESFAS-SIS subchannel can be actuated to initiate diesel engine start.
- D. Diesel generator control circuit preparedness can be manually simulated by a diesel generator circuit breaker closed test signal input. This input simulates that diesel generator voltage and speed have been established and that the normal and preferred bus supply breakers have been tripped open.

During a test start of the diesel generator, indicating lights at the diesel generator room provide verification of the proper functioning of the speed and voltage relays. In addition, These inputs as well as inputs showing supply breaker status are indicated by light emitting diodes (LEDs) at the solid state interposing logic system (SSILS) cabinet.

The diesel generator load shedding/load sequencing system is designed to facilitate periodic testing during reactor operation. Testing of the system comprises manual and automatic testing as follows:

- A. Individual testing of the undervoltage logic is accomplished by opening normally closed contacts between the potential transformers and the undervoltage relays, thus simulating a loss-of-voltage condition. Indication of proper operation is via LEDs at the SSILS cabinet.
- B. A MANUAL test signal together with an OVERLAP test signal verifies the continuity of the logic circuitry comprising the two-out-of-four undervoltage logic generating an undervoltage signal as described in A above.

- C. Outputs from any of the logic matrices may be individually tested by coincident injection of simulated test signals as outlined in A and B above. Injecting any simulated undervoltage signal and simultaneously injecting any of the two test signals results in generation of an output to:

1. Send a logic signal internally to the sequencing logic.
2. Shed loads.
3. Start the diesel generators, open preferred source circuit breakers.

Generation of these outputs is verified by both indicating LEDs in SSILS cabinet and actual shedding of loads and starting of the diesel. In the case of the signal generated internal to the sequencer, the indicating LED is the only means of verification.

- D. The undervoltage sequencing segment of the system is tested as part of the diesel generator testing scheme. The diesel is started, brought up to speed and frequency, connected to its bus, manually loaded, and then the bus is isolated from the preferred source. This initiates the sequencer, which cycles through its nine timing steps (Figure 8.3-2, sheet 5 of 5). Indicating LEDs at the sequencer output indicate proper sequencer operation. Any sequencer-controlled loads which were not in operation prior to the diesel test routine are actuated, excluding MCC controlled loads initiated by the solid-state protection system. Proper operation of all output contacts is tested in the modes described.
- E. The LOCA sequencing segment of the system is tested in conjunction with the testing routine of the Westing-house solid-state protection system (SSPS). The timing delays between closures are verified as described in D above.
- F. An automatic testing system internal to the sequencer provides continuous surveillance of circuit operation from the sequencing portion input signals through to the sequencer outputs.

8.3.1.1.3.7 Instrumentation and Control Systems for Standby Power Supply. Controls are provided in the main control room for each diesel generator for the following operations:

- A. Remote manual starting and stopping
- B. Remote manual synchronization
- C. Remote manual frequency and voltage adjustment
- D. Governor and voltage droop selection
- E. Automatic or manual voltage regulator selection
- F. Local and remote selection.

Equipment is provided at the diesel generator room for the following operations (the LOCAL/REMOTE switch in the main control room must be in the LOCAL position).

- A. Manual starting and stopping
- B. Frequency and voltage regulation
- C. Automatic or manual voltage regulation selection
- D. Exciter field removal and reset
- E. Maintenance and return to normal.

The transfer to local control operation is annunciated in the control room. The dc power source for the diesel generator instrumentation and control system is part of the same load group as the respective diesel generator, and is discussed in subsection 8.3.2.

Each diesel generator is equipped with the following alarms at the diesel generator room panel:

- A. Lube oil low pressure
- B. Lube oil high and low temperature
- C. Jacket water low pressure
- D. Jacket water high and low temperature
- E. Turbo (control) oil low pressure
- F. Fuel oil high level in day tank
- G. Fuel oil low level in day tank.

- H. Fuel oil high-low level in storage tank
- I. Fuel oil low pressure
- J. Start failure
- K. Generator undervoltage/overvoltage
- L. Generator field ground
- M. Lube oil low pressure trip
- N. Lube oil high temperature trip
- O. Turbo (control) oil low pressure trip
- P. Jacket water high temperature trip
- Q. Jacket water low pressure trip
- R. Jacket water low level
- S. Sequencer in test mode or trouble
- T. Safety injection signal (SIS) T 0
- U. Generator bearing high temperature U
- V. Generator potential transformer voltage imbalance
- W. Generator load imbalance W.
- X. Generator fault trip
- Y. Generator differential trip
- Z. Ground fault trip
- AA. Engine vibration trip
- AB. Diesel cooling pumps or air compressors not in auto control
- AC. Barring device engaged
- AD. Maintenance lockout
- AE. Local/remote switch in local
- AF. Control air low pressure
- AG. Starting air low pressure

AH. Crankcase high pressure trip	
AI. Engine overspeed trip	
AJ. Generator breaker closed	
AK. Generator breaker tripped	
AL. Bearing high temperature trip	
AM. Loss of excitation trip	
AN. Generator underfrequency trip	
AO. Reverse power trip	
AP. Loss of dc control power	
AQ. Day tank room exhaust fan off	
AR. Lube oil filter high differential pressure	
AS. Lube oil strainer high differential pressure	
AT. Fuel oil filter high differential pressure	
AU. Fuel oil strainer high differential pressure	
AV. Emergency Start	
AW. Diesel generator, PCB permissive	
AX. Diesel generator bus 2/4 low volt	
AY. Trouble during ESFAS	
AZ. Sequencer in overlap test.	
BA. Excitation Global.	515
BB. Excitation Start Fault	536
BC. Diesel Generator Slow Operation	660

The following conditions are annunciated in the main control room:

- A. Diesel generator trouble (in local alarm)
- B. Diesel generator in maintenance mode
- C. Diesel generator trouble during ESFAS
- D. Diesel generator electrical protection trip
- E. Diesel generator overspeed/differential trip
- F. Diesel generator fail to start
- G. Load sequencer trouble/test.

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8.3.1.1.3.10 Alternate AC Power Supply(SBO)

One non-Class 1E diesel generator, which is in the independent AAC building separated from the existing power blocks, is provided as an alternate AC(AAC) source to cope with Station Blackout(SBO) for the common use of YGN 1&2, as required by 10CFR 50.63, Regulatory Guide 1.155 and MEST(Ministry of Science & Technology in Korea) Decree 31, Article 24 (©). The AAC source is designed to start manually at the main control room of each unit of YGN 1&2, and one division of two safety-related buses is available to power within 10 minutes of the onset of Station Blackout. In order to provide power to AAC D/G building, the AAC bus can be connected only to one safety-related bus of YGN 1&2 through Class 1E circuit breaker during normal plant operation. The Class 1E circuit breaker is located in Class 1E 4.16kV SWGR panel and allowed as an isolation device to connect between Class 1E bus and non-Class 1E bus. The AAC source may be synchronized and operated in parallel with a preferred power source to allow test of AAC source during normal operation of power plant. Interlocks are provided to permit control of the AAC source from only one unit at a time in order to prevent the parallel operation from two(2) units. The AAC source is designed to be inspected, maintained and tested periodically in accordance with NUMARC 8700.

The AAC source and its supporting systems can be controlled and monitored locally and remotely from each main control room of YGN 1&2. The following instruments are provided on each control panel of YGN 1&2 and on local control panel which is installed in AAC D/G building. The status lights of AAC D/G and supply breaker position are provided in the main control room and at the circuit breaker cubicle.

Indicators in the main control room and the AAC D/G room :

- A. AAC D/G Output Voltage
- B. AAC D/G Output Ampere
- C. AAC D/G Output Watt and VAR
- D. AAC D/G Output Frequency
- E. Field Voltage
- F. Field Ampere

Handswitches and status lights in the main control room :

- A. Handswitches for AAC D/G and AAC power supply breakers control to each unit
- B. Status lights for AAC D/G operation and AAC power supply breakers position

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If the loss of offsite power(LOOP) is occurred in the unit which supplies auxiliary power to the AAC facility, the AAC bus is automatically disconnected by the undervoltage relays on Class 1E bus, or if the SIS is occurred in the unit which supplies auxiliary power to the AAC facility, the AAC bus is also automatically disconnected from the safety related bus.

And then AAC bus is manually connected to any Class 1E bus of the units which are available offsite power.

If SBO occurred in any of the units, the AAC source is manually started by the operator in main control room and connected to the AAC bus which is tied to the Class 1E bus.

And then it is manually started to the loads required to bring and maintain the hot stand-by and hot shutdowns mode of plant.

During SBO, the trip of AAC diesel generator is only provided by differential relay, engine overspeed device and operator's manual action with handswitch, but the actuation of other protective devices bypasses the trip circuits of AAC D/G and gives only alarm signal. But the trip of AAC diesel generator is provided by all protective devices during testing of the AAC diesel generator.

When the offsite power is restored, the Class 1E bus can be synchronized through the normal or alternate offsite source and the loads of the Class 1E bus will be transferred to the normal or alternate offsite power. The AAC source can then be unloaded, disconnected, and shut down. If the Class 1E diesel generator is restored, it can be connected to the Class 1E bus after tripping of the AAC feed breaker to the bus.

Rating for AAC diesel generator sets are calculated to satisfy the requirements of Regulatory Guide 1.155.

The continuous rating of the AAC source is based on the maximum total loads required at any one time. The AAC source is capable of supplying all loads necessary to shut down and maintain the plant in a safe shutdown condition to mitigate the consequences of postulated accident. The SBO load list is provided in Table 8.3-2A

The AAC diesel generator is rated as shown below :

- A. Continuous Rating 5,500 KW
- B. 2-hour rating in any 24-hour period 6,050 KW

Electrical metering instruments are provided in the main control room and at the diesel generator room panel for surveillance of generator voltage, current, frequency, power, and reactive power. The status of each 4.16 kV Class 1E breaker position is indicated in the main control room and at the circuit breaker cubicle.

The analog instrumentation for the diesel generator provides for the following indicators in the main control room:

- A. Voltage of output
- B. Frequency of output
- C. Amperes of output
- D. Watts of output
- E. VARs of output
- F. Voltage of field
- G. Amperes of field.

The following indicators are provided at the diesel generator room :

- A. Voltage of output
- B. Frequency of output
- C. Amperes of output
- D. Watts of output
- E. VARs of output
- F. Voltage of field
- G. Amperes of field.

8.3.1.1.3.8 Fuel Oil Storage and Transfer Systems. The diesel generator fuel oil storage and transfer systems are de-scribed in subsection 9.5.4.

8.3.1.1.3.9 Diesel Generator Cooling and Heating Systems. The diesel generator cooling water system is described in subsection 9.5.5.

8.3.1.1.3.10 4.16kV mobile gas turbine generator and power connection equipment

8.3.1.1.3.10.1 Design basis

According to Fuku-shima nuclear power plant accident follow-up actions, the buildings are changed to be waterproof, if the integrity of power supply facilities, such as, EDG, AAC D/G and power distribution systems are secured by these actions, the current power system is sufficient for coping with variety of accident scenarios. But considering unexpected loss of power, Hanbit unit 1, 2, 3, 4, 5 and 6 shall secure a common mobile gas turbine generator to increase the safety of the system.

The mobile gas turbine generator shall be 3 phase/4.16 kV/60 Hz, the rating capacity for continuous operation of 72 hours is 3,200 kW.

Mobile gas turbine generator will not perform plant-specific safety function, but it is emergency equipment to cope with long-term station blackout, like that occurred by Fuku-shima nuclear power plant accident, so it is designed as quality class 3.

By the lessons learned from Fuku-shima nuclear power plant accident,

Mobile gas turbine generator is kept in a safe zone from flooding. If situation occurs, it is moved to access point where power supply is possible, after connecting temporary cables, the power is supplied.

In the event of power failure, mobile gas turbine generator shall supply emergency power within two(2) hours.

8.3.1.1.3.10.2.1 Long-term SBO coping analysis

8.3.1.1.3.10.2.1 Coping period

4.16 kV mobile gas turbine generator is installed in order to cope with the situation of unavailability of AAC D/G, which is to cope with station blackout. 4.16 kV mobile gas turbine generator supplies power for AC and DC loads essential to secure safety of plant and supplies for facilities to prevent damage to the core of the reactor by maintaining the cooling function by natural circulation of reactor coolant.

4.16 kV mobile gas turbine generator is installed with a day tank, of one hour capacity, and it is designed to operate continuously more than 72 hours.

Since the same fuel, that is used for 4.16 kV mobile gas turbine generator, is available on-site inside EDG fuel tank, if more than one hour operation is required, continuous operation is possible by transferring of fuel manually, etc.

8.3.1.1.3.10.2.2 Coping ability

Coping ability of 4.16 kV mobile gas turbine generator for long term SBO is considered as the follows:

- A. In the event of SBO and condition of unavailability of AAC D/G power occurs at the same time under long-term, to provide power for essential facilities, 4.16 kV mobile gas turbine generator is secured.
- B. Considering the capacity of essential loads that is required in the situation of station blackout under long-term, the capacity of 4.16 kV mobile gas turbine generator shall be 3,200 kW.
- C. If the long term station blackout occurs, 4.16 kV mobile gas turbine generator is moved to power supply point, using temporary power cable and terminal box power is supplied to the bus, A-PB-301 or B-PB-301, after the connection the generator is operated and load is input manually in sequence.
- D. 4.16 kV mobile gas turbine generator from the position of connection point, temporary power cable length, considering enough margin, shall be maximum 70 m.
- E. 4.16 kV mobile gas turbine generator is equipped with a day tank, with capacity of one hour, if additional fuel is supplied continuous operation is possible.
- F. Mobile gas turbine generator is kept in highlands of plant site safe from flooding, and a place considering convenience of mobility, rapidity and suitability of storage.
- G. 4.16 kV mobile gas turbine generator moves along the existing road network to the point, where power is supplied, near the location of EDG building, where distance from power connection terminal is minimum, considering the period of time for flooding water level to decline to a level that power supply is possible, when the mobile gas turbine gas generator arrives at the location, Site layout, building structure and convenience of installation of temporary power cable are also considered.
- H. To minimize the time required for power supply by 4.16 kV mobile gas turbine generator, three groups, i.e., the first group for mobile gas turbine generator movement, second group for installation and connection of cable and third group for operating the breaker, shall be organized to establish the task.

8.3.1.1.3.10.3 Periodic Testing

4.16 kV mobile gas turbine generator shall be periodically tested according to manufacturer's instruction manual to prove availability for operation.

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8.3.1.1.3.11 120V transportable diesel generator and power connection equipment

8.3.1.1.3.11.1 Design basis

According to Fuku-shima nuclear power plant accident follow-up actions, the buildings are changed to be waterproof, if the integrity of power supply facilities, such as, EDG, AAC D/G and power distribution systems are secured by these actions, the current power system is sufficient for coping with variety of accident scenarios. But considering unexpected loss of power, Yonggwang unit 1, 2, 3, 4, 5 and 6 shall secure a common transportable diesel generator to increase the safety of the system.

120V transportable diesel generator shall supply emergency power for Safety Parameter Display System(1 phase / 220V / 30kVA / 72 hours continuous operation capacity)

Transportable diesel generator will not perform plant-specific safety function, but it is emergency equipment to cope with long-term station blackout, like that occurred by Fuku-shima nuclear power plant accident, so it is designed as quality class 3.

By the lessons learned from Fuku-shima nuclear power plant accident, transportable diesel generator is kept in a safe zone from flooding. If situation occurs, it is moved to access point where power supply is possible, after connecting temporary cables, the power is supplied.

In the event of power failure, transportable diesel generator shall supply emergency power within two(2) hours.

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8.3.1.1.3.11.2 Coping analysis of power loss of SPDS

8.3.1.1.3.11.2.1 Coping period.

120V transportable diesel generator is installed in order to cope with the situation of power loss of SPDS. 120V transportable diesel generator supplies power for Safety Parameter Display System(SPDS) to provide safety parameter for emergency response organization.

120V transportable diesel generator is installed with a day tank, of eight(8) hours capacity, and it is designed to operate continuously more than 72 hours.

Since the same fuel, that is used for 120V transportable diesel generator, is available on-site inside EDG fuel tank, if more than eight(8) hours operation is required, continuous operation is possible by transferring of fuel manually, etc.

8.3.1.1.3.11.2.2 Coping ability.

Coping ability of 120V transportable diesel generator for power loss of SPDS is considered as the follows:

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- A. In the event of SPDS(Safety Parameter Display System), 120V transportable diesel generator is secured.
- B. Considering the capacity of essential loads that is required in the situation of power loss of SPDS, transportable diesel generator shall supply emergency power for SPDS (1 phase / 120 V / 30kVA).
- C. 120V transportable diesel generator moved to power supply points, connected cables and the generator supplies power to distribution panel(N-7E-NQ-F003A or N-7E-NQ-F008) manually after generator started.
- D. The distance from 120V transportable diesel generator to power connection box shall not exceed the length 30m.
- E. 120V transportable diesel generator is equipped with a auxiliary fuel tank and it is possible to operate continuously if additional fuel is supplied.
- F. Transportable diesel generator is kept in highlands of plant site against flooding, and a place considering convenience of mobility, rapidity and suitability of storage.
- G. 120V transportable diesel generator moves along the existing road network to the nearest point from the installed power connection box inside EDG BLDG.

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8.3.1.1.3.11.3 Periodic Testing

120V transportable diesel generator shall be periodically tested according to manufacturer's instruction manual to prove availability for operation.

8.3.1.1.4 Control Rod Assembly Power Supply

Electrical power for operation of control rod drive mechanisms is supplied by two motor-generator sets each fed from a separate non-Class 1E 480 volt load center.

8.3.1.1.5 Vital Instrumentation and Control Power Supply

The vital instrumentation and control ac power supply system consists of six equipment groups. These equipment groups and the loads they supply are described as follows:

Two equipment groups comprising the components tabulated below each supply power to the solid-state interposing logic cabinets associated with one redundant ESF load group. In each group, the panel (F002) is selectively fed from the inverter or regulating transformer via an automatic transfer switch as discussed in subparagraph 8.3.1.1.2. In each group, panel (F003) is fed only by regulating transformers.

<u>Load Group</u>	<u>Inverter</u>	<u>Regulating Transformer</u>	<u>Backup</u>	<u>Transformer Switch</u>	<u>Panel</u>
A	A-EE-PQ-N002		A-SE-PQ-X023	Automatic Transfer switch (A-EE-PQ-N002)	A-EE-PQ-F002
		A-SE-PQ-X03	A-SE-PQ-X023	A-EE-PQ-Z003	A-EE-PQ-F003
B	B-EE-PQ-N002		B-SE-PQ-X023	Automatic Transfer switch (B-EE-PQ-N002)	B-EE-PQ-F002
		B-EE-PQ-X03	B-SE-PQ-X023	B-EE-PQ-Z003	B-EE-PQ-F003

Two equipment groups comprising the components tabulated below each supply power to nuclear instrumentation system instrumentation and logic cabinets. For each group, the panel is selectively fed from the inverter or the regulating transformer via an automatic transfer switch which can be bypassed by a maintenance switch in the inverter.

<u>Nuclear Instrumentation system Channel</u>	<u>Inverter</u>	<u>Regulating Transformer</u>	<u>Automatic Transfer Switch</u>	<u>Maintenance Switch</u>	<u>Panel</u>
C	C-EE-PQ-N001	C-EE-PQ-X01	Automatic Transfer switch (C-EE-PQ-N001)	Maintenance Switch (C-EE-PQ-N001)	C-EE-PQ-F001
D	D-EE-PQ-N001	D-EE-PQ-X01	Automatic Transfer switch (D-EE-PQ-N001)	Maintenance Switch (D-EE-PQ-N001)	D-EE-PQ-F001

Two equipment groups comprising the components tabulated below each supply power to nuclear instrumentation system instrumentation and logic cabinets, and to equipment associated with ESF load groups. For each group, the panel is selectively fed from the inverter or the regulating transformer via an automatic static transfer switch which can be bypassed by maintenance switch in the inverter.

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Nuclear Instrumentation System ESF Load Group	Inverter	Regulating Transformer	Automatic Transfer Switch	Maintenance Switch	Panel
I or A	A-EE-PQ- NO01	A-EE-PQ- X01	Automatic Transfer switch (A-EE-PQ-NO01)	Maintenance Switch (A-EE-PQ-NO01)	A-EE- PQ-F001
II Or B	B-EE-PQ- NO01	B-EE-PQ- X01	Automatic Transfer switch (B-EE-PQ-NO01)	Maintenance Switch (B-EE-PQ-NO01)	B-EE- PQ-F001

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8.3.1.1.6 Non-Class 1E Instrument and Computer AC Power Supply

8.3.1.1.6.1 Non-Class 1E Instrument AC Power Supply. The 120V non-Class 1E instrument ac power supply furnishes reliable power to non-Class 1E nuclear steam supply system (NSSS) and miscellaneous instrumentation systems.

The non-Class 1E instrument ac power supply for each unit consists of six subsystems, as described in subparagraph 8.3.1.1.1.

Refer to figure 8.3-3 for the single-line arrangement of this system.

8.3.1.1.6.2 Non-Class 1E Computer AC Power Supply. The computer power supply system consists of the following components.

A. Main power supply is a 50kVA inverter with their 120V, single-phase, 60 hertz outputs connected in parallel normally fed by a 480V, 3 phase, 60 hertz supply with a 125V dc backup supply. Also contained in this enclosure are an automatic static transfer switch, with a maximum transfer time of 1/4 cycle including sensing time, and a three-position manual transfer switch for bypassing the automatic transfer switch.

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B. A 50kVA 480-120 volt, single-phase, 60 hertz, regulating transformer for main power supply.

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C. The other 30kVA 480-120 volt, single-phase, 60 hertz, regulating transformer for backup power supply.

D. fused disconnect switch distribution panel supplying main power to the computer.

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E. The other fused disconnect switch distribution panel supplying backup power to the computer.

Normally, the inverters supply power to the computer through the automatic transfer switch. In the event of failure of any of the three inverters or their sources of power, the static transfer switch will operate automatically to transfer the computer to the regulating transformer which is connected to an alternate 480V source. Transfer is inhibited in the event of abnormality of the alternate source. The transfer back to

the inverters is automatic upon restoration of normal power to the inverters.

8.3.1.1.7 Electric Equipment Layout

Following are the general features of the electrical equipment layout:

- A. Class 1E switchgear, load centers, and motor control centers of the redundant load groups are located in separate rooms of the control building or the auxiliary building. Separate ventilation systems are used for the switchgear rooms, powered from the corresponding redundant load group.
- B. Class 1E batteries are located in the control building. Each battery is located in a separate room, and each room is equipped with a separate ventilation system powered from the corresponding redundant load group.
- C. Two cable spreading rooms are provided, one above and one below the control room. This arrangement enhances redundant cable separation.
- D. Redundant diesel generators and associated equipment are located in separate rooms of the Seismic Category I diesel generator building.
- E. The Class 1E battery chargers, inverters, and dc buses associated with each of the redundant ESF subsystems are located in separate rooms.

Electrical equipment layout drawings showing the location of electrical equipment and cable raceways are listed in section 1.7.

8.3.1.1.8 Design Criteria for Class 1E Equipment

The following design criteria are applied to the Class 1E equipment.

8.3.1.1.8.1 Motor Size. Motor size (horsepower capability)

is equal to or greater than the maximum horsepower required by the driven load under normal running, runout, or discharge valve (or damper) closed condition.

8.3.1.1.8.2 Minimum Motor Accelerating Voltage. The electrical system is designed such that Class 1E motors will have no less than 75 percent rated voltage at their terminals. Class 1E motors are specified with accelerating capability at 75 percent nominal voltage at their terminals.

8.3.1.1.8.3 Motor Starting Torque. The motor starting torque is capable of starting and accelerating the connected load to normal speed within sufficient time to perform its safety function for all expected operating conditions, including the design minimum terminal voltage.

8.3.1.1.8.4 Minimum Motor Torque Margin over Pump Torque Through Accelerating Period. The minimum motor torque margin over pump torque through the motor accelerating period is determined by using actual pump torque curve and calculated motor torque curve values at 75 percent terminal voltage. The minimum torque margin (accelerating torque) at this voltage is such that the pump-motor assembly reaches nominal speed in less than 7.1 seconds. This margin is usually not less than 10 percent of the pump torque requirement.

8.3.1.1.8.5 Motor Insulation. Insulation systems are selected on the basis of the particular ambient conditions to which the insulation is exposed. For Class 1E motors located within the containment, the insulation system is selected to withstand the postulated accident environment.

8.3.1.1.8.6 Temperature Monitoring Devices Provided in Large Horsepower Motors. Six resistance-temperature detectors (RTD) are provided in the motor slots, two per phase, for all motors, 100 horsepower and over, where available from the manufacturer. For these same motors, one copper or iron-constantan thermocouple bearing temperature device is provided on each bearing which is not the antifriction type.

8.3.1.1.8.7 Interrupting Capacities. The interrupting capacities of the protective equipment are determined as follows:

A. Switchgear

Switchgear interrupting capacities are greater than the maximum short circuit current available at the point of application. The magnitude of short circuit currents in medium voltage systems is determined in accordance with ANSI C37.010-1979. The offsite power system, the main turbine generator, a single operating

diesel generator, and running motor contributions are considered in determining the fault level. The interrupting capacity of the switchgear is not designed to handle fault conditions occurring simultaneously with the momentary paralleling of offsite and onsite power sources. High voltage power circuit breaker interrupting capacity ratings are selected in accordance with ANSI C37.06a-1971.

B. Load Centers, Motor Control Centers, and Distribution Panels

Load center, motor control center, and distribution panel interrupting capacities are greater than the maximum short circuit current available at the point of application. The magnitude of short circuit currents in low-voltage systems is determined in accordance with ANSI C37.13, 1973, and NEMA AB 1. Low-voltage power circuit breaker interrupting capacity ratings are selected in accordance with ANSI C37.16, 1970. Molded case circuit breaker interrupting capacities are determined in accordance with NEMA AB 1.

8.3.1.1.8.8 Electric Circuit Protection. Electric circuit protection criteria are discussed in paragraph 8.3.1.1.2.11.

8.3.1.1.8.9 Grounding Requirements. A buried ground grid is furnished over the station area to provide personnel safety and to provide facilities for systems, structures, and equipment grounding. Bare copper conductors are of sufficient size to carry the maximum ground fault current. Conductors are located to limit touch and step potentials to safe values under all ground fault conditions. The design and analysis are based on the procedures and recommendations of IEEE Standard No. 80-1976. The ground fault limits are :

- 0 Main generator - high resistance grounded to limit the ground current to the value of the capacity of the charging current of the system
- 0 Class 1E diesel generator - Same as for the main generator.
- 0 13.8kV and 4.16kV systems - Limited to 1000 amps
- 0 480V system - solid ground - limited by the impedance of the system at the point of fault not exceeding the maximum breaker interrupting capability.

8.3.1.1.9 Logic and Schematic Diagrams

A sufficient number of logic and schematic diagrams are listed in section 1.7 to permit an independent evaluation of compliance with safety criteria.

8.3.1.1.10 The power supply of RHR suction MOVs is a 25KVA inverter with their 480V three-phases, 60 hertz outputs.

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8.3.1.2 Analysis

8.3.1.2.1 Compliance with General Design Criteria and Regulatory Guides.

The following paragraphs analyze compliance with General Design Criteria 17 and 18. Applicable Regulatory Guides are discussed in subparagraph 8.1.5.2.2.

A failure modes and effects analysis is provided in accordance with IEEE 308-1972. Refer to table 8.3-4.

8.3.1.2.1.1 General Design Criterion 17, Electric Power Systems. An onsite electric power system is provided to permit functioning of structures, systems, and components important to safety. With total loss of offsite power, the onsite power system provides sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents. Section 3.2 contains a list of structures, systems, and components important to safety. Table 8.3-1 provides assurance that each of these loads important to safety is supplied from the onsite electric power supply.

The onsite electric power system of each unit includes two load groups. The load groups are redundant in that only one load group is required to assure (1) and (2) above. Sufficient independence is provided between redundant load groups to ensure that postulated single failures affect only a single load group and are limited to the extent of total loss of that load group. The redundant load group remains intact in order to provide for the measures specified in (1) and (2) above.

In the case of a total loss of offsite power, and a turbine and/or reactor trip, the Class 1E electrical system is automatically isolated from the non-Class 1E auxiliary power system. Power to each redundant load group is then provided by the assigned diesel generator, operating independently, isolated, and separated. Undervoltage relays are provided on the Class 1E buses to trip the supply circuit breakers in the event offsite power is lost.

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Protective relaying is provided to trip the diesel generator circuit breaker if abnormal conditions occur while the diesel generator is synchronized to the preferred power source during testing. The combination of these factors minimizes the probability of losing electric power from the onsite power supplies as a result of the loss of power from the transmission system.

The turbine-generator is automatically isolated from the switchyard following a turbine or reactor trip as described in subparagraph 8.3.1.1.1. Transmission system stability is discussed in subsection 8.2.2.

8.3.1.2.1.2 General Design Criterion 18, Inspection and Testing of Electrical Power Systems. The Class 1E system is designed to permit:

- A. Periodic inspection and testing, during equipment shut-down, of wiring, insulation, connections, and relays to assess the continuity of the systems and the condition of components.
- B. During normal plant operation, periodic testing of the operability and functional performance of onsite power supplies, circuit breakers, and associated control circuits, relays, and buses.
- C. During plant shutdown, testing of the operability of the Class 1E system as a whole. Under conditions as close to design as practical, the full operational sequence that brings the system into operation, including operation of signals of the ESFAS and the transfer of power between the offsite and the onsite power system, will be tested.

Refer to appendix 3A for discussions on Regulatory Guides 1.6, 1.9, and 1.32.

8.3.1.2.2 Safety-Related Equipment Exposed to Hostile Environment

Information on all Class 1E equipment that must operate in a hostile environment, during and/or subsequent to an accident, is furnished in section 3.11.

8.3.1.3 Physical Identification of Safety-Related Equipment

8.3.1.3.1 Circuit and Raceway Identification

Each circuit and raceway is given a unique alphanumeric identification. This identification provides a means of distinguishing a circuit or raceway associated with a particular voltage level or function as well as with a particular channel or load group. The latter is provided by one alpha character of the identification and is assigned on the basis of the following criteria. Raceways are identified by ink stenciling. Control and instrumentation wires are identified at terminations by imprinted sleeves and all cables are identified by tags.

8.3.1.3.1.1 Separation Group A (Color - Red), Class 1E instrumentation, control and power cables, raceways, and equipment associated with load group A, vital ac instrumentation and control channel A, and dc subsystem A.

8.3.1.3.1.2 Separation Group B (Color - Green), Class 1E instrumentation, control and power cables, raceways, and equipment associated with load group B, vital ac instrumentation and control channel B, and dc subsystem B.

8.3.1.3.1.3 Separation Group C (Color - Yellow), Class 1E instrumentation, control and power cables, raceways, and equipment associated with vital ac instrumentation and control channel C, and dc subsystem C.

8.3.1.3.1.4 Separation Group D (Color - Blue), Class 1E instrumentation, control and power cables, raceways, and equipment associated with vital ac instrumentation and control channel D, and dc subsystem D.

8.3.1.3.1.5 Separation Group N (Nonsafety-Related: Color - Black), Non-Class 1E instrumentation, control, and power cables, raceways, and associated equipment.

8.3.1.3.1.6 Separation Group S (Color - White), Class 1E power, instrumentation and control cables, raceways, and equipment which can be associated with either load group A or load group B. One specific example of this separation group assignment is the common charging pump which can be powered from either of the redundant Class 1E load groups via an interlocked

manual transfer switch. Refer to subparagraph 8.3.1.1.2.5 for a discussion of the manual transfer switch and interlocking.

8.3.1.3.1.7 Identification of Separation Groups. Nameplates of color background are provided for all Class 1E equipment. Each separation group has its distinguishing color. The applicable channel or load group designation is marked on each nameplate.

Raceways will be marked at intervals not to exceed 15 feet and at points of entry to and exit from enclosed areas. The cables in these raceways will be color coded at intervals not to exceed 5 feet throughout the entire cable length.

Within control panels, where more than one separation group is present, wiring is identified by separation group designation, or if enclosed by conduit, the conduit is identified by separation group designation.

Within a cabinet or panel, which is related to and identified with only a single separation group, the internal wiring is exclusively associated with the same separation group and, therefore, requires no further identification.

Design drawings provide distinct identification of Class 1E equipment. The applicable separation group or load group designation is also identified.

Operating and maintenance documents pertaining to Class 1E equipment are distinctly identified.

8.3.1.4 Independence of Redundant Systems

8.3.1.4.1 Separation Criteria

This paragraph establishes the criteria, and their bases, for preserving the independence of redundant Class 1E power systems.

8.3.1.4.1.1 Raceway and Cable Routing. Cable trays in stacks are arranged from top to bottom, with trays containing the highest voltage cables at the top and trays containing the lowest voltage cables at the bottom. Raceways designated for a single-voltage category of cables contain only cables of the same voltage category, with the service level designations given below:

Service Level	Description
A, B, C, D	15 kV power
E, F, G	5 kV power
H, I, J, K	Large 600V power (cables from load centers)
L, M, N, P	600V power (cables from motor control centers)
Q, R, S, T, U, V, W	Control cables
X, Y, Z	Instrumentation cables

All 120V ac, 125V dc and 250V dc power cables will be run in the L, M, N, or P, 600V power raceways unless special applications require individual conduit runs.

Cables associated with each separation group, as defined in paragraph 8.3.1.3, are run in separate conduits, cable trays, ducts, and penetrations.

The arrangement of electrical equipment, raceways, and cabling will prevent a fire in one separation group from propagating to another separation group. In the absence of confirming analyses to support less stringent requirements, the following general rules are applied to those areas in which the only source of fire is of electrical origin. Refer to subsection 8.3.3.

A. General Plant Areas

1. Minimum horizontal separation between different separation groups is 3 feet. In areas where a 3-foot separation is unattainable, the redundant safety-related circuits are run in totally enclosed raceways (conduit, solid top and solid bottom tray or wireway), or a fire barrier is installed extending at least 1 foot above the top of the tray (or to the ceiling) and 1 foot below the bottom of the tray (or to the floor), with a minimum separation of 1 inch between enclosed raceways or between raceways and the barrier.
2. When the trays are stacked vertically, minimum vertical separation between different separation groups is 5 feet. In areas where a 5-foot separation is unattainable, the redundant circuits in the top tray are run in solid bottom tray and those in the lower tray are run in tray with a

solid cover or a fire barrier is installed extending at least 6 inches beyond each side of the tray (or to the wall if it exists). The minimum separation between the top tray and the barrier is 1 inch.

3. When trays cross each other, minimum vertical separation between different separation groups is 5 feet. In areas where a 5-foot separation is unattainable, the redundant circuits in the top tray are run in solid bottom tray, and those in the lower tray are run in a tray with solid cover for a distance of 1 foot along each tray from the crossover or a fire barrier is installed. The minimum separation between the barrier and the top tray is 1 inch. The barrier extends 1 foot minimum from each side of the top tray and 3 feet minimum from each side of the bottom tray.
4. Minimum separation distance between safety-related and nonsafety-related separation groups in open-top, solid bottom trays, where the top tray is the open tray is the minimum separation distance that applies between trays of different safety-related separation groups.

B. Cable Spreading Areas

1. Minimum horizontal separation between different separation groups is 1 foot. In areas where a 1-foot separation is unattainable, the redundant circuits are run in totally enclosed raceways or a fire barrier is installed extending at least 1 foot above the top of the tray (or to the ceiling).
2. When the trays are stacked vertically, minimum vertical separation between different separation groups is 3 feet. In areas where a 3-foot separation is unattainable, the redundant circuits in the top tray are run in a solid bottom tray and those in the lower tray are run in a tray with a solid cover, or a fire barrier is installed extending at least 6 inches from both sides of the tray (or to the wall if it exists). The separation between the top tray and the barrier is 1 inch minimum.
3. When trays cross each other, minimum vertical separation between different separation groups is 3 feet. In areas where a 3-foot separation is unattainable, the redundant circuits in the top tray are run in solid bottom tray and those in

the lower tray are run in solid cover tray for a distance of 1 foot from the crossover, or a fire barrier is installed. The separation between the barrier and the top tray is 1 inch minimum. The barrier extends 1 foot minimum from each side of the top tray and 1 foot minimum from each side of the bottom tray.

4. Minimum separation distance between safety-related and nonsafety-related separation groups in open-top trays is the minimum separation distance that applies between trays of different safety-related separation groups, except that minimum separation distance between safety-related open-top trays and nonsafety-related totally enclosed raceways is 1 inch minimum.

Fire barriers having a one hour rating are used in areas protected by water sprinkler-systems.

Fire barriers having a three hour rating are used in areas which have no water sprinkler system.

Openings in floors, for vertical runs of raceways, are sealed with fire resistant material equal to the fire rating of the floor. Fire stops are also provided at fire rated wall penetrations equal to the fire rating of the wall.

Where it is necessary for cables of different separation groups to approach the same or adjacent control panels with less than 1 foot horizontal or 3 foot vertical separation, isolation is maintained by installing cables of the redundant safety-related separation groups in separate enclosed metallic raceways with 1 inch minimum separation between them, or by installing suitable barriers between these separation groups with 1 inch minimum separation between the raceways and the barrier. The barriers installed in lieu of horizontal separation extend from 1 foot below the bottom of the tray to 1 foot above the top of the tray (or to the ceiling). The barrier installed in lieu of vertical separation extends 6 inches beyond each side of the tray system (or to a wall).

Arrangement and/or use of protective barriers preclude locally generated forces or missiles from destroying redundant systems. In the absence of confirming analyses to support less stringent requirements, the following rules are applied:

- A. The routing of Class 1E circuits and the location of Class 1E electrical equipment, is reviewed for exposure to hazards such as high pressure piping, missiles, flammable materials, and flooding. A degree of separation or physical protection commensurate with the damage potential of the hazard is provided such that

the independence of redundant Class 1E subsystems is maintained. The separation of redundant Class 1E circuits and equipment makes use of features inherent in the plant design such as using different rooms or opposite sides of rooms or areas. This does not apply to confined spaces such as tunnels or other effectively unventilated areas.

- B. The separation of Class 1E circuits and equipment is such that the required independence is not compromised by the failure of mechanical systems served by the Class 1E systems. For example, Class 1E circuits are routed or protected such that failure of related mechanical equipment of one redundant subsystem cannot disable Class 1E circuits or equipment essential to the operation of another redundant subsystem.

Non-Class 1E cables are not routed through Class 1E raceways. A non-Class 1E cable may be fed from a Class 1E power source through a qualified isolation device. When this is done the circuit after leaving the isolation device is not classified as an associated circuit and is not routed through safety-related raceways.

Cables of load group A and protection channels A and C, and load group B and protection channels B and D are routed through separate cable chases and cable spreading rooms. Load group A and channels A and C circuits enter the upper cable spreading room, while load group B and channels B and D circuits enter the lower cable spreading room. Load group N circuits may enter either the upper or the lower cable spreading rooms.

The independence of redundant NSSS safety-related systems is discussed below:

Safety-related reactor trip, engineered safety feature actuation, and instrumentation and control power supply systems are designed to meet the independence and separation requirements of Criterion 22 of 10 CFR 50, Appendix A, and Paragraph 4.6 of IEEE 279, 1971.

Channel independence is maintained throughout the system, extending from the sensor to the devices actuating the protective function. Physical separation of wiring for each redundant channel set is maintained. Redundant analog equipment is separated by locating modules in different protection rack sets. Each redundant channel set is energized from a separate ac power source.

There are four separate process protection analog rack sets. Separation of redundant analog channels begins at the process sensors and is maintained in the analog protection racks to the

redundant trains in the logic racks. Redundant analog channels are separated by locating modules in different rack sets.

The two reactor trip breakers are actuated by two separate logic matrices which interrupt power to the control rod drive mechanisms. The breaker main contacts are connected in series with the power supply so that opening either breaker interrupts power to all control rod drive mechanisms, permitting the rods to free-fall into the core.

Protection system channel inputs are separated from the solid-state protection system train outputs as follows:

- A. Class 1E, shielded cables, defined in the N333 vendor protection system documentation (process sensing circuits, solid-state protection system logic cabinet inputs from control board switches, and pushbuttons) are separated from Class 1E 120V ac, instrumentation and vital instrument bus voltage cables and the Class 1E 120V ac, and 125V dc control voltage cables.
- B. Prefabricated cables, which connect process control system Class 1E 24V dc signals to the protection system input, are separated from Class 1E 120V ac instrumentation and vital instrument bus voltage cables, and 120V ac and 125V dc control voltage cables.
- C. The Class 1E 48V dc reactor trip logic train A and train B output circuits are installed in separate conduits.
- D. 125V dc Class 1E control voltage unshielded cables only) are contained in the same trays as protection system channel A unshielded cables.
- E. Train B protection system outputs (120V ac and 125V dc Class 1E control voltage unshielded cables only) are contained in the same trays as protection system channel B unshielded cables.

These requirements are complied with in the field circuiting.

8.3.1.4.1.2 Control Boards and Other Panels. Single control devices, to which different separation groups are connected, are avoided where possible. Where not possible, the devices have separation barriers built in. Within the main control boards, non-Class 1E wiring is run separately from Class 1E wiring. Harnesses of different separation groups are separated physically by a minimum distance of 6 inches. Where the

6-inch physical separation is impractical, then metal barriers, metallic conduit, metallic gutter or metallic wire duct are used for maintenance of independence.

- A. A 6-inch minimum physical separation is maintained between field cables of different separation groups entering an enclosure (main control boards, switchboards, equipment cabinets, panels, and termination cabinets), and between any of these field cables and the internal wiring of different separation groups within the enclosure, and between the internal wiring of different separation groups within the enclosure. Where a 6-inch minimum physical separation between two separation groups cannot be maintained, one of the following is performed:

1. The cables or wires of at least one of the redundant safety-related separation groups must be installed in an enclosed raceway (rigid steel conduit, flexible metallic conduit, or enclosed metallic gutter) maintaining 1-inch minimum separation between the enclosed raceway(s) and/or cable (wire) of a redundant separation group. The enclosed raceway is installed over the entire length of the cables or wires from/to the point where a 6-inch minimum separation distance can be established.
2. Where a 6-inch minimum separation distance cannot be established, then a metal barrier is erected between the cabling, terminal boxes, or components of the separation groups, and a 1-inch air gap is maintained between the barrier and the separation group component, where possible. Where not possible, a thermal barrier equivalent to a 1-inch air gap is placed on each side of the barrier.

- B. When non-Class 1E cables enter an enclosure containing Class 1E wiring (field or internal wiring), a 6-inch minimum physical separation is maintained between the non-Class 1E cables and any Class 1E wiring. Where a 6-inch separation cannot be maintained, the non-Class 1E cables are installed in enclosed raceways (rigid steel conduit, flexible metallic conduit, or enclosed metallic gutter) and a minimum of 1 inch separation is maintained between the non-Class 1E enclosed raceways and the Class 1E cables.

8.3.1.4.1.3 Containment Electrical Penetration Areas. Two separate main electrical penetration rooms are provided for the majority of the cables which must pass through the containment wall. Two additional separate electrical penetration rooms at the next higher elevation are provided for the remainder of the cables which must pass through the containment wall. The two

rooms forming the west electrical penetration area contain cable for separation groups B, D, and N, each group having separate penetration assemblies. The two rooms forming the east penetration area contain cable for separation groups A, C, and N, each group having separate penetration assemblies. Raceway separation criteria, as described in the general plant areas, subparagraph 8.3.1.4.1.1, applies in routing cable through the penetration areas.

8.3.1.4.2 Administrative Responsibilities and Controls for Assuring Separation Criteria

The separation group identification described in paragraph 8.3.1.3 facilitates and ensures the maintenance of separation in the routing of cables and the connection of control boards and panels. At the time of cable routing assignment during design, those persons responsible for cable and raceway scheduling check to make sure that the separation group designation on the scheme to be routed is compatible with a single-line diagram load group designation and other schemes previously routed. Extensive use of computer facilities assists in ensuring correct separation. Each cable and raceway is identified in the computer program. The identification includes the applicable separation group designation. Auxiliary programs are made available specifically to ensure that cables of a particular separation group are routed through the appropriate raceways. The routing is also confirmed by quality control personnel during installation to be consistent with the design document. Color identification of equipment and cabling (discussed in paragraph 8.3.1.3) assists field personnel in this effort.

8.3.2 DC POWER SYSTEMS

8.3.2.1 Description

8.3.2.1.1 Class 1E DC Power

Four Class 1E dc power subsystems are provided for each unit. These subsystems are identified as Class 1E on figure 8.3-3. The dc subsystems A and B provide control power for ac load groups A and B respectively. These subsystems also provide dc power to the inverters for channels A and B respectively. Power for solenoid valves and diesel generator field flashing is also supplied by dc subsystems A and B. The dc subsystems C and D provide dc power to the inverters for channels C and D respectively, as well as to the inverters for the two redundant residual heat removal isolation valves. Subsystem C also provides dc power to the turbine driven auxiliary feedwater pump controls. Each Class 1E dc power subsystem consists of one 125V battery, one battery charger, and one dc control center.

The battery chargers of each subsystem are supplied with 480V ac power from the associated load group. Non-Class 1E loads are supplied by a separate dc system. (See paragraph 8.3.2.1.2.)

Subsystems A and B each use the following batteries:

- 218 | Lead calcium type, with 60 cells, 2415 ampere-hours (at an 8-hour rate), 125V .

Subsystems C and D each use the following batteries:

- 218 | Lead calcium type, with 60 cells, 825 ampere-hours (at an 8-hour rate) 125V

Specific characteristics of the lead calcium cell are as follows:

0 Float voltage	2.17V/cell (minimum) 2.25V/cell (maximum)
0 Equalizing charge	2.33V/cell
0 Minimum operating voltage	1.75V/cell
0 Voltage range (60 cell)	105-140v

Thyristor-controlled battery chargers with solid-state output voltage regulators provide the necessary charging currents to the batteries. Each unit features automatic "float" and "equalize" cycling to ensure optimum battery performance. AC input circuit breaker with thermal-magnetic trip, output circuit current limiting, dc output circuit breaker with reverse power prevention feature, and all necessary hardware (i.e., shunts, terminal strips, etc.) required to accommodate the instrumentation and alarms described in subparagraph 8.3.2.2.1.9, are provided. Specific electrical parameters are as follows:

- | | |
|--|--|
| A. Subsystems A and B | - Two chargers, rated output 500 amperes each. |
| B. Subsystems C and D | - Two chargers, rated output 200 amperes each. |
| C. Spare (any subsystem) | - One charger, rated output 500 amperes. |
| D. Parameters common to all chargers: | |
| 0 Input - 3 phase, 460V ac + 10 percent, 60 hertz ±5 percent | |

- 0 Output - Current limiting to 110 percent rated for overload; 125 percent for connection to "zero charge" battery.

- Rated voltage 130V dc @ ± 0.5 percent regulation
- Float range 2.08-2.25V/cell
- Equalize range 2.24-2.42V/cell, set for 2.33V/cell

Four 125V dc control centers rated 1200 amperes, for subsystems A, B, C, and D each equipped with all required feeder and branch circuit protection are provided in NEMA 1 enclosures. Top entry for all cabling is provided with separate vertical compartments for the incoming feeders from the battery charger and the battery. Branch circuits are equipped with fused disconnect switches. Specific circuits are provided as follows:

- A. Subsystems A and B
 - One each, 800 ampere fused disconnect switch for battery charger connections.
 - One each, 1200 ampere fused disconnect switch for connection to the battery
 - One each, 400 ampere and one each 200 ampere fused disconnect switch for connection to inverter loads.
 - Two each 400 ampere: one each 200 ampere: and three 60 ampere fused disconnect switches feeding miscellaneous branch circuits.
- B. Subsystems C and D
 - One each, 800 ampere fused disconnect switch for battery charger connections
 - One each, 800 ampere fused disconnect switch for connection to connections
 - One each, 400 ampere and one 200 ampere fused disconnect switch for connection to inverter load.

8.3.2.1.1.1 Safety-Related DC Loads. Table 8.3-3 identifies loads related to each Class 1E 125V dc subsystem.

8.3.2.1.1.2 Class 1E Station Batteries and Battery Chargers.

8.3.2.1.1.2.1 Battery Capacity. Each Class 1E battery has sufficient capacity to independently supply the required loads as shown in table 8.3-3 for 2.2 hours. Sizing of the batteries will be based on a minimum temperature of 50F in the battery room for the 2.2-hour service period.

In accordance with Section 6, Battery Replacement Criteria, of IEEE Standard 450, initial battery capacity is 25 percent greater than required. This margin allows a battery replacement criterion of 80 percent of rated capacity.

8.3.2.1.1.2.2 Battery Charger Capacity. The capacity of each Class 1E battery charger is based on the largest combined demand of all the steady-state loads and the charging capacity to restore the battery from the design minimum charge state to the fully charged state within 12 hours, regardless of the status of the plant during which these demands occur.

8.3.2.1.1.2.3 Inspection Maintenance, and Testing. Testing of the dc power system is performed prior to, and during, plant operation in accordance with the procedures described in IEEE Standard 450 and chapter 14.

8.3.2.1.1.3 Separation and Ventilation. The Class 1E batteries, chargers, and dc switchgear are located in separate rooms of the Seismic Category I control building. Chargers and dc switchgear are in separate rooms from the batteries. Each battery room is provided with separate and independent exhaust fans. The ventilation system is designed to preclude the possibility of hydrogen accumulation. Hydrogen buildup is monitored in the battery rooms. Any hydrogen concentration in excess of 2 percent will be annunciated in the control room. Refer to paragraph 9.4.1.2 for details regarding the battery room ventilation system.

8.3.2.1.2 Non-Class 1E DC Power

The non-Class 1E system consists of two 125V batteries and one 250V battery per unit, three battery chargers, two backup battery chargers (one for each battery voltage) and three dc control centers. Seven 125V dc distribution panels are provided for control loads, while the 250V dc control center provides power to motor loads. The non-Class 1E dc power system is shown in figure 8.3-3.

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Two 125V batteries, each consisting of 60 lead calcium type cells, and one 250V battery consisting of 120 lead calcium type cells, are provided for each unit.

One of the 125V batteries has a capacity of 2250 ampere-hours; the other has a capacity of 2550 ampere-hours. The 250V battery has a capacity of 1950 ampere-hours. Each of these capacities is based on an 8-hour discharge rate which exceeds the design requirements by 25 percent. This allows a replacement criterion of 80 percent rated capacity. Cell characteristics are as follows:

A. Float voltage	2.17V/cell (minimum) 2.25V/cell (maximum)
B. Equalizing charge	2.33V/cell
C. Minimum operating voltage	1.75V/cell
D. Voltage range (60 cell)	105-140v
E. Voltage range (120 cell)	210-280V

Three 800 ampere, 125V, (one backup) and two 400 ampere, 250V, (one backup) thyristor-controlled battery chargers with solidstate output voltage regulators provide the necessary "float" and "equalize" cycling to ensure optimum battery performance. AC input circuit breaker with thermal-magnetic trip, output circuit current limiting, dc output circuit breaker with reverse power protection feature, and all necessary hardware (i.e., shunts, terminal strips, etc.) required to accommodate the required instrumentation and alarms is provided. The 125V dc system is comprised of two separate buses, each with its own battery and charger. A backup charger is furnished that can be connected to either bus through a manual transfer switch.

The 250V dc system consists of a bus with a charger and a backup charger. Either charger can be connected to the bus through a manual transfer switch.

Specific electrical parameters are as follows :

- A. Five - 100 percent capacity battery chargers (three 125V and two 250V).

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- B. Input - 3 phase, 460V ac ± 10 percent, 60 hertz ± 5 percent.
- C. Output-Rated Current - Three 800 amperes, 125V, and two 400 amperes, 250V, current limiting to 110 percent rated for overload: 125 percent for connection to "zero charge" battery.

- | | |
|-------------------|--|
| 0 Rated Voltage: | 130V dc @ ± 0.5 percent regulation (800 amp)
260V dc @ ± 0.5 percent regulation (400 amp) |
| 0 Float Range: | 2.08-2.25V/cell |
| 0 Equalize Range: | 2.24-2.42V/cell |

Two 125V dc, 2000 ampere buses, and one 250V dc, 1500 ampere bus with all required feeder and branch circuit equipments are provided in NEMA I enclosures. Top entry into this control center is provided for all cabling with separate vertical compartments for the incoming feeders from the two battery chargers and the battery. Circuits are provided as follows:

Bus 1

- A. Two 800-ampere fused disconnect switches for battery charger connections.
- B. One 2000-ampere fused disconnect switch, for battery connection.
- C. Seven 400-ampere fused disconnect switches.
- D. One 600-ampere fused disconnect switch.

Bus 2

- A. Two 800-ampere fused disconnect switches for battery charger connections.
- B. One 2000-ampere fused disconnect switch for battery connection.
- C. Four 400-ampere fused disconnect switches.
- D. Two 600-ampere fused disconnect switches.

Bus 3

- A. Two 400-ampere fused disconnect switches for battery charger connections.
- B. One 1600-ampere fused disconnect switch for battery connection.

- C. One 400-ampere fused disconnect switches for the main turbine emergency lube pump.
- D. One 200-ampere fused disconnect switch for main turbine airside seal oil backup pump.
- E. Three 60-amperes fused disconnect switches for steam generator feedwater pump emergency oil pumps.
- F. One 400-ampere, one 200 ampere and two 60 ampere for spare fused disconnect switches.

All circuits are equipped with auxiliary contacts for use in remote trip alarm circuits.

8.3.2.1.3 Non-Class 1E DC Power for AAC System

In addition to the existing batteries, a separate non-class 1E DC power system is provided for the loads to related AAC source. The DC power system consists of one 125V battery, one battery charger and one control center. This DC power system provides control and DC power for the loads to related AAC source and common UPS located in the AAC diesel generator building. Maintenance, test and replacement are performed in accordance with IEEE std. 250. Non-Class 1E DC power for AAC Source is shown in figure 8.3-3.

The 125V battery consists for 58 lead antimony type cells.

The 125V battery consists for 58 lead antimony type cells.

The 125V battery has a capacity of 400 ampere-hours to be based on an 4-hour discharge rate. Cell characteristics are as follows :

A. Float Voltage	2.15V / cell (minimum) 2.17V / cell (maximum)
B. Equalizing charge	2.25V / cell (minimum) 2.40V / cell (maximum)
C. Minimum operating voltage	1.81V / cell
D. Voltage range (58 Cells)	105 - 140V

The 200 ampere, 125V, thyristor-controlled battery charger with solid-state out voltage regulator provide the necessary "float" and "equalize" cycling to ensure optimum battery performance. Battery charger characteristics are as follows :

A. Input - 3 phase, 480V AC \pm 10 percent, 60 Hertz \pm 5 percent

B. Output - Rated current - 200 ampere, current limiting to 110 percent rated for overload

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- Rated Voltage : 125V DC \pm @0.5 percent regulation
 - Float Range : 124 - 128V
 - Equalize Range : 130 - 140V

8.3.2.2 Analysis

8.3.2.2.1 Compliance with General Design Criteria, Regulatory Guides, and Industry Standards. The following paragraphs analyze compliance of the Class 1E dc power system with General Design Criteria 17 and 18, Regulatory Guides 1.6, 1.32, 1.41, 1.75, -1.81, 1.120 and IEEE Standards 308 and 450.

8.3.2.2.1.1 General Design Criterion 17, Electric Power Systems. Consideration of Criterion 17 leads to the inclusion of the following factors in the design of the dc power system:

- A. Separate Class 1E 125V dc subsystems supply control power for each of the Class 1E ac load groups.
- B. The ac power for the battery charger in each of these dc subsystems is supplied from the same ac load group for which the dc subsystem supplies the control power.
- C. The Class 1E dc subsystems, including batteries, chargers, dc switchgear, and distribution equipment are physically separate and independent.
- D. Sufficient capacity, capability, independence, redundancy, and testability are provided in the Class 1E dc subsystems, to ensure the performance of safety functions assuming a single failure.

8.3.2.2.1.2 General Design Criterion 18, Inspection and Testing of Electric Power Systems. Each of the Class 1E 125V dc subsystems is designed to permit the following:

- A. Inspection and testing of wiring, insulation, and connections, during equipment shutdown to assess the continuity of the subsystem and the condition of its components.
- B. Periodic testing of the operability and functional performance of the subsystem during normal plant operation by isolating the subsystem.

The battery and charger of each Class 1E 125V dc subsystem is periodically inspected and tested to assess the condition of battery cells and other components. Moreover, all important system components can be tested during service to detect faults. Abnormal conditions of important system parameters are annunciated in the unit control room. Preoperational testing is discussed below in the assessment of compliance with Regulatory Guide 1.41.

8.3.2.2.1.3 Regulatory Guide 1.6, Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution systems. Physical separation, electrical isolation, and redundancy are provided for in the 125V dc Class 1E system, so that a single failure and an event in one load group will not prevent the Class 1E system from performing its safety functions. The dc system is separated into four subsystems, two per load group: subsystems A and C (Channels 1 and 3) belong to load group A, and subsystems B and D (Channels 2 and 4) to load group B.

Each dc subsystem is energized by one battery and one battery charger. Each battery is exclusively associated with a single 125V dc bus. Each battery charger is supplied from one ac load group only. The battery and the battery charger exclusively associated with one 125V dc subsystem cannot be interconnected with any other 125V dc subsystem. The battery chargers are supplied from the same ac load group for which the associated dc subsystem supplies the control power. No provision exists for transferring loads between redundant 125V dc subsystems. Thus, sufficient independence and redundancy exist between the 125V dc subsystems to ensure performance of minimum safety functions assuming a single failure. A spare battery charger is provided to replace any one of the four chargers.

8.3.2.2.1.4 Regulatory Guide 1.32, 1977 -- Use of IEEE Standard 308-1974, Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations. The battery charger capacity for each of the Class 1E 125V dc subsystems complies with the regulatory position of the guide.

Each Class 1E battery charger has sufficient capacity to supply the largest combined demand of the various steady-state loads and the charging current required to restore the battery from the design minimum charge state to the fully charged state irrespective of the status of the plant during which these demands occur.

8.3.2.2.1.5 Regulatory Guide 1.41, 19730-Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments. In compliance with this regulatory guide, the Class 1E 125V dc subsystems designed in accordance with Regulatory Guides 1.6 and 1.32 are tested as follows.

- A. Testing of the dc power system, including an acceptance test of battery capacity, is performed prior to unit operation, and after major modifications or repairs in accordance with the procedures described in chapter 14.
- B. The charger, battery connections, and charger supply are checked for assignment to the proper ac load group.
- C. Class 1E 125V dc subsystems are functionally tested, along with the associated ac load group, by disconnecting and isolating the other ac load group, its ac power sources, and the associated dc subsystem. Each test includes simulation of an ESFAS, startup of the standby diesel generator and the load group under test, sequencing of loads, and the functional performance of the loads. During these tests, the ability of the 125V dc subsystem to perform its intended functions: e.g., supply of power for control of diesel generators and Class 1E ac switchgear, is checked.
- D. During the testing of the Class 1E 125V dc subsystem associated with one ac load group, the buses and loads of the 125V dc subsystem associated with the ac loads groups not under test are monitored to verify absence of voltage indicating no interconnection of dc systems.

8.3.2.2.1.6 Regulatory Guide 1.75, 1978--Physical Independence of Electric Systems. Refer to appendix 3A for discussion of this guide.

8.3.2.2.1.7 Regulatory Guide 1.81--Shared Emergency and Shutdown Electrical Systems for Multi-Unit Nuclear Power Plants. Refer to appendix 3A for discussion of this guide.

8.3.2.2.1.8 Regulatory Guide 1.120--Fire Protection Guidelines for Nuclear Power Plants. Refer to appendix 3A for discussion of this guide.

8.3.2.2.1.9 IEEE Standard 308, IEEE Standard Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations. The Class 1E dc system provides dc power to the Class 1E dc loads, and for control and switching of the Class 1E systems. Physical separation, electrical isolation, and redundancy are provided to prevent the occurrence of common failure mode. The design of the Class 1E dc system includes the following:

- A. The dc system is separated into four subsystems.
- B. The safety actions by each group of loads are independent of the safety actions provided by its redundant counterparts.
- C. Each dc subsystem includes power supplies that consist of one battery and one battery charger.
- D. The batteries are not interconnected between load groups of each unit or between units.
- E. The batteries do not have a common failure mode.

Each Class 1E distribution circuit is capable of transmitting sufficient energy to start and operate all required loads in that circuit. Distribution circuits to redundant equipment are independent of each other. The distribution system is monitored to the extent that it is shown to be ready to perform its intended function. The dc auxiliary devices required to operate equipment of a specific ac load group are supplied from the same load group.

Each battery supply is continuously available during normal operations and following the loss of power from the ac system, to start and operate all required loads.

Control room instrumentation is provided to monitor the status of the battery supply as follows:

- A. DC bus trouble alarm including bus undervoltage, ground, and charger input breaker trip.
- B. Battery current indication.
- C. DC voltage indication.

The batteries are maintained in a fully charged condition and have sufficient stored energy to operate all necessary circuit breakers, and to provide an adequate amount of energy for all required emergency loads for 2.2 hours after loss of ac power.

Each Class 1E battery charger has sufficient capacity to re-store the battery from the design minimum charge to its fully charged state while supplying the maximum demand of the steady-state loads. The battery charger of one subsystem is independent of the battery charger for the redundant subsystem. Instrumentation provided to monitor the status of each battery charger is as follows:

- A. Output voltage indication at the charger.
- B. Output current indication at the charger.
- C. Charger malfunction alarm in the control room, including input ac undervoltage, dc undervoltage, dc overvoltage, and charger failure.

Each battery charger has an input ac and output dc circuit breaker for isolation of the charger. Each battery charger power supply is designed to prevent the ac supply from becoming a load on the battery due to a power feedback as the result of the loss of ac power to the charger.

Equipment of the Class 1E dc system is protected and isolated by fuses in case of short circuit or overload conditions. The following indications are provided to identify equipment that is made unavailable:

<u>Event</u>	<u>Availability Indication</u>
Battery charger ac input breaker trip	Charger trouble alarm
Battery charger dc output breaker trip	Charger trouble alarm
Battery disconnect switch open or battery input fuse open	Bus trouble alarm
Loss of 125V dc bus voltage	Bus trouble alarm
125V dc distribution panel supply disconnect switch open or fuse blown.	Bus trouble alarm
Inverter dc supply disconnect switch open or fuse blown	Inverter trouble alarm
DC bus ground detection	Bus trouble alarm

The battery charger ac supply breaker is periodically opened to verify the load-carrying ability of the battery.

Each Class 1E 125V dc subsystem is designed to meet environmental and Seismic Category I requirements as stated in sections 3.10 and 3.11. The batteries, battery chargers, and other components of the dc subsystem are housed in the control building, which is a Seismic Category I structure.

848 The periodic testing and surveillance requirements for the Class 1E batteries are detailed in ITS Chapter 1 3.8.

8.3.2.2.1.10 IEEE Standard 450, Recommended Practice for Maintenance, Testing, Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries. The following recommended practices of IEEE 450 for maintenance, testing, and replacement of batteries are followed for the Class 1E batteries:

- 848 A. Maintenance inspections and tests are carried out on a regularly scheduled basis to comply with the requirements of IEEE Standard 450. (Refer also to subparagraph 8.3.2.1.1.2 and ITS Chapter 1 3.8).
- 848 B. The first performance test of battery capacity will be carried out within the first 2 years of service. The subsequent performance tests of battery capacity will be made once every 3 years during refueling cycles. (Refer to ITS Chapter 1 3.8)
- C. The rating of the battery, is 25 percent greater than that required for present and anticipated future emergency load requirements. This 25 percent margin permits a battery replacement criteria of 80 percent rated capacity. (Refer to subparagraph 8.3.2.1.1.2.)
- D. An acceptance test of battery capacity is performed at the factory to determine if it meets the specified discharge rate and duration.
- E. Records of the data obtained from inspections and tests are kept along with test procedures to comply with the requirements.

8.3.2.2.2 Physical Identification of Safety-Related Equipment

Physical identification of Class 1E equipment is discussed in paragraph 8.3.1.3.

8.3.2.2.3 Independence of Redundant Systems

The general considerations for the independence of Class 1E dc power subsystems are described in paragraph 8.3.1.4.

8.3.3 FIRE PROTECTION FOR CABLE SYSTEMS

The measures employed for the prevention of fire and protection of Class 1E and non-Class 1E electrical cables are as follows:

A. Cable derating and cable tray fill

Ampacity rating and group derating factors of cables are in accordance with manufacturers standards or, as a minimum, with ICEA P-46-426 for cables in conduit or ducts, and with ICEA P-54-440 for cables in tray.

Additional derating factors are applied to cable ampacities for electrical power cables passing through fire stops, where test data or analysis supports the need for the same. Appropriate derating factors are applied to cable ampacities for electrical power cables installed in raceways enclosed with solid covers or fire retardant materials.

The following methods are used for determining cable tray fill in cable raceways:

1. For 15 kV, 5 kV, and load center 600V power cables, the maintained spacing method is used. This method of raceway fill computes in inches the space required to route the cables in a tray with sufficient space between each adjacent cable. To preclude tray overflow, the computed required width is limited to the tray's usable width.

The required width is calculated by summing the diameters of the included cables plus the sum of the products of the required space factor for the tray's voltage level times the diameter of the larger of each adjacent cable pair.

2. For MCC and smaller 600V power cables, the cable depth method is used. This method of raceway fill calculation is based on the assumption of a 30 percent fill of a 3.0 inch usable depth cable tray which gives an equivalent cable depth of 1.15 inches and is not exceeded for trays of greater depth.

The required cable depth is calculated by dividing the sum of the cross sectional areas of the included cables by the usable width of the tray.

3. For control and instrumentation cables, the percent fill method is used. This method of raceway fill calculation compares the cross sectional areas of the included cables to the available cross sectional area of the tray. Tray fill for control and instrumentation cable is generally limited to a maximum of 40 percent of the usable cross sectional area of the tray. Trays containing both power and control cable are considered as containing only power cables.

In cases where the limiting conditions discussed above are exceeded, a design engineer reviews each individual case for the adequacy of the design.

Conduit fill uses guidance of the National Electric Code 1981.

- B. Fire detection and protection devices in the areas where cables are installed. Adequate fire detection and protection is provided in areas where cables are installed as described in subsection 9.5.1.
- C. Fire barriers and separation between redundant trays. Subparagraph 8.3.1.4.1, Separation Criteria, provides information regarding separation between redundant cable trays.
- D. Design criteria, physical locations, properties of materials, and qualification tests for fire stops at penetrations in walls or floors and in long cable runs 1

Fire stops are provided for cable trays at penetrations in fire rated walls and floors.

The materials used for fire stops at penetrations will be tested for conformance to ASTM-E119 including the hose stream test and/or IEEE STD 634. High density lead filled silicone elastomer foam is used as firestops in areas with high levels of radiation. In other areas, fire stops are made of material such as silicone foam and Marinite I.

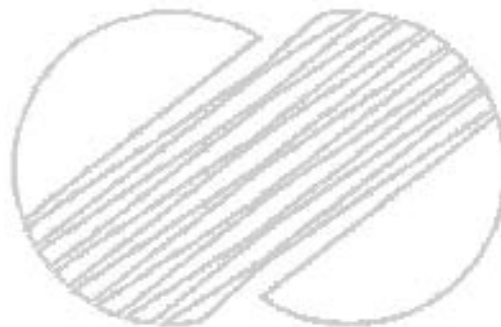


Table 0.3-1
CLASS 1E LOADS
(Sheet 1 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
LOAD GROUP A <u>4160 Volt Loads</u>						
Charging Pump A-7E-BG-M091, (Standby) S-7E-BG-M093	A-7E-PB-S01	2	900	709	111	767
Residual Heat Removal Pump A-7E-BG-M024 Containment Spray Pump A-7E-BK-M028	A-7E-PB-S01	1	300	241	38	223
Nuclear Service Water Pump A-7E-EF-M103, -M104	A-7E-PB-S01	2	950	750	122.3	755
Component Cooling Water Pump A-7E-EG-M065, -M066	A-7E-PB-S01	2	800	635	103	616

Table 0.3-1
CLASS 1E LOADS
(Sheet 2 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Essential Chiller Compressor A-7E-GJ-Z006	A-7E-PB-S01	1	402	260	52.9	343.85
Auxiliary Feed-water Pump A-7E-AL-M017	A-7E-PB-S01	1	800	635	103	618
480 Volt Loads						
Spent Fuel Pool Cooling Pump A-7E-EC-M032	A-7E-PG-S02	1	125	100	145	877
Aux Bldg Air Handling Unit Heater A-7E-GK-F022	A-7E-PG-S04	1	150kW	150	180	Not applicable
Containment Fan Cooler A-7E-GN-M007, -M008	A-7E-PH-E03	2	60/30	50/27	74.3/70.2	589/373
125V Battery Charger "A" A-7E-PK-N001	A-7E-PG-S01	1	115kVA	86.25	135	Not applicable

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Table 0.3-1
CLASS 1E LOADS
(Sheet 8 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
125V Battery Charger "C" C-7E-PK-M001	A-7E-PH-E04	1	45kVA	33.75	55	Not applicable
Aux Bldg Elect Penetration Room AHU A-7E-GL-M076	A-7E-PH-E04	1	10	8.4	13.1	81
Control Room Emergency Supply Recirc AHU A-7E-GK-M022	A-7E-PH-E01	1	40	34	46.5	290
Control Room Emergency Filtration Fan A-7E-GK-M023	A-7E-PH-E01	1	15	12.3	17.6	105
Control Room Emergency Filtration Unit A-7E-GK-Z023A	A-7E-PH-E08	1	7	9	10.8	Not applicable
Control Bldg Swgr/Battery Room AHU A-7E-GK-M040	A-7E-PH-E01	1	30	25	34.5	217

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 4 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Battery Room						
Emergency Exhaust Fan						
A-7E-GK-M033 Diesel Gen Bldg	A-7E-PH-E01	1	3	2.8	4.6	29.2
ESF Fan A-7E-GM-M082, -M084 Diesel Fuel Oil Transfer Pump	A-7E-PH-E02	2	30	26	42	210
A-7E-KJ-M046 Diesel Fuel Transfer Pump	A-7E-PH-E02	1	4.4	4	6.7	26.1
A-7E-KJ-M047 Aux Bldg ESF Swgr Room AHU	A-7E-PH-E02	1	4.4	4	6.7	26.1
A-7E-GL-M080 Fuel Bldg Emergency Exhaust	A-7E-PH-E04	1	10	8.4	13.1	81
A-7E-GG-F088	A-7E-PH-E04	1	25	21	29.7	178

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Table 0.3-1
CLASS 1E LOADS
(Sheet 5 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Fuel Bldg Emergency Exhaust Heater A-7E-GG-Z088 Nuc Service Wtr Travel Screen A-7E-DC-M075 Condensate Trans- fer and Storage Pump A-7E-AP-M100 NSCW Pump House Supply Fan A-7E-GD-M094, A-7E-GD-M095 Nuc Service Wtr Screen Wash Pump A-7E-DC-M130 Essential Chilled Water Pump A-7E-GJ-M030	A-7E-PH-E04 A-7E-PH-E06 A-7E-PH-E01 A-7E-PH-E06 A-7E-PH-E06 A-7E-PH-E01	1 1 2 1 1	24kW 3 15 20 50 40	24 2.8 13 17 42 33.5	29 4.7 18.5 26 59.8 46	Not applicable 32 116 140 387 280

Table 0.3-1
CLASS 1E LOADS
(Sheet 6 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Component Clg Wtr Pump Rm AHU A-7E-GL-M041	A-7E-PH-E03	1	15	12.5	18.6	116
Charging Pump Room AHU A-7E-GL-M058, -M061	A-7E-PH-E04	2	2	1.6	2.64	25
Residual Heat Removal Pump Room AHU A-7E-GL-M065	A-7E-PH-E04	2	2	1.9	3.1	25
Boron Injection Recirculation Pump A-7E-BH-M026	A-7E-PH-E03	1	2.5 kw	3.2	3.63	13.1
Boric Acid Transfer Pump A-7E-BG-M004	A-7E-PH-E03	1	20 kw	20	27.6	151
Containment Spray Pump Room AHU A-7E-GL-M056	A-7E-PH-E04	1	2	1.9	3.1	25
Aux Feedwater Pump Room AHU A-7E-GL-M047	A-7E-PH-E04	1	3	2.8	3.64	32

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Table 0.3-1
CLASS 1E LOADS
(Sheet 7 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Aux Feedwater Pump Room AHU A-7E-GL-M045	A-7E-PH-E04	1	3	2.8	4.75	32
Fuel Pool Pump Room AHU A-7E-GG-M149	A-7E-PH-E04	1	5	4.34	6.8	44
Delete						
Switchgear Battery Room Air Handling Unit Heater A-7E-GK-Z040A	A-7E-PH-E01	1	65kw	65	78	Not applicable
Radiation Monitoring System A-7E-GK-RE128	A-7E-PH-E02	1	3	2.7	3.6	21.6
A-7E-GT-RE119	A-7E-PH-E04	1	3	2.7	3.6	21.6
Inverter A-YE-PQ-N001	A-7E-PH-E04	1	7.5kW	6.37	62	Not applicable
Inverter A-7E-PQ-N002	A-7E-PH-E07	1	25kW	21.2	208	Not applicable

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Table 0.3-1
CLASS 1E LOADS
(Sheet 6 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Inverter C-7E-PQ-N001	A-7E-PH-E05	1	7.5kW	6.37	62	Not applicable
Fuel Bldg Isolated Damper A-7J-GG-HZ114	A-7E-PH-E09	1	8	7.2	9.6	48
Voltage Regulating Transformer A-7E-PQ-X01	A-7E-PH-E01	1	7.5kW	6.76	9	Not applicable
Voltage Regulating Transformer A-7E-PQ-X03	A-7E-PH-E08	1	30kW	27	36	Not applicable
Voltage Regulating Transformer A-7E-PQ-X023	A-7E-PH-E01	1	30kW	27	36	Not applicable
Voltage Regulating Transformer C-7E-PQ-X01	A-7E-PH-E03	1	7.5kW	6.76	9	Not applicable
120/208 Volt ac Panel A-7E-PH-E01-C2	A-7E-PH-E01	1	30kW	27	36	Not applicable

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ONSITE POWER SYSTEMS

Table 0.3-1
Classification of Loads

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
120/208 Volt ac Panel						Not applicable
A-7E-PH-E02-D2	A-7E-PH-E02	1	15kVA	18.5	18	applicable
120/208 volt ac Panel						Not applicable
A-7E-PH-E03-F2	A-7E-PH-E03	1	15kVA	18.5	18	applicable
120/208 Volt ac Panel						Not applicable
A-7E-PH-E04-I2	A-7E-PH-E04	1	15kVA	18.5	18	applicable
120/208 Volt ac Panel						Not applicable
A-7E-PH-E05-C2	A-7E-PH-E05	1	15kVA	18.5	18	applicable
120/208 volt ac Panel						Not applicable
A-7E-PH-E06-H2	A-7E-PH-E06	1	15kVA	18.5	18	applicable
120/208 volt ac Panel						Not applicable
A-7E-PH-E07-E2	A-7E-PH-E07	1	15kVA	18.5	18	applicable
120/208 volt ac Panel						Not applicable
A-7E-PH-E08-G2	A-7E-PH-E08	1	15kVA	18.5	18	applicable

Table 0.3-1
CLASS 1E LOADS
(Sheet 10 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Essential Lighting Panel N-7E-QB-F003	A-7E-PH-E04	1	30kVA	27	36	Not applicable
Essential Lighting Panel I N-7E-QB-F001	A-7E-PH-E07	1	30kVA	27	36	Not applicable
N-7E-QB-F005 Heat Tracing Panel-Containment Air Purification and Combustible Gas Control	A-7E-PH-E06	1	30kVA	27	36	Not applicable
N-7E-QM-F090 Heat Tracing Panel-Safety 'Injection/Radio- active Drain System	A-7E-PH-E03	1	15kVA	13.5	10.6	Not applicable
N-7E-QM-F050 Heat Tracing Panel-Chemical Volume Control System	A-7E-PH-E03	1	30kVA	27	18	Not applicable
N-7E-QM-F040	A-7E-PH-E03	1	45kVA	40.5	54	Not applicable

Table 0.3-1
CLASS 1E LOADS
(Sheet 11 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(D) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Freeze Protection Panel-Condensate Transfer Storage System						Not applicable
N-7E-QJ-F010 Heat Tracing Panel-Chemical Volume Control System	A-7E-PH-E03	1	80kVA	27	86	Not applicable
N-7E-QM-F042 Freeze Protection Panel-Condensate Storage Tanks	A-7E-PH-E03	1	45	40.5	54	Not applicable
N-7E-QJ-F012 Freeze Protection Panel-Condensate Storage Tanks	A-7E-PH-E03	1	75	67.5	90	Not applicable
ON-7E-QJ-F014 Non-IE Fire Pump	A-7E-PH-E03	1	75	67.5	90	Not applicable
N-7E-KC-M243	A-7E-PH-E09	1	40	33.5	45	Not applicable

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Table 0.3-1
CLASS 1E LOADS
(Sheet 12 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
H ₂ Recombiner Power Control Cabinet A-7E-GT-R006	A-7E-PH-E04	1	60 kW	60	60	Not applicable 70 49
Boron Injection Tank Heater S-7E-BH-Z022A	A-7E-PH-E09	1	6 kW	6	7.5	Not applicable
Boron Injection Surge Tank Heater S-7E-BH-Z021	A-7E-PH-E09	1	6 kW	6	7.5	Not applicable
Motor Operated Valves	Various MCC		90 ^(b)	50 ^(b)	Not applicable	Not applicable
<u>Isolated Non-Class 1E Loads</u>						
CRDM Cooling Fan N-7E-GN-M011, -M014	A-7E-PG-S02	2	60	50	71.4	455
Pressurizer Heater Power Panels N-7E-NH-F002, -F003	A-7E-PG-S03	1	266.5 kW	266.5	643.5	Not applicable
		1	266.5 kW	266.5	643.5	Not applicable

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Table 0.3-1
CLASS 1E LOADS
(Sheet 18 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Diesel Generator MCCs N-7E-NH-E27A	A-7E-PH-E02	1	184 kVA	187	220	Not applicable
N-7E-NH-E27B	A-7E-PH-E02	1	165 kVA	124	198	Not applicable
Air Compressor N-7E-KA-M003	A-7E-PG-S04	1	150	122.3	209	1150
LOAD GROUP B <u>4160 Volt Loads</u>						
Charging Pump B-7E-BG-M092 (Standby)						
S-7E-BG-M093	B-7E-PB-S01	2 ^(c)	900	709	111	767
Residual Heat Removal Pump B-7E-BC-M028	B-7E-PB-S01	1	600	241	88	228
Containment Spray Pump B-7E-BK-M029	B-7E-PB-S01	1	600	478	75	477
Nuclear Service Water Pump B-7E-EF-M106, -M106	B-7E-PB-S01	2	950	750	122.3	755

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 14 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Component Cooling Water Pump B-7E-EG-M067, -M068	B-7E-PB-S01	2	800	885	103	818
Essential Chiller Compressor B-7E-GJ-M007	B-7E-PB-S01	1	402	280	32.9	343.83
Auxiliary Feed-water Pump B-7E-AL-M018 <u>480 Volt Loads</u>	B-7E-PB-S01	1	800	885	103	818
Spent Fuel Pool Cooling Pump B-7E-EC-M033	B-7E-PG-S02	1	125	100	145	877
Control Room Air Handling Unit B-7E-GK-Z025 Containment Fan Cooler B-7E-GN-M009, -M010	B-7E-PG-S04	1	150kW	150	180	Not applicable
	B-7E-PH-E03	2	80/30	50/27	74.8/70.2	589/373

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Table 0.3-1
CLASS 1E LOADS
(Sheet 15 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
125V Battery Charger "B"						Not applicable
B-7E-PK-N001	B-7E-PH-E08	1	115kVA	86.25	185	Not applicable
125V Battery Charger "D"						Not applicable
D-7E-PK-N001	B-7E-PH-E04	1	45kVA	33.75	55	Not applicable
Aux Bldg Elect Penetration						
Room AHU						
B-7E-GL-M077	B-7E-PH-E04	1	10	6.4	18.1	61
Control Room Emergency Supply						
Recirc AHU						
B-7E-GK-M025	B-7E-PH-E01	1	40	34	46.5	290
Control Room Emergency						
Filtration Fan						
B-7E-GK-M024	B-7E-PH-E01	1	15	12.3	17.6	105
Control Room Emergency						
Filtration Unit						Not applicable
B-7E-GK-Z024A	B-7E-PH-E08	1	7kW	7	6	Not applicable

Table 0.3-1
CLASS 1E LOADS
(Sheet 16 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Control Bldg Swgr/Battery Room AHU	B-7E-PH-E01	1	30	25	34.5	217
Battery Room Emergency Exhaust Fan	B-7E-PH-E01	1	3	2.8	4.6	29.2
B-7E-GK-M034 Diesel Gen Bldg Vent Fan	B-7E-PH-E02	2	30	26	42	210
B-7E-GN-M083, -M085 Diesel Fuel Transfer Pump	B-7E-PH-E02	1	4.4	4	6.7	26.1
B-7E-KJ-M147, -M148	B-7E-PH-E02	1	4.4	4	6.7	26.1
Aux Bldg ESF Swgr Room AHU	B-7E-PH-E04	1	10	8.4	13.1	81
B-7E-GL-M081 Fuel Bldg Emergency Exhaust	B-7E-PH-E04	1	25	21	29.7	176
B-7E-GG-M089						

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Table 0.3-1
CLASS 1E LOADS
(Sheet 17 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Fuel Bldg Emergency Exhaust Heater B-7E-GG-Z089	B-7E-PH-E04	1	24kW	24	29	Not applicable
Nuc Service Wtr Travel Screen B-7E-DC-M077	B-7E-PH-E06	1	8	2.8	4.7	82
Condensate Transfer and Storage Pump B-7E-AP-M101	B-7E-PH-E01	1	15	15	18.5	116
NSCW Pump House Supply Fan B-7E-GD-M096, -M097	B-7E-PH-E06	2	20	17	26	140
Nuc Service Wtr Screen Wash Pump B-7E-DC-M131	B-7E-PH-E06	1	50	42	59.8	387
Essential Chilled Water Pump B-7E-GJ-M031	B-7E-PH-E01	1	40	33.5	96	280
Component Clg Wtr Pump Room AHU B-7E-GL-M042	B-7E-PH-E03	1	15	12.5	18.8	116

Table 0.3-1
CLASS 1E LOADS
(Sheet 10 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(a) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Boron Injection Recirculation Pump B-7E-BH-M027	B-7E-PH-E03	1	2.5kW	4.95	5.83	13.1
Boric Acid Transfer Pump B-7E-BG-M005	B-7E-PH-E03	1	20kW	20	27.8	151
Charging Pump Room AHU B-7E-GL-M060, -M063	B-7E-PH-E04	2	2	1.8	2.65	25
Residual Heat Removal Pump Room AHU B-7E-GL-M066	B-7E-PH-E04	1	2	1.9	3.1	25
Containment Spray Pump Room AHU B-7E-GL-M057	B-7E-PH-E04	1	2	1.9	3.1	25
Aux Feedwater Pump Room AHU B-7E-GL-M048,	B-7E-PH-E04	1	3	2.8	3.84	32
B-7E-GL-M046	B-7E-PH-E04	1	3	2.8	4.75	32

Table 0.3-1
CLASS 1E LOADS
(Sheet 19 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Fuel Pool Pump Room AHU B-7E-GG-M150	B-7E-PH-E04	1	5	4.34	6.8	44
		Delete				
Switchgear Battery Room Air Handling Unit Heater B-7E-GK-Z039A	B-7E-PH-E01	1	65kW	65	78	Not applicable
Radiation Monitoring System B-7J-GK-RE-228	B-7E-PH-E02	1	3	2.7	3.6	21.6
B-7J-GG-RE-213	B-7E-PH-E04	1	3	2.7	3.6	21.6
Inverter B-7E-PQ-N001	B-7E-PH-E04	1	7.5kVA	6.37	62	
Inverter B-7E-PQ-N002	B-7E-PH-E07	1	25kVA	21.2	208	

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 20 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Inverter D-7E-PQ-N001	B-7E-PH-E08	1	7.5 kVA	6.87	62	Not applicable
Fuel Building Isolation Damper B-7J-GG-HZ-214	B-7E-PH-E09	1	8	7.2	9.6	48
Voltage Regulating Transformer B-7E-PQ-X01	B-7E-PH-E01	1	7.5 kVA	6.75	9	Not applicable
Voltage Regulating Transformer B-7E-PQ-X03	B-7E-PH-E08	1	80 kVA	27	86	Not applicable
Voltage Regulating Transformer B-7E-PQ-X023	B-7E-PH-E01	1	80 kVA	27	86	Not applicable
Voltage Regulating Transformer D-7E-PQ-X01	B-7E-PH-E03	1	7.5 kVA	6.75	9	Not applicable
120/208 Volt ac Panel B-7E-PH-E01-C2	B-7E-PH-E01	1	80 kVA	27	86	Not applicable

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 21 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
120/208 Volt ac Panel B-7E-PH-E02-D2	B-7E-PH-E02	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E03-F2	B-7E-PH-E03	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E04-12	B-7E-PH-E04	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E05-C2	B-7E-PH-E05	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E06-H2	B-7E-PH-E06	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E07-B2	B-7E-PH-E07	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E08-G2	B-7E-PH-E08	1	15 kVA	18.5	18	Not applicable
120/208 Volt ac Panel B-7E-PH-E09-12	B-7E-PH-E09	1	15 kVA	18.5	18	Not applicable

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 22 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Essential Lighting Panel N-7E-QB-F004	B-7E-PH-E04	1	30kVA	27	36	Not applicable
Essential Lighting Panel N-7E-QB-F002	B-7E-PH-E07	1	30kVA	27	36	Not applicable
N-7E-QB-F006 Heat Tracing Panel- Containment Air Purification and Combustible Gas Control	B-7E-PH-E03	1	30kVA	27	36	Not applicable
N-7E-QM-F091 Heat Tracing Panel- Safety Injection/Radio active Drain System	B-7E-PH-E03	1	15kVA	8.1	10.8	Not applicable
N-7E-QM-F051 Heat Tracing Panel- Chemical Volume Control System	B-7E-PH-E03	1	30kVA	13.5	18	Not applicable
N-7E-QM-F041	B-7E-PH-E03	1	45kVA	40.5	54	Not applicable

0.3-01

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 28 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Freeze Protection Panel- Condensate Transfer Storage System N-7E-QJ-F011	B-7E-PH-E03	1	30	27	36	Not applicable
Heat Tracing Panel- Chemical Volume Control System N-7E-QM-F043	B-7E-PH-E03	1	45	40.5	54	Not applicable
Freeze Protection Panel- Condensate Storage Tanks N-7E-QJ-F018TET	B-7E-PH-E03	1	75	67.5	90	Not applicable
Freeze Protection Panel- Condensate Storage Tanks N-7E-QJ-F015	B-7E-PH-E03	1	75	67.5	90	Not applicable
Non-1E Fire / Pump N-7E-KC-M244	B-7E-PH-E09	1	40	33.5	45	Not applicable

0.3-02

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ONSITE POWER SYSTEMS

Table 0.3-1
CLASS 1E LOADS
(Sheet 24 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
H ₂ Recombiner Pwr Control Cabinet B-7E-GT-R007	B-7E-PH-E04	1	60kw	60	60	Not applicable 70 49
Boron Injection Tank Heater S-7E-BH-Z022B	B-7E-PH-E09	1	6kW	6	7.5	Not applicable
Motor-Operated Valves <u>Isolated Non- Class 1E Loads</u>	Various MCC		90 ^(a)	50 ^(c)	Not applicable	Not applicable
Diesel Generator Bldg MCC N-7E-NH-E28A,	B-7E-PH-E02	1	147kVA	154	177	Not applicable
N-7E-NH-E28B	B-7E-PH-E02	1	199kVA	190	239	
CRDM Cooling Fan N-7E-GN-M012, -M013	B-7E-PG-S02	2	60	50	71.4	435

0.3-03

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ONSITE POWER SYSTEMS

Table 8.3-1
CLASS 1E LOADS
(Sheet 25 of 25)

Description	Bus Feeder	Number on Bus	Rated hp (Each)	Actual Load (kW) ^(b) (Each)	Rated Full Load Current (Amp)	Locked Rotor Current (Amp)
Pressurizer Heater Power Panels N-7E-NH-F004, -F005	B-7E-PG-S03	1 1	268.5 kW 268.5 kW	268.5 268.5	343.5 343.5	Not applicable Not applicable
Air Compressor N-7E-KA-M001	B-7E-PG-S04	1	150	122.3	209	1150

375

- a. For discussion of the common (standby) charging pump operation, refer to subparagraph 8.3.1.1.2.5.
- b. Conversion from hp to kw is based on a factor of 0.746/motor efficiency.
- a. Actual individual MOV horsepower ratings vary between 0.13 and 10.5 hp; the hp value shown represents a summation of the number on bus quantity shown in the table.

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ONSITE POWER SYSTEMS

8-3-84

Table 8.3-2a
Station Blackout(SBO) Load List
(Sheet 1 of 3)

Description	Bus Feeder	Number on bus	Rating (Each)	SBO / kW	
				Hot Standby	Hot Shutdown
LOAD GROUP A <u>4.16 KV LOADS</u>					
Charging Pump A-7E-BG-M091 (Standby) S-7E-BC-M093	A-7E-PB-S01	2 ^(a)	900 HP	709.0	709.0
RHR Pump A-7E-BC-M024	A-7E-PB-S01	1	300 HP	-	242.0
Component Cooling Water Pump A-7E-EG-M065/M066	A-7E-PB-S01	2 ^(a)	900 HP	634.0	634.0
Nuclear Service Water Pump A-7E-EF-M103/M104	A-7E-PB-S01	2 ^(a)	950 HP	750.0	750.0
Auxiliary Feedwater Pump A-7E-AL-M017	A-7E-PB-S01	1	800 HP	625.0	625.0
Essential Chiller Compressor A-7E-GJ-M006	A-7E-PB-S01	1	453 KW	453.0	453.0
<u>480V Loads</u> Load Center Transformer (1000 KVA) A-7E-PG-X01			1000KVA	208.0	208.0

8-3-04a

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ON-SITE POWER SYSTEMS

Table 8.3-2a
Station Blackout(SBO) Load List
(Sheet 2 of 3)

Description	Bus Feeder	Number on bus	Rating (Each)	SBO / kW	
				Hot Standby	Hot Shutdown
Load Center Transformer (1000 KVA) A-7E-PG-X02			1000 KVA	425.0	425.0
Load Center Transformer (1000 KVA) A-7E-PG-X03			1000 KVA	537.0	537.0
Load Center Transformer (1000 KVA) A-7E-PG-X04			1000 KVA	173.0	178.0
Total Load Capacity (Load Group A)				4314.0	4756.0
LOAD GROUP B 4.16 KV LOADS					
Charging Pump B-7E-BG-M092 (Standby) S-7E-BG-M093	B-7E-PB-S01	2 ^(a)	900 HP	709.0	709.0
RHR Pump B-7E-BC-M025	A-7E-PB-S01	1	300 HP	-	242.0
Component Cooling Water Pump B-7E-EG-M067/M068	B-7E-PB-S01	2 ^(a)	800 HP	634.0	634.0
Nuclear Service Water Pump B-7E-EF-M105/M106	B-7E-PB-S01	2 ^(a)	950 HP	750.0	750.0

8.3-84b

YGN 1 & 2 FSAR

ON-SITE POWER SYSTEMS

Table 8.3-2a
Station Blackout(SBO) Load List
(Sheet 3 of 3)

Description	Bus Feeder	Number on bus	Rating (Each)	SBO / kW	
				Hot Standby	Hot Shutdown
Auxiliary Feedwater Pump B-7E-AL-M018	B-7E-PB-S01	1	800 HP	625.0	625.0
Essential Chiller Compressor B-7E-GJ-M007	B-7E-PB-S01	1	566 HP	453.0	453.0
<u>480V Loads</u>					
Load Center Transformer (1000 kVA) B-7E-PG-X01			1000 kVA	208.0	208.0
Load Center Transformer (1000 kVA) B-7E-PG-X02			1000 kVA	425.0	425.0
Load center Transformer (1000 kVA) B-7E-PG-X03			1000 kVA	537.0	537.0
Load center Transformer (1000 kVA) B-7E-PG-X04			1000 kVA	173.0	173.0
Total Load Capacity (Load Group B)				4514.0	4756.0
AAC Facility Loads				337.0	337.0

a. Operate only one(1) pump of two(2) pumps during Station Blackout

Table 8.3-2
AUTOMATIC LOADING SEQUENCE OF CLASS 1E EQUIPMENT
Sheet 1 of 6

Equipment	Rate hp	Load ^(a) kW	Motor Eff	Motor pf	Motor % LRC	LOCA ^{(b)(c)}		Blackout	
						Injection Phase kW	Recirculation Phase kW	Hot Shutdown kW	Cold Shutdown kW
<u>STEP NO. 1</u>									
Time to start 0 set (a)									
0 No Load Energization (e) (4) 1000 kVA Load Cen- ter transformers (i) 0 A-7E-PG-X01 0 A-7E-PG-X02 0 A-7E-PG-X03 0 A-7E-PG-X04	—	—	—	—	—	—			
<u>STEP NO. 2</u>									
Time to start: 1 sec. (a)									
0 Secondary PCB of 1000 kVA Load Cen- ter transformers. 0 A-7E-PG-X01 0 A-7E-PG-X02 0 A-7E-PG-X03 0 A-7E-PG-X04									
o LC (A-7E-PG-Sol) (j) 12EV Battery (k) Charger "A" (A-7E-PK-N001)	—	100	0.86	0.86	—	26	26	26	26
o MCC (A-7E-PH-E01) (j)	—	109.6	—	0.86	600	109.6	109.6	109.6	109.6
c MCC (A-7E-PH-E02) (j)	—	71.9	—	0.82	600	71.9	71.9	71.9	71.9
o MCC (A-7E-PH-E03) (j)	—	108	—	0.82	600	108	108	108	108
o MCC (A-7E-PH-E04) (j)	—	100.4	—	0.88	600	100.4	100.4	100.4	100.4

Table 8.3-2

AUTOMATIC LOADING SEQUENCE OF CLASS 1E EQUIPMENT

Sheet 2 of 6

Equipment	Rate hp	Load ^(a) kW	Motor Eff	Motor pf	Motor % LRC	LOCA ^{(a)(c)}		Blackout	
						Injection Phase kW	Recirculation Phase kW	Hot Shutdown kW	Cold Shutdown kW
o MCC (A-7E-PH-E06) (j)	—	19.9	—	0.88	600	19.9	19.9	19.9	19.9
o MCC (A-7E-PH-E06) (j)	—	69.4	—	0.80	600	69.4	69.4	69.4	69.4
o MCC (A-7E-PH-E07) (j)	—	79.6	—	0.86	600	79.6	79.6	79.6	79.6
o MCC (A-7E-PH-E08) (j)	—	42	—	0.90	600	42	42	42	42
o MCC (A-7E-PH-E09) (j)	—	23.2	—	0.83	600	23.2	23.2	23.2	23.2
<u>4.16 kV LOADS</u>									
o Charging Pump (A-7E-BG-P091)	900	709	.949	.923	691	709	709	709	709
TOTAL FOR STEP 2						1348	1348	1348	1348
<u>STEP NO. 3</u>									
Time to start 5 seconds									
o RHR Pump (A-7E-BC-P024)	300	242	.927	.924	687	242	242	—	242
o Containment Spray ^(a) Pump (A-7E-BK-P027)	600	479	.931	.908	691	— ^(a)	— ^(a)	— ^(a)	— ^(a)
TOTAL LOAD FOR STEP 3						242	—	242	242
<u>STEP NO. 4</u>									
Time to start 16 seconds									
o Component Cooling Water Pump No. 1 (A-7E-EG-P066)	800	634	.94	.866	660	634	634	634	634
TOTAL FOR STEP NO. 4							634	634	634
<u>STEP NO. 5</u>									
Time to start 19 seconds									
o Nuclear Service Cooling Water Pump No. 1 (A-7E-EF-P103)	960	760	.946	.880	661	760	760	760	7660

8-3-06

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ONSITE POWER SYSTEMS

Table 8.3-2

AUTOMATIC LOADING SEQUENCE OF CLASS 1E EQUIPMENT

Sheet 5 of 6

Equipment	Rate hp	Load ^(a) kW	Motor Eff	Motor pf	Motor % LRC	LOCA ^{(b)(c)}		Blackout	
						Injection Phase kW	Recirculation Phase kW	Hot Shutdown kW	Cold Shutdown kW
0 Containment Spray (f) Pump (A-7E-BK-P028)	600	479	.931	.908	691	— ^(d)	— ^(d)	— ^(d)	— ^(d)
0 NSCW Pump House Supply Fan (A-3E-GD- M-094) (A-7E-GD-M096)- Standby	20	17.2	.870	.828	672	17.2	17.2	17.2	17.2
0 NSCW Pump Discharge Valve (A-7J-EF-HV126)	2	1.8				1.8	1.8	1.8	1.8
TOTAL FOR STEP NO. 5						769	769	769	769
STEP NO. 6 Time to start 28 seconds (a)									
0 Auxiliary Feedwater Pump ^(a) (A-7E-AL-P017)	800	626	.966	.900	660	626	626	626	626
TOTAL FOR STEP NO. 6						626	626	626	626
STEP NO. 7 Time to start 36 seconds (a)									
0 Nuclear Service (b,h) Cooling Water Pump No. 2 (A-7E-EF-P104)	960	760	.946	.880	661	760	760	—	—
0 Containment Spray (f) Pump (A-7E-BK-P028)	600	479	.931	.908	691	— ^(d)	— ^(d)	— ^(d)	— ^(d)
0 NSCW Pump Housing Supply Fan (A-7E-GD-M096)	20	17.2	.87	.828	672	17.2	17.2		
0 NSCW Pump Discharge Valve (A-7J-EF-HV126)	2	1.8				1.8	1.8		
TOTAL FOR STEP NO. 7						769	769	—	—
STEP NO. 8 (a) Time to start 46 seconds.									
0 Component ^(a) Water Cooling Pump NO. 2 (A-7E-EG-P066)	800	634	.94	.866	660	—	—	—	—
TOTAL FOR STEP NO. 8						—	—		

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ON-SITE POWER SYSTEMS

Table 8.3-2

AUTOMATIC LOADING SEQUENCE OF CLASS 1E EQUIPMENT

Sheet 4 of 6

Equipment	Rate hp	Load ^(a) kW	Motor Eff	Motor pf	Motor % LRC	LOCA ^{(b)(c)}		Blackout	
						Injection Phase kW	Recirculation Phase kW	Hot Shutdown kW	Cold Shut down kW
STEP NO. 9									
Time to start 51 seconds (9)									
• Essential Chiller A-7E-GJ-Z06	402	260	0.915	0.895	660	260	260	260	260
• Fuel Building Emerg. HVAC	25	21	.895	.88	599	21	21	21	21
A-7E-GG-F088	5	4.3	.860	.82	647	4.3	4.3	4.3	4.3
A-7E-GG-F149	-	24	-	.98	-	24	24	24	24
A-7E-GG-Z088									
• Control Bldg. Emerg. HVAC	40	32.4	.879	.813	529	32.4	32.4	32.4	32.4
A-7E-GK-F022	15	12.8	-	.81	-	12.8	12.8	12.8	12.8
A-7E-GK-F023	3	2.8	.80	.80	634	2.8	2.8	2.8	2.8
A-7E-GK-F033	30	24.5	.882	.87	551	24.5	24.5	24.5	24.5
A-7E-GR-F040	-	150	-	.98	-	150	150	150	150
A-7E-GX-Z022	-	9.0	-	.98	-	9.0	9.0	9.0	9.0
A-7E-GX-Z023	-	65.0	-	.98	-	65.0	65.0	65.0	65.0
A-7E-GX-Z040A									
• Aux. Bldg. Emerg. HVAC									
A-7E-GL-F041	15	12.5	.895	.86	634	12.5	12.5	12.5	12.5
A-7E-GL-F058	2	1.8	.725	.68	689	1.8	1.8	1.8	1.8
A-7E-GL-F061	2	1.8	.725	.68	689	1.8	1.8	1.8	1.8
A-7E-GL-F065	2	1.8	.729	.64	870	1.8	1.8	1.8	1.8
A-7E-GL-F076	10	8.5	.866	.87	989	8.5	8.5	8.5	8.5
A-7E-GL-F080	10	8.5	.866	.87	989	8.5	8.5	8.5	8.5

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ONSITE POWER SYSTEMS

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2008. 7. 25

Table 8.3-2

AUTOMATIC LOADING SEQUENCE OF CLASS 1E EQUIPMENT

Sheet 5 of 6

Equipment	Rated hp	Load ^(a) kW	Motor Eff	Motor pf	Motor % LRC	LOCA ^{(b)(4)}		Blackout	
						Injection Phase kW	Recirculation Phase kW	Hot Shutdown kW	Cold Shutdown kW
Subtotal for Step No. 9	-	-	-	-	-	736.2	736.2	736.2	736.2
Containment Spray Pump (A-EE-BK-P028)	600	479	.931	.908	691	479	479	-	-
TOTAL FOR STEP NO. 9						1312.7	1312.7	833.7	833.7
MANUAL START Time to start T > 61 seconds									
0 Spent Fuel Pool Cooling Pump (A-7E-EC-M032)	126	100	.928	.870	808	100	100	-	-
0 Pressurizer Heaters (N-7E-NH-F002, F003)	-	637	-	-	-	-	-	637	637
0 CRDM Cooling Fans (N-7E-ON-M011)	60	48.6	.914	.882	616	-	-	48.6	48.6
(N-7E-GN-M014)	60	48.6	.914	.882	616	-	-	48.6	48.6
0 Non 1E Air Compressor (N-7E-KA-M003)	160	122.3	.916	.736	660	-	122.3	122.3	122.3
0 Class 1E MCC (A-7E-PH-E09)									
Non 1E Fire Pp.	40	33.6	.891	.919	611	33.6	33.6	33.6	33.6
Boron Inj. Tank Htr. (A-7E-PH-E09)	-	6	-	-	-	-	-	6	6
Heat Tracing Pwr. Pnl. (A-7E-PH-E03)	-	280	-	-	-	-	280	280	280
0 Non Class 1E MCC's									
N-7E-NH-E26	118	97.8	-	-	-	-	-	97.8	97.8
N-7E-NH-E27A	-	169	-	-	-	169	169	169	169
N-7E-NH-E27B	-	176	-	-	-	-	-	176	176
N-7E-NH-E32									
Air Comp. Auxiliaries	10	10	-	-	-	-	10	10	10
Other Loads	-	76	-	-	-	-	-	76	76

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ON-SITE POWER SYSTEMS

Table 8.3-2

AUTOMATIC LOADING SEQUENCE OF CLASS 1E EQUIPMENT

Sheet 6 of 6

Equipment	Rated hp	Load ^(a) kW	Motor Eff	Motor pf	Motor % LRC	LOCA ^{(b)(c)}		Blackout	
						Injection Phase kW	Recirculation Phase kW	Hot Shutdown kW	Cold Shutdown kW
TOTAL LOAD FOR STEP (MANUAL START)						502.9	714.8	1602.8	1602.8
TOTAL DIESEL LOAD						6002	6419	9893	6099
DIESEL GENERATOR RATING						7000	7000	7000	7000
MARGIN						998	989	1147	909

- a. The start times shown exclude the 10 seconds maximum allowable time for the diesel generator to come up to speed and voltage after a start signal.
- b. Only Load Group (A) loads are shown for total diesel loading, since this load group is capable of safely bringing the unit to a cold shutdown condition. Load Group (B) loads are identical to Load Group (A) loads, with the exception of NSCW standby pump No. 2 and its associated NSCW pump discharge valve which will be loaded on step No. 6 and the auxiliary feedwater pump B-7E-AL-P018 which will be loaded on step No. 7.
- c. Loss of coolant accident.
- d. Conversion from HP to kW is based 0.746/motor efficiency. Motor efficiency values were obtained from actual vendor data when available.
- e. Magnetisation inrush current of LC transformers is about 12 to 15 times its rated full load current for a few cycles. Generator will restore its voltage and frequency rating within 1 second.
- f. Containment spray pump starts if ESFAS-CIS-B signal is present (load not added since it is considered during step No. 9 at t=51.0 seconds, representing the worst case condition).
- g. Component cooling water standby Pump No. 2 will be started on step No. 8, if Pump No. 1 fails to start on step No. 4.
- h. Load Group (A) Nuclear service water standby pump No. 2 is required to start on step No. 7, if leading pump No. 1 fails to start on step No. 5 or if the pump is not producing enough flow. Load Group B NSCW standby pump No. 2 is required to start on step No. 6, if leading pump No. 1 fails to start on step No. 5 or if the pump is not producing enough flow.
- i. Primary PCBs of transformers are not tripped, the load center transformers will be energized when the diesel generator breaker is closed.
- j. Load (kW) shown is based on required loads, not connected loads.
- k. Class 1E battery charger load (kW) assumed to be 25 percent rated kVA @ 0.89 efficiency.

Amendment 7

B-3-90

Feb. 1991

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YGN 1 & 2 FSAR

ONSITE POWER SYSTEMS

Table 8.3-3
CLASS 1E DC SYSTEM LOADS

(Sheet 1 of 4)

Item	Description	Emergency Loads on Bus, Amperes			
		0 - 1 Min	59-60 Min	131-132 Min	Steady State Load
	DC Subsystem A				
1	Inverter (7.5 kVA): A-7E-PQ-N001	72	72	72	72
2	Inverter (25 kVA) A-7E-PQ-N002	296	296	296	296
3	Diesel A - generator field flash ^(x)	100	100	100	--
4	Diesel A - generator control panel ^(x)	10	10	10	--
5	4.16 kV switchgear - Indication	6	6	6	6
	- Trip	66	66	66	--
	- Closing ^(a)	--	--	--	--
6	480V load center - Indication vs ion ^(b)	10	10	10	10
	- Trip ^(b)	28	28	28	--
	Reactor trip switchgear - Train A	66			--
7	SSILS - solenoid valves - Train A	15	15	15	15
8	Solid State protection system -				
9	Train A	5	5	5	
10	Diesel A - engine control panel ^(a)	20	20	20	5
11	Reactor coolant pump trip switchgear				--
	- Indication ^(a)	5	5	5	5
	- Trip ^(a)	66	--	--	--
12	Isolation relay panels	4	4	4	4
13	Pressurizer power-operated relief valves ^(a)	16	--	--	--
	Total on Subsystem A	756	666	666	412

Table 8.3-3
CLASS 1E DC SYSTEM LOADS

(Sheet 2 of 4)

Item	Description	Emergency Loads on Bus, Amperes			
		0 - 1 Min	59-60 Min	131-132 Min	Steady State Load
	DC Subsystem A				
1	Inverter (7.5 kVA) B-7E-PQ-NO01	72	72	72	72
2	Inverter (25 kVA) B-8E-PQ-NO02	298	298	298	298
3	Diesel B - generator field flash ^(a)	100	100	100	--
4	Diesel B - generator control panel ^(a)	10	10	10	--
5	4.16 kV switchgear - Indication	3	3	3	3
	- Trip	66	66	66	--
	- Closing ^(a)				
6	480V load center - Indication ^(b)	10	10	10	10
	- Trip ^(b)	28	28	28	--
7	Reactor trip switchgear - Train B	66			--
8	SSILS - solenoid valves - Train B	15	15	15	15
9	Solid State protection system - Train B	5	5	5	5
10	Diesel B - engine control panel ^(c)	20	20	20	--
11	Reactor coolant pump trip switchgear				
	- Indication ^(d)	5	5	5	5
	- Trip ^(d)	36	--	--	--
12	Isolation relay panels	4	4	4	4
13	Pressure power-operated relief valves ^(a)	18	--	--	--
	Total on Subsystem A	756	636	636	412

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YGN 1 & 2 FSAR

ONSITE POWER SYSTEMS

Table 8.3-3

CLASS 1E DC SYSTEM LOADS

(Sheet 3 of 4)

Item	Description	Emergency Loads on Bus, Amperes		
		0 - 1 Min	1-120 Min	Steady State Load
	DC Subsystem C			
1	Inverter (7.5 kVA) C-7E-PQ-N001	72	72	72
2	Reactor coolant pump trip switchgear (e)	1	1	1
	Emergency feedwater turbine controls			
	- Valve control	1	1	1
	- Speed control	2	2	2
3	Isolation relay panels	1	1	1
4	Inverter (25 kVA) C-7E-PH-N001	285+5	5	5
	Total on Subsystem C	367		
	DC Subsystem D			
1	Inverter (7.5 kVA) D-7E-PQ-N001	72	72	72
3	Isolation relay panels	1	1	1
4	Inverter (25 kVA) D-7E-PH-N001	285+5	5	5
	Total on Subsystem D	363	78	78

Table 8.3-3
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 4 of 4)

- a. Due to sequential reclosing of breakers through sequencer, closing coil currents have a negligible effect on battery loading.
- b. Emergency load value shown is for four loadcenters.
- c. Emergency load value shown is for two feeders at 15 and 5 amperes each.
- d. Emergency load value shown is for three switchgear (S-5E-NA-305, 306, and 307) and includes Channel A or B reactor coolant pump bus undervoltage and underfrequency relay loads.
- e. Emergency load value shown is for reactor coolant pump bus undervoltage and underfrequency relay loads only (switchgear S-5E-NA-307 only).
- f. Field flush and generator control are on the same circuit breaker.
- g. This load is considered as a random load which may occur at any time during the duty cycle. However, this load is shown in the first cycle of emergency loads on the bus.

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 1 of 22)

Item No and Name	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
4AA/5AA Off-site Power	Loss of power	0 Open circuit 0 Short circuit 0 XFMR failure	Loss of pre-ferred power to load group A	Undervoltage alarm	Offsite power 4AB, 5AB or diesel generator backup	No effect. Redundant load available
4AA/5AA 4AB/5AB Offsite Power	Loss of power	0 Open circuit 0 Short circuit	Loss of pre-ferred power to both load groups A & B	Undervoltage alarm	Diesel generators provide backup	No effect
7AA Air Circuit Breaker	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power load group A	Undervoltage alarm	Circuit breaker 7BA performs a redundant function	No effect. Redundant load Group B available
	Fail to interrupt on a fault	0 Operating mechanism failure 0 Relay malfunction	Loss of power to load group A	Undervoltage alarm	Switchyard breakers 2AB and 2AF operate to interrupt fault. Circuit breaker 7BA performs a redundant function.	No effect. Redundant load Group B available
7AC Air Circuit Breaker	Fail to close	Mechanical or electrical failure	Unavailability of standby onsite power to load group A	Undervoltage alarm and breaker alarm	Load group B picks up the load	No effect
8AA Diesel Generator	Fail to start	Mechanical or electrical failure	Unavailability of standby onsite power to load group A	disable trouble alarm	Load group B picks up the load	No effect
	Fail once started	Mechanical or electrical failure	Unavailability of standby onsite power to load group A	Undervoltage alarm Diesel trouble alarm	load group B picks up the load	No effect

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 2 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
8AA Diesel Generator (Cont)	Degraded voltage	Mechanical or electrical failure	Inadequate power to load group A	Undervoltage alarm Diesel trouble alarm	Load group B picks up the load	No effect
	Degraded frequency	Mechanical or electrical failure	Inadequate power to load group A	Diesel trouble alarm	Load group B picks up the load	No effect
8AA Bus A-EE-PB-201	Fails to deliver power	Bus fault	Loss of load group A loads on bus	Undervoltage alarm	Load group B continues to function	No effect. Redundant load available.
8AB Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to transformer A-EE-PG-X01	Load center trouble alarm	Circuit breaker 8BE performs a redundant function	No effect. Redundant load available.
	Fails to interrupt on a fault	Operating mechanism failure OR Relay malfunction	Loss of bus A-EE-PB-201	Undervoltage alarm	Backup breaker 7AA operates to interrupt fault. Bus 8BA performs redundant functions	No effect. Redundant load available.
8AD Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to transformer A-EE-PGX03	Load center trouble alarm	Circuit breaker 8BD performs a redundant function	No effect. Redundant load available
	Fails to interrupt on a fault	Operating mechanism failure OR Relay malfunction	Loss of bus A-EE-PB-201	Undervoltage alarm	Backup breaker 7AA operates to interrupt fault. Bus 8BA performs redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 3 of 22)

Item No and Name	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
8AC Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure of wrong trip setting	Loss of power to transformer A-EE-PG-202	Load center trouble alarm	Circuit breaker 8AC performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	0 Operating mechanism failure 0 Relay malfunction	Loss of Bus A-EE-PB-203	Undervoltage alarm	Backup breaker 7AA operates to interrupt fault. Bus 8BA performs redundant function.	No effect. Redundant load available
8AA Transformer	No output	0 Open circuit 0 Short circuit	Loss of bus A-EE-PG-201	Load center trouble alarm	Transformer 8BA performs a redundant function	No effect. Redundant load available
8AB Transformer	No output	0 Open circuit 0 Short circuit	Loss of power to bus 8E-PG-202	Load center trouble alarm	Transformer 8BB performs a redundant function	No effect. Redundant load available
8AC Transformer	No output	0 Open circuit 0 Short circuit	Loss of power to bus A-EE-PG-203	Load center trouble alarm	Transformer 8BC performs a redundant function	No effect. Redundant load available
8AD Air Circuit Breaker (NC)	Inadvert opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-EE-PG-201	Load center trouble alarm	Circuit breaker 8ED performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-EE-PG-201	Load center trouble alarm	Backup breaker 8AB operates to interrupt fault. Bus 8EG performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 4 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
9AE Air Circuit Breaker(NC)	Inadvertent opening	opening mechanism failure or wrong trip setting	Loss of power to bus A-SE-PG-SO2	Load center trouble alarm	Circuit breaker 9AE performs a redundant function	No effect. Redundant load available
	Fails to interrupt on a fault	Operating mechanism failure	Loss of bus A-SE-PG-SO2	Load center trouble alarm	Backup breaker 9AC operates to interrupt a fault. Bus 9EH performs a redundant function	No effect. Redundant load available
9AG Bus A-SE-PG-SO1	Fails to deliver power	Bus fault	Loss of power to breakers 9AC, 9AK, 9AM and 9AJ	Load center and MCC trouble alarm	Bus B-SE-PG-SO1 performs a redundant function	No effect. Redundant load available
9AI Bus A-SE-PG-SO3	Fails to deliver power	Bus fault	Loss of power to breakers 9AS and 9AT	Load center and MCC trouble alarm	Bus B-SE-PG-SO3 performs a redundant function	No effect. Redundant load available
9AF Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-SE-PG-SO3	Load center trouble alarm	Circuit breaker 9AF performs a redundant function	No effect. Redundant load available
	Fails to interrupt on a fault	Operating mechanism failure	Loss of bus A-SE-PG-SO3	Load center trouble alarm	Backup breaker 9AD operates to interrupt fault. Bus 9EI performs a redundant function	No effect. Redundant load available
9AH Bus A-SE-PG-SO2	Fails to deliver power	Bus fault	Loss of power to breakers 9AN, 9AL, 9AP 9AQ, and 9AR	Load center and MCC trouble alarm	Bus B-SE-PG-SO2 performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 5 of 22)

Item No and Name	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
9AL Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to A-SE-PH-E08	MCC trouble alarm	Circuit breaker 9EL performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-SE-PG-E02	Load center and MCC trouble alarm	Backup breaker 9AE operates to interrupt fault. Bus 9EH performs a redundant function	No effect. Redundant load available
9AJ Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to Bus A-SE-PH-E01	MCC trouble alarm	Circuit breaker 9BJ performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of power to Bus A-SE-PG-E01	Load center and MCC trouble alarm	Backup breaker 9AD operates to interrupt fault. Bus 9EG performs a redundant function	No effect. Redundant load available
9AP Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-SE-PH-E04	MCC trouble alarm	Circuit breaker 9EP performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of power to bus A-SE-PH-E04 Loss of power to bus A-SE-PH-E02	Load center and MCC trouble alarm	Backup breaker 9AE operates to interrupt fault. Bus 9EH performs a redundant function	No effect. Redundant available load

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 6 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
9AR Air Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-3E-PH-E03	MCC trouble alarm	Circuit breaker 9ER performs a redundant function	No effect. Redundant load available
	Fails to interrupt on a fault	Operating mechanism failure	Loss of power to bus A-3E-PH-E03 and loss of bus A-3E-PG-303	Load center and MCC trouble alarm	Bus E-3E-PH-E03 performs a redundant function	No effect. Redundant load available
10AC Bus A-3E-PH-E03	Fails to deliver power	Bus fault	Loss of power to circuit breakers 10AN and 10AQ and connected bus loads	MCC trouble alarm	Backup breaker 9AE operates to interrupt fault. Bus 9EH performs a redundant function.	No effect. Redundant available load
10AA Bus A-3E-PH-E01	Fails to deliver power	Bus fault	Loss of power to circuit breakers 10AJ and 10AK and connected bus loads	MCC trouble alarm	Bus E-3E-PH-E03 performs a redundant function	No effect. Redundant load available
10AD Bus A-3E-PH-E04	Fails to deliver power	Bus fault	Loss of power to circuit breakers 10AP and 10AQ, and connected bus loads	MCC trouble alarm	Bus E-3E-PH-E01 performs a redundant function	No effect. Redundant Load available
10AF Bus A-3E-PH-E03	Fails to deliver power	Bus fault	Loss of power to circuit breaker 10AR and connected bus loads	MCC trouble alarm	Bus E-3E-PH-E04 performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 7 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
8AF Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to motors (typ)	Plant process or breaker trouble alarms	Circuit Breaker 8BF performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-SE-PB-SOI	Undervoltage alarm	Backup breaker 7AA operates to interrupt fault. Bus 8BA performs a redundant function	No effect. Redundant load available
8AE(a) Circuit Breaker (No)	Fail to open on d fault given a demand on charging PP XFR SW	Mechanical or electrical failure	Loss of bus A-SE-PE-SOI	Undervoltage alarm	Backup breaker 7AA operates to interrupt fault. Bus 8BA performs a redundant function	No effect. Redundant load available
8AK Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-SE-PH-EQ2	MCC trouble alarm	Circuit breaker 8EK performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of buses A-SE-PGEO1 and A-SE-PH-EQ2	MCC trouble alarm	Backup breaker 8AD operates to interrupt fault. Bus 8BG performs a redundant function	No effect. Redundant load available
8AM Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-SE-PH-EQ6	MCC trouble alarm	Circuit breaker 8BM performs a redundant function	No effect. Redundant load available

Table 3.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 3 of 22)

Item No and Name	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
9AM Circuit Breaker (NC) (Con't)	Fail to interrupt on a fault	Operating mechanism failure	Loss of buses A-3E-PG-201 and A-3E-PH-206	Load center and MCC trouble alarm	Backup breaker 9AD operates to interrupt fault. Bus 9EG performs a redundant function	No effect. Redundant load available
9AN Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-3E-PH-203	MCC trouble alarm	Circuit breaker 9BN performs a redundant function	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-3E-PG-202	Load center trouble alarm	Backup breaker 9AE operates to interrupt fault. Bus 9BN performs a redundant function	No effect. Redundant load available
9AO Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-3E-PH-207	MCC trouble alarm	Circuit breaker 9BO performs a redundant function	No effect. MCC is not safety related
	Fail to interrupt on fault	Operating mechanism failure	Loss of bus A-3E-PG-202	Load center or MCC trouble alarm	Backup breaker 9AE operates to interrupt fault. Bus 9BN performs a redundant function	No effect. Redundant load available
9AQ Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to bus A-3E-PH-208	MCC trouble alarm	Circuit breaker 9BQ performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 9 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
(Can't) 9AQ Circuit Breaker (NC)	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-3E-PG-202	Load center or MCC trouble alarm	Backup breaker 9AE operates to interrupt fault. Bus 9EH performs a redundant function	No effect. Redundant load available
9AE Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to P002 pressurizer HTR PNL	Periodic testing and inspection	Circuit breaker 9ES performs a similar function	No effect. Pressurizer heaters are not safety related
	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-3E-PG-203	Load center trouble alarm	Backup breaker 9AF operates to interrupt fault. Bus 9EI performs a redundant function	No effect. Redundant load available
9AT Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to P003 pressurizer HTR PNL	Periodic testing and inspection	Circuit breaker 9ET performs a redundant function	No effect. Pressurizer heaters are not safety related
	Inadvertent opening	Operating mechanism failure	Loss of bus A-3E-PG-203	Load center trouble alarm	Backup breaker 9AF operates to interrupt fault. Bus 9EI performs a redundant function	No effect. Redundant load available.
10AB Bus A-3E-PH-202	Fail to deliver power	Bus fault	Loss of power to connected bus loads	MCC trouble alarm	Bus B-3E-PH-202 performs a redundant function	No effect. Redundant load available.

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 10 of 22)

Item No and Name	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
10AE Bus A-SE-PH-E07	Fails to deliver power	Bus fault	Loss of power to connected busloads	MCC trouble alarm	Bus E-SE-PH-E07 performs a redundant function	No effect. Redundant available load
10AG Bus A-SE-PH-E09	Fails to deliver power	Bus fault	Loss of power to connected busloads	MCC trouble alarm	Bus E-SE-PH-E09 performs a redundant function.	No effect. Redundant load available.
10AH Bus A-SE-PH-E08	Fails to deliver power	Bus fault	Loss of power to connected busloads	MCC trouble alarm	Bus E-SE-PH-E08 performs a redundant function.	No effect. Redundant load available.
10AI Bus A-SE-PH-E08	Fails to deliver power	Bus fault	Loss of power to breakers 10AL and 10AM and connected loads	MCC trouble alarm	Bus E-SE-PH-E08 performs a redundant function	No effect. Redundant load available.
10AN Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting.	Loss of ac power to inverter A-SE-PQ-W002	Inverter alarm trouble	Backup dc input to inverter available from bus 11AA. Breaker 10BN performs a redundant function.	No effect. Redundant load available.
	Fails to interrupt on a fault	Operating mechanism failure	Loss of ac bus A-SE-PH-E03	MCC trouble alarm	Backup breaker 8AN operates to clear fault, Bus 10BC performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}

Item No and Name	Failures/Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
10AP Circuit Breaker (NC)	Inadvertent Opening	Operating mechanism failure or wrong trip setting.	Loss of ac power to inverter A-3E-PQ-W001	Inverter trouble alarm	Backup dc input to inverter from bus 11AA Breaker 10BP performs a redundant function.	No effect. Redundant load available.
	Fail to interrupt on a fault.	Operating mechanism failure.	Loss of ac bus A-3E-PH-E04	MCC trouble alarm	Backup breaker 9AP operates to clear fault. Bus 10ED performs a redundant function.	No effect. Redundant load available.
10AJ Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to transformer A-3E-PQ-X01	Periodic testing and inspection	Circuit breaker 10BJ performs a redundant function.	No effect. Redundant load available.
	Fail to interrupt on a fault	Operating mechanism failure	No effect. Loss of power to bus A-3E-PH-E01	MCC trouble alarm	Backup breaker 9AJ operates to interrupt fault. Bus 10EA performs a redundant function.	No effect. Redundant load available.
10AK Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to transformer A-3E-PQ-X023	Periodic testing and inspection ^(d)	Circuit breaker 10BK performs a redundant function.	No effect. Redundant load available.
	Fail to interrupt on a fault	Operating mechanism failure	Loss of power to transformer A-3E-PQ-X023 Loss of bus A-3E-PH-E01	NOC trouble alarm.	Backup breaker 9AJ operates to interrupt fault. Bus 10EA performs a redundant function.	No effect. Redundant load available.

Table 3.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 12 of 22)

Item No and Name	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
10AL Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of ac power to charger A-SE-PK-N001	Charger trouble alarm	Redundant dc input to bus 11AA available from battery 11AD	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of power to charger A-SE-PK-N001 and loss of bus A-SE-PH-E08	Charger/MCC trouble alarm	Backup breaker 9AL operates to interrupt fault. Bus 10BI performs a redundant function.	No effect. Redundant load available
10AQ Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to charger C-SE-PK-N001	Charger trouble alarm	Redundant dc input to bus 11CA available from battery 11CD	No effect. Redundant available function. load
	Fail to interrupt on a fault	Operating mechanism failure	Loss of power to charger C-SE-PK-N001 Loss of bus A-SE-PH-E04	Charger/MCC trouble alarm	Backup breaker 9AP operates to interrupt fault. Bus 10BD performs a redundant function.	No effect. Redundant load available
10AR Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of ac input to inverter C-SE-PQ-N001	Inverter trouble alarm	Backup dc input to inverter available from bus 11CA	No effect. Redundant load available
	Fail to interrupt on a fault	Operating mechanism failure	Loss of bus A-SE-PH-E08	Inverter/MCC trouble alarm	Backup breaker 9AR operates to interrupt fault. Bus 10BF performs a redundant function.	No effect. Redundant available load

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 13 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
10A Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to transformer C- SE-PQ-X01	Periodic testing and inspection ^(a)	Circuit breaker 10B0 performs a redundant function	No effect. Redundant available
	Fails to interrupt on a fault	Operating mechanism failure	Loss of power to transformer C- SE-PQ-X01 Loss of bus A- SE-PH-E05	MCC trouble alarm	Backup breaker 9AN operates to clear fault. Bus 10B0 performs a redundant function.	No effect. Redundant load available
10AM Circuit Breaker (NC)	Inadvertent opening	Operating mechanism failure or wrong trip setting	Loss of power to transformer A- SE-PQ-X05	Periodic testing and inspection ^(a)	Circuit breaker 10BM performs a redundant function.	No effect. Redundant load available
	Fails to interrupt on a fault	Operating mechanism failure	Loss of power to transformer A- SE-PQ-X05. Loss of bus A- SE-PH-E08	MCC trouble alarm	Backup breaker 9AL operates to clear fault. Bus 10B1 performs a redundant function	No effect. Redundant load available.
11AB Charger A-SE-PK-N001	No electrical output	Component failure	Loss of charging power to battery A- SE-PK-B001 and bus A- SE-PK-F001	Charger	Battery A-SE-PK-B001 provides backup dc power. Charger B-SE-PK-N001 performs a redundant function.	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 14 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
(Cont) 11AB Charger A-SE-PK-N001	Low electrical output	Component failure	Loss of charging power to battery A-SE-PK-B001 and bus A-SE-PK-F001	Charger trouble alarm Charger alarm	Battery -SE-PK-B001 provides backup dc power. Charger B-SE-PK-N001 performs a redundant function.	No effect. Redundant load available.
	Fault	Component failure	Loss of charging power to battery A-SE-PK-B001 and bus A-SE-PK-F001	Charger trouble alarm	Battery -SE-PK-B001 provides backup dc power. Charger B-SE-PK-N001 performs redundant function	No effect. Redundant load available
	Erratic electrical output	Component failure	Loss of charging power to battery A-SE-PK-B001 and bus A-SE-PK-F001	Charger trouble alarm	Battery -SE-PK-B001 provides backup dc power. Charger B-SE-PK-N001 performs redundant function	No effect. Redundant load available
11AA dc Bus A-SE-PK-F001	Fails to deliver power	Bus fault	Loss of power to inverters A-SE-PQ-N001 N002, and panels A-SE-PK-F002, F003.	DC bus failure alarm	DC bus 11BA performs a redundant function	No effect Redundant available
11CB Charger C-SE-PK-N001	No electrical output	Component failure	Loss of charging power to battery C-SE-PK-B001 and bus C-SE-PK-F001	Charger trouble alarm	Battery -SE-PK-B001 provides backup dc power. Charger D-SE-PK-N001 performs redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 16 of 28)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
11CB Charger C-SE-PK-N001 (Can't)	Low electrical output	Component failure	Loss of charging power to battery C-SE-PK-B001 and bus C-SE-PK-P01	Charger alarm trouble	Battery C-SE-PK-B001 provides backup dc power. Charger D-SE-PK-N001 performs redundant function	No effect. Redundant load available
	High electrical output	Component failure	Loss of charging power to battery C-SE-PK-B001 and bus C-SE-PK-P01	Charger alarm trouble	Battery C-SE-PK-B001 provides backup dc power. Charger P-SE-PK-N001 performs redundant function	No effect. Redundant load available.
	Erratic electrical output	Component failure	Loss of charging power to battery C-SE-PK-B001 and bus C-SE-PK-P01	Charger trouble alarm	Battery C-SE-PK-B001 provides backup dc power. Charger D-SE-PK-N001 performs redundant function	No effect. Redundant load available
11AC Battery A-SE-PK-B001	No electrical output	Component failure	Loss of dc back-up power to bus A-SE-PK-P001	DC system trouble alarm	Battery B-SE-PK-B001 performs a redundant function	No effect. Redundant load available
	Low electrical output	Component failure	Loss of dc back-up power Bus A-SE-PK-P001	DC system trouble alarm	Battery B-SE-PK-B001 performs a redundant function	No effect. Redundant load available
	High electrical output	Component failure	Loss of dc back-up power to bus A-SE-PK-P001	DC system trouble alarm	Battery B-SE-PK-B001 performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 16 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
11AC Battery A-SE-PK-B001 (Cont)	Erratic electrical output	Component failure	Loss of dc back-up power to bus A-SE-PK-F001	DC system trouble alarm	Battery B-SE-PK-B001 forms a redundant function	No effect. Redundant load available
11CD Battery C-SE-PK-B001	No electrical output	Component failure	Loss of dc back-up power to bus A-SE-PK-F001	DC system trouble alarm	Battery D-SE-PK-B001 performs a redundant function	No effect. Redundant load available
	Low electrical output	Component failure	Loss of dc back-up power to bus C-SE-PK-F001	DC system trouble alarm	Battery D-SE-PK-B001 performs a redundant function	No effect. Redundant load available
	High electrical output	Component failure	Loss of dc back-up power to bus C-SE-PK-F001	DC system trouble alarm	Battery D-SE-PK-B001 performs a redundant function	No effect. Redundant load available
	Erratic electrical output	Component failure	Loss of dc back-up power to bus C-SE-PK-F001	DC system trouble alarm	Battery D-SE-PK-B001 performs a redundant function	No effect. Redundant load available
11AE Fused Switch (NC)	Switch left open	Operator error	Loss of charging power to battery A-SE-PK-B001	DC system trouble alarm	Fused switch 11BE performs a redundant function	No effect. Redundant load available
11CC Fused Switch (NC)	Switch left open	Operator error	Loss of charging power to battery C-SE-PK-B001	DC system trouble alarm	Fused Switch 11DC performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 17 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
11AD Fused Switch (NC)	Switch left open	Operator error	Loss of battery power to bus A-SE-PK-F001	DC system trouble alarm	Fused switch 11BD performs a redundant function	No effect. Redundant load available
11CE Fused Switch (NC)	Switch left open	Operator error	Loss of battery power to bus C-SE-PK-F001	DC system trouble alarm	Fused switch 11DE performs a redundant function	No effect.. Redundant load available
11CA Bus C-SE-PK-F001	Fails to deliver power	Bus fault	Loss of power to inverter C-SE-PQ-N001	DC system trouble alarm redundant	Bus D-SE-PK-F001 performs a redundant function	No effect. Redundant load
12AB Fused Switch (NC)	Switch left open	Operator error	Loss of dc power to inverter A-SE-PQ-N00	DC system trouble alarm	Backup ac power to inverter available from breaker 10AP. Fuse switch 12BB performs a redundant function	No effect. Redundant load available
13AD Transformer A-SE-PQ-X01	No output	Open circuit/ Short circuit	Loss of back-up power to 120 V-ac vital bus A-SE-PQ-F001	Periodic testing and inspection ^(a)	Transformer 13BD performs a redundant function	No effect. Redundant load available
12AA fused Switch	Switch left open	Operator error	Loss of dc power to A-SE-PK-F002	Loss of power alarms for individual loads powered by A-SE-PK-F002	Fused switch 12BA performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 18 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
12AD Fused switch	Switch left open	Operator error	Loss of dc power to A-SE-PK-P003	Loss of power alarms for individual loads powered by A-SE-PK-P003	Fused switch 12BD performs a redundant function	No effect. Redundant load available
12CA Fused Switch (NC)	Switch left open	Operator error	Loss of dc power to inverter C-SE-PQ-N001	Inverter alarm trouble	Backup ac power available to inverter from breaker 0AR. Fused switch 12DA performs a redundant function.	No effect. Redundant available load
12AC Fused switch (NC)	Switch left open	Operator error	Loss of dc power to inverter A-SE-PQ-N002	Inverter alarm trouble	Backup ac power available to inverter from breaker 10AN. Fused switch 12FE performs a redundant function.	No effect. Redundant load available.
13CB Trans-former C-SE-PQ-X01	No output	Open circuit Short circuit	Loss of back-up power to 120 V-ac vital bus C-SE-PQ-P001	Periodic testing and inspection ^(a)	Transformer 13DB performs a redundant function	No effect. Redundant load available
13AE Transformer A-SE-PQ-X025	No output	Open circuit Short circuit	Loss of backup power to 120 V-ac vital buses A-SE-PQ-P002, -P00T4	Periodic testing and inspection	Transformer 13BE performs a redundant function	No effect. Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 19 of 22)

Item No and Name	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on system
15AF Transformer A-SE-PQ-X03	No output	Open circuit Short circuit	Loss of normal power to 120 Vac vital bus A-SE-PQ-P003.	Periodic test & inspection	Transformer 15BP performs a redundant function	No effect. Redundant load available
15AA Inverter A-SE-PQ-H001	No output	Component failure	Loss of normal power Supply to 120 Vac vital bus A-SE-PQ-P001	Inverter trouble alarm	Backup power provided by XFMR A-SE-PQ-X01. Inverter B-SE-PQ-N001 performs a redundant function	No effect. Redundant load available
	Fault	Component failure	Loss of normal power Supply to 120 Vac vital bus A-SE-PQ-P001	Inverter trouble alarm	Backup power provided by XFMR A-SE-PQ-X01. Inverter B-SE-PQ-N001 performs a redundant function	No effect. Redundant load available
15AB Inverter A-SE-PQ-N002	No output	Component failure	Loss of normal power Supply to 120 Vac vital bus A-SE-PQ-P002	Inverter trouble alarm	Backup power provided by XFMR A-SE-PQ-X023. Inverter B-SE-N002 performs a redundant function	No effect. Redundant load available
	Fault	Component failure	Loss of normal power Supply to 120 Vac vital bus A-SE-PQ-P002	Inverter trouble alarm	Backup power provided by XFMR A-SE-PQ-X023. Inverter B-SE-PQ-N002 performs a redundant function	No effect Redundant load available

Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 20 of 22)

Item No and Name (C)	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
13CA Inverter W001 C-SE-PQ- W001	No output	Component Failure	Loss of normal power supply to 120 V-ac Vital bus C-SE-PQ-F001	Inverter trouble alarm	Backup power provided by XFMR C-SE-PQ-X01 Inverter D-SE-PQ-X01 performs a redundant function	No effect. Redundant load available
	Fault	Component Failure	Loss of normal power supply to 120 V-ac Vital bus C-SE-PQ-F001	Inverter trouble I alarm	Backup power provided by XFMR C-SE-PQ-X01 Inverter D-SE-PQ-X01 performs a redundant function	No effect. Redundant load available
14AE Maintenance Switch	Fails to transfer	Mechanical Failure	LOSS of 120 V-AC vital bus A-SE-PQ-F002	Periodic Testing and Inspection(+)	E-SE-PQ-Z002 performs a redundant function	No effect. Redundant load available
	Fails to conduct	Mechanical Failure	LOSS of 120 V-AC vital bus A-SE-PQ-F002	Periodic Testing and Inspection(+)	E-SE-PQ-2002 performs a redundant function	No effect. Redundant load available
14AA Automatic Static Transfer Switch	Fails to transfer	Electrical Failure	Loss of 120 V-AC vital bus A-SE-PQ-F002	Loss of power alarms for individual loads powered by A-SE-PQ-F002	Automatic static transfer switch(14BE) performs a redundant function	No effect. Redundant load available
	Fails to conduct	Electrical Failure	Loss of 120 V-AC vital bus A-SE-PQ-F002	Loss of power alarms for individual loads powered by A-SE-PQ-F002	Automatic static transfer switch(14BE) performs a redundant function	No effect. Redundant load available

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Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 21 of 22)

Item No and Name (c)	Failures Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
14AA Automatic Static Transfer Switch	Fails to conduct	Electrical Failure	Loss of 120V- AC vital bus A-SE-PQ-F001	Loss of power alarms for individual loads powered by A-SE-PQ-F001	Automatic static transfer switch(14BA) performs a redundant function	No effect. Redundant load available
	Fails to conduct	Electrical Failure	Loss of 120V-AC vital bus A-SE-PQ-F001	Loss of power alarms for individual loads powered by C-SE-PQ-F001	Automatic static transfer switch(14BA) performs a redundant function	No effect. Redundant load available
14CA Automatic Static Transfer Switch	Fails to transfer	Electrical Failure	Loss of 120V- AC vital bus C-SE-PQ-F001	Loss of power alarms for individual loads powered by C-SE-PQ-F001	Automatic static transfer switch(14DA) performs a redundant function	No effect. Redundant load available
	Fails to conduct	Electrical Failure	Loss of 120V-AC vital bus C-SE-PQ-F001	Loss of power alarms for individual loads powered by C-SE-PQ-F001	Automatic static transfer switch(14DA) performs a redundant function	No effect. Redundant load available
14AC Automatic Switch A-SE-PQ-Z003	Fails to transfer	Electrical Failure	Loss of 120V-AC vital bus A-SE-PQ-F003	Loss of power alarms for individual loads powered by A-SE-PQ-F003	Automatic transfer switch B-SE-PQ-Z003 performs redundant function	No effect. Redundant load available
	Fails to conduct	Electrical Failure	Loss of 120V-AC vital bus A-SE-PQ-F003	Loss of power alarms for individual loads powered by A-SE-PQ-F003	Automatic transfer switch B-SE-PQ-Z003 performs redundant function	No effect. Redundant load available

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Table 8.3-4
FAILURE MODES AND EFFECTS ANALYSIS^{(a)(b)}
(Sheet 22 of 22)

Item No and Name (c)	Failure Mode	Cause	Symptoms and Local Effects (Including Dependent Failure)	Method of Detection	Hazards Produced and/or Compensating Provisions	Effect on System
14AD Maintenance Switch	Fails to transfer	Mechanical Failure	Loss of 120 V-AC vital bus A-SE-PQ-NO1	Periodic Testing and Inspection(+)	B-SE-PQ-Fool performs a redundant function	No effect. Redundant load available
	Fails to conduct	Mechanical failure	Loss of 120 V-AC vital bus A-SE-PQ-FOO1	Periodic Testing and Inspection(+)	B - SE - PQ - Fool performs a redundant function	No effect. Redundant load available
14CB Maintenance Switch	Fails to transfer	Mechanical Failure	Loss of 120 V-AC vital bus C-SE-PQ-Fool	Periodic Testing and Inspection(+)	D-SE-PQ-FOO1 performs a redundant function	No effect. Redundant load available
	Fails to conduct	Mechanical Failure	Loss of 120 V-AC vital bus C-SE-PQ-FOO1	Periodic Testing and Inspection(+)	D - SE - PQ - Fool performs a redundant function	No effect. Redundant load available

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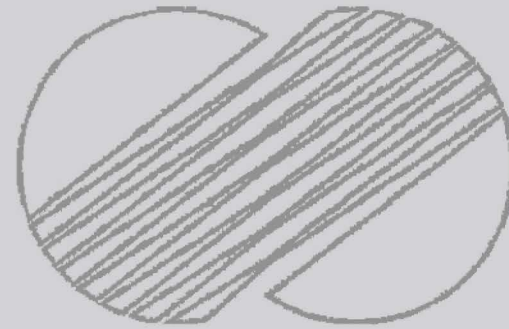
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- a. This table presents the failure modes and effects analysis (FMEA) of the engineered safety features (ESF) Class 1E electrical ac power system. The purpose of the analysis is to demonstrate that a failure of a single component in the Class 1E power system does not prevent satisfactory performance of the minimum Class 1E loads required for safe shutdown as defined in IEEE Standard 308 - 1974.
- b. The Failure Mode and Effects Analysis is performed for one channel or one train only.
- * This source is provided as a standby source for inverter maintenance: Power to vital bus is normally available from the inverter source.
- c. Components that are included in the analysis have been assigned alphanumeric item numbers. Refer to figure 8.3-3 for the location of these components in the power system.
- d. This source is provided as a standby source for inverter maintenance: power to vital bus is normally available from the inverter source.
- e. This breaker is closed only during period of maintenance for other load group A charging pump, i.e., load group A breaker CAF open. If breaker BAE is in service and fails to open on a fault condition, redundant function is performed by breaker BEF for charging pump on load group B.

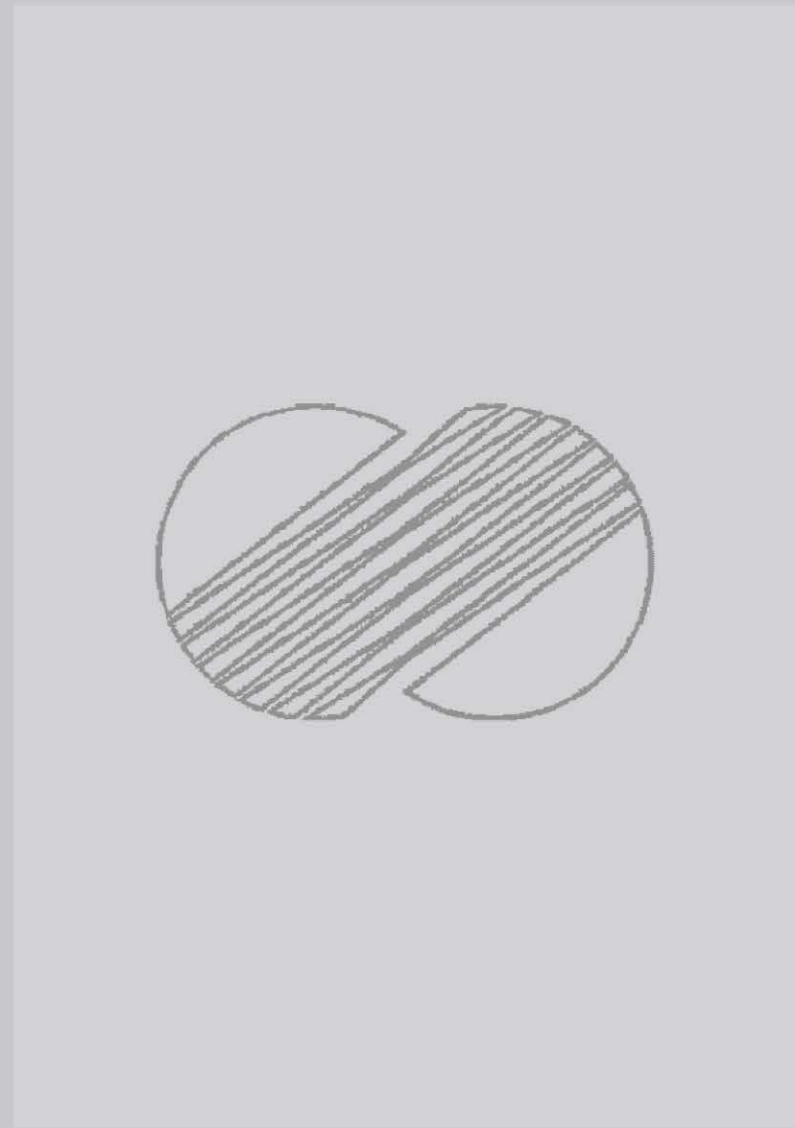
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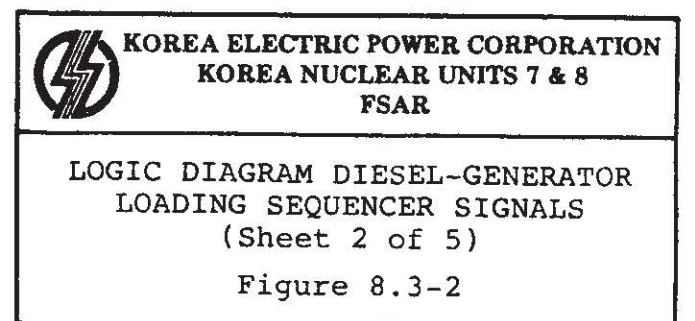
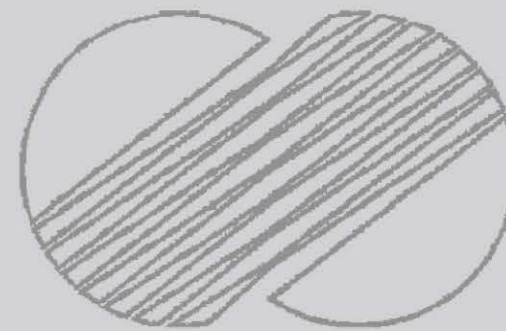
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개정안



Amendment 406
2009. 1.12

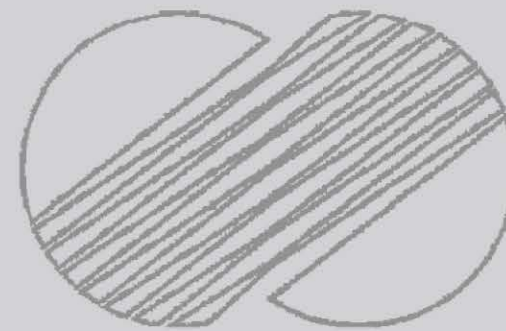


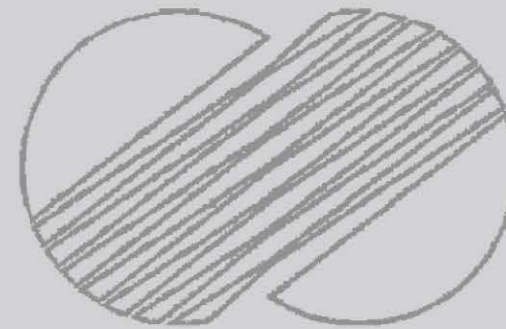
Amendment 160
2001.12.28

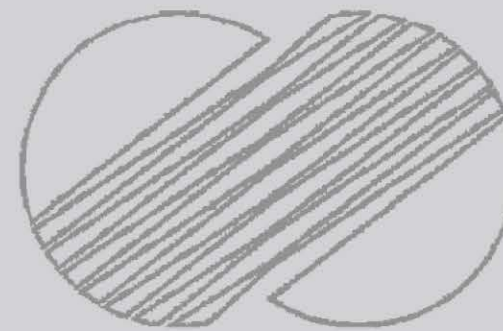


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AMENDMENT 7







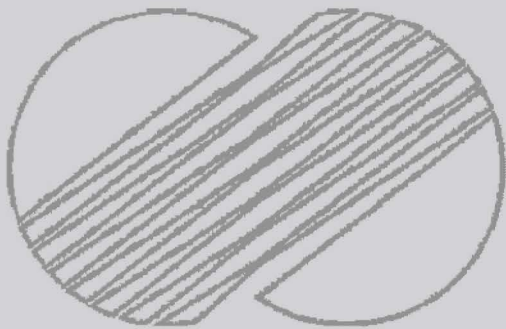
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LOGIC DIAGRAM DIESEL-GENERATOR
LOADING SEQUENCER SIGNALS
(Sheet 5 of 5)


Figure 8.3-2

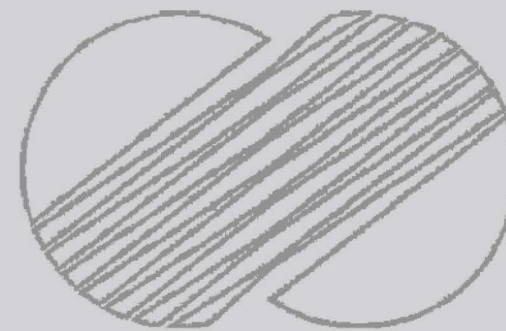
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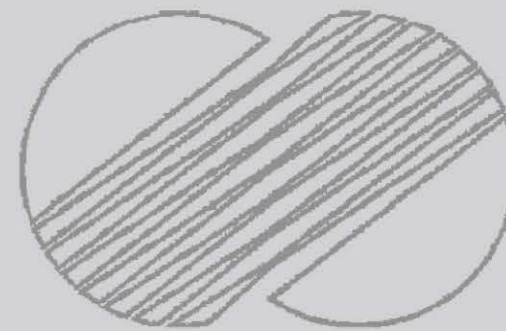
Amendment 7




Amendment 417
2009. 3.10

	KOREA ELECTRIC POWER CORPORATION
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	SINGLE LINE DIAGRAM DC POWER AND CONTROL CLASS-1E 480/208/120V AC INSTRUMENTATION (Sheet 1 of 2)
Figure 8.3-3	

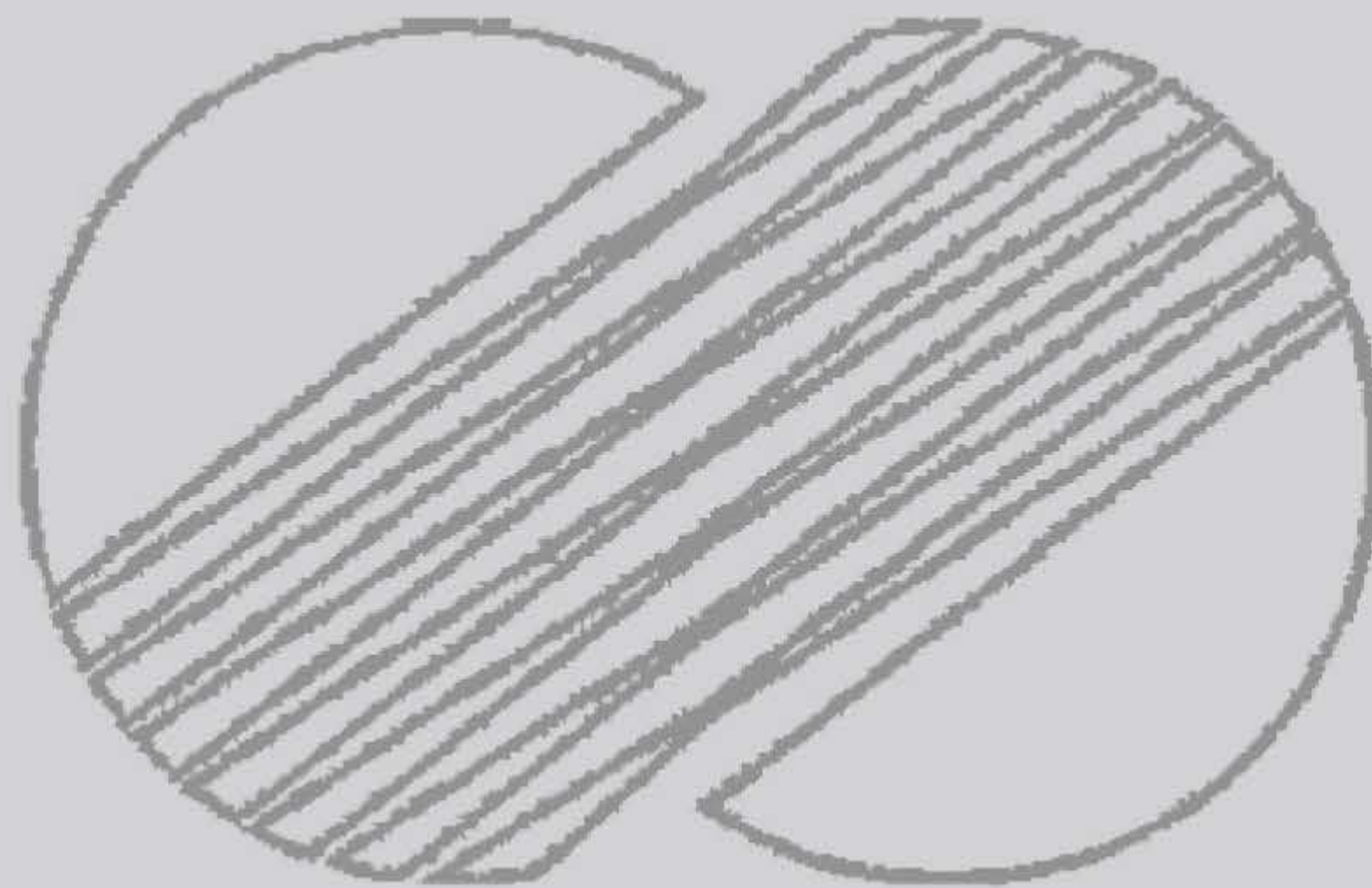




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**SCHEMATIC DIAGRAM CLASS 1E DIESEL
GEN. B-5E-PE-Z02 DC PROTECTION
SYSTEM**

Figure 8.3-4



Amendment 517
2011. 10. 14

8/10/84



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RELIABILITY ANALYSIS
DIAGRAM AUXILIARY POWER
FOR CLASS 1E SYSTEM

Figure 8.3-5