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 (13.8 kV and 4.16 kV) switchgear. The system consists of four load groups on non-Class 1E 13.8 kV Power Generation (PG) buses, three load groups on non-Class 1E 4.16 kV Plant Investment Protection (PIP) buses, and three load groups on Class 1E 4.16 kV buses. 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 4.16 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 4.16 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 4.16 kV Class 1E bus feeds its associated 480V unit power center through a 4.16 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. CTG Bus 1 can be tied to CTG Bus 2 by the manual closing of the CTG bus tie breaker. The breakers can only be closed after complying with the shedding requirements and loads limitations in accordance with off-normal/emergency procedures.

AC power is supplied at 13.8 kV or 4.16 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 13.8 kV or 4.16 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 four 13.8 kV PG buses and three 4.16 kV PIP buses. The four bus configuration was chosen to meet the requirement that the ten Reactor Internal Pumps (RIPs) be powered by four independent buses. This will minimize large core flow reduction events and match the mechanical power generation systems which are mostly four trains (e.g. four feedwater pumps, four condensate pumps, four condensate booster pumps, four heater drain pumps, and four circulating water pumps). The three bus configuration was chosen to match the supported mechanical systems, which typically consist of two or three trains.

The four power generation buses supply power production loads. Each one of these buses has access to power from one winding of its assigned unit auxiliary transformer. Each PG bus also has access to a reserve auxiliary transformer or CTG 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.

Plant Investment Protection (PIP) buses supply power to non-safety loads (e.g. the turbine building HVAC, the turbine building service water and the turbine building closed cooling water systems) in three load groups. On loss of normal or alternate preferred power an automatic transfer of pre-selected buses occurs via a dead bus transfer to the combustion turbine which automatically starts on loss of power. The PIP systems for each selected load group automatically restart to support their loads.

The non-Class 1E switchgear interruption ratings are chosen to be capable of clearing the maximum expected fault current. The continuous ratings are chosen to carry the maximum expected normal currents. The 13.8 kV/4.16 kV switchgear is rated at 15 kV/4.76 kV, respectively. Instrument and control power is from the non-Class 1E, 125VDC power system.

The 13.8 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 medium voltage 13.8 kV and 4.16 kV bus has a spare space which can be used to insert a manual grounding circuit device for use during maintenance activities.

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 13.8 kV/480V or 4.16 kV/480V transformers and associated metal-clad switchgear (see Figure 8.3-1). There is at least one power center on each of the medium voltage PG and PIP buses.

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 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 devices.

8.3.1.0.6.3 Bus Protection

Bus protection is as follows:

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

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

(3) Not Used.

(4) Medium voltage 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 4.16 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 with normal and interrupting ratings that are sized to carry normal loads and to clear expected faults. Control and instrument power for each Class 1E division are supplied by its associated Class 1E 125 VDC power system. Each medium voltage 4.16 kV bus has a spare space which can be used to insert a manual grounding circuit device for use during maintenance activities. A main control room indication is provided when the bus grounding circuit device is installed.

Standby AC power for Class 1E buses is supplied by diesel generators at 4.16 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 4). 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.

Class 1E microprocessor controlled protective relaying equipment senses fault current flowing in the non-Class 1E load. This equipment utilizes digital timers that can reproduce the timing requirements by sensing the number of cycles of the electrical waveform itself. Coordination of the definite time delay and the upstream bus feeder breakers allows termination of the fault current before the feeder breakers are free to trip.Tripping of the Class 1E feed breaker is normal for faults which occur on the Class 1E bus it feeds.

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 all have the capability of being tested (Subsection 8.3.4.29).

Power is supplied to each FMCRD load group from either the Division I Class 1E bus or a non-Class 1E PIP bus through a non-Class 1E automatic transfer switch located between the power sources and the 480V FMCRD power distribution panels. Switchover 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. Per IEEE-384 and Regulatory Guide 1.75, isolation between the Class 1E bus and non-1E load is maintained.

The design minimizes the probability of a single failure affecting more than one FMCRD group by providing six independent feeds (two for each group) directly from the Division I Class 1E and PIP 480V buses. (see sheet 3 and 4 of Figure 8.3-1). The two Class 1E protective devices connected in series provide isolation between the Class 1E bus and non-Class 1E load. The transfer switches are non-Class 1E. 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.

The Safety System Logic and Control (SSLC) initiates a trip of the condensate pumps when a feedwater line break is detected in the drywell. Although not credited in the FWLB analysis in Chapter 6.2, this trip provides added assurance of conservatism in the feedwater mass flow used in the analysis. This FWLB mitigation adds safety related instrumentation to sense and confirm a FWLB based on high differential pressure between feedwater lines coincident with high drywell pressure to trip the condensate pumps. In order to trip the condensate pumps, a provision of 13.8 kV medium voltage safety-related breaker in series with the non-safety 13.8 kV feeder breaker exists for each condensate pump. The trip circuit of each safety-related 13.8 kV breaker includes two independent trip coils. Each trip coil is powered from a separate division of Class 1E 125V DC system. Two separate divisions of safety related control signals for feedwater line break are provided to initiate the trip of each breaker. This dual breaker in series arrangement ensures that the condensate pumps will trip on a feedwater line break.

The 13.8 kV breakers (both safety-related and nonsafety-related) are located in the Turbine Building. The procurement and design of the safety-related breakers are required to meet the criteria for performing the safety function of tripping the condensate pump breakers in case of the feedwater line break design basis event. The 125V DC control power and trip circuits of the safety-related breakers are also required to meet the independence criteria per RG 1.75. In addition, the safety-related breakers and its components are required to be seismically installed and missile protected at their location in the Turbine Building. Although the breaker control power and trip circuits will not fully meet the seismic Category I installation and RG 1.75 separation requirements, the following considerations provide reasonable assurance for tripping of condensate pumps during a feedwater line break in the drywell:

- The control power and SSLC circuits are provided with isolation devices.
- The control power cables are installed in dedicated raceways. Adequate separation exists between control circuit raceways and other non-safety raceways.
- The design of the raceway supports is performed considering seismic loads throughout their routing.
- The safety-related breakers are located in a separate electrical room.
- The design of the safety-related breaker supports is performed considering seismic loads.
- The probability of trip and control power circuit failure is very low. Even in case of failure of non-safety power cable, the breaker trip circuit is expected to perform the safety function of tripping the condensate pump feeder breakers due to redundancy of trip coils, trip signals and control power supply.

- The design does not impact or degrade any other safety-related equipment or function.
- A reliability assessment for this design has been performed.

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 4.16 kV/480V transformers and associated metal clad switchgear (see Figure 8.3-1). There are at least 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 to the four divisions of instrument power (Figure 8.3-2). Each Class 1E divisional transformer is supplied from a 480V MCC in the same division except for the Division IV transformer, which is supplied from the 480V MCC of Division II. There are three divisions (I, II and III), each backed up by its associated divisional diesel generator as the source when the offsite source is lost. Division IV is backed up by the Division II diesel generator, 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.

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 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 devices.

8.3.1.1.6.3 Bus Protection

Bus protection is as follows:

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

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

(3) Not Used.

(4) Medium voltage 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 4.16 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 4.16 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 (4.16 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 4.16 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 4.16 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 4.16 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 4.16 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

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[*] 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.

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.)

(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 in less than ten 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 Class 1E bus is Class 1E and the other breakers are non-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, 8.1.4.1, and 8.3.4.2 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 4.16 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 9MV·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 95% of the continuous power output rating of the diesel generator. See Table 8.3-1 for diesel generator loads applicable to each division.

(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 4.16 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, 5, 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. The Class 1E load breakers or protective devices connected in series for the bus are tripped by fault current for faults in the non-Class 1E load prior to initiation of a trip of upstream breakers. This meets the intent of the Regulatory Guide position.

There are three 4.16 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) Not Used

(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

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

Not Applicable to a single-unit ABWR.

(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.)

Normal plant operating loads can be supplied by either the reserve or unit auxiliary transformers. Any non-safety power generation loads can be manually connected to receive power from any of the two sources (i.e., the two switching stations represented by the UATs and RATs) due to the interconnection capability for the ABWR. Any Plant Investment Protection

(PIP) load can be manually connected to receive power from three sources (i.e., two switching stations and the CTG). Any Class 1E safety bus can be manually connected to receive power from four sources (i.e., two switching stations, the CTG, and the EDGs). Either the UATs or either of the RATs can supply the three Class 1E safety buses. 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 overcurrent 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 medium voltage kV and 480V switchgear, control relays, meters and indicators, 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.

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, 9.5.13.21, and 1C.4.1 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.

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

Not Applicable to a single-unit ABWR.

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. 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 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):

Note: V5 = Medium voltage power, 13.8 kV (15 kV insulation class) for non-Class 1E systems only.

(a) V4 = Medium voltage power, 4.16 kV (5 kV 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, 4.16 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.

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 (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.

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/ WC-5	Thermoplastic Insulated Wire & Cable for the Transmission and NEMA 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.
WCAP-17119-NP(P)	"Methodology for STP-3/4 ABWR Tech. Spec. Setpoints", Revision 2, July 2010.
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

Medium voltage 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	160x3	X	X	X	(2)
C12	FMCRD	432x1	432	–	–	
C41	SLC Pump	50x2	50	50	–	
E11	RHR Pump	589x3	589	589	589	
	Fill Pump	4x3	X	X	X	
E22	HPCF Pump	1689x2	–	1689	1689	
P21	RCW Pump (Div I, II)	389x4	778	778	–	
	(Div III)	300x2	–	–	600	
P25	HECW Pump	50x5	50	100	100	
	HECW Refrigerator	367x5	367	734	734	
P41	RSW Pump	530x6	1060	1060	1060	
R23	P/C Transformer Loss	30x6	60	60	60	
R42	DC 125V Charger (Div I,II,III)	98x3	98	98	98	
	(Div IV)	56x1	–	56	–	(3)
	125 VDC Standby Charger	98	98	–	98	
R46	Vital CVCF					
	(Div I,II,III)	28x3	28	28	28	
	(Div IV)	28	–	28	–	(3)
R47	Instrument and Control Power					
	(Div I,II,III)	40x3	40	40	40	
	(Div IV)	40	–	40	–	(3)
R52	Lighting	100x3	100	100	100	
T22	SGTS Fan	61x2	–	61	61	
	SGTS Heaters	26x2	–	26	26	
	SGTS Cooling Fan	4x2	–	4	4	
U41	CRHA Supply Fans	122x4	–	244	244	(5)
	CRHA HVAC Emergency Filter Unit Supply Fans	17x4	–	34	34	(5)
	CBSREA HVAC Supply Fans	61x6	122	122	122	(5)
	RBSREEHVAC Supply Fans	61x6	122	122	122	(5)
	RBSRDGHVAC Emergency Supply Fans	50x6	100	100	100	(5)
	RBSREEHVAC Supply					

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*
	Electrical Heating Coil	101x6	X	X	X	
	Cooling Tower Fan	208x6	416	416	416	
	UHS HVAC Fan	41x3	41	41	41	
	UHS Unit Heater	180x3	180	180	180	
Other Loads			174	140	131	
Total Connected Loads			5271	7306	7043	
Total Standby Loads and Short Time Loads			538	677	677	
Total Operating Loads			4733	6629	6366	

* 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 is fed from Div. II motor control center.

(4) Load description acronyms are interpreted as follows:

CRHA	Control Room Habitability Area		
CBSREA	Control Building Safety-Related Equipment Area		
RBSREEHVAC	Reactor Building Safety-Related Electrical Equipment HVAC System		
RBSRDGHVAC	Reactor Building Safety-Related Diesel Generator HVAC System		
UHS	Ultimate Heat Sink		
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
		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

		Block Time	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)	
	Mode	**Div.**										
Non-Accident Loads	LOPP	I	MOV	DG HVAC	RCW Pump	RCW Pump	RSW Pump	RSW Pump	SGTS	Chargers	SLC Pump	RHR Pump
			Inst. Tr Lighting FMCRD*		HECW Pump		R/B Emer. HVAC C/B Emer. HVAC			CVCFs	HECW Refrig	
	LOPP	II	MOV	DG HVAC	RCW Pump	RCW Pump	RSW Pump	RSW Pump	SGTS	Chargers	SLC Pump	RHR Pump
			Inst. Tr Lighting		HECW Pump	MCR HVAC	R/B Emer. HVAC C/B Emer. HVAC			CVCFs	HECW Refrig	
	LOPP	III	MOV	DG HVAC	RCW Pump	RCW Pump	RSW Pump	RSW Pump		Chargers	HECW Refrig	RHR Pump
			Inst. Tr Lighting		HECW Pump	MCR HVAC	R/B Emer. HVAC C/B Emer. HVAC			CVCFs		
LOCA Loads	LOCA & LOPP	I	MOV	RHR Pump	RCW Pump	RCW Pump	RSW Pump	RSW Pump	SGTS	Chargers	SLC Pump	
			Inst. Tr Lighting FCMRD*	DG HVAC	HECW Pump		R/B Emer. HVAC C/B Emer. HVAC			CVCFs	HECW Refrig	
	LOCA & LOPP	II	MOV	RHR Pump	RCW Pump	RCW Pump	RSW Pump	RSW Pump	SGTS	Chargers	SLC Pump	
			HPCF Pump Inst. Tr Lighting	DG HVAC	HECW Pump	MCR HVAC	R/B Emer. HVAC C/B Emer. HVAC			CVCFs	HECW Refrig	
	LOCA & LOPP	III	MOV	RHR Pump	RCW Pump	RCW Pump	RSW Pump	RSW Pump		Chargers	HECW Refrig	
			HPCF Pump Inst. Tr Lighting	DG HVAC	HECW Pump	MCR HVAC	R/B Emer. HVAC C/B Emer. HVAC			CVCFs		

* 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:

Figure 8.3-1 Electrical Power Distribution System SLD (Sheets 1–4)

Figure 8.3-2 Instrument and Control Power Supply System SLD

Figure 8.3-3 Plant Vital AC Power Supply System SLD (Sheets 1–2)

Figure 8.3-4 Plant Vital DC Power Supply System SLD (Sheets 1–3)