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ABWR Design Control Document

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8.0 Electric Power

8.1 Introduction

8.1.1 Offsite Transmission Network

The description of the offsite transmission network is out of the ABWR Standard Plant scope, however there are interface requirements contained in Section 8.2.3 which must be complied with by the COL applicant.

8.1.2 Electric Power Distribution System

8.1.2.0 Definitions

The definitions used throughout Chapter 8 are consistent with Section 3 of IEEE-308 with the following important clarifications for the ABWR:

Division—The designation applied to a given safety-related system or set of components that enables the establishment and maintenance of physical, electrical, and functional independence from other redundant sets of components. (The term “safety-related” is added to the IEEE-308 definition.)

Load group—An arrangement of buses, transformers, switching equipment, and loads fed from a common power supply. (The last three words “...within a division” are deleted with respect to the IEEE-308 definition.) A load group may be safety-related or non-safety-related depending on its common power supply.

Safety-related—Any Class 1E power or protection system device included in the scope of IEEE-279 or IEEE-308. (This term is explicitly defined in IEEE-100, though not in IEEE-308.) Note that “safety-related” includes both electrical and non-electrical equipment, whereas “Class 1E” pertains only to electrical equipment (i.e., any equipment which has an electrical interface).

8.1.2.1 Description of Offsite Electrical Power System

The scope of the offsite electrical power system includes the entire offsite transmission network and the transmission lines coming into the switchyards to the termination of the bus duct and power cables at the input terminals of the circuit breakers for the 6.9 kV switchgear. The COL applicant has design responsibility for portions of the offsite power system. The scope split is as defined in the detailed description of the offsite power system in Subsection 8.2.1.1.

The 1500 MVA main power transformer is a bank of three single phase transformers. One single phase installed spare transformer is provided.

A main generator circuit breaker capable of interrupting the maximum available fault current is provided. This allows the generator to be taken off line and the offsite transmission network to be utilized as a power source for the unit auxiliary transformers and their loads, both Class 1E and non-Class 1E. This is also the startup power source for the unit.

There are three unit auxiliary transformers, connected to supply power to three approximately equal load groups of equipment. The “Normal Preferred” power feed is from the unit auxiliary transformers so that there normally are no bus transfers required when the unit is tripped off the line.

One, three-winding 37.5 MV·A unit reserve auxiliary transformer (RAT) provides power via one secondary winding for the Class 1E buses as an alternate to the “Normal Preferred” power. The other secondary winding supplies reserve power to the non-Class 1E buses. This is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed from the offsite transmission network over the main power circuit to the unit auxiliary transformers. The two low voltage windings of the reserve transformer are rated 18.75 MV·A each.

A 9mW combustion turbine generator is provided as an alternate AC power source. The unit is capable of providing power to non-Class 1E plant investment protection buses and Class 1E buses. The combustion turbine generator is non-safety-related.

8.1.2.2 Description of Onsite AC Power Distribution System

Three non-Class 1E buses and one Class 1E division receive power from the single unit auxiliary transformer assigned to each load group. Load groups A, B and C line up with Divisions I, II and III, respectively. One winding of the reserve auxiliary transformer may be utilized to supply reserve power to the non-Class 1E buses either directly or indirectly through bus tie breakers. The three Class 1E buses may be supplied power from the other winding of the reserve auxiliary transformer.

A combustion turbine generator (CTG) supplies automatic standby power to plant investment protection non-Class 1E loads. These loads are grouped on the three plant investment protection (PIP) buses as shown in Figure 8.3-1. The CTG also has the capability to be manually connected to any of the three Class 1E buses, for mitigation of the station blackout (SBO) event (see Subsection (9) of 8.3.1.1.7).

In general, motors larger than 300 kW are supplied from the 6.9 kV metal-clad (M/C) bus. Motors 300 kW or smaller but larger than 100 kW are supplied power from 480V power center (P/C) switchgear. Motors 100 kW or smaller are supplied power from 480V motor control centers (MCC). The 6.9 kV and 480V single line diagrams are shown in Figure 8.3-1.

During normal plant operation all of the non-Class 1E buses and two of the Class 1E buses are supplied with power from the main turbine generator through the unit auxiliary transformers. The remaining Class 1E bus is supplied from the reserve auxiliary transformer. This division is immediately available, without a bus transfer, if the normal preferred power is lost to the other two divisions.

Three safety related, Class 1E diesel generator standby AC power supplies provide a separate onsite source of power for each Class 1E division when normal or alternate preferred power supplies are not available. The transfer from the normal preferred or alternate preferred power supplies to the diesel generator is automatic. The transfer back to the normal preferred or the alternate preferred power source is a manual transfer.

The Division I, II, and III standby AC power supplies consist of an independent 6.9 kV Class 1E diesel generator (D/G), one for each division. Each D/G may be connected to its respective 6.9 kV Class 1E switchgear bus through a circuit breaker located in the switchgear.

The standby AC power system is capable of providing the required power to safely shut down the reactor after loss of preferred power (LOPP) and/or loss of coolant accident (LOCA) and to maintain the safe shutdown condition and operate the Class 1E auxiliaries necessary for plant safety after shutdown.

The plant 480 VAC power system distributes sufficient power for normal auxiliary and Class 1E 480 volt plant loads. All Class 1E elements of the 480V power distribution system are supplied via the 6.9 kV Class 1E switchgear and, therefore, are capable of being fed by the normal preferred, alternate preferred, standby diesel generator, or combustion turbine generator power supplies.

The 120 VAC non-Class 1E instrumentation power system, Figure 8.3-2, provides power for non-Class 1E control and instrumentation loads.

The Class 1E 120 VAC instrument power system, Figure 8.3-2, provides for Class 1E plant controls and instrumentation. The system is separated into Divisions I, II and III with distribution panels and local control panels fed from their respective divisional sources.

The 125 VDC power distribution system provides four independent and redundant onsite battery sources of power for operation of Class 1E DC power, control, and instrument loads. The 125 VDC non-Class 1E power control and instrument loads are supplied from three 125 VDC batteries located in the turbine building. A separate non-Class 1E 250V battery is provided to supply uninterruptible power to the plant computers and non-Class 1E DC motors (Figure 8.3-4).

The safety system and logic control (SSLC) for the Reactor Protection System (RPS) and Main Steamline Isolation Valves (MSIV) derives its power from four uninterruptible 120 VAC divisional buses (See Figure 8.3-3). The SSLC for the Emergency Core Cooling System (ECCS) derives its power from the four divisions of 125 VDC buses. The four buses provide the redundancy for various instrumentation, logic and trip circuits and solenoid valves. The SSLC power supply is further described in Subsection 8.1.3.1.1.2.

8.1.2.3 Safety Loads

The safety loads utilize various Class 1E AC and/or DC sources for instrumentation and motive or control power or both for all systems required for safety. Combinations of power sources may be involved in performing a single safety function. For example, low voltage DC power in the control logic may provide an actuation signal to control a 6.9 kV circuit breaker to drive a large AC-powered pump motor. The systems required for safety are listed below:

(1) Safety System Logic and Control Power Supplies including the Reactor Protection System

(2) Core and Containment Cooling Systems

  (a) Residual Heat Removal (RHR) System

  (b) High Pressure Core Flooder (HPCF) System

  (c) Automatic Depressurization System (ADS)

  (d) Reactor Core Isolation Cooling (RCIC) System

(3) ESF Support Systems

  (a) Diesel generator Sets and Class 1E AC/DC power distribution systems

  (b) HVAC Emergency Cooling Water (HECW) System

  (c) Reactor Building Cooling Water (RCW) System

  (d) Not Used

  (e) Standby Gas Treatment System (SGTS)

  (f) Reactor Building Emergency HVAC System

  (g) Control Building HVAC System

  (h) High Pressure Nitrogen Gas Supply (HPIN) System

(4) Safe Shutdown Systems

   (a) Standby Liquid Control System (SLCS)

   (b) Nuclear Boiler System (NBS)

      (i) Safety/Relief Valves (SRVs)

      (ii) Steam Supply Shutoff Portion

   (c) Residual Heat Removal (RHR) System decay heat removal

(5) Class 1E Monitoring Systems

   (a) Neutron Monitoring System (NMS)

   (b) Process Radiation Monitoring System (PRMS)

   (c) Containment Atmosphere Monitoring System (CAMS)

   (d) Suppression Pool Temperature Monitoring System (SPTM)

For detailed listings of Division I, II and III loads, see Tables 8.3-1 and 8.3-2.

8.1.3 Design Bases

8.1.3.1 Safety Design Bases–Onsite Power

8.1.3.1.1 General Functional Requirements

8.1.3.1.1.1 Onsite Power Systems–General

The unit's total Class 1E power load is divided into three divisions. Each division is fed by an independent 6.9 kV Class 1E bus, and each division has access to one onsite and two offsite power sources. An additional power source is provided by the combustion turbine generator (CTG). A description of the CTG is provided in Subsection 9.5.11.

Each of the two normally energized offsite power feeders (i.e., normal preferred and alternate preferred power) are provided for the Divisions I, II and III Class 1E systems. Normally two divisions are fed from the normal preferred power source and the remaining division is fed from the alternate preferred power source. Both feeders are used during normal plant operation to prevent simultaneous de-energization of all divisional buses on the loss of only one of the offsite power supplies. The transfer to the other preferred feeder is manual. During the interim, power is automatically supplied by the diesel generators.

The redundant Class 1E electrical divisions (Divisions I, II, and III) are provided with separate onsite standby AC power supplies, electrical buses, distribution cables, controls, relays and other electrical devices. Redundant parts of the system are physically separated and electrically independent to the extent that in any design basis event with any resulting loss of equipment, the plant can still be shut down with the remaining two divisions. Independent raceway systems are provided to meet cable separation requirements for Divisions I, II, and III.

Divisions I, II, and III standby AC power supplies have sufficient capacity to provide power to all their respective loads. Loss of the preferred power supply, as detected by 6.9 kV Class 1E bus under-voltage relays, will cause the standby power supplies to start and connect automatically, in sufficient time to safely shut down the reactor or limit the consequences of a design basis accident (DBA) to acceptable limits and maintain the reactor in a safe condition. The standby power supplies are capable of being started and stopped manually and are not stopped automatically during emergency operation unless required to preserve integrity. Automatic start will also occur on receipt of a Level 1 1/2 signal (HPCF initiate for Divisions II and III), Level 1 signal (RHR initiate for Division I) and high drywell pressure.

The Class 1E 6.9 kV Divisions I, II, and III switchgear buses, and associated 6.9 kV diesel generators, 480 VAC distribution systems, and Divisions I, II, III and IV, 120 VAC and 125 VDC power and control systems conform to Seismic Category I requirements. This equipment is housed in Seismic Category I structures except for some control sensors associated with the Reactor Protection System [Subsection 9A.5.5.1], and the Leak Detection System [Subsection 9A.5.5.7]. Seismic Qualification is in accordance with IEEE-344 (Section 3.10).

In addition, non-safety-related equipment are designed to resist failure that could prevent any safety-related equipment from performing its nuclear safety-related function [Subsection 3.2.5.1, item (5)].

8.1.3.1.1.2 Safety System Logic and Control Power Supply System Design Bases

In order to provide redundant, reliable power of acceptable quality and availability to support the safety logic and control functions during normal, abnormal and accident conditions, the following design bases apply:

(1) SSLC power has four separate and independent Class 1E inverter uninterruptible constant voltage constant frequency (CVCF) power supplies each backed by separate Class 1E batteries.

(2) Provision is made for automatic switching to the alternate bypass supply from its respective division in case of a failure of the inverter power supply. The inverter power supply is synchronized in both frequency and phase with the alternate bypass supply, so that unacceptable voltage spikes will be avoided in case of an automatic transfer from normal to alternate supply. The SSLC uninterruptible power supply complies with IEEE-944 (Reference 8.1-1).

8.1.3.1.1.3 Controls and Indication

The ABWR electrical system design provides controls and indicators in accordance with IEEE-308 guidelines. The specific design bases are described as follows:

(1) The ABWR electrical system provides controls and indicators in the main control room.

(a) Displays provided for the Plant Main Generator (PMG) consist of PMG output voltage, amperes, watts, VARS, and frequency. Displays provided for the Electrical Power Distribution (EPD) System consists of medium voltage M/C switchgear bus voltages, feeder and load amperes, and circuit breaker positions. Controls are provided for the PMG output circuit breaker, medium voltage M/C Switchgear feeder circuit breakers, load circuit breakers from the medium voltage M/C switchgear to their respective low voltage P/C switchgear, and the low voltage feeder circuit breakers to the low voltage P/C switchgear.

(2) The design provides for control and indication outside the main control room for:

(a) Circuit breakers that switch Class 1E buses between the preferred and standby power supply

(b) The standby power supply

(c) Circuit breakers and other equipment as required for safety systems that must function to bring the plant to a safe shutdown condition

(d) EPD System displays and controls are provided at the Remote Shutdown System (RSS). Displays provided consist of bus voltages for the Class 1E Divisions I and II medium voltage M/C switchgear. Controls are provided for the UAT, RAT, CTG, and EDG Class 1E feeder circuit breakers to the Class 1E Divisions I and II medium voltage M/C switchgear and the load circuit breakers from the Class 1E Division I and II medium voltage M/C switchgear to their respective low voltage P/C Switchgear, and the low voltage feeder circuit breakers to the Class 1E Division I and II low voltage P/C switchgear.

(3) Operational status information is provided for Class 1E power systems.

(4) Class 1E power systems required to be controlled from outside the main control room also have operational status information provided outside the central control room at the equipment itself, or at its power supply, or at an alternate central location.

(5) The operator is provided with accurate, complete, and timely information pertinent to the status of the execute features in the control room.

(6) Indication is provided in the control room of protective actions and execute features unavailability.

(7) Electric power systems and equipment have the capability of being periodically tested.

(8) Testability of electrical systems and equipment is not so burdensome operationally that required testing intervals cannot be included.

8.1.3.1.2 Regulatory Requirements

The following list of criteria is addressed in accordance with Table 8.1-1 which is based on Table 8-1 of the Standard Review Plan. In general, the ABWR is designed in accordance with all criteria. Any exceptions or clarifications are so noted.

8.1.3.1.2.1 General Design Criteria

(1) GDC 2—Design Bases for Protection against Natural Phenomena

(2) GDC 4—Environmental and Dynamic Effects Design Bases

(3) GDC 5—Sharing of Structures, Systems and Components

The ABWR is a single-unit plant design. Therefore, this GDC is not applicable.

(4) GDC 17—Electric Power Systems

(5) GDC 18—Inspection and Testing of Electrical Power Systems

(6) GDC 50—Containment Design Bases

8.1.3.1.2.2 NRC Regulatory Guides

(1) RG 1.6—Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

(2) RG 1.9—Selection, Design, Qualification and Testing of Emergency Diesel Generator Units Used as Class 1E Electric Power Systems at Nuclear Power Plants

(3) RG 1.32—Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

Functional operation of fuses can not be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE-741. However, periodic inspection for continuity, correct size, etc, shall be performed.

(4) RG 1.47—Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

(5) RG 1.63—Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

(6) RG 1.75—Physical Independence of Electric Systems

Isolation between Class 1E power supplies and non-Class 1E loads is discussed in Subsection 8.3.1.1.1.

(7) RG 1.81—Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants

The ABWR is designed as a single-unit plant. Therefore, this Regulatory Guide is not applicable.

(8) RG 1.106—Thermal Overload Protection for Electric Motors on Motor-Operated Valves

(9) RG 1.108—Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants

(10) RG 1.118—Periodic Testing of Electric Power and Protection Systems

(11) RG 1.128—Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants

(12) RG 1.129—Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants

(13) RG 1.153—Criteria for Power, Instrumentation, and Control Portions of Safety Systems

Functional operation of fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE-741. However, periodic inspection for continuity, correct size, etc., shall be performed.

(14) RG 1.155—Station Blackout

See Appendix 1C.

8.1.3.1.2.3 Branch Technical Positions

(1) BTP ICSB 4 (PSB)—Requirements on Motor-Operated Valves in the ECCS Accumulator Lines

This BTP is written for Pressurized Water Reactor (PWR) plants only and is therefore not applicable to the ABWR.

(2) BTP ICSB 8 (PSB)—Use of Diesel Generator Sets for Peaking

The diesel generator sets are not used for peaking in the ABWR design. Therefore, this criteria is satisfied.

(3) BTP ICSB 11 (PSB)—Stability of Offsite Power Systems

(4) BTP ICSB 18 (PSB)—Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves

(5) BTP ICSB 21—Guidance for Application of Regulatory Guide 1.47

(6) BTP PSB 1—Adequacy of Station Electric Distribution System Voltages (Subsection 8.3.1.1.7 (8))

(7) BTP PSB 2—Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status

8.1.3.1.2.4 Other SRP Criteria

(1) NUREG/CR 0660—Enhancement of Onsite Diesel Generator Reliability

Operating procedures and the training of personnel are outside the scope of the ABWR Standard Plant. NUREG/CR 0660 is therefore imposed as COL license information. (Subsection 8.1.4.1).

(2) TMI Action Item II.E.3.1.—Emergency Power Supply for Pressurizer Heater

This criteria is applicable only to PWRs and does not apply to the ABWR.

(3) TMI Action Item II.G.1—Emergency Power for Pressurizer Equipment

This criteria is applicable only to PWRs and does not apply to the ABWR.

8.1.4 COL License Information

8.1.4.1 Diesel Generator Reliability

NUREG/CR 0660 pertaining to the enhancement of onsite diesel generator reliability through operating procedures and training of personnel will be addressed by the COL applicant (Subsection 8.1.3.1.2.4(1)).

8.1.5 References

8.1-1 IEEE-944, Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations.

Table 8.1-1 Onsite Power System SRP Criteria Applicable Matrix

Applicable Criteria	Ref. IEEE Std	Offsite Power System	AC Power Systems (Onsite)	DC Power System (Onsite)
GDC 2			X	X
GDC 4			X	X
GDC 5*				
GDC 17		X	X	X
GDC 18		X	X	X
GDC 50			X	X
RG 1.6			X	X
RG 1.9	387		X	
RG 1.32	308	X	X	X
RG 1.47		X	X	X
RG 1.63	317		X	X
RG 1.75	384		X	X
RG 1.81*				
RG 1.106			X	X
RG 1.108			X	
RG 1.118	338		X	X
RG 1.128	484			X
RG 1.129	450			X
RG 1.153	603		X	X
RG 1.155†	NUMARC 8700		X	X
BTP ICSB 4‡	279			
BTP ICSB 8	308		X	
BTP ICSB 11		X		
BTP ICSB 18			X	
BTP ICSB 21		X	X	X
BTP PSB 1			X	
BTP PSB 2			X	
NUREG CR0060			X	
II. E. 3.1‡				
II. G. 1‡				

* Multi-unit plants only; not applicable to single-unit ABWR

† See Appendix 1C

‡ PWR only; not applicable to ABWR

8.2 Offsite Power Systems

8.2.1 Description

8.2.1.1 Scope

This section provides a description of the design and performance requirements for the offsite power system. The offsite power system, as defined in the USNRC Standard Review Plan Section 8.2, consists of the following:

Applicant Scope

(1) The offsite transmission network [including the tie lines to the switchyard(s)]

(2) The plant switchyard(s)

(3) The separated switching stations

(4) The high voltage tie lines from the switching stations to the main power transformers, and to the reserve auxiliary transformer

(5) The main step-up power transformers

(6) The reserve auxiliary transformer

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(7) The three unit auxiliary transformers

(8) The plant main generator

(9) The combustion turbine generator

(10) The isolated phase buses from the main power transformer to the main generator circuit breaker, and to the unit auxiliary transformers

(11) The main generator circuit breaker

(12) The non-segregated phase buses from the unit auxiliary transformers to the input terminals of the non-safety-related medium voltage (6.9 kV) switchgear, the non-safety-related medium voltage switchgear (A4, B4, C4) and the power cables form the non-safety related medium voltage switchgear to the safety-related switchgear.

(13) The non-segregated phase bus and power cables from the reserve auxiliary transformer to the input terminals of the non-safety-related and safety-related medium voltage (6.9 kV) switchgear

(14) The power cables from the combustion turbine generator to medium voltage (6.9 kV) switchgear, including the disconnect and interconnecting bus

The design scope for the ABWR ends at the low voltage terminals of the main power transformer and the low voltage terminals of the reserve auxiliary transformer. Although the remainder of the offsite power system is not in the scope of the ABWR design, the ABWR design is based on a power system which meets certain design concepts. Design bases (10CFR52 interface requirements) consistent with these concepts are included in Subsection 8.2.3. Meeting the design bases presented in Subsection 8.2.3 will ensure that the power system within the design scope for the ABWR meets all regulatory requirements. Meeting the conceptual design bases presented in Section 8.2.5 will ensure that the total power system design is consistent and meets all regulatory requirements.

The portions of the offsite power system which fall under the design responsibility of the COL applicant will be unique to each COL application. It is the responsibility of all concerned parties to insure that the total completed design of equipment and systems falling within the scope of this section be in line with the description and requirements stated in. See Subsection 8.2.4 for a detailed listing and description of the COL license information.

8.2.1.2 Description of Offsite Power System

The offsite electrical power system components within the scope of the applicant include items (1) through (6) identified in Subsection 8.2.1.1. The remaining items (7) through (14) are within the scope of the ABWR standard plant design.

When used for normal operation, each preferred power supply is sized to supply the maximum expected coincident Class 1E and non-Class 1E loads.

The normal and alternate preferred power circuits are designed in accordance with industry-recommended practice in order to minimize the likelihood that they will fail while operating under the environmental conditions (such as, wind, ice, snow, lightning, temperature variations, or flood) to which they are subject.

Performance and operating characteristics of the normal and alternate preferred power circuits are required to meet operability and design-basis requirements, such as: (1) the ability to withstand short-circuits, (2) equipment capacity, (3) voltage and frequency transient response, (4) voltage regulation limits, (5) step load capability, (6) coordination of protective relaying and (7) grounding.

Air cooled isolated phase bus duct is sized to provide its load requirements and withstand fault currents until the fault is cleared. It is rated 36 kA and provides for a power feed to the main power transformer and unit auxiliary transformers from the main generator. The sections of the isolated phase bus supplying the unit auxiliary transformers are rated less than 36 kA as appropriate to the load requirements (see Figure 8.3-1).

A generator circuit breaker is provided in the isolated phase bus duct at an intermediate location between the main generator and the main power transformer. The generator circuit breaker provided is capable of interrupting a maximum fault current of 275 kA symmetrical and 340 kA asymmetrical at 5 cycles after initiation of the fault. This corresponds to the maximum allowable interface fault current specified in Subsection 8.2.3. The main generator circuit breaker allows the generator to be taken offline and the offsite transmission network to be utilized as a power source by backfeeding to the unit auxiliary transformers and their loads, both Class 1E and non-Class 1E. This is also the startup power source for the unit. Short circuit analysis will be performed in accordance with IEEE 141 and/or other acceptable industry standards or practices to determine fault currents.

Unit synchronization will normally be through the main generator circuit breaker. A coincidental three-out-of-three logic scheme and synchro-check relays are used to prevent faulty synchronizations.

It is a design basis requirement that synchronization be possible through the switching station’s circuit breakers (Subsection 8.2.5 (24)).

Dual trip coils are provided on the main generator circuit breakers and control power is supplied from redundant load groups of the non-Class 1E onsite 125 VDC power system.

There are three unit auxiliary transformers. Each transformer has three windings and each transformer feeds one Class 1E bus directly, two non-Class 1E buses directly, and one non-Class 1E bus indirectly through a non 1E to non 1E bus tie. The medium voltage buses are in a three load group arrangement with three non-Class 1E buses and one Class 1E bus per load group. Each unit auxiliary transformer has an oil/air rating at 65°C of 37.5 MV·A for the primary winding and 18.75 MV·A for each secondary winding. The forced air/forced oil (FOA) rating is 62.5 and 31.25/31.25 MV·A respectively. The normal loading of the six secondary windings of the transformers is balanced with the heaviest loaded winding carrying a load of 17.7 MV·A. The heaviest transformer loading occurs when one of the three unit auxiliary transformers is out of service with the plant operating at full power. Under these conditions the heaviest loaded winding experiences a load of 21.6 MV·A, which is about two-thirds of its forced air/forced oil rating.

Disconnect links are provided in the isolated phase bus duct feeding the unit auxiliary transformers so that any single failed transformer may be taken out of service and operation continued on the other two unit auxiliary transformers. One of the buses normally fed by the failed transformer would have to be fed from the reserve auxiliary transformer in order to keep all reactor internal pumps operating so as to attain full power. The reserve auxiliary transformer is sized for this type of service.

One, three-winding 37.5 MV·A reserve auxiliary transformer provides power as the “Alternate Preferred” power to the “Normal Preferred” power. One of the equally rated secondary windings supplies reserve power to the nine (three through cross-ties) non-Class 1E buses and the other winding supplies reserve power to the three Class 1E buses. The combined load of the three Class 1E buses is equal to the oil/air the rating of the transformer winding serving them. This is equal to 60% of the forced air/forced oil (FOA) rating of the transformer winding. The transformer is truly a reserve transformer because unit startup is accomplished from the normal preferred power, which is backfed over the main power circuit to the unit auxiliary transformers. The reserve auxiliary transformer serves no startup function. The operational configurations are such that the FOA ratings of the reserve auxiliary transformer, or any unit auxiliary transformer, will not be exceeded under any operating mode (Subsection 8.2.4.5).

The normal and alternate offsite preferred power circuits are designed with sufficient capacity and capability to limit variations of the operating voltage of the onsite power distribution system to a range appropriate to ensure: (1) normal and safe steady-state operation of all plant loads, (2) starting and acceleration of the limiting drive system with the remainder of the loads in service, and (3) reliable operation of the control and protection systems under conditions of degraded voltage [Subsection 8.3.1.1.7 (8)]. Specifically, the unit auxiliary transformers and the reserve auxiliary transformer are designed to limit the voltage variation of the onsite power distribution system to ±10% of load rated voltage during all modes of steady state operation and a voltage dip of no more that 20% during motor starting.

Voltage levels at the low-voltage terminals of the unit and reserve auxiliary transformers will be analyzed to determine the maximum and minimum load conditions that are expected throughout the anticipated range of voltage variations of the offsite transmission system and the main generator. Separate analyses will be performed for each possible circuit configuration of the offsite power supply system.

The unit auxiliary transformers are designed and constructed to withstand the mechanical and thermal stresses produced by external short circuits. In addition, these transformers meet the corresponding requirements of the latest revisions of ANSI Standard C57.12.00. See Subsection 8.2.3(8) for interface requirements on the main step-up transformers and the reserve auxiliary transformer. See Subsection 8.2.3(10) for interface requirements on the high-voltage circuit breakers and disconnect switches.

The non-segregated phase bus that connects the unit auxiliary and reserve auxiliary transformers to the 6.9 kV switchgear is sized to supply its load requirements and rated to withstand fault currents until the fault is cleared.

Redundant offsite system circuits derive their control, protection, and instrument DC power from redundant non-Class 1E DC sources that are independent of the Class 1E DC sources.

8.2.1.3 Separation

The location of the main power transformer, unit auxiliary transformers, and reserve auxiliary transformer are shown on Figure 8.2-1. The reserve auxiliary transformer is separated from the main power and unit auxiliary transformers by a minimum distance of 15.24m. It is a requirement that the 15.24m minimum separation be maintained between the switching stations and the incoming tie lines (see Section 8.2.3). The transformers are provided with oil collection pits and drains to a safe disposal area.

Reference is made to Figures 8.3-1 for the single line diagrams showing the method of feeding the loads. The circuits associated with the alternate offsite circuit from the reserve auxiliary transformer to the Class 1E buses are separated by walls or floors, or by at least 15.24m, from the main and unit auxiliary transformers. The circuits associated with the normal preferred offsite circuit from the unit auxiliary transformers to the Class 1E buses are separated by walls or floors, or by at least 15.24m, from the reserve auxiliary transformer. Separation of the normal preferred and alternate preferred circuits is accomplished by floors and walls over their routes through the Turbine, Control and Reactor Buildings except within the switchgear rooms where they are routed to opposite ends of the same switchgear lineups.

The normal preferred feeds from the unit auxiliary transformers are routed around the outside of the Turbine Building in an electrical tunnel from the unit auxiliary transformers to the Turbine Building switchgear rooms as shown on Figure 8.2-1. (An underground duct bank is an acceptable alternate.) From there the feeds to the Reactor Building exit the Turbine Building and continue across the roof on the Divisions I and III side of the Control Building (Figure 8.2-1, Sheet 3). They drop down the side of the Control Building in the space between the Control and Reactor Buildings where they enter the Reactor Building and continue on through the Divisions I and III side of the Reactor Building to the respective Class 1E switchgear rooms in the Reactor Building.

The alternate preferred feeds from the reserve auxiliary transformer are routed inside the Turbine Building. The Turbine Building switchgear feed from the reserve auxiliary transformer is routed directly to the Turbine Building switchgear rooms. The feed to the Control Building is routed in corridors outside of the Turbine Building switchgear rooms. It exits the Turbine Building and crosses the Control Building roof on the opposite side of the Control Building from the route for the normal preferred power feeds. The steam tunnel is located between the normal preferred feeds and the alternate preferred feeds across the stepped roof of the Control Building. The alternate preferred power feed turns down between the Control and Reactor Building and enters the Reactor Building on the Division II side of the Reactor Building. From there it continues on to the respective switchgear rooms in the Reactor Building.

Feeder circuit breakers from the unit auxiliary and reserve auxiliary transformers to the medium voltage (6.9 kV) switchgear are interlocked to prevent paralleling the normal and alternate power sources.

Instrument and control cables associated with the normal preferred power circuits are separated [i.e., by 15.24m, or by walls or floors] from the instrument and control cables associated with the alternate preferred power circuits; with exception of the circuits in the control room, the circuits at the control and instrument DC power sources, and the interlock circuitry required to prevent paralleling of the two offsite sources. However, these circuits are electrically isolated and separated to the extent practical, and are not routed together in the same raceway. The reserve auxiliary transformer power, instrument and control cables do not share raceways with any other cables. The instrumentation and control circuits for the normal and alternate preferred power shall not rely on a single common DC power source [see Subsection 8.2.3 items (13) and (15)].

The instrumentation and control cables for the unit auxiliary transformers and the main generator circuit breaker may be routed in the raceways corresponding to the load group of their power source.

Class 1E rotating equipment, which could produce potential missile hazards, are not located in the same rooms as feeder circuits from the offsite to the Class 1E buses, unless protective barriers are installed to preclude possible interaction between offsite and onsite systems.

A combustion turbine generator (CTG) supplies standby power to the non-Class 1E buses which supply the non-Class 1E plant investment protection (PIP) loads. It is a 9 MW rated self-contained unit which is capable of operation without external auxiliary systems. Although it is located on site, it is treated as an additional offsite source in that it supplies power to multiple load groups. In addition, manually controlled breakers provide the capability of connecting the combustion turbine generator to any of the Class 1E buses if all other AC power sources are lost.

In this way, the CTG provides a second “offsite” power source to any Class 1E bus being fed from the reserve auxiliary transformer while the associated unit auxiliary transformer is out of service.

The combustion turbine generator (CTG) is located in the Turbine Building, and is shown on Figure 8.2-1, Sheet 2. The CTG standby power feed and instrument and control cables for the Turbine Building are routed directly to the switchgear rooms in the Turbine Building. The power feeders and instrument and control cables to the

Reactor Building are routed adjacent to the alternate preferred feeds across the Control and Reactor Buildings in their own raceway.

8.2.2 Analysis

In accordance with the NRC Standard Review Plan (NUREG-0800), Table 8-1 and Section 8.2, the offsite power distribution system is designed consistent with the following criteria, so far as it applies to the non-Class 1E equipment. Any exceptions or clarifications are so noted.

8.2.2.1 General Design Criteria

(1) GDC 5 and RG 1.81—Sharing of Structures, Systems and Components

The ABWR is a single unit plant design. Therefore, these criteria are not applicable.

(2) GDC 17—Electric Power Systems

Each circuit of the preferred power supply is designed to provide sufficient capacity and capability to power equipment required to ensure that: (1) Fuel design limits and design conditions of the reactor coolant pressure boundary will not be exceeded as a result of anticipated operational occurrences, and (2) In the event of plant design-basis accidents, the core will be cooled, and containment integrity and other vital functions will be maintained.

As shown in Figure 8.3-1, each of the Class 1E divisional 6.9 kV M/C buses can receive power from multiple sources. There are separate utility feeds from the offsite transmission network (via the main power transformer and the reserve auxiliary transformer). The unit auxiliary transformer output power feeds and instrumentation and control circuits and the reserve auxiliary transformer output power feeds and instrumentation and control circuits are routed by two completely separate paths through the yard, the Turbine Building, Control Building and Reactor Building to their destinations in the electrical equipment rooms and main control room. The transformers are provided with separate oil collection pits and drains to a safe disposal area.

Separation of offsite equipment is discussed in Subsection 8.2.1.3. The plant fire protection system is discussed in Section 9.5.1. Although these preferred power sources are non-Class 1E, such separation and provision assure the physical independence requirements of GDC 17 are preserved.

Switching and lightning surge protection is provided by the station grounding and surge protection systems described in Appendix 8A, and by the independent feeds (i.e., normal and alternate preferred power circuits described in Subsection 8.2.1.2). Maximum and minimum voltage ranges are specified in Subsection 8.2.3(2) and transformers are designed per Subsection 8.2.1.2. Allowable frequency variation or stability limitations are addressed in Subsection 8.2.3. Surge and EMI protection for Class 1E systems, equipment and components is described in Appendix 7A. Protection for degraded voltage conditions is discussed in Subsection 8.3.1.1.7(8).

(3) GDC 18—Inspection and Testing of Electrical Power Systems

All equipment can be tested, as necessary, to assure continued and safe operation of the plant. For equipment which cannot be tested during plant operation, the reliability will be such that testing can be performed during plant shutdown (for example, the main generator circuit breaker). See Subsection 8.2.4 for COL license information.

Isolated and non-segregated phase bus ducts provide access for inspection and maintenance. They also have provisions for excluding debris and fluids, and for draining condensates.

The ABWR is designed to provide testing and/or verification capability as described above, including the items identified in Subsection 8.2.4.1.

(4) RG’s 1.32, 1.47, and BTP ICSB 21

These distribution load groups are non-Class 1E and non-safety-related. However, they are important to safety and are in compliance with these guidelines.

(5) RG 1.153—Criteria For Power, Instrumentation and Control Portions of Safety Systems

(6) RG 1.155—Station Blackout

See Appendix 1C

(7) BTP ICSB 11 (PSB)—Stability of Offsite Power Systems

(8) Appendix A to SRP Section 8.2

It is a requirement that the design, testing and installation of the main generator circuit breaker meet the specific guidelines of this appendix, therefore compliance with the appendix is assured.

(9) IEEE-765, IEEE Standard for Preferred Power Supply for Nuclear Powered Generating Stations

It is a requirement that the total design provided by GE and the applicant meet the requirements of this IEEE standard as modified by the specific additional requirements and explanatory statements in Table 8.2-1. The additional requirements are more restrictive than the requirements which they replace or modify from the IEEE standard. Any stated requirements in Tier 2 which are in conflict with the requirements stated in this standard take precedence over the requirements of the standard.

8.2.3 Interface Requirements

The standard design of the ABWR is based on certain assumptions concerning the design bases which shall be met by the COL applicant in designing the portion of the offsite power system in his scope, as defined in Subsection 8.2.1.1. Those design bases assumptions are listed here which the COL applicant shall meet.

(1) The offsite system shall consist of a minimum of two independent offsite transmission circuits from the transmission network.

(2) Voltage variations of the offsite transmission network during steady state operation shall not cause voltage variations at the loads of more than plus or minus 10% of the loads nominal ratings.

(3) The normal steady state frequency of the offsite transmission network shall be within plus or minus 2 hertz of 60 hertz during recoverable periods of system instability.

(4) The offsite transmission circuits from the transmission network through and including the main step-up power and reserve auxiliary transformers shall be sized to supply their load requirements, during all design operating modes, of their respective Class 1E divisions and non-Class 1E load groups.

(5) The impedence of the main step-up power and reserve auxiliary transformers shall be compatible with the interrupting capability of the plant’s circuit interrupting devices.

(6) The independence of offsite transmission power, instrumentation, and control circuits shall be compatible with the portion of the offsite transmission power, instrumentation, and control circuits within the ABWR Standard Plant scope.

(7) Instrumentation and control system loads shall be compatible with the capacity and capability design requirements of DC systems within the ABWR Standard Plant scope.

8.2.4 COL License Information

8.2.4.1 Periodic Testing of Offsite Equipment

Appropriate plant procedures shall include periodic testing and/or verification to ensure the following:

(1) The normal and alternate offsite power circuits are verified to be energized and connected to the appropriate Class 1E distribution system division at least once every 12 hours.

(2) The instrumentation, control, and protection systems, equipment, and components associated with the normal and alternate offsite preferred circuits are properly calibrated and perform their required functions.

(3) The required Class 1E and non-Class 1E loads can be powered from their designated preferred power supply within the capacity and capability margins specified in Tier 2 for the offsite system circuits.

(4) The loss of the offsite preferred power supply can be detected.

(5) Switching between preferred power supplies can be accomplished.

(6) The batteries and chargers associated with the preferred power system can meet the requirements of their design loads.

(7) The generator breaker can open on demand. (Note: The breaker’s actual opening and closing mechanisms are inherently confirmed during the shutdown and synchronizing processes. Trip circuits shall be periodically verified during shutdown periods while the breaker is open.)

(8) Isolated and non-segregated phase bus ducts are inspected and maintained such that they are clear of debris, fluids, and other undesirable materials. Also, terminals and insulators are inspected, cleaned and tightened, as necessary.

The test and inspection intervals will be established and maintained according to the guidelines of IEEE-338, Section 6.5, as appropriate for non-Class 1E systems (i.e., Items (4) and (7) of Section 6.5.1 are not applicable).

8.2.4.2 Procedures when a Reserve or Unit Auxiliary Transformer is Out of Service

Appropriate plant operating procedures will be imposed whenever the reserve auxiliary transformer or a unit auxiliary transformer is out of service.

8.2.4.3 Offsite Power Systems Design Bases

Interface requirements for the COL applicant offsite power systems design bases are provided in Subsection 8.2.3.

8.2.4.4 Offsite Power Systems Scope Split

Interface requirements for the COL applicant pertaining to offsite power systems scope split are provided in Subsection 8.2.3.

8.2.4.5 Capacity of Auxiliary Transformers

Appropriate plant procedures shall be provided to assure FOA ratings of the reserve auxiliary transformer, or any unit auxiliary transformer, will not be exceeded under any operating mode (Subsection 8.2.1.2).

8.2.5 Conceptual Design

(1) Voltage variations of the offsite transmission network during steady state operation do not cause variations at the loads of more than plus or minus 10% of the loads nominal ratings.

(2) The normal steady state frequency of the offsite transmission network are within plus or minus 2 hertz of 60 hertz during recoverable periods of system instability.

(3) The offsite transmission lines from the transmission network to the main power and reserve switching stations do not have a common takeoff structure or use common structure for support.

(4) The tie lines from the main step-up power and reserve auxiliary switching stations to their respective transformers do not have a common takeoff structure or use common structures for support.

(5) The two offsite circuits from the transmission network to the transformers are designed to minimize their simultaneous loss as a result of failure of any transmission tower, crossing line, single breaker, switchgear bus, or cable.

(6) The main and reserve offsite power systems' transmission lines from the transmission network and tie lines do not cross over each others offsite lines or switching station equipment.

(7) The offsite circuits are designed in accordance with industry recommended practice in order to minimize the likelihood that they will fail while operating under the environmental conditions (such as, wind, ice, snow, lightning, temperature variations, or flood) to which they are subject.

(8) System studies demonstrate that the offsite transmission network will not degrade below a level consistent with the availability goals of the plant as a result of contingencies such as loss of any of the following elements: Nuclear power generating unit, largest generating unit, most critical transmission circuit or intertie, or largest load.

(9) Separation between the main and reserve offsite circuits (e.g., the transmission lines, tie lines, switching stations, transformers, bus ducts, and power, instrumentation and control cables), is at least 15.24 meters and is greater than the height of any component which could cause loss of both offsite circuits up to the point at which the component can no longer affect both circuits. (Note: the switching stations may be in the same switchyard or separated switchyards provided the required minimum separation is maintained).

(10) The reserve auxiliary transformer is separated by a minimum of 15.24m from the unit auxiliary transformers.

(11) Instrumentation and control circuits of the main power offsite circuit (i.e., normal preferred power circuit) are separated from the instrumentation and control circuits for the reserve power circuit (i.e., alternate preferred power circuit) in the same manner as described in (9) and (10) above.

(12) Lightning arresters are provided for each phase of all tie lines connecting the plant electrical systems to the switchyard and transmission network. These arresters are connected to the high-voltage terminals of the main step-up power and reserve auxiliary transformers. Transformers are also grounded.

(13) The main step-up power and reserve auxiliary transformers are provided with separate oil collection pits and drains to safe disposal area, and are provided with fire protection deluge systems as specified in Section 9A.4.6.

(14) Analyses of the incoming transmission lines assures that the expected availability of the offsite power is as good as the assumptions made in performing the plant probability risk analysis (see item 5.1.2 of Table 8.2-1, and Chapter 19).

(15) The main step-up power and the reserve auxiliary transformers are designed to meet the requirements of ANSI Standard C37.06 (Reference 8.2-1), General Requirements for Liquid-Immersed Distribution, Power Regulating Transformers.

(16) The main power transformer consists of three normally energized single-phase transformers with an additional installed spare. Provisions are made to permit connecting and energizing the spare transformer in no more than 12 hours following a failure of one of the normally energized transformers.

(17) The offsite transmission circuits from the transmission network through and including the main step-up power and reserve auxiliary transformers are designed and constructed to withstand the mechanical and thermal stresses from the worst case faults.

(18) The calculated rated conditions for the main step-up power transformer is 1500 MV·A at a power factor of 0.9 and a voltage of 26.325 kV plus or minus 10%. The main step-up power transformer and high voltage circuit has sufficient impedance to limit the primary side maximum available fault current contribution from the system to that required by the main generator output circuit breaker as defined in Subsection 8.2.1.2.

(19) The calculated rated conditions for the reserve auxiliary transformer is 37.5 MV·A at a 0.9 power factor. When coordinated with the design of the reserve auxiliary transformer, the offsite transmission system circuit supports a maximum allowable voltage dip of 20% during the starting of large motors.

(20) The offsite transmission circuits from the transmission network through and including the main step-up power and reserve auxiliary transformers are sized to supply their load requirements, during all design operating modes, of their respective Class 1E divisions and non-Class 1E load groups.

(21) The impedances of the main step-up power transformer and reserve auxiliary transformer are compatible with the interrupting capability of the plant's circuit interrupting devices.

(22) Circuit breakers and disconnect switches are sized and designed in accordance with the latest revision of ANSI Standard C37.06 (Reference 8.2-1), Preferred Ratings and Related Capabilities for AC high-Voltage Circuit Breakers Rated on a Symmetrical Current Basis. All circuit breakers are purchased new (i.e, not refurbished used ones) in accordance with resolution of NRC Information Notice 88-46 (see Question/Response 435.56 in Subsection 20.3.8).

(23) The main power switching station has at least two full capacity main buses arranged such that:

    (a) Any incoming or outgoing transmission line can be switched without affecting another line;

(b) Any single circuit breaker can be isolated for maintenance without interrupting service to any circuit; and

(c) Faults of a single main bus are isolated without interrupting service to any circuit.

(24) Provisions are made to synchronize the generating unit through the main power switching station's circuit breakers.

(25) All relay schemes used for protection of the offsite power circuits and the switching station's equipment include primary and backup protection features. All breakers are equipped with dual trip coils. Each protection circuit which supplies a trip signal is connected to a separate trip coil. All equipment and cabling associated with primary and backup protection circuits are physically separated from each other.

(26) Each transformer has a primary and backup protective devices. DC power to the primary and backup devices is supplied from separate non Class 1E DC sources.

(27) The DC power needed to operate primary and backup protection and control equipment of the offsite power system is supplied from two separate switching station batteries located in each switching station, each with a battery charger fed from a separate AC bus. Each battery is capable of supplying the DC power required for normal operation of the switching station's equipment. Each charger is capable of supplying the required loads while recharging its battery.

(28) Two redundant low voltage AC power supply systems are provided to supply AC power to the switching station's auxiliary loads. Each system is supplied from separate, independent AC buses. The capacity of each system is adequate to meet the AC power requirements for normal operation of the switching station's equipment.

8.2.6 References

8.2-1 ANSI Std C37.06, Preferred Ratings and Related Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

8.2-2 ANSI Std C57.12.00, General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

Table 8.2-1 Additional Requirements IEEE-765

IEEE-765 Reference		Requirement or Explanatory Note
4.1	General	Tier 2 Figure 8.3-1 should be used as the reference single line instead of the IEEE Std example, Figures 2, (a), (b) and (c).
4.2	Safety Classification	The separation criteria called for in Subsection 8.2.1.3 must be met.
4.5	Availability	The ABWR design utilizes direct connection of the two preferred power circuits to the Class 1E buses.
5.1.2	Transmission System Reliability	Additional analysis is required per Section 8.2.3(4).
5.1.3	Transmission System Independence	
	5.1.3.2	Specific requirements for tolerance to equipment failures are stated in Tier 2 and must be met.
	5.1.3.3	Since a separation of at least 15.24m is required for the exposed circuits, a common takeoff structure cannot be used.
5.3.2	Class 1E Power System Interface Independence	(See 5.1.3.3 comments)
5.3.3	Connections with Class 1E Systems	
	5.3.3.2	Automatic dead-bus transfers are used to transfer from the preferred power supply to the onsite AC source. Manual dead-bus transfers are used between preferred power supplies, and to transfer from the onsite source back to the preferred power supply. Automatic live-bus transfers are not required and are not used.
	5.3.3.3	Only standby power sources may be paralleled with the preferred power sources for load testing. The available fault current must be less than the rating of the breakers. It is not required and not allowed for the normal and alternate preferred power supply breakers for a bus to be closed simultaneously so there is no time that the available fault current at a bus exceeds the equipment rating.
7.0	Multi-Unit Considerations	The ABWR is a single unit design, therefore there is no sharing of preferred power supplies between units.

The following figure is located in Chapter 21:

Figure 8.2-1 Power Distribution System Routing Diagram (Sheets 1–7)

8.3 Onsite Power Systems

(See Section 8.3.3 for information generally applicable to all onsite power equipment.)

8.3.1 AC Power Systems

The onsite power system interfaces with the offsite power system at the input terminals to the supply breakers for the normal, alternate, and combustion turbine generator power feeds to the medium voltage (6.9 kV) switchgear. It is a three load group system with each load group consisting of a non-Class 1E and a Class 1E portion. The three load groups of the Class 1E power system (i.e., the three divisions) are independent of each other. The principal elements of the auxiliary AC electric power systems are shown on the single line diagrams (SLD) in Figures 8.3-1 through 8.3-3.

Each Class 1E division has a dedicated safety-related, Class 1E diesel generator, which automatically starts on high drywell pressure, low reactor vessel level or loss of voltage on the division's 6.9 kV bus. The signals generated from high drywell pressure and low reactor vessel level are arranged in two-out-of-four logic combinations, and are utilized to sense the presence of a LOCA condition and subsequently start the diesel. These signals also initiate the emergency core cooling systems.

The loss of voltage condition and the degraded voltage condition are sensed by independent sets of three undervoltage relays (one on each phase of the 6.9 kV bus) which are configured such that two-out-of-three trip states will initiate circuitry for transferring power from offsite power to the onsite diesel generator (after a time delay for the degraded voltage condition). The primary side of each of the instrument potential transformers (PTs) is connected phase-to-phase (i.e., a "delta" configuration) such that a loss of a single phase will cause two of the three undervoltage relays to trip, thus satisfying the two-out-of-three logic. (For more information on the degraded voltage condition and associated time delays, etc., see Subsection (8) of 8.3.1.1.7.)

Each 6.9 kV Class 1E bus feeds its associated 480V unit substation through a 6.9 kV/ 480/277V power center transformer.

Standby power is provided to plant investment protection non-Class 1E loads in all three load groups by a combustion turbine generator located in the turbine building.

AC power is supplied at 6.9 kV for motor loads larger than 300 kW and transformed to 480V for smaller loads. The 480V system is further transformed into lower voltages as required for instruments, lighting, and controls. In general, motors larger than 300 kW are supplied from the 6.9 kV buses. Motors 300 kW or smaller but larger than 100 kW are supplied power from 480V switchgear. Motors 100 kW or smaller are supplied power from 480V motor control centers.

See Subsection 8.3.4.9 for COL license information.

8.3.1.0 Non-Class 1E AC Power System

8.3.1.0.1 Non-Class 1E Medium Voltage Power Distribution System

The non-Class 1E medium voltage power distribution system consists of nine 6.9 kV buses divided into three load groups. The three load group configuration was chosen to match the mechanical systems which are mostly three trains (e.g. three feedwater pumps, three circulating water pumps, three turbine building supply and exhaust fans).

Within each load group there is one power generation bus which supplies power production loads which do not provide water to the pressure vessel. Each one of these buses has access to power from one winding of its assigned unit auxiliary transformer. It also has access to the reserve auxiliary transformer as an alternate source if its unit auxiliary transformer fails or during maintenance outages for the normal feed. Bus transfer between preferred power sources is manual dead bus transfer and not automatic.

Another power generation bus within each load group supplies power to pumps which are capable of supplying water to the pressure vessel during normal power operation (i.e., the condensate and feedwater pumps). These buses normally receive power from the unit auxiliary transformer and supply power to the third bus [plant investment protection (PIP)] in the load group through a cross-tie. The cross-tie automatically opens on loss of power but may be manually re-closed if it is desired to operate a condensate and feedwater pump or a condensate pump from the reserve auxiliary transformer which is connectable to the PIP buses. In addition, the combustion turbine generator is capable of supplying power to any of the condensate pumps through the bus ties from the PIP buses. This provides three load groups of non-safety grade equipment, in addition to the divisional Class 1E load groups, which may be used to supply water to the reactor vessel in emergencies.

A third Plant Investment Protection (PIP) bus supplies power to non-safety loads (e.g. the turbine building HVAC, the turbine building service water and the turbine building closed cooling water systems). On loss of normal preferred power the cross-tie to the power generation bus is automatically tripped open and the non-Class 1E PIP bus is automatically transferred (two out of the three buses in the load groups transfer) via a dead bus transfer to the combustion turbine which automatically starts on loss of power. The PIP systems for each load group automatically restart to support their load groups.

The non-Class 1E buses are comprised of metal clad switchgear rated for 7.2 kV 500 MV·A with a bus full load rating of 2000A. Maximum calculated full load short time current is 1700A. Bus ratings of 3000A are available for the switchgear as insurance against future load growth, if necessary. The circuit breaker interrupting capacity is 41,000 amperes. Instrument and control power is from the non-Class 1E, 125VDC power system.

The 6.9 kV buses supply power to adjustable speed drives for the feedwater and reactor internal pumps. These adjustable speed drives are designed to the requirements of IEEE-519. Voltage distortion limits are as stated in Table 4 of the IEEE Std.

Each 6.9 kV bus has a safety grounding circuit breaker designed to protect personnel during maintenance operations (see Figure 8.3-1). During periods when the buses are energized, these breakers are racked out (i.e., in the disconnect position). A control room annunciator sounds whenever any of these breakers are racked for service. The interlocks for the bus grounding devices are as follows:

(1) Under-voltage relays must be actuated.

(2) Bus Feeder breakers must be in the disconnect position.

(3) Voltage for bus instrumentation must be available.

Conversely, the bus feeder breakers are interlocked such that they cannot close unless their associated grounding breakers are in their disconnect positions.

8.3.1.0.2 Non-Class 1E Low Voltage Power Distribution System

8.3.1.0.2.1 Power Centers

Power for the non-Class 1E 480V auxiliaries is supplied from power centers consisting of 6.9 kV/480V transformers and associated metal-clad switchgear (see Figure 8.3-1). There are six non-Class 1E, (two per load group), power centers. One power center per load group is supplied power from the non-Class 1E PIP bus in the load group.

Non-Class 1E 480V power centers supplying non-Class 1E loads are arranged as independent radial systems, with each 480V bus fed by its own power transformer.

The 480V power centers are sized to supply motor control centers and motor loads greater than 100 kW, and up to and including 300kW. Switchgear for the 480V load centers is of indoor, metal-enclosed type with draw-out circuit breakers which will interrupt maximum fault currents. Control power is from the non-Class 1E 125 VDC power system of the same non-Class 1E load group.

8.3.1.0.2.2 Motor Control Centers

The non-Class 1E 480V MCCs are sized to supply motors 100kW or smaller, control power transformers, process heaters, motor-operated valves and other small electrically operated auxiliaries, including 480-120V and 480-240V transformers. Non-Class 1E motor control centers are located in proximity to their loads.

Starters for the control of 460V motors 100kW or smaller are MCC-mounted, across-the-line magnetically operated, air break type. Power circuits entering into the containment area through electrical penetration assemblies have a fuse in series with the circuit breakers as a backup protection for fault currents in the penetration in the event of circuit breakers over-current fault protection failure.

8.3.1.0.3 120/240V Distribution System

Individual transformers and distribution panels are located in the vicinity of the loads requiring non-Class 1E 120/240V power. This power is used for non-Class 1E standby AC lighting, and other 120V non-Class 1E loads.

8.3.1.0.4 Instrument Power Supply Systems

8.3.1.0.4.1 120V AC Non-Class 1E Instrument Power System

Individual regulating transformers supply 120VAC instrument power (see Figure 8.3-2). Each non-Class 1E transformer is supplied from a 480V MCC in the same non-Class 1E load group. Power is distributed to the individual loads from distribution panels. Transformers are sized to supply their respective distribution panel instrumentation and control loads.

8.3.1.0.4.2 120V AC Non-Class 1E Vital Power Supply System

8.3.1.0.4.2.1 CVCF Power Supply for the Non-Safety Systems

The function of the non-Class 1E Vital AC Power Supply System is to provide reliable 120VAC uninterruptible power for non-Class 1E loads that are required for continuity of power plant operation. The system consists of three 120 VAC uninterruptible constant voltage, constant frequency (CVCF) power supplies, each including a static inverter, AC and DC static transfer switches, a regulating step-down transformer (as an alternate AC power supply), and a distribution panel (see Figure 8.3-3). The primary source of power comes from the non-Class 1E AC motor control center in the same non-Class 1E load group. The secondary source is the non-Class 1E 125 VDC battery in the same load group.

There are three automatic switching modes for the CVCF power supplies, any of which may be initiated manually. First, the frequency of the output of the inverter is normally synchronized with the input AC power. If the frequency of the input power goes out of range, the power supply switches over to internal synchronization to restore the frequency of its output. Switching back to external synchronization is automatic and occurs if the frequency of the AC power has been restored and maintained for approximately 60 seconds.

The second switching mode is from AC to DC for the power source. If the voltage of the input AC power is less than 88% of the rated voltage, the input is switched to the DC power supply. The input is switched back to the AC power after a confirmation period of approximately 60 seconds.

The third switching mode is between the inverter and the voltage regulating transformer, which receives power from the same bus as the primary source. If any of the conditions listed below occur, the power supply is switched to the voltage regulating transformer, and this condition is alarmed in the main control room.

(1) Output voltage out of rating by more than plus or minus 10%

(2) Output frequency out of rating by more than plus or minus 3%

(3) High temperature inside of panel

(4) Loss of control power supply

(5) Commutation failure

(6) Over-current of smoothing condenser

(7) Loss of control power for gate circuit

(8) Incoming MCCB trip

(9) Cooling fan trip

Following correction of any of the above events transfer back is by manual initiation only.

8.3.1.0.4.2.2 Components

Each of the three non-Class 1E CVCF power supplies includes the following components:

(1) a power distribution cabinet, including the CVCF 120 VAC bus and circuit breakers for the loads;

(2) a solid-state inverter, to convert 125 VDC power to 120 VAC uninterruptible power supply;

(3) a solid-state transfer switch to sense inverter failure and automatically switch to alternate 120 VAC power;

(4) a 480/120V bypass transformer for the alternate power supply;

(5) a solid-state transfer switch to sense AC input power failure and automatically switch to alternate 125 VDC power;

(6) and a manual transfer switch for maintenance.

8.3.1.0.4.2.3 Computer Vital AC Power Supply System (Non-Class 1E)

Two constant voltage and constant frequency power supplies are provided to power the process computers. Each of the power supplies consists of an AC to DC rectifier, and a DC to AC inverter, a bypass transformer and DC and AC solid-state transfer switches (Figure 8.3-3, sheet 2). The normal feed for the power supplies is from a non-Class 1E power center supplied from the PIP buses which receive power from the combustion turbine if offsite power is lost. The backup for the normal feeds is from the 250 VDC battery. In addition, each power supply is provided with a backup AC feed though isolation transformers and a static transfer switch. The backup feed is provided for alternate use during maintenance periods. Switching of the power supply is similar to that described for the non-Class 1E vital AC power supply system, above. (Subsection 8.3.1.0.4.2).

8.3.1.0.5 Non-Class 1E Electric Equipment Considerations

The following guidelines are utilized for non-Class 1E equipment.

(1) Motors are sized in accordance with NEMA standards. The manufacturer's ratings are at least large enough to produce the starting, pull-in and driving torque needed for the particular application, with due consideration for the capabilities of the power sources. Plant design specifications for electrical equipment require such equipment be capable of continuous operation for voltage fluctuations of ± 10%.

(2) Power sources, distribution equipment and branch circuits are designed to maintain a voltage and frequency within acceptable limits. Load and voltage drop analyses will be performed from the source to the utilization equipment in accordance with IEEE 141 and/or other acceptable industry standards or practices to assure that power sources and distribution equipment will be capable of transmitting sufficient energy to start and operate all the required loads for all designed plant conditions.

(3) The selection of motor insulation such as Class F, H or B is a design consideration based on service requirements and environment.

(4) Capacity of switchgear, power centers with their respective transformers, motor control centers, and distribution panels is equal to or greater than the maximum available fault current to which it is exposed under all designed modes of operation until the fault is cleared.

    Interrupting capability of the non-Class 1E switchgear and MCC's breakers is selected to interrupt the available short-circuit current at the circuit breaker load terminals. Short circuit analyses will be performed in accordance with

IEEE 141 and/or other acceptable industry standards or practices to determine fault currents.

Power center transformers are sized and impedances chosen to facilitate the selection of low-voltage switchgear, MCCs and distribution panels, which are optimized within the manufacturer's recommended ratings for interrupting capacity and coordination of over-current devices. Impedance of connecting upstream cable is factored in for a specific physical layout.

8.3.1.0.6 Circuit Protection

8.3.1.0.6.1 Philosophy of Protection

Simplicity of load grouping facilitates the use of conventional, protective relaying practices for isolation of faults. Emphasis has been placed in preserving function and limiting loss of equipment function in situations of power loss or equipment failure.

Breaker coordinates analysis will be performed in accordance with IEEE 141, 242 and/or other acceptable industry standards or practices.

Circuit protection of the non-Class 1E buses is interfaced with the design of the overall protection system.

8.3.1.0.6.2 Grounding Methods

Station grounding and surge protection is discussed in Section 8A.1. The medium voltage (6.9kV) system is low resistance grounded except that the combustion turbine generator is high resistance grounded to maximize availability.

See Subsection 8.3.4.14 for COL license information pertaining to administrative control for bus grounding circuit breakers.

8.3.1.0.6.3 Bus Protection

Bus protection is as follows:

(1) 6.9kV bus incoming circuits have inverse time over-current, ground fault, bus differential and under-voltage protection.

(2) 6.9kV feeders for power centers have instantaneous, inverse time over-current and ground fault protection.

(3) 6.9kV feeders for heat exchanger building substations have inverse time over-current and ground fault protection.

(4) 6.9kV feeders used for motor starters have instantaneous, inverse time over-current, ground fault protection.

(5) 480V bus incoming line and feeder circuits have inverse time over-current and ground fault protection.

8.3.1.1 Class 1E AC Power Distribution System

8.3.1.1.1 Medium Voltage Class 1E Power Distribution System

Class 1E AC power loads are divided into three divisions (Divisions I, II, and III), each fed from an independent 6.9 kV Class 1E bus. During normal operation (which includes all modes of plant operation; i.e., shutdown, refueling, startup, and run), two of the three divisions are fed from an offsite normal preferred power supply. The remaining division is fed from the alternate preferred power source (Subsection 8.3.4.9).

The Class 1E buses are comprised of metal clad switchgear rated for 7.2kV 500MV·A with a bus full load rating of 2,000 amperes. Maximum calculated full load short time current is 1,700 amperes. Bus ratings of 3,000 amperes are available for the switchgear as insurance against further load growth, if necessary. The circuit breaker interrupting capacity is 41,000 amperes. Instrument and control power is from the Class 1E 125VDC power system in the same Class 1E division.

Each 6.9 kV bus has a safety grounding circuit breaker designed to protect personnel during maintenance operations (see Figure 8.3-1). During periods when the buses are energized, these breakers are racked out (i.e., in the disconnect position). A control room annunciator sounds whenever any of these breakers are racked in for service.

The interlocks for the bus grounding devices are as follows:

(1) Under-voltage relays must be actuated.

(2) Bus Feeder breakers must be in the disconnect position.

(3) Voltage for bus instrumentation must be available.

Conversely, the bus feeder breakers are interlocked such that they cannot close unless their associated grounding breakers are in their disconnect positions.

Standby AC power for Class 1E buses is supplied by diesel generators at 6.9 kV and distributed by the Class 1E power distribution system. Division I, II and III buses are automatically transferred to the diesel generators when the preferred power supply to these buses is ≤ 70% bus voltage.

The Division I Class 1E bus supplies power to three separate groups of non-Class 1E fine motion control rod drive (FMCRD) motors (see Figure 8.3-1, sheet 3). Although these motors are not Class 1E, the drives may be inserted as a backup to scram and are of special importance because of this. It is important that the first available standby power be available for the motors, therefore, a diesel supplied bus was chosen as the first source of standby AC power and a combustion turbine supplied PIP bus as the second backup source. Division I was chosen because it was the most lightly loaded diesel generator.

The load breakers in the Division I switchgear are part of the isolation scheme between the Class 1E power and the non-Class 1E load. In addition to the normal over-current tripping of these load breakers, Class 1E zone selective interlocking is provided between them and the upstream Class 1E bus feed breakers.

If fault current flows in the non-Class 1E load, it is sensed by the Class 1E current device for the load breaker and a trip blocking signal is sent to the upstream Class 1E feed breakers. This blocking lasts for about 75 milliseconds. This allows the load breaker to trip in its normal instantaneous tripping time of 35 to 50 milliseconds, if the magnitude of the fault current is high enough. This assures that the fault current has been terminated before the Class 1E upstream breakers are free to trip. For fault currents of lesser magnitude, the blocking delay will time out without either bus feeder or load breakers tripping, but the load breaker will eventually trip and always before the upstream feeder breaker. This order of tripping is assured by the coordination between the breakers provided by long-time pickup, long-time delay and instantaneous pickup trip device characteristics. Tripping of the Class 1E feed breaker is normal for faults which occur on the Class 1E bus it feeds. Coordination is provided between the bus main feed breakers and the load breakers.

The fault interrupt capability of all Class 1E breakers, fault interrupt coordination between the supply and load breakers for each Class 1E load and the Division I non-Class 1E load, and the zone selective interlock feature of the breaker for the non-Class 1E load all have the capability of being tested (Subsection 8.3.4.29). The zone selective interlock is a feature of the trip unit for the breaker and is tested when the other features such as current setting and long-time delay are tested.

Power is supplied to each FMCRD load group from either the Division I Class 1E bus or the non-Class 1E PIP bus through a pair of interlocked transfer switches located between the power sources and the 6.9 kV/480V transformer feeding the FMCRD MCC. These transfer switches are classified as associated, and are treated as Class 1E. Switch-over to the non-Class 1E PIP bus source is automatic on loss of power from the Class 1E diesel bus source. Switching back to the Class 1E diesel bus power is by manual action only.

The design minimizes the probability of a single failure affecting more than one FMCRD group by providing three independent Class 1E feeds (one for each group) directly from the Division I Class 1E 6.9 kV bus (see sheet 3 of Figure 8.3-1).

The Class 1E load breakers in conjunction with the zone selective interlocking feature (which is also Class 1E), provide the needed isolation between the Class 1E bus and the non-Class 1E loads. The feeder circuits on the upstream side of the Class 1E load breakers are Class 1E. The FMCRD circuits on the load side of the Class 1E load breakers down to and including the transfer switches are associated. Control power for the transfer switches is provided from Division I. The feeder circuits from the non-Class 1E PIP bus to the transfer switch, and circuits downstream of the transfer switch, are non-Class 1E.

Each FMCRD power train has current limiting features to limit the FMCRD motor fault current. Continuous operation of the FMCRD motors at the limiting fault current will not degrade operation of any Class 1E loads. Also, the Division I diesel generator has sufficient capacity margin to supply continuous overload currents up to the trip setpoint of the Class 1E feeder breaker to the FMCRDs.

Non-Class 1E loads being supplied from a Class 1E bus exists only in Division I, as described above for the FMCRDs. Except for associated AC standby and associated DC emergency lighting circuits, non-Class 1E loads are not permitted on Divisions II or III. This prevents any possibility of interconnection between Class 1E divisions.

8.3.1.1.2 Low Voltage Class 1E Power Distribution System

8.3.1.1.2.1 Power Centers

Power for 480V auxiliaries is supplied from power centers consisting of 6.9 kV/480V transformers and associated metal clad switchgear (see Figure 8.3-1). There are two power centers in each Class 1E division.

Class 1E 480V power centers supplying Class 1E loads are arranged as independent radial systems, with each 480V bus fed by its own power transformer. Each 480V Class 1E bus in a division is physically and electrically independent of the other 480V buses in other divisions and non-Class 1E load groups.

The 480V power centers are sized to supply motor control centers and motor loads greater than 100 kW, and up to and including 300 kW. Switchgear for the 480V power centers is of indoor, metal-enclosed type with draw-out circuit breakers which will interrupt maximum fault currents. Control power is from the Class 1E 125 VDC power system of the same Class 1E division.

Power centers are located in their respective divisional equipment areas.

8.3.1.1.2.2 Motor Control Centers

The Class 1E 480V MCCs are sized to supply motors 100 kW or smaller, control power transformers, process heaters, motor-operated valves and other small electrically operated auxiliaries, including 480-120V and 480-240V transformers. Class 1E motor control centers are located in their respective divisional areas in proximity to their division loads. Control and instrument power is internal to the MCC.

Starters for the control of 460V motors 100 kW or smaller are MCC-mounted, across-the-line magnetically operated, air break type. Power circuits entering into the containment area through electrical penetration assemblies have a fuse in series with the circuit breakers as a backup protection for fault currents in the penetration in the event of circuit breaker over-current fault protection failure.

8.3.1.1.3 120/240V Distribution System

Individual transformers and distribution panels are located in the vicinity of the loads requiring Class 1E 120/240V power. This power is used for emergency lighting, and other 120V Class 1E loads.

8.3.1.1.4 Instrument Power Supply Systems

8.3.1.1.4.1 120 VAC Class 1E Instrument Power System

Individual regulating transformers supply 120 VAC instrument power (Figure 8.3-2). Each Class 1E divisional transformer is supplied from a 480V MCC in the same division. There are three divisions, each backed up by its divisional diesel generator as the source when the offsite source is lost. Power is distributed to the individual loads from distribution panels, and to logic level circuits through the control room logic panels. Transformers are sized to supply their respective distribution panel instrumentation and control loads.

8.3.1.1.4.2 120 VAC Class 1E Vital AC Power Supply System

8.3.1.1.4.2.1 CVCF Power Supply for the Safety System Logic and Control

The design basis for the safety system logic and control is provided in Subsection 8.1.3.1.1.2. The function of the Class 1E Vital AC Power Supply System is to provide reliable 120V uninterruptible power to the individual trip systems of the SSLC System. The system consists of four 120 VAC uninterruptible constant voltage, constant frequency (CVCF) power supplies (Divisions I, II, III, IV), each including a static inverter, AC and DC static transfer switches, a regulating step-down transformer (as an alternate AC power supply), and a distribution panel (see Figure 8.3-3). The primary source of power comes from the Class 1E 480 VAC motor control centers in the same Class 1E division, except for Division IV, which is powered from Division II. The secondary source is the Class 1E 125 VDC battery in the same division.

The CVCF power supply buses are designed to provide logic and control power to the four division SSLC system that operates the RPS. [The SSLC for the ECCS derives its power from the 125 VDC power system (see Figure 8.3-4)]. The AC buses also supply power to the neutron monitoring system and parts of the process radiation monitoring system and MSIV function in the leak detection system. Power distribution is arranged to prevent inadvertent operation of the reactor scram initiation or MSIV isolation upon loss of any single power supply.

The capacity of each of the four redundant Class 1E CVCF power supplies is based on the largest combined demands of the various continuous loads, plus the largest combination of non-continuous loads that would likely be connected to the power supply simultaneously during normal or accident plant operation, whichever is higher. The design also provides capability for being tested for adequate capacity (Subsection 8.3.4.34).

There are three automatic switching modes for the CVCF power supplies, any of which may be initiated manually. First, the frequency of the output of the inverter is normally synchronized with the input AC power. If the frequency of the input power goes out of range, the power supply switched over to internal synchronization to restore the frequency of its output. Switching back to external synchronization is automatic and occurs if the frequency of the AC power has been restored and maintained for approximately 60 seconds.

The second switching mode is from AC to DC for the power source. If the voltage of the input AC power is less than 88% of the rated voltage, the input is switched to the DC power supply. The input is switched back to the AC power after a confirmation period of approximately 60 seconds.

The third switching mode is between the inverter and the voltage regulating transformer, which receives power from the same bus as the primary source. If any of the conditions listed below occur, an annunciator is activated in the main control room and the power supply is switched to the voltage regulating transformer.

(1) Output voltage out of rating by more than ±10%

(2) Output frequency out of rating by more than ±3%

(3) High temperature inside of panel

(4) Loss of control power supply

(5) Commutation failure

(6) Over-current of smoothing condenser

(7) Loss of control power for gate circuit

(8) Incoming MCCB trip

(9) Cooling fan trip

Routine maintenance can be conducted on equipment associated with the CVCF power supply. Inverters and solid-state switches can be inspected, serviced and tested channel by channel without tripping the RPS logic.

8.3.1.1.4.2.2 Components

Each of the four Class 1E CVCF power supplies includes the following components:

(1) A power distribution cabinet, including the CVCF 120 VAC bus and circuit breakers for the SSLC and other loads;

(2) A solid-state inverter, to convert 125 VDC power to 120 VAC uninterruptible power supply;

(3) A solid-state transfer switch to sense inverter failure and automatically switch to alternate 120 VAC power;

(4) A 480V/120V bypass transformer for the alternate power supply;

(5) A solid-state transfer switch to sense AC input power failure and automatically switch to alternate 125 VDC power.

(6) A manual transfer switch for maintenance.

(7) In addition, external electrical protection assemblies (EPAs)are provided as output power monitors which monitor the 120 VAC power from the CVCF power supplies to their output power distribution cabinets. If the voltage or frequency of the AC power gets out of design range, the power monitors trip and interrupt the power supplies to their distribution cabinets. The purpose of the power monitors is to protect the scram solenoids from voltage levels and frequencies which could result in their damage (Figure 8.3-3).

8.3.1.1.4.2.3 Operating Configuration

The four 120 VAC Class 1E power supplies operate independently, providing four divisions of CVCF power supplies for the SSLC which facilitate the two-out-of-four logic. The normal lineup for each division is through Class 1E 480 VAC power supply, the AC/DC rectifier, the inverter and the static transfer switch. The bus for the RPS A solenoids is supplied by the Division II CVCF power supply. The RPS B solenoids bus is supplied from the Division III CVCF power supply. The #3 solenoids for the MSIVs are powered from the Division I CVCF; and the #2 solenoids, from the Division II CVCF power supply.

8.3.1.1.5 Class 1E Electric Equipment Considerations

The following guidelines are utilized for Class 1E equipment.

(1) Motors are sized in accordance with NEMA standards. The manufacturers' ratings are at least large enough to produce the starting, pull-in and driving torque needed for the particular application, with due consideration for capabilities of the power sources. Plant design specifications for electrical equipment require such equipment be capable of continuous operation for voltage fluctuations of ±10%. In addition, Class 1E motors must be able to withstand voltage drops to 70% rated during starting transients.

(2) Power sources, distribution equipment and branch circuits are designed to maintain voltage and frequency within acceptable limits. Load and voltage drop analyses will be performed from the source to the utilization equipment in accordance with IEEE-141, 242 and/or other acceptable industry standards or practices to assure that power sources and distribution equipment will be capable of transmitting sufficient energy to start and operate all required loads for all designed plant conditions.

(3) The selection of motor insulation such as Class F, H or B is a design consideration based on service requirements and environment. The Class 1E motors are qualified by tests in accordance with IEEE-334.

(4) Capacity of switchgear, power centers with their respective transformers, motor control centers, and distribution panels is equal to or greater than the maximum available fault current to which it is exposed under all design modes of operation until the fault is cleared.

    Interrupting capability of the Class 1E switchgear and MCC breakers is selected to interrupt the available short-circuit current at the circuit breaker load terminals. Short circuit analysis will be performed in accordance with IEEE 141 and/or other acceptable industry standards or practices to determine fault currents. See Subsection 8.2.3(16) for interface requirement.

Power center transformers are sized and impedances chosen to facilitate the selection of low-voltage switchgear, MCCs and distribution panels, which are optimized within the manufacturer's recommended ratings for interrupting capacity and coordination of over-current devices. Impedance of connecting upstream cable is factored in for a specific physical layout.

8.3.1.1.6 Circuit Protection

8.3.1.1.6.1 Philosophy of Protection

Simplicity of load grouping facilitates the use of conventional, protective relaying practices for isolation of faults. Emphasis has been placed on preserving function and limiting loss of Class 1E equipment function in situations of power loss or equipment failure.

Breaker coordination analysis will be performed in accordance with IEEE 141, 242 and/or other acceptable industry standards or practices.

Circuit protection of the Class 1E buses is interfaced with the design of the overall protection system.

8.3.1.1.6.2 Grounding Methods

Station grounding and surge protection is discussed in Section 8A.1. The medium voltage (6.9 kV) system is low resistance grounded except that each diesel generator is high resistance grounded to maximize availability.

See Subsection 8.3.4.14 for COL license information pertaining to administrative control for bus grounding circuit breakers.

8.3.1.1.6.3 Bus Protection

Bus protection is as follows:

(1) 6.9 kV bus incoming circuits have inverse time over-current, ground fault, bus differential and under-voltage protection.

(2) 6.9 kV feeders for power centers have instantaneous, inverse time over-current and ground fault protection.

(3) 6.9 kV feeders for heat exchanger building substations have inverse time over-current and ground fault protection.

(4) 6.9 kV feeders used for motor starters have instantaneous, inverse time over-current, ground fault and motor protection.

(5) 480V bus incoming line and feeder circuits have inverse time over-current and ground fault protection.

8.3.1.1.6.4 Protection Requirements for Diesel Generators

Protective devices of the diesel generators meet all requirements of IEEE-603. When the diesel generators are called upon to operate during LOCA conditions, the only protective devices which shut down the diesel are the generator differential relays, and the engine over-speed trip. These protection devices are retained under accident conditions to protect against possible, significant damage. Other protective relays, such as loss of excitation, anti-motoring (reverse power), over-current voltage restraint, low jacket water pressure, high jacket water temperature, and low-lube oil pressure, are used to protect the machine when operating in parallel with the offsite power system, during periodic tests. The relays are automatically isolated from the tripping circuits during LOCA conditions when there is a concurrent LOPP signal. However, all of these bypassed parameters are annunciated in the main control room (Subsection 8.3.1.1.8.5). The bypasses and protective relays are testable and meet all IEEE-603 requirements, and are manually reset as required by Position 1.8 of Regulatory Guide 1.9. No trips are bypassed during LOPP or testing. See Subsection 8.3.4.22 for COL license information.

Synchronizing interlocks are provided to prevent incorrect synchronization whenever the diesel generator is required to operate in parallel with the preferred power supply (see Section 5.1.4.2 of IEEE-741). Such interlocks are capable of being tested, and shall be periodically tested per Section 8.3.4.23).

8.3.1.1.7 Load Shedding and Sequencing on Class 1E Buses

This subsection addresses Class 1E Divisions I, II, and III. Load shedding, bus transfer and sequencing on a 6.9 kV Class 1E bus is initiated on loss of bus voltage. Only LOPP signals (≤70% bus voltage) or degraded voltage signals are used to trip the loads. However, the presence of a LOCA during LOPP reduces the time delay for initiation of bus transfer from 3 seconds to 0.4 seconds. The Class 1E equipment is designed to sustain operation for this 3-second period without damage to the equipment. The load sequencing for the diesels is given on Table 8.3-4.

Load shedding and bus ready -to-load signals are generated by the under-voltage relays monitoring the Class 1E medium voltage switchgear buses. Individual timer start and reset signals for the LOPP condition are generated, for each major LOPP load, by the bus under-voltage relays. Individual timer start and reset signals for the LOCA condition are generated, for each major LOCA load, by the Safety System Logic and Control (SSLC) system. Table 8.3-4 defines which loads are sequenced onto the diesel generator for the LOPP and LOPP + LOCA conditions. (i.e. if a LOCA signal is not present, only LOPP loads are sequenced).

(1) **Loss of Preferred Power (LOPP)**—The 6.9 kV Class 1E buses are normally energized from the normal or alternate preferred power supplies. Should the bus voltage decay to ≤ 70% of its nominal rated value, a bus transfer is initiated and the signal will trip the supply breaker, and start the diesel generator. When the bus voltage decays to 30%, large pump motor breakers (6.9 kV) are tripped. The transfer then proceeds to the diesel generator. If the standby

diesel generator is ready to accept load (i.e., voltage and frequency are within normal limits and no lockout exists, and the normal and alternate preferred supply breakers are open), the diesel-generator breaker is signalled to close, following the tripping of the large motors. This accomplishes automatic transfer of the Class 1E bus to the diesel generator. Motor loads will be sequence started as required and shown on Table 8.3-4.

(2) **Loss of Coolant Accident (LOCA)—**When a LOCA occurs, the standby diesel generator is started and remains in the standby mode (i.e. voltage and frequency are within normal limits and no lockout exists) unless a LOPP signal is also present as discussed in (3) and (4) below. In addition, with or without a LOPP, the load sequence timers are started if the 6.9 kV emergency bus voltage is greater than 70%, and loads are applied to the bus at the end of preset times.

Each load has an individual load sequence timer which will start if a LOCA occurs and the 6.9 kV emergency bus voltage is greater than 70%, regardless of whether the bus voltage source is normal or alternate preferred power or the diesel generator. The load sequence timers are part of the low level circuit logic for each LOCA load and do not provide a means of common mode failure that would render both onsite and offsite power unavailable. If a timer failed, the LOCA load could be applied manually provided the bus voltage is greater than 70%.

(3) **LOPP following LOCA—**If the bus voltage (normal or alternate preferred power) is lost during post-accident operation, transfer to the diesel generator occurs as described in (1) above.

(4) **LOCA following LOPP—**If a LOCA occurs following loss of the normal or alternate preferred power supplies, the LOCA signal sequences ESF equipment onto the bus as required. Running loads are not tripped. Automatic (LOCA + LOPP) time delayed load sequencing assures that the diesel-generator will not be overloaded.

(5) **LOCA when diesel generator is parallel with preferred power source during test—**If a LOCA occurs when the diesel generator is paralleled with either the normal preferred power or the alternate preferred power source, the D/G will automatically be disconnected from the 6.9 kV emergency bus regardless of whether the test is being conducted from the local control panel or the main control room.

(6) **LOPP during diesel generator paralleling test—**If the normal preferred power supply is lost during the diesel-generator paralleling test, the diesel-generator circuit breaker is automatically tripped. Transfer to the diesel generator then proceeds as described in (1).

If the alternate preferred source is used for load testing the diesel generator, and the alternate preferred source is lost, the diesel-generator breaker is automatically tripped. Load shedding and bus transfer will proceed as described in (1).

(7) **Restoration of offsite power—**Upon restoration of offsite power, the Class 1E bus(es) can be transferred back to the offsite source by manual operation only.

(8) **Protection against degraded voltage—**For protection of the Division I, II and III electrical equipment against the effects of a sustained degraded voltage, the 6.9 kV divisional bus voltages are monitored. If the bus voltage increases to 110% of its rated value, the over-voltage will be annunciated in the control room. If the bus voltage degrades to 90% (or below) of its rated value, and after a time delay (to prevent triggering by transients), under-voltage will be annunciated in the control room. Simultaneously, a protective relay timer is started to allow the operator to take corrective action. The timer settings are based on the system load analysis* such that the respective feeder breaker trips, which consequently starts the diesel generator, before any of the Class 1E loads experience degraded conditions exceeding those for which the equipment is qualified. This assures such loads will restart when the diesel generator assumes the degraded bus and sequences its loads. If the bus voltage recovers within the time delay period, the protective timer will reset. Should a LOCA occur during the time delay, or if the degraded voltage condition reaches 70% bus voltage, the feeder breaker with the under-voltage will be tripped instantly. Subsequent bus transfer will be as described above. These bus voltage monitoring schemes are designed in accordance with Section 5.1.2 of IEEE-741.

Equipment is qualified for continuous operation with voltage ±10% of nominal and for degraded voltages below 90% for the time period established in the load analysis* for the degraded voltage protective time delay relay. (See 8.3.4.20 for COL license information.)

* Load analyses will be performed in accordance with IEEE-141, IEEE-242 and/or other acceptable industry standards or practices, for the power distribution system to demonstrate proper sizing of power source and distribution equipment. Such analyses will provide the basis for the degraded voltage protective relay timer settings and other protective relay settings.

(9) **Station Blackout (SBO) considerations**—A station blackout event is defined as the total loss of all offsite (preferred) and onsite Class IE AC power supplies except Class IE AC power generated through inverters from the station batteries. In such an event, the combustion turbine generator (CTG) will automatically start and achieve rated speed and voltage within two minutes. The CTG will then automatically assume pre-selected loads on the plant investment protection (PIP) buses. With the diesel generators unavailable, the reactor operator will manually shed PIP loads and connect the non-Class 1E CTG with the required shutdown loads within ten minutes of the event initiation. Specifically, the operator will energize one of the Class 1E distribution system buses by closing each of the two circuit breakers (via controls in the main control room) between the CTG unit and the Class 1E bus. The circuit breaker closest to the CTG is non-Class 1E and the circuit breaker closest to the Class 1E bus is Class 1E. Later, the operator will energize other safety-related and non-safety-related loads, as appropriate, to complete the shutdown process. See Appendix 1C and Subsection 9.5.11 for further information on Station Blackout and the CTG, respectively.

8.3.1.1.8 Standby AC Power System

The diesel generators comprising the Divisions I, II and III standby AC power supplies are designed to quickly restore power to their respective Class 1E distribution system divisions as required to achieve safe shutdown of the plant and/or to mitigate the consequences of a LOCA in the event of a LOPP. Figure 8.3-1 shows the interconnections between the preferred power supplies and the Divisions I, II and III diesel-generator standby power supplies.

See Subsection 9.5.13.8 for COL license information.

8.3.1.1.8.1 Redundant Standby AC Power Supplies

Each standby power system division, including the diesel generator, its auxiliary systems and the distribution of power to various Class 1E loads through the 6.9 kV and 480V systems, is segregated and separated from the other divisions. No automatic interconnection is provided between the Class 1E divisions. Each diesel generator set is operated independently of the other sets and is connected to the offsite transmission network by manual control only during testing or for bus transfer (see Subsection 8.3.4.21 for COL license information). Each diesel generator and its auxiliary systems are classified Seismic Category I.

8.3.1.1.8.2 Ratings and Capability

The size of each of the diesel-generators serving Divisions I, II and III satisfies the requirements of NRC Regulatory Guide 1.9 and IEEE-387 and conforms to the following criteria:

(1) Each diesel generator is capable of starting, accelerating and supplying its loads in the sequence shown in Table 8.3-4.

(2) Each diesel generator is capable of starting, accelerating and supplying its loads in their proper sequence without exceeding a 25% voltage drop or a 5% frequency drop measured at the bus.

(3) Each diesel generator is capable of starting, accelerating and running its largest motor at any time after the automatic loading sequence is completed, assuming that the motor had failed to start initially.

(4) Each diesel generator is capable of reaching full speed and voltage within 20 seconds after receiving a signal to start, and is capable of being fully loaded within the next 65 seconds as shown in Table 8.3-4. The limiting condition is for the RHR and HPCF injection valves to be open 36 seconds after the receipt of a high drywell or low reactor vessel level signal. Since the motor operated valves are not tripped off the buses, they start to open, if requested to do so by their controls, when power is restored to the bus at 20 seconds. This gives them an allowable travel time of 16 seconds, which is attainable for the valves.

    See Subsection 8.3.4.2 for COL license information.

(5) Each diesel generator is sized to supply its post accident (LOCA) load requirements, and has a continuous load rating of 6.25MV·A @ 0.8 power factor (Figure 8.3-1). The overload rating is 110% of the rated output for a two-hour period out of a 24-hour period. A load profile analysis for each diesel generator will be performed in accordance with acceptable industry standards and/or practices.

(6) Each diesel generator has stored energy (fuel) at the site in its own storage tank with the capacity to operate the standby diesel generator power supply, while supplying post-accident load requirements to a unit for seven days (Subsection 9.5.4.1.1).

(7) Each diesel generator has stored energy (fuel) at the site in its own day tank with the capacity to operate the standby diesel generator power supply while supplying its maximum LOCA load demand for 8 hours. The fuel transfer system automatically maintains the capacity of the day tank (Subsection 9.5.4.2).

(8) Each diesel generator is capable of operating in its service environment during and after any design basis event, without support from the preferred power supply. It can start up and run, with no cooling available, for the time required to bring the cooling equipment into service as it sequences onto the bus (see Subsection 20.3.6, Question/Answer 430.282).

(9) Each diesel generator is capable of restarting with an initial engine temperature equal to the continuous rating full load engine temperature.

(10) Each diesel generator is capable of accepting design load following operation at light or no load for a period of 4 hours. This capability will be demonstrated by the supplier prior to shipment, but is exempt from periodic testing to avoid undue stress to the diesel engine.

(11) Each diesel generator is capable of carrying its continuous load rating for 22 hours following 2 hours of operation at its short time rating.

(12) The maximum loads expected to occur for each division (according to nameplate ratings) do not exceed 90% of the continuous power output rating of the diesel generator.

(13) Each diesel generator's air receiver tanks have capacity for sufficient starts without recharging as defined in Subsection 9.5.6.2.

(14) During diesel generator load sequencing, the frequency will be restored to within 2% of nominal, and voltage will be restored to within 10% of nominal within 60% of each load sequence time interval (see Position 1.4 of Regulatory Guide 1.9).

(15) During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel generator unit will not exceed the nominal speed plus 75% of the difference between nominal speed and the over-speed trip setpoint or 115% of nominal, whichever is lower (see Position 1.4 of Regulatory Guide 1.9).

(16) The transient following the complete loss of load will not cause the speed of the diesel generator unit to attain the over-speed trip setpoint (see Position 1.4 of Regulatory Guide 1.9).

(17) Bus voltage and frequency will recover to 6.9 kV±10% at 60±2% Hz within 10 seconds following trip and restart of the largest load.

(18) Bus voltage and frequency regulation will assure an operating voltage and frequency at the terminals of the Class 1E utilization equipment that is within the utilization equipment tolerance limits.

(19) Each of the above design criteria has the capability of being periodically verified (Subsection 8.3.4.36). However, note exception for Item (10).

8.3.1.1.8.3 Starting Circuits and Systems

Diesel generators A, B and C (Divisions I, II and III, respectively) start automatically on loss of bus voltage. Under-voltage relays are used to start each diesel engine in the event of a drop in bus voltage below preset values for a predetermined period of time. Low-water-level switches and drywell high-pressure switches in each division are used to initiate diesel start under accident conditions. Manual start capability is also provided and shall be periodically verified (Subsection 8.3.4.36). The Class 1E batteries provide power for the diesel control and protection circuits. The transfer of the Class 1E buses to standby power supply is automatic, should this become necessary, on loss of preferred power. After the breakers connecting the buses to the preferred power supplies are open, the diesel-generator breaker is closed when required generator voltage and frequency are established.

Diesel generators A, B and C are designed to start and attain required voltage and frequency within 20 seconds. The generator, and voltage regulator are designed to permit the unit to accept the load and to accelerate the motors in the sequence within the time requirements. The voltage drop caused by starting the large motors does not exceed the requirements set forth in Regulatory Guide 1.9, and proper acceleration of these motors is ensured. A transient voltage analysis will be performed in accordance with acceptable industry practices. Control and timing circuits are provided, as appropriate, to ensure that each load is applied automatically at the correct time. The design provides capability for periodic verification of these criteria. Each diesel generator set is provided with two independent starting air systems.

8.3.1.1.8.4 Automatic Shedding, Loading and Isolation

The diesel generator is connected to its Class 1E bus only when the incoming preferred source breakers have been tripped (Subsection 8.3.1.1.7). Under this condition, major loads are tripped from the Class 1E bus, except for the Class 1E 480V power center feeders, before closing the diesel generator breaker.

The large motor loads are later re-applied sequentially and automatically to the bus after closing of the diesel-generator breaker.

8.3.1.1.8.5 Protection Systems

The diesel generator is shut down and the generator breaker tripped under the following conditions during all modes of operation and testing operation:

(1) Engine over-speed trip; and

(2) Generator differential relay trip.

These and other protective functions (alarms and trips) of the engine or the generator breaker and other off-normal conditions are annunciated in the main control room and/or locally as shown in Table 8.3-5. Local alarm/annunciation points have auxiliary isolated switch outputs. These outputs provide inputs to alarm/annunciator refresh units in the main control room for identification of the diesel generator and general anomaly concerned. Those anomalies which cause the respective D/G to become inoperative are so indicated in accordance with Regulatory Guide 1.47 and BTP PSB-2.

8.3.1.1.8.6 Local and Remote Control and Indication

Each diesel generator is capable of being started or stopped manually from the main control room. Start/stop control and bus transfer control may be transferred to a local control station in the diesel generator area by operating key switches at that station. When the diesel is started from the main control room or the local control station, the engine will attain rated voltage and frequency, then remain on standby without load sequencing (i.e., the generator breaker will remain open). This function is capable of being periodically tested (Subsection 8.3.4.36).

Control room indications are provided for system output, i.e., volts, amps, watts, vars, frequency, synchronization, field volts, field amps, engine speed, and watt-hours. Diesel generator status (i.e., “RUN”, “STOP”) indication is provided for the Remote Shutdown System.

8.3.1.1.8.7 Engine Mechanical Systems and Accessories

Descriptions of these systems and accessories are given in Section 9.5.

8.3.1.1.8.8 Interlocks and Testability

Each diesel generator, when operating other than in test mode, is totally independent of the preferred power supply. Interlocks from the LOCA and LOPP sensing circuits terminate parallel operation test and cause the diesel generator to automatically revert and reset to its standby mode if either signal appears during a test. These interlocks are designed to be testable, and are periodically tested per 8.3.4.21. A lockout or maintenance mode removes the diesel generator from service. The inoperable status is indicated in the control room.

8.3.1.1.8.9 Reliability Qualification Testing

The qualification tests are performed on the diesel generator per IEEE-387 as modified by Regulatory Guide 1.9 requirements.

8.3.1.2 Analysis

The general AC power systems are illustrated in Figure 8.3-1. The analysis demonstrates compliance of the Class 1E AC power system to NRC General Design Criteria (GDC), NRC Regulatory Guides and other criteria consistent with the Standard Review Plan (SRP).

Table 8.1-1 identifies the onsite power system and the associated codes and standards applied in accordance with Table 8-1 of the SRP. Criteria are listed in order of the listing on the table, and the degree of conformance is discussed for each. Any exceptions or clarifications are so noted.

(1) General Design Criteria (GDC):

(a) Criteria: GDCs 2, 4, 17, 18 and 50.

(b) Conformance: The AC power system is in compliance with these GDCs. The GDCs are generically addressed in Subsection 3.1.2.

(2) Regulatory Guides (RGs):

(a) RG 1.6—Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

(b) RG 1.9—Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants

(c) RG 1.32—Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE-741.

Section 5.2 of IEEE-308 is addressed for the ABWR as follows:

Those portions of the Class 1E power system that are required to support safety systems in the performance of their safety functions meet the requirements of IEEE-603. In addition, those other normal components, equipment, and systems (that is, overload devices, protective relaying, etc.) within the Class 1E power system that have no direct safety function and are only provided to increase the availability or reliability of the Class 1E power system meet those requirements of IEEE-603 which assure that those components, equipment, and systems do not degrade the Class 1E power system below an acceptable level. However, such elements are not required to meet criteria as defined in IEEE-603 for: operating bypass, maintenance bypass, and bypass indication.

(d) RG 1.47—Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

(e) RG 1.63—Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

(f) RG 1.75—Physical Independence of Electric Systems

Regarding Position C-1 of Regulatory Guide 1.75 (Subsection 8.3.1.1.1), the non-Class 1E FMCRD motors are supplied power from the Division 1 Class 1E bus through three dedicated power center transformers. The Class 1E load breaker for the bus is tripped by fault current for faults in the non-Class 1E load. There is also a zone selective interlock provided from the load breaker to the Class 1E bus supply breaker so that the supply breaker is delayed from tripping while fault current is flowing in the non-Class 1E load feeder. This meets the intent of the Regulatory Guide position in that the main supply breaker is prevented from tripping on faults in the non-safety-related loads. The transfer switch downstream of the load feeder is associated, and meets Class 1E requirements.

There are three 6.9 kV electrical divisions which are independent load groups backed by individual diesel-generator sets. The low voltage AC systems consists of four divisions which are backed by independent DC battery, charger and inverter systems.

There is no sharing of standby power system components between divisions, and there is no sharing of diesel-generator power sources between units, since the ABWR is a single-unit plant design.

Each standby power supply for each of the three divisions is composed of a single generator driven by a diesel engine having fast start characteristics and sized in accordance with Regulatory Guide 1.9.

Table 8.3-1 and 8.3-2 show the rating of each of the Divisions I, II and III diesel generators, respectively, and the maximum coincidental load for each.

(g) RG 1.106—Thermal Overload Protection for Electric Motors on Motor-Operated Valves

Safety functions which are required to go to completion for safety have their thermal overload protection devices in force during normal plant operation but the overloads are bypassed under accident conditions per Regulatory Position 1.(b) of the guide. These overloads and the overload bypasses meet the requirements of IEEE-603, and are capable of being periodically tested (Subsection 8.3.4.24).

(h) RG 1.108—Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants

(i) RG 1.118—Periodic Testing of Electric power and Protection Systems

(j) RG 1.153—Criteria for Power, Instrumentation, and Control Portions of Safety Systems

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE-741.

(k) RG 1.155—Station Blackout

See Appendix 1C

(3) Branch Technical Positions (BTPs):

(a) BTP ICSB 8 (PSB – Use of Diesel Generator Sets for Peaking)

(b) BTP ICSB 18 (PSB)—Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves.

(c) BTP ICSB 21—Guidance for Application of Regulatory Guide 1.47

(d) BTP PSB 1—Adequacy of Station Electric Distribution System Voltages

(e) BTP PSB 2—Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status

The onsite AC power system is designed consistent with these positions.

(4) Other SRP Criteria:

(a) NUREG/CR 0660—Enhancement of Onsite Diesel Generator Reliability

As indicated in Subsection 8.1.3.1.2.4, the operating procedures and training of personnel are outside of the scope of the ABWR Standard Plant. NUREG/CR 0660 is therefore imposed as an interface requirement for the COL applicant. (Subsection 8.1.4.1)

(b) NRC Policy Issue On Alternate Power for Non-safety Loads

This policy issue states that "...an alternate power source be provided to a sufficient string of non-safety loads so that forced circulation could be maintained, and the operator would have available to him the complement of non-safety equipment that would most facilitate his ability to bring the plant to a stable shutdown condition, following a loss of the normal power supply and plant trip." (Quote from EPRI Evolutionary SER, Section 4.2.1, Page 11.4-4, May 1992.)

The ABWR reserve auxiliary transformer has the same rating as the three unit auxiliary transformers, and therefore can assume the full load of any one unit auxiliary transformer (Subsection 8.2.1.2). The interconnection capability for the ABWR is such that any plant loads can be manually connected to receive power from any of the six sources (i.e., the two switching stations, the combustion turbine, and the three diesel generators). Administrative controls are provided to prevent paralleling of sources (Subsection 8.3.4.15). The ABWR therefore exceeds the requirements of the policy issue.

(5) Other Criteria

(a) IEEE-741—"Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations"

The ABWR fully meets the requirements of this standard.

8.3.2 DC Power Systems

8.3.2.1 Description

8.3.2.1.1 General Systems

A DC power system is provided for switchgear control, control power, instrumentation, critical motors and emergency lighting in control rooms, switchgear rooms and fuel handling areas. Four independent Class 1E 125 VDC divisions, three independent non-Class 1E 125 VDC load groups and one non-Class 1E 250 VDC computer and motor power supply are provided. See Figures 8.3-4 for the single lines.

Each battery is separately housed in a ventilated room apart from its charger and distribution panels. Each battery feeds a DC distribution switchgear panel which in turn feeds local distribution panels and, where required, DC motor control centers. An emergency eye wash is supplied in each battery room.

All batteries are sized so that designed loads will not exceed warranted capacity at end-of-installed-life with 100% design demand.

8.3.2.1.1.1 Class 1E 125 VDC System

The 125 VDC system provides a reliable control and switching power source for the Class 1E systems.

Each 125 VDC battery is provided with a charger, and a standby charger shared by two divisions.

The capacity of each of the Class 1E battery chargers is based on the largest combined demands of the various continuous steady-state loads, plus 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.

The battery chargers are load limiting battery replacement type chargers capable of operating without a battery connected to the bus. They are also designed to prevent the AC power supply from becoming a load on the battery. They also have provisions to isolate transients from the AC system from affecting the DC system; and conversely, provisions to isolate transients from the DC system from affecting the AC system. The battery charger system is sized in accordance with the guidelines of IEEE-946. The design of the DC system includes the capability to periodically verify the required capacity for each of the battery charger power supplies (Subsection 8.3.4.35).

Batteries are sized for the DC load in accordance with IEEE-485.

In accordance with this standard, each of the four Class 1E 125V batteries:

(1) Is capable of starting and operating its required steady state and transient loads

(2) Is immediately available during both normal operations and following loss of power from the alternating current systems

(3) Has sufficient stored energy to provide an adequate source of power for starting and operating all required LOCA and/or LOPP loads and circuit breakers for two hours with no AC power

(4) Has sufficient stored energy to provide power in excess of the capacity of the battery charger when needed for transients

(5) Has a capacity design margin of 5 to 15% to allow for less than optimum operating conditions

(6) Has a 25% capacity design margin to compensate for battery aging

(7) Has a 19% capacity design margin to allow for the lowest expected electrolyte temperature of 10°C

(8) Has a number of battery cells that correctly matches the battery-to-system voltage limitations

(9) Bases the first minute of the batteries' duty cycle on the sum of all momentary, continuous, and non-continuous loads that can be expected to operate during the one minute following a LOCA and/or LOPP

(10) Is designed so that each battery's capacity can periodically be verified

The battery output breaker has an over-current trip and interrupts fault current flow from the battery to a bus fault. A combination disconnect switch and fuse is an acceptable alternate for the battery output breaker. The charger output breaker is used as a disconnect switch only, because the charger is load limiting and therefore protects itself. Bus load breakers have over-current trips coordinated with the battery output breaker. Fault current necessary to trip the load breakers is supplied by the battery because the battery charger is load limiting.

The batteries are installed in accordance with industry recommended practice as defined in IEEE-484, and meet the recommendations of Section 5 of IEEE-946 (Subsection 8.3.4.32).

8.3.2.1.2 Class 1E DC Loads

The 125 VDC Class 1E power is required for emergency lighting, diesel-generator field flashing, control and switching functions such as the control of 6.9 kV and 480V switchgear, control relays, meters and indicators, multiplexers, vital AC power supplies, as well as DC components used in the reactor core isolation cooling system.

The four divisions that are essential to the safe shutdown of the reactor are supplied from four independent Class 1E 125 VDC buses.

8.3.2.1.3 Class 1E Station Batteries and Battery Chargers, General Considerations

The four ESF divisions are supplied from four independent Class 1E 125 VDC systems (Figure 8.3-4). Each of the Class 1E 125 VDC systems has a 125 VDC battery, a battery charger and a distribution panel. One standby battery charger can be connected to either of two divisions and another standby battery charger can be connected to either of two other divisions. Kirk key interlocks prevent cross connection between divisions. The main DC distribution buses include distribution panels, drawout-type breakers and molded case circuit breakers.

The Class 1E 125 VDC systems supply DC power to Divisions I, II, III and IV, respectively, and are designed as Class 1E equipment in accordance with IEEE-308. They are designed so that no single failure in any 125 VDC system will result in conditions that prevent safe shutdown of the plant with the remaining AC power divisions. The plant design and circuit layout from these DC systems provide physical separation of the equipment, cabling and instrumentation essential to plant safety.

Each division of the system is located in an area separated physically from other divisions. All the components of Class 1E 125 VDC systems are housed in Seismic Category I structures.

8.3.2.1.3.1 Class 1E 125 VDC Systems Configuration

Figure 8.3-4 shows the overall 125 VDC system provided for Class 1E Divisions I, II, III and IV. One divisional battery charger is used to supply each divisional DC distribution panel bus and its associated battery. The divisional battery charger is normally fed from its divisional 480V MCC bus, with no automatic interconnection or transfer between buses. Also, there are no manual interconnections between DC divisions except those involving the standby battery chargers, as described below.

Each Class 1E 125 VDC battery is provided with a charger, and a standby charger shared by two divisions, each of which is capable of recharging its battery from a discharged state to a fully charged state while handling the normal, steady-state DC load. Cross connection between two divisions through a standby charger is prevented by at least two interlocked breakers, kept normally open, in series in each potential cross-connect path. (Figure 8.3-4 and Subsection 8.3.4.18.)

The maximum equalizing charge voltage for Class 1E batteries is 140 VDC. The DC system minimum discharge voltage at the end of the discharge period is 1.75 VDC per cell (105V for the battery). The operating voltage range of Class 1E DC loads is 100 to 140V.

The batteries have sufficient stored energy to operate connected Class 1E loads continuously or intermittently as required for at least two hours without recharging. During the station blackout event, the load reductions also extend the times these batteries are available. Under such conditions the division I battery has the capacity to support RCIC operation for approximately 8 hours (See Subsection 19E.2.1.2.2). Each distribution circuit is capable of transmitting sufficient energy to start and operate all required loads in that circuit.

A capacity and voltage drop analysis will be performed in accordance with IEEE-141 to assure that power sources and distribution equipment will be capable of transmitting sufficient energy to start and operate all required loads for all plant conditions.

A load capacity analysis has been performed based on IEEE-485, and submitted on the docket as part of letter transmittals dated September 27, 1991, November 27, 1991, and April 3, 1992, for estimated Class 1E DC battery loads as of September, 1989. A final analysis will be performed when specific battery parameters are known.

An initial composite test of onsite AC and DC power systems is called for as a prerequisite to initial fuel loading. This test will verify that each battery capacity is sufficient to satisfy a safety load demand profile under the conditions of a LOCA and loss of preferred power.

Thereafter, periodic capacity tests will be conducted in accordance with IEEE-450. These tests will ensure that the battery has the capacity to continue to meet safety load demands.

8.3.2.1.3.1.1 Class 1E Electric Equipment Considerations

The following guidelines are utilized for Class 1E equipment.

(1) Motors are sized in accordance with NEMA standards. The manufacturer's ratings are at least large enough to produce the starting, pull-in and driving torque needed for the particular application, with due consideration for capabilities of the power sources. Plant design specifications for electrical equipment require such equipment be capable of continuous operation for voltages from 100 to 140 VDC.

(2) The selection of motor insulation such as Class F, H or B is a design consideration based on service requirements and environment. The Class 1E motors are qualified by tests in accordance with IEEE 334.

(3) Power sources, distribution panels, MCCs, and their circuit breakers, battery, and battery charger circuit breakers are sized to supply their load requirements.

(4) Power sources, distribution equipment and branch circuits are designed to maintain voltage within acceptable limits. Load and voltage drop analyses will be performed from the source to the utilization equipment in accordance with IEEE 946 and/or other acceptable industry standards or practices to assure that power sources and distribution equipment will be capable of transmitting sufficient energy to start and operate all the required loads for all designed plant conditions.

(5) Capacity of motor control centers, and distribution panels and their circuit breakers is equal to or greater than the maximum available fault current to which it is exposed under all design modes of operation until the fault is cleared.

    Interrupting capability of the Class 1E breakers is selected to interrupt the available short-circuit current at the circuit breaker load terminals. Short circuit analyses will be performed in accordance with IEEE 946 and/or other acceptable industry standards or practices to determine fault currents.

(6) Breaker coordination analyses will be performed in accordance with IEEE 141, 242, and/or other acceptable industry standards or practices.

See Subsection 8.3.4.6 for COL license information.

8.3.2.1.3.2 Non-Class 1E 125 VDC System

A non-class 1E 125 VDC power supply, Figure 8.3-4, is provided for non-Class 1E switchgear, valves, converters, transducers, controls and instrumentation. The system has three load groups with one battery, charger and bus per load group. There are bus tie breakers between buses. Normal operation is with bus tie breakers open and interlocks prevent paralleling batteries. Each load group's battery and charger may be removed from service as a unit for maintenance or testing. A battery can be recharged by its charger prior to being placed back into service.

One backup charger is provided and is connectable to any of the three buses, one bus at a time, under control of Kirk key interlocks to:

(1) Perform extended maintenance on the normal charger for the load group.

(2) To make a live transfer of a bus to supply power from the bus of another load group without paralleling the two batteries.

The chargers are load limiting battery replacement type chargers capable of operation without a battery connected to the bus. The backup charger may be supplied from the AC supply of any one of the three non-Class 1E load groups. It may be used to charge any one battery at a given time. For example the load Group B battery may be charged from load Groups A or B or C AC power via the backup charger.

Each bus is connectable to either of the other two buses via Kirk key interlocked tie breakers. The Kirk key interlock system allows paralleling of chargers. Since the chargers are self load limiting, parallel operation is acceptable. The Kirk key interlock system prevents parallel operation of batteries. This is to prevent the possibility of paralleling batteries which have different terminal voltages and experiencing a large circulating current as a result.

The battery output breaker has an over-current trip and interrupts fault current flow from the battery to a bus fault. A combination disconnect switch and fuse is an acceptable alternate for the battery output breaker. The charger output breaker is used as a disconnect switch only, because the charger is load limiting and therefore protects itself. Bus load breakers have over-current trips coordinated with the battery output breaker. Tripping current for the load breakers is supplied by the battery.

8.3.2.1.3.3 Non-Class 1E 250 VDC Power Supply

A non-Class 1E 250 VDC power supply, Figure 8.3-4, is provided for the computers and the turbine turning gear motor. The power supply consists of one 250 VDC battery and two chargers. The normal charger is fed by 480 VAC from either the load Group A or load Group C Turbine Building load centers. Selection of the desired AC supply is by a mechanically interlocked transfer switch. The standby charger is fed from a load Group A control building motor control center. Selection of the normal or the standby charger is controlled by key interlocked breakers. A 250 VDC central distribution board is provided for connection of the loads, all of which are non-Class 1E.

The non-Class 1E 250 VDC battery and associated non-Class 1E equipment is located on the same floor as the Class 1E batteries and associated equipment within the control building. However, the non-Class 1E equipment area is separated from the Class 1E areas by the control building load bearing walls. Therefore, the non-Class 1E equipment cannot damage the Class 1E equipment during a seismic event.

8.3.2.1.3.4 Ventilation

Battery rooms are ventilated to remove the minor amounts of gas produced during the charging of batteries.

8.3.2.1.3.5 Station Blackout

Station blackout performance is discussed in Subsection 8.3.1.1.7(9) and Appendix 1C. See Subsections 9.5.13.19, 9.5.13.20, and 9.5.13.21 for COL license information.

8.3.2.1.3.6 Non-Class 1E Electrical Equipment Considerations

The following guidelines are utilized for non-Class 1E equipment.

(1) Motors are sized in accordance with NEMA standards. The manufacturer’s ratings are at least large enough to produce the starting, pull-in and driving torque needed for the particular application, with due consideration for capabilities of the power sources. Plant design specifications for electrical equipment require such equipment be capable of continuous operation for voltages from 100 to 140 VDC or 210 to 280 VDC as appropriate.

(2) The selection of motor insulation such as Class F, H or B is a design consideration based on service requirements and environment.

(3) Power sources, distribution panels, MCCs, and their circuit breakers, battery, and battery charger circuit breakers are sized to supply their load requirements.

(4) Power sources, distribution equipment and branch circuits are designed to maintain voltage within acceptable limits. Load and voltage drop analyses will be performed in accordance with IEEE 946 and/or other acceptable industry standards or practices to assure that power sources and distribution equipment will be capable of transmitting sufficient energy to start and operate all the required loads for all designed plant conditions.

(5) Capacity of motor control centers, and distribution panels and their circuit breakers is equal to or greater than the maximum available fault current to which it is exposed under all design modes of operation until the fault is cleared.

Interrupting capability of the Class 1E breakers is selected to interrupt the available short-circuit current at the circuit breaker load terminals. Short circuit analyses will be performed in accordance with IEEE 946 and/or other acceptable industry standards or practices to determine fault currents.

(6) Breaker coordination analyses will be performed in accordance with IEEE 141, 242, and/or other acceptable industry standards or practices.

8.3.2.2 Analysis

8.3.2.2.1 General DC Power Systems

The 480 VAC power supplies for the divisional battery chargers are from the individual Class 1E MCC to which the particular 125 VDC system belongs (Figure 8.3-4). In this way, separation between the independent systems is maintained and the AC power provided to the chargers can be from either preferred or standby AC power sources. The DC system is so arranged that the probability of an internal system failure resulting in loss of that DC power system is extremely low. Important system components are either self-alarming on failure or capable of clearing faults or being tested during service to detect faults. Each battery set is located in its own ventilated battery room. All abnormal conditions of important system parameters such as charger failure or low bus voltage are annunciated in the main control room and/or locally. Displays for battery voltage, DC amperes, breakers/disconnect switch position and ground detection are provided in the main control room.

Power circuit breakers in each division receive control power from the batteries in their respective division ensuring the following:

(1) The unlikely loss of one 125 VDC system does not jeopardize the Class 1E feed supply to the Class 1E buses.

(2) The differential relays in one division and all the interlocks associated with these relays are from one 125 VDC system only, thereby eliminating any cross connections between the redundant DC systems.

8.3.2.2.2 Regulatory Requirements

The following analyses demonstrate compliance of the Class 1E Divisions I, II, III and IV DC power systems to NRC General Design Criteria, NRC Regulatory Guides and other criteria consistent with the standard review plan. The analyses establish the ability of the system to sustain credible single failures and retain their capacity to function.

The following list of criteria is addressed in accordance with Table 8.1-1 which is based on Table 8-1 of the Standard Review Plan (SRP). In general, the ABWR is designed in accordance with all criteria. Any exceptions or clarifications are so noted.

(1) General Design Criteria (GDC):

(a) Criteria: GDCs 2, 4, 17, and 18.

(b) Conformance: The DC power system is in compliance with these GDCs. The GDCs are generically addressed in Subsection 3.1.2.

(2) Regulatory Guides (RGs):

(a) RG 1.6—Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

(b) RG 1.32—Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE-741.

Section 5.2 of IEEE-308 is addressed for the ABWR as follows:

Those portions of the Class 1E power system that are required to support safety systems in the performance of their safety functions meet the requirements of IEEE-603. In addition, those other normal components, equipment, and systems (that is, overload devices, protective relaying, etc.) within the Class 1E power system that have no direct safety function and are only provided to increase the availability or reliability of the Class 1E power system meet those requirements of IEEE-603 which assure that those components, equipment, and systems do not degrade the Class 1E power system below an acceptable level. However, such elements are not required to meet criteria as defined in IEEE-603 for: operating bypass, maintenance bypass, and bypass indication.

(c) RG 1.47—Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

(d) RG 1.63—Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

(e) RG 1.75—Physical Independence of Electric Systems

The DC emergency standby lighting system circuits up to the lighting fixtures are associated and are routed in seismic Category I raceways. However, the lighting fixtures themselves are not seismically qualified, but are seismically supported. This is acceptable to the Class 1E power supply because of over-current protective device coordination. The cables and circuits from the power source to the lighting fixtures are associated. The bulbs cannot be seismically qualified. The bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

Besides the emergency lighting circuits, any other associated circuits added beyond the certified design must be specifically identified and justified. Associated circuits are defined in Section 5.5.1 of IEEE-384-1981, with the clarification for Items (3) and (4) that non-Class 1E circuits being in an enclosed raceway without the required physical separation or barriers between the enclosed raceway and the Class 1E or associated cables makes the circuits (related to the non-Class 1E cable in the enclosed raceway) associated circuits.

(f) RG 1.106—Thermal Overload Protection for Electric Motors on Motor-Operated Valves

Safety functions which are required to go to completion for safety have their thermal overload protection devices in force during normal plant operation but the overloads are bypassed under accident conditions per Regulatory Position 1.(b) of the guide. These overloads and the overload bypasses meet the requirements of IEEE-603, and are capable of being periodically tested (Subsection 8.3.4.24).

(g) RG 1.118—Periodic Testing of Electric Power and Protection Systems

(h) RG 1.128—Installation Designs and Installation of Large Lead Storage Batteries for Nuclear Power Plants

(i) RG 1.129—Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants

(j) RG 1.153—Criteria for Power, Instrumentation, and Control Portions of Safety Systems

Fuses cannot be periodically tested to verified setpoints, and are exempt from such requirements per Section 4.1.7 of IEEE-741.

(k) RG 1.155—Station Blackout

See Appendix 1C.

The Class 1E DC power system is designed in accordance with the listed Regulatory Guides. It is designed with sufficient capacity, independence and redundancy to assure that the required power support for core cooling, containment integrity and other vital functions is maintained in the event of a postulated accident, assuming a single failure.

The batteries consist of industrial-type storage cells, designed for the type of service in which they are used. Ample capacity is available to serve the loads connected to the system for the duration of the time that alternating current is not available to the battery charger. Each division of Class 1E equipment is provided with a separate and independent 125 VDC system.

The DC power system is designed to permit inspection and testing of all important areas and features, especially those which have a standby function and whose operation is not normally demonstrated.

(3) Branch Technical Positions (BTPs):

BTP ICSB 21—Guidance for Application of Regulatory Guide 1.47.

The DC power system is designed consistent with this criteria.

(4) Other SRP Criteria:

According to Table 8-1 of the SRP, there are no other criteria applicable to DC power systems.

(5) Other Criteria

(a) IEEE-946 “Recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Generating Stations”

(b) IEEE-741 “Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations”

(c) IEEE-485 “Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations”

The ABWR fully meets the requirements of these standards.

8.3.3 General Onsite Power System Information

The NRC Standard Review Plan (SRP) format identifies Subsections 8.3.1 and 8.3.2 as AC and DC power systems, respectively. However, some information is applicable to both AC and DC systems. This information is presented in this section in order to avoid the need for repetition in Subsections 8.3.1 and 8.3.2.

8.3.3.1 Physical Separation and Independence

All cables are supported in raceways (i.e., tray, conduit, or wireways). All electrical equipment is separated in accordance with IEEE-384, Regulatory Guide 1.75 and General Design Criterion 17, with the following clarifying interpretations of IEEE-384:

(1) Enclosed solid metal raceways are required for separation between Class 1E or associated cables of different safety divisions or between Class 1E or associated cables and non-Class 1E cables if the vertical separation distance is less than 1.5m, the horizontal separation distance is less than 0.9m and the cables are in the same fire area;

(2) Both groupings of cables requiring separation per item one must be enclosed in solid metal raceways and must be separated by at least 2.54 cm.

To meet the provisions of Policy Issue SECY-89-013, which relates to fire tolerance, three hour rated fire barriers are provided between areas of different safety divisions throughout the plant except in the primary containment and the control room complex. See Subsection 9.5.1.0 for a detailed description of how the provisions of the Policy Issue are met.

The overall design objective is to locate the divisional equipment and its associated control, instrumentation, electrical supporting systems and interconnecting cabling such that separation is maintained among all divisions. Redundant divisions of electric equipment and cabling are located in separate rooms or fire areas wherever possible.

Electric equipment and wiring for the Class 1E systems which are segregated into separate divisions are separated so that no design basis event is capable of disabling more than one division of any ESF total function.

The protective actions (that is, the initiation of a signal with the sense and command features, or the operation of equipment within the execute features, for the purpose of accomplishing a safety function) of each safety-related load group is electrically independent of the protective actions provided by redundant safety-related load groups. Cross talk between divisions to facilitate the two-out-of-four logic for the Safety System Logic and Control (SSLC) is accomplished by fiber-optic medium.

The Class 1E divisional AC switchgear, power centers, battery rooms and DC distribution panels and MCCs are located to provide separation and electrical isolation among the divisions. Separation is provided among divisional cables being routed between the equipment rooms, the Main Control Room, containment and other processing areas. Equipment in these areas is divided into Divisions I, II, III and IV and separated by barriers formed by walls, floors, and ceilings. The equipment is located to facilitate divisional separation of cable trays and to provide access to electrical penetration assemblies. Exceptions to this separation objective are identified and analyzed as to equivalency and acceptability in the fire hazard analysis (Section 9A.5).

The electrical penetration assemblies are safety-related, and are located around the periphery of the containment and at different elevations to facilitate reasonably direct routing to and from the equipment. No penetration carries cables of more than one division. Electrical penetrations are classified as seismic category I.

Separation within the main control room is designed in accordance with IEEE-384, and is discussed in Subsection 8.3.3.6.2.2.3.

Wiring for all Class 1E equipment indicating lights is an integral part of the Class 1E cables used for control of the same equipment and are considered to be Class 1E circuits.

Associated circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated; or associated circuits remain with or are physically separated in the same manner as those Class 1E circuits with which they are associated, from the Class 1E equipment to and including an isolation device. Associated circuits (including their isolation devices or their connected safety or non-safety system loads without isolation devices) are subject to all requirements placed on Class 1E circuits.

The careful placing of equipment is important to the necessary segregation of circuits by division. Deliberate routing in separate fire areas on different floor levels, and in embedded ducts is employed to achieve physical independence.

8.3.3.2 Testing

The design provides for periodically testing the chain of power system elements from power supplies through driven equipment to assure that Class 1E equipment is functioning in accordance with design requirements. Such online testing is greatly enhanced by the design, which utilizes three independent power divisions. For equipment which cannot be tested during plant operation, the reliability is such that testing can be performed during plant shutdown (for example, safety relief valves and certain isolation valves). The requirements of IEEE-379 Regulatory Guide 1.118 and IEEE-338 are met.

8.3.3.3 Quality Assurance Requirements

A planned quality assurance program is provided in Chapter 17. This program includes a comprehensive system to ensure that the purchased material, manufacture, fabrication, testing and quality control of the equipment in the Class 1E power system conforms to the evaluation of the Class 1E power system equipment vendor quality assurance programs and preparation of procurement specifications incorporating quality assurance requirements. The administrative responsibility and control provided are also described in Chapter 17.

These quality assurance requirements include an appropriate vendor quality assurance program and organization, purchaser surveillance as required, vendor preparation and maintenance of appropriate test and inspection records, certificates and other quality assurance documentation, and vendor submittal of quality control records considered necessary for purchaser retention to verify quality of completed work.

A necessary condition for receipt, installation and placing of equipment in service has been the signing and auditing of QA/QC verification data and the placing of this data in permanent onsite storage files.

8.3.3.4 Environmental Considerations

In addition to the effects of operation in normal service environment, all Class 1E equipment is designed to operate during and after any design basis event, in the accident environment expected in the area in which it is located. All Class 1E electric equipment is qualified to IEEE-323 as discussed in Section 3.11.2.

8.3.3.5 Physical Identification of Safety-Related Equipment

8.3.3.5.1 Power, Instrumentation and Control Systems

Electrical and control equipment, assemblies, devices, and cables grouped into separate divisions are identified so that their electrical divisional assignment is apparent and so that an observer can visually differentiate between Class 1E equipment and wiring of different divisions, and between Class 1E and non-Class 1E equipment and wires. The identification method shall be placed on color coding. All markers within a division shall have the same color. For associated cables treated as Class 1E (see NOTE below), there shall be an “A” appended to the divisional designation (e.g., “A1”). The letter “A” stands for associated. “N” shall be used for non-divisional cables. Associated cables are uniquely identified by a longitudinal stripe or other color coded method and the data on the label. The color of the cable marker for associated cables shall be the same as the related Class 1E cable. Divisional separation requirements of individual pieces of hardware are shown in the system elementary diagrams. Identification of raceways, cables, etc., shall be compatible with the identification of the Class 1E equipment with which it interfaces. Location of identification shall be such that points of change of circuit classification (at isolation devices, etc.) are readily identifiable.

NOTE: Associated lighting circuits are described in Section 9.5.3 and associated Fine Motion Control Rod Drive (FMCRD) circuits are described in Section 8.3.1.1.1. Any other associated circuits added beyond those described above must be specifically identified and justified. Associated circuits are defined in Section 5.5.1 of IEEE-384, with the clarification for Items (3) and (4) that non-Class 1E circuits being in an enclosed raceway without the required physical separation or barriers between the enclosed raceway and the Class 1E or associated cables makes the circuits (related to the non-Class 1E cable in the enclosed raceway) associated circuits.

8.3.3.5.1.1 Equipment Identification

Equipment (panels, racks, junction or pull boxes) of each division of the Class 1E electric system and various CVCF power supply divisions are identified as follows:

(1) The background of the nameplate for the equipment of a division has the same color as the cable jacket markers and the raceway markers associated with that division.

(2) Power system distribution equipment (e.g., motor control centers, switchgear, transformers, distribution panels, batteries, chargers) is tagged with an equipment number the same as indicated on the single-line diagrams.

(3) The nameplates are laminated black and white plastic, arranged to show black engraving on a white background for non-Class 1E equipment. For Class 1E equipment, the nameplates have color coded background with black engraving.

8.3.3.5.1.2 Cable Identification

All cables for Class 1E systems and associated circuits (except those routed in conduits) are tagged every 1.52m prior to (or during) installation. All cables are tagged at their terminations with a unique identifying number (cable number) in addition to the marking characteristics shown below.

Cables shall be marked in a manner of sufficient durability to be legible throughout the life of the plant, and to facilitate initial verification that the installation is in conformance with the separation criteria.

Such markings shall be colored to uniquely identify the division (or non-division) of the cable. Generally, individual conductors exposed by stripping the jacket are also color coded or color tagged [at intervals not to exceed 30.5 cm] such that their division is still discernible. Exceptions are permitted for individual conductors within cabinets or panels where all wiring is unique to a single division. Any non-divisional cable within such cabinets shall be appropriately marked to distinguish it from the divisional cables.

8.3.3.5.1.3 Raceway Identification

All conduit is tagged with a unique conduit number, in addition to the marking characteristics shown below, at 4.57m intervals, at discontinuities, at pull boxes, at points of entrance and exit of rooms and at origin and destination of equipment. Conduits containing cables operating at above 600V (i.e., 6.9 kV) are also tagged to indicate the operating voltage. These markings are applied prior to the installation of the cables.

All Class 1E cable raceways are marked with the division color, and with their proper raceway identification at 4.57m intervals on straight sections, at turning points and at points of entry and exit from enclosed areas. Cable trays are marked prior to installation of their cables.

To help distinguish the neutron-monitoring and scram solenoid cables from other type cables, the following unique voltage class designations and markings are used:

Type of Special Cables	Unique Voltage Class
Neutron-monitoring	VN
Scram solenoid cable	VS

The VN or VS markings are superimposed on the divisional color markings, and placed at the same intervals.

For EMI protection, neutron-monitoring cables are run in their own dedicated divisional conduits and cable trays. Scram solenoid cables are run in a separate conduit for each rod scram group.

The redundant Class 1E, equipment and circuits, assigned to redundant Class 1E divisions and non-Class 1E system equipment and circuits are readily distinguishable from each other without the necessity for consulting reference materials. This is accomplished by color coding of equipment, nameplates, cables and raceways, as described above.

8.3.3.5.1.4 Sensory Equipment Grouping and Designation Letters

Redundant sensory logic/control and actuation equipment for safety-related systems shall be identified by suffix letters. Sensing lines are discussed in Subsection 7.7.1.1.

8.3.3.6 Independence of Redundant Systems

8.3.3.6.1 Power Systems

The Class 1E onsite electric power systems and major components of the separate power divisions are shown on Figure 8.3-1.

Independence of the electric equipment and raceway systems between the different divisions is maintained primarily by firewall-type separation as described in Subsection 8.3.3.6.2. Any exceptions are justified in Appendix 9A, Subsection 9A.5.5.5.

The physical independence of electric power systems complies with the requirements of IEEE-384, General Design Criteria 17, 18 and 21 and NRC Regulatory Guides 1.6 and 1.75.

8.3.3.6.1.1 Class 1E Electric Equipment Arrangement

(1) Class 1E electric equipment and wiring is segregated into separate divisions so that no single credible event is capable of disabling enough equipment to hinder reactor shutdown and removal of decay heat by either of two unaffected divisional load groups or prevent isolation of the containment in the event of an accident. Separation requirements are applied to control power and motive power for all systems involved.

(2) Equipment arrangement and/or protective barriers are provided such that no locally generated force or missile can destroy any RPS, NSSS, ECCS, or ESF functions. In addition, arrangement and/or separation barriers are provided to ensure that such disturbances do not affect both HPCF and RCIC systems.

(3) Routing of wiring/cabling is arranged such as to eliminate, insofar as practical, all potential for fire damage to cables and to separate the redundant divisions so that fire in one division will not propagate to another division. Class 1E and non-Class 1E cables are separated in accordance with IEEE-384 and R.G. 1.75, as explained in 8.3.3.1. This includes cables within cable chases. (Figures 9A.4-1 through 9A.4-16).

(4) An independent raceway system is provided for each division of the Class 1E electric system. The raceways are arranged, physically, top to bottom, as follows (based on the function and the voltage class of the cables):

   (a) V4 = Medium voltage power, 6.9 kV (8kv insulation class).

   (b) V3 = Low voltage power including 480 VAC, 120 VAC, 125 VDC power and all instrumentation and control power supply feeders (600V insulation class).

(c) V2 = High level signal and control, including 125 VDC and 120 VAC controls which carry less than 20A of current and 250 VDC or AC for relay contactor control.

(d) V1 = Low level signal and control, including fiber-optic cables and metallic cables with analog signals up to 55 VDC and digital signal up to 12 VDC.

Power cables (V3) are routed in flexible metallic conduit under the raised floor of the control room. For EMI considerations, power cables are routed in metallic conduit wherever they come in close proximity with low level (V1) cables.

(5) Class 1E power system power supplies and distribution equipment (including diesel generators, batteries, battery chargers, CVCF power supplies, 6.9 kV switchgear, 480V load centers, and 480V motor control centers) are located in areas with access doors that are administratively controlled. In addition, AC and DC distribution panels are located in the same or similar areas as Class 1E power supplies and distribution equipment, or the distribution panels are designed to be locked, so that access to circuit breakers located inside such panels can be administratively controlled. The physical design of the ABWR permits the administrative control of access to Class 1E power equipment areas (Subsection 13.6.3). See Subsection 8.3.4.19 for COL license information.

8.3.3.6.1.2 Electric Cable Installation

(1) **Cable de-rating and cable tray fill—**Base ampacity rating of cables is established as described in Subsection 8.3.3.8.1. Electric cables of a discrete Class 1E electric system division are installed in a cable tray system provided for the same division. Cables are installed in trays in accordance with their voltage ratings and as described in Subsection 8.3.3.6.1.1(4). Tray fill is as established in Subsection 8.3.3.8.

(2) **Cable routing in potentially hostile areas—**Circuits of different safety divisions are not routed through the same potentially hostile area, with the exception of main steam line instrumentation and control circuits and main steam line isolation valves circuits which are exposed to possible steam line break and turbine missiles, respectively. Cable routing in the drywell is discussed in association with the equipment it serves in the “Special Cases” Section 9A.5.

(3) **Sharing of cable trays—**All divisions of Class 1E AC and DC systems are provided with independent raceway systems.

(4) **Cable fire protection and detection**—For details of cable fire protection and detection, refer to Subsections 8.3.3.8 and 9.5.1.

(5) **Cable and raceway markings**—All cables (except lighting and non-vital communications) are tagged at their terminations with a unique identifying number. Colors used for identification of cables and raceways are covered in Subsection 8.3.3.5.

(6) **Spacing of wiring and components in control boards, panels and relay racks**—Separation is accomplished by mounting the redundant devices or other components on physically separated control boards if, from a plant operational point of view, this is feasible. When operational design dictates that redundant equipment be in close proximity, separation is achieved by a barrier or enclosure to retard internal-fire or by a maintained air space in accordance with criteria given in Subsection 8.3.3.6.2.

Redundant Class 1E circuits which must enter a common panel, cabinet, etc., enter through separated apertures and terminate on separated terminal blocks. Where redundant circuits unavoidably terminate on the same device, barriers are provided between the device terminations to ensure circuit separation, or approved isolators (generally optical) are used.

Class 1E and non-Class 1E power, instrumentation, and control cables enter cabinets or panels through separate apertures.

(7) **Electric penetration assembly**—The separation of electric penetration assemblies exceeds the requirements for cables and raceways given in Section 6.1.5 of IEEE-384. Separation by distance (without barriers) is allowed only within the inerted containment. Here, the minimum allowable distances of 0.9m and 1.52m apply, as delineated in Section 6.1.5 of IEEE-384. However, the lesser distances allowed by IEEE-384 for enclosed raceways does not apply to the containment penetrations themselves. Grouping of circuits in penetration assemblies follows the same raceway voltage groupings as described in Subsection 8.3.3.6.1.1(4). Circuits within penetration assemblies follow the same installation method as described in 8.3.3.6.1.2 for divisional assignment.

For the other ends of the penetrations, which are outside the containment in the non-inerted areas, separation by distance alone is not allowed. These are separated by separate rooms, or barriers, or different floor levels. Such walls, barriers or floors are 3-hour fire-rated.

Such separation criteria applies to the following:

(a) Between redundant (divisional) penetrations

(b) Between penetrations containing non-Class 1E and penetrations containing Class 1E or associated circuits

(c) Between penetrations containing Class 1E circuits and other divisional or non-divisional cables

Redundant interrupting protective devices are provided for all electrical circuits (including all instrumentation and control devices, as well as power circuits) going through containment penetrations, if the maximum available fault current (assuming failure of an upstream device) is greater than the continuous current rating of the penetration. This avoids penetration damage in the event of failure of any single protective device to clear a fault within the penetration or beyond it. See Subsection 8.3.4.4 for COL license information.

8.3.3.6.1.3 Compliance with Separation During Design and Installation

Compliance with the criteria which insures independence of redundant systems is a supervisory responsibility during both the design and installation phases. The responsibility is discharged by:

(1) Identifying applicable criteria;

(2) Issuing working procedure to implement these criteria;

(3) Modifying procedures to keep them current and workable;

(4) Checking the manufacturer’s drawings and specifications to ensure compliance with procedures; and

(5) Controlling installation and procurement to assure compliance with approved and issued drawings and specifications.

The equipment nomenclature used on the ABWR standard design is one of the primary mechanisms for ensuring proper separation. Each equipment and/or assembly of equipment carries a single number, (e.g., the item numbers for motor drivers are the same as the machinery driven). Based on these identification numbers, each item can be identified as Class 1E or non-Class 1E, and each Class 1E item can further be identified to its safety separation division. This is carried through and dictates appropriate treatment at the design level during preparation of the manufacturer’s drawings.

Non-Class 1E equipment is separated where desired to enhance power generation reliability, although such separation is not a safety consideration.

Once the safety-related equipment has been identified with a Class 1E safety division, the divisional assignment dictates a characteristic color (Subsection 8.3.3.5) for positive visual identification. Likewise, the divisional identification of all ancillary equipment, cable and raceways match the divisional assignment of the system it supports.

8.3.3.6.2 Independence of Redundant Class 1E Instrumentation and Control Systems

This subsection defines independence criteria applied to Class 1E electrical systems and instrumentation and control equipment. Safety-related systems to which the criteria apply are those necessary to mitigate the effects of anticipated and abnormal operational transients or design basis accidents. This includes all those systems and functions enumerated in Subsections 7.1.1.3, 7.1.1.4, 7.1.1.5, and 7.1.1.6. The term "systems" includes the overall complex of actuated equipment, actuation devices (actuators), logic, instrument channels, controls, and interconnecting cables which are required to perform system safety functions. The criteria outlines the separation requirements necessary to achieve independence of safety-related functions compatible with the redundant and/or diverse equipment provided and postulated events.

8.3.3.6.2.1 General

Separation of the equipment for the systems referred to in Subsections 7.1.1.3, 7.1.1.4, 7.1.1.5, and 7.1.1.6 is accomplished so that they are in compliance with 10CFR50 Appendix A, General Design Criteria 3, 17, 21 and 22, and NRC Regulatory Guides 1.75 (IEEE-384) and 1.53 (IEEE-379).

Independence of mutually redundant and/or diverse Class 1E equipment, devices, and cables is achieved by three-hour fire-rated barriers and electrical isolation. This protection is provided to maintain the independence of nuclear Class 1E circuits and equipment so that the protective function required during and following a design basis event including a single fire anywhere in the plant or a single failure in any circuit or equipment can be accomplished. The exceptional cases where it is not possible to install such barriers have been analyzed and justified in Section 9A.5.

8.3.3.6.2.2 Separation Techniques

The methods used to protect safety systems from results of single failures or events are utilization of safety class structures, three-hour fire-rated protective barriers, and isolation devices.

8.3.3.6.2.2.1 Safety Class Structure

The basic design consideration of plant layout is such that redundant Class 1E circuits and equipment are located in seismic category I structures, and in separate safety class areas (i.e., separate fire zones) insofar as possible. The separation of Class 1E circuits and equipment is such that the required independence will not be compromised by the failure of mechanical systems served by the Class 1E electrical system. For example, Class 1E circuits are routed or protected so that failure of related mechanical equipment of one system cannot disable Class 1E circuits or equipment essential to the operation of a redundant system. This separation of Class 1E circuits and equipments make effective use of features inherent in the plant design such as using different rooms or floors.

8.3.3.6.2.2.2 Three-Hour Fire-Rated Protective Barriers

Three-hour fire-rated protective barriers shall be such that no locally generated fire, or missile resulting from a design basis event (DBE) or from random failure of Seismic Category I equipment can disable a safety-related function. The electrical equipment from the Class 1E power supplies to the distribution centers are separated by 3-hour-rated fire barriers. Beyond the distribution centers, the exceptional cases where it is not possible to install such barriers have been analyzed and justified in Section 9A.5.

Separation in all safety equipment or cable areas shall equal or exceed the requirements of IEEE-384.

8.3.3.6.2.2.3 Main Control Room and Relay Room Panels

The control room area and cable chases are considered non-hazard areas (as defined in Section 6.1.3 of IEEE-384). These areas do not contain potential hazards such as high energy switchgear, power distribution panels, transformers, or rotating equipment; nor are they exposed to potential sources of missiles, pipe failure hazards, or fire hazards.

The protection system and ESF control, logic, and instrument panels/racks shall be located in a safety class structure in which there are no potential sources of missiles or pipe breaks that could jeopardize Class 1E cabinets and raceways.

Control, relay, and instrument panels/racks will be designed in accordance with the following general criteria to preclude failure of non-safety circuits from causing failure of any safety circuit and to preclude failure of one safety circuit from causing failure of any other redundant safety circuit. Single panels or instrument racks will not contain circuits or devices of the redundant protection system or ESF systems except:

(1) Certain operator interface control panels may have operational considerations which dictate that redundant protection system or ESF system circuits or devices be located in a single panel. These circuits and devices are separated horizontally and vertically by a minimum distance of 15.24 cm or by steel barriers or enclosures. Solid or flexible metallic conduit is considered an acceptable barrier, providing 2.54 cm separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(2) Class 1E circuits and devices will also be separated from the non-Class 1E circuits and from each other horizontally and vertically by a minimum distance of 15.24 cm or by steel barriers or enclosures. Solid or flexible metallic conduit is considered an acceptable barrier, providing 2.54 cm separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(3) Where electrical interfaces between Class 1E and non-Class 1E circuits or between Class 1E circuits of different divisions cannot be avoided, Class 1E isolation devices are used (Subsection 8.3.3.6.2.2.4). Solid or flexible metallic conduit is considered an acceptable barrier, providing 2.54 cm separation is maintained between the outside wall of the conduit and other wiring not of the same division.

(4) If two panels containing circuits of different separation divisions are less than 0.9 m apart, there shall be a steel barrier between the two panels. Panel ends closed by steel end plates are considered to be acceptable barriers provided that terminal boards and wireways are spaced a minimum of 2.54 cm from the end plate.

(5) Penetration of separation barriers within a subdivided panel is permitted, provided that such penetrations are sealed or otherwise treated so that fire generated by an electrical fault could not reasonably propagate from one section to the other and disable a protective function.

(6) Class 1E, associated, or non-Class 1E power circuits routed in the control room area are limited to those required to operate systems, equipment, or components located in the control room area (power cables are not permitted to traverse through from one side of the control room area to the other without being terminated in the control room area).

8.3.3.6.2.2.4 Isolation Devices

Where electrical interfaces between Class 1E and non-Class 1E circuits or between Class 1E circuits of different divisions cannot be avoided, Class 1E isolation devices will be used. AC isolation (the FMCRD drives on Division 1 is the only case) is provided by Class1E interlocked circuit breaker coordination as described in Subsection 8.3.1.1.1.

Wiring from Class 1E equipment or circuits which interface with non-Class 1E equipment circuits (i.e., annunciators or data loggers) is treated as Class 1E and retain its divisional identification up to and including its isolation device. The output circuits from this isolation device are classified as non-divisional and shall be physically separated from the divisional wiring.

8.3.3.6.2.3 System Separation Requirements

Specific divisional assignment of safety-related systems and equipment is given in Table 8.3-1. (Note that in Table 8.3-1, diesel generator “A” corresponds with Class 1E electrical Division “I”, “B” with “II”, and “C” with “III”.) Other separation requirements pertaining to the RPS and other ESF systems are given in the following subsections.

8.3.3.6.2.3.1 Reactor Protection (Trip) System (RPS)

The following separation requirements apply to the RPS wiring:

(1) RPS sensors, sensor input circuit wiring, trip channels and trip logic equipment will be arranged in four functionally independent and divisionally separate groups designated Divisions I, II, III and IV. The trip channel wiring associated with the sensor input signals for each of the four divisions provides inputs to divisional logic cabinets which are in the same divisional group as the sensors and trip channels and which are functionally independent and physically separated from the logic cabinets of the redundant divisions.

(2) Where trip channel data originating from sensors of one division are required for coincident trip logic circuits in other divisions, Class 1E isolation devices (i.e., fiber optic medium) will be used as interface elements for signals sent from one division to another such as to maintain electrical isolation between divisions.

(3) Sensor wiring for several trip variables associated with the trip channels of one division may be run together in the same conduits or in the same raceways of that same and only division. Sensor wiring associated with one division will not be routed with any wiring or cabling associated with a redundant division.

(4) The scram solenoid circuits, from the actuation devices to the solenoids of the scram pilot valves of the CRD hydraulic control units, will be run in grounded steel conduits, with no other wiring contained within the conduits, so that each scram group is protected against a hot short to any other wiring by a grounded enclosure. Short sections (< 1m) of flexible metallic conduit will be permitted for making connections within panels and the connections to the solenoids.

(5) Separate grounded steel conduits will be provided for the scram solenoid wiring for each of four scram groups. Separate grounded steel conduits will also be provided for both the A solenoid wiring circuits and for the B solenoid wiring circuits of the same scram group.

(6) Scram group conduits will have unique identification and will be separately routed as Division II and III conduits for the A and B solenoids of the scram pilot valves, respectively. This corresponds to the divisional assignment of their power sources. The conduits containing the scram solenoid group wiring of any one scram group will also be physically separated by a minimum separation distance of 2.54 cm from the conduit of any other scram group, and from metal enclosed raceways which contain either divisional or non-Class 1E (non-divisional) circuits. The scram group conduits may not be routed within the confines of any other tray or raceway system. The RPS conduits containing the scram group wiring for the A and B solenoids of the scram pilot valves (associated with Divisions II and III, respectively), shall be separated from non-enclosed raceways associated with any of the four electrical divisions or non-divisional cables by 0.9m horizontal, or 1.5 m vertical, or with an additional barrier that is separated from any raceway by 2.54 cm.

(7) Any scram group conduit may be routed alongside of any cable or raceway containing either Class 1E circuits (of any division), or any cable or raceway containing non-Class 1E circuits, as long as the conduit itself is not within the boundary of any raceway which contains either the divisional or the non-Class 1E circuits and is physically separated from said cables and raceway boundaries as stated in (6) above. Any one scram group conduit may also be routed along with scram group conduits of the same scram group or with conduits of any of the three other scram groups as long as the minimum separation distance of 2.54 cm is maintained.

(8) The standby liquid control system redundant Class 1E controls will be run as Division I and Division II so that no failure of standby liquid control (SLC) function will result from a single electrical failure in a RPS circuit.

(9) The startup range monitoring (SRNM) subsystem cabling of the NMS cabling under the vessel is treated as divisional. The SRNM cables will be assigned to Division I, II, III and IV. Under the vessel, cables will be enclosed and separated as defined in Subsection 9A.5.5.5.

8.3.3.6.2.3.2 Other Safety-Related Systems

(1) Separation of redundant systems or portions of a system shall be such that no single failure can prevent initiation and completion of an engineered safeguard function.

(2) The inboard and outboard isolation valves are redundant to each other so they are made independent of and protected from each other to the extent that no single failure can prevent the operation of at least one of an inboard/ outboard pair.

(3) Isolation valve circuits require special attention because of their function in limiting the consequences of a pipe break outside the primary containment. Isolation valve control and power circuits are required to be protected from the pipe lines that they are responsible for isolating.

Class 1E isolation valve wiring in the vicinity of the outboard valve (or downstream of the valve) shall be installed in conduits and routed to take advantage of the mechanical protection afforded by the valve operator or other available structural barriers not susceptible to disabling damage from the pipe line break. Additional mechanical protection (barriers) shall be interposed as necessary between wiring and potential sources of disabling mechanical damage consequential to a break downstream of the outboard valve.

(4) The several systems comprising the ECCS have their various sensors, logics, actuating devices and power supplies assigned to divisions in accordance with Table 8.3-1 so that no single failure can disable a redundant ECCS function. This is accomplished by limiting consequences of a single failure to equipment listed in any one division of Table 8.3-1. (Note that in Table 8.3-1, diesel generator "A" corresponds with Class 1E electrical division "I", "B" with "II", and "C" with "III".) The wiring to the ADS solenoid valves within the drywell shall run in rigid conduit. ADS conduit for solenoid A shall be divisionally separated from solenoid B conduit. Short pieces (less than 1m) of flexible conduit may be used in the vicinity of the valve solenoids.

(5) Electrical equipment and raceways for systems listed in Table 8.3-1 shall not be located in close proximity to primary steam piping (steam leakage zone), or be designed for short term exposure to the high temperature leak.

(6) Class 1E electrical equipment located in the suppression pool level swell zone is limited to suppression pool temperature monitors and their feeder cables. The terminations are sealed such that operation would not be impaired by submersion due to pool swell or LOCA. Consistent with their Class 1E status, these devices are also qualified to the requirements of IEEE-323 for the environment in which they are located.

(7) Containment penetrations are so arranged that no design basis event can disable cabling in more than one division. Penetrations do not contain cables of more than one divisional assignment.

(8) Annunciator and computer inputs from Class 1E equipment or circuits are treated as Class 1E and retain their divisional identification up to a Class 1E isolation device. The output circuit from this isolation device is classified as non-divisional.

Annunciator and computer inputs from non-Class 1E equipment or circuits do not require isolation devices.

8.3.3.7 Electrical Penetration Assemblies

When the vendor-unique characteristics of the penetrations are known, the following will be provided:

(1) Fault current clearing-time curves of the electrical penetrations' primary and secondary current interrupting devices plotted against the thermal capability (I^2t) curve of the penetration, along with an analysis showing proper coordination of these curves;

(2) A simplified one-line diagram showing the location of the protective devices in the penetration circuit, with indication of the maximum available fault current of the circuit;

(3) Specific identification and location of power supplies used to provide external control power for tripping primary and backup electrical penetration breakers (if utilized);

(4) An analysis demonstrating the thermal capability of all penetrations is preserved and protected by one of the following:

  (a) The maximum available fault current (including single-failure of an upstream device) is less than the maximum continuous current capacity of the penetration; or

  (b) Redundant circuit protection devices are provided, and are adequately designed and set to interrupt current, in spite of single-failure, at a value below the maximum continuous current capacity of the penetration. Such devices must be located in separate panels or be separated by barriers and must be independent such that failure of one will not adversely affect the other. Furthermore, they must not be dependent on the same power supply.

(5) A demonstration of leak tightness under the severe accident containment pressure and temperature loadings described in Subsection 19F.3.2.2.

(6) Electrical penetrations are designed and tested in accordance with IEEE 317 and Section 6.2.6.2 Containment Penetration Leakage Rate Test (Type B).

Protective devices designed to protect the penetrations are capable of being tested, calibrated and inspected (see Subsection 8.3.4.4).

8.3.3.8 Fire Protection of Cable Systems

The basic concept of fire protection for the cable system in the ABWR design is that it is incorporated into the design and installation rather than added onto the systems. By use of fire resistant and non-propagating cables, conservative application in regard to ampacity ratings and raceway fill, and by separation, fire protection is built into the system. Cables are rated to withstand fault currents until the fault is cleared. Short circuit analysis will be performed in accordance with IEEE 141 and/or other acceptable industry standards or practices to determine fault currents. Fire suppression systems (e.g., automatic sprinkler systems) are provided as listed in Table 9.5.1-1.

8.3.3.8.1 Resistance of Cables to Combustion

The electrical cable insulation is designed to resist the onset of combustion by limiting cable ampacity to levels which prevent overheating and insulation failures (and resultant possibility of fire) and by choice of insulation and jacket materials which have flame-resistive and self-extinguishing characteristics. Polyvinyl chloride or neoprene cable insulation is not used in the ABWR. All cable trays are fabricated from noncombustible material. Base ampacity rating of the cables was established as published in ICEA-46-426/IEEE-S-135 and ICEA-54-440/ NEMA WC-51. Each coaxial cable, each single conductor cable and each conductor in multiconductor cable is specified to pass the vertical flame test in accordance with UL-44.

In addition, each power, control and instrumentation cable is specified to pass the vertical tray flame test in accordance with IEEE-383.

Power and control cables are specified to continue to operate at a conductor temperature not exceeding 90°C and to withstand an emergency overload temperature of up to 130°C in accordance with ICEA S-66-524/NEMA WC-7 Appendix D. Each power cable has stranded conductor and flame-resistive and radiation-resistant covering. Conductors are specified to continue to operate at 100% relative humidity with a service life expectancy of 60 years. Also, Class 1E cables are designed and qualified to survive the LOCA ambient condition at the end of the 60-yr. life span. The cable installation (i.e., redundant divisions separated by fire barriers) is such that direct impingement of fire suppressant will not prevent safe reactor shutdown, even if failure of the cable occurs. Cables are specified to be submersible, however. (See the fourth requirement/compliance in Subsection 9.5.1.1).

8.3.3.8.2 Localization of Fires

In the event of a fire, the installation design will localize the physical effects of the fire by preventing its spread to adjacent areas or to adjacent raceways of different divisions. Localization of the effect of fires on the electric system is accomplished by separation of redundant cable systems and equipment as described in Subsection 8.3.3.6. Floors and walls are effectively used to provide vertical and horizontal fire-resistive separations between redundant cable divisions.

In any given fire area an attempt is made to insure that there is equipment from only one Class 1E division. This design objective is not always met due to other over-riding design requirements; however, separation requirements of 8.3.3.1 are complied with. In addition an analysis is made and documented in Section 9A.5.5 to ascertain that the requirement of being able to safely shut the plant down with complete burnout of the fire area without recovery of the equipment is met. The fire detection, fire suppression and fire containment systems provided should assure that a fire of this magnitude does not occur, however.

Maximum separation of equipment is provided through location of redundant equipment in separate fire areas. The Class 1E divisional AC medium voltage switchgear, power centers, motor control centers, and DC distribution panels are located to provide separation and electrical isolation between the divisions. Clear access to and from the main switchgear rooms is also provided. Cable chases are ventilated and smoke removal capability is provided. Local instrument panels and racks are separated by safety division and located to facilitate required separation of cabling.

8.3.3.8.3 Fire Detection and Protection Systems

All areas of the plant are covered by a fire detection and alarm system. Double manual hose coverage is provided throughout the buildings. Sprinkler systems are provided as listed on Table 9.5.1-1. The diesel generator rooms and day tank rooms are protected by foam sprinkler systems. The foam sprinkler systems are dry pipe systems with pre-action valves which are actuated by compensated rate of heat rise and ultraviolet flame detectors. Individual sprinkler heads are opened by their thermal links.

8.3.4 COL License Information

8.3.4.1 Not Used

8.3.4.2 Diesel Generator Design Details

Subsection 8.3.1.1.8.2 (4) requires the diesel generators be capable of reaching full speed and voltage within 20 seconds after the signal to start. The COL applicant will demonstrate the reliability of the diesel generator startup circuitry designed to accomplish this.

8.3.4.3 Not Used

8.3.4.4 Protective Devices for Electrical Penetration Assemblies

Appropriate plant procedures shall include periodic testing and calibration of protective devices (except fuses which will be inspected) to demonstrate their functional capability to perform their required safety functions.

8.3.4.5 Not Used

8.3.4.6 Not Used

8.3.4.7 Not Used

8.3.4.8 Not Used

8.3.4.9 Offsite Power Supply Arrangement

The COL applicant operating procedures shall require one of the three divisional buses of Figure 8.3-1 be fed by the alternate power source during normal operation; in order to prevent simultaneous de-energization of all divisional buses on the loss of only one of the offsite power supplies. The selection of that division should be based on the Class 1E bus loads, the reliability/stability of the offsite circuits, and on the separation of the offsite feeds as they pass through the divisional areas.

Continued plant operation will be appropriately limited when the reserve auxiliary transformer is inoperable. See 8.2.4 for COL license information requirements.

8.3.4.10 Not Used

8.3.4.11 Not Used

8.3.4.12 Not Used

8.3.4.13 Load Testing of Class 1E Switchgear and Motor Control Centers

The COL applicant will provide procedures for load testing the Class 1E switchgear and motor control centers by operating connected Class 1E loads at 9% to 10% above, and 9% to 10% below design voltage.

8.3.4.14 Administrative Controls for Bus Grounding Circuit Breakers

Figure 8.3-1 shows bus grounding circuit breakers, which are intended to provide safety grounds during maintenance operations. Administrative controls shall be provided by the COL applicant to keep these circuit breakers racked out (i.e., in the disconnect position) whenever corresponding buses are energized (Subsection 8.3.1.1.6.2).

8.3.4.15 Administrative Controls for Manual Interconnections

As indicated in Subsection 8.3.1.2(4)(b), the ABWR has capability for manually connecting any plant loads to receive power from any of the six sources. Appropriate plant operating procedures shall prevent paralleling of the redundant onsite Class 1E power supplies.

8.3.4.16 Not Used

8.3.4.17 Common Industrial Standards Referenced in Purchase Specifications

In addition to the regulatory codes and standards required for licensing, purchase specifications shall contain a list of common industrial standards, as appropriate, for the assurance of quality manufacturing of both Class 1E and non-Class 1E equipment. Such standards would include ANSI, ASTM, IEEE, NEMA, UL, etc. (Subsection 8.3.5).

8.3.4.18 Administrative Controls for Switching 125 VDC Standby Charger

Administrative controls shall be provided to assure all input and output circuit breakers are normally open when standby battery chargers are not in use (See Figure 8.3-4, Note 1). Administrative controls shall also be provided to assure at least two circuit breakers (in series) are open between redundant divisions when placing the standby charger into service. This includes controls for the keys associated with the switching interlocks. The only exception is an emergency condition requiring one division's loads be assumed by a redundant division by manual connection via the standby charger interface.

8.3.4.19 Control of Access to Class 1E Power Equipment

Administrative control of access to Class 1E power equipment areas and/or distribution panels shall be provided [Subsection 8.3.3.6.1.1 (5)].

8.3.4.20 Periodic Testing of Voltage Protection Equipment

Appropriate plant procedures shall include periodic testing of instruments, timers, and other electrical equipment designed to protect the distribution system from: (1) loss of offsite voltage, and (2) degradation of offsite voltage. These protection features are described in Subsection 8.3.1.1.7.

8.3.4.21 Diesel Generator Parallel Test Mode

The technical specifications require periodic testing of the diesel generator loading capabilities by operating the diesel generators in parallel with the offsite power source. Appropriate plant procedures shall be provided for periodic testing of the interlocks which restore the units to emergency standby on event of a LOCA or LOPP.

Appropriate plant procedures shall require that each diesel generator set be operated independently of the other sets, and be connected to the utility power system only by manual control during testing or for bus transfer. Also, such procedures shall require that the duration of the connection between the preferred power supply and the standby power supply shall be minimized in accordance with Section 6.1.3 of IEEE-308 (Subsection 8.3.1.1.8.1).

8.3.4.22 Periodic Testing of Diesel Generator Protective Relaying

Appropriate plant procedures shall include periodic testing of all diesel generator protective relaying, bypass circuitry and annunciation.

8.3.4.23 Periodic Testing of Diesel Generator Synchronizing Interlocks

Appropriate plant procedures shall include periodic testing of diesel generator synchronizing interlocks (see 8.3.1.1.6.4).

8.3.4.24 Periodic Testing of Thermal Overloads and Bypass Circuitry

Appropriate plant procedures shall include periodic testing of thermal overloads and associated bypass circuitry for Class 1E MOVs. The testing shall be performed in accordance with the requirements of Regulatory Guide 1.106 (see 8.3.1.2(2)(g) and 8.3.2.2.2(2)(f)).

8.3.4.25 Periodic Inspection/Testing of Lighting Systems

Appropriate plant procedures shall include periodic inspections of all lighting systems installed in safety-related areas, and in passageways leading to and from these areas. In addition, lighting systems installed in such areas which are normally de-energized (e.g., DC-powered lamps) shall be periodically tested.

8.3.4.26 Controls for Limiting Potential Hazards into Cable Chases

Appropriate plant procedures shall provide administrative control of operations and maintenance activities to control and limit introduction of potential hazards into cable chases and the control room area.

8.3.4.27 Periodic Testing of Class 1E Equipment Protective Relaying

Appropriate plant procedures shall include periodic testing of all protective relaying and/or thermal overloads associated with Class 1E motors and switchgear.

8.3.4.28 Periodic Testing of CVCF Power Supplies and EPAs

Appropriate plant procedures shall include periodic testing (including alarms) of the CVCF power supplies and associated Electrical Protection Assemblies (EPAs) which provide power to the Reactor Protection System.

8.3.4.29 Periodic Testing of Class 1E Circuit Breakers

Appropriate plant procedures shall include periodic calibration and functional testing of the fault interrupt capability of all Class 1E breakers, fault interrupt coordination between the supply and load breakers for each Class 1E load and the Division I non-Class 1E load, and the zone selective interlock feature of the breaker and transfer switch for the non-Class 1E load (Subsection 8.3.1.1.1).

8.3.4.30 Periodic Testing of Electrical Systems & Equipment

Appropriate plant procedures shall include periodic testing of all Class 1E electrical systems and equipment in accordance with Section 7 of IEEE-308.

8.3.4.31 Not Used

8.3.4.32 Class 1E Battery Installation and Maintenance Requirements

The installation, maintenance, testing, and replacement of the Class 1E station batteries shall meet the requirements of IEEE-484 and Section 5 of IEEE-946 (Subsection 8.3.2.1.1.1).

8.3.4.33 Periodic Testing of Class 1E Batteries

Appropriate plant procedures shall include periodic testing of Class 1E batteries, in accordance with Section 7 of IEEE-308, to assure they have sufficient capacity and capability to supply power to their connected loads.

8.3.4.34 Periodic Testing of Class 1E CVCF Power Supplies

Appropriate plant procedures shall include periodic testing of Class 1E constant voltage constant frequency (CVCF) power supplies to assure they have sufficient capacity to supply power to their connected loads (Subsection 8.3.1.1.4.2.1).

8.3.4.35 Periodic Testing of Class 1E Battery Chargers

Appropriate plant procedures shall include periodic testing of Class 1E battery chargers to assure they have sufficient capacity to supply power to their connected loads (Subsection 8.3.2.1.1). Such periodic tests shall be in conformance with Section 7.5.1 of IEEE-308 (i.e., IEEE-338).

8.3.4.36 Periodic Testing of Class 1E Diesel Generators

Appropriate plant procedures shall include periodic testing and/or analysis of Class 1E diesel generators (Subsections 8.3.1.1.8.2, 8.3.1.1.8.3 and 8.3.1.1.8.6), including demonstration of their capability to supply the actual full design basis load current for each sequenced load step.

8.3.5 References

In addition to those codes and standards required by the SRP the following codes and standards will be used and have been referenced in the text of this chapter of the SSAR.

IEEE-141 Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book)

IEEE-242 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)

IEEE-323 Qualifying Class 1E Equipment for Nuclear Power Generating Stations

IEEE-334 Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations

IEEE-379 Applications of the Single-Failure Criterion to Nuclear Power Generating Stations Class 1E Systems

IEEE-382 Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.

IEEE-383 Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations

IEEE-387 Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations

IEEE-399 Recommended Practice for Industrial and Commercial Power Systems Analysis (IEEE Brown Book)

IEEE-450 Recommended Practice for Large Lead Storage Batteries for Generating Stations and Substations

IEEE-484 Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations.

IEEE-485 Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations

IEEE-519 Guide for Harmonic Control and Reactive Compensation of Static Power Converters

IEEE-741	Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.
IEEE-946	Recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Generating Stations
ICEA S-61-402/ NEMA WC-5	Thermoplastic Insulated Wire & Cable for the Transmission and Distribution of Electrical Energy
ICEA-46-426/ IEEE-S-135	Power Cable Ampacities
ICEA-54-440/ NEMA WC-51	Ampacities Cables in Open-Top Cable Trays
ICEA S-66-524/ NEMA WC-7	Cross-Linked-Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
SECY-89-013	Stello, Victor, Jr., Design Requirements Related To The Evolutionary Advanced Light Water Reactors (ALWRS), Policy Issue, SECY-89-013, The Commissioners, United States Nuclear Regulatory Commission, January 19, 1989.
NEDC-31336	Topical Report, “General Electric Instrument Setpoint Methodology”
UL-44	UL Standard for Safety Rubber-Insulated Wires and Cables

A partial listing of other common industry standards which may be used as applicable is given below. There are many more standards referenced in the standards which are listed below:

Motor Control Centers

NEMA ICS-2	Standards for Industrial Control Devices, Controllers and Assemblies
UL-845	UL Standard for Low Voltage Circuit Breakers
ANSI C37.13	Low Voltage Power Circuit Breakers
ANSI C37.16	Preferred Ratings and Related Requirements for Low Voltage AC Power Circuit Breakers and AC Power Service Protectors
ANSI C37.17	Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers

ANSI C37.50	Test Procedures for Low Voltage AC Power Circuit Breakers Used in Enclosures

Molded Case Circuit Breakers

UL-489	UL Standard for Branch Circuit and Service Circuit Breakers
NEMA AB-1	Molded Case Circuit Breakers

7.2 kV-rated metal-clad Switchgear

ANSI C37.01	Application Guide for Power Circuit Breakers
ANSI C37.04	AC Power Circuit Breaker Rating Structure
ANSI C37.06	Preferred Ratings of Power Circuit Breakers
ANSI C37.09	Test Procedure for Power Circuit Breakers
ANSI C37.11	Power Circuit Breaker Control Requirements
ANSI C37.20	Switchgear Assemblies and Metal-Enclosed Bus
ANSI C37.100	Definitions for Power Switchgear
ANSI C37.20	Switchgear Assemblies and Metal-Enclosed Bus
ANSI C37.100	Definitions for Power Switchgear Transformers
ANSI C57.12	General Requirements for Distribution, Power, and Regulating Transformers
ANSI C57.12.11	Guide for Installation of Oil-immersed Transformers (10mV·A and Larger, 69–287 kV rating)
ANSI C57.12.80	Terminology for Power and Distribution Transformers
ANSI C57.12.90	Test Code for Distribution, Power, and Regulating Transformers

See Subsection 8.3.4.17 for COL license information pertaining to common industrial standards referenced in purchase specifications.

Table 8.3-1 D/G Load Table—LOCA + LOPP

			Generator Connected Loads (kW)			
Sys. No	Load Description	Rating (kW)	A (Div I)	B (Div II)	C (Div III)	Note*
—	Motor operated Valves	231x3	X	X	X	(2)
C12	FMCRD (@0.25 pF)	210x1 (840kV·A)	210	—	—	
C41	SLC Pump	45x2	45	45	—	
E11	RHR Pump	540x3	540	540	540	
	Fill Pump	3.7x3	X	X	X	
E22	HPCF Pump	1400x2	—	1400	1400	
P21	RCW Pump	370x4	740	740	—	
		280x2	—	—	560	
P25	HECW Pump	22x5	22	44	44	
	HECW Refrigerator	135x5	135	270	270	
P41	RSW Pump	270x6	540	540	540	
R23	P/C Transf. Loss	42.1x6	84.2	84.2	84.2	
R42	DC 125V CHGR Div. I	70x1	70	—	—	
	Div. II, III, IV	34x3	—	68	34	
	125VDC stby charger		70	—	34	(3)
R46	Vital CVCF		—	—	—	
	(Div. 1, 2, 3)	20x3	20	20	20	
	(Div. 4)	20		20		
R47	Transf. C/R Inst	20x6	40	40	40	
R52	Lighting	100x3	100	100	100	
T22	SGTS Fan	18.5x2	—	18.5	18.5	
	SGTS Heater	10x6	—	30	30	
T49	FCS Heater	130x2		130	130	
	FCS Blower	12x2		12	12	
U41	MCR HVAC Fans B-C	74.5x4	—	149	149	(5)
	MCR Recirc Fans B-C	14x4	—	28	28	(5)
	C/B Elec Equip Area HVAC Fans A-C	14x6	28	28	28	(5)
	R/B DG/Elec Equip Area HVAC Fans A-C	84x6	168	168	168	(5)
	R/B DG Room Emergency Supply Fans A-C	46.5x6	93	93	93	(5)
	R/B Equip Area Room Coolers A-C		89	107	84	(5)

Table 8.3-1 D/G Load Table—LOCA + LOPP (Continued)

			Generator Connected Loads (kW)			
Sys. No	Load Description	Rating (kW)	A (Div I)	B (Div II)	C (Div III)	Note*
	Other Loads		62.5	62.5	60.5	
	Total Connected Loads		3291.4	4971.9	4701.9	
	Total Standby Loads and Short Time Loads		423.7	521.2	509.7	
	Total Operating Loads		2867.7	4450.7	4192.2	

* See Table 8.3-3 for Notes

Table 8.3-2 D/G Load Table—LOPP (W/O LOCA)

			Generator Output (kW)			
Sys. No	Load Description	Rating (kW)	A	B	C	Note*
(Since there are no LOPP only loads on the diesel generators the LOCA load table envelopes the LOPP loading. See Table 8.3-1)						

* See Table 8.3-3 for Notes

Table 8.3-3 Notes for Tables 8.3-1 and 8.3-2

(1) – : shows that the load is not connected to the switchgear of this division.

X : shows that the load is not counted for D/G continuous output calculation by the reasons shown on other notes.

(2) "Motor operated valves" are operated only 30–60 seconds. Therefore they are not counted for the DG continuous output calculation.

(3) Div. IV battery charger is fed from Div. II motor control center.

(4) Load description acronyms are interpreted as follows:

C/B	Control Building	HX	Heat Exchanger
COMP	Computer	IA	Instrument Air
CRD	Control Rod Drive	MCR	Main Control Room
		MUWC	Make Up Water System (condensed)
CVCF	Constant Voltage Constant Frequency	NPSS	Nuclear Protection Safety System
DG	Diesel Generator	R/B	Reactor Building
FCS	Flammability Control System	RCW	Reactor Cooling Water (building)
		RHR	Residual Heat Removal
FMCRD	Fine Motion Control Rod Drive	RSW	Reactor Service Water
HECW	Emergency Cooling Water	SGTS	Standby Gas Treatment
HPCF	High Pressure Core Flooder	SLC	Standby Liquid Control

(5) Redundant units, one unit of a division operates and one unit is in standby in case the operating unit shuts down. Total connected load is shown on the table, but operating loads are half these amounts.

Table 8.3-4 D/G Load Sequence Diagram Major Loads

	Mode	Div.	Block 1 (20 s)	Block 2 (30 s)	Block 3 (35 s)	Block 4 (40 s)	Block 5 (45 s)	Block 6 (50 s)	Block 7 (55 s)	Block 8 (60 s)	Block 9 (After 65 s)	
Non-Accident Loads	LOPP	I	MOV Inst. Tr Lighting FMCRD*	DG HVAC	RCW Pump HECW Pump	RCW Pump	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	RHR Pump
	LOPP	II	MOV Inst. Tr Lighting	DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	RHR Pump
	LOPP	III	MOV Inst. Tr Lighting	DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump		Chargers CVCFs	HECW Refrig	RHR Pump
LOCA Loads	LOCA & LOPP	I	MOV Inst. Tr Lighting FCMRD*	RHR Pump DG HVAC	RCW Pump HECW Pump	RCW Pump	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	FCS
	LOCA & LOPP	II	MOV HPCF Pump Inst. Tr Lighting	RHR Pump DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump	SGTS	Chargers CVCFs	SLC Pump HECW Refrig	FCS
	LOCA & LOPP	III	MOV HPCF Pump Inst. Tr Lighting	RHR Pump DG HVAC	RCW Pump HECW Pump	RCW Pump MCR HVAC	RSW Pump R/B Emer. HVAC C/B Emer. HVAC	RSW Pump		Chargers CVCFs	HECW Refrig	

* FMCRDs are the only Non-Class 1E loads on the DG buses.

Table 8.3-5 Diesel Generator Alarms*

Annunciation	DOS	DTS	DTT	GDT	GCB	GTT	LBP
Engine Overspeed Trip	X	X	X		X		
Generator Differential Relay Trip		X		X	X	X	
Generator Ground Overcurrent					X	X	X
Generator Voltage Restraint Overcurrent					X	X	X
Generator Overvoltage						X	
Generator Phase Overcurrent						X	
Generator Bus Underfrequency					X	X	X
Generator Reverse Power		X			X	X	X
Generator Loss of Field		X			X	X	X
Generator Bus Differential Relay Trip					X		X
High-High Jacket Water Temperature		X	X		X		X
D/G Bearing High Temperature		X	X		X	X	X
Low-Low Lube Oil Temperature		X	X		X		X
D/G Bearings High Vibration		X	X		X	X	X
High-High Lube Oil Temperature		X	X		X		X
Low-Low Lube Oil Pressure		X	X		X		X
High Crankcase Pressure		X	X		X		X
Low-Low Jacket Water Pressure		X	X		X		X
Low Level—Jacket Water			X				
Low Pressure—Jacket Water			X				
Low Temperature—Jacket Water In			X				
High Temperature—Jacket Water Out			X				
Low Level—Lube Oil Mark			X				
Low Temperature—Lube Oil In			X				
High Temperature—Lube Oil Out			X				
High Diff. Pressure—Lube Oil Filter			X				

Legend:
- DOS = Diesel OverSpeed
- DTS = Diesel Trip or Inoperative
- DTT = Diesel Trouble or in Test
- GDT = Generator Differential Trip
- GCB = Generator Circuit Breaker Trip
- GTT = Generator Trouble or in Test
- LBP = LOCA Bypass (i.e., trip bypassed during LOCA) (Not an annunciator window)

Table 8.3-5 Diesel Generator Alarms* (Continued)

Annunciation	DOS	DTS	DTT	GDT	GCB	GTT	LBP
Low Pressure—Turbo Oil Right/Left Bank			X				
Low Pressure—Lube Oil			X				
Control Circuit Fuse Failure			X				
Low Pressure—Starting Air			X				
In Maintenance Mode			X			X	
D/G Unit Fails to Start			X				
Out of Service		X			X		
Lockout Relay Operated		X			X	X	
Low-High Level—Fuel Day Tank			X				
Low Level—Fuel Storage Tank			X				
Low Pressure—Fuel Oil			X				
High Diff. Pressure—Fuel Filter			X				
In Local control Only			X				

Legend:
- DOS = Diesel OverSpeed
- DTS = Diesel Trip or Inoperative
- DTT = Diesel Trouble or in Test
- GDT = Generator Differential Trip
- GCB = Generator Circuit Breaker Trip
- GTT = Generator Trouble or in Test
- LBP = LOCA Bypass (i.e., trip bypassed during LOCA) (Not an annunciator window)

* This list may vary depending on unique characteristics of specific diesel generator selected.

The following figures are located in Chapter 21:

8A Miscellaneous Electrical Systems

8A.1 Station Grounding and Surge Protection

8A.1.1 Description

The electrical grounding system is comprised of:

(1) An instrument and computer grounding network

(2) An equipment grounding network for grounding electrical equipment (e.g. transformer, switchgear, motors, distribution panels, cables, etc.) and selected mechanical components (e.g. fuel tanks, chemical tanks, etc.)

(3) A plant grounding grid

(4) A lightning protection network for protection of structures, transformers and equipment located outside buildings

The plant instrumentation is grounded through a separate insulated radial grounding system comprised of buses and insulated cables. The instrumentation grounding systems are connected to the station grounding grid at only one point and are insulated from all other grounding circuits. Separate instrumentation grounding systems are provided for plant analog (i.e., relays, solenoids, etc.) and digital instrumentation systems.

The equipment grounding network is such that all major equipment, structures and tanks are grounded with two diagonally opposite ground connections. The ground bus of all switchgear assemblies, motor control centers and control cabinets are connected to the station ground grid through at least two parallel paths. Bare copper risers are furnished for all underground electrical ducts and equipment, and for connections to the grounding systems within buildings. One bare copper cable is installed with each underground electrical duct run, and all metallic hardware in each manhole is connected to the cable.

A plant grounding grid consisting of bare copper cables is provided to limit step and touch potentials to safe values under all fault conditions. The buried grid is located at the switchyard and connected to systems within the buildings by a 500 MCM bare copper loop which encircles all buildings (Figure 8A-1).

Each building is equipped with grounding systems connected to the station grounding grid. As a minimum, every other steel column of the building perimeter will connect directly to the grounding grid.

The plant's main generator is grounded with a neutral grounding device. The impedance of that device will limit the maximum phase current under short-circuit conditions to a value not greater than that for a three-phase fault at its terminals. Provisions are included to ensure proper grounding of the isophase buses when the generator is disconnected.

The onsite, medium-voltage AC distribution system is resistance grounded at the neutral point of the low-voltage windings of the unit auxiliary and reserve transformers.

The neutral point of the generator windings of the onsite, standby power supply units (i.e., the diesel generators and the combustion turbine generator), is through distribution-type transformers and loading resistors, sized for continuous operation in the event of a ground fault.

The neutral point of the low-voltage AC distribution systems are either solidly or impedance grounded, as necessary, to ensure proper coordination of ground fault protection. The DC systems are ungrounded.

The target value of ground resistance is one ohm or less for the Reactor, Turbine, Control, Service and Radwaste buildings. This is consistent with Section 12.1 of IEEE-80. If the target grounding resistance is not achieved by the ground grid, auxiliary ground grids, shallow buried ground rods or deep buried ground rods will be used in combination as necessary to meet the target ground resistance value.

The lightning protection system covers all major plant structures and is designed to prevent direct lightning strikes to the buildings, electric power equipment and instruments. It consists of air terminals, bare downcomers and buried grounding electrodes which are separate from the normal grounding system. Lightning arresters are provided for each phase of all tie lines connecting the plant electrical systems to the switchyard and offsite line. These arresters are connected to the high-voltage terminals of the main step-up and reserve transformers. Plant instrumentation located outdoors or connected to cabling running outdoors is provided with surge suppression devices to protect the equipment from lightning induced surges.

8A.1.2 Analysis

No SRP or regulatory guidance is provided for the grounding and lightning protection system. It is designed and required to be installed to the applicable sections of the following codes and standards.

(1) IEEE-80, Guide for Safety in AC Substation Grounding (Reference 8A-1)

(2) IEEE-81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Reference 8A-2)

(3) IEEE-665, Guide for Generation Station Grounding (Reference 8A-3)

(4) NFPA-78, National Fire Protection Association's Lightning Protection Code (Reference 8A-4)

This code is utilized as recommended practices only. It does not apply to electrical generating plants.

8A.1.3 COL License Information

It is the responsibility of the COL applicant to perform ground resistance measurements to determine that the required value of one ohm or less has been met and to make additions to the system if necessary to meet the target resistance.

8A.2 Cathodic Protection

8A.2.1 Description

A cathodic protection system is provided. Its design is plant unique as it must be tailored to the site conditions. The COL applicant must provide a design meeting the requirements listed in Subsection 8A.2.3.

8A.2.2 Analysis

There are no SRP or regulatory requirements nor any national standards for cathodic protection systems. The system is designed to the requirements listed in Subsection 8A.2.3.

8A.2.3 COL License Information

The COL applicant is required to meet the following minimum requirements for the design of the cathodic protection systems. These requirements are the same as those called for in Chapter 11, Section 9.4 of the Utility Requirements Document issued by the Electric Power Research Institute (Reference 8A-5).

(1) The need for cathodic protection on the entire site, portions of the site, or not at all shall be determined by analyses. The analyses shall be based on soil resistivity readings, water chemistry data, and historical data from the site gathered from before commencement of site preparation to the completion of construction and startup.

(2) Where large protective currents are required, a shallow interconnected impressed current system consisting of packaged high silicon alloy anodes and transformer-rectifiers, shall normally be used. The rectifiers shall be approximately 50% oversized in anticipation of system growth and possible higher current consumption.

(3) The protected structures of the impressed current cathodic protection system shall be connected to the station grounding grid.

(4) Localized sacrificial anode cathodic protection systems shall be used where required to supplement the impressed current cathodic protection system and protect surfaces which are not connected to the station grounding grid or are located in outlying areas.

(5) Prepackaged zinc type reference electrodes shall be permanently installed near poorly accessible protected surfaces to provide a means of monitoring protection level by measuring potentials.

(6) Test stations above grade shall be installed throughout the station adjacent to the areas being protected for termination of test leads from protected structures and permanent reference electrodes.

8A.3 Electric Heat Tracing

8A.3.1 Description

The electric heat tracing system provides freeze protection where required for outdoor service components and fluid warming of process fluids if required, either in or out doors. If the operation of the heat tracing is required for proper operation of a safety-related system, the heat tracing for the safety-related system is required to be Class 1E. Power for heat tracing is supplied from buses backed by the onsite standby generators. Non-Class 1E heat tracing has access to the combustion turbine generator through the same load group as the components protected. Class 1E heat tracing is assigned to the appropriate division of Class 1E power.

8A.3.2 Analysis

There are no SRP or regulatory guidance provided for electric heat tracing systems. They are required to be designed and installed to the applicable sections of the following codes and standards.

(1) IEEE-622, Recommended Practice for the Design and Installation of Electric Heat Tracing Systems in Nuclear Power Generating Stations (Reference 8A-6)

(2) IEEE-622A, Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems in Nuclear Power Generating Stations (Reference 8A-7)

8A.3.3 COL License Information

No COL applicant information is required.

8A.3.4 References

The following codes and standards have been referenced in this section of Tier 2.

8A-1 IEEE-80, Guide for Safety in AC Substation Grounding

8A-2 IEEE-81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

8A-3 IEEE-665, Guide for Generation Station Grounding

8A-4 NFPA-78, National Fire Protection Association's Lightning Protection Code

8A-5 Utility Requirements Document, Advanced Light Water Reactor, Volume II, ALWR Evolutionary Plant, Electric Power Research Institute

8A-6 IEEE-622, Recommended Practice for the Design and Installation of Electric Heat Tracing Systems in Nuclear Power Generating Stations

8A-7 IEEE-622A, Recommended Practice for the Design and Installation of Electric Pipe Heating Control and Alarm Systems in Nuclear Power Generating Stations